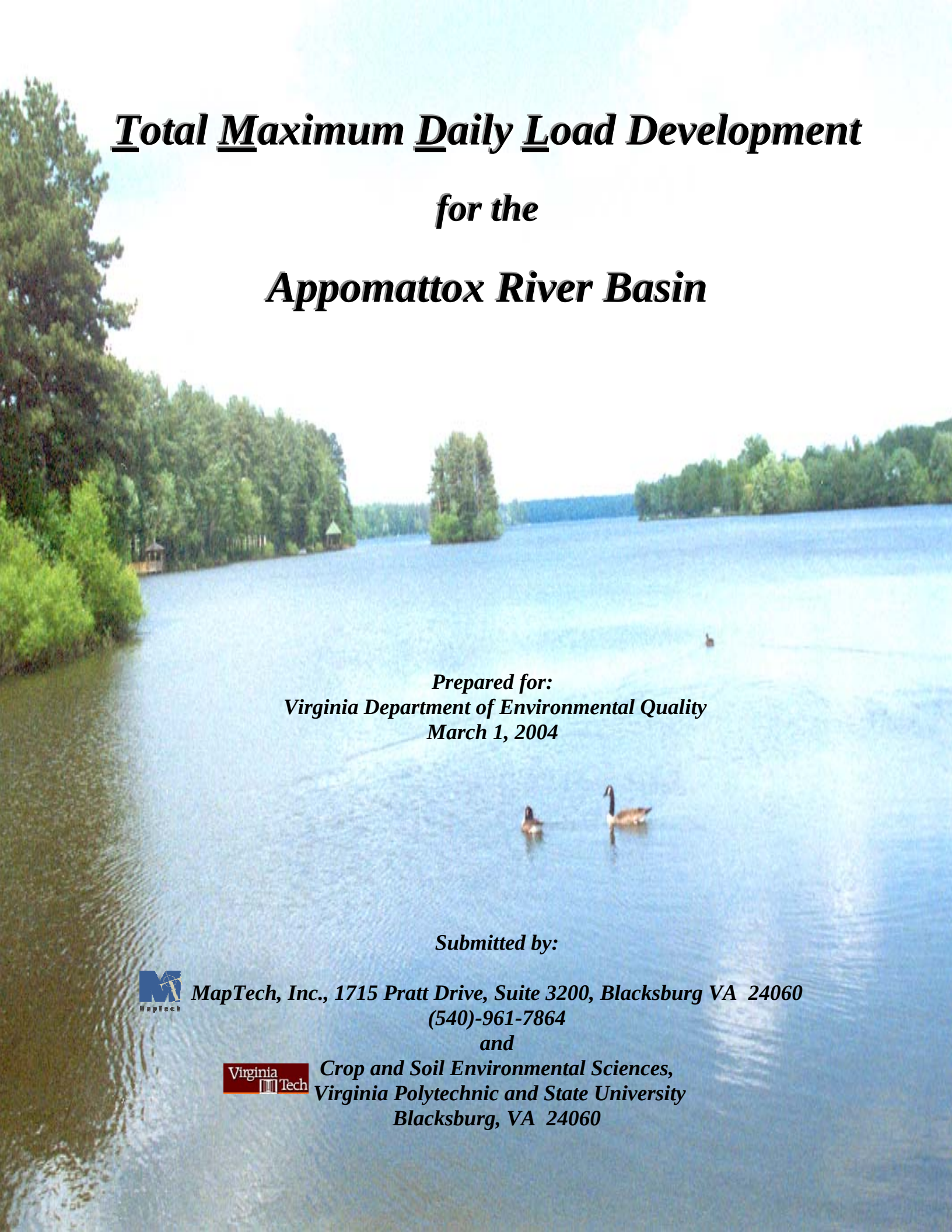

Total Maximum Daily Load Development

for the

Appomattox River Basin

Prepared for:
Virginia Department of Environmental Quality
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EXECUTIVE SUMMARY

Fecal Coliform Impairment

The Appomattox River and Deep Creek were initially placed on the Virginia 1996 303(d) TMDL Priority List based on monitoring performed. Additional stream segments within the basin were progressively placed on the 1996 303(d) TMDL Priority List, the 1998 303(d) Total Maximum Daily Load Priority List and Report, and the 2002 303(d) Report on Impaired Waters (see Table 1.1). All segments remained on the 2002 Section 303(d) Report on Impaired Waters. These listings are referenced in this document as the 'Appomattox River watershed' and have resulted in the development of 19 Total Maximum Daily Loads (TMDLs). These TMDLs focus on fecal coliform impairments. Based on exceedances of the standard recorded at Virginia Department of Environmental Quality (VADEQ) monitoring stations, the stream does not support primary contact recreation (*e.g.*, swimming). In January 2003, Virginia adopted two new criteria to protect the primary contact recreational use. The new applicable fecal coliform state standard (Virginia Water Quality Standard 9 VAC 25-260-170) specifies that no more than 10% of the total samples taken during any calendar month exceed 400 colony forming units (cfu) per 100 milliliters (ml). Alternatively, if data is available, the geometric mean of two or more observations taken in a calendar month should not exceed 200 cfu/100 ml. A review of available monitoring data for the watershed indicated that fecal coliform bacteria were consistently elevated above the 400 cfu/100 ml standard.

Sources of Fecal Coliform

Potential sources of fecal coliform include both point source and nonpoint source contributions. Nonpoint sources include: wildlife; grazing livestock; pets; land application of manure; land application of biosolids; urban/suburban runoff; failed, malfunctioning, and operational septic systems; and uncontrolled discharges (straight pipes, dairy parlor waste, etc.). There are 29 permitted facilities in the Appomattox River watershed, 23 of these facilities are permitted for fecal discharges as well as four locations covered by VPDES Phase Stormwater Permits. The list of permitted facilities is found in Table ES.1.1.

Water Quality Modeling

The The US Geological Survey (USGS) Hydrologic Simulation Program - Fortran (HSPF) water quality model was selected as the modeling framework to simulate existing conditions and perform TMDL allocations. In establishing the existing and allocation conditions, seasonal variations in hydrology, climatic conditions, and watershed activities were explicitly accounted for in the model. The time periods covered by calibration and validation represent a broad range of hydrologic and climatic conditions and are representative of the long-term precipitation and discharge record. For purposes of modeling watershed inputs to in-stream water quality, the Appomattox River drainage area was divided into one hundred forty-nine subwatersheds, which was then split into seven linked models in order to manage the constraints of the modeling system. For the lower Appomattox tidal impairment, the USEPA Water Quality Analysis Simulation Program (WASP) was coupled with the USEPA Link-Node Tidal Hydrodynamic Model (DYNHYD) to simulate existing conditions and to perform TMDL allocations.

The hydrologic model was calibrated to daily flows from the US Geological Survey gages USGS Station USGS02039000 on Buffalo Creek, USGS02039500 on the Appomattox River, USGS02040000 on the Appomattox River, USGS02041000 in Deep Creek and USGS02041650 on the Appomattox River for the period October 1993 through September 1998. The model was validated using daily flows recorded at the same gaging stations from October 1988 through September 1993. The hydrologic models performed well during calibration, with average predicted total volume within 4.4% of observed, average predicted peak flows within 6.8% of observed, and average predicted low flows within 3.5% of the observed. Validation runs performed similarly, with the predicted total volume averaging within 4.3% of observed, peak flows averaging 5.8% from observed and low flows averaging 6.4% from observed.

The models were calibrated for water quality predictions using data collected at VADEQ monitoring stations between October 1998 and August 2003, and validated using data collected between October 1993 and September 1998. The water quality models also

performed well, matching the observed levels of fecal coliform in a variety of flow conditions during both calibration and validation.

After calibrating the water quality model to a point such that it represents the response of the watershed accurately, allocation runs are performed. The purpose of allocation runs is to determine the reduction in source loadings necessary to meet water quality standards. It is essential that these allocations be performed assuming loads at current levels over a representative hydrological period. For this reason allocation runs were completed by projecting fecal source loadings to 2003 levels, and using the meteorological data from the period 1993-1998.

Existing Loadings and Water Quality Conditions

Wildlife populations and ranges, biosolids application rates and practices, rate of failure, location and number of septic systems, domestic pet populations, numbers of cattle and other livestock, and information on livestock and manure management practices for the Appomattox River watershed were used to calculate fecal coliform load from land-based nonpoint sources in the watershed. The estimated fecal coliform production and accumulation rates due to these sources were calculated for the watershed and incorporated into the model. To accommodate the structure of the model, calculation of the fecal coliform accumulation and source contributions on a monthly basis accounted for seasonal variation in watershed activities such as wildlife feeding patterns and land application of manure. Also represented in the model were uncontrolled discharges, direct deposition by wildlife, and direct deposition by livestock.

Contributions from all of these sources were represented in the model to establish existing conditions for the watershed over a representative hydrologic period (1993-1998). Under existing conditions (2003), the HSPF model provided a comparable match to the VADEQ monitoring data, with output from the model indicating violations of both the instantaneous and geometric mean standards throughout the watershed.

Margin of Safety

In order to account for uncertainty in modeled output, a margin of safety (MOS) was incorporated into the TMDL development process. Individual errors in model inputs, such as data used for developing model parameters or data used for calibration, may affect the load allocations in a positive or a negative way. A margin of safety can be incorporated implicitly in the model through the use of conservative estimates of model parameters, or explicitly as an additional load reduction requirement. The intention of a MOS in the development of a fecal coliform TMDL is to ensure that the modeled loads do not under-estimate the actual loadings that exist in the watershed. An implicit MOS was used in the development of this TMDL. By adopting an implicit MOS in estimating the loads in the watershed, it is insured that the recommended reductions will, in fact, succeed in meeting the water quality standard. Examples of implicit MOS used in the development of this TMDL were:

- Allocating permitted point sources at the maximum allowable fecal coliform concentration
- The selection of a modeling period that represented the critical hydrologic conditions in the watershed
- Modeling biosolids applications at the maximum allowable rate and fecal coliform concentration in all permitted fields

Load Allocation Scenarios

The next step in the TMDL process was to determine how to proceed from existing watershed conditions to reduce the various source loads to levels that would result in attainment of the water quality standards. Because Virginia's E. coli standard does not permit any exceedances of the standard, modeling was conducted for a target value of 0% exceedance of the 126 cfu/100 ml geometric mean standard and 0% exceedance of the single sample maximum E. coli standard of 235 cfu/100 ml. Scenarios were evaluated to predict the effects of different combinations of source reductions on final in-stream water quality. Modeling of these scenarios provided predictions of whether the reductions would achieve the target of 0% exceedance.

Table ES.1.1 shows the final load allocations for the impaired segments of the Appomattox River watershed.

Table ES.1.1 Average annual E. coli loads (cfu/year) modeled after TMDL allocation in the Appomattox River watershed impairments.

Impairment	WLA (cfu/year)	LA (cfu/year)	MOS	TMDL (cfu/year)
Angola Creek (1)	0.00E+00	6.76E+12		6.76E+12
	0.00E+00			
Angola Creek (2)	0.00E+00	1.80E+13		1.80E+13
	0.00E+00			
Appomattox River (1)	4.74E+12	6.86E+14		6.90E+14
Chesterfield --VA0088609	6.64E+09			
VAG402047	1.75E+09			
VAG404002	1.75E+09			
VAG404107	1.75E+09			
VAG404129	1.75E+09			
VAG404140	1.75E+09			
VAG404161	1.75E+09			
VA0083135	4.18E+12			
VAG407199	1.75E+09			
VAG407198	1.75E+09			
VAG404092	1.75E+09			
VA0057088	0.00E+00			
VA0089206	0.00E+00			
VA0086681	5.24E+11			
VA0020222	1.15E+10			
VA0089931	0.00E+00			
Appomattox River (2)	1.07E+13	5.90E+14		6.01E+14
Chesterfield --VA0088609	2.07E+11			
Colonial Heights –VAR040009	1.74E+10			
Petersburg –VAR040013	1.31E+11			
VAG402047	1.75E+09			
VAG404002	1.75E+09			
VAG404107	1.75E+09			
VAG404129	1.75E+09			
VAG404140	1.75E+09			
VAG404161	1.75E+09			
VA0083135	4.18E+12			
VAG407199	1.75E+09			
VAG407198	1.75E+09			
VAG404092	1.75E+09			
VA0057088	0.00E+00			
VA0089206	0.00E+00			
VA0086681	5.24E+11			
VA0020222	1.15E+10			
VA0089931	0.00E+00			
VA0020303	8.71E+11			
VA0090131	0.00E+00			
VA0023540	2.62E+10			
VA0005819	4.70E+12			
VA0059099	0.00E+00			
VA0089516	0.00E+00			

Implicit

Table ES.1.1 Average annual E. coli loads (cfu/year) modeled after TMDL allocation in the Appomattox River watershed impairments. (Continued)

Impairment	WLA (cfu/year)	LA (cfu/year)	MOS	TMDL (cfu/year)
Appomattox River (3)-tidal	6.87E+13	7.22E+14		7.91E+14
Chesterfield --VA0088609	1.14E+13			
Colonial Heights –VAR040009	2.49E+12			
Hopewell – VAR040015	1.44E+12			
Petersburg –VAR040013	1.76E+12			
VAG402047	1.75E+09			
VAG404002	1.75E+09			
VAG404107	1.75E+09			
VAG404129	1.75E+09			
VAG404140	1.75E+09			
VAG404161	1.75E+09			
VA0083135	4.18E+12			
VAG407199	1.75E+09			
VAG407198	1.75E+09			
VAG404092	1.75E+09			
VA0057088	0.00E+00			
VA0089206	0.00E+00			
VA0086681	5.24E+11			
VA0020222	1.15E+10			
VA0089931	0.00E+00			
VA0020303	8.71E+11			
VA0090131	0.00E+00			
VA0023540	2.62E+10			
VA0005819	4.70E+12			
VA0059099	0.00E+00			
VA0089516	0.00E+00			
VA0025437	4.01E+13			
VA0028258	6.81E+10			
VA0059161	8.73E+11			
VA0006254	1.05E+10			
VA0023426	9.59E+10			
VA0020206	1.67E+10			
VA0027561	1.75E+10			
VA0090344	6.99E+10			
Briery Creek	3.50E+09	3.84E+13		3.84E+13
VAG407198	1.75E+09			
VAG404092	1.75E+09			
Bush River (1)	3.50E+09	9.03E+13		9.03E+13
VAG407198	1.75E+09			
VAG404092	1.75E+09			
Bush River (2)	3.50E+09	1.10E+14		1.10E+14
VAG407198	1.75E+09			
VAG404092	1.75E+09			

Implicit

Table ES.1.1 Average annual E. coli loads (cfu/year) modeled after TMDL allocation in the Appomattox River watershed impairments. (Continued)

Impairment		WLA (cfu/year)	LA (cfu/year)	MOS	TMDL (cfu/year)
Deep Creek (FC)		8.71E+11	1.06E+14		1.06E+14
	VA0020303	8.71E+11			
	VA0090131	0.00E+00			
Flat Creek		5.24E+11	8.75E+13		8.80E+13
	VA0086681	5.24E+11			
Horsepen Creek		0.00E+00	4.44E+12		4.44E+12
Little Sandy Creek		0.00E+00	1.62E+12		1.62E+12
Nibbs Creek		5.24E+11	1.23E+13		1.29E+13
	VA0086681	5.24E+11			
Saylers Creek		0.00E+00	1.40E+13		1.40E+13
Spring Creek		0.00E+00	2.08E+13		2.08E+13
Swift Creek (1)		8.37E+09	2.01E+13		2.01E+13
	Chesterfield --VA0088609	*8.37E+09*			
Swift Creek (2)		3.07E+11	8.39E+13		8.42E+13
	Chesterfield --VA0088609	1.84E+11			
	VA0006254	1.05E+10			
	VA0023426	9.59E+10			
	VA0020206	1.67E+10			
Swift Creek (3)		4.59E+11	1.28E+14		1.29E+14
	Chesterfield --VA0088609	2.38E+11			
	Colonial Heights –VAR040009	1.03E+10			
	VA0006254	1.05E+10			
	VA0023426	9.59E+10			
	VA0020206	1.67E+10			
	VA0027561	1.75E+10			
	VA0090344	6.99E+10			
West Creek		0.00E+00	3.91E+13		3.91E+13
	VA0090131	*0.00E+00*			

Implicit

Recommendations for TMDL Implementation

The goal of this TMDL is to establish a three-step path that will lead to attainment of water quality standards. The first step in this process is to develop TMDLs that will result in meeting water quality standards. Virginia's 1997 Water Quality Monitoring,

Information and Restoration Act states in section 62.1-44.19.7 that the "Board shall develop and implement a plan to achieve fully supporting status for impaired waters".

The TMDLs developed for the Appomattox River watershed impairments provide allocation scenarios that will be a starting point for developing implementation strategies. A staged implementation plan is essential to the process of restoring water quality. The goal of the first stage is to foster local support for the implementation plan and to reduce the violations of the instantaneous standard to no more than 10% in the main stem of the Appomattox River. The model scenario developed for the first stage included a 100% reduction in loads from sewer overflows and uncontrolled residential discharges (straight pipes), a 90-100% reduction in direct in-stream loads from livestock (loads that don't require a runoff event to be delivered to the stream, *e.g*. direct defecation by livestock), a 50-60% reduction in land-based loads from urban and agricultural sources, and a 0% reduction in all wildlife loads.

A staged implementation plan is necessarily an iterative process. There is a measure of uncertainty associated with the final allocation development process. Continued monitoring can provide insight into the effectiveness of implementation strategies, the need for amending the plan, and/or progress toward the eventual removal of the impairment from the Section 303(d) list.

Also critical to the implementation process is public participation. While permitted point sources provide a limited contribution to the overall water quality problem, nonpoint direct deposition to streams is the critical factor in addressing the problem. These sources cannot be addressed without public understanding of, and support for, the implementation process. Stakeholder input will be critical from the onset of the implementation process in order to develop an implementation plan that is effective.

Public Participation

During development of the TMDL for the Appomattox River watershed, public involvement was encouraged through three meetings. A basic description of the TMDL

process and the agencies involved was presented at the kickoff meeting. The 1st public meeting was held on May 21, 2003 to discuss the source assessment input, bacterial source tracking, and model calibration data. There were no comments received after the 1st public meeting. The 2nd public meeting was held on November 11, 2003. The final model simulations and the TMDL load allocations were presented during the this public meeting. There were no comments received after the 2nd public meetig. The 3rd public meeting was held on March 30, 2004. Two comments were received during the final public comment period.

The meetings served to facilitate understanding of, and involvement in, the TMDL process. Posters that graphically illustrated the status of the watershed were on display at each meeting to provide an additional information component for the stakeholders. MapTech personnel were on hand to provide further clarification of the data as needed. Input from these meetings was utilized in the development of the TMDL and improved confidence in the allocation scenarios developed.

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1. INTRODUCTION

1.1 Background

The need for TMDLs to be conducted in the Appomattox River watershed is based on provisions of the Clean Water Act. The document, *Guidance for Water Quality-Based Decisions: The TMDL Process* (United States Environmental Protection Agency, 1999), states:

> *According to Section 303(d) of the Clean Water Act and EPA water quality planning and management regulations, States are required to identify waters that do not meet or are not expected to meet water quality standards even after technology-based or other required controls are in place. The waterbodies are considered water quality-limited and require TMDLs.*
>
> *…A TMDL is a tool for implementing State water quality standards, and is based on the relationship between pollution sources and in-stream water quality conditions. The TMDL establishes the allowable loadings or other quantifiable parameters for a waterbody and thereby provides the basis for States to establish water quality-based controls. These controls should provide the pollution reduction necessary for a waterbody to meet water quality standards.*

The Appomattox River watershed (USGS Hydrologic Unit Code #02080207) includes portions of Virginia's Appomattox, Buckingham, Cumberland, Prince Edward, Amelia, Nottoway, Powhatan, Chesterfield, Dinwiddie, and Prince George Counties and Cities of Petersburg, Colonial Heights, and Hopewell (Figure 1.1). The Appomattox River drains to the James River, which flows into the Chesapeake Bay. Impaired segments within the Appomattox River basin include: Appomattox River (1), Appomattox River (2), Appomattox River (3), Angola Creek (1), Angola Creek (2), Briery Creek, Bush River (1), Bush River (2), Deep Creek, Deep Creek-UT, Flat Creek, Horsepen Creek, Little Sandy Creek, Nibbs Creek, Saylers Creek, Spring Creek, Swift Creek (1), Swift Creek (2), Swift Creek (3), and West Creek (Figure 1.2). The Virginia Department of Environmental Quality (VADEQ) has identified all of these segments as impaired with regard to fecal coliform, except Deep Creek-UT, which is impaired with regard to the general standard (benthic). The Deep Creek – UT impairment is addressed in a separate report entitled, “General Standard Total Maximum Daily Load for Deep Creek, UT.”

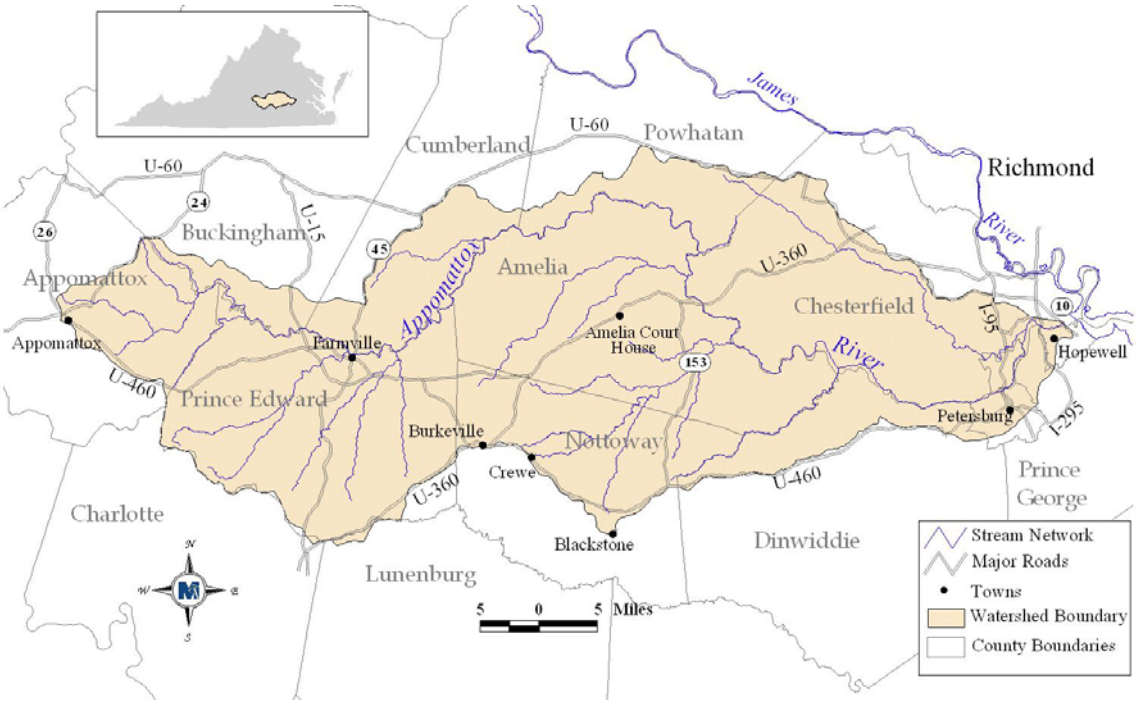

Figure 1.1 Location of the Appomattox River watershed.

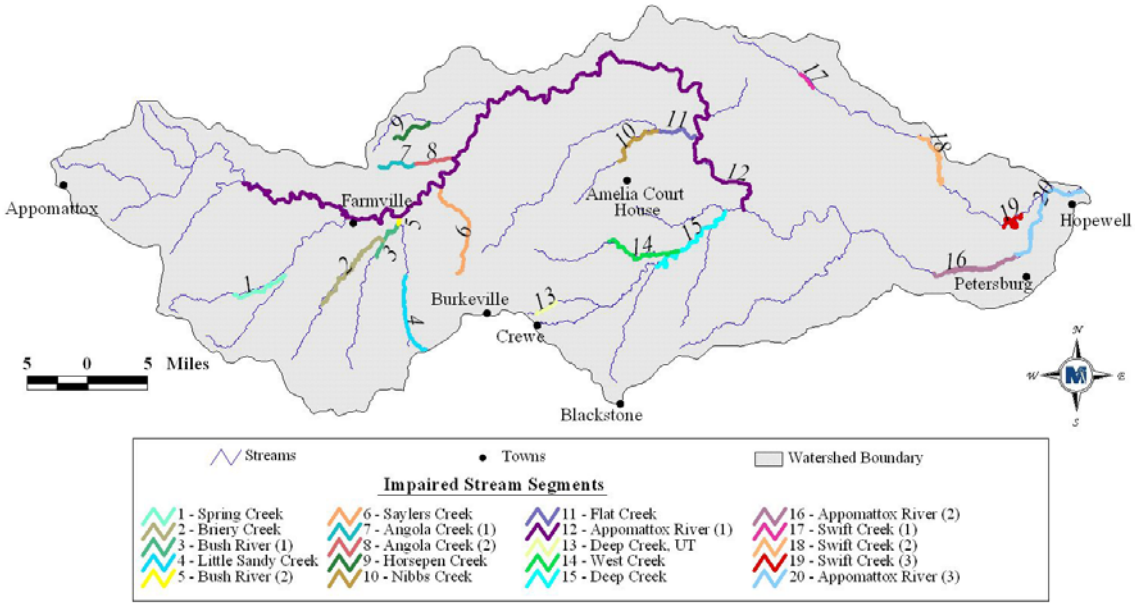

Figure 1.2 Impaired stream segments in the Appomattox River watershed.

Table 1.1 lists for each impairment the VADEQ water quality monitoring station used for impaired waters assessment, the initial year in which the segment was listed in the Section 303(d) TMDL Priority List and Report, stream miles affected in listing, impairment status, and location of listing.

The land area of the affected watersheds is approximately 1,025,000 acres, with forest and pasture as the primary land uses (Figure 1.3).

Table 1.1 Fecal coliform and benthic impairments on 2002 Section 303(d) TMDL Priority List and Report within the Appomattox River watershed.

Stream Name, HUP	Listing Station ID	Initial Listing	Miles Affected	2002 303(d) List FC Violation Rate	Location
Spring Creek, J02	2-SPA001.46	1998	5.50	3/27	Mud Creek to Buffalo Creek
Briery Creek, J05	2-BRI001.00	1998	9.94	4/16	Briary Creek to Bush River
Bush River (1), J04	2-BSR002.82	2002	4.22	4/23	Mountain Creek to the limit of the watershed
Little Sandy Creek, J03	2-LIT002.40	2002	7.35	3/13	Headwaters to Sandy Reservoir
Bush River (2), J04	2-BSR002.82	2002	0.78	4/23	Sandy River to Appomattox River
Saylers Creek, J06	2-SYL001.26	1996	8.90	11/27	Headwaters to Appomattox
Angola Creek (1), J06	2-ANG003.35	2002	4.59	7/11	Headwaters to UT @ Rt. 664
Angola Creek (2), J06	2ANG001.27	2002	2.56	9/11	UT downstream of RT. 664 to Appomattox River
Horsepen Creek, J06	2-HRP000.42	2002	3.82	5/13	Headwaters to Big Guinea Creek
Nibbs Creek, J09	2-NBB003.65 2-NBB002.92 2-XQK000.15 2-NBB001.54	1998	5.28	4/27 5/13 7/7 5/15	From Amelia Courthouse STP to Flat Creek
Flat Creek , J08	2-FLA001.95	1996	3.99	5/27	Nibbs Creek to Appomattox River
Appomattox River (1), J01	2-APP118.04	1996	80.60	12/55	Vaughans Creek to Deep Creek
Deep Creek, UT,	2-XGP001.80	1996	2.13	General Standard Severely impaired	Downstream of Crewe STP
West Creek, J11	2-WET004.96	2002	7.22	3/20	Tanners Branch to Deep Creek
Deep Creek, J11	2-DPC005.20	1998	11.19	4/25	Cellar Creek to Beaverpond Creek
Appomattox River (2), J15	2-APP012.79	2002	7.44	14/58	Lake Chesdin dam to fall line at Route 1/301 bridge
Swift Creek (1),	2-SFT035.26	1998	1.61	3/25	Turkey Creek to Reservoir
Swift Creek (2), J17	2-SFT019.15	1998	7.09	4/27	Swift Creek Lake Dam to Licking Creek
Swift Creek (3), J17	2-SFT004.92	2002	4.00	5/26	Lakeview Reservoir Dam to Timsbury Creek
Appomattox River (3), J15	2-APP001.53	1998	2.68+	7/59	Entire estuarine Appomattox River

+ Units are square miles

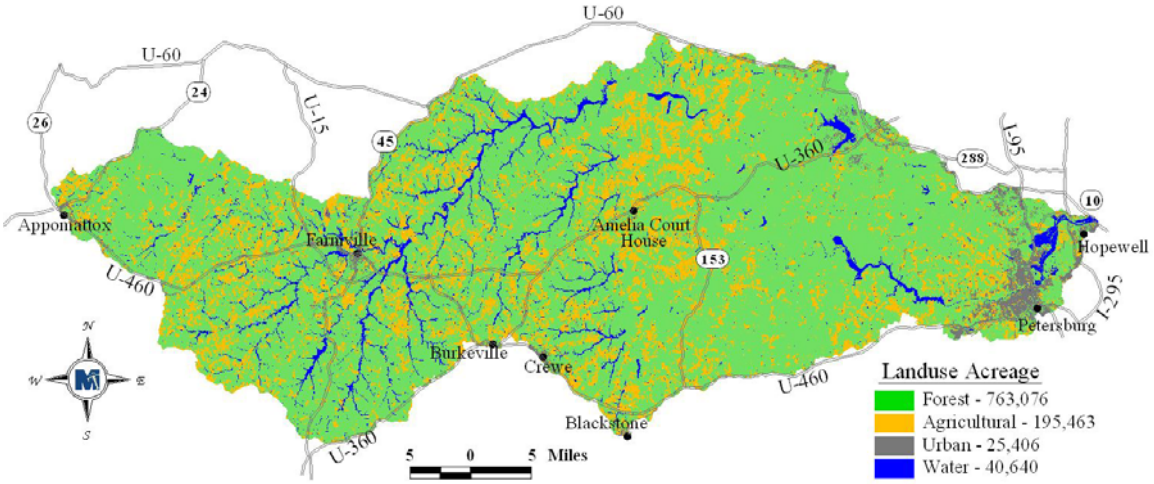

Figure 1.3 Land uses in the Appomattox River watershed.

The National Land Cover Data (NLCD) produced cooperatively between the U.S. Geological Survey (USGS) and U.S. Environmental Protection Agency (USEPA) was utilized for this study. The collaborative effort to produce this dataset is part of a Multi-Resolution Land Characteristics (MRLC) Consortium project lead by four U.S. government agencies: U.S. EPA, USGS, the Department of the Interior National Biological Service (NBS), and the National Oceanic and Atmospheric Administration (NOAA). Using 30-meter resolution Landsat 5 Thematic Mapper (TM) satellite images taken between 1990 and 1994, digital land use coverage was developed identifying up to 21 possible land use types. Classification, interpretation, and verification of the land cover dataset involved several data sources when available including: aerial photography; soils data; population and housing density data; state or regional land cover data sets; USGS land use and land cover (LUDA) data; 3-arc second Digital Terrain Elevation Data (DTED) and derived slope, aspect and shaded relief; and National Wetlands Inventory (NWI) data. Approximate acreages and land use proportions for each impaired segment are given in Table 1.2.

Table 1.2 Contributing land use area for impairment segments in the Appomattox River watershed.

Impaired Segment	Land Use								
	Water (ac)	Residential (ac)	Commercial & Services (ac)	Barren (ac)	Woodland (ac)	Pasture (ac)	Cropland (ac)	Wetlands (ac)	Livestock Access (ac)
Spring Creek	203	86	33	283	14,327	5,168	261	612	118
Briery Creek	744	407	39	271	21,257	3,498	132	1,123	80
Bush River (1)	868	540	135	736	57,390	8,287	353	3,878	139
Little Sandy Creek	17	22	24	41	5,490	1,706	56	265	27
Bush River (2)	1,024	780	243	1,031	77,351	13,832	731	5,506	216
Saylers Creek	78	18	8	126	10,322	4,087	240	541	50
Angola Creek (1)	54	1	1	26	3,072	1,557	121	145	20
Angola Creek (2)	90	17	1	188	5,969	2,931	196	480	35
Horsepen Creek	2	1	0	26	1,877	506	76	85	8
Nibbs Creek	42	116	54	220	9,083	6,240	370	328	113
Flat Creek	251	288	223	2,084	59,650	22,548	2,118	3,253	337
Appomattox River (1)	3,955	3,967	1,454	12,968	432,395	111,989	10,074	23,912	2,012
Deep Creek, UT	8	188	75	4	1,177	383	5	51	4
West Creek	120	64	41	665	21,624	6,601	651	1,141	88
Deep Creek	562	1,003	479	4,219	80,361	24,793	2,982	3,109	406
Appomattox River (2) *	7,556	8,088	4,032	22,214	627,437	156,214	18,283	27,306	2,772
Swift Creek (1)	129	369	20	22	11,860	1,493	500	82	23
Swift Creek (2)	1,714	2,702	645	955	55,577	4,568	2,053	197	74
Swift Creek (3)	2,003	3,299	816	1,790	87,929	8,476	3,258	368	125
Appomattox River (3) **	10,785	17,633	7,772	26,229	737,027	168,790	23,619	29,812	2,937

*The acreages given for Appomattox River (2) are inclusive of the acreages in Appomattox River (1).
** The acreages given for Appomattox River (3) are inclusive of the acreages in Appomattox River (2).

.

The estimated human population within the drainage area in 2003 is 222,170 (calculated from 1990 and 2000 U.S. Census Bureau data) with 47,624 dogs and 53,332 cats associated with this population. See section 3.2 for a detailed discussion of source assessment Table 1.3 lists agricultural production rankings for counties in Appomattox River basin compared to all counties in Virginia. Counties in the Appomattox River basin are home to numerous species of wildlife, including mammals (*e.g.*, beaver, raccoon, white-tailed deer) and birds (*e.g.*, wood duck, wild turkey, Canada goose) (Table 1.4).

Table 1.3 Agricultural production rankings for counties in Appomattox River basin compared to all counties in Virginia.[1]

County/City	County Rankings Compared to Other Counties in Virginia					
	Cattle & Calves	*Dairy*	*Beef*	*Horses*	*Layers*	*Broilers*
Amelia	43	16	51	32	N/A	5
Appomattox	33	41	32	N/A	N/A	N/A
Buckingham	32	N/A	25	32	3	9
Chesterfield	77	N/A	73	22	N/A	12
Cumberland	44	38	41	N/A	N/A	6
Dinwiddie	61	34	64	30	N/A	N/A
Nottoway	39	34	38	N/A	N/A	8
Powhatan	56	22	65	18	39	N/A
Prince Edward	40	27	32	N/A	N/A	11
Prince George	80	N/A	78	N/A	37	N/A
Petersburg	N/A	N/A	N/A	N/A	N/A	N/A
Colonial Heights	N/A	N/A	N/A	N/A	N/A	N/A
Hopewell	N/A	N/A	N/A	N/A	N/A	N/A

[1]Virginia Agricultural Statistics Service.

Table 1.4 Number of wildlife species, mammal types, and bird types inhabiting counties and cities within Appomattox River watershed.

County / City	Number of Wildlife Species	Number of Mammal Types	Number of Bird Types
Appomattox	358	44	155
Buckingham	398	45	190
Cumberland	357	45	156
Prince Edward	417	44	70
Amelia	373	47	169
Nottoway	362	43	160
Powhatan	373	43	77
Chesterfield	459	45	222
Dinwiddie	416	46	172
Prince George	447	44	140
Petersburg	329	45	167
Colonial Heights	376	43	207
Hopewell	388	44	102

[1]Virginia Department of Game and Inland Fisheries (http://www.dgif.state.va.us).

For the period from 1948 to 2000, the portion of Appomattox River watershed near Town of Appomattox received average annual precipitation of approximately 42.8 inches, with 53% of the precipitation occurring during the May – October growing season (SERCC, 2002). Average annual snowfall is 14.1 inches with the highest snowfall occurring during January (SERCC, 2002). Average annual daily temperature is 55.3 ºF. The highest average daily temperature of 86.7 ºF occurs in July, while the lowest average daily temperature of 24.1 ºF occurs in January (SERCC, 2002).

For the period from 1914 to 2000, the portion of Appomattox River watershed near Town of Farmville received average annual precipitation of approximately 44.3 inches, with 53% of the precipitation occurring during the May – October growing season (SERCC, 2002). Average annual snowfall is 14.2 inches with the highest snowfall occurring during January (SERCC, 2002). Average annual daily temperature is 57.3 ºF. The highest average daily temperature of 88.8 ºF occurs in July, while the lowest average daily temperature of 26.1 ºF occurs in January (SERCC, 2002).

For the period from 1970 to 2000, the portion of Appomattox River watershed near Town of Amelia received average annual precipitation of approximately 44.7 inches, with 53% of the precipitation occurring during the May – October growing season (SERCC, 2002). Average annual snowfall is 12.5 inches with the highest snowfall occurring during January (SERCC, 2002). Average annual daily temperature is 56.5 ºF. The highest average daily temperature of 88.5 ºF occurs in July, while the lowest average daily temperature of 24.6 ºF occurs in January (SERCC, 2002).

For the period from 1914 to 2000, the portion of Appomattox River watershed near City of Hopewell received average annual precipitation of approximately 43.6 inches, with 56% of the precipitation occurring during the May – October growing season (SERCC, 2002). Average annual snowfall is 8.2 inches with the highest snowfall occurring during January (SERCC, 2002). Average annual daily temperature is 60.1 ºF. The highest average daily temperature of 90.3 ºF occurs in July, while the lowest average daily temperature of 30.0 ºF occurs in January (SERCC, 2002).

1.2 Applicable Water Quality Standards

According to 9 VAC 25-260-5 of Virginia's State Water Control Board *Water Quality Standards*, 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 and the federal Clean Water Act."

As stated in Virginia state law 9 VAC 25-260-10 (Designation of uses),

> *A. All state waters, including wetlands, are designated for the following uses: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish.*
>
> ◆
>
> *D. At a minimum, uses are deemed attainable if they can be achieved by the imposition of effluent limits required under §§301(b) and 306 of the Clean Water Act and cost-effective and reasonable best management practices for nonpoint source control.*
>
> *G. The [State Water Control] board may remove a designated use which is not an existing use, or establish subcategories of a use, if the board can demonstrate that attaining the designated use is not feasible because:*
>
> 1. *Naturally occurring pollutant concentrations prevent the attainment of the use;*
>
> 2. *Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating state water conservation requirements to enable uses to be met;*
>
> ◆
>
> 6. *Controls more stringent than those required by §§301(b) and 306 of the Clean Water Act would result in substantial and widespread economic and social impact.*

For fecal bacteria impairments, Virginia law 9 VAC 25-260-170 applies.

1.2.1 Applicable Criteria for Fecal Coliform Impairment

Prior to 2002, Virginia Water Quality Standards specified the following criteria for a non-shellfish supporting waterbody to be in compliance with Virginia's fecal standard for contact recreational use:

> *A. General requirements. In all surface waters, except shellfish waters and certain waters addressed in subsection B of this section, the fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 ml of water for two or more samples over a 30-day period, or a fecal coliform bacteria level of 1,000 per 100 ml at any time.*

If the waterbody exceeded either criterion more than 10% of the time, the waterbody was classified as impaired and the development and implementation of a TMDL was indicated in order to bring the waterbody into compliance with the water quality criterion. Based on the sampling frequency, only one criterion was applied to a particular datum or data set. If the sampling frequency was one sample or less per 30 days, the instantaneous criterion was applied; for a higher sampling frequency, the geometric criterion was applied. This was the criterion used for listing the impairments included in this study. Sufficient fecal coliform bacteria standard violations were recorded at VADEQ water quality monitoring stations to indicate that the recreational use designations are not being supported.

EPA has since recommended that all states adopt an *E. coli* or *enterococci* standard for fresh water and *enterococci* criteria for marine waters by 2003. EPA is pursuing the states' adoption of these standards because there is a stronger correlation between the concentration of these organisms (*E. coli* and *enterococci*) and the incidence of gastrointestinal illness than with fecal coliform. *E. coli* and *enterococci* are both 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. The adoption of the *E. coli* and *enterococci* standard is in effect in Virginia as of January 15, 2003.

The new criteria, outlined in 9 VAC 25-260-170, read as follows

A. In surface waters, except shellfish waters and certain waters identified in subsection B of this section, the following criteria shall apply to protect primary contact recreational uses:

1. Fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 ml of water for two or more samples over a calendar month nor shall more than 10% of the total samples taken during any calendar month exceed 400 fecal coliform bacteria per 100 ml of water. This criterion shall not apply for a sampling station after the bacterial indicators described in subdivision 2 of this subsection have a minimum of 12 data points or after June 30, 2008, whichever comes first.

2. E. coli and enterococci bacteria per 100 ml of water shall not exceed the following:

	Geometric Mean[1]	*Single Sample Maximum*[2]
Freshwater[3]		
E. coli	*126*	*235*
Saltwater and Transition Zone[3]		
enterococci	*35*	*104*

[1] For two or more samples taken during any calendar month.
[2] No single sample maximum for enterococci and *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 and 0.7 shall be as the log standard deviation in saltwater and transition zone. Values shown are based on a log standard deviation of 0.4 in freshwater and 0.7 in saltwater.
[3] See 9 VAC 25-260-140 C for freshwater and transition zone delineation.

These criteria were used in developing the bacteria TMDLs included in this study.

2. TMDL ENDPOINT AND WATER QUALITY ASSESSMENT

2.1 Selection of a TMDL Endpoint and Critical Condition

The Appomattox River and Deep Creek were initially placed on the Virginia 1996 Section 303(d) TMDL Priority List and Report based on monitoring performed. Additional stream segments within the basin were progressively placed on the 1996, 1998, and 2002 Section 303(d) TMDL Priority List and Reports (see Table 1.1). All segments remained on the 2002 Section 303(d) TMDL Priority List and Report. Elevated levels of fecal coliform bacteria recorded at VADEQ ambient water quality monitoring stations showed that these stream segments do not support the primary contact recreation use.

The first step in developing a TMDL is the establishment of in-stream numeric endpoints, which are used to evaluate the attainment of acceptable water quality. In-stream numeric endpoints, therefore, represent the water quality goals that are to be achieved by implementing the load reductions specified in the TMDL. For the Appomattox River TMDL, the applicable endpoints and associated target values can be determined directly from the Virginia water quality regulations (Section 1.2 of this document). In order to remove a water body from a state's list of impaired waters; the Clean Water Act requires compliance with that state's water quality standard. Since modeling provided simulated output of *E. coli* concentrations at daily intervals, assessment of TMDLs was made using both the calendar month geometric mean standard of 126 cfu/100 ml and the instantaneous standard of 235 cfu/100 ml. Therefore, the in-stream *E. coli* targets for these TMDLs were a monthly geometric mean not exceeding 126 cfu/100 ml and a single sample not exceeding 235 cfu/100 ml.

USEPA regulations at 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 Appomattox River is protected during times when it is most vulnerable.

Critical conditions are important because they describe the factors that combine to cause a violation of water quality standards and will help in identifying the actions that may have to be undertaken to meet water quality standards. Fecal coliform sources within the Appomattox River watershed are attributed to both point and nonpoint sources. Critical conditions for waters impacted by land-based nonpoint sources generally occur during periods of wet weather and high surface runoff. In contrast, critical conditions for point source-dominated systems generally occur during low flow and low dilution conditions. Point sources, in this context also, include nonpoint sources that are not precipitation driven (*e.g.*, fecal deposition to stream).

A graphical analysis of measured fecal coliform concentrations versus the level of flow at the time of measurement showed that there was no obvious critical flow level (Figures 2.1 through 2.21). That is, the analysis showed no obvious dominance of either nonpoint sources or point sources. High concentrations were recorded during both wet and dry periods. Based on this analysis, time periods for hydrologic and water quality calibration and validation of the model was chosen based on the overall distribution of wet and dry seasons (see Section 4.5).

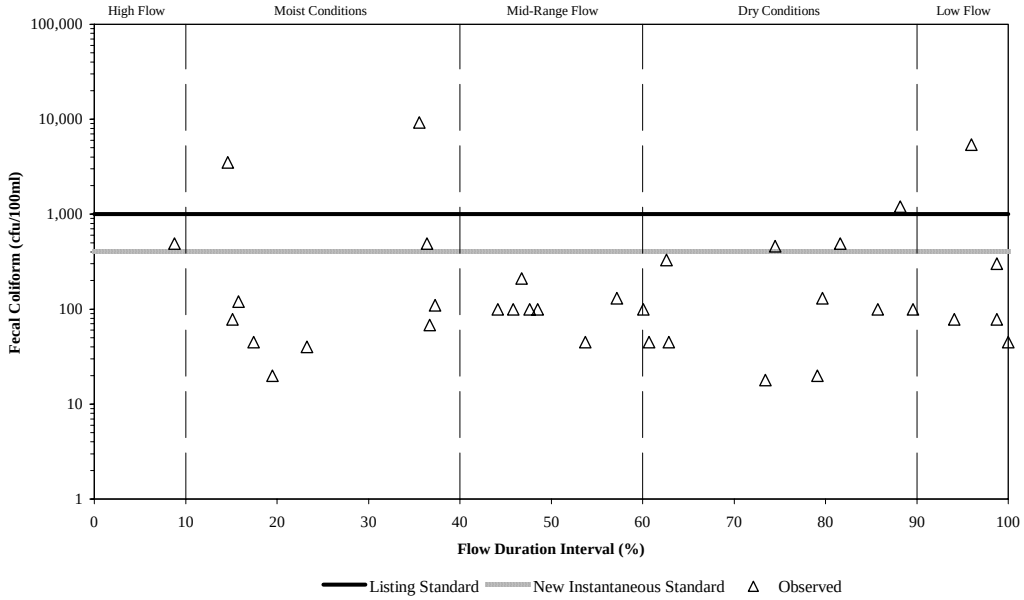

Figure 2.1 Relationship between fecal coliform concentrations (VADEQ Station 2SPA001.46) and discharge (USGS Gaging Station #02039500) in the Spring Creek impairment.

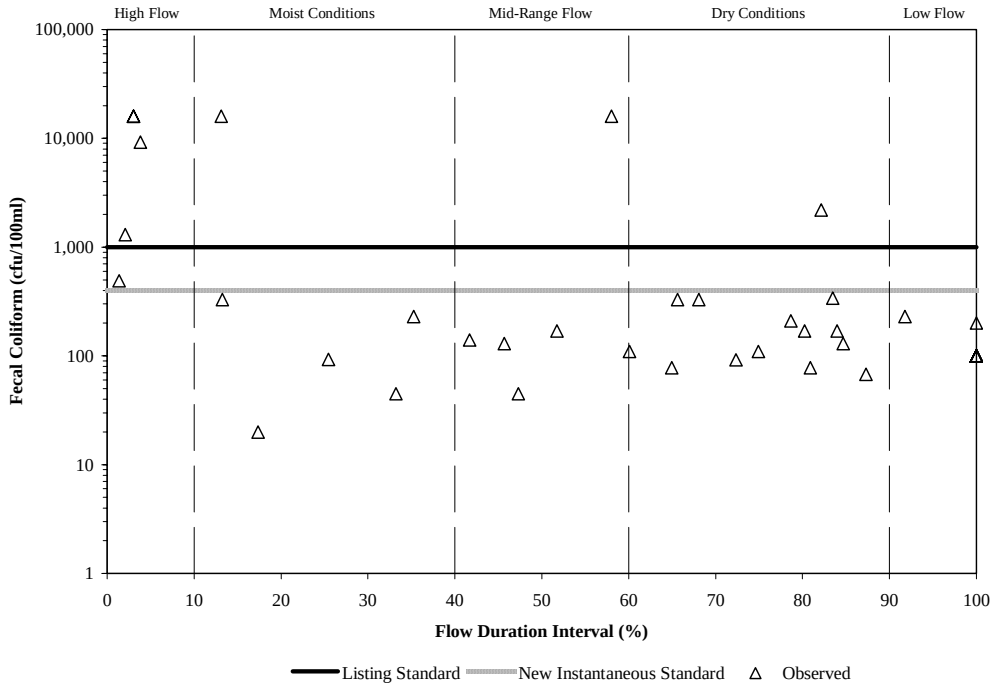

Figure 2.2 Relationship between fecal coliform concentrations (VADEQ Station 2BRI001.00) and discharge (USGS Gaging Station #02039500) in the Briery Creek impairment.

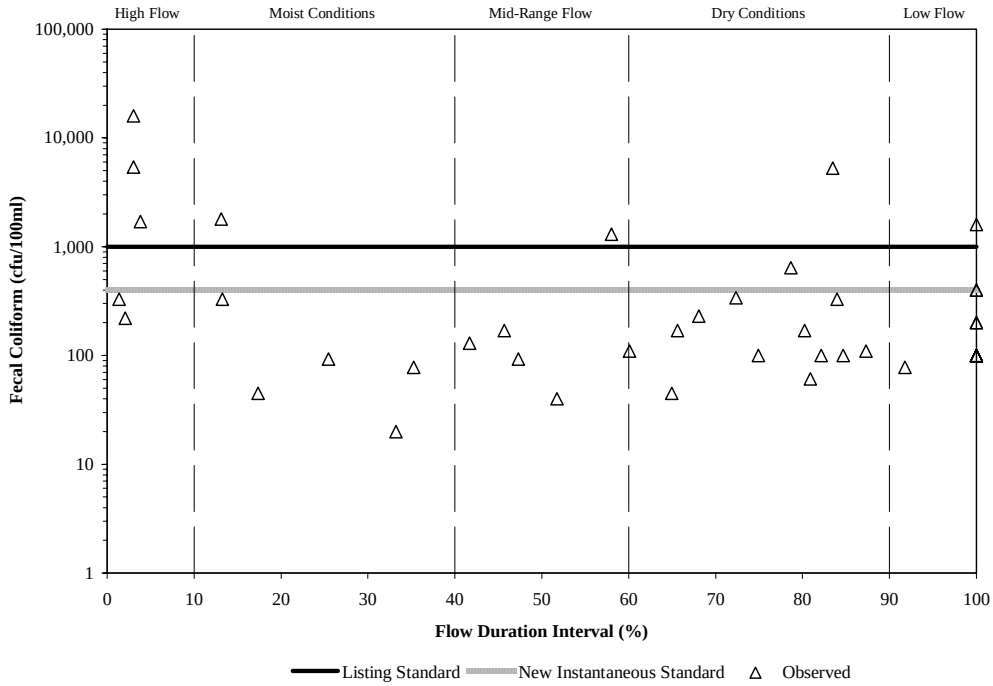

Figure 2.3 Relationship between fecal coliform concentrations (VADEQ Station 2BSR002.82) and discharge (USGS Gaging Station #02039500) in the Bush River (1) and Bush River (2) impairment.

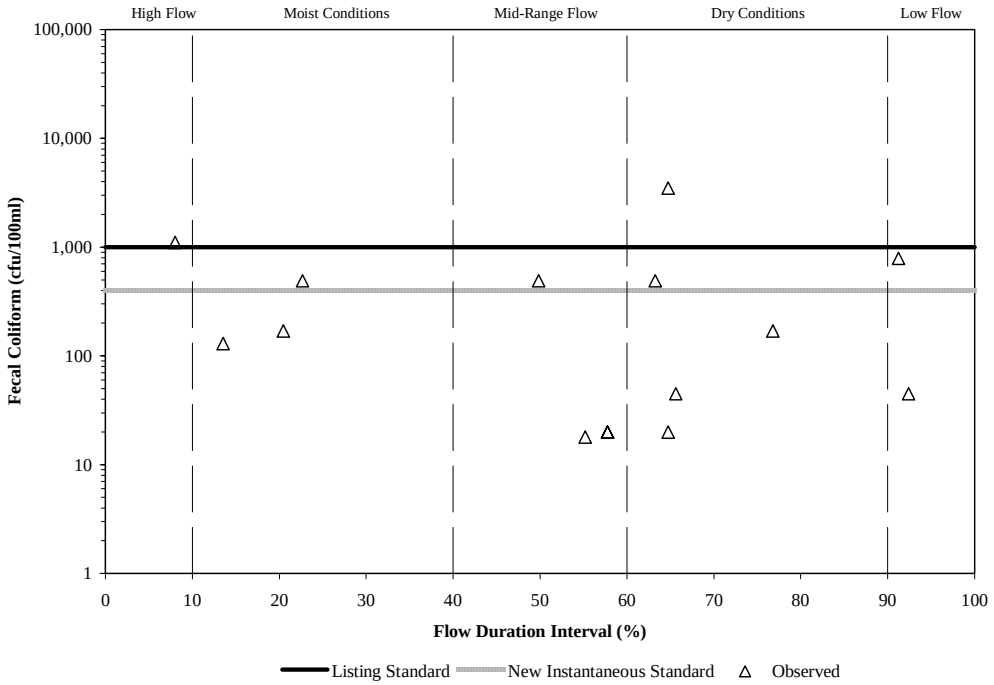

Figure 2.4 Relationship between fecal coliform concentrations (VADEQ Station 2LIT002.40) and discharge (USGS Gaging Station #02039500) in the Little Sandy Creek impairment.

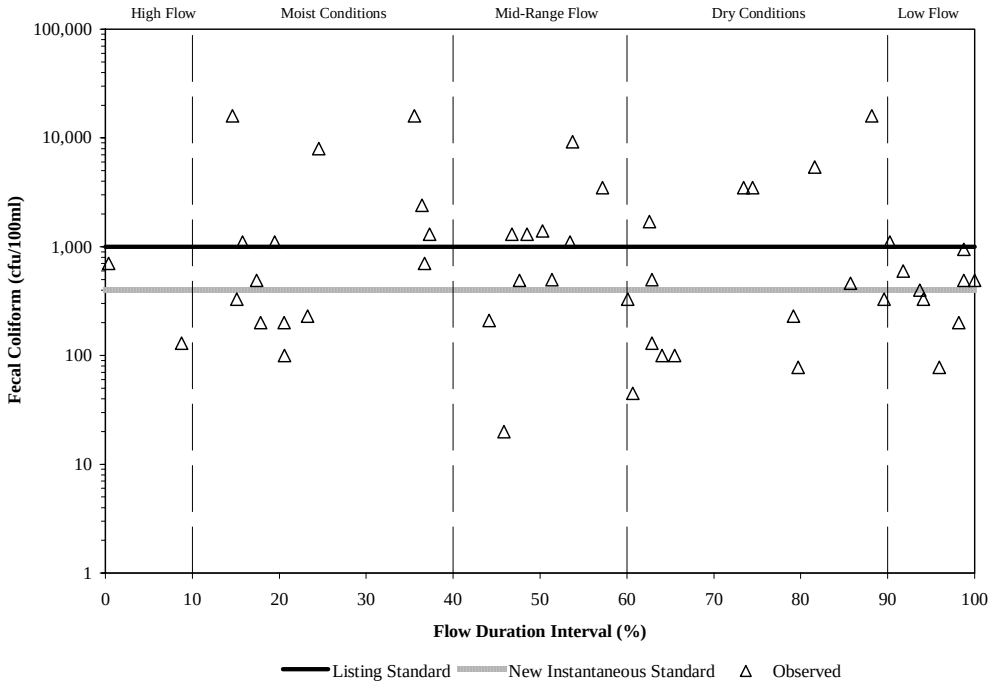

Figure 2.5 Relationship between fecal coliform concentrations (VADEQ Station 2SYL001.26) and discharge (USGS Gaging Station #02039500) in the Saylers Creek impairment.

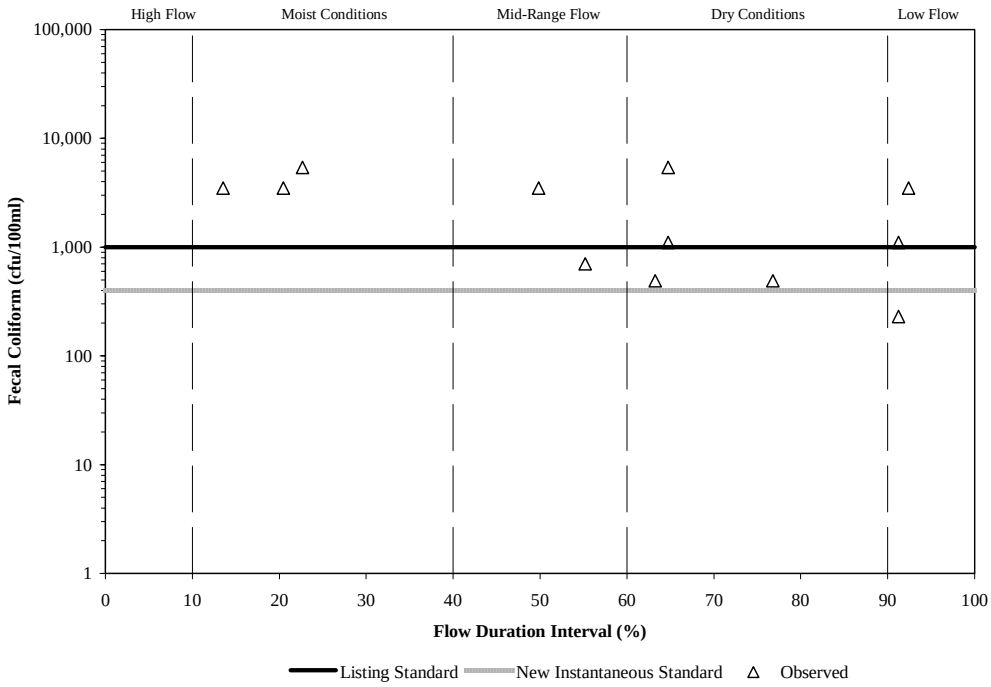

Figure 2.6 Relationship between fecal coliform concentrations (VADEQ Station 2ANG003.35) and discharge (USGS Gaging Station #02039500) in the Angola Creek (1) impairment.

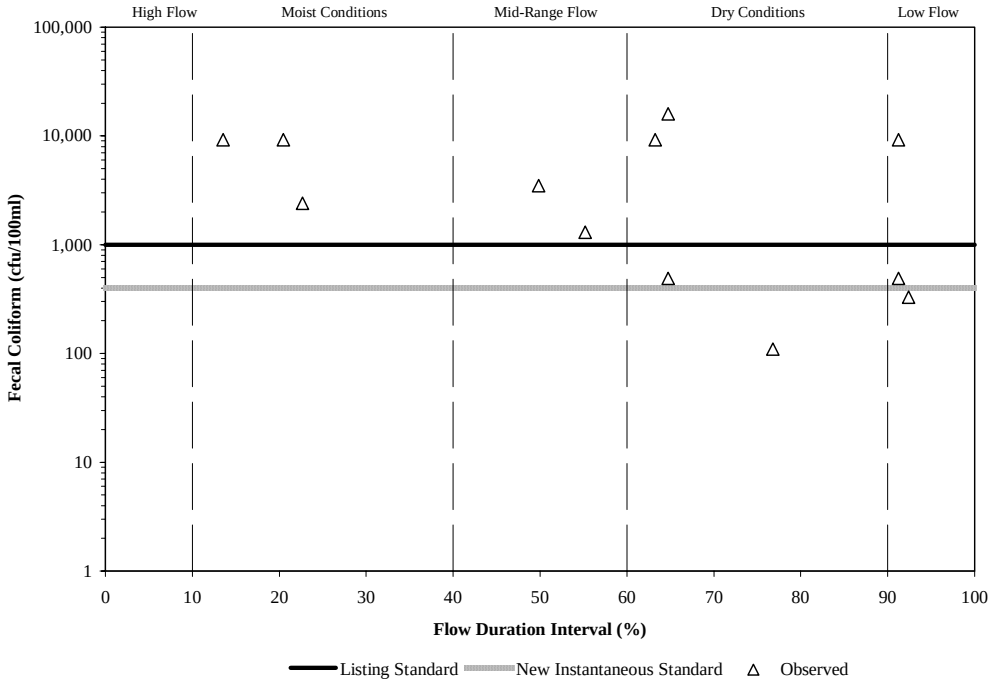

Figure 2.7 Relationship between fecal coliform concentrations (VADEQ Station 2ANG001.27) and discharge (USGS Gaging Station #02039500) in the Angola Creek (2) impairment.

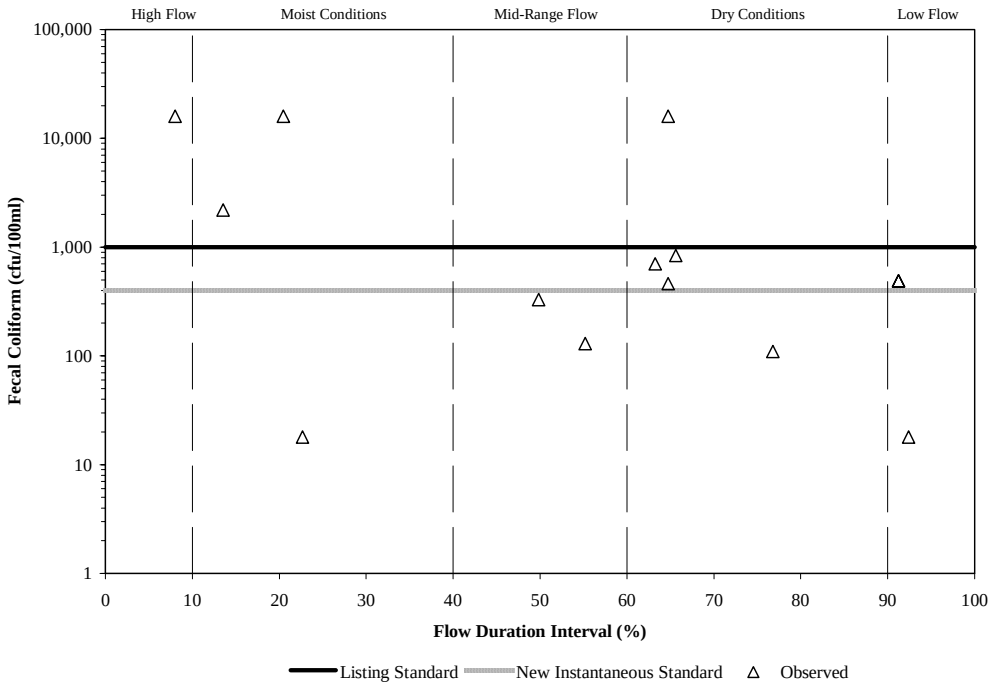

Figure 2.8 Relationship between fecal coliform concentrations (VADEQ Station 2HRP000.42) and discharge (USGS Gaging Station #02039500) in the Horsepen Creek impairment.

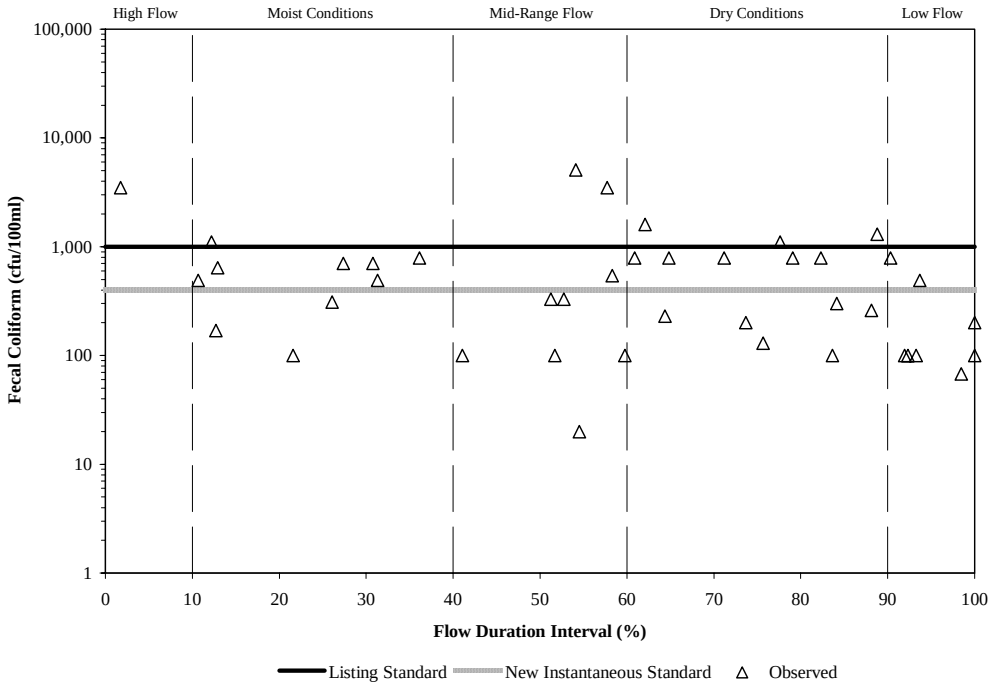

Figure 2.9 Relationship between fecal coliform concentrations (VADEQ Station 2NBB003.65) and discharge (USGS Gaging Station #02040000) in the Nibbs Creek impairment.

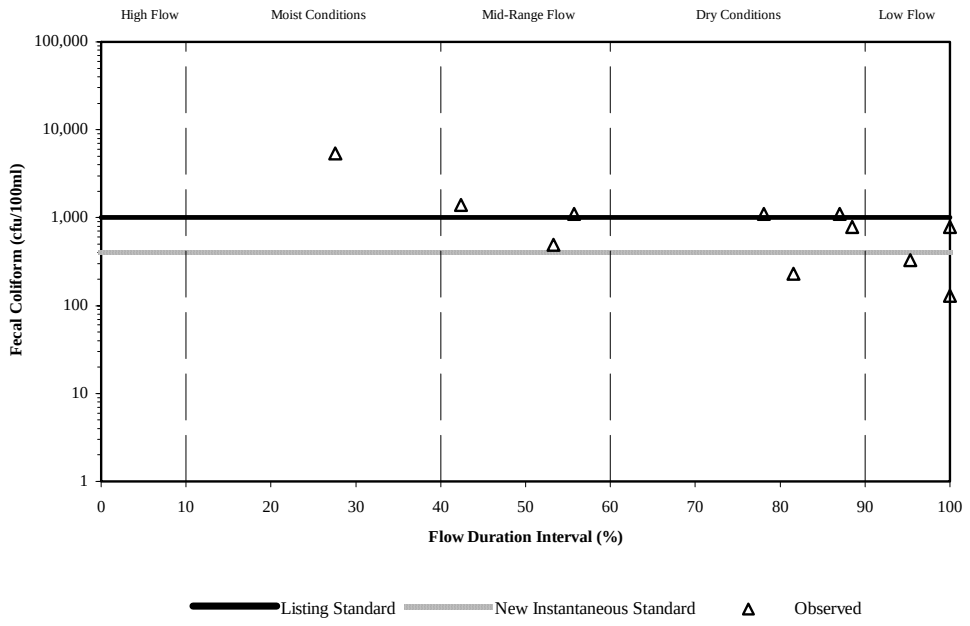

Figure 2.10 Relationship between fecal coliform concentrations (VADEQ Station 2NBB002.92) and discharge (USGS Gaging Station #02040000) in the Nibbs Creek impairment.

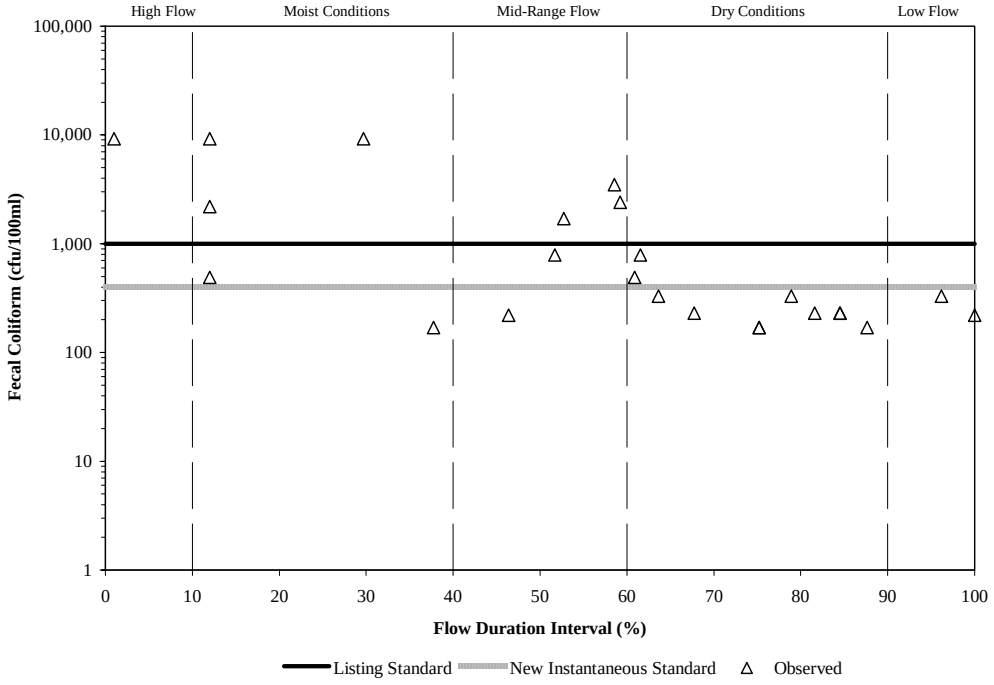

Figure 2.11 Relationship between fecal coliform concentrations (VADEQ Station 2NBB001.54) and discharge (USGS Gaging Station #02040000) in the Nibbs Creek impairment.

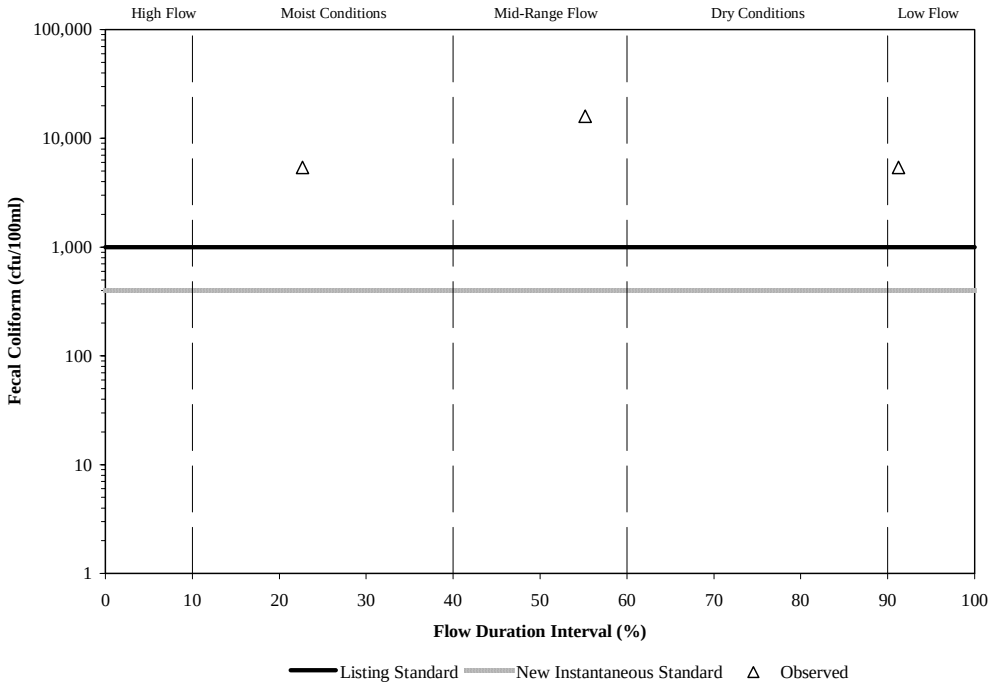

Figure 2.12 Relationship between fecal coliform concentrations (VADEQ Station 2XQK000.15) and discharge (USGS Gaging Station #02040000) in the Nibbs Creek impairment.

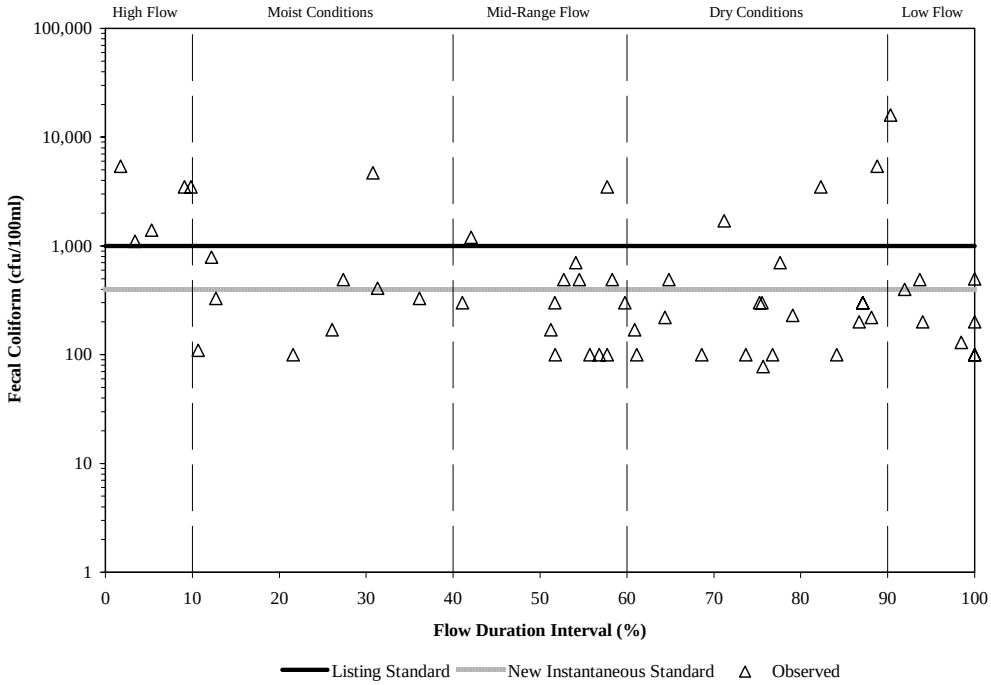

Figure 2.13 Relationship between fecal coliform concentrations (VADEQ Station 2FLA001.95) and discharge (USGS Gaging Station #02040000) in the Flat Creek impairment.

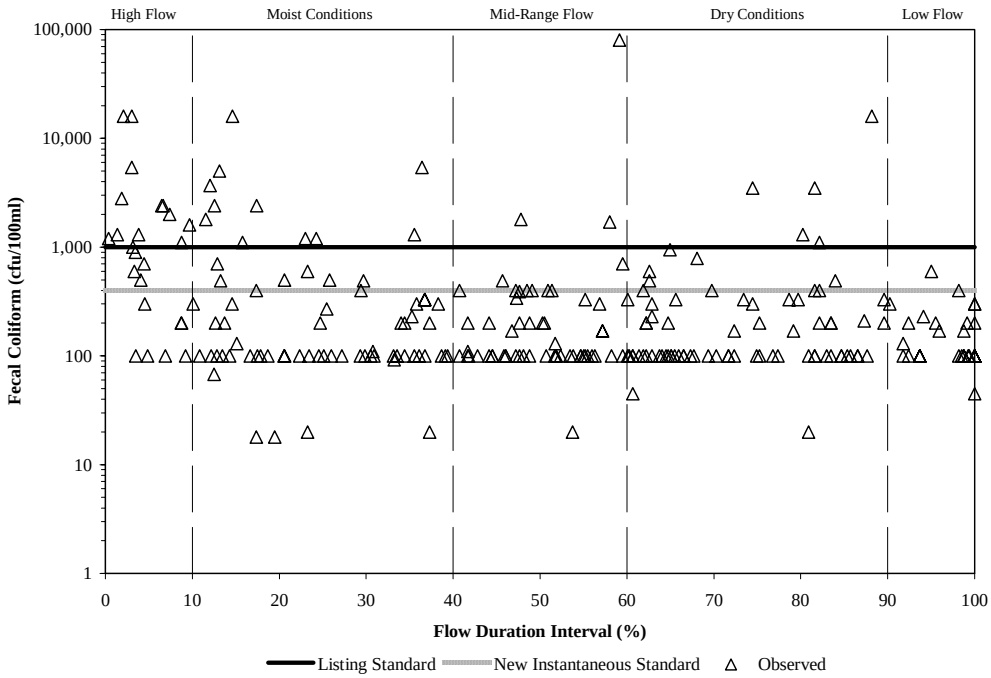

Figure 2.14 Relationship between fecal coliform concentrations (VADEQ Station 2APP118.04) and discharge (USGS Gaging Station #02039500) in the Appomattox River (1) impairment.

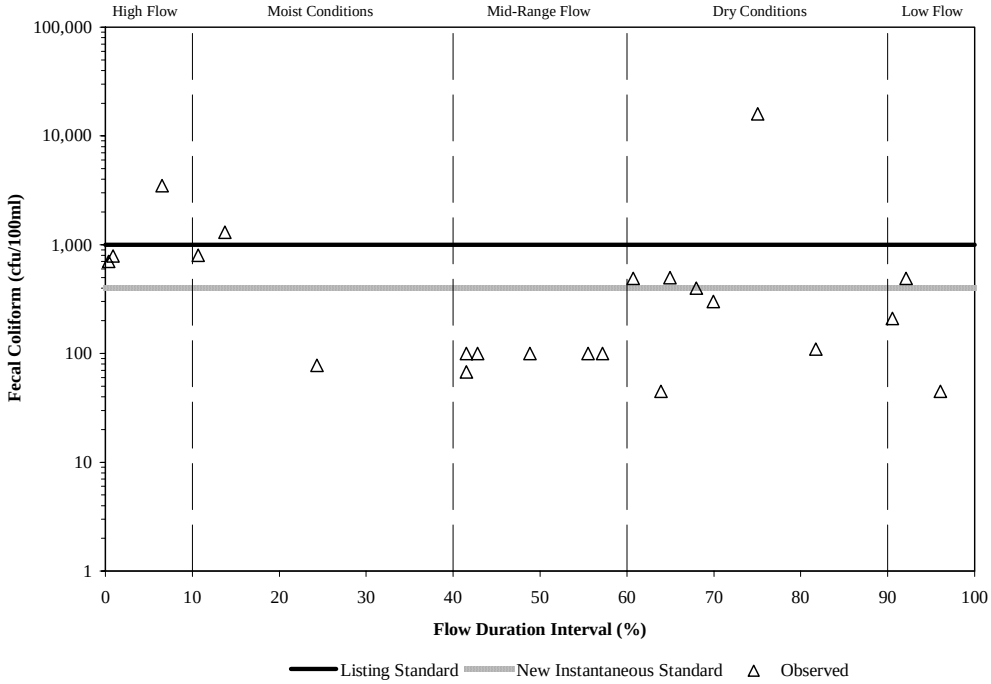

Figure 2.15 Relationship between fecal coliform concentrations (VADEQ Station 2WET004.96) and discharge (USGS Gaging Station #02041000) in the West Creek impairment.

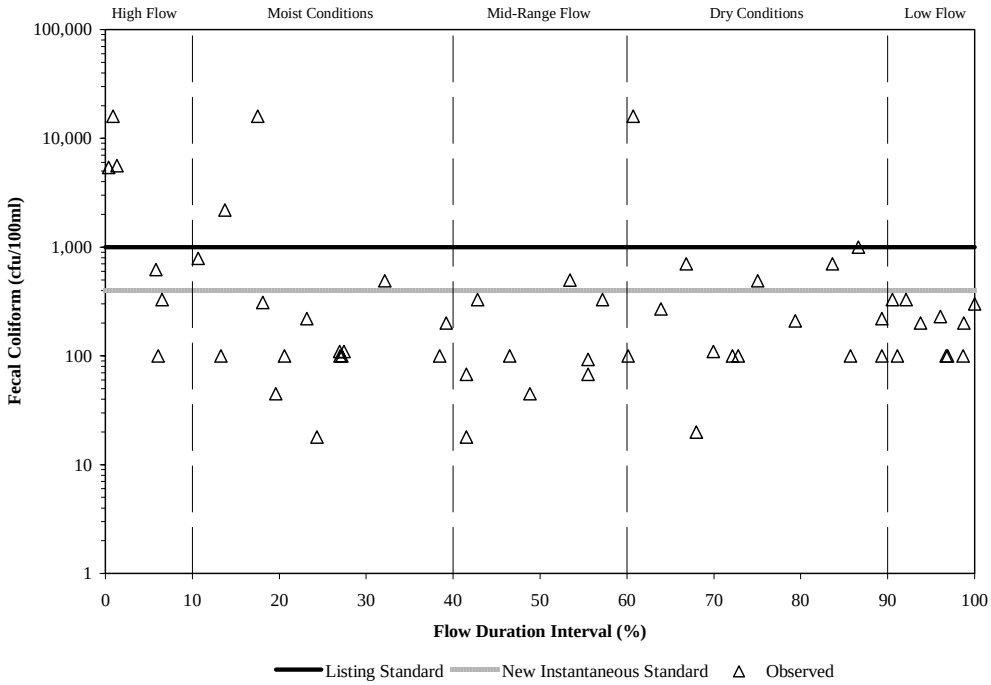

Figure 2.16 Relationship between fecal coliform concentrations (VADEQ Station 2DPC005.20) and discharge (USGS Gaging Station #02041000) in the Deep Creek impairment.

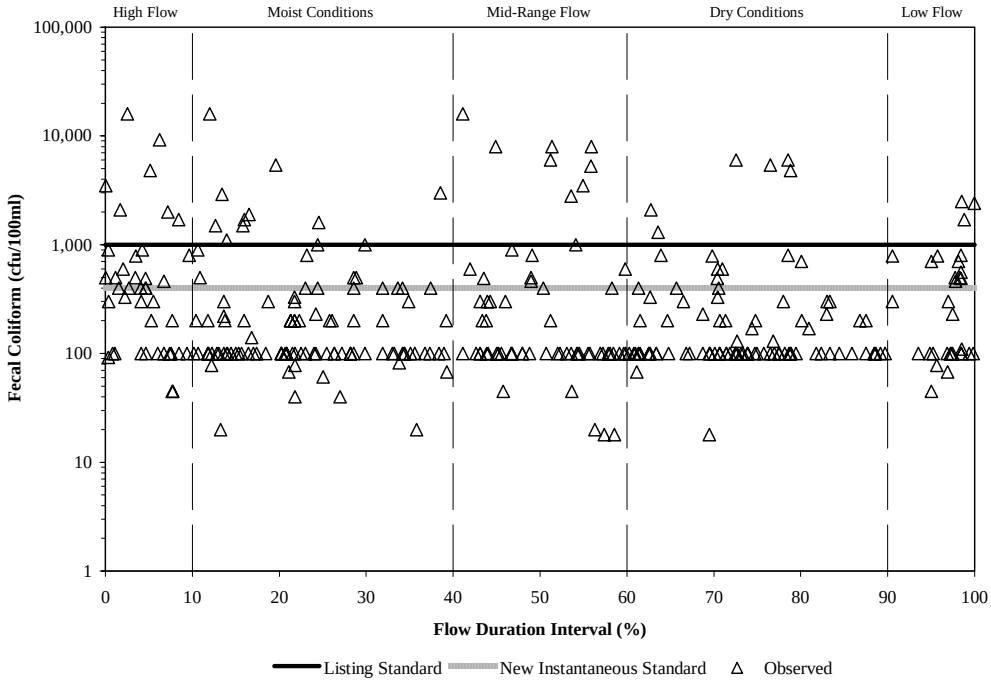

Figure 2.17 Relationship between fecal coliform concentrations (VADEQ Station 2APP012.79) and discharge (USGS Gaging Station #02041650) in the Appomattox River (2) impairment.

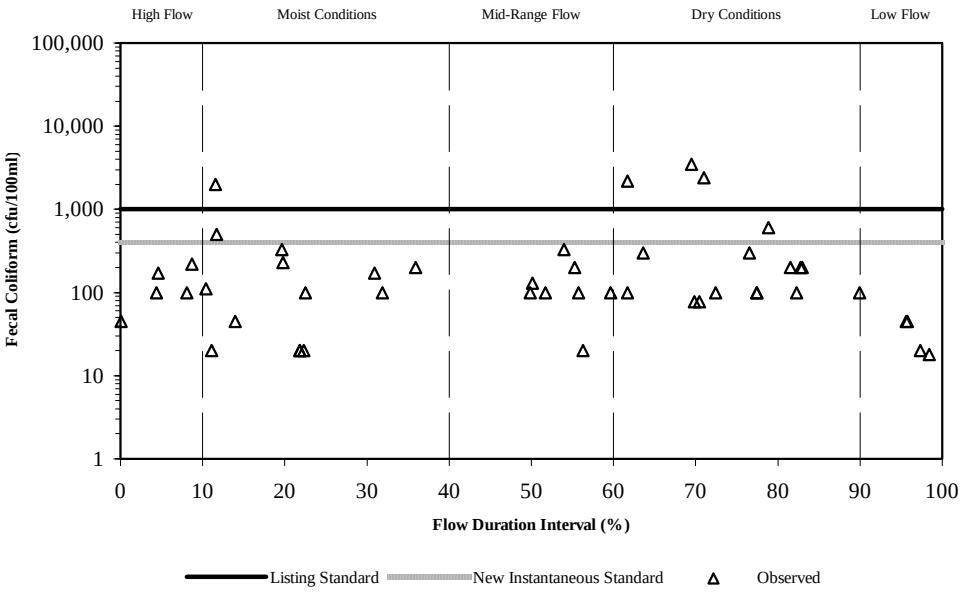

Figure 2.18 Relationship between fecal coliform concentrations (VADEQ Station 2SFT035.26) and discharge (USGS Gaging Station #02041650) in the Swift Creek (1) impairment.

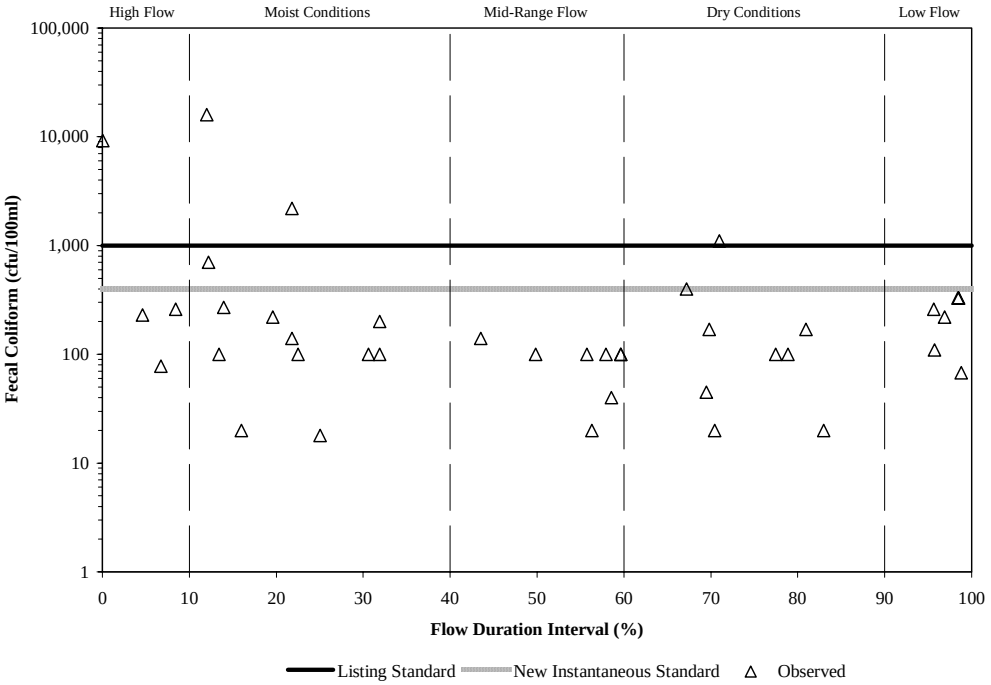

Figure 2.19 Relationship between fecal coliform concentrations (VADEQ Station 2SFT019.15) and discharge (USGS Gaging Station #02041650) in the Swift Creek (2) impairment.

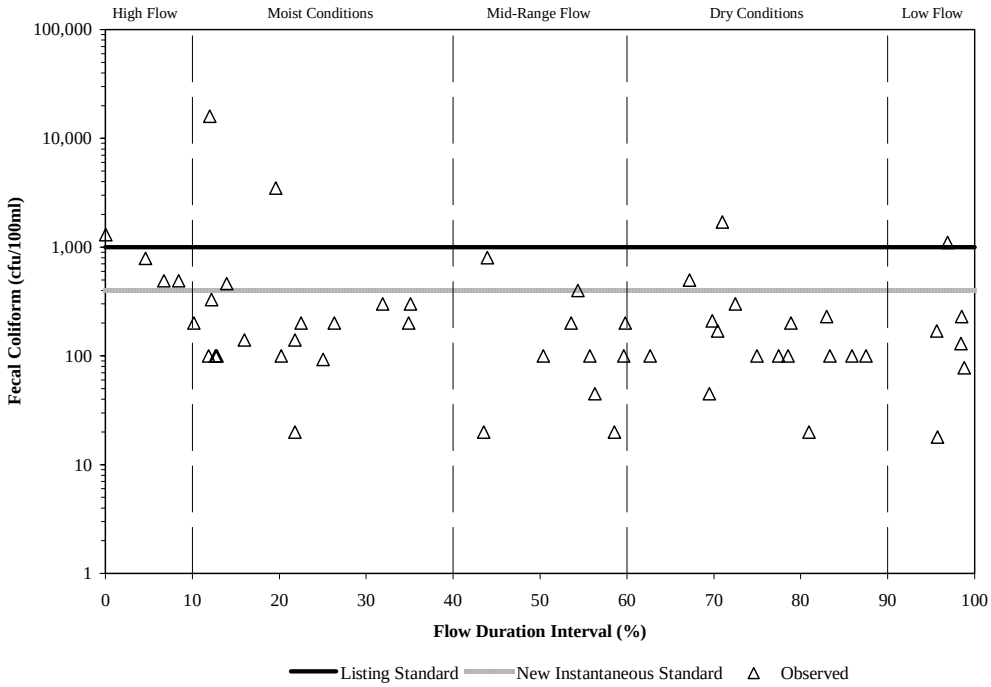

Figure 2.20 Relationship between fecal coliform concentrations (VADEQ Station 2SFT004.92) and discharge (USGS Gaging Station #02041650) in the Swift Creek (3) impairment.

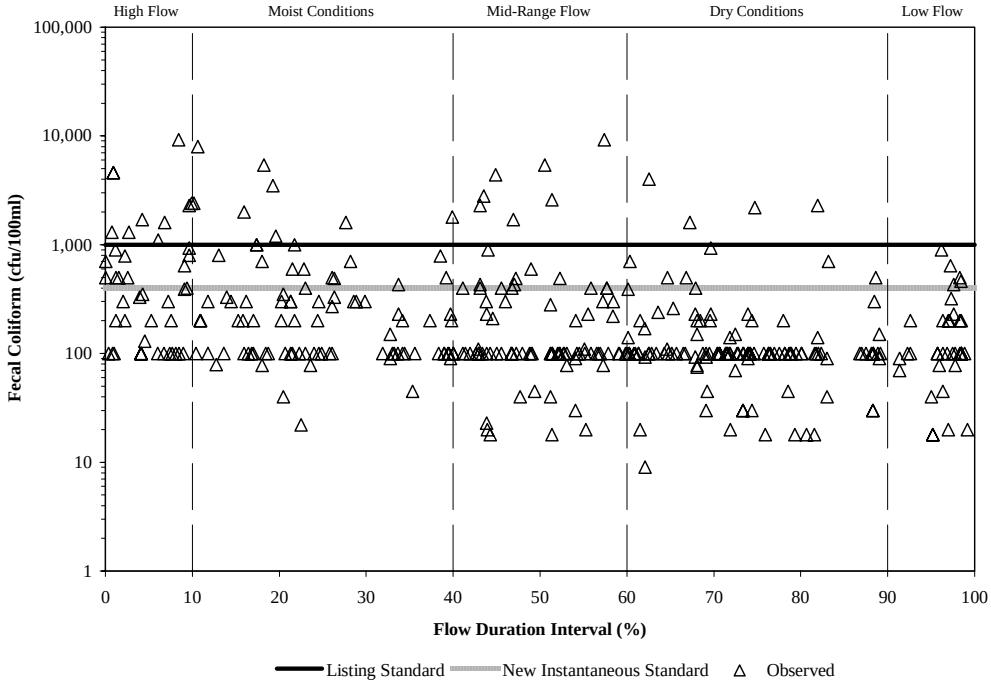

Figure 2.21 Relationship between fecal coliform concentrations (VADEQ Station 2APP001.53) and discharge (USGS Gaging Station #02041650) in the Appomattox River (3) impairment.

2.2 Discussion of In-stream Water Quality

This section provides an inventory and analysis of available observed in-stream fecal coliform monitoring data throughout the Appomattox River watershed. An examination of data from water quality stations used in the 303(d) assessment and data collected during TMDL development were analyzed. Sources of data and pertinent results are discussed.

2.2.1 Inventory of Water Quality Monitoring Data

The primary sources of available water quality information are:

- Bacteria enumerations from 23 VADEQ in-stream monitoring stations used for TMDL assessment; and
- Bacteria enumerations and bacterial source tracking from 32 VADEQ in-stream monitoring stations analyzed during TMDL development.

2.2.1.1 Water Quality Monitoring for TMDL Assessment

Data from in-stream fecal coliform samples, collected by VADEQ, were analyzed from January 1990 through February 2003 (Figure 2.22) and are included in the analysis. Samples were taken for the expressed purpose of determining compliance with the state instantaneous standard limiting concentrations to less than 1,000 cfu/100 ml. Therefore, as a matter of economy, samples showing fecal coliform concentrations below 100 cfu/100 ml or in excess of a specified cap (*e.g.*, 8,000 or 16,000 cfu/100 ml, depending on the laboratory procedures employed for the sample) were not further analyzed to determine the precise concentration of fecal coliform bacteria. The result is that reported concentrations of 100 cfu/100 ml most likely represent concentrations below 100 cfu/100 ml, and reported concentrations of 8,000 or 16,000 cfu/100 ml most likely represent concentrations in excess of these values. Table 2.1 summarizes the fecal coliform samples collected at the in-stream monitoring stations used for TMDL assessment.

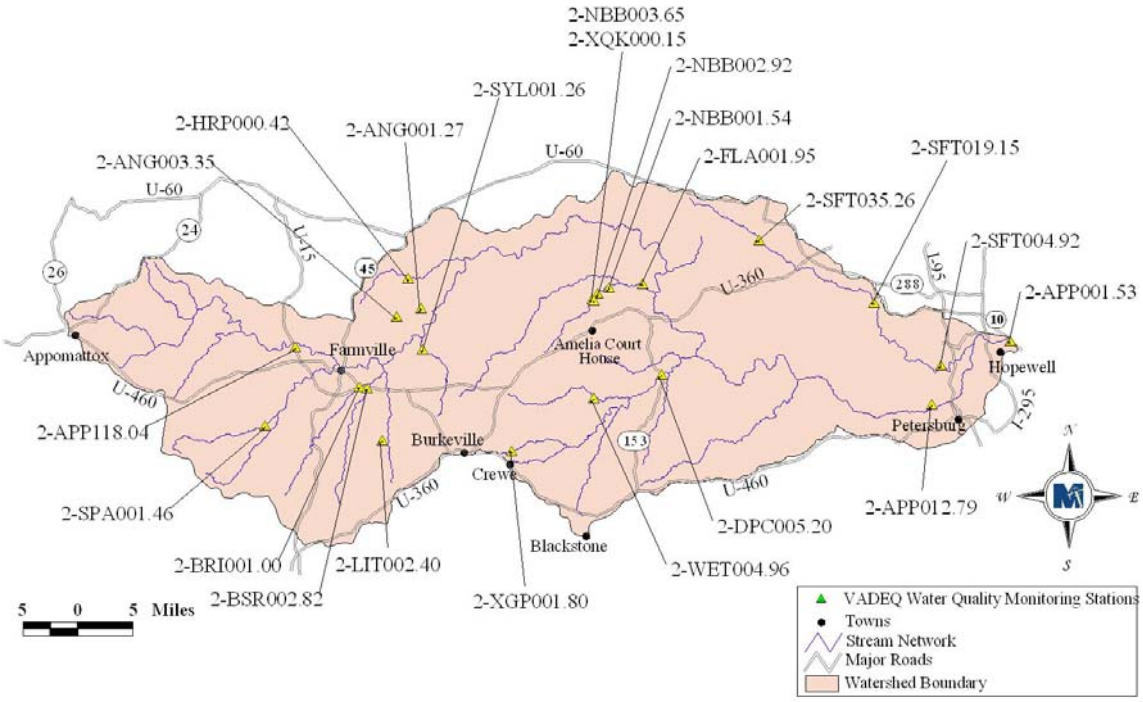

Figure 2.22 Location of VADEQ water quality monitoring stations used for TMDL assessment in the Appomattox River watershed.

Table 2.1 Summary of water quality sampling conducted by VADEQ for period January 1990 through February 2003. Fecal coliform concentrations (cfu/100 ml).

Impairment	VADEQ Station	Count (#)	Minimum (cfu/100ml)	Maximum (cfu/100ml)	Mean (cfu/100 ml)	Median (cfu/100ml)	Violations[1] (%)	Violations[2] (%)
Spring Creek	2-SPA001.46	35	18	9,200	682	100	11	23
Briery Creek	2-BRI001.00	40	20	16,000	2,046	135	18	20
Bush River (1) and (2)	2-BSR002.82	40	20	16,000	971	170	18	20
Little Sandy Creek	2-LIT002.40	2	20	3,500	1,760	1,760	50	50
Saylers Creek	2-SYL001.26	50	20	16,000	2,101	495	38	60
Angola Creek (1)	2-ANG003.35	2	1,100	5,400	3,250	3,250	100	100
Angola Creek (2)	2-ANG001.27	2	490	16,000	8,245	8,245	50	100
Horsepen Creek	2-HRP000.42	16	10	16,000	2,374	395	19	50
Nibbs Creek	2-NBB003.65	44	20	5,100	707	410	16	50
Nibbs Creek	2-NBB002.92	11	130	5,400	1,169	790	45	73
Nibbs Creek	2-XQK000.15	3	5400	16,000	8,933	5,400	100	100
Nibbs Creek	2-NBB001.54	7	170	9,200	1,587	230	14	29
Flat Creek	2-FLA001.95	58	78	16,000	1,095	300	21	40
Appomattox River (1)	2-APP118.04	107	17	16,000	1,146	200	19	28
West Creek	2-WET004.96	22	45	16,000	1,197	255	14	41
Deep Creek	2-DPC005.20	57	18	16,000	1,281	200	11	25
Appomattox River (2)	2-APP012.79	140	18	16,000	814	100	12	27
Swift Creek (1)	2-SFT036.00	58	18	4,000	404	100	10	14
Swift Creek (2)	2-SFT019.15	40	18	16,000	852	105	10	13
Swift Creek (3)	2-SFT004.92	54	18	16,000	617	170	9	20
Appomattox River (3)	2-APP001.53	145	18	9,200	501	100	10	21

[1]Violations are based on the listing fecal coliform instantaneous standard (*i.e.*, 1,000 cfu/100ml)
[2]Violations are based on the new fecal coliform instantaneous standard (*i.e.*, 400 cfu/100ml)

2.2.1.2 Water Quality Monitoring Conducted During TMDL Development

Ambient water quality monitoring was performed from November 2002 through October 2003. Specifically, water quality samples were taken at 32 sites throughout the Appomattox River watershed (Figure 2.23). All samples were analyzed for fecal coliform and *E. coli* concentrations, and for bacteria source (*i.e.*, human, livestock, pets, wildlife) by the Environmental Diagnostics Laboratory at MapTech. Table 2.2 and 2.3 summarizes the fecal coliform and *E. coli* concentration data, respectively, at the ambient stations. BST is presented and discussed in greater detail in Section 2.2.2.2.

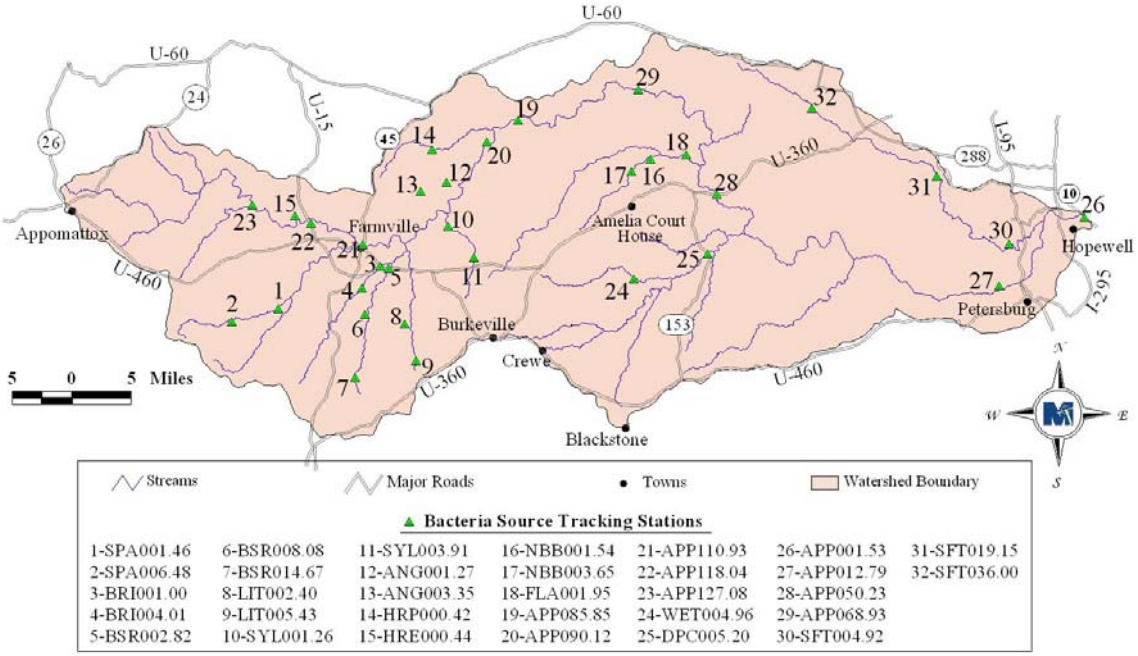

Figure 2.23 Location of BST water quality monitoring stations in the Appomattox River watershed.

Table 2.2 Summary of water quality sampling conducted by VADEQ during TMDL development. Fecal coliform concentrations (cfu/100 ml).

Impairment	Station	Count (#)	Minimum (cfu/100ml)	Maximum (cfu/100ml)	Mean (cfu/100ml)	Median (cfu/100ml)	Violations[1] (%)	Violations[2] (%)
Spring Creek	2-SPA006.48	9	50	5,000	755	310	11	22
	2-SPA001.46	9	80	5,300	823	250	11	33
Briery Creek	2-BRI004.01	9	10	620	322	290	0	44
	2-BRI001.00	9	60	6,000	1,218	220	22	33
Bush River (1)	2-BSR014.67	9	30	620	192	130	0	11
	2-BSR008.08	9	20	600	241	250	0	11
Little Sandy Creek	2-LIT005.43	9	90	720	392	500	0	56
	2-LIT002.40	9	70	490	314	340	0	33
Bush River (2)	2-BSR002.82	9	70	400	286	300	0	0
Saylers Creek	2-SYL003.91	8	10	2,700	442	50	13	25
	2-SYL001.26	9	50	2,100	507	260	11	44
Angola Creek (1)	2-ANG003.35	9	20	2,700	606	370	11	44
Angola Creek (2)	2ANG001.27	9	10	4,500	1,516	260	44	44
Horsepen Creek	2-HRP000.42	8	10	640	293	190	0	44
Nibbs Creek	2-NBB003.65	9	200	2,900	957	640	22	78
	2-NBB001.54	9	210	2,500	1,349	1,200	56	78
Flat Creek	2-FLA001.95	9	210	2,700	801	610	22	67
Appomattox River (1)	2-APP127.08	9	30	440	186	190	0	11
	2-HRE000.44	9	10	800	233	110	0	22
	2-APP118.04	9	10	770	242	210	0	22
	2-APP110.93	9	10	550	233	180	0	22
	2-APP090.12	8	20	440	198	165	0	13
	2-APP085.85	9	50	8,100	1,296	340	22	33
West Creek	2-WET004.96	9	90	2,400	757	400	22	44
Deep Creek	2-DPC005.20	9	80	4,100	1,026	182	22	33
Appomattox River (2)	2-APP068.93	9	50	5,700	1,214	510	33	56
	2-APP050.23	9	70	2,600	889	380	33	44
	2-APP012.79	9	40	3,900	634	200	11	22
Swift Creek (1)	2-SFT036.00	9	40	2,000	345	80	11	11
Swift Creek (2)	2-SFT019.15	8	30	850	230	180	0	13
Swift Creek (3)	2-SFT004.92	9	10	4,600	696	210	11	22
Appomattox River (3)	2-APP001.53	8	60	6,000	1,205	255	25	38

[1]Violations based on listing fecal coliform instantaneous standard (*i.e.*, 1,000 cfu/100ml)
[2]Violations based on new fecal coliform instantaneous standard (*i.e.*, 400 cfu/100ml)

Table 2.3 Summary of water quality sampling conducted by VADEQ during TMDL development. E. coli concentrations (cfu/100 ml).

Impairment	Station	Count (#)	Minimum (cfu/100ml)	Maximum (cfu/100ml)	Mean (cfu/100ml)	Median (cfu/100ml)	Violations[1] (%)
Spring Creek	2-SPA006.48	9	18	870	198	120	22
	2-SPA001.46	9	53	2,700	405	76	22
Briery Creek	2-BRI004.01	9	1	450	122	65	22
	2-BRI001.00	9	11	1,000	279	70	22
Bush River (1)	2-BSR014.67	9	25	230	74	53	0
	2-BSR008.08	9	1	210	103	100	0
Little Sandy Creek	2-LIT005.43	9	50	650	208	130	22
	2-LIT002.40	9	1	390	151	120	22
Bush River (2)	2-BSR002.82	9	50	350	164	130	22
Saylers Creek	2-SYL003.91	8	1	120	24	10	0
	2-SYL001.26	9	1	680	143	58	22
Angola Creek (1)	2-ANG003.35	9	1	480	167	140	22
Angola Creek (2)	2ANG001.27	9	1	2,100	409	110	33
Horsepen Creek	2-HRP000.42	9	1	510	184	130	22
Nibbs Creek	2-NBB003.65	9	150	870	400	330	67
	2-NBB001.54	9	110	1,200	492	310	78
Flat Creek	2-FLA001.95	9	100	750	290	250	56
Appomattox River (1)	2-APP127.08	9	1	310	86	56	11
	2-HRE000.44	9	1	320	72	40	11
	2-APP118.04	9	1	500	119	64	11
	2-APP110.93	9	1	350	90	80	11
	2-APP090.12	8	1	440	113	80	13
	2-APP085.85	9	1	340	154	110	22
West Creek	2-WET004.96	9	50	1,000	251	130	22
Deep Creek	2-DPC005.20	9	38	2,800	424	90	22
Appomattox River (2)	2-APP068.93	9	1	1,100	277	110	33
	2-APP050.23	9	49	2,100	484	120	33
	2-APP012.79	9	1	2,000	334	22	33
Swift Creek (1)	2-SFT036.00	9	27	210	79	56	0
Swift Creek (2)	2-SFT019.15	8	22	380	87	44	13
Swift Creek (3)	2-SFT004.92	9	1	530	116	50	11
Appomattox River (3)	2-APP001.53	8	28	2,000	304	65	13

[1]Violations based on *E. coli* instantaneous standard (*i.e.*, 235 cfu/100ml)

2.2.1.3 Summary of In-stream Water Quality Monitoring Data

A wide range of fecal coliform concentrations have been recorded in the watershed. Concentrations reported during TMDL development were within the range of historical values reported by VADEQ during TMDL assessment. Exceedances of the instantaneous standard were reported in all flow regimes, leaving no apparent relationship between flow and water quality.

2.2.2 Analysis of Water Quality Monitoring Data

The data collected were analyzed for frequency of violations, patterns in fecal source identification, and seasonal impacts. Results of the analyses are presented in the following sections.

2.2.2.1 Summary of Frequency of Violations at the Monitoring Stations

All water quality data were collected at a time-step of at least one month. The state standard of 1,000 cfu/100 ml and 400 cfu/100 ml was used to test for fecal coliform violations. For samples with *E.coli* concentrations, violations of the state standard of 235 cfu/100 ml were calculated. Violation rates are listed in Tables 2.1 through 2.3. A distribution of fecal coliform concentrations at each sampling station in the watershed can be found in Appendix A.

2.2.2.2 Bacterial Source Tracking

MapTech, Inc. was contracted to perform an analysis of fecal coliform and *E. coli* concentrations as well as BST. BST is intended to aid in identifying sources (i.e. human, pets, livestock, or wildlife) of fecal contamination in water bodies. Data collected provided insight into the likely sources of fecal contamination, aided in distributing fecal loads from different sources during model calibration, and will improve the chances for success in implementing solutions.

Several procedures are currently under study for use in BST. Virginia has adopted the Antibiotic Resistance Analysis (ARA) methodology implemented by MapTech's EDL.

This method was selected because it has been demonstrated to be a reliable procedure for confirming the presence or absence of human, pet, livestock and wildlife sources in watersheds in Virginia. The results of sampling were reported as the percentage of isolates acquired from the sample that were identified as originating from either human, pet, livestock, or wildlife sources.

BST results of water samples collected at 32 ambient stations in the Appomattox River drainage are reported in Tables 2.4 – 2.23. The *E. coli* enumerations are given to indicate the bacteria concentration at the time of sampling. The proportions reported are formatted to indicate statistical significance (*i.e.*, **BOLD** numbers indicate a statistically significant result). The statistical significance was determined through 2 tests. The first was based on the sample size. A z-test was used to determine if the proportion was significantly different from zero (alpha = 0.10). Second, the rate of false positives was calculated for each source category in each library, and a proportion was not considered significantly different from zero unless it was greater than the false-positive rate plus three standard deviations.

Table 2.4 Summary of bacterial source tracking results from water samples collected in the Spring Creek impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-SPA006.48	11/18/02	62	46	4	0	**88**	8
	12/16/02	400	140	0	0	**71**	**29**
	1/21/03	100	72	0	0	**83**	**17**
	2/20/03	100	68	**17**	**53**	**17**	**13**
	3/17/03	50	18	6	6	**69**	**19**
	4/14/03	310	280	8	**33**	**51**	8
	5/2903	460	170	0	**50**	**25**	**25**
	6/23/03	5,000	870	0	**17**	**38**	**45**
	7/14/03	310	120	0	4	**71**	**25**
	8/25/03	700	260	0	0	**96**	4
	9/22/03	300	240	0	0	**67**	**33**
	10/20/03	50	60	0	0	75	25
	11/10/03	320	8	0	0	83	17
	12/1/03	20	32	0	**21**	**58**	**21**
2-SPA001.46	11/18/02	120	66	4	8	**88**	0
	12/16/02	250	76	0	0	**83**	**17**
	1/21/03	80	53	0	**25**	**62**	**13**
	2/20/03	150	57	0	**29**	**67**	4
	3/17/03	150	72	4	**25**	**50**	**21**
	4/14/03	260	230	**33**	8	**59**	0
	5/29/03	600	140	0	**42**	**25**	**33**
	6/23/03	5,300	2,700	0	**33**	**33**	**34**
	7/14/03	500	250	4	**41**	**17**	**38**
	8/25/03	290	92	8	**13**	**54**	**25**
	9/22/03	280	340	0	0	**54**	**46**
	10/20/03	70	10	0	0	100	0
	11/10/03	300	<1	--	--	--	--
	12/1/03	50	36	0	**12**	**71**	**17**

BOLD type indicates a statistically significant value.

Table 2.5 Summary of bacterial source tracking results from water samples collected in the Briery Creek impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-BRI004.01	11/18/02	130	76	4	**13**	**79**	4
	12/16/02	290	72	0	0	**92**	8
	1/21/03	60	<1	--	--	--	--
	2/20/03	480	450	0	4	**92**	4
	3/17/03	10	<1	--	--	--	--
	4/14/03	120	23	20	0	60	20
	5/29/03	590	57	0	**44**	**31**	**25**
	6/23/03	600	65	**29**	**25**	**13**	**33**
	7/14/03	620	350	0	0	**62**	**38**
	8/25/03	390	70	0	4	**54**	**42**
	9/22/03	170	120	0	6	**50**	**44**
	10/20/03	50	20	0	0	100	0
	11/10/03	130	<1	--	--	--	--
	12/1/03	50	62	0	8	**88**	4
2-BRI001.00	11/18/02	200	160	0	0	**33**	**67**
	12/16/02	250	52	**21**	0	**75**	4
	1/21/03	150	70	**29**	**21**	**46**	4
	2/20/03	1,000	1,000	0	0	**89**	11
	3/17/03	80	11	0	13	74	13
	4/14/03	60	45	0	**19**	**62**	**19**
	5/29/03	6,000	120	8	0	**75**	**17**
	6/23/03	220	50	4	**13**	**58**	**25**
	7/14/03	3,000	1,000	0	4	**83**	**13**
	8/25/03	470	84	0	0	**100**	0
	9/22/03	260	150	6	**19**	**63**	12
	10/20/03	180	140	**43**	0	**36**	**21**
	11/10/03	270	<1	--	--	--	--
	12/1/03	120	66	0	**71**	**25**	4

BOLD type indicates a statistically significant value.

Table 2.6 Summary of bacterial source tracking results from water samples collected in the Bush River (1) impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-BSR014.67	11/18/02	92	78	**29**	0	**50**	**21**
	12/16/02	210	100	0	0	**79**	**21**
	1/21/03	30	25	**13**	**25**	**58**	4
	2/20/03	130	53	4	4	**88**	4
	3/17/03	80	50	**21**	0	**62**	**17**
	4/14/03	130	73	**13**	**38**	**41**	8
	5/29/03	620	230	4	**13**	**58**	**25**
	6/23/03	240	36	0	6	**38**	**56**
	7/14/03	200	25	0	0	**62**	**38**
	8/25/03	300	12	0	25	50	25
	9/22/03	100	220	0	**44**	**31**	**25**
	10/20/03	40	40	25	0	50	25
	11/10/03	220	<1	--	--	--	--
	12/1/03	120	94	0	**33**	**38**	**29**
2-BSR008.08	11/18/02	160	100	0	17	**66**	17
	12/16/02	350	140	0	0	**92**	8
	1/21/03	70	52	0	0	**96**	4
	2/20/03	60	55	0	10	**70**	20
	3/17/03	20	<1	--	--	--	--
	4/14/03	250	210	0	**50**	**17**	**33**
	5/29/03	350	210	**13**	**33**	**41**	**13**
	6/23/03	310	60	**33**	**17**	**13**	**37**
	7/14/03	600	100	0	0	**58**	**42**
	8/25/03	360	50	0	4	**71**	**25**
	9/22/03	200	320	0	4	**58**	**38**
	10/20/03	40	10	0	0	100	0
	11/11/03	240	<1	--	--	--	--
	12/1/03	110	84	0	8	**92**	0

BOLD type indicates a statistically significant value.

Table 2.7 Summary of bacterial source tracking results from water samples collected in the Little Sandy Creek impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-LIT005.43	11/18/02	720	650	**38**	0	**62**	0
	12/16/02	200	150	**29**	0	**63**	8
	1/21/03	90	75	8	**13**	**75**	4
	2/20/03	550	460	0	**13**	**83**	4
	3/17/03	91	84	**13**	**17**	**53**	**17**
	4/14/03	240	50	6	**19**	**69**	6
	5/2903	580	130	8	**13**	**29**	**50**
	6/23/03	500	220	8	**13**	**41**	**38**
	7/14/03	560	56	0	0	**25**	**75**
	8/25/03	600	280	**21**	0	**29**	**50**
	9/22/03	280	240	0	0	**62**	**38**
	10/20/03	80	250	4	0	**58**	**38**
	11/10/03	130	<1	--	--	--	--
	12/1/03	90	76	0	**46**	**42**	**12**
2-LIT002.40	11/18/02	210	140	**21**	4	**62**	**13**
	12/16/02	210	120	0	0	**62**	**38**
	1/21/03	340	120	0	8	**92**	0
	2/20/03	470	390	0	0	**87**	**13**
	3/17/03	173	<1	--	--	--	--
	4/14/03	70	<10	--	--	--	--
	5/29/03	460	220	0	**17**	**54**	**29**
	6/23/03	490	260	8	**13**	**46**	**33**
	7/14/03	400	96	0	0	**42**	**58**
	8/25/03	510	80	4	0	**38**	**58**
	9/22/03	420	200	**33**	0	**42**	**25**
	10/20/03	60	90	33	0	33	34
	11/10/03	230	<1	--	--	--	--
	12/1/03	180	124	0	**58**	**21**	**21**

BOLD type indicates a statistically significant value.

Table 2.8 Summary of bacterial source tracking results from water samples collected in the Bush River (2) impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-BSR002.82	11/18/02	370	350	0	**17**	**45**	**38**
	12/16/02	300	120	4	0	**96**	0
	1/21/03	70	50	4	8	**80**	8
	2/20/03	240	200	0	**17**	**70**	**13**
	3/17/03	173	78	8	**17**	**75**	0
	4/14/03	280	250	**26**	**26**	**44**	4
	5/29/03	400	200	**16**	0	**42**	**42**
	6/23/03	390	100	0	**25**	**71**	4
	7/14/03	350	130	0	0	**67**	**33**
	8/25/03	600	230	0	0	**100**	0
	9/22/03	140	120	16	0	**42**	**42**
	10/20/03	170	160	**21**	0	**25**	**54**
	11/10/03	480	124	0	4	**84**	**12**
	12/1/03	180	130	0	**12**	4	**84**

BOLD type indicates a statistically significant value.

Table 2.9 Summary of bacterial source tracking results from water samples collected in the Saylers Creek impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-SYL003.91	11/19/02	80	50	0	0	**100**	0
	12/17/02	73	30	0	0	**96**	4
	1/22/03	10	<1	--	--	--	--
	2/19/03	40	<1	--	--	--	--
	3/18/03	10	10	0	38	25	37
	4/16/03	50	18	0	0	50	50
	5/28/03	2,700	120	**17**	0	**38**	**45**
	6/24/03	600	9	0	0	33	67
	7/15/03	50	4	0	0	100	0
	8/26/03	3,000	2	0	0	0	100
	9/23/03	1,200	5,700	0	**12**	**29**	**59**
	10/21/03	60	20	0	0	0	100
2-SYL001.26	11/19/02	760	680	0	0	**83**	**17**
	12/17/02	140	40	4	0	**75**	**21**
	1/22/03	260	<1	--	--	--	--
	2/19/03	50	20	0	**75**	**25**	0
	3/18/03	50	48	**17**	4	**71**	8
	4/16/03	120	64	4	**13**	**33**	**50**
	5/28/03	460	270	4	**12**	**42**	**42**
	6/24/03	2,100	58	0	**29**	**54**	**17**
	7/15/03	620	110	0	0	**67**	**33**
	8/26/03	690	94	**17**	8	**50**	**25**
	9/23/03	6,000	6,100	4	**33**	**59**	4
	10/21/03	210	140	0	6	**94**	0

BOLD type indicates a statistically significant value.

Table 2.10 Summary of bacterial source tracking results from water samples collected in the Angola Creek (1) impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-ANG003.35	11/19/02	480	480	8	**21**	**25**	**46**
	12/1702	320	96	0	8	**71**	**21**
	1/22/03	20	<1	--	--	--	--
	2/19/03	60	12	0	**53**	**47**	0
	3/18/03	50	44	**21**	0	**79**	0
	4/16/03	370	210	0	0	**79**	**21**
	5/28/03	2,700	370	0	**33**	**50**	**17**
	6/24/03	790	150	0	8	**54**	**38**
	7/15/03	660	140	0	**38**	**17**	**45**
	8/26/03	3,400	320	0	0	**50**	**50**
	9/24/03	1,400	1,000	0	**29**	**54**	**17**
	10/21/03	450	270				

BOLD type indicates a statistically significant value.

Table 2.11 Summary of bacterial source tracking results from water samples collected in the Angola Creek (2) impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-ANG001.27	11/19/02	2,700	2,100	0	**21**	**75**	4
	12/17/02	180	92	0	0	**87**	**13**
	1/22/03	10	<1	--	--	--	--
	2/19/03	90	50	0	4	**96**	0
	3/18/03	100	72	**13**	4	**83**	0
	4/16/03	260	230	0	**21**	**17**	**62**
	5/28/03	2,400	430	**38**	0	**13**	**49**
	6/24/03	3,400	110	0	4	**38**	**58**
	7/15/03	4,500	600	**13**	0	**17**	**70**
	8/26/03	3,300	210	0	4	**83**	**13**
	9/24/03	410	8,000	0	0	**100**	0
	10/21/03	150	30	0	40	0	60

BOLD type indicates a statistically significant value.

Table 2.12 Summary of bacterial source tracking results from water samples collected in the Horsepen Creek impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-HRP000.42	11/19/02	520	510	0	8	**38**	**54**
	12/17/02	80	76	0	4	**75**	**21**
	1/22/03	10	<1	--	--	--	--
	2/19/03	80	53	0	5	**95**	0
	3/18/03	90	78	**29**	0	**67**	4
	4/16/03	290	200	0	0	**75**	**25**
	5/28/03	640	190	8	**13**	**50**	**29**
	6/24/03	630	420	0	**45**	**42**	**13**
	7/15/03	700	130	8	0	**29**	**63**
	8/26/03	6,000	180	0	8	**54**	**38**
	9/24/03	340	530	0	**25**	**63**	**12**
	10/21/03	140	20	0	33	67	0

BOLD type indicates a statistically significant value.

Table 2.13 Summary of bacterial source tracking results from water samples collected in the Nibbs Creek impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-NBB003.65	11/18/02	2,000	870	0	0	**92**	8
	12/17/02	380	280	4	0	**75**	**21**
	1/21/03	500	400	0	0	**87**	**13**
	2/20/03	750	620	**41**	**17**	**17**	**25**
	3/18/03	200	150	**25**	0	**54**	**21**
	4/15/03	640	550	0	4	**88**	8
	5/27/03	470	330	8	**46**	**33**	**13**
	6/24/03	2,900	230	0	**38**	**41**	**21**
	7/28/03	770	170	**38**	8	**13**	**41**
	8/26/03	2,400	130	0	**21**	**54**	**25**
	9/24/03	360	520	0	0	**71**	**29**
	10/28/03	270	280	**25**	0	**71**	4
2-NBB001.54	11/18/02	1,200	900	0	8	**84**	8
	12/17/02	800	310	0	**13**	**66**	**21**
	1/21/03	210	160	**17**	0	**75**	8
	2/20/03	2,000	1,200	4	**17**	**58**	**21**
	3/18/03	360	240	8	0	**92**	0
	4/15/03	870	750	9	**30**	**44**	**17**
	5/27/03	2,500	520	**21**	**13**	**53**	**13**
	6/24/03	2,100	240	0	**21**	**33**	**46**
	7/28/03	2,100	110	0	**29**	**29**	**42**
	8/26/03	2,500	240	0	**21**	**46**	**33**
	9/24/03	170	390	0	**24**	**38**	**38**
	10/28/03	70	600	**17**	0	**66**	**17**

BOLD type indicates a statistically significant value.

Table 2.14 Summary of bacterial source tracking results from water samples collected in the Flat Creek impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-FLA001.95	11/18/02	1,300	750	8	8	**71**	**13**
	12/17/02	490	100	0	0	**71**	**29**
	1/21/03	300	250	0	0	**96**	4
	2/20/03	620	460	4	**42**	**54**	0
	3/18/03	210	120	**17**	0	**66**	**17**
	4/15/03	300	250	0	**29**	**58**	**13**
	5/27/03	680	420	**37**	**17**	**25**	**21**
	6/24/03	2,700	140	0	8	**33**	**59**
	7/28/03	610	120	0	**33**	**17**	**50**
	8/26/03	690	180	0	**45**	**42**	**13**
	9/24/03	140	470	0	0	**62**	**38**
	10/28/03	1,000	590	**29**	0	**38**	**33**

BOLD type indicates a statistically significant value.

Table 2.15 Summary of bacterial source tracking results from water samples collected in the Appomattox River (1) impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-APP127.08	11/19/02	190	100	0	8	**79**	**13**
	12/17/02	91	35	0	8	**79**	**13**
	1/22/03	30	<1	--	--	--	--
	2/19/03	30	13	0	0	100	0
	3/19/03	60	56	4	0	**83**	**13**
	4/17/03	210	120	0	8	**84**	8
	5/27/03	370	310	0	0	**75**	**25**
	6/24/03	250	26	13	25	13	49
	7/15/03	440	110	0	**83**	**17**	0
	8/26/03	640	350	0	**13**	**79**	8
	9/24/03	180	280	0	0	**50**	**50**
	10/21/03	60	40	0	60	40	0
2-HRE000.44	11/19/02	84	40	4	8	**84**	4
	12/17/02	30	28	0	8	**88**	4
	1/22/03	10	<1	--	--	--	--
	2/19/03	10	<1	--	--	--	--
	3/19/03	110	<1	--	--	--	--
	4/17/03	120	40	0	4	**58**	**38**
	5/27/03	800	320	**13**	8	**50**	**29**
	6/24/03	320	40	**13**	**17**	**29**	**41**
	7/15/03	610	180	0	**42**	**33**	**25**
	8/26/03	710	62	0	0	**17**	**83**
	9/24/03	160	160	0	0	**67**	**33**
	10/21/03	140	20	0	33	67	0
2-APP118.04	11/19/02	210	210	**18**	9	**64**	9
	12/17/02	160	64	**13**	0	**83**	4
	1/22/03	10	<1	--	--	--	--
	2/19/03	30	30	4	**13**	**79**	4
	3/19/03	80	64	4	**29**	**67**	0
	4/17/03	220	100	**42**	**17**	**33**	8
	5/27/03	770	500	**13**	**13**	**29**	**45**
	6/24/03	450	30	**19**	**25**	13	**43**
	7/15/03	250	72	9	**33**	**25**	**33**
	8/26/03	800	86	0	**21**	**50**	**29**
	9/24/03	80	580	0	4	**54**	**42**
	10/21/03	220	50	0	25	50	25

BOLD type indicates a statistically significant value.

Table 2.16 Summary of bacterial source tracking results from water samples collected in the Appomattox River (1) impairment (cont.).

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-APP110.93	11/19/02	180	130	0	4	**92**	4
	12/17/02	100	27	**46**	**25**	**25**	4
	1/22/03	20	<1	--	--	--	--
	2/19/03	30	10	13	49	25	13
	3/19/03	10	<1	--	--	--	--
	4/17/03	310	80	0	**54**	4	**42**
	5/27/03	550	350	**13**	**21**	**33**	**33**
	6/24/03	500	88	0	**38**	**33**	**29**
	7/15/03	400	120	4	**54**	**29**	**13**
	8/26/03	7,000	90	0	**21**	**38**	**41**
	9/24/03	180	540	0	8	**46**	**46**
	10/21/03	150	70	0	12	25	63
2-APP090.12	11/19/02	440	440	0	4	**88**	8
	12/17/02	130	52	**42**	0	**50**	8
	1/22/03	20	<1	--	--	--	--
	2/19/03	60	34	0	**13**	**74**	**13**
	3/18/03	91	70	**21**	0	**79**	0
	4/16/03	200	90	0	**38**	**21**	**41**
	6/24/03	300	130	**13**	**61**	**13**	**13**
	7/15/03	340	90	**17**	**37**	**17**	**29**
	8/26/03	2,000	220	0	8	**63**	**29**
	10/21/03	260	80	0	12	63	25
2-APP085.85	11/19/02	460	340	0	0	**87**	**13**
	12/17/02	200	110	0	0	**54**	**46**
	1/22/03	80	66	**46**	0	**54**	0
	2/19/03	50	<1	--	--	--	--
	3/18/03	80	50	8	**21**	**54**	**17**
	4/16/03	340	200	0	**29**	**38**	**33**
	5/28/03	2,000	320	**33**	8	**13**	**46**
	6/24/03	350	73	0	**29**	**63**	8
	7/15/03	8,100	230	0	0	**50**	**50**
	8/26/03	550	180	**13**	4	**54**	**29**
	9/23/03	2,000	680	0	**17**	**33**	**50**
	10/21/03	110	160	0	**33**	**67**	0

BOLD type indicates a statistically significant value.

Table 2.17 Summary of bacterial source tracking results from water samples collected in the West Creek impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-WET004.96	11/18/02	2,400	1,000	0	0	**87**	**13**
	12/17/02	110	50	0	0	**87**	**13**
	1/21/03	90	80	0	8	**84**	8
	2/20/03	400	210	**13**	0	**78**	9
	3/18/03	100	76	8	**29**	**25**	**38**
	4/15/03	160	130	4	**46**	**42**	8
	5/27/03	600	400	8	**33**	**46**	**13**
	6/24/03	2,300	110	0	8	**59**	**33**
	7/28/03	650	200	8	**25**	**29**	**38**
	8/26/03	550	94	0	0	**58**	**42**
	9/24/03	220	560	0	0	**71**	**29**
	10/28/03	40	180	0	**12**	**50**	**38**

BOLD type indicates a statistically significant value.

Table 2.18 Summary of bacterial source tracking results from water samples collected in the Deep Creek impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-DPC005.20	11/18/02	750	450	**29**	**21**	**42**	8
	12/17/02	150	90	0	8	**88**	4
	1/21/03	90	38	**29**	**58**	**13**	0
	2/20/03	180	140	8	0	**88**	4
	3/18/03	182	110	**13**	8	**71**	8
	4/15/03	80	62	4	**13**	**58**	**25**
	5/27/03	3,500	2,800	**13**	0	**79**	8
	6/24/03	4,100	53	6	**56**	**19**	**19**
	7/28/03	200	74	4	**33**	**42**	**21**
	8/26/03	630	110	0	0	**71**	**29**
	9/24/03	120	700	0	0	**58**	**42**
	10/28/03	50	54	4	**12**	**63**	**21**

BOLD type indicates a statistically significant value.

Table 2.19 Summary of bacterial source tracking results from water samples collected in the Appomattox River (2) impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-APP068.93	11/18/02	1,400	1,100	**25**	8	**13**	**54**
	12/17/02	360	120	0	**21**	**75**	4
	1/21/03	90	<1	--	--	--	--
	2/20/03	510	500	0	**25**	**71**	4
	3/18/03	50	48	0	**54**	**21**	**25**
	4/15/03	230	110	0	**29**	**21**	**50**
	5/27/03	2,000	460	**21**	**17**	**25**	**37**
	6/24/03	5,700	78	0	**46**	**33**	**21**
	7/28/03	590	78	0	**54**	**17**	**29**
	8/26/03	2,800	100	0	**42**	**58**	0
2-APP050.23	11/18/02	1,400	1,100	**33**	**13**	**41**	**13**
	12/17/02	380	210	0	**17**	**79**	4
	1/21/03	70	49	**17**	**79**	4	0
	2/20/03	600	500	4	4	**88**	4
	3/18/03	80	74	4	0	**88**	8
	4/15/03	150	120	0	**38**	**33**	**29**
	5/27/03	2,600	2,100	8	0	**67**	**25**
	6/24/03	2,500	80	0	62	25	13
	7/28/03	220	120	**17**	**41**	**21**	**21**
2-APP012.79	11/19/02	200	50	0	0	50	50
	12/17/02	740	630	0	**25**	**67**	8
	1/21/03	40	<1	--	--	--	--
	2/20/03	60	22	13	13	61	13
	3/18/03	40	15	13	0	62	25
	4/15/03	370	250	**13**	**41**	**38**	8
	5/27/03	3,900	2,000	**13**	**33**	**46**	8
	6/24/03	200	20	0	17	33	50
	7/28/03	160	20	0	13	25	62
	8/26/03	3,800	40	**18**	**27**	**18**	**37**
	9/24/03	170	30	25	0	50	25
	10/28/03	90	18	0	15	**70**	15

BOLD type indicates a statistically significant value.

Table 2.20 Summary of bacterial source tracking results from water samples collected in the Swift Creek (1) impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-SFT036.00	11/19/02	230	64	0	8	**13**	**79**
	12/17/02	40	27	0	0	87	13
	1/21/03	40	35	4	**88**	0	8
	2/20/03	50	35	**66**	**13**	8	**13**
	3/18/03	72	56	0	**46**	0	**54**
	4/15/03	80	40	0	**38**	**24**	**38**
	5/27/03	330	210	4	**25**	**29**	**42**
	6/24/03	2,000	150	4	**25**	**25**	**46**
	7/28/03	260	94	8	**55**	4	**33**
	8/26/03	4,000	350	0	**21**	**79**	0
	9/24/03	500	270	0	0	**50**	**50**
	10/28/03	1,200	340	0	**71**	8	**21**

BOLD type indicates a statistically significant value.

Table 2.21 Summary of bacterial source tracking results from water samples collected in the Swift Creek (2) impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-SFT019.15	11/19/02	280	60	**25**	**38**	8	**29**
	12/17/02	82	33	13	13	**74**	0
	1/21/03	30	25	**42**	0	**16**	**42**
	2/20/03	40	22	14	7	**65**	14
	3/18/03	190	100	0	8	**84**	8
	4/15/03	170	54	4	4	**33**	**59**
	5/27/03	850	380	8	**13**	**38**	**41**
	6/24/03	200	24	0	**50**	**33**	17
	7/28/03	240	42	**87**	0	0	13
	8/26/03	3,600	62	0	**33**	**46**	**21**
	9/24/03	520	350	0	0	**62**	**38**
	10/28/03	60	14	0	24	38	38

BOLD type indicates a statistically significant value.

Table 2.22 Summary of bacterial source tracking results from water samples collected in the Swift Creek (3) impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-SFT004.92	11/19/02	600	220	10	**38**	**52**	0
	12/17/02	230	76	0	**13**	**45**	**42**
	1/21/03	10	<1	--	--	--	--
	2/20/03	100	46	**19**	**19**	**62**	0
	3/18/03	100	19	13	0	**87**	0
	4/15/03	190	74	0	**42**	**54**	4
	5/27/03	4,600	530	**41**	**38**	**13**	8
	6/24/03	210	50	0	**21**	**66**	**13**
	7/28/03	220	27	0	**44**	**31**	**25**
	8/26/03	300	10	17	50	33	0
	9/24/03	320	450	8	4	**63**	**25**
	10/28/03	130	56	4	**42**	**50**	4

BOLD type indicates a statistically significant value.

Table 2.23 Summary of bacterial source tracking results from water samples collected in the Appomattox River (3) impairment.

Station	Date	Fecal Coliform (cfu/100 ml)	*E. coli* (cfu/100 ml)	Percent Isolates classified as: Human	Pets	Livestock	Wildlife
2-APP001.53	11/19/02	680	110	4	9	**83**	4
	12/10/02	160	100	0	**21**	**75**	4
	1/21/03	140	60	**25**	**17**	**58**	0
	2/20/03	150	70	8	8	**76**	8
	3/18/03	60	28	0	**38**	**29**	**33**
	5/27/03	6,000	2,000	0	4	**75**	**21**
	6/24/03	2,100	38	5	**20**	**40**	**35**
	7/28/03	350	28	0	75	0	25
	8/26/03	250	15	12	38	12	38
	9/24/03	100	120	0	**23**	8	**69**
	10/28/03	200	42	0	**88**	**12**	0

BOLD type indicates a statistically significant value.

2.2.2.3 Trend and Seasonal Analyses

In order to improve TMDL allocation scenarios and, therefore, the success of implementation strategies, trend and seasonal analyses were performed on precipitation, discharge, and fecal coliform concentrations. A Seasonal Kendall Test was used to examine long-term trends. The Seasonal Kendall Test ignores seasonal cycles when looking for long-term trends. This improves the chances of finding existing trends in data that are likely to have seasonal patterns. Additionally, trends for specific seasons

can be analyzed. For instance, the Seasonal Kendall Test can identify the trend (over many years) in discharge levels during a particular season or month.

A seasonal analysis of precipitation, discharge, and fecal coliform concentration data was conducted using the Mood Median Test. This test was used to compare median values of precipitation, discharge, and fecal coliform concentrations in each month. Significant differences between months within years were reported.

2.2.2.4 Precipitation

Total monthly precipitation measured at stations Bremo Bluff #440993 in Fluvanna County, Lynchburg #445120 in Campbell County, Camp Picket #441322 in Nottoway County, and Richmond #447201 in Henrico County, was analyzed, and no overall, long-term trend or seasonality was found.

2.2.2.5 Discharge

Total monthly flow measured at Station #02038850 in Buckingham County, Virginia from January 1970 to September 2001, was analyzed, and an overall, long-term decrease in flow was found. The slope of this decrease was estimated at –0.06 cfs/year (Table 2.24). Differences in mean monthly flow at Station #02038850 are indicated in Table 2.25. Flows in months with the same median group letter are not significantly different from each other at the 95% significance level. For example, July, August, September, and October are all in median group “A” and are not significantly different from each other. Flows in months with multiple median groups are the result of the 95% confidence interval, for that month, overlapping more than one median group. For example, November is in both median group “B” and median group “C” and is not significantly different than either group. In general, flow in the winter-spring months tends to be higher than flow in the fall-summer months.

Table 2.24 Summary of trend analysis on flow (cfs).

Station	Mean	Median	Max	Min	SD[1]	N[2]	Significant Trend[3]
USGS #02038850	9.0	6.8	70.1	0.3	7.8	0.8	-0.06
USGS #02039000	73.6	55.8	365.3	6.7	57.7	0.8	-0.45
USGS #02039500	326.3	241.7	1866.2	25.7	285.3	0.8	No Trend
USGS #02040000	789.4	538.7	4368.8	45.0	724.7	0.8	-5.21
USGS #02041000	161.1	102.6	1002.3	3.4	166.9	0.8	-1.21
USGS #02041650	1359.1	871.3	6869.4	60.5	1308.1	0.8	-8.20

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--" insufficient data

Table 2.25 Summary of the Mood Median Test on mean monthly flow at Holiday Creek USGS 02038850.

Month	Mean (cfs)	Minimum (cfs)	Maximum (cfs)	Median Groups			
January	11.23	2.40	30.45				D
February	12.94	2.22	36.89				D
March	14.25	4.12	37.85				D
April	12.16	4.44	32.60				D
May	10.00	2.93	35.99			C	
June	8.56	1.91	70.15		B		
July	4.60	0.98	15.34	A			
August	4.50	0.46	24.94	A			
September	6.52	0.32	36.81	A			
October	6.02	0.32	25.57	A			
November	7.67	1.72	32.34		B	C	
December	8.43	2.16	25.64			C	

Total monthly flow measured at Station #02039000 in Prince Edward County, Virginia (near Hampden Sydney) from January 1970 to September 2001, was analyzed, and an overall, long-term decrease in flow was found. The slope of this decrease was estimated at –0.45 cfs/year (Table 2.24). Differences in mean monthly flow at Station #02039000 are indicated in Table 2.26. Flows in months with the same median group letter are not significantly different from each other at the 95% significance level. For example, July, August, September, and October are all in median group "A" and are not significantly different from each other. In general, flow in the winter-spring months tends to be higher than flow in the summer-fall months.

Table 2.26 Summary of the Mood Median Test on mean monthly flow at Buffalo Creek USGS 02039000.

Month	Mean (cfs)	Minimum (cfs)	Maximum (cfs)	Median Groups		
January	102.49	27.68	313.45			C
February	103.19	30.43	294.86			C
March	121.14	37.45	323.64			C
April	101.04	30.33	255.77			C
May	72.38	23.71	173.13		B	
June	55.52	11.16	294.13		B	
July	40.19	14.02	129.39	A		
August	37.37	9.00	148.23	A		
September	48.40	6.67	168.00	A		
October	60.07	9.94	365.32	A		
November	68.18	20.03	314.53		B	
December	72.95	21.32	156.74		B	

Total monthly flow measured at Station #02039500 in Prince Edward County, Virginia (near Farmville) from January 1970 to September 2001, was analyzed, and no overall, long-term trend was found (Table 2.24). Differences in mean monthly flow at Station #02039500 are indicated in Table 2.27. Flows in months with the same median group letter are not significantly different from each other at the 95% significance level. For example, July, August, September, and October are all in median group “A” and are not significantly different from each other. Flows in months with multiple median groups are the result of the 95% confidence interval, for that month, overlapping more than one median group. For example, November is in both median group “B” and median group “C” and is not significantly different than either group. In general, flow in the winter-spring months tends to be higher than flow in the summer-fall months.

Table 2.27 Summary of the Mood Median Test on mean monthly flow at Appomattox River @ Farmville USGS 02039500.

Month	Mean (cfs)	Minimum (cfs)	Maximum (cfs)	Median Groups			
January	464.05	110.58	1429.96				D
February	479.51	140.18	1401.78				D
March	554.75	125.52	1518.16				D
April	451.26	129.10	1155.13				D
May	327.22	100.94	871.64			C	
June	254.84	29.47	1866.19		B		
July	160.15	47.87	517.58	A			
August	156.40	33.52	737.77	A			
September	222.08	25.67	1140.36	A			
October	231.26	46.19	1190.32	A			
November	291.01	78.33	1287.29		B	C	
December	318.53	99.32	960.54			C	

Total monthly flow measured at Station #02040000 in Amelia County, Virginia (near Mattoax) from January 1970 to September 2001, was analyzed, and an overall, long-term decrease in flow was found. The slope of this decrease was estimated at –5.21 cfs/year (Table 2.24). Differences in mean monthly flow at Station #02040000 are indicated in Table 2.28. Flows in months with the same median group letter are not significantly different from each other at the 95% significance level. For example, July, August, September, and October are all in median group "A" and are not significantly different from each other. Flows in months with multiple median groups are the result of the 95% confidence interval, for that month, overlapping more than one median group. For example, November is in both median group "B" and median group "C" and is not significantly different than either group. In general, flow in the winter-spring months tends to be higher than flow in the summer-fall months.

Table 2.28 Summary of the Mood Median Test on mean monthly flow at Appomattox River @ Mattoax USGS 02040000.

Month	Mean (cfs)	Minimum (cfs)	Maximum (cfs)	Median Groups			
January	1136.57	269.06	3650.18				D
February	1222.26	366.82	3604.63				D
March	1375.87	308.55	3565.73				D
April	1175.69	273.87	2974.99				D
May	752.74	246.90	1888.80			C	
June	596.89	95.03	4368.78		B		
July	353.63	74.35	1300.19	A			
August	311.19	60.48	992.06	A			
September	453.65	45.00	2294.12	A			
October	625.32	64.58	3932.24	A			
November	638.69	131.07	2727.89		B	C	
December	821.74	237.64	2620.44			C	

Total monthly flow measured at Station #02041000 in Amelia County, Virginia (near Mannboro) from January 1970 to September 2001, was analyzed, and an overall, long-term decrease in flow was found. The slope of this decrease was estimated at –1.21 cfs/year (Table 2.24). Differences in mean monthly flow at Station #02041000 are indicated in Table 2.29. Flows in months with the same median group letter are not significantly different from each other at the 95% significance level. For example, June, July, August, and October are all in median group "B" and are not significantly different from each other. In general, flow in the winter-spring months tends to be higher than flow in the summer months.

Table 2.29 Summary of the Mood Median Test on mean monthly flow at Deep Creek USGS 02041000.

Month	Mean (cfs)	Minimum (cfs)	Maximum (cfs)	Median Groups			
January	246.47	57.03	799.58				D
February	266.03	69.29	793.21				D
March	312.17	74.77	717.90				D
April	232.41	51.23	632.23				D
May	139.96	36.39	406.39			C	
June	90.36	11.00	448.53		B		
July	69.16	7.26	301.13		B		
August	51.68	3.43	309.00		B		
September	93.04	4.11	1002.30	A			
October	125.42	3.55	859.29		B		
November	146.98	14.64	820.80			C	
December	157.64	51.42	452.97			C	

Total monthly flow measured at Station #02041650 in Chesterfield County, Virginia near Matoaca) from January 1970 to September 2001, was analyzed, and an overall, long-term decrease in flow was found. The slope of this decrease was estimated at –8.20 cfs/year (Table 2.24). Differences in mean monthly flow at Station #02041650 are indicated in Table 2.30. Flows in months with the same median group letter are not significantly different from each other at the 95% significance level. For example, July, August, September, and October are all in median group "A" and are not significantly different from each other. In general, flow in the winter-spring months tends to be higher than flow in the summer-fall months.

Table 2.30 Summary of the Mood Median Test on mean monthly flow at Appomattox River @ Matoaca USGS 02041650.

Month	Mean (cfs)	Minimum (cfs)	Maximum (cfs)	Median Groups			
January	2005.39	383.77	5868.17				D
February	2208.13	590.57	6531.76				D
March	2531.57	478.00	6097.72				D
April	2105.30	497.96	5002.98				D
May	1292.32	411.42	4451.50			C	
June	898.16	104.97	5292.95		B		
July	543.22	99.23	2123.25	A			
August	472.88	60.55	1818.15	A			
September	733.59	79.93	5311.64	A			
October	1053.68	87.84	6869.33	A			
November	1064.35	92.50	5648.11		B		
December	1382.37	382.29	3857.40			C	

2.2.2.6 Fecal Coliform Concentrations

Water quality monitoring data collected by VADEQ were described in section 2.2.1.1. The trend analysis was conducted on data, if sufficient, collected at stations used in TMDL assessment. An overall trend in fecal coliform concentrations was detected at station 2-BRI001.00. The slope of this decrease was estimated at –20 cfu/100 ml. Remaining stations had no overall trend (Table 2.31). Differences in mean monthly fecal coliform concentration for station 2-APP001.53 are indicated in Table 2.32. Fecal coliform concentrations in months with the same median group letter are not significantly different from each other at the 95% significance level. For example, January, February, March, September, November, and December are all in median group "B" and are not

significantly different from each other. Flows in months with multiple median groups are the result of the 95% confidence interval, for that month, overlapping more than one median group. For example, January, February, March, September, and November are in both median group "A" and median group "B" and are not significantly different than either group. The remaining stations had no seasonality effect.

Table 2.31 Summary of trend analysis on fecal coliform (cfu/100 ml).

Station	Mean	Median	Max	Min	SD[1]	N[2]	Significant Trend[3]
2-SPA001.46	682	100	9,200	18	1,819	35	No Trend
2-BRI001.00	2,046	135	16,000	20	4,933	40	-20
2-BSR002.82	971	170	16,000	20	2,715	40	No Trend
2-SYL001.26	2,101	495	16,000	20	4,008	50	--
2-FLA001.95	1,109	300	16,000	78	2,400	58	--
2-APP118.04	1,146	200	16,000	18	3,110	107	No Trend
2-WET004.96	1,197	255	16,000	45	3,390	22	No Trend
2-DPC005.20	1,281	200	16,000	18	3,647	57	--
2-APP012.79	819	100	16,000	18	2,443	139	No Trend
2-SFT019.15	852	105	16,000	18	2,861	40	--
2-SFT004.92	617	170	16,000	18	2,202	54	--
2-APP001.53	497	100	9,200	18	1,298	144	No Trend

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--" insufficient data

Table 2.32 Summary of the Mood Median Test on mean monthly fecal coliform at 2-APP001.53 (p=0.001).

Month	Mean (cfu/100 ml)	Minimum (cfu/100 ml)	Maximum (cfu/ 100ml)	Median Groups	
January	1,165	78	9,200	A	B
February	347	100	1,700	A	B
March	385	22	1,800	A	B
April	141	20	350	A	
May	861	18	9,200	A	
June	193	18	1,600	A	
July	536	18	5,400	A	
August	142	18	640	A	
September	414	18	2,400	A	B
October	388	78	3,500	A	
November	295	78	790	A	B
December	1,260	200	5,400		B

3. SOURCE ASSESSMENT

The TMDL development described in this report includes examination of all potential sources of fecal coliform in the Appomattox River watershed. The source assessment was used as the basis of model development and ultimate analysis of TMDL allocation options. In evaluation of the sources, loads were characterized by the best available information, landowner input, literature values, and local management agencies. This section documents the available information and interpretation for the analysis. The source assessment chapter is organized into point and nonpoint sections. The representation of the following sources in the model is discussed in Section 4.

3.1 Assessment of Point Sources

Twenty-nine point sources are permitted to discharge in the Appomattox River watershed through the Virginia Pollutant Discharge Elimination System (VPDES). Figure 3.1 shows their discharge locations. Permitted point discharges that may contain pathogens associated with fecal matter are required to maintain a fecal coliform concentration below 200 cfu/100 ml. Currently, these permitted dischargers are expected not to exceed the 126 cfu/100ml *E. coli* standard. One method for achieving this goal is chlorination. Chlorine is added to the discharge stream at levels intended to kill off any pathogens. The monitoring method for ensuring the goal is to measure the concentration of total residual chlorine (TRC) in the effluent. If the concentration is high enough, pathogen concentrations, including fecal coliform concentrations, are considered reduced to acceptable levels. Typically, if minimum TRC levels are met, bacteria concentrations are reduced to levels well below the standard. Table 3.1 summarizes data from these point discharges.

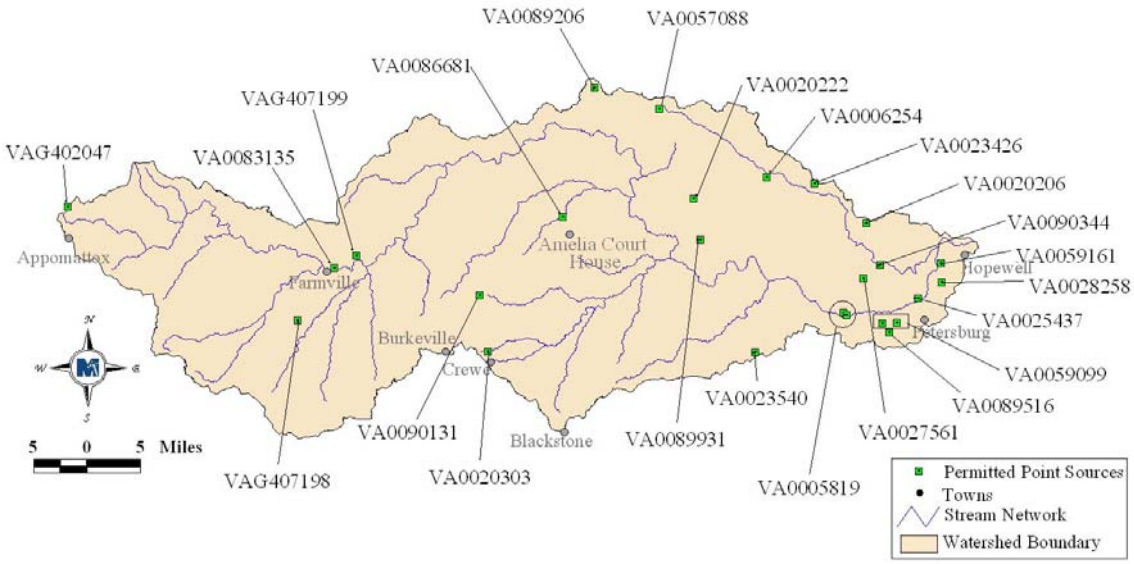

Figure 3.1 Location of VPDES permitted point sources in the Appomattox River watershed.

Table 3.1 Summary of VPDES permitted point discharges in the Appomattox River watershed.

Facility	VPDES #	Design Discharge (MGD)	Permitted For Fecal Control	Data Availability
Farmville WWTP	VA0083135	2.4	Yes	May 1999 – March 2003
Crewe WWTP	VA0020303	0.5	Yes	Feb 1999-Feb 2003
App. River Water Authority	VA0005819	2.7	Yes	N/A
Swift Creek WTP	VA0006254	0.006	Yes	N/A
Thomas Dale West STP	VA0020206	0.0096	Yes	May 1999-July 2002
Chesterfield Co. Grange Elementary WWTP	VA0020222	0.0066	Yes	May 1999-June 2003
DOC Pocahontas Correctional Unit 13	VA0023426	0.055	Yes	May 1999-June 2003
DOC Dinwiddie Field Unit 27 WWTP	VA0023540	0.015	Yes	May 1999-June 2003
So. Central Wastewater Authority WWTF	VA0025437	23	Yes	May 1999-June 2003
Children's Home of VA Baptists Lagoon	VA0027561	0.01	Yes	N/A
Red Hill Mobile Home Park WWTP	VA0028258	0.039	Yes	May 1999-March 2003
US Army Fort Lee - Aerial Delivery Site	VA0059161	0.5	Yes	Nov 2000-Oct 2001
Amelia Co Sanitary District	VA0086681	0.3	Yes	May 1999-June 2003
New Matoaca High School	VA0090344	0.04	Yes	Oct 2002-May 2003
Colonial Pipeline Powhatan	VA0057088	3	No	N/A
Southside VA Training Center	VA0059099	0.159	No	N/A
Fighting Creek WWTF	VA0089206	0.1	No	N/A
Tidewater Materials Inc – Dinwiddie	VA0089516	0.012	No	N/A
Taylor Road Landfill	VA0089931	0.018	No	N/A
Tyson Foods Inc - Feed Mill	VA0090131	0.0012	No	N/A
Residence	VAG402047	0.001	Yes	ND
Residence	VAG404002*	0.001	Yes	ND
PRJ Land Trust	VAG404092*	0.001	Yes	ND
Residence	VAG404107*	0.001	Yes	ND
Landing View Golf Club	VAG404129*	0.001	Yes	ND
Residence	VAG404140*	0.001	Yes	ND
Residence	VAG404161*	0.001	Yes	ND
Residence	VAG407198	0.001	Yes	ND
Residence	VAG407199	0.001	Yes	ND

* Location of permits unknown.
ND – no data, facility not required to submit monitoring data

3.2 Assessment of Nonpoint Sources

In the Appomattox River watershed, both urban and rural nonpoint sources of fecal coliform bacteria were considered. Sources include residential sewage treatment systems, land application of waste (livestock and biosolids), livestock, wildlife, and pets. Sources were identified and enumerated. MapTech collected samples of fecal coliform sources (i.e. wildlife, livestock, pet, and human waste) and enumerated the density of fecal coliform bacteria to support the modeling process, and to expand the database of known fecal coliform sources for purposes of bacterial source tracking (Section 2.2.2.2). Where appropriate, spatial distribution of sources was also determined.

3.2.1 Private Residential Sewage Treatment

In the U.S. Census questionnaires, housing occupants were asked which type of sewage disposal existed. Houses can be connected to a public sanitary sewer, to a septic tank or cesspool, or the sewage is disposed of in some other way. The Census category “Other Means” includes the houses that dispose of sewage other than by public sanitary sewer or a private septic system. The houses included in this category are assumed to be disposing sewage via straight pipes. Population, housing units, and type of sewage treatment from U.S. Census Bureau (USCB 2000) were calculated using GIS (Table 3.2).

Sanitary sewers are piping systems designed to collect wastewater from individual homes and businesses and carry it to a wastewater treatment plant. Sewer systems are designed to carry a specific "peak flow" volume of wastewater to the treatment plant. Within this design parameter, sanitary collection systems are not expected to overflow, surcharge or otherwise release sewage before their waste load is successfully delivered to the wastewater treatment plant.

When the flow of wastewater exceeds the design capacity, the collection system will "back up" and sewage discharges through the nearest escape location. These discharges into the environment are called overflows. Wastewater can also enter the environment through exfiltration caused by line cracks, joint gaps, or breaks in the piping system.

Typical private residential sewage treatment systems (septic systems) consist of a septic tank, distribution box, and a drainage field. Waste from the household flows first to the septic tank, where solids settle out and are periodically removed by a septic tank pump-out. The liquid portion of the waste (effluent) flows to the distribution box, where it is distributed among several buried, perforated pipes that comprise the drainage field. Once in the soil, the effluent flows downward to groundwater, laterally to surface water, and/or upward to the soil surface. Removal of fecal coliform is accomplished primarily by die-off during the time between introduction to the septic system and eventual introduction to naturally occurring waters. Properly designed, installed, and functioning septic systems contribute virtually no fecal coliform to surface waters.

A septic failure occurs when a drain field has inadequate drainage or a "break", such that effluent flows directly to the soil surface, bypassing travel through the soil profile. In this situation the effluent is either available to be washed into waterways during runoff events or is directly deposited in-stream due to proximity. A survey of septic pump-out contractors performed by MapTech, showed that failures were more likely to occur in the winter-spring months than in the summer-fall months, and that a higher percentage of system failures were reported because of a back-up to the household than because of a failure noticed in the yard.

MapTech sampled waste from septic tank pump-outs and found an average fecal coliform density of 1,040,000 cfu/100 ml. An average fecal coliform density for human waste of 13,000,000 cfu/g and a total waste load of 75 gal/day/person was reported by Geldreich (1978).

Table 3.2 Human population, housing units, houses on sanitary sewer, houses on septic systems, and houses on other treatment system for 2003 in areas contributing to impaired segments in the Appomattox River watershed.

Impaired Segment	Population	Housing Units	Sanitary Sewer	Septic Systems	Other *
Spring Creek	775	406	12	377	17
Briery Creek	2,983	1,221	361	823	37
Bush River (1)	5,155	2,220	392	1,719	109
Little Sandy Creek	146	73	2	67	4
Bush River (2)	6,392	2,803	409	2,250	144
Saylers Creek	1,101	479	6	455	18
Angola Creek (1)	213	91	0	79	12
Angola Creek (2)	370	148	0	132	16
Horsepen Creek	167	78	0	75	3
Nibbs Creek	1,771	667	111	508	48
Flat Creek	5,698	2,331	166	2,023	142
Appomattox River (1)	46,165	18,442	3,038	14,677	727
West Creek	1,503	608	29	539	40
Deep Creek	9,279	4,016	1,504	2,341	171
Appomattox River (2)	89,710	36,458	14,027	21,399	1,032
Swift Creek (1)	2,580	988	16	960	12
Swift Creek (2)	55,474	20,474	14,966	5,447	61
Swift Creek (3)	69,646	26,070	17,113	8,871	86
Appomattox River (3)	222,170	89,184	54,031	33,934	1,219

* Houses with treatment systems other than sanitary sewer and septic systems.

3.2.2 Biosolids

Biosolids from 29 wastewater sources (Table 3.3) have been applied to agricultural lands in the Appomattox River watershed. Between 1997 and 2001 an average of 6,726.45 dry tons with an average fecal coliform density of 3.75E+05 cfu/g were applied per year to the watershed. Table 3.4 lists the acres permitted for biosolids application, number of acres biosolids applied to, dry tons of biosolids applied, and amount of fecal coliform applied to area contributing to impairments in the Appomattox River watershed. The application of biosolids to agricultural lands is strictly regulated in Virginia (VDH, 1997). Biosolids are required to be spread according to sound agronomic requirements and consideration for topography and hydrology. Class B biosolids may not have a fecal coliform density greater than 1,995,262 cfu/g (total solids). Application rates must be limited to a maximum of 15 dry tons/ac per three-year period.

Table 3.3 Source and application of biosolids within the Appomattox River watershed.

Source of Biosolids	Average cfu/gram	Dry Tons Applied In 1997	1998	1999	2000	2001
Blue Plains	1.11E+03					1,975.33
Blue Plains/ New York #2	1.94E+05					11.13
Red Hook	7.27E+05			36.54	23.09	
26th Ward	2.22E+05		210.35	89.31		
Bergen Co.	3.86E+05		792.18	767.96	157.94	
BPLS/Richmond[1,2,4]	9.98E+05					
Chesterfield	1.54E+04					17.05
Chesterfield/Henrico/South Central	5.52E+03					228.74
Chesterfield/Henrico	8.27E+03					107.09
Chesterfield/South Central	7.73E+03					70.44
Farmville WWTP[1]	2.00E+06			724.78		211.85
Henrico	1.11E+03			298.25		83.18
Henrico Co./ Bergen Co.	1.94E+05			768.32		
Henrico/South Central	5.66E+02			337.36	268.37	
Hunts Point	4.05E+05		179.45			
Hunts Point/26th Ward	3.14E+05		1,444.24			
Hunts Point/Redhook	5.66E+05		11.47			
Jamaica	2.58E+05		101.74			
Jamaica/26th Ward	2.40E+05		589.24			
Jamaica/Hunts Point	3.32E+05		133.21			
Jamaica/New York #2	3.22E+05	54.93		1,310.98	42.68	
Jamaica/Ward's Island	2.89E+05		57.45			
Middlesex	2.45E-01					2,494.67
New York #2	3.86E+05	32.26		3,086.80	1,144.10	1,535.49
PCFC[3]	1.41E+04	1,263.67	680.71			
Red Hook/New York #2	5.57E+05			365.29	3,704.15	3,665.87
South Central	2.35E+01				84.92	
Ward's Island	3.19E+05		32.11	224.85		
Ward's Island/26th Ward	2.71E+05		1,980.87	2,087.52		
Ward's Island/Bowery Bay	1.87E+06			144.34		
	TOTAL=	1,350.86	6,213.02	10,242.30	5,425.25	10,400.84

[1]Data not available for Farmville or Richmond so a maximum allowable cfu/g was used.
[2]Cfu/g is an average of maximum allowable and the BPLS number.
[3]PCFC is an average of Proctor's Creek and Falling Creek cfu/g numbers.
[4]The only application for the BPLS/Richmond source was in 1983.

Table 3.4 Acres permitted for biosolids application, number of acres biosolids applied to, dry tons of biosolids applied, and amount of fecal coliform applied to areas contributing to impairments in the Appomattox River watershed.

Impairment	Subwatersheds	Acres Permitted	Acres Applied (1997-2001)	Dry Tons Applied (1997-2001)	Fecal Coliform Applied
Spring Creek	13 – 17	308.80	0.00	0.00	0.00000E+00
Briery Creek	24 – 28	262.90	0.00	0.00	0.00000E+00
Bush River (1)	24 – 33	782.20	30.00	85.75	1.27682E+14
Little Sandy Creek	34 – 35	11.60	0.00	0.00	0.00000E+00
Bush River (2)	24 – 40	967.30	95.00	282.60	1.27682E+14
Saylers Creek	42 – 46	970.50	864.00	3,868.77	4.92045E+14
Angola Creek (1)	48	364.20	2,702.30	2,219.30	7.84409E+14
Angola Creek (2)	48 – 49	751.00	2,995.80	3,117.16	1.07416E+15
Horsepen Creek	54	18.40	52.20	173.80	3.88253E+13
Nibbs Creek	69 – 71	541.60	46.30	177.41	1.46827E+11
Flat Creek	66 – 72	2,543.60	46.30	177.41	1.46827E+11
Appomattox River (1)	1 – 77	15,028.20	9,996.70	29,906.75	8.92168E+15
West Creek	91 – 94	523.30	242.60	1,162.79	2.24682E+13
Deep Creek	78 – 97	3,377.17	404.20	1,819.81	4.22550E+13
Appomattox River (2)[1,2]	1 – 118	25,930.97	10,810.40	35,570.84	8.97980E+15
Swift Creek (1)	124 – 126	0.00	0.00	0.00	0.00000E+00
Swift Creek (2)	124 – 138	0.00	0.00	0.00	0.00000E+00
Swift Creek (3)	124 – 143	0.00	0.00	0.00	0.00000E+00
Appomattox River(3)[1,2]	1 – 149	26,229.47	10,810.40	35,570.84	8.97980E+15

[1] Subwatershed 118 received 1,796.30 dry tons in 1983. No more applications were reported.
[2] Subwatershed 118 received 1,796.30 dry tons in 1983. Fecal Coliform Numbers are not available for this application.

3.2.3 Pets

Among pets, cats and dogs are the predominant contributors of fecal coliform in the watershed and were the only pets considered in this analysis. Cat and dog populations were derived from American Veterinary Medical Association Center for Information Management demographics in 1997. Dog waste load was reported by Weiskel et al. (1996), while cat waste load was measured. Fecal coliform density for dogs and cats was measured from samples collected throughout Virginia by MapTech. A summary of the data collected is given in Table 3.5. Table 3.6 lists the domestic animal populations for impairments in the Appomattox River watershed.

Table 3.5 Domestic animal population density, waste load, and fecal coliform density.

Type	Population Density (an/house)	Waste load (g/an-day)	FC Density (cfu/g)
Dog	0.534	450	480,000
Cat	0.598	19.4	9

Table 3.6 Domestic animal populations in areas contributing to impaired segments in the Appomattox River watershed.

Impaired Segment	Dogs	Cats
Spring Creek	217	243
Briery Creek	652	730
Bush River (1)	1,186	1,328
Little Sandy Creek	39	44
Bush River (2)	1,497	1,676
Saylers Creek	256	286
Angola Creek (1)	49	55
Angola Creek (2)	79	89
Horsepen Creek	42	47
Nibbs Creek	356	399
Flat Creek	1,245	1,394
Appomattox River (1)	9,848	11,028
West Creek	325	364
Deep Creek	2,145	2402
Appomattox River (2)	19,469	21,802
Swift Creek (1)	528	591
Swift Creek (2)	10,933	12,243
Swift Creek (3)	13,921	15,590
Appomattox River (3)	47,624	53,332

3.2.4 Livestock

The predominant types of livestock in the Appomattox River watershed are beef cattle and poultry although all types of livestock identified were considered in modeling the watershed. Animal populations were based on communication with Virginia Cooperative Extension Service (VCE), Natural Resources Conservation Service (NRCS), Peter Francisco Soil and Water Conservation District (PFSWCD), James River Soil and Water District (JRSWCD), watershed visits, and verbal communication with farmers. Table 3.7 gives a summary of livestock populations in the Appomattox River watershed. Values of fecal coliform density of livestock sources were based on sampling performed by MapTech. Reported manure production rates for livestock were taken from ASAE, 1998. A summary of fecal coliform density values and manure production rates is presented in Table 3.8.

Table 3.7 Livestock populations in areas contributing to impaired segments in the Appomattox River watershed.

Impaired Segment	Dairy	Beef	Horses	Swine	Broilers	Layers	Goats
Spring Creek	0	1,200	29	0	0	14,000	0
Briery Creek	0	870	20	0	0	0	0
Bush River (1)	250	1,640	46	1,800	144,000	0	0
Little Sandy Creek	745	520	9	1,800	168,000	0	0
Bush River (2)	995	2,950	77	3,600	408,000	0	0
Saylers Creek	150	1,430	20	0	0	0	0
Angola Creek (1)	0	960	8	0	198,000	29,000	15
Angola Creek (2)	200	1,550	15	0	198,000	29,000	15
Horsepen Creek	100	0	3	0	0	20,000	0
Nibbs Creek	700	400	17	0	192,000	0	0
Flat Creek	1,670	1,650	81	0	1,872,000	140,000	0
Appomattox River (1)	5,815	24,625	1,036	3,650	4,018,000	437,500	15
West Creek	300	600	17	0	48,000	0	150
Deep Creek	1,200	5,780	102	0	768,000	50,000	450
Appomattox River (2)	8,915	32,615	1,289	3,650	4,858,000	487,500	465
Swift Creek (1)	0	100	29	0	0	0	0
Swift Creek (2)	0	320	102	0	0	0	0
Swift Creek (3)	0	650	194	0	0	0	0
Appomattox River (3)	8,915	33,265	1,565	3,650	4,858,000	487,500	465

Table 3.8 Average fecal coliform densities and waste loads associated with livestock.

Type	Waste Load (lb/d/an)	Fecal Coliform Density (cfu/g)
Dairy (1,400 lb)	120.4	271,000
Beef (800 lb)	46.4	101,000
Horse (1,000 lb)	51.0	94,000
Swine (135 lb)	11.3	400,000
Swine Lagoon	N/A	95,300[1]
Sheep (60 lb)	2.4	43,000
Goat (140 lb)	5.7	15,000
Dairy Separator	N/A	32,000[1]
Dairy Storage Pit	N/A	44,600[1]
Poultry		
Broiler	0.17	586,000
Layer	0.26	586,000

[1]units are cfu/100ml

Fecal coliform produced by livestock can enter surface waters through four pathways. First, waste produced by animals in confinement is typically collected, stored, and applied to the landscape (*e.g*. pasture and cropland), where it is available for wash-off during a runoff-producing rainfall event. Second, grazing livestock deposit manure directly on the land, where it is available for wash-off during a runoff-producing rainfall event. Third, livestock with access to streams occasionally deposit manure directly in streams. Fourth, some animal confinement facilities have drainage systems that divert wash-water and waste directly to drainage ways or streams.

Poultry is one of the major livestock commodities in the Appomattox River watershed and poultry litter is the primary source of land-applied livestock waste. Other livestock operations within the watershed include two swine farms with total confinement in which waste is stored in lagoons and typically spread on pastureland. There are also seven beef feedlots and 26 dairy operations, from which one hundred percent of waste is collected and spread on pasture and cropland. Time in confinement and estimates of the timing of applications throughout the year were based on data reported by PFSWCD, NRCS, VADCR, and VCE (Tables 3.9 - 3.11).

Table 3.9 Average percentage of collected livestock waste applied throughout year.

Month	Applied % of Total				Land use
	Dairy	*Beef*	*Swine*	*Poultry*	
January	1.50	8.33	0.00	0.00	Cropland
February	1.75	8.33	0.00	5.00	Cropland
March	17.00	8.34	20.00	25.00	Cropland
April	17.00	8.34	20.00	20.00	Cropland
May	17.00	8.33	20.00	5.00	Cropland
June	1.75	8.33	0.00	5.00	Pasture
July	1.75	8.33	0.00	5.00	Pasture
August	1.75	8.33	0.00	5.00	Pasture
September	5.00	8.34	0.00	10.00	Cropland
October	17.00	8.34	20.00	10.00	Cropland
November	17.00	8.33	20.00	10.00	Cropland
December	1.50	8.33	0.00	0.00	Cropland

Table 3.10 Average time dairy milking cows spend in different areas per day.

Month	Pasture (hr)	Stream Access (hr)	Loafing Lot (hr)
January	2.4	0.5	21.1
February	2.4	0.5	21.1
March	3.5	0.8	19.7
April	5.5	1.2	17.3
May	6.4	1.4	16.2
June	6.9	1.5	15.6
July	7.6	1.6	14.8
August	7.6	1.6	14.8
September	7.7	1.5	14.8
October	7.3	1.3	15.4
November	6.4	1.1	16.5
December	4.7	0.8	18.5

All livestock were expected to deposit some portion of waste on land areas. The percentage of time spent on pasture for dairy and beef cattle was reported by the PFSWCD, NRCS, VADCR, and VCE (Tables 3.10 through 3.12). Horses, sheep, donkeys, and goats were assumed to be in pasture 100% of the time.

Based on discussions with PFSWCD, VCE, and NRCS, it was concluded that beef and dairy cattle were expected to make a significant contribution through direct deposition to streams. The average amount of time spent by dairy and beef cattle in stream access areas

(*i.e.*, within 50 feet of the stream) for each month is given in Tables 3.10 through Table 3.12.

Table 3.11 Average time dry cows and replacement heifers spend in different areas per day.

Month	Pasture (hr)	Stream Access (hr)	Loafing Lot (hr)
January	23.3	0.7	0
February	23.3	0.7	0
March	22.6	1.4	0
April	21.8	2.2	0
May	21.8	2.2	0
June	21.1	2.9	0
July	21.1	2.9	0
August	21.1	2.9	0
September	21.8	2.2	0
October	22.6	1.4	0
November	22.6	1.4	0
December	23.3	0.7	0

Table 3.12 Average time beef cows not confined in feedlots spend in pasture and stream access areas per day.

Month	Pasture (hr)	Stream Access (hr)
January	23.3	0.7
February	23.3	0.7
March	23.0	1.0
April	22.6	1.4
May	22.6	1.4
June	22.3	1.7
July	22.3	1.7
August	22.3	1.7
September	22.6	1.4
October	23.0	1.0
November	23.0	1.0
December	23.3	0.7

3.2.5 Wildlife

The predominant wildlife species in the watershed were determined through consultation with wildlife biologists from the Virginia Department of Game and Inland Fisheries (VDGIF), citizens from the watershed, source sampling, and site visits. Population densities were provided by VDGIF and are listed in Table 3.13 (Bidrowski, 2003; Castanzo, 2003; Farrar, 2003; Knox, 2003; Norman and Lafon, 2002; and Rose and Cranford, 1987). The numbers of animals estimated to be in the Appomattox River

watershed are reported in Table 3.14. Habitat and seasonal food preferences were determined based on information obtained from The Fire Effects Information System (1999) and VDGIF (Costanzo, 2003; Norman, 2003; Rose and Cranford, 1987; and VDGIF, 1999). Waste loads were comprised from literature values and discussion with VDGIF personnel (ASAE, 1998; Bidrowski, 2003; Costanzo, 2003; Weiskel et al., 1996, and Yagow, 1999). Table 3.15 summarizes the habitat and fecal production information that was obtained. Where available, fecal coliform densities were based on sampling of wildlife waste performed by MapTech. The only value that was not obtained from MapTech sampling in the watershed was for beaver. The fecal coliform density of beaver waste was taken from sampling done for the Mountain Run TMDL development (Yagow, 1999). Percentage of waste directly deposited to streams was based on habitat information and location of feces during source sampling. Percentage of time spent in stream access areas and percentage of waste directly deposited to streams was based on habitat information and location of feces during source sampling. Fecal coliform densities and estimated percentages of time spent in stream access areas (*i.e.*, within 100 feet of stream) are reported in Table 3.16.

Table 3.13 Wildlife population density.

County	Deer (an/ac of habitat)	Turkey (an/ac of forest)	Goose (an/ac)	Duck (an/ac)	Muskrat (an/ac of habitat)	Raccoon (an/ac of habitat)	Beaver (an/mi of stream)
Amelia	0.039	0.015	0.006	0.003	2.75	0.0703	3.8
Appomattox	0.025	0.010	0.006	0.003	2.75	0.0703	3.8
Buckingham	0.026	0.006	0.006	0.003	2.75	0.0703	3.8
Chesterfield	0.025	0.007	0.014	0.012	2.75	0.0703	3.8
Colonial Heights	0.000	0.000	0.014	0.012	2.75	0.0703	3.8
Cumberland	0.042	0.013	0.006	0.003	2.75	0.0703	3.8
Dinwiddie	0.020	0.010	0.014	0.012	2.75	0.0703	3.8
Hopewell	0.000	0.000	0.014	0.012	2.75	0.0703	3.8
Nottoway	0.030	0.009	0.006	0.003	2.75	0.0703	3.8
Petersburg	0.000	0.000	0.014	0.012	2.75	0.0703	3.8
Powhatan	0.044	0.011	0.006	0.003	2.75	0.0703	3.8
Prince Edward	0.030	0.012	0.006	0.003	2.75	0.0703	3.8
Prince George	0.036	0.002	0.014	0.012	2.75	0.0703	3.8

Table 3.14 Wildlife populations in the Appomattox River watershed.

Impairment	Deer	Turkey	Goose	Duck	Muskrat	Raccoon	Beaver
Spring Creek	610	177	127	63	1,239	253	68
Briery Creek	778	266	165	83	1,604	370	113
Bush River (1)	2,089	730	434	217	4,225	993	291
Little Sandy Creek	226	69	46	23	404	99	28
Bush River (2)	2,911	987	604	302	6,067	1,417	411
Saylers Creek	475	130	93	46	827	198	54
Angola Creek (1)	205	42	30	15	311	69	20
Angola Creek (2)	398	82	59	30	751	147	38
Horsepen Creek	107	26	15	8	123	31	8
Nibbs Creek	623	139	99	50	1,132	242	63
Flat Creek	3,240	858	545	272	6,466	1,349	361
Appomattox River (1)	19,358	5,396	3,825	2,043	36,070	8,577	2,352
West Creek	1,074	292	186	93	3,009	536	135
Deep Creek	3,650	905	707	354	8,998	1,826	474
Appomattox River (2)	26,893	7,505	6,211	3,710	54,679	12,344	3,321
Swift Creek (1)	457	101	154	119	1,481	213	57
Swift Creek (2)	1,655	402	910	767	4,310	860	306
Swift Creek (3)	2,570	623	1,464	1,242	6,542	1,437	421
Appomattox River (3)	30,078	8,238	8,272	5,463	69,271	14,531	5,849

Table 3.15 Wildlife fecal production rates and habitat.

Animal	Waste Load (g/an-day)	Habitat
Raccoon	450	Primary = region within 600 ft of continuous streams Infrequent = region between 601 and 7,920 ft from continuous streams
Muskrat	100	Primary = region within 66 ft from continuous streams Less frequent = region between 67 and 308 ft
Beaver[1]	200	Continuous stream below 500 ft elevation (defined as distance in feet)
Deer	772	Primary = forested, harvested forest land, orchards, grazed woodland, open urban, cropland, pasture Infrequent = low density residential, medium density residential Seldom/None = rest of land use codes
Turkey[2]	320	Primary = forested, harvested forest land, grazed woodland Infrequent = open urban, orchards, cropland, pasture Seldom/None = Rest of land use codes
Goose[3]	225	Primary = region within 0-66 ft from ponds and continuous streams Infrequent = region between 67 and 308 ft from ponds and continuous streams
Mallard	150	Primary = region within 0-66 ft from ponds and continuous streams Infrequent = region between 67 and 308 ft from ponds and Continuous streams

1 Beaver waste load was calculated as twice that of muskrat, based on field observations.
2 Waste load for domestic turkey (ASAE, 1998).
3 Goose waste load was calculated as 50% greater than that of duck, based on field observations and conversation with Gary Costanzo (Costanzo, 2003).

Table 3.16 Average fecal coliform densities and percentage of time spent in stream access areas for wildlife.

Animal Type	Fecal Coliform Density (cfu/g)	Portion of Day in Stream Access Areas (%)
Raccoon	2,100,000	5
Muskrat	1,900,000	90
Beaver	1,000	100
Deer	380,000	5
Turkey	1,332	5
Goose	250,000	50
Duck	3,500	75

4. MODELING PROCEDURE: LINKING THE SOURCES TO THE ENDPOINT

Establishing the relationship between instream water quality and the source loadings is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired water quality endpoint. In the development of a TMDL for the Appomattox River watershed, the relationship was defined through computer modeling based on data collected throughout the watershed. Monitored flow and water quality data were then used to verify that the relationships developed through modeling were accurate. There are five basic steps in the development and use of a water quality model: model selection, source assessment, selection of a representative modeling period, model calibration, model validation and model implementation.

Model selection involves identifying an approved model that is capable of simulating the pollutants of interest with the available data. Source assessment involves identifying and quantifying the potential sources of pollutants in the watershed. Selection of a representative period involves the identification of a time period that accounts for critical conditions associated with all potential sources within the watershed. Calibration is the process of comparing modeled data to observed data and making appropriate adjustments to model parameters to minimize the error between observed and simulated events. Validation is the process of comparing modeled data to observed data during a period other than that used for calibration, with the intent assessing the capability of the model in hydrologic conditions other than those used during calibration. During validation, no adjustments are made to model parameters. Once a suitable model is constructed, the model is then implemented to predict the effects of current loadings and potential management practices on water quality. In this section, the selection of modeling tools, source assessment, selection of a representative period, calibration/validation, and model application are discussed.

4.1 Modeling Framework Selection

The USGS Hydrologic Simulation Program - Fortran (HSPF) water quality model was selected as the modeling framework to simulate existing conditions and to perform

TMDL allocations. The HSPF model is a continuous simulation model that can account for NPS pollutants in runoff, as well as pollutants entering the flow channel from point sources. In establishing the existing and allocation conditions, seasonal variations in hydrology, climatic conditions, and watershed activities were explicitly accounted for in the model. The use of HSPF allowed consideration of seasonal aspects of precipitation patterns within the watershed.

The HSPF model simulates a watershed by dividing it up into a network of stream segments (referred to in the model as RCHRES), impervious land areas (IMPLND) and pervious land areas (PERLND). Each subwatershed contains a single RCHRES, modeled as an open channel, and numerous PERLNDs and IMPLNDs, representing the various landuses in that subwatershed. Water and pollutants from the land segments in a given subwatershed flow into the RCHRES in that subwatershed. Point discharges and withdrawals of water and pollutants are simulated as flowing directly to or withdrawing from a particular RCHRES as well. Water and pollutants from a given RCHRES flow into the next downstream RCHRES. The network of RCHRESs is constructed to mirror the configuration of the stream segments found in the physical world. Therefore, activities simulated in one impaired stream segment affect the water quality downstream in the model.

EPA's Water Quality Analysis Simulation Program (WASP) coupled with the its Link-Node Tidal Hydrodynamic Model (DYNHYD) was selected as the modeling framework to simulate existing conditions and to perform TMDL allocations on the tidal impairment of the Appomattox River. The documented model selection process can be seen in "Appomattox River Tidal Estuary Model Recommendation," prepared cooperatively by Virginia Tech and MapTech, Inc. and submitted in April 2003 to VADEQ.

Within DYNHYD, the tidal impairment is simulated as a series of nodes connected by links. Time-variable outflow hydrographs from HSPF serve as upstream inputs to the model nodes and NOAA-provided tide predictions for Hopewell, Virginia are the downstream boundary condition. The model solves the equation of continuity at every

node to provide instream heads and volumes. In addition, the model solves the equation of motion within each link to provide instream velocities and flow rates. These values are recorded at each simulation time step and are averaged over a longer period of time to be used by WASP for water quality calculations.

Within WASP, the tidal impairment is simulated as a series of river reaches, known as segments. Time-variable pollutant loadings and instream pollutant concentrations from HSPF function as upstream model inputs. Due to the lack of extensive observed pollutant concentrations in the James River, the downstream boundary condition was set equal to the geometric mean of all water quality samples taken in the James River during the modeling time period. At each time step, WASP solves the pollutant mass balance equation utilizing the volumes and velocities provided by the DYNHYD hydrodynamic linkage file.

4.2 Model Setup

To adequately represent the spatial variation in the watershed, the Appomattox River drainage area was divided into one hundred forty nine (149) subwatersheds (Figure 4.1). The rationale for choosing these subwatersheds was based on the availability of water quality data and the limitations of the HSPF model. The HSPF model is constrained by the number of operations that it is capable of representing and, thus, necessitated a division of the watershed model into seven distinct linked models. The output from one model was then routed into the next downstream model. Figure 4.1 shows the sub-model linkages which were used to achieve the unified model. Water quality data (*i.e.,* fecal coliform concentrations) are available at specific locations throughout the watershed. Subwatershed outlets were chosen to coincide with these monitoring stations, since output from the model can only be obtained at the modeled subwatershed outlets (Figure 4.1 and Table 4.1). In an effort to standardize modeling efforts across the state, VADEQ has required that fecal bacteria models be run at a 1-hour time-step. The HSPF model requires that the time of concentration in any subwatershed be greater than the time-step being used for the model. These modeling constraints as well as the desire to maintain a spatial distribution of watershed characteristics and associated parameters were considered in the delineation of subwatersheds. The spatial division of the watershed

allowed for a more refined representation of pollutant sources, and a more realistic description of hydrologic factors in the watershed.

For DYNHYD, the tidal impairment of the Appomattox River was divided into twenty-three nodes and twenty-nine links. The rationale for choosing the utilized configuration was based upon the location of HSPF subwatershed outlets and the limitations of the DYNHYD model. Node locations were chosen to coincide with HSPF subwatershed outlet locations when possible, since inflow hydrographs can only be input at the modeled nodes. The DYNHYD model requires that the length of any given model link be greater than the wave celerity plus channel velocity, quantity multiplied by the computational time step. Given this constraint and the desire to align model nodes with HSPF subwatershed outlets, a 30 second modeling time step was determined to be required. For a detailed explanation on model setup, see "The Dynamic Estuary Model Hydrodynamics Program, DYNHYD5, Model Documentation and User Manual" by Ambrose et al (1993).

Within WASP, the tidal Appomattox River was divided into twenty-three segments corresponding directly to the established DYNHYD nodes. The process was automated with the use of a DYNHYD to a WASP hydrodynamic linkage file, which contains segment volumes, depths, velocities, and flows at every water quality model time step. A 15 minute modeling time step was chosen in order to ensure model stability. For a detailed description on model setup see "Water Quality Analysis Simulation Program (WASP), Version 6.0, Draft: User's Manual" by Wool et al.

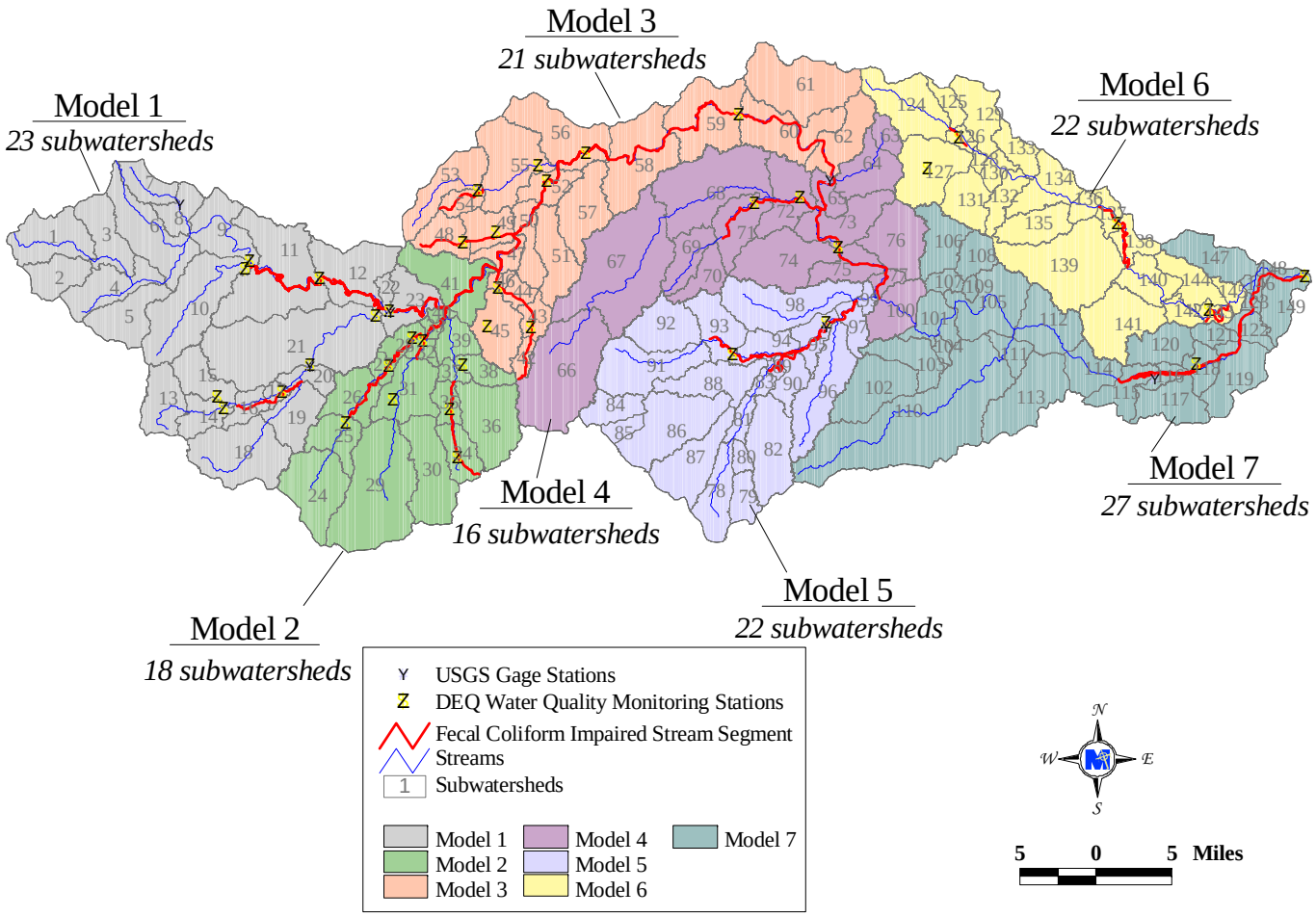

Figure 4.1 Subwatersheds delineated for modeling and location of VADEQ water quality monitoring stations and USGS Gaging Station in the Appomattox River watershed.

Table 4.1 VADEQ monitoring stations and corresponding reaches in the Appomattox River watershed.

Station Number	Reach Number	Station Number	Reach Number
2-APP127.08	9	2-SYL001.26	46
2-VNS000.31	10	2-ANG003.35	48
2-APP118.04	11	2-ANG001.27	49
2-SPA006.48	14	2-APP090.12	52
2-MUC001.49	15	2-HRP000.42	54
2-SPA001.46	17	2-BGU001.39	55
2-BFL011.03	20	2-APP085.85	56
2-BFL002.00	21	2-APP068.93	59
2-APP110.93	22	2-NBB003.65	71
2-BRI010.78	25	2-NBB001.54	71
2-BRI004.01	27	2-FLA001.95	72
2-BRI001.00	28	2-APP050.23	73
2-BSR008.08	31	2-WET004.96	93
2-BSR002.82	32	2-DPC005.20	95
2-LIT005.43	34	2-APP012.79	118
2-LIT002.40	35	2-SFT036.00	126
2-MBN000.96	38	2-HEP001.27	127
2-SYL003.91	43	2-SFT019.15	137
2-LIU002.75	45	2-SFT004.92	143
2-LIU000.70	45	2-APP001.53	149

Using aerial photographs, MRLC identified 14 landuse types in the watershed. The 14 landuse types were consolidated into 9 categories based on similarities in hydrologic and waste application/production features (Table 4.2). Within each subwatershed, up to the nine landuse types were represented. Each landuse had parameters associated with it that described the hydrology of the area (*e.g.*, average slope length) and the behavior of pollutants (*e.g.*, fecal coliform accumulation rate). Table 4.3 shows the consolidated landuse types and the area existing in each impairment. These landuse types are represented in HSPF as pervious land segments (PERLNDs) and impervious land segments (IMPLNDs). Impervious areas in the watershed are represented in three IMPLND types, while there are nine PERLND types, each with parameters describing a particular landuse (Table 4.2). Some IMPLND and PERLND parameters (*e.g.*, slope length) vary with the particular subwatershed in which they are located. Others vary with season (*e.g.*,upper zone storage) to account for plant growth, die-off, and removal.

Table 4.2 Consolidation of MRLC landuse categories for the Appomattox River subwatersheds.

TMDL Landuse Categories	Pervious/Impervious (Percentage)	MRLC Landuse Classifications (Class No.)
Water	Impervious (100%)	Open Water (11)
Residential	Pervious (80%) Impervious (20%)	Low Intensity Residential (21) High Intensity Residential (22) Urban/Recreational Grasses (85)
Commercial and Services	Pervious (80%) Impervious (20%)	Commercial/Industrial/Transportation (23)
Barren	Pervious (100%)	Transitional (33) Quarries/Strip Mines/Gravel Pits (32)
Woodland	Pervious (100%)	Evergreen Forest (42) Deciduous Forest (41) Mixed Forest (43)
Pasture	Pervious (100%)	Pasture/Hay (81)
Cropland	Pervious (100%)	Row Crops (82)
Wetlands	Pervious (100%)	Emergent Herbaceous Wetlands (92) Woody Wetlands (91)
Livestock Access	Pervious (100%)	Pasture/Hay (81)

Table 4.3 Spatial distribution of landuse types in the Appomattox River drainage area.

Impaired Segment	Landuse								
	Water (ac)	Residential (ac)	Commercial & Services (ac)	Barren (ac)	Woodland (ac)	Pasture (ac)	Cropland (ac)	Wetlands (ac)	Livestock Access (ac)
Spring Creek	203	86	33	283	14,327	5,168	261	612	118
Briery Creek	744	407	39	271	21,257	3,498	132	1,123	80
Bush River (1)	868	540	135	736	57,390	8,287	353	3,878	139
Little Sandy Creek	17	22	24	41	5,490	1,706	56	265	27
Bush River (2)	1,024	780	243	1,031	77,351	13,832	731	5,506	216
Saylers Creek	78	18	8	126	10,322	4,087	240	541	50
Angola Creek (1)	54	1	1	26	3,072	1,557	121	145	20
Angola Creek (2)	90	17	1	188	5,969	2,931	196	480	35
Horsepen Creek	2	1	0	26	1,877	506	76	85	8
Nibbs Creek	42	116	54	220	9,083	6,240	370	328	113
Flat Creek	251	288	223	2,084	59,650	22,548	2,118	3,253	337
Appomattox River (1)	3,955	3,967	1,454	12,968	432,395	111,989	10,074	23,912	2,012
Deep Creek, UT	8	188	75	4	1,177	383	5	51	4
West Creek	120	64	41	665	21,624	6,601	651	1,141	88
Deep Creek	562	1,003	479	4,219	80,361	24,793	2,982	3,109	406
Appomattox River (2)	7,556	8,088	4,032	22,214	627,437	156,214	18,283	27,306	2,772
Swift Creek (1)	129	369	20	22	11,860	1,493	500	82	23
Swift Creek (2)	1,714	2,702	645	955	55,577	4,568	2,053	197	74
Swift Creek (3)	2,003	3,299	816	1,790	87,929	8,476	3,258	368	125
Appomattox River (3)*	10,785	17,633	7,772	26,229	737,027	168,790	23,619	29,812	2,937

*Numbers represent totals for Appomattox River Basin.

Die-off of fecal coliform can be handled implicitly or explicitly. For land-applied fecal matter (mechanically applied and deposited directly), die-off was addressed implicitly through monitoring and modeling. Samples of collected waste prior to land application (*i.e.,* dairy waste from loafing areas) were collected and analyzed by MapTech. Therefore, die-off is implicitly accounted for through the sample analysis. Die-off occurring in the field was represented implicitly through model parameters such as the maximum accumulation and the 90% wash off rate, which were adjusted during the calibration of the model. These parameters were assumed to represent not only the delivery mechanisms, but the bacteria die-off as well. Once the fecal coliform entered the stream, the general decay module of HSPF was incorporated, thereby explicitly addressing the die-off rate. The general decay module uses a first order decay function to simulate die-off.

4.3 Source Representation

Both point and nonpoint sources can be represented in the model. In general, point sources are added to the model as a time-series of pollutant and flow inputs to the stream. Land-based nonpoint sources are represented as an accumulation of pollutants on land, where some portion is available for transport in runoff. The amount of accumulation and availability for transport vary with landuse type and season. The model allows for a maximum accumulation to be specified. The maximum accumulation was adjusted seasonally to account for changes in die-off rates, which are dependent on temperature and moisture conditions. Some nonpoint sources, rather than being land-based, are represented as being deposited directly to the stream (*e.g.,* animal defecation in stream). These sources are modeled similarly to point sources, as they do not require a runoff event for delivery to the stream. These sources are primarily due to animal activity, which varies with the time of day. Direct depositions by nocturnal animals were modeled as being deposited from 6:00 PM to 6:00 AM, and direct depositions by diurnal animals were modeled as being deposited from 6:00 AM to 6:00 PM. Once in stream, die-off is represented by a first-order exponential equation.

Much of the data used to develop the model inputs for modeling water quality is time-dependent (*e.g.,* population). Depending on the timeframe of the simulation being run,

different numbers should be used. Data representing 1995 were used for the water quality calibration and validation period (1993-2003). Data representing 2003 were used for the allocation runs in order to represent current conditions. Additionally, data projected to 2008 were analyzed to assess the impact of changing populations.

4.3.1 Point Sources

There are 29 permitted point discharges in the Appomattox River drainage area. Twenty three of these facilities are permitted for fecal control, with design discharges ranging from 0.001-23 MGD (see Table 3.1). The design flow capacity was used for allocation runs. This flow rate was combined with a fecal coliform concentration of 200 cfu/100 ml, where discharges were permitted for fecal control, to ensure that compliance with state water quality standards could be met even if permitted loads were at maximum levels. For calibration and current condition runs, a lower value of fecal coliform concentration was used, based upon a regression analysis relating Total Residual Chlorine (TRC) levels and fecal coliform concentrations. Nonpoint sources of pollution that were not driven by runoff (*e.g.*, direct deposition of fecal matter to the the stream by wildlife) were modeled similarly to point sources. These sources, as well as land-based sources, are identified in the following sections.

4.3.2 Private Residential Sewage Treatment

The number of septic systems in the 149 subwatersheds modeled for the Appomattox River watershed was calculated by overlaying U.S. Census Bureau data (USCB, 1990; USCB, 2000) with the watershed to enumerate the septic systems. Each residential landuse area was assigned a number of septic systems based on census data. A total of 27,088 septic systems were estimated in the Appomattox River watershed in 1995. During allocation runs, the number of households was projected to 2003, based on current growth rates (USCB, 2000) resulting in 33,934 septic systems (Table 4.4). The number of septic systems was projected to increase to 38,213 by 2008.

Table 4.4 Estimated failing septic systems.

Impaired Segment	Septic Systems	Failing Septic Systems	Straight Pipes
Spring Creek	377	86	3
Briery Creek	823	169	8
Bush River (1)	1,719	340	22
Little Sandy Creek	67	16	1
Bush River (2)	2,250	461	27
Saylers Creek	455	97	3
Angola Creek (1)	79	15	2
Angola Creek (2)	132	24	3
Horsepen Creek	75	11	1
Nibbs Creek	508	116	8
Flat Creek	2,024	430	26
Appomattox River (1)	14,677	3,027	135
Deep Creek, UT	116	35	1
West Creek	539	125	7
Deep Creek	2,341	559	31
Appomattox River (2)	21,398	4,397	186
Swift Creek (1)	960	179	2
Swift Creek (2)	5,447	692	10
Swift Creek (3)	8,871	1,172	16
Appomattox River (3)	33,934	6,304	216

*Deep Creek, UT is a benthic impairment

4.3.2.1 Failing Septic Systems

Failing septic systems were assumed to deliver all effluent to the soil surface where it was available for wash-off during a runoff event. In accordance with estimates from Raymond B. Reneau, Jr. from Virginia Tech, a 40% failure rate for systems designed and installed prior to 1964, a 20% failure rate for systems designed and installed between 1964 and 1984, and a 5% failure rate on all systems designed and installed after 1984 was used in development of the TMDL for the Appomattox River watershed. Total septic systems in each category were calculated using U.S. Census Bureau block demographics. The applicable failure rate was multiplied by each total and summed to get the total failed septic systems per subwatershed. The fecal coliform density for septic system effluent was multiplied by the average design load for the septic systems in the subwatershed to determine the total load from each failing system. Additionally, the loads were distributed seasonally based on a survey of septic pump-out contractors to account for more frequent failures during wet months.

4.3.2.2 Uncontrolled Discharges

Uncontrolled discharges were estimated using 1990 U.S. Census Bureau block demographics. Houses listed in the Census sewage disposal category "other means" were assumed to be disposing sewage via uncontrolled discharges if located within 200 feet of a stream. Corresponding block data and subwatershed boundaries were intersected to determine an initial estimate of uncontrolled discharges in each subwatershed. A 200-foot buffer was created from the stream segments. The corresponding buffer and subwatershed areas were intersected resulting in uncontrolled discharges within 200 feet of the stream per subwatershed. Fecal coliform loads for each discharge were calculated based on the fecal density of human waste and the wasteload for the average size household in the subwatershed. The loadings from uncontrolled discharges were applied directly to the stream in the same manner that point sources are handled in the model.

4.3.2.3 Sewer System Overflows

During the model calibration/validation period, (October 1993 to July 2003) there were 84 reported sewer overflows, leading to a significant input of fecal bacteria into the watershed. It was assumed that additional occurrences of sewer overflows were likely undetected, and a procedure was determined to estimate the quantity of unreported overflows. Overflows were considered to occur during sufficiently wet periods, as based on the average rainfall over a three day period encompassing a reported overflow event. Additional three day wet periods exceeding this average value were considered to contain an unreported sewer overflow. The concentration of fecal bacteria discharged was considered to be equivalent to the concentration of septic tank effluent, and the magnitude of the discharge was estimated as the average discharge volume of reported sewer overflow events. As some biodegradation occurs in a septic system, it is felt that the estimate of concentration is conservative.

4.3.3 Livestock

Fecal coliform produced by livestock can enter surface waters through four pathways: land application of stored waste, deposition on land, direct deposition to streams, and diversion of wash-water and waste directly to streams. Each of these pathways is accounted for in the model. The number of fecal coliform directed through each pathway

was calculated by multiplying the fecal coliform density with the amount of waste expected through that pathway. Livestock numbers determined for 2003 were used for the allocation runs, while these numbers were projected back to 1995 for the calibration and validation runs. The numbers are based on data provided by VCE, NRCS, PFSWCD, and JRSWCD, as well as taking into account growth rates in Appomattox, Buckingham, Cumberland, Prince Edward, Amelia, Nottoway, Powhatan, Chesterfield, Dinwiddie and Prince George counties as determined from data reported by the Virginia Agricultural Statistics Service (VASS, 1995; VASS, 2000). Similarly, when growth was analyzed, livestock numbers were projected to 2008. For land-applied waste, the fecal coliform density measured from stored waste was used, while the density in as-excreted manure was used to calculate the load for deposition on land and to streams (Table 3.8). The use of fecal coliform densities measured in stored manure accounts for any die-off that occurs in storage. The modeling of fecal coliform entering the stream through diversion of wash-water was accounted for by the direct deposition of fecal matter to streams by cattle.

4.3.3.1 Land Application of Collected Manure

Significant collection of livestock manure occurs on various dairy, beef, horse, and swine farms. For each farm in the drainage area, the average daily waste production per month was calculated using the number of animal units, weight of animal, and waste production rate as reported in Section 3.2.2. For dairy farms, the amount of waste collected was first based on proportion of milking cows, as the milking herd represented the only cows subject to confinement and, therefore, waste collection. Second, the total amount of waste produced in confinement was calculated based on the proportion of time spent in confinement. If beef cattle were reported as being confined for some percentage of time, the waste produced while in confinement was added to this total. Finally, values for the percentage of loafing lot waste collected, based on data provided by PFSWCD and JRSWCD, were used to calculate the amount of waste available to be spread on pasture and cropland (Table 3.9). Swine were assumed to be in confinement 100% of the time with all waste stored in a lagoon. Stored waste was spread on pastureland. It was assumed that 100% of land-applied waste is available for transport in surface runoff

transport unless the waste is incorporated in the soil by plowing during seedbed preparation. Percentage of cropland plowed and amount of waste incorporated was adjusted using calibration for the months of planting.

4.3.3.2 Deposition on Land

For cattle, the amount of waste deposited on land per day was a proportion of the total waste produced per day. The proportion was calculated based on the study entitled "Modeling Cattle Stream Access" conducted by the Biological Systems Engineering Department at Virginia Tech and MapTech, Inc. for VADCR. The proportion was based on the amount of time spent in pasture, but not in close proximity to accessible streams, and was calculated as follows:

Proportion = [(24 hr) – (time in confinement) – (time in stream access areas)]/(24 hr)

All other livestock (horse and goat) were assumed to deposit all feces on pasture. The total amount of fecal matter deposited on the pasture land-use type was area-weighted.

4.3.3.3 Direct Deposition to Streams

Beef and dairy cattle are the primary sources of direct deposition by livestock in the Appomattox River watershed. The amount of waste deposited in streams each day was a proportion of the total waste produced per day by cattle. First, the proportion of manure deposited in "stream access" areas was calculated based on the "Modeling Cattle Stream Access" study. The proportion was calculated as follows:

Proportion = (time in stream access areas)/(24 hr)

For the waste produced on the "stream access" landuse, 30% of the waste was modeled as being directly deposited in the stream and 70% remained on the land segment adjacent to the stream. The 70% remaining was treated as manure deposited on land. However, applying it in a separate land-use area (stream access) allows the model to consider the

proximity of the deposition to the stream. The 30% that was directly deposited to the stream was modeled in the same way that point sources are handled in the model.

4.3.4 Biosolids

Investigation of VDH data indicated that biosolids applications have occurred within the Appomattox River watershed. For model calibration, biosolids were modeled at the average reported load and average fecal coliform density. With urban populations growing, the disposal of biosolids will take on increasing importance. Class B biosolids have been measured with 68,467 cfu/g-dry and are permitted to contain up to 1,995,262 cfu/g-dry, as compared with approximately 240 cfu/g-dry for dairy waste. During allocation runs, biosolids applications were modeled at the highest permitted loading rate (*i.e.*, 15 dry tons/ac at 1,995,262 cfu/g) applied to all acreages in the month of May each year. The total loading sensitivity analysis (see section 4.6.2, Figure 4.6) predicted a linear relationship between increased fecal coliform concentrations in land applications and concentrations in the stream, implying that a significant increase in the area of land eligible for biosolid application could potentially have a large negative impact on water quality.

4.3.5 Wildlife

For each species, a GIS habitat layer was developed based on the habitat descriptions that were obtained (Section 3.2.4). An example of one of these layers is shown in Figure 4.2. This layer was overlaid with the landuse layer and the resulting area was calculated for each landuse in each subwatershed. The number of animals per land segment was determined by multiplying the area by the population density. Fecal coliform loads for each land segment were calculated by multiplying the wasteload, fecal coliform densities, and number of animals for each species.

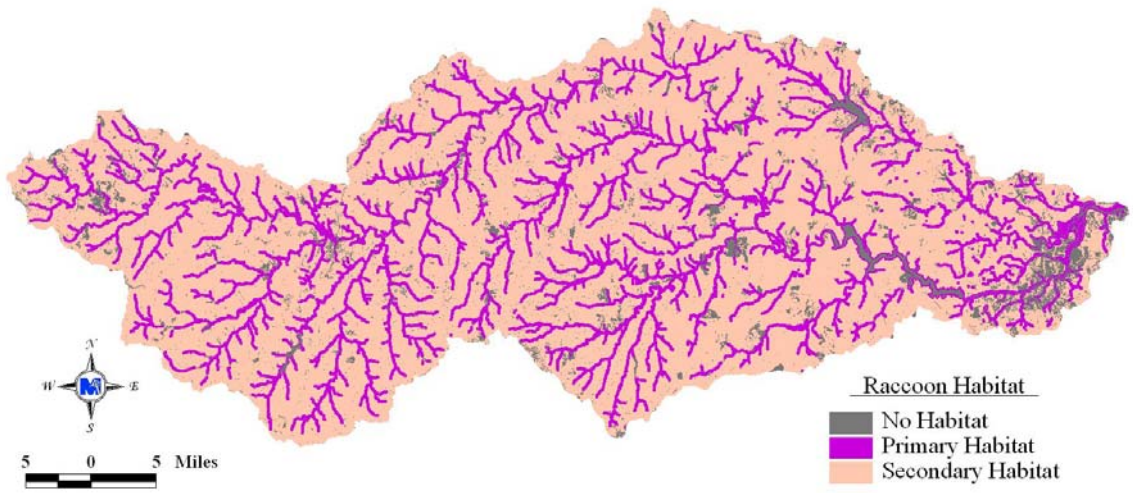

Figure 4.2 Example of raccoon habitat layer in the Appomattox River watershed, as developed by MapTech

Seasonal distribution of waste was determined using seasonal food preferences for deer and turkey. Goose and duck wasteloads were varied based on migration patterns, but the load available for delivery to the stream was never reduced below 40% of the maximum to account for the resident population of birds. No seasonal variation was assumed for the remaining species. For each species, a portion of the total wasteload was considered to be land-based, with the remaining portion being directly deposited to streams. The portion being deposited to streams was based on the amount of time spent in stream access areas (Table 3.16). It was estimated that, for all animals other than beaver, 5% of fecal matter produced while in stream access areas was directly deposited to the stream. For beaver, it was estimated that 100% of fecal matter would be directly deposited to streams. No long-term (1995–2008) adjustments were made to wildlife populations, as there was no available data to support such adjustments.

4.3.6 Pets

Cats and dogs were the only pets considered in this analysis. Population density (animals/house), wasteload, and fecal coliform density are reported in Section 3.2.3. Waste from pets was distributed on residential landuse. The location of households was

taken from the 1990 and 2000 Census (USCB, 1990, 2000). The landuse and household layers were overlaid, which resulted in number of households per landuse. The number of animals per landuse was determined by multiplying the number of households by the population density. The amount of fecal coliform deposited daily by pets in each landuse segment was calculated by multiplying the wasteload, fecal coliform density, and number of animals for both cats and dogs. The wasteload was assumed not to vary seasonally. The populations of cats and dogs were projected from 1990 data to 1995, 2003, and 2008 based on housing growth rates.

4.4 Stream Characteristics

HSPF requires that each stream reach be represented by constant characteristics (*e.g.*, stream geometry and resistance to flow). In order to determine a representative stream profile for each stream reach, cross-sections were surveyed at the subwatershed outlets. One outlet was considered the beginning of the next reach, when appropriate. In the case of a confluence, sections were surveyed above the confluence for each tributary and below the confluence on the main stream.

Most of the sections exhibited distinct flood plains with pitch and resistance to flow significantly different from that of the main channel slopes. The streambed, channel banks, and flood plains were identified. Once identified, the streambed width and slopes of channel banks and flood plains were calculated using the survey data. A representative stream profile for each surveyed cross-section was developed and consisted of a trapezoidal channel with pitch breaks at the beginning of the flood plain (Figure 4.3). With this approach, the flood plain can be represented differently from the streambed. To represent the entire reach, profile data collected at each end of the reach were averaged.

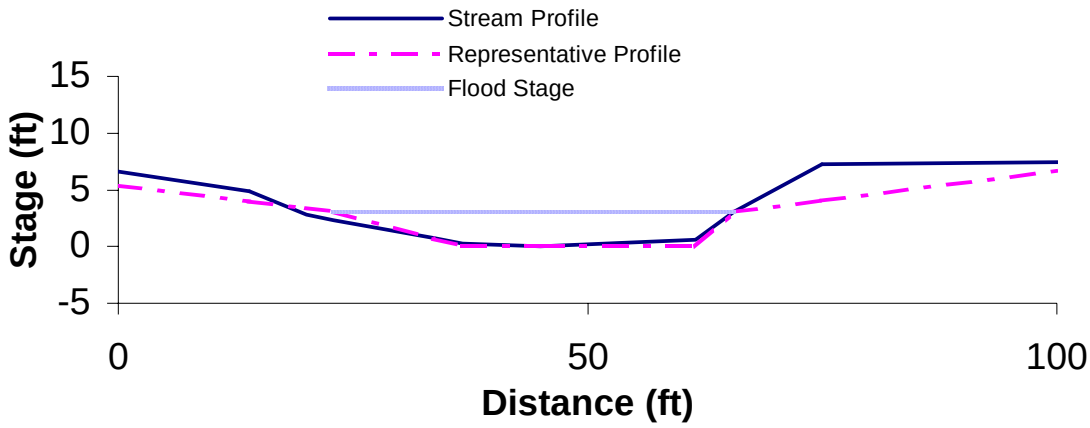

Figure 4.3 Stream profile representation in HSPF.

Conveyance was used to facilitate the calculation of discharge in the reach with different values for resistance to flow (Manning's n) assigned to the flood plains and streambeds. The conveyance was calculated for each of the two flood plains and the main channel, then added together to obtain a total conveyance. Calculation of conveyance was performed following the procedure described by Chow (1959). The total conveyance was then multiplied by the square root of the average reach slope to obtain the discharge (in ft^3/s) at a given depth.

A key parameter used in the calculation of conveyance is the Manning's roughness coefficient, n. There are many ways to estimate this parameter for a section. The method first introduced by Cowan (1956) and adopted by the Soil Conservation Service (1963) was used to estimate Manning's n. This procedure involves a 6-step process of evaluating the properties of the reach, explained in more detail by Chow (1959). Field data describing the channel bed, bank stability, vegetation, obstructions, and other pertinent parameters were collected. Photographs were also taken of the sections while in the field. Once the field data were collected, they were used to estimate the Manning's roughness for the section observed. The pictures were compared to pictures contained in Chow (1959) for validation of the estimates of the Manning's n for each section.

The result of the field inspections of the reach sections was a set of characteristic slopes (channel sides and field plains), bed widths, heights to flood plain, and Manning's

roughness coefficients. Average reach slope and reach length were obtained from GIS layers of the watershed, which included elevation from Digital Elevation Models (DEMs) and a stream-flow network digitized from USGS 7.5-minute quadrangle maps (scale 1:24,000). These data were used to derive the Hydraulic Function Tables (F-tables) used by the HSPF model (Table 4.5). The F-tables developed consist of four columns: depth (ft), area (ac), volume (ac-ft), and outflow (ft^3/s). The depth represents the possible range of flow, with a maximum value beyond what would be expected for the reach. The area listed is the surface area of the flow in acres. The volume corresponds to the total volume of the flow in the reach, and is reported in acre-feet. The outflow is simply the stream discharge, in cubic feet per second.

Table 4.5 Example of an "F-table" calculated for the HSPF model.

Depth (ft)	Area (ac)	Volume (ac-ft)	Outflow (ft^3/s)
0	0	0	0
0.1	0.6	1.69	0.05
0.17	10.76	4.46	24.26
0.77	10.76	10.44	241.7
7.67	11.84	82.36	11150.2
9.59	13.64	104.21	16167.77
11.99	35.37	186.7	21029.3
14.39	36.12	270.99	38599.01
246.99	108.79	16985.15	17519166
479.6	181.45	50601.57	76135368

4.5 Selection of Representative Modeling Period

Selection of the modeling period was based on two factors: availability of data (discharge and water-quality) and the need to represent critical hydrological conditions. Mean daily discharge at USGS Gaging Station 02039500 on the Appomattox River near Farmville and USGS Gaging Station 02041650 on the Appomattox River near Matoaca were available from 1971 to 2001. The modeling period was selected to include the VADEQ assessment period from July 1990 through June 2001 that led to the inclusion of the Appomattox River segments on the 1996 303(d) TMDL Priority List, the 1998 303(d) Total Maximum Daily Load Priority List and Report, and the 2002 303(d) Report on Impaired Waters. The fecal concentration data from this period were evaluated to determine the relationship between concentration and the level of flow in the stream. High concentrations of fecal coliform were recorded at all flow levels, thus it was

concluded that the critical hydrological condition included a wide range of wet and dry seasons.

In order to select a modeling period representative of the critical hydrological condition from the available data, the mean daily flow and precipitation for each season were calculated for the period 1971 through 2001. The results of this analysis are shown in Figures 4.4 and 4.5. (Appendix C contains additional figures depicting seasonal and annual flow and precipitation in the Appomattox River basin.) This resulted in 31 observations of flow and precipitation for each season. The mean and variance of these observations were calculated. Next, a candidate period was chosen based on the availability of mean discharge data closest to the fecal coliform assessment period (7/90-6/01). The representative period was chosen from this candidate period such that the mean and variance of each season in the modeled period was not significantly different from the historical data (see Table 4.6). Therefore, the period was selected as representing the hydrologic regime of the study area, accounting for critical conditions associated with all potential sources within the watershed. The resulting period for hydrologic calibration was October 1993 through September 1998. Not only did this period satisfy criteria for a representative hydrologic period and hydrologic data availability, it also coincided with the beginning of a period of intensive water quality monitoring in the Appomattox basin. For hydrologic validation, the period selected was October 1988 through September 1993. It may be noted that the calibration period precedes the validation period. The calibration period was chosen because it fell within the representative hydrological period, and also coincided with the period of intensive water quality monitoring. The validation period for hydrology was chosen based on the availability of hydrologic data.

For water quality calibration, data availability was the governing factor in the choice of calibration, validation, and allocation periods. The period containing the greatest amount of monitored data (10/1/1998 to 8/1/2003) was chosen as the calibration period, with 872 water quality data points spread over 44 stations. The period from 10/1/1993 to 9/30/1998 was chosen as the validation period, as it had the second highest amount of

water quality data available, with 555 data points over 25 water quality sampling stations. This validation period also coincided with the representative hydrological period and, therefore, was chosen as the allocation period to insure that the critical conditions in the watershed were being simulated during water quality allocations.

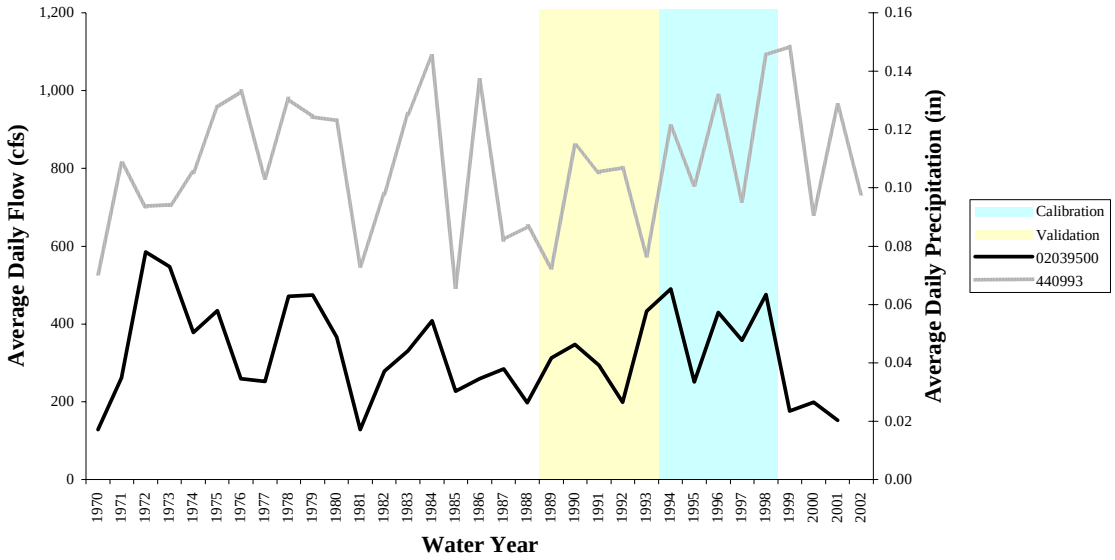

Figure 4.4 Annual Historical Flow (USGS Station 02039500) and Precipitation (Station 440993) Data

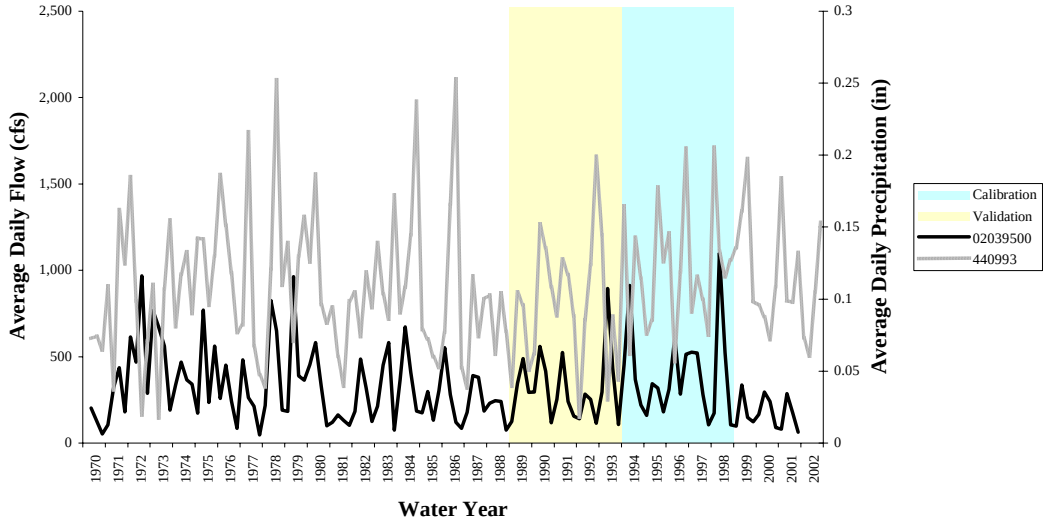

Figure 4.5 Seasonal Historical Flow (USGS Station 020395000) and Precipitation (Station 440993) Data

Table 4.6 Comparison of modeled period to historical records.

	Mean Flow (cfs) USGS Station 02039500				Precipitation (in/day) Station 440993			
	Fall	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**
	Historical Record (1971-2001)				**Historical Record (1971-2001)**			
Mean	280.15	500.01	344.25	179.8	0.1078	0.1017	0.1159	0.1100
Variance	29,059	59,145	32,625	16,000	0.0022	0.0021	0.0026	0.0023
	Calibration & Validation Period (10/93-9/98, 10/88-9/93)							
Mean	273.56	610.03	360.96	191.68	0.1036	0.0954	0.1216	0.1139
Variance	17,963	75,460	10,157	16,543	0.0035	0.0015	0.0007	0.0023
	P-Values							
Mean	0.4502	0.1315	0.3566	0.3937	0.4182	0.3338	0.3198	0.4198
Variance	0.2280	0.2888	0.0347	0.4363	0.1604	0.3056	0.0203	0.2640

4.6 Sensitivity Analysis

Sensitivity analysis is performed to determine the model's response to changes in certain parameters. This process involves changing a single parameter a certain percentage from a baseline value while holding all other parameters constant. This process is repeated for several parameters in order to gain a complete picture of the models behavior. The information gained during sensitivity analysis can aid in model calibration, and it can also help to determine the potential effects of uncertainty in parameter estimation. Sensitivity analyses were conducted to assess the sensitivity of the model to changes in hydrologic and water quality parameters as well as to assess the impact of unknown variability in source allocation (*e.g.*, seasonal and spatial variability of waste production rates for wildlife, livestock, septic system failures, uncontrolled discharges, background loads, and point source loads). Additional analyses were performed to define the sensitivity of the modeled system to growth or technology changes that impact waste production rates.

4.6.1 Hydrology Sensitivity Analysis

The HSPF parameters adjusted for the hydrologic sensitivity analysis are presented in Table 4.7, with base values for the model runs given. The parameters were adjusted to -50%, -10%, 10%, and 50% of the base value, and the model was run for water years 1993-1998. Where an increase of 50% exceeded the maximum value for the parameter, the maximum value was used and the parameters increased over the base value was reported. The hydrologic quantities of greatest interest in a fecal coliform model are those that govern peak flows and low flows. Peak flows, being a function of runoff, are important because they are directly related to the transport of fecal coliforms from the land surface to the stream. Peak flows were most sensitive to changes in the parameters governing infiltration such as INFILT (Infiltration) and, LZSN (Lower Zone Storage), and to a lesser extent by UZSN (Upper Zone Storage), which governs surface transport, and LZETP (Lower Zone Evapotranspiration), which affects soil moisture. Low flows are important in a water quality model because they control the level of dilution during dry periods. Parameters with the greatest influence on low flows (as evidenced by their influence in the *Low Flows* and *Summer Flow Volume* statistics) were AGWRC,

BASETP, LZETP and, to a lesser extent, infiltration. The responses of these and other hydrologic outputs are reported in Table 4.8. The main hydraulic parameter in the DYNHYD model, Manning's Roughness Coefficient (Manning's n) was adjusted to -50%, -25%, -10%, 10%, 25%, and 50% of the base value. The results of this analysis indicate that changes in Manning's n are far out-weighed by the tidal input, which is a measured quantity, and the driving hydrologic force in a tidal area such as the lower Appomattox. The response of hydrologic outputs was recorded, and is shown in Appendix C.

Table 4.7 Base parameter values used to determine hydrologic model response.

Parameter	Description	Units	Base Value
LZSN	Lower Zone Nominal Storage	in	5.2 – 5.85
INFILT	Soil Infiltration Capacity	in/hr	0.035 – 0.462
AGWR	Groundwater Recession Rate	---	0.950 – 0.989
BASETP	Base Flow Evapotranspiration	---	0.062 – 0.150
INTFW	Interflow Inflow	---	1.0 – 1.2
MON-INTERCEP	Monthly Interception Storage Capacity	in	0.011 – 0.455
MON-UZSN	Monthly Upper Zone Nominal Storage	in	0.042 – 2.947
MON-MANNING	Monthly Manning's *n* for Overland Flow	---	0.011 – 0.450
MON-LZETP	Monthly Lower Zone Evapotranspiration	in	0.033 – 1.04

Table 4.8 Sensitivity analysis results for hydrologic model parameters.

Model Parameter	Parameter Change (%)	Percent Change In							
		Total Flow	High Flows	Low Flows	Winter Flow Volume	Spring Flow Volume	Summer Flow Volume	Fall Flow Volume	Total Storm Volume
AGWR	-50	6.15	40.30	-71.86	7.97	-19.39	33.49	14.49	6.84%
AGWR	-10	3.05	13.82	-39.61	7.97	-24.12	17.66	10.77	3.74%
AGWR[1]	1.5	-1.43	-6.13	53.90	-12.52	9.33	30.00	1.62	-12.45%
BASETP	-50	4.24	-3.23	42.18	-1.22	13.96	31.99	-2.57	0.66%
BASETP	-10	0.71	-0.62	7.26	-0.21	2.65	4.92	-0.52	0.41%
BASETP	10	-0.65	0.60	-6.67	0.19	-2.53	-4.21	0.47	-0.48%
BASETP	50	-2.71	2.78	-28.10	0.75	-11.38	-15.29	1.97	-2.12%
DEEPFR	-50	10.80	4.61	25.80	8.65	14.61	18.71	9.24	10.25
DEEPFR	-10	2.15	0.93	5.05	1.73	2.91	3.62	1.86	2.08
DEEPFR	10	-2.14	-0.93	-4.98	-1.73	-2.89	-3.57	-1.86	-2.09
DEEPFR	50	-10.65	-4.69	-24.16	-8.69	-14.37	-17.07	-9.31	-10.43
INFILT	-50	4.19	28.59	-32.04	8.40	-11.97	6.39	8.40	4.83
INFILT	-10	0.55	4.31	-5.50	1.36	-2.07	0.32	1.18	0.68
INFILT	10	-0.46	-3.83	5.01	-1.23	1.92	-0.04	-1.04	-0.60
INFILT	50	-1.69	-15.52	21.66	-5.18	8.36	1.86	-4.25	-2.53
INTFW	-50	-0.56	1.37	-0.10	-0.49	-0.84	-0.46	-0.52	-0.60
INTFW	-10	-0.07	0.04	0.06	-0.06	-0.11	-0.08	-0.07	-0.08
INTFW	10	0.06	0.00	-0.10	0.05	0.10	0.06	0.06	0.07
INTFW	50	0.24	0.11	-0.50	0.20	0.35	0.25	0.24	0.27
LZSN	-50	10.16	21.69	-11.18	15.16	-0.45	-11.13	16.40	10.58
LZSN	-10	1.32	2.97	-2.26	2.25	0.20	-1.69	1.39	1.44
LZSN	10	-1.08	-2.50	2.15	-1.94	-0.28	1.45	-0.84	-1.18
LZSN	50	-4.00	-9.44	9.41	-7.67	-1.75	5.25	-1.43	-4.53
MON-INTERCEP	-50	2.36	-1.39	17.47	0.15	7.00	8.42	0.87	1.87
MON-INTERCEP	-10	0.38	-0.26	2.85	0.01	1.18	1.41	0.11	0.34
MON-INTERCEP	10	-0.36	0.24	-2.70	-0.01	-1.12	-1.34	-0.08	-0.32
MON-INTERCEP	50	-1.54	1.06	-11.71	-0.01	-4.92	-5.82	-0.34	-1.37
MON-LZETP	-50	14.30	14.71	29.72	8.60%	1.51	29.05	32.34	13.68
MON-LZETP	-10	1.80	1.70	4.50	1.07	0.22	3.58	4.10	1.63
MON-LZETP	10	-1.72	-1.59	-4.48	-1.03	-0.21	-3.55	-3.87	-1.61
MON-LZETP	50	-8.07	-7.21	-21.75	-5.10	-1.20	-21.04	-15.72	-7.93
MON-MANNING	-50	0.28	1.24	-0.97	0.41	-0.15	0.49	0.31	0.30
MON-MANNING	-10	0.05	0.22	-0.16	0.07	-0.03	0.09	0.05	0.05
MON-MANNING	10	-0.04	-0.19	0.14	-0.06	0.03	-0.08	-0.04	-0.04
MON-MANNING	50	-0.18	-0.88	0.61	-0.26	0.12	-0.36	-0.19	-0.19
MON-UZSN	-50	5.16	13.34	-3.03	3.85	5.23	10.89	5.85	5.22
MON-UZSN	-10	0.79	2.04	-0.50	0.65	0.81	1.52	0.81	0.81
MON-UZSN	10	-0.72	-1.85	0.45	-0.61	-0.76	-1.31	-0.69	-0.72
MON-UZSN	50	-3.03	-7.87	2.24	-2.74	-3.53	-5.11	-2.43	-3.05

[1]Maximum value used corresponds to the maximum allowable value for the parameter.

4.6.2 Water Quality Parameter Sensitivity Analysis

For the water quality sensitivity analysis, an initial base run was performed using precipitation data from water year, 1993 through 1998, and model parameters established for 2003 conditions (see section 4.5 for a complete explanation of selected model time periods). The three HSPF parameters impacting the model's water quality response (Table 4.9) were increased and decreased by amounts that were consistent with the range of values for the parameter. FSTDEC (First Order Decay) was the parameter with the greatest influence on monthly geometric mean concentration, although MON-SQOLIM and WSQOP also showed significant potential to influence this value (Table 4.10). Graphical depictions of the results of this sensitivity analysis can be found in Appendix C.

Table 4.9 Base parameter values used to determine water quality model response.

Parameter	Description	Units	Base Value
MON-SQOLIM	Maximum FC Accumulation on Land	FC/ac	8E+6 to 1E+12
WSQOP	Wash-off Rate for FC on Land Surface	in/hr	0.3 – 2.5
FSTDEC	Instream First Order Decay Rate	1/day	0.25 to 2.20

Table 4.10 Percent Change in average monthly FC geometric mean for the years 1993-1997.

Model Parameter	Parameter Change (%)	Percent Change in Average Monthly FC Geometric Mean for the Years 1993-1997											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
FSTDEC	-50	37.28	34.83	35.06	37.45	43.33	43.61	41.99	41.97	42.72	48.00	45.77	38.14
FSTDEC	-10	5.96	5.64	5.61	5.90	6.68	6.68	6.41	6.36	6.53	7.21	6.93	6.03
FSTDEC	10	-5.42	-5.16	-5.11	-5.34	-5.99	-5.99	-5.74	-5.68	-5.84	-6.41	-6.19	-5.47
FSTDEC	50	-22.95	-21.98	-21.70	-22.48	-24.87	-24.74	-23.74	-23.41	-24.11	-26.24	-25.49	-23.08
SQOLIM	-50	-22.35	-16.21	-14.68	-9.66	-21.67	-15.44	-17.15	-5.93	-6.17	-15.69	-21.19	-19.84
SQOLIM	-25	-9.85	-7.10	-6.34	-3.92	-9.42	-7.07	-7.82	-2.64	-2.71	-6.42	-9.14	-8.57
SQOLIM	50	16.09	9.62	8.17	5.16	14.19	10.89	14.10	5.06	4.15	9.79	15.46	16.01
SQOLIM	100	31.44	18.22	13.65	8.36	24.07	19.24	25.55	9.32	7.55	17.23	26.97	29.16
WSQOP	-50	23.23	21.37	21.42	13.50	27.52	15.38	16.43	6.75	7.25	16.25	20.70	17.62
WSQOP	-10	2.84	2.78	2.78	1.73	3.50	1.94	2.10	0.81	0.86	2.14	2.66	2.14
WSQOP	10	-17.34	-17.17	-16.33	-9.61	-20.48	-9.63	-14.81	-5.14	-5.01	-15.81	-21.74	-17.26
WSQOP	50	-24.26	-24.14	-22.86	-13.66	-27.23	-14.04	-19.52	-7.05	-7.10	-20.08	-26.68	-22.18

In addition to analyzing the sensitivity of the model response to changes in water quality transport and die-off parameters, the response of the model to changes in land-based and direct loads was also analyzed. It is evident in Figure 4.6 that the model predicts a linear relationship between increased fecal coliform concentrations in both land and direct applications, and total load reaching the stream. The magnitude of this relationship differs greatly between land applied and direct loadings, however, as a 100% increase in the land applied loads results in an increase of over 90% in stream loads, while a 100% increase in direct loads results in less than a 10% increase in stream loads. The sensitivity analysis of geometric mean concentrations showed that direct loads had the greatest impact, with land applied loads having a lesser, but still significant impact. A graphical analysis depicting the impacts of land-based and direct load changes on the maximum monthly geometric mean can be found in Appendix C.

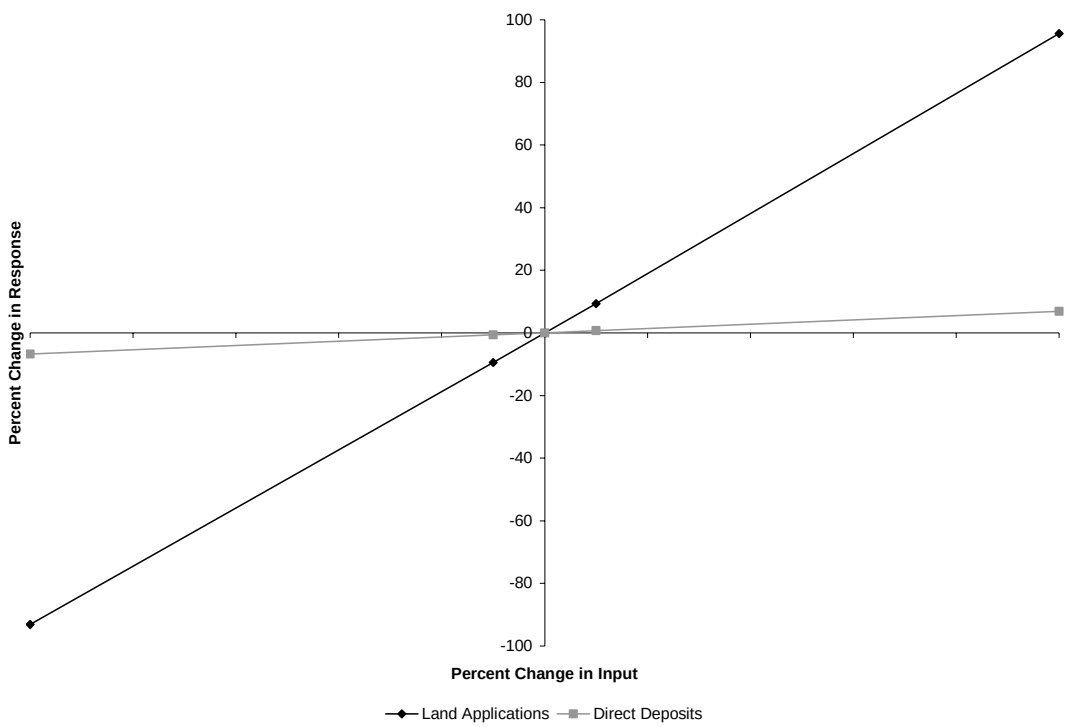

Figure 4.6 Results of total loading sensitivity analysis for the Appomattox River watershed.

4.7 Model Calibration and Validation Processes

Calibration and validation are performed in order to ensure that the model accurately represents the hydrologic and water quality processes in the watershed. The model's hydrologic parameters were set based on available soils, landuse, and topographic data. Qualities of fecal coliform sources were modeled as described in chapters 3 and 4. Through calibration, these parameters were adjusted within appropriate ranges until the model performance was deemed acceptable.

4.7.1 Hydrologic Calibration and Validation

Parameters that were adjusted during the hydrologic calibration represented: the amount of evapotranspiration from the root zone (LZETP), the recession rates for groundwater (AGWRC) and interflow (IRC), the length of overland flow (LSUR), the amount of soil moisture storage in the upper zone (UZSN) and lower zone (LZSN), the amount of interception storage (CEPSC), the infiltration capacity (INFILT), the amount of soil water contributing to interflow (INTFW), deep groundwater inflow fraction (DEEPER), baseflow PET (BASETP), forest coverage (FOREST), slope of overland flow plane (LSUR), groundwater recession flow (KVARY), maximum and minimum air temperature affecting PET (PETMAX, PETMIN, respectively), infiltration equation exponent (INFEXP), infiltration capacity ratio (INFILD), active groundwater storage PET (AGWETP), Manning's n for overland flow plane (NSUR), interception (RETSC), and the weighting factor for hydraulic routing (KS). Table 4.11 contains the typical range for the above parameters along with the initial estimate and final calibrated value. State variables in the PERLND water (PWAT) section of the User's Control Input (UCI) file were adjusted to reflect initial conditions.

NCDC weather stations Amelia (440187), Appomattox (440243), Buckingham (441136), Camp Pickett (441322), Charlotte Court House (1585), Farmville (442941), Hopewell (444101), Powhatan (446906) and Winterpock (449213) were used to supply precipitation input for the HSPF model. For the entire modeling period, only daily precipitation values were available, thus daily rainfall values were interpolated to hourly values in order to provide model input on an hourly basis. This interpolation was performed in an HSPF utility called WDMUtil, and is referred to as disaggregation. In

this process, a daily rainfall total is divided up into hourly values using a representative distribution scheme. Daily values were disaggregated using two different schemes: 1) a station matching disaggregation scheme and 2) a triangular disaggregation scheme. The station matching procedure involved identifying a rain gage reporting hourly data in close proximity to the Appomattox watershed whose daily total precipitation was within 5% of the total daily precipitation value of a station within the Appomattox River watershed. In this case, the distribution of rainfall at the station within the watershed was disaggregated based on the precipitation pattern reported at the hourly station. When this condition failed, the precipitation was disaggregated based on a triangular distribution, over an 8-hour period.

Table 4.11 Model parameters utilized for hydrologic calibration.

Parameter	Units	Typical Range of Parameter Value	Initial Parameter Estimate	Calibrated Parameter Value
FOREST	---	0.0 – 0.95	0.0	0.0
LZSN	in	2.0 – 15.0	14.0	5.2-5.85
INFILT	in/hr	0.001 – 0.50	0.1 – 0.3	.035 – 0.462
LSUR	ft	100 – 700	30.3 – 2816.9	30.3 - 2816.9
SLSUR	---	0.001 – 0.30	0.01 – 0.289	0.01 – 0.289
KVARY	l/in	0.0 – 5.0	0.0	0.0
AGWRC	l/day	0.85 – 0.999	0.98	0.950 – 0.989
PETMAX	degF	32.0 – 48.0	40.0	40.0
PETMIN	degF	30.0 – 40.0	35.0	35.0
INFEXP	---	1.0 – 3.0	2.0	2.0
INFILD	---	1.0 – 3.0	2.0	2.0
DEEPFR	---	0.0 – 0.50	0.0	0.1 – 0.29
BASETP	---	0.0 – 0.20	0.0	0.062 – 0.15
AGWETP	---	0.0 – 0.20	0.0	0.0 – 0.7
CEPSC	in	0.01 - 0.40	0.05 – 0.20	0.011 – 0.455
UZSN	in	0.05 – 2.0	0.65 – 1.46	0.042 – 2.947
NSUR	---	0.10 – 0.50	0.1 – 0.4	0.011 – 0.450
INTFW	---	1.0 – 10.0	0.56 – 1.69	1.0 – 1.2
IRC	l/day	0.30 – 0.85	0.50	0.3 – 0.5
LZETP	---	0.1 – 0.9	0.01 – 0.84	0.011 – 1.04
RETSC	in	0.0 – 1.0	0.1	0.1
KS	---	0.0 – 0.9	0.5	0.5

The model was calibrated for hydrologic accuracy using daily flow data from USGS Station USGS02039000 on Buffalo Creek, USGS02039500 on the Appomattox River, USGS02040000 on the Appomattox River, USGS02041000 in Deep Creek and USGS02041650 on the Appomattox River for the period October 1993 through September 1998. Table 4.12 shows a comparison of modeled versus observed hydrologic data for model reach 22, which corresponds to USGS gaging station #02039500 on Appomattox River near Farmville. Additional comparisons of modeled versus observed hydrologic data can be found in Appendix C. Figures 4.7-4.10 display comparisons of modeled versus observed data for the entire calibration period, representative single water years, and for individual storms for USGS02039500 on the Appomattox River. Figures pertaining to additional stations can be found in Appendix C.

Table 4.12 Hydrology calibration criteria and model performance for period 10/1/1993 through 9/30/1998 at gaging station USGS02039500 on Appomattox River (model segment 1, subshed 22).

Criterion	Observed	Modeled	Error
Total Instream Flow:	87.03	84.22	-3.23%
Upper 10% Flow Values:	39.78	35.12	-11.71%
Lower 50% Flow Values:	14.91	15.06	1.03%
Winter Flow Volume	37.57	36.57	-2.64%
Spring Flow Volume	19.25	18.52	-3.82%
Summer Flow Volume	12.38	10.02	-19.07%
Fall Flow Volume	17.83	19.11	7.14%
Total Storm Volume	72.46	69.99	-3.41%
Winter Storm Volume	33.96	33.05	-2.70%
Spring Storm Volume	15.62	14.96	-4.20%
Summer Storm Volume	8.72	6.46	-25.92%
Fall Storm Volume	14.16	15.53	9.63%

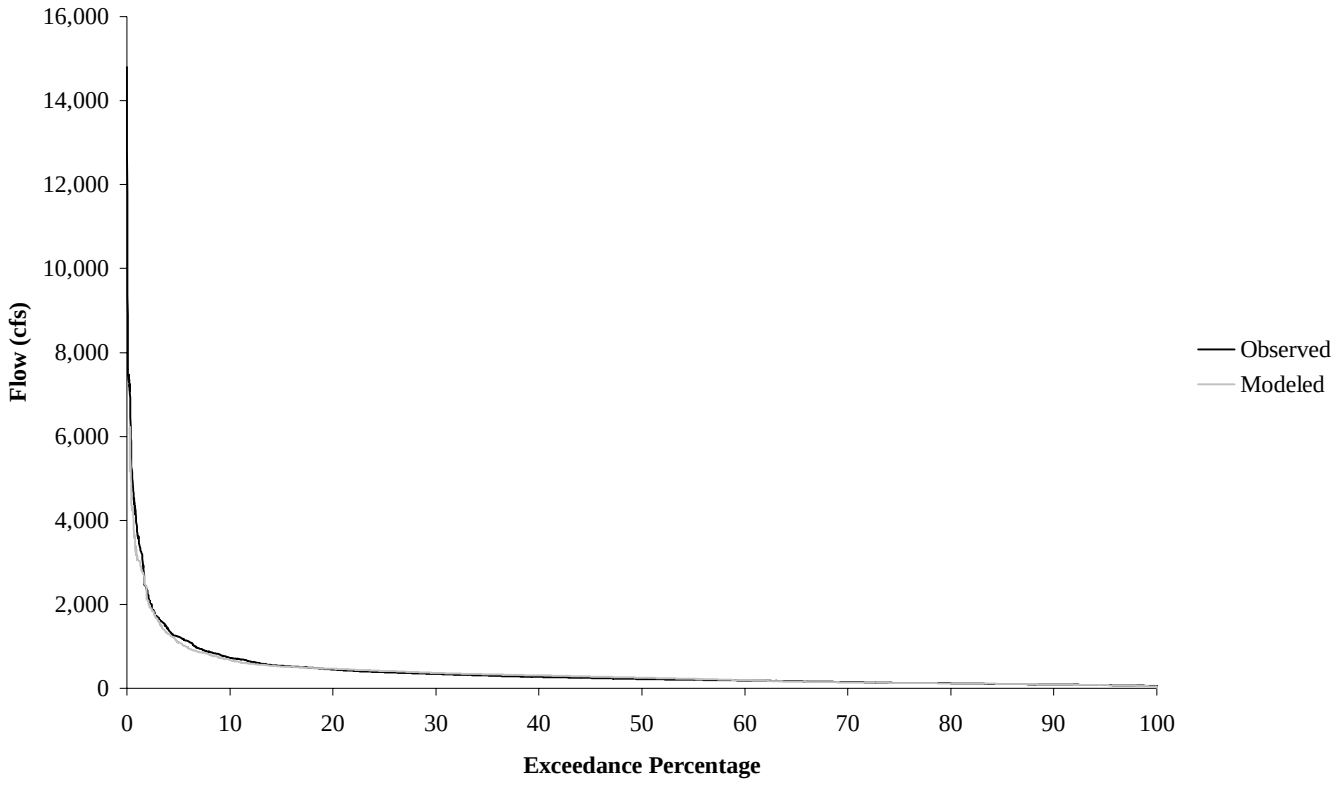

Figure 4.7 Appomattox River flow duration at gage station USGS02039500 for calibration period 10/1/1993 through 9/30/1998 (model segment 1, subshed 22).

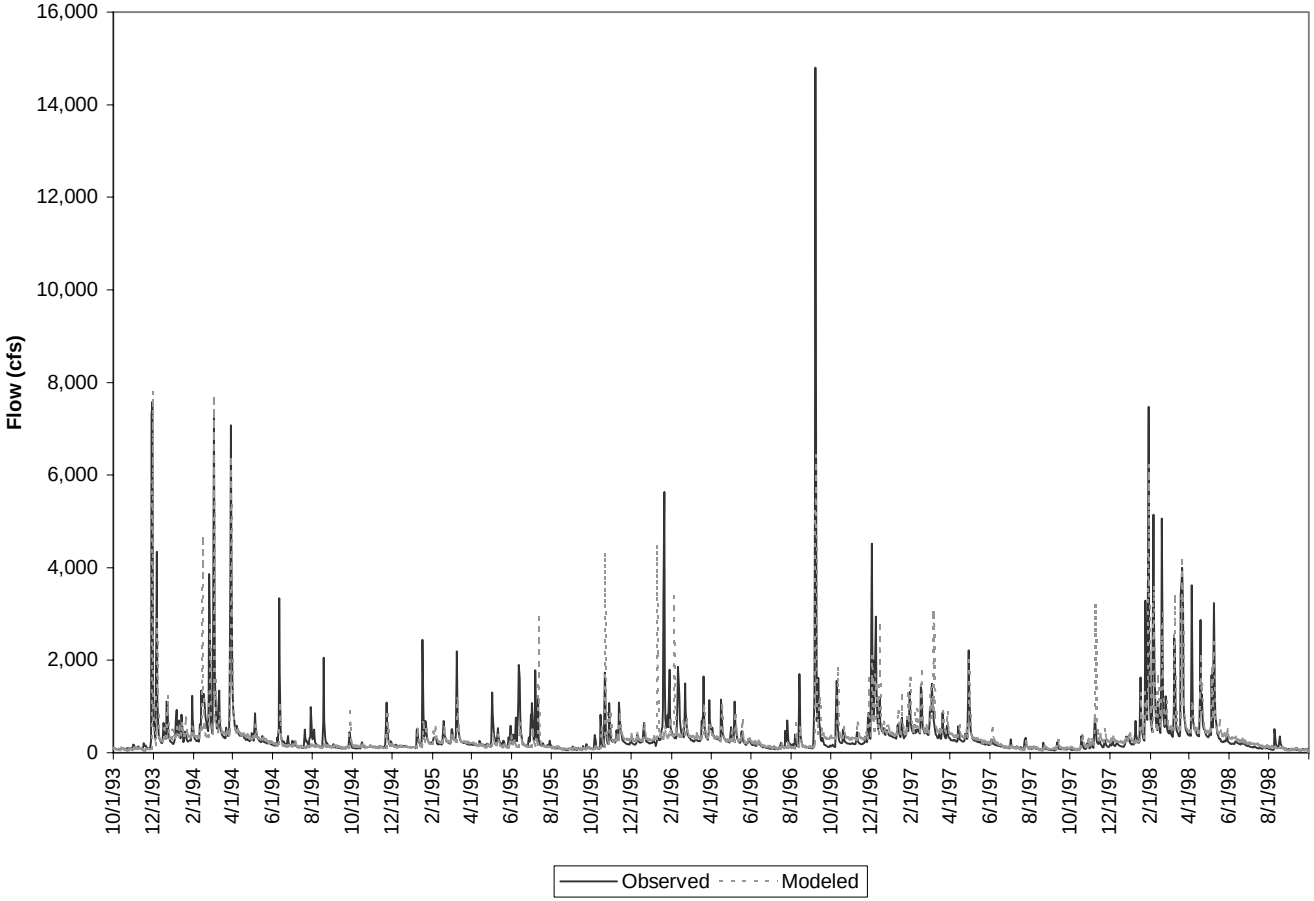

Figure 4.8 Calibration results for period 10/1/1993 through 9/30/1998 at gage station USGS02039500 on Appomattox River (model segment 1, subshed 22)

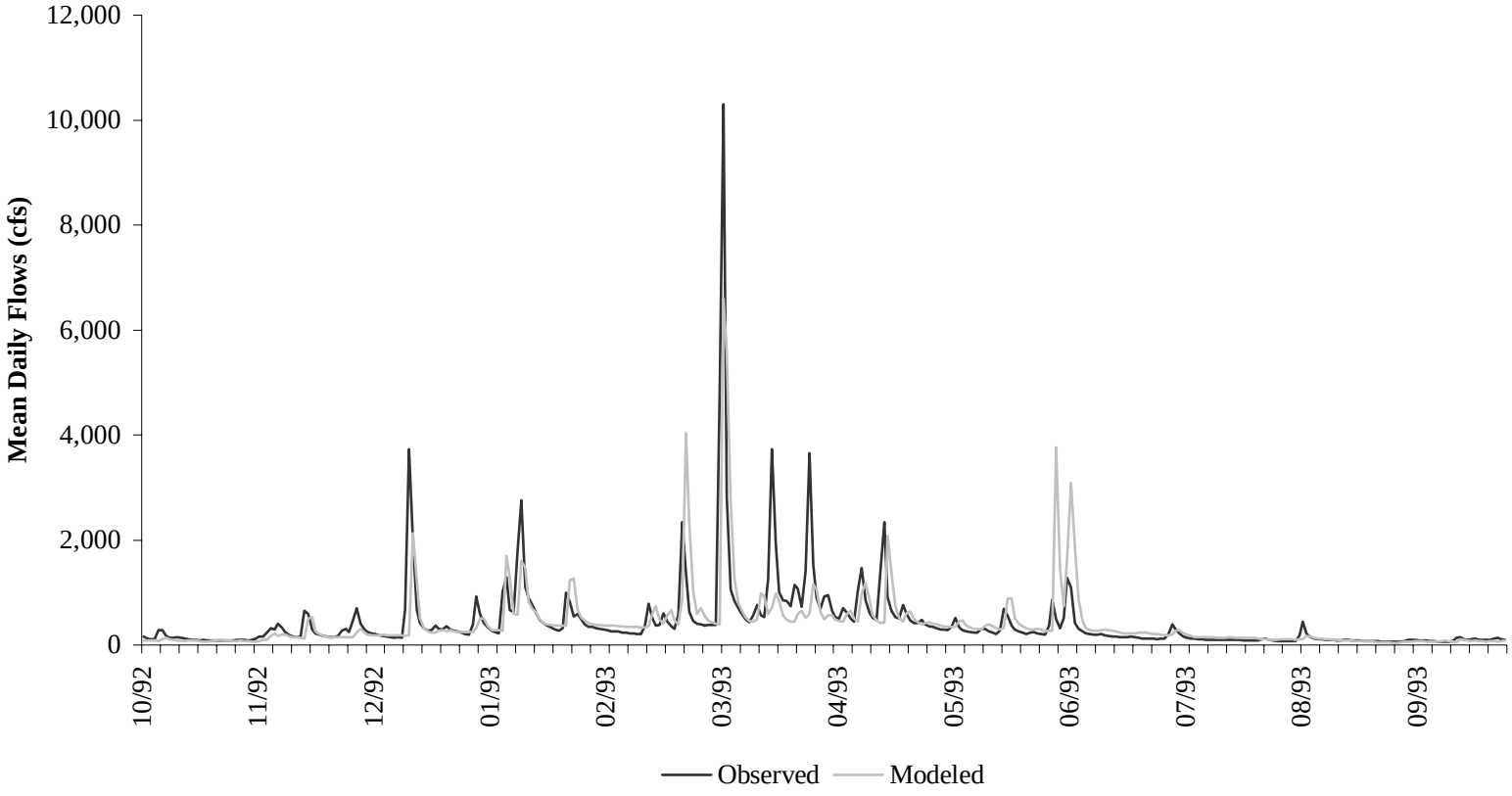

Figure 4.9 Calibration results for water year period 10/01/92 through 09/30/93 for USGS Station 02039500.

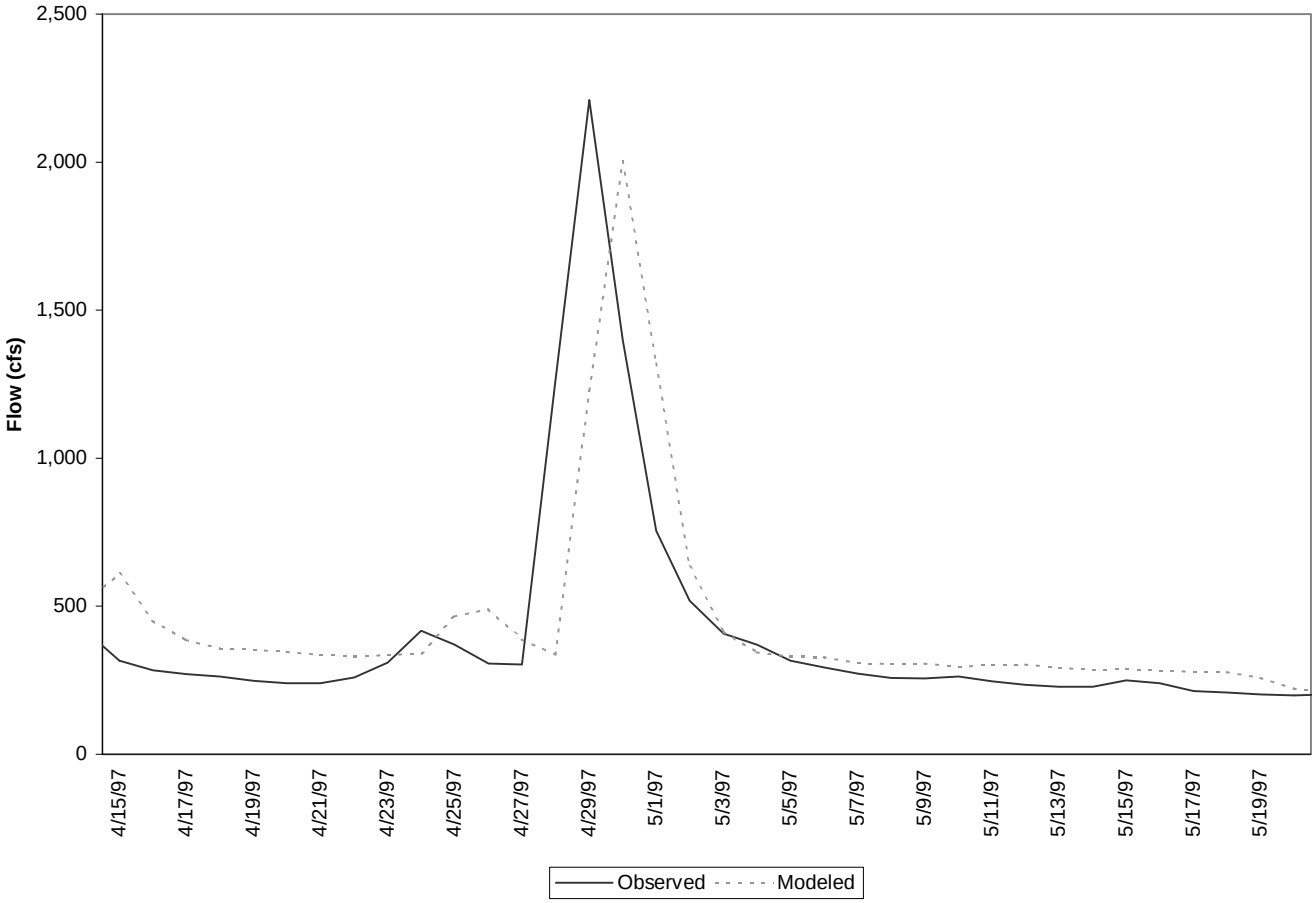

Figure 4.10 Calibration results for a single storm event at gage station USGS02039500 on Appomattox River (model segment 1, subshed 22)

The model was validated for the period October 1988 through September 1993 (Table 4.13 and Appendix C). Figures 4.11 through 4.14 display comparisons of modeled versus observed data for the entire validation period, representative single water years, and for individual storms (data for additional stations are in Appendix C).

Table 4.13 Hydrology validation criteria and model performance for period 10/1/1988 through 9/30/1993 at gaging station USGS02039500 on Appomattox River (model segment 1, subshed 22).

Criterion	Observed	Modeled	Error
Total Instream Flow:	68.84	71.26	3.52%
Upper 10% Flow Values:	28.98	27.37	-5.55%
Lower 50% Flow Values:	12.25	13.23	8.04%
Winter Flow Volume	28.05	27.62	-1.52%
Spring Flow Volume	19.94	23.25	16.61%
Summer Flow Volume	8.66	8.35	-3.68%
Fall Flow Volume	12.20	12.05	-1.19%
Total Storm Volume	55.14	61.84	12.14%
Winter Storm Volume	24.66	25.28	2.53%
Spring Storm Volume	16.52	20.89	26.46%
Summer Storm Volume	5.21	6.00	15.03%
Fall Storm Volume	8.76	9.67	10.47%

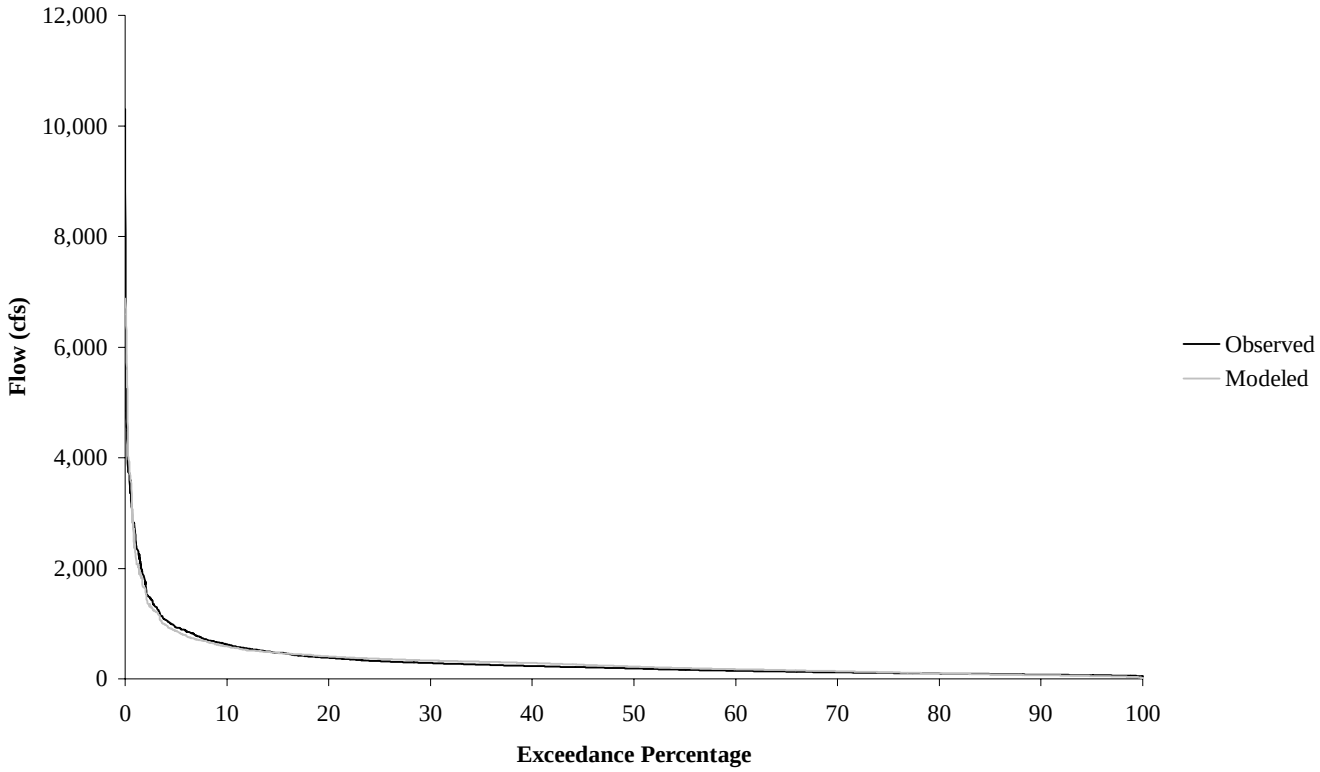

Figure 4.11 Appomattox River flow duration at gage station USGS02039500 for validation period 10/1/1988 through 9/30/1993 (model segment 1, subshed 22).

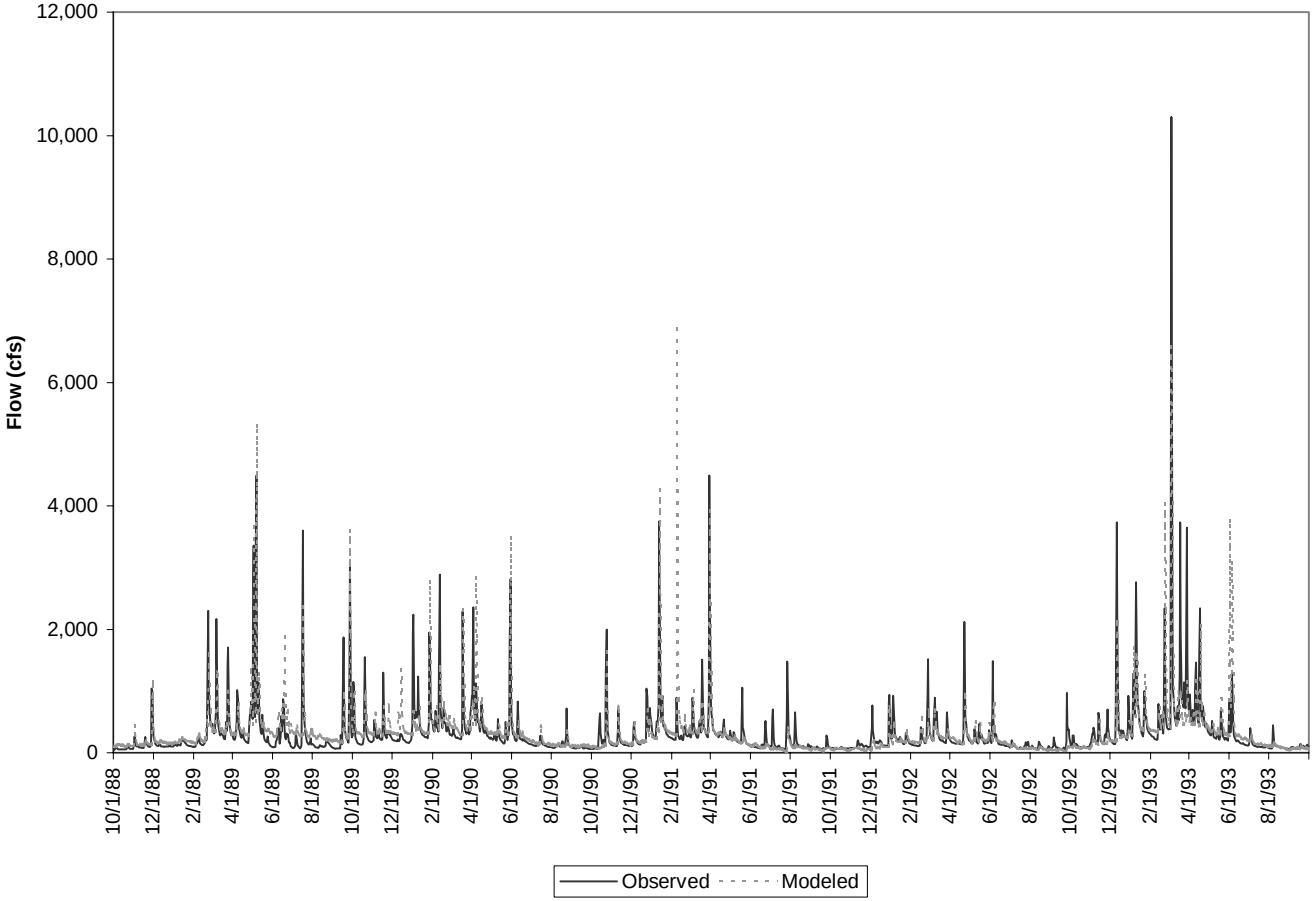

Figure 4.12 Validation results for period 10/1/1988 through 9/30/1993 at gage station USGS02039500 on Appomattox River (model segment 1, subshed 22)

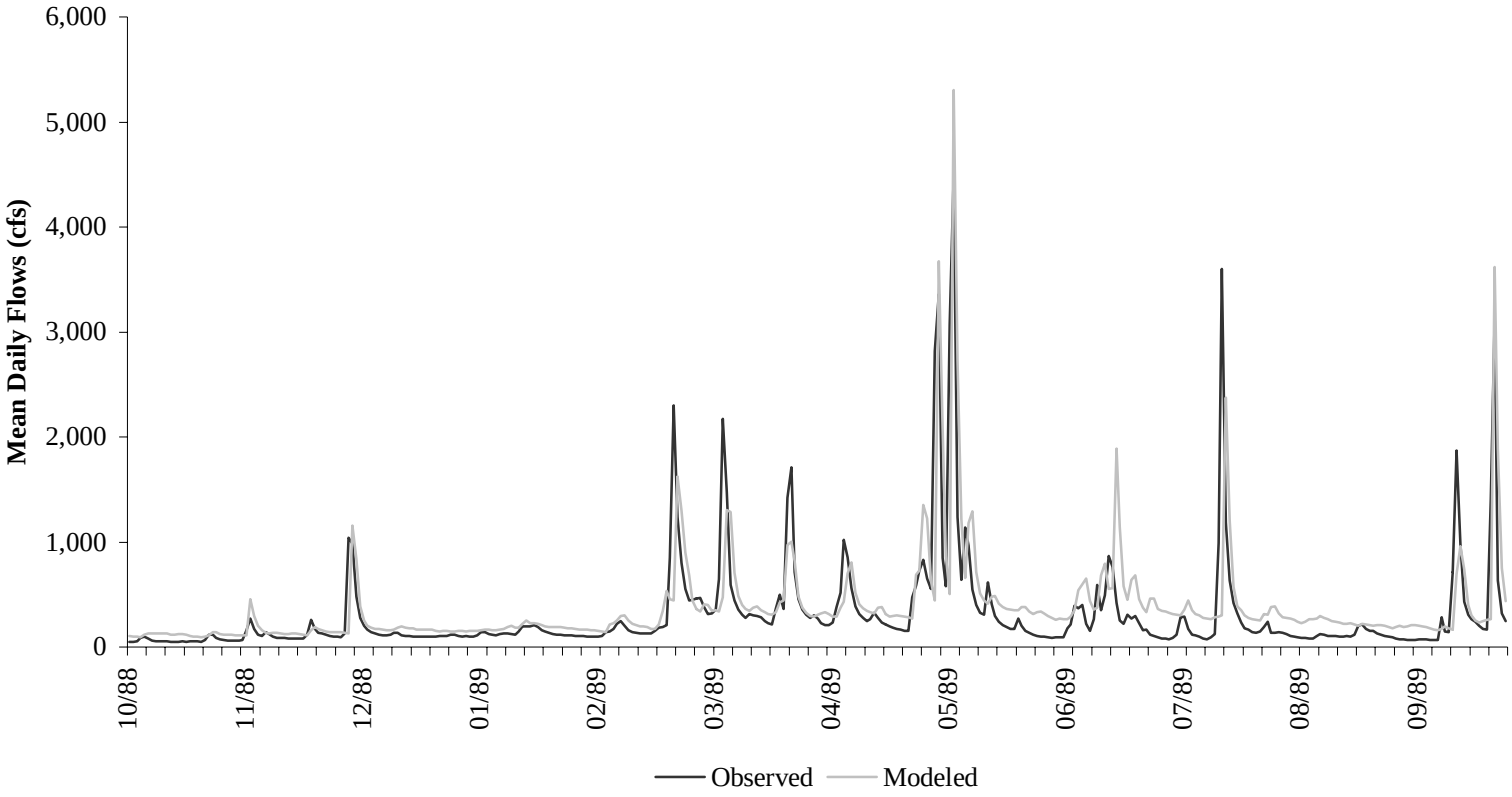

Figure 4.13 Validation results for period 10/01/88 through 09/30/89 for USGS Station 02039500.

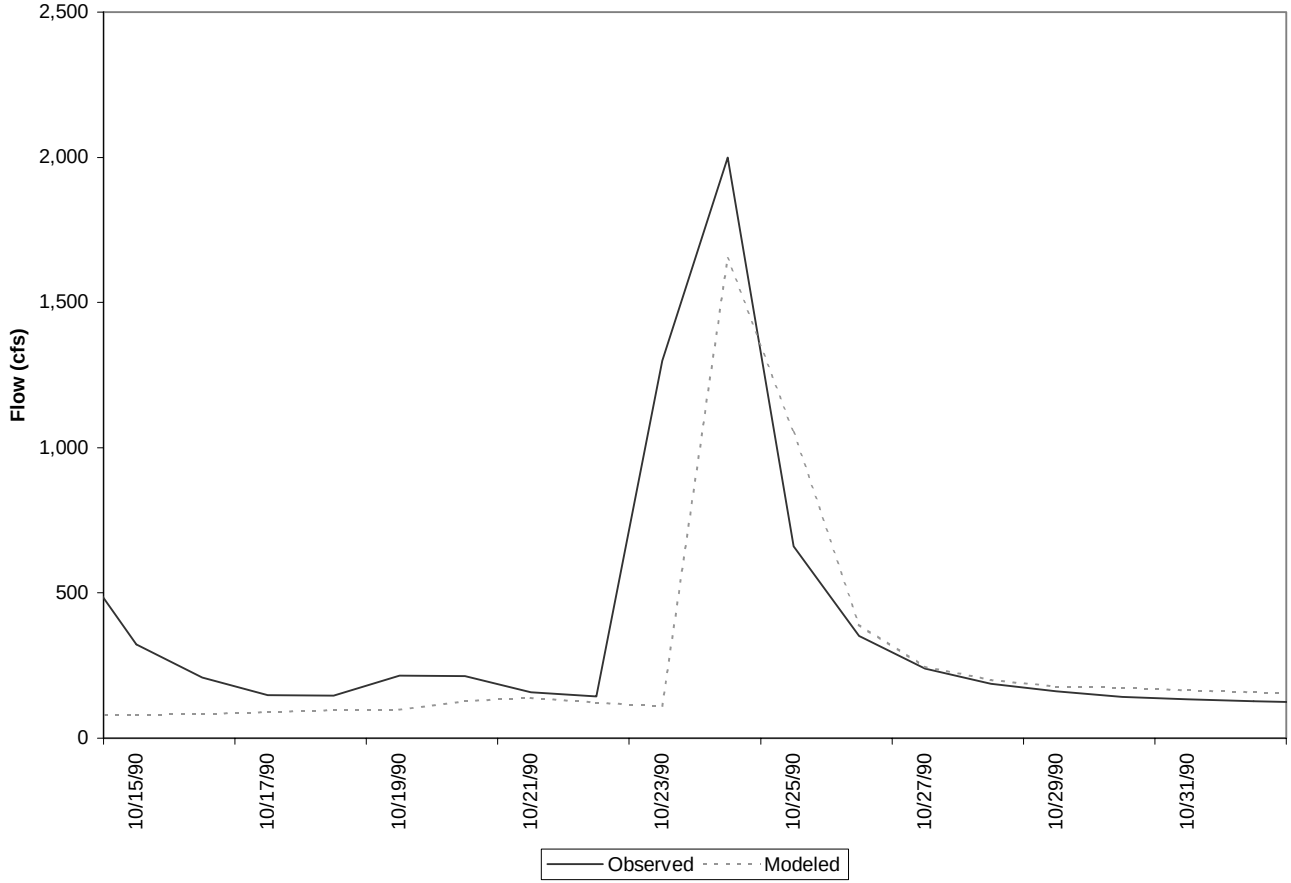

Figure 4.14 Validation results for a single storm event at gage station USGS02039500 on Appomattox River (model segment 1, subshed 22)

4.7.2 Water Quality Calibration and Validation

Water quality calibration is complicated by a number of factors, some of which are described here. First, water quality concentrations (*e.g.*, fecal coliform concentrations) are highly dependent on flow conditions. Any variability associated with the modeling of stream flow compounds the variability in modeling water quality parameters such as fecal coliform concentration. Second, the concentration of fecal coliform is particularly variable. Variability in location and timing of fecal deposition, variability in the density of fecal coliform bacteria in feces (among species and for an individual animal), environmental impacts on regrowth and die-off, and variability in delivery to the stream all lead to difficulty in measuring and modeling fecal coliform concentrations. Additionally, the maximum values were at times censored at 8,000 cfu/100ml and, at other times, at 16,000 cfu/100ml. Limited amount of measured data for use in calibration and the practice of censoring both high (over 24,000 cfu/100 ml) and low (under 100 cfu/100 ml) concentrations impede the calibration process.

The water quality calibration was conducted from 10/1/1998 through 7/30/2003. Four parameters were utilized for model adjustment: instream first-order decay rate (FSTDEC), maximum accumulation on land (SQOLIM), rate of surface runoff that will remove 90% of stored fecal coliform per hour (WSQOP), and concentration of fecal coliform in interflow (IOQC). All of these parameters were initially set at expected levels for the watershed conditions and adjusted within reasonable limits until an acceptable match between measured and modeled fecal coliform concentrations was established (Table 4.14). Figure 4.15 shows the results of calibration at VADEQ Station 2-APP090.12. Additional comparisons of modeled versus observed fecal concentrations can be found in Appendix C. Short-period fluctuations in the modeled data denote the effective modeling of the variability within daily concentrations. That was achieved through distributing direct depositions from wildlife, livestock, and uncontrolled discharges across each day (Section 4.3).

Table 4.14 Model parameters utilized for water quality calibration.

Parameter	Units	Typical Range of Parameter Value	Initial Parameter Estimate	Calibrated Parameter Value
MON-ACCUM	FC/ac*day	0.0E+00 – 1.0E+20	8.1E+05 to 3E+10	8.1E+05 to 3E+10
MON-SQOLIM	FC/ac	1.0E-02 – 1.0E+30	8E+6 to 1E+11	8E+7 to 1E+12
WSQOP	in/hr	0.05 – 3.00	0.2 – 3.0	0.1 – 2.5
MON-IFLW-CON	FC/ft^3	0.0E+00 – 1.0E+06	1,000	1,000
AOQC	FC/ft^3	0 – 10	0	0
DQAL	FC/100ml	0 – 1,000	200	200
FSTDEC	1/day	0.01 – 10.00	1.15	0.25 to 2.20
THFST	---	1.0 – 2.0	1.07	1.07

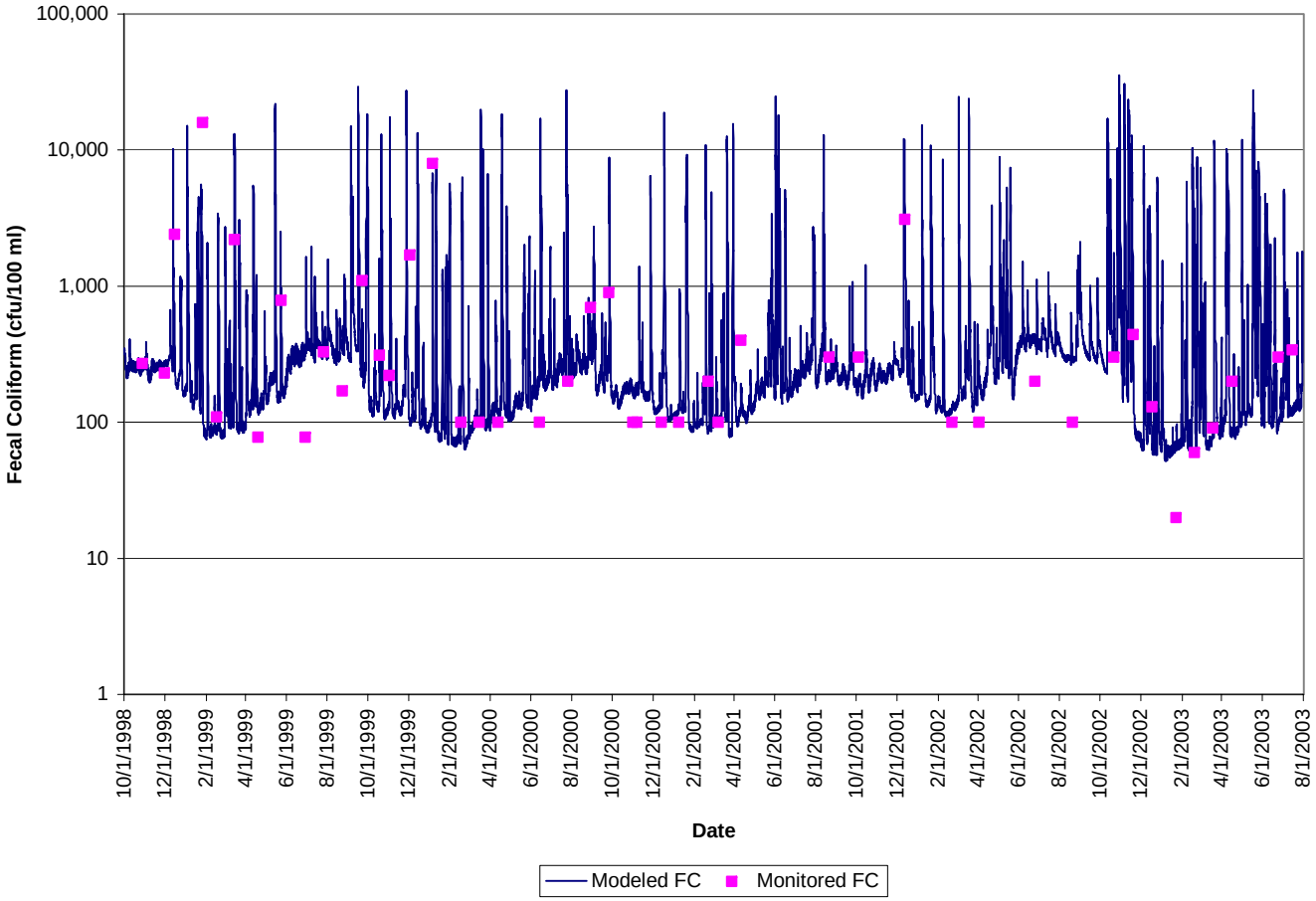

Figure 4.15 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 3, subshed 52

Careful inspection of graphical comparisons between continuous simulation results and limited observed points was the primary tool used to guide the calibration process. To provide a quantitative measure of the agreement between modeled and measured data while taking the inherent variability of fecal coliform concentrations into account, each observed value was compared with modeled concentrations in a 2-day window surrounding the observed data point. Standard error in each observation window was calculated as follows:

$$Standard\ Error = \frac{\sqrt{\dfrac{\sum_{i=1}^{n}\left(observed - modeled_i\right)^2}{\left(n-1\right)}}}{\sqrt{n}}$$

where

$$\begin{aligned} observed &= \text{an observed value of fecal coliform} \\ modeled_i &= \text{a modeled value in the 2-day window surrounding the observation} \\ n &= \text{the number of modeled observations in the 2-day window} \end{aligned}$$

This is a non-traditional use of standard error, applied here to offer a quantitative measure of model accuracy. In this context, standard error measures the variability of the sample mean of the modeled values about an instantaneous observed value. The use of limited instantaneous observed values to evaluate continuous data introduces error and, therefore, increases standard error. The mean of all standard errors for each station analyzed was calculated. Additionally, the maximum concentration values observed in the simulated data were compared with maximum values obtained from uncensored data (Section 2) and found to be at reasonable levels (Table 4.15). The standard errors in Table 4.15 range from a low of 44 to a high of 286. The higher values in this range can be considered quite reasonable when one takes into account the censoring of maximum values that is practiced in the taking of actual water quality samples. The standard error will be biased upwards when an observed high value censored at 8,000 cfu is compared to a simulated high value that may be an order of magnitude or more above the censor limit. Considering the data in Table 4.15, it is evident that the higher standard errors coincide with the higher simulated maximum values as expected. Thus, the standard

errors calculated for these impairments are considered to be an indicator of strong model performance.

Table 4.15 Results of analyses on calibration runs.

WQ Monitoring Station	Mean Standard Error (cfu/100 ml)	Maximum Simulated Value (cfu/100 ml)
2-APP118.04	105	65,319
2-SPA001.46	68	8,358
2-BRI001.00	178	17,690
2-BSR002.82	69	67,876
2-SYL001.26	44	8,314
2-ANG003.35	127	48,574
2-ANG001.27	276	78,514
2-HRP000.42	286	87,632
2-NBB003.65	172	175,510
2-NBB001.54	172	175,510
2-FLA001.95	172	77,828
2-WET004.96	75	62,088
2-DPC005.20	153	46,223
2-APP012.79	58	9,937.7
2-SFT036.00	53	7,616.3
2-SFT019.15	70	15,665
2-SFT004.92	59	14,808

Table 4.16 shows the geometric mean and instantaneous standard violation percentage for modeled and observed data at each water quality sampling station used in the development of this water quality model. A simple least squares regression of predicted versus observed geometric mean concentrations for stations with a minimum of 35 data points yields an R^2 value of 0.81, good evidence of model performance. Similarly, a regression of predicted versus observed violation rate yields an R^2 value of 0.78, also a strong indicator of the models performance.

Table 4.16 Comparison of Modeled and Observed Geometric Means.

Reach ID	Station ID	Modeled Calibration Load Fecal Coliform 10/1/93-9/30/98			Monitored Fecal Coliform 1/1/90-2/28/03		
		n[1]	Geometric Mean (cfu/100ml)	Exceedances of Instantaneous Standard	*n*[1]	Geometric Mean (cfu/100ml)	Exceedances of Instantaneous Standard
11	2-APP118.04	1,826	249.66	19%	107	264.54	28%
17	2-SPA001.46	1,826	119.10	10%	35	173.46	23%
28	2-BRI001.00	1,826	141.33	16%	40	294.15	20%
32	2-BSR002.82	1,826	194.60	23%	40	227.44	20%
35	2-LIT002.40	1,826	388.56	42%	2	188.54	50%
46	2-SYL001.26	1,826	335.31	46%	50	551.70	60%
48	2-ANG003.35	1,826	273.09	35%	2	687.86	100%
49	2-ANG001.27	1,826	367.18	47%	2	1,033.09	100%
54	2-HRP000.42	1,826	286.90	31%	16	359.49	50%
71	2-NBB001.54	1,826	492.23	58%	44	855.50	50%
71	2-NBB003.65	1,826	492.23	58%	7	855.50	29%
72	2-FLA001.95	1,826	357.64	47%	58	407.43	40%
93	2-WET004.96	1,826	259.51	31%	22	314.78	41%
95	2-DPC005.20	1,826	276.58	31%	57	253.33	25%
118	2-APP012.79	1,826	93.19	18%	140	218.90	27%
126	2-SFT036.00	1,826	154.10	7%	58	138.38	14%
137	2-SFT019.15	1,826	117.28	13%	40	165.92	13%
143	2-SFT004.92	1,826	137.59	13%	54	186.81	20%
149	2-APP001.53	1,826	101.00	17%	145	169.73	21%

[1]Number of Observations

The water quality validation was conducted for the time period from 10/1/1993 to 9/30/1998. The relationship between observed values and modeled values can be seen in Figure 4.16. Additional comparisons of modeled versus observed fecal concentrations can be found in Appendix C.

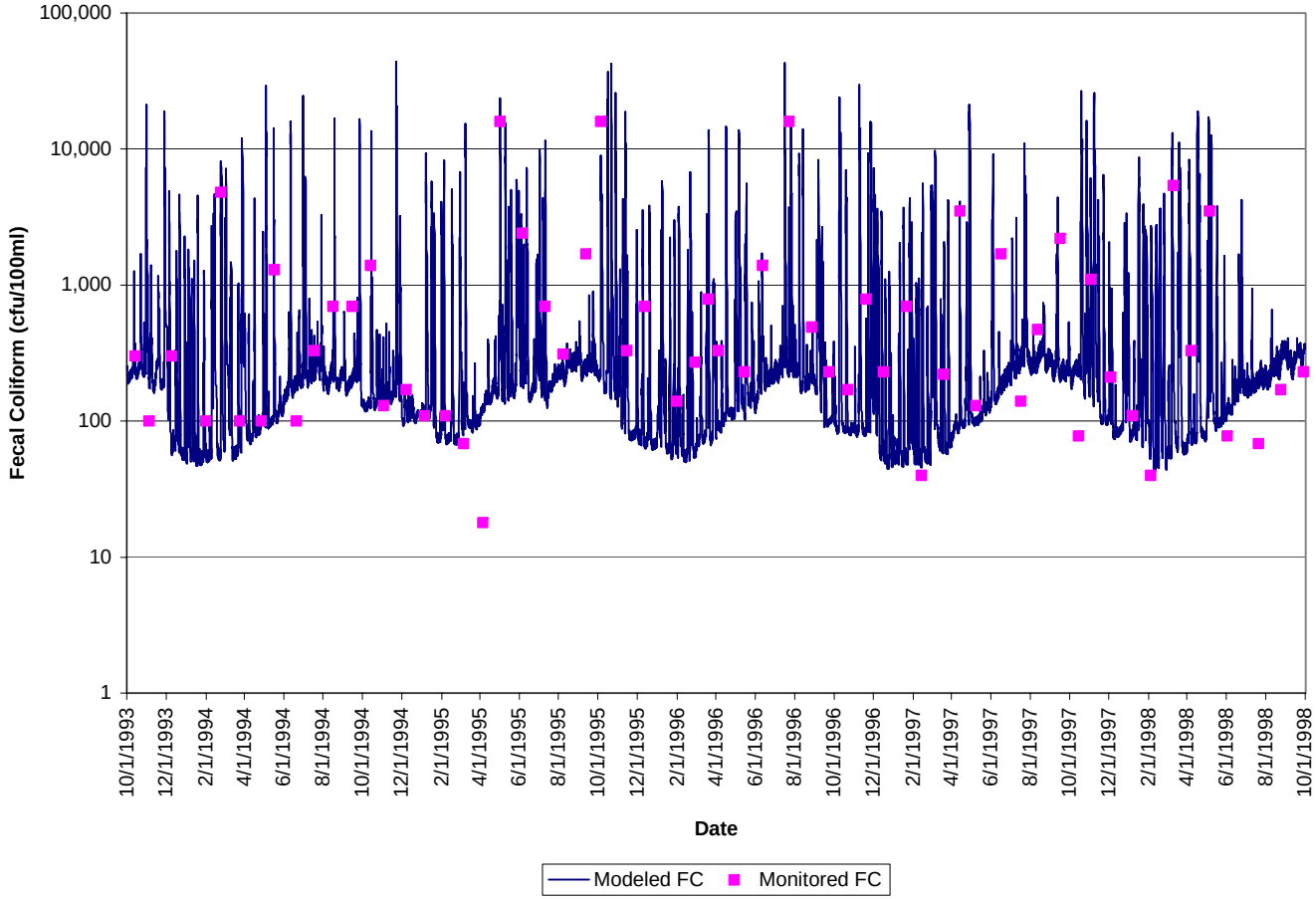

Figure 4.16 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 3, subshed 52.

5. ALLOCATION

Total Maximum Daily Loads (TMDLs) consist of waste load allocations (WLAs, point sources) and load allocations (LAs, nonpoint sources) including natural background levels. Additionally, the TMDL must include a margin of safety (MOS) that either implicitly or explicitly accounts for the uncertainties in the process (*e.g*. accuracy of wildlife populations). The definition is typically denoted by the expression:

$$TMDL = WLAs + LAs + MOS$$

The TMDL becomes the amount of a pollutant that can be assimilated by the receiving water body and still achieve water quality standards. For fecal coliform bacteria, TMDL is expressed in terms of colony forming units (or resulting concentration). A sensitivity analysis was performed to determine the impact of uncertainties in input parameters.

5.1 Incorporation of a Margin of Safety

In order to account for uncertainty in modeled output, a margin of safety (MOS) was incorporated into the TMDL development process. Individual errors in model inputs, such as data used for developing model parameters or data used for calibration, may affect the load allocations in a positive or a negative way. A margin of safety can be incorporated implicitly in the model through the use of conservative estimates of model parameters, or explicitly as an additional load reduction requirement. The intention of a MOS in the development of a fecal coliform TMDL is to ensure that the modeled loads do not under-estimate the actual loadings that exist in the watershed. An implicit MOS was used in the development of this TMDL. By adopting an implicit MOS in estimating the loads in the watershed, it is insured that the recommended reductions will, in fact, succeed in meeting the water quality standard. Examples of implicit MOS used in the development of this TMDL were:

- Allocating permitted point sources at the maximum allowable fecal coliform concentration
- The selection of a modeling period that represented the critical hydrologic conditions in the watershed

- Modeling biosolids applications at the maximum allowable rate and fecal coliform concentration in all permitted fields

5.2 Scenario Development

Allocation scenarios were modeled using HSPF. Existing conditions were adjusted until the water quality standard was attained. The TMDLs developed for the Appomattox River watershed 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* shall not exceed 235 cfu/100 ml. According to the guidelines put forth by the VADEQ (VADEQ, 2003) for modeling *E. coli* with HSPF, the model was set up to estimate loads of fecal coliform, then the model output was converted to concentrations of *E. coli* through the use of the following equation (developed from a data set containing n-493 paired datapoints):

$$\log_2(C_{ec}) = -0.0172 + 0.91905 \cdot \log_2(C_{fc})$$

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.

Pollutant concentrations were modeled over the entire duration of a representative modeling period, and pollutant loads were adjusted until the standard was met (Figures 5.9 through 5.52). The development of the allocation scenario was an iterative process that required numerous runs with each followed by an assessment of source reduction against the water quality target.

5.2.1 Wasteload Allocations

There are twenty-nine point sources currently permitted to discharge into the Appomattox River watershed (Figure 3.1 and Table 3.1). Of these sources, twenty-three are permitted for fecal control. For allocation runs, sources without fecal control permits were modeled as discharging the average recorded value of water, with no E. coli. The allocation for these sources is zero cfu/100 ml. The allocation for the sources permitted for fecal control is equivalent to their current permit levels (design discharge and 126 cfu/100 ml).

Within the Appomattox River basin there are four Municipal Separate Storm Sewer System (MS4) permits requiring TMDL allocations. Table 5.1 lists municipalities and receiving streams for these MS4 discharges. In allocating their TMDL, loads were based on each municipality's share of the contributing urbanized area of the impairment.

Table 5.1 Regulated small MS4 discharges in the Appomattox River watershed.

Municipality	Receiving Stream
Chesterfield County – VA0088609 (Phase I)	Skinquarter Creek Winterpock Creek Horsepen Creek Turkey Creek Swift Creek
Colonial Heights City – VAR040009 (Phase II)	Swift Creek Appomattox River Oldtown Creek
Hopewell City – VAR040015 (Phase II)	Appomattox River
Petersburg City – VAR040013 (Phase II)	Appomattox River

5.2.2 Load Allocations

Load allocations to nonpoint sources are divided into land-based loadings from land uses and directly applied loads in the stream (*e.g.*, livestock, sewer overflows, and wildlife). Source reductions include those that are affected by both high and low flow conditions. Within this framework, however, initial criteria that influenced developing load allocations included how sources were linked for representing existing conditions, and results from BST in the area. Land-based NPS loads had their most significant impact during high-flow conditions, while direct deposition NPS had their most significant impact on low flow concentrations. BST during 2002-2003 sampling periods confirmed the presence of human, livestock, pet, and wildlife contamination.

Allocation scenarios were run sequentially, beginning with headwater impairments, then continuing with downstream impairments until all impairments were allocated to have 0% exceedances of the instantaneous standard. Since part of the TMDL development is the identification of phased implementation strategies, typical management scenarios are

explored as well. Tables 5.2 through 5.22 represent a small portion of the scenarios developed to determine the TMDL for each impairment. Scenario 1 in each table describes a baseline scenario that corresponds to the existing conditions in the watershed. Model results indicate that human, livestock, and in-stream depositions by wildlife are significant in all areas of the watershed. This is in agreement with the results of BST analysis presented in section 2.2.2.2.

Reduction scenarios exploring the role of anthropogenic sources in standards violations were explored first to determine the feasibility of meeting standards without wildlife reductions. In each table, scenario 2 attempts to determine the impact of non-anthropogenic sources (i.e. wildlife), by exploring 100% reductions in all anthropogenic land-based and direct loads. In each case, the model predicts that water quality standards will not be met without reductions in wildlife loads.

Scenario 3 in each table contains reductions of 50% in all anthropogenic land-based loads, 100% reduction in sewer overflows and uncontrolled residential discharges, 90% reduction in direct livestock deposition and a 0% reduction in wildlife direct and land-based loading to the stream. This scenario corresponds to what is considered to be a reasonable scenario for a stage I implementation. Further scenarios in each table explore a range of management scenarios, leading to the final allocation scenario which contains the predicted reductions needed to meet the water quality standard of 0% instantaneous violations.

5.2.2.1 Spring Creek

Spring Creek is a tributary to the Appomattox River with woodland and pasture land uses predominating. Scenario 1 in the Spring Creek predicts an instantaneous violation rate of 10.57% under existing conditions. Scenario 2 predicts that removing all agricultural, and urban loads would still result in an instantaneous standard violation rate of 0.71%. Scenario 3 explores a potential management scenario, and predicts significant reductions in instantaneous standard violations, and the elimination of geometric mean violations with reductions of 90% in direct livestock loads, and 50% reductions in agricultural and

urban land loads. Scenarios 4 and 5 demonstrate the difficulty of achieving the elimination of instantaneous standard violations. Scenario 5 predicts that reductions of 70% in land based wildlife loads, 100 % in direct livestock loads, and 99% in agricultural and urban NPS loads would be required to achieve a 0% violation rate of the instantaneous standard.

Table 5.2 Allocation scenarios for bacterial concentration with current loading estimates in impairment #1, Spring Creek.

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	13.33	10.57
2	0	0	100	100	100	100	0.0	0.71
3	0	0	90	50	50	100	0.0	2.04
4	0	60	100	99	99	100	0.00	0.05
5	0	70	100	99	99	100	0.00	0.00

5.2.2.2 Briery Creek

Briery Creek is a headwater tributary to the Bush River, with a variety of forest and pasture type land uses in its upstream reaches, with an increasing amount of residential land uses as it nears Bush River. Scenario 2 in the Briery Creek predicts that even with removal of all anthropogenic sources, violations of the instantaneous standard will occur nearly 3% of the time. Additionally, the predicted violations of the geometric mean standard in this scenario – 20.0% – further demonstrates that wildlife is a significant contributor to fecal loading in this stream. Scenarios 3 and 4 explore typical management scenarios, and predict that violations of the instantaneous standard can be reduced to under 10% with a 50% reduction in all anthropogenic loads. Scenario 5 demonstrates that even with significant reductions in direct loads by wildlife, geometric mean standards will still be violated 30% of the time. Scenario 6 predicts that a 78% reduction in land-based wildlife loads, 38% reduction in direct wildlife loads, along with 99% reductions in anthropogenic land loads and elimination of direct loads from livestock will be required to achieve 0% exceedances of the instantaneous and geometric mean standards.

Table 5.3 Allocation scenarios for bacterial concentration with current loading estimates in impairment #2, Briery Creek.

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	33.33	17.70
2	0	0	100	100	100	100	20.00	2.58
3	0	0	90	50	50	100	23.33	7.51
4	0	0	50	50	50	100	25.0	9.70
5	30	0	100	80	80	100	13.79	3.55
6	38	78	100	99	99	100	0.0	0.0

5.2.2.3 Bush River (1)

Bush River(1) is a tributary to the Appomattox River which receives flow from Briery Creek, with a variety of forest and pasture type land uses in its upstream reaches, with an increasing amount of residential land uses as it nears Bush River(2). Scenario 2 in the Bush River predicts that even with removal of all anthropogenic sources, violations of the instantaneous standard will occur nearly 7% of the time, with a 20.0% violations of the geometric mean standard, demonstrating the wildlife are a significant source of fecal bacteria in this stream. Scenario 3 explores a typical management scenario, and predicts that violations of the instantaneous standard will remain fairly high, even with a 50% reduction of all anthropogenic land-based loads, and a reduction of 90% of direct loads from livestock. Scenario 4, with reductions of 75% to land-based anthropogenic loads, and violations in the upstream tributary, Briery Creek reduced below 10%, still predicts a violation rate of 14.58%. The final 3 scenarios explore increasing reductions in human and finally wildlife reductions, concluding that an 88% reduction in land-based wildlife loads, 48% reduction in direct wildlife loads, along with 99% reductions in anthropogenic land loads and elimination of direct loads from livestock will be required to achieve 0% exceedances of the instantaneous and geometric mean standards.

Table 5.4 Allocation scenarios for bacterial concentration with current loading estimates in impairment #3, Bush River (1).

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	45.00	23.95
2	0	0	100	100	100	100	20.	7.01
3	0	0	90	50	50	100	31.67	16.93
4*	0	0	90	75	75	100	28.33	14.58
5*	0	0	100	90	90	100	23.33	12.38
6*	0	0	100	99	99	100	20	10.85
7**	48	88	100	99	99	100	0.00	0.00

* - Indicates modeled water quality if upstream impairment #2 - Briery Creek is allocated to <10% exceedances of instantaneous standard.
** - Indicates modeled water quality if upstream impairment #2 - Briery Creek is allocated to 0% exceedances of instantaneous standard.

5.2.2.4 Little Sandy Creek

Impairment #4 Little Sandy Creek is a tributary to the Bush River (2), with approximately 22% of its land in pasture, with an extremely high density of animal units per acre, resulting in a predicted violation rate of the geometric mean standard of over 88%, and nearly 44% rate of exceedance of the instantaneous standard. Nearly all of the remaining land is forested, and even with total elimination of anthropogenic sources significant instantaneous and geometric mean standards violations are predicted to occur. Scenarios 3 through 5 explore increasingly drastic reductions of land based loads from urban and agricultural land uses, with scenario 5 predicting that a 98% reduction in anthropogenic land loads is required to reduce the percentage of instantaneous violations to below 10%. Additionally, the predicted violations of the geometric mean standard in this scenario – 16.7% – further demonstrates that wildlife is a significant contributor to fecal loading in this stream. The final scenario predicts that a 99% reduction in land-based wildlife loads, 48% reduction in direct wildlife loads, along with 99.8% reductions agriculture related land loads, a 99% reductions in urban land loads and elimination of direct loads from livestock will be required to achieve 0% exceedances of the instantaneous and geometric mean standards.

Table 5.5 Allocation scenarios for bacterial concentration with current loading estimates in impairment #4, Little Sandy Creek.

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	88.33	43.68
2	0	0	100	100	100	100	16.67	8.16
3	0	0	90	50	50	100	33.33	20.11
4	0	0	100	90	90	100	23.33	12.66
5	0	0	100	98	98	100	16.67	9.53
6	48	99	100	99.8	99	100	0.00	0.00

5.2.2.5 Bush River (2)

Bush River (2) is a tributary to the Appomattox River that receives flow from Bush River (1), Briery Creek and Little Sandy Creek; load reductions in these tributaries will affect the water quality in this segment greatly. Scenario 2 in predicts that even with removal of all anthropogenic sources, violations of the instantaneous standard will occur 2.5% of the time. Scenario 3 explores the implications of a 90% reduction in direct livestock loads, and a 50% reduction in all anthropogenic land-based loads in all contributing areas to this stream segment, and results in a predicted instantaneous violation rate of 11.84%. Scenario 5 predicts that an 88% reduction in land-based wildlife loads, 35% reduction in direct wildlife loads, along with 99% reductions in anthropogenic land loads and elimination of direct loads from livestock will be required to achieve 0% exceedances of the instantaneous and geometric mean standards.

Table 5.6 Allocation scenarios for bacterial concentration with current loading estimates in impairment #5, Bush River (2).

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	45.00	23.95
2	0	0	100	100	100	100	11.67	2.52
3	0	0	90	50	50	100	21.67	11.84
4*	0	0	75	75	75	75	18.97	7.09
5**	35	88	100	99	99	100	0.00	0.00

* - Indicates modeled water quality if upstream impairment #2 - Briery Creek, #3 - Bush River (1) and #4 – Little Sandy Creek are allocated to <10% exceedances of instantaneous standard.

** - Indicates modeled water quality if upstream impairments #2 - Briery Creek, #3 - Bush River (1) and #4 – Little Sandy Creek are allocated to 0% exceedances of instantaneous standard.

5.2.2.6 Saylers Creek

Saylers Creek is a headwater tributary to the Appomattox River, with primarily forest and pasture land. Scenario 2 in the Briery Creek predicts that the removal of all anthropogenic sources will result violations of the instantaneous standard approximately 2% of the time, and violations of the geometric mean standard 8.33% of the time. Scenarios 3, 4 and 5 explore possible management scenarios, and predict that it will be difficult to reduce the percentage of instantaneous standard violations with reasonable anthropogenic reductions. Scenario 6 predicts that an 80% reduction in land-based wildlife loads, 55% reduction in direct wildlife loads, and 99% reductions in anthropogenic land loads and elimination of direct loads from livestock will be required to achieve 0% exceedances of the instantaneous and geometric mean standards.

Table 5.7 Allocation scenarios for bacterial concentration with current loading estimates in impairment #6, Saylers Creek.

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	70.0	45.59
2	0	0	100	100	100	100	8.33	1.92
3	0	0	90	50	50	100	36.67	17.04
4	0	0	100	60	0	100	23.33	14.08
5	0	0	100	75	50	100	20.00	12.22
6	55	80	100	99	99	100	0.00	0.00

5.2.2.7 Angola Creek (1)

Angola Creek(1) empties into the Angola Creek(2) impairment, which ultimately drains to the Appomattox River. This is a heavily agricultural area, with nearly half of the land in pasture, however, wildlife reductions are still predicted to be necessary in order to reach a 0% rate of exceedance of the instantaneous standard. Scenarios 2 through 5 explore typical reduction scenarios, focusing primarily on agricultural land uses, as the urban land uses in this area are negligible. Scenario 5 predicts that violations of the instantaneous standard may be reduced to a rate of approximately 10% by eliminating livestock direct deposition and reducing land based loads by 62%. However, even with 100% of the direct loads from livestock eliminated, the predicted rate of geometric mean violations is still at 20%. Scenario 6 predicts that a 90% reduction in land-based wildlife loads, 50% reduction in direct wildlife loads, along with 99% reductions in anthropogenic land loads and elimination of direct loads from livestock will be required to achieve 0% exceedances of the instantaneous and geometric mean standards.

Table 5.8 Allocation scenarios for bacterial concentration with current loading estimates in impairment #7, Angola Creek (1).

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	71.67	37.81
2	0	0	100	100	100	100	8.33	1.92
3	0	0	90	50	50	100	31.67	11.78
4	0	0	100	60	0	100	20.0	10.19
5	0	0	100	62	0	100	20.00	10.03
6	60	88	100	99	99	100	0.00	0.06
7	50	90	100	99	99	100	0.0	0.0

5.2.2.8 Angola Creek (2)

Angola Creek (2) is fed by Angola Creek (1) and drains to the Appomattox River. As with Angola Creek (1) this is a heavily agricultural area, with nearly half of the land in pasture, and small amounts of residential area. Scenario 2 explores the removal of all anthropogenic sources, and predicts 0% violations of the geometric mean standard, and 1.59% violations of the instantaneous standard. Scenarios 3, 4 and 5 explore typical management scenarios, and predict that violations of the instantaneous standard can be reduced to 10.9% with a 68% reduction in all land-based agricultural loads, and a 100% reduction in direct deposition by livestock. Scenario 6 shows that even with an 88% reduction in loads to forest and wetland areas, the instantaneous standard is violated 0.11% of the time – this also includes a 0% rate of instantaneous violations in the contributing impairment, Angola (1). Scenarios 7 reduces loads to forest and wetland areas by 95%, along with the 99% reduction in land-based anthropogenic loads in order to achieve a standards violation percentage of 0%.

Table 5.9 Allocation scenarios for bacterial concentration with current loading estimates in impairment #8, Angola Creek (2).

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	81.67	46.41
2	0	0	100	100	100	100	0.00	1.59
3	0	0	90	50	50	100	35.0	13.53
4*	0	0	100	60	0	100	20.0	12.05
5*	0	0	100	68	0	100	16.67	10.9
6**	0	88	100	99	99	100	0.00	0.11
7**	0	95	100	99	99	100	0.00	0.00

* Indicates modeled water quality if upstream impairment #7, Angola Creek (1) is allocated to < 10% exceedances of instantaneous standard.
** Indicates modeled water quality if upstream impairment #7, Angola Creek (1) is allocated to 0% exceedances of instantaneous standard.

5.2.2.9 Horsepen Creek

Horsepen Creek is a tributary to the Guinea Creek, with predominantly forest and pasture type land. Scenario 2 in the Horsepen Creek predicts that even with removal of all anthropogenic sources, violations of the instantaneous standard will occur nearly 15% of the time, and that violations of the geometric mean will occur 43.33% of the time, implying that wildlife is a significant contributor to fecal loading in this stream. Scenarios 3, 4 and 5 predict that typical management scenarios will have little success in reducing the rate of instantaneous violations to below 10%. Scenario 6 predicts that a 99% reduction in land-based wildlife loads, 62% reduction in direct wildlife loads, along with 99% reductions in anthropogenic land loads and elimination of direct loads from livestock will be required to achieve 0% exceedances of the instantaneous and geometric mean standards.

Table 5.10 Allocation scenarios for bacterial concentration with current loading estimates in impairment #9, Horsepen Creek.

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	81.67	46.41
2	0	0	100	100	100	100	43.33	14.47
3	0	0	90	50	50	100	68.33	30.36
4	0	0	100	60	50	100	58.33	27.78
5	0	0	100	75	50	100	55.00	26.14
6	62	98	100	99	99	100	0.0	0.11
7	62	99	100	99	99	100	0.0	0.0

5.2.2.10 Nibbs Creek

Nibbs Creek is a heavily agricultural tributary to Flat Creek with nearly two-thirds of its land in pasture. Scenario 2 predicts that the removal of all anthropogenic sources will reduce violations of the instantaneous standard less to than 1%, and that geometric mean standard violations will occur just under 2% of the time. Additionally, the predicted violations of the geometric mean standard in this scenario – 20.0% – further demonstrates that wildlife is a significant contributor to fecal loading in this stream. Management scenarios 3, 4 and 5 explore the reductions in anthropogenic loads required to reduce instantaneous standards violations to below 10%. Scenario 9 demonstrates the difficulty in eliminating instantaneous standard violations, as a 99% reduction in all land based loads is required, along with a 100% reduction in direct livestock loads, and a 20% reduction in direct loads from wildlife.

Table 5.11 Allocation scenarios for bacterial concentration with current loading estimates in impairment #10, Nibbs Creek.

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	98.28	69.6
2	0	0	100	100	100	100	1.72	0.51
3	0	0	90	50	50	100	51.72	12.42
4	0	0	90	70	70	100	40	9.92
5	0	0	90	75	75	100	35.0	8.49
6	15	60	100	99	99	100	1.72	0.40
7	18	70	100	99	100	100	1.72	0.34
8	20	90	100	99	99	100	0.0	0.11
9	20	95	100	99	99	100	0.0	0.0

5.2.2.11 Flat Creek

Flat Creek is a tributary to the Appomattox River that receives flow from Nibbs Creek, with a mix of forest and pasture type land. Scenario 2 predicts that even with removal of all anthropogenic sources, wildlife loads will cause violations of the geometric mean standard at a rate of approximately 32%, and violations of the instantaneous standard at a rate of just over 1%. Scenarios 3, 4 and 5 explore typical management scenarios with a goal of reducing the predicted violations of the instantaneous standard to below 10%. Scenario 7 predicts that an 80% reduction in land-based wildlife loads, 51% reduction in direct wildlife loads, along with 99% reductions in anthropogenic land loads and elimination of direct loads from livestock will be required to achieve 0% exceedances of the instantaneous and geometric mean standards.

Table 5.12 Allocation scenarios for bacterial concentration with current loading estimates in impairment #11, Flat Creek.

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	80.0	55.84
2	0	0	100	100	100	100	31.67	1.15
3	0	0	90	50	50	100	50.0	12.6
4*	0	0	75	70	70	100	50	9.92
5*	0	0	90	70	70	100	45	9.64
6**	60	50	100	99	99	100	0.00	0.11
7**	51	80	100	99	99	100	0.00	0.00

* - Indicates modeled water quality if upstream impairment #10, Nibbs Creek is allocated to < 10% exceedances of instantaneous standard.
** - Indicates modeled water quality if upstream impairment #10, Nibbs Creek is allocated to 0% exceedances of instantaneous standard.

5.2.2.12 Appomattox River (1)

The Appomattox River (1) impairment spans the upper and lower Appomattox watersheds, until it meets the outlet of Deep Creek. This portion of the Appomattox River receives the waters from 11 other impaired stream segments and drains nearly 600,000 acres of land. Loads in upstream impairments greatly impact the water quality in this large stream segment. Thus, as you move down this stretch of the Appomattox River, the water quality will vary as it receives inputs from its various tributaries.

Due to this large drainage area, and the variation in land uses which drain to this portion of the Appomattox River, the allocation scenarios for this impairment are being reported in three portions, in order to present reduction scenarios that reflect the changing land use and conditions as you move downstream in the Appomattox. The first portion of this impairment, hereafter referred to as Appomattox 1a, stretches from river mile 126.67 to river mile 99.4. The portion of this impairment, hereafter referred to as Appomattox River 1b, stretches from river mile 99.4 to river mile 57.91. The third and final portion of this impairment, Appomattox 1c, stretches from river mile 57.91 to the confluence with Deep Creek, at river mile 43.58. Figure 5.1 shows these divisions.

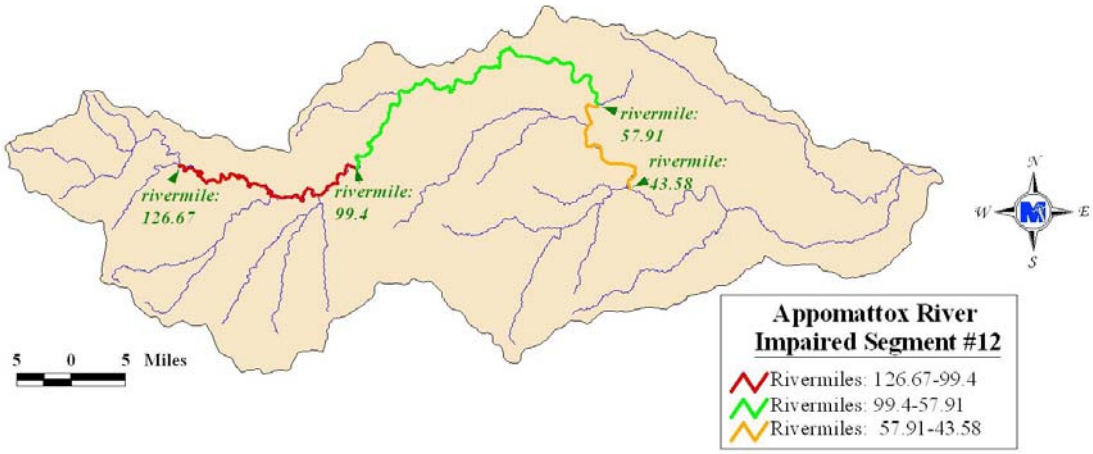

Figure 5.1 Portions of Impairment #12, Appomattox River (1) divided for the purpose of allocation.

In the allocation process, reductions are first applied to the lands draining into the impaired tributaries of the Appomattox, then further reductions are applied to the remaining lands that drain into un-impaired tributaries of the Appomattox, or directly into the Appomattox itself. It may be noted that as one moves farther down the Appomattox, the model predicts the cumulative effect of load reductions in its tributary impairments will allow for less severe reductions in the main stem of the Appomattox River itself. The load reductions needed in Appomattox 1a are less than those required in any of their impaired tributaries, the reductions required in Appomattox 1b are less than those in Appomattox 1a, and the reductions required Appomattox 1c are still less.

Appomattox River (1a) stretches from river mile 126.67 to river mile 99.4 and is predicted to have a instantaneous standard violation rate of 24.7% under existing conditions. Scenario 2 predicts that a 90% of direct agricultural loads, and 50% of all land-based anthropogenic loads in the entire contributing area (sub-watersheds 1 through 41) will bring the number of instantaneous standard violations down to 10.44%. Scenarios 4 and 5 explore the impact of land only reductions in the lands that drain into un-impaired tributaries of the Appomattox, or directly into the Appomattox itself, after

tributary impairments have had their rate of instantaneous violations reduced below 10%. The final two scenarios explore the reductions necessary to reduce violations of the instantaneous and geometric mean standards to 0%. Scenario 7 predicts that reductions of 80% from land-based wildlife loads, 100% of direct livestock loads, and 99% of all anthropogenic land-based loads will be required in order to eliminate violations of the instantaneous standard.

Table 5.13 Allocation scenarios for bacterial concentration with current loading estimates in impairment #12, Appomattox River (1a) (from river mile 126.67 to river mile 99.4).

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	74.14	24.67
2	0	0	100	100	100	100	0.0	2.85
3	0	0	90	50	50	100	22.41	10.44
4 *	0	0	0	60	60	100	38.33	12.05
5 *	0	0	0	75	75	100	35	9.75
6 **	0	75	100	99	99	100	0.0	0.06
7 **	0	80	100	99	99	100	0.0	0.0

* Indicates modeled water quality if all upstream impairments are allocated to < 10% exceedances of the instantaneous standard.
** - Indicates modeled water quality if all upstream impairments are allocated to 0% exceedances of instantaneous standard.

Appomattox River (1b) stretches from river mile 99.4 to river mile 57.91 and is predicted to have a instantaneous standard violation rate of 19.29% under existing conditions. Scenario 2 predicts that a 90% of direct agricultural loads, and 50% of all land-based anthropogenic loads in the entire contributing area will bring the number of instantaneous standard violations down to 15.07%. Scenarios 4 explores the impact of reductions in the agricultural lands that drain into un-impaired tributaries of the Appomattox, or directly into the Appomattox itself, after tributary impairments have had their rate of instantaneous violations reduced below 10%. The final two scenarios explore the reductions necessary to reduce violations of the instantaneous and geometric mean standards to 0%. Scenario 7 predicts that reductions of 69% from land-based wildlife loads, 93% of direct livestock loads, and 99% of all anthropogenic land-based loads will be required in order to eliminate violations of the instantaneous standard.

Table 5.14 Allocation scenarios for bacterial concentration with current loading estimates in impairment #12, Appomattox River (1b) (from river mile 99.4 to river mile 57.91).

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	53.33	19.29
2	0	0	100	100	100	100	0.0	4.33
3	0	0	90	50	50	100	15.0	15.07
4*	0	0	100	60	0	100	23.33	12.11
5**	0	75	100	99	99	100	0.0	0.0
6**	0	69	93	99	99	100	0.0	0.0

* Indicates modeled water quality if all upstream impairments are allocated to < 10% exceedances of the instantaneous standard.
** Indicates modeled water quality if all upstream impairments are allocated to 0% exceedances of instantaneous standard.

Appomattox River (1c) stretches 57.91 to the confluence with Deep Creek at river mile 43.58 and is predicted to have an instantaneous standard violation rate of 18.58% under existing conditions. Scenario 2 predicts that a 90% of direct agricultural loads, and 50% of all land-based anthropogenic loads in the entire contributing will bring the number of instantaneous standard violations down to 14.03%. Scenario 4 predicts that after tributary impairments have had their rate of instantaneous violations reduced below 10% and with the elimination of sewer overflows and straight pipe violations of the instantaneous standard would be just over 5%. The final two scenarios explore the reductions necessary to reduce violations of the instantaneous and geometric mean standards to 0%. Scenario 6 predicts that reductions of 52% from land-based wildlife loads, and 99% of all anthropogenic land-based loads will be required in order to eliminate violations of the instantaneous standard.

Table 5.15 Allocation scenarios for bacterial concentration with current loading estimates in impairment #12, Appomattox River (1c), (57.91 to the confluence with Deep Creek, at river mile 43.58).

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	30.0	18.58
2	0	0	100	100	100	100	0.0	3.01
3	0	0	90	50	50	100	13.33	14.03
4*	0	0	0	0	0	100	1.67	5.04
5**	0	75	100	99	99	100	0.0	0.0
6**	0	52	0	99	99	100	0.0	0.0

* Indicates modeled water quality if all upstream impairments are allocated to < 10% exceedances of the instantaneous standard.
** Indicates modeled water quality if all upstream impairments are allocated to 0% exceedances of instantaneous standard.

5.2.2.13 West Creek

West Creek is a tributary to Deep Creek with a large amount of forest and pasture land uses. Scenario 2 predicts significant violations of the instantaneous and geometric mean standard even after the removal of all anthropogenic sources. Scenarios 3 and 4 explore possible management scenarios, which predict that violations of the instantaneous standard will remain above 20% with a 75% reduction in all land-based anthropogenic loads. Scenario 7 predicts that a 89% reduction in land-based wildlife loads, 62% reduction in direct wildlife loads, along with 99% reductions in anthropogenic land loads and an 100% reductions in direct loads from livestock will be required to achieve 0% exceedances of the instantaneous and geometric mean standards.

Table 5.16 Allocation scenarios for bacterial concentration with current loading estimates in impairment #14, West Creek.

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	71.67	37.64
2	0	0	100	100	100	100	41.67	16.44
3	0	0	90	50	50	100	50.00	24.82
4	0	0	90	75	75	100	48.33	21.81
5	0	0	100	99	99	100	41.67	16.99
6	70	74	95	100	100	100	0.0	0.04
7	62	89	100	99	99	100	0.0	0.0

5.2.2.14 Deep Creek

Deep Creek is a tributary to the Appomattox River that receives flow from the West Creek impairment. Scenario 2 in Deep Creek predicts that even with removal of all anthropogenic sources, violations of the instantaneous standard will occur nearly 13% of the time. Additionally, the predicted violations of the geometric mean standard in this scenario – 28.3% – further demonstrates that wildlife is a significant contributor to fecal loading in this stream. Scenarios 3, 4 and 5 explore the impact of reductions in human loads only, and predict that violations of the instantaneous standard will still remain above 10% with a 99% reduction in all anthropogenic loads. Scenario 7 predicts that a 95% reduction in land-based wildlife loads, 70% reduction in direct wildlife loads, along with 99% reductions in anthropogenic land loads and elimination of direct loads from livestock will be required to achieve 0% exceedances of the instantaneous and geometric mean standards.

Table 5.17 Allocation scenarios for bacterial concentration with current loading estimates in impairment #15, Deep Creek.

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	85.00	45.75
2	0	0	100	100	100	100	28.33	12.27
3	0	0	90	50	50	100	48.33	24.71
4*	0	0	90	75	75	100	40	20.55
5*	0	0	100	99	99	100	28.33	12.77
6**	62	90	100	99	100	100	6.62	0.11
7**	70	95	100	99	99	100	0.00	0.00

* Indicates modeled water quality if upstream impairment #14, West Creek is allocated to < 10% exceedances of instantaneous standard.
** Indicates modeled water quality if upstream impairment #14, West Creek is allocated to 0% exceedances of instantaneous standard.

5.2.2.15 Appomattox River (2)

The Appomattox River (2) impairment drains approximately 80% of the Appomattox River basin and empties into the Appomattox (3) impairment – the tidal portion of the lower Appomattox. This portion of the Appomattox River receives the waters from 14 other impaired stream segments and drains over 800,000 acres of land. Loads in upstream impairments greatly impact the water quality in this large stream segment. Thus, load reductions in the tributary impairments will improve water quality in this segment as well. Scenario 3 predicts that a watershed wide management scenario of 90% reduction in livestock direct loads, and 50% reduction in all anthropogenic land loads will lead to 0% violations of the geometric mean standard, and 11.89% violations of the instantaneous standard. Scenario 4 indicates that this impairment will have a rate of instantaneous violations below 10% with no reductions beyond the elimination of sewer overflows and straight pipe discharges, provided that its tributary impairments are all reduced to less then 10% instantaneous violations. Scenario 5 predicts that a 75% reduction in land-based anthropogenic loads will reduce the instantaneous standard violation rate to below 1%, however, a reduction of 96% of all anthropogenic land based loads would be required to eliminate all instantaneous standard violations.

Table 5.18 Allocation scenarios for bacterial concentration with current loading estimates in impairment #16, Appomattox River (2).

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	25.00	17.75
2	0	0	100	100	100	100	0.0	0.71
3	0	0	90	50	50	100	0.00	11.89
4*	0	0	0	0	0	100	0.00	7.84
5**	0	0	0	75	75	100	0.00	0.45
6**	0	0	0	96	96	100	0.0	0.0

* Indicates modeled water quality if all upstream impairments are allocated to < 10% exceedances of instantaneous standard.
** Indicates modeled water quality if all upstream impairments are allocated to 0% exceedances of instantaneous standard.

5.2.2.16 Swift Creek

Swift Creek (1) flows into the Swift Creek reservoir, and has a predominantly forested contributing area, with approximately 10% agricultural land uses. Scenario 2 predicts that the impact of eliminating anthropogenic sources will still leave a 1.5% incidence of instantaneous standard violations, and 31.67% instance of geometric mean violations. Scenarios 3 and 4 explore typical management scenarios, and predict that while violations of the instantaneous standard can be reduced to under 10% with a 25% reduction in all anthropogenic land loads, significant violations of the geometric mean standard will remain. Scenario 6 predicts that a 74% reduction in land-based wildlife loads, 51% reduction in direct wildlife loads, along with 99% reductions in anthropogenic land loads and elimination of direct loads from livestock will be required to achieve 0% exceedances of the instantaneous and geometric mean standards.

Table 5.19 Allocation scenarios for bacterial concentration with current loading estimates in impairment #17, Swift Creek (1).

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	36.67	7.4
2	0	0	100	100	100	100	31.67	1.53
3	0	0	90	50	50	100	36.67	4.49
4	0	0	90	25	25	100	36.67	5.86
5	65	73	100	99	99	100	0.0	0.06
6	51	74	100	99	99	100	0.0	0.0

Swift Creek (2) flows into the Swift Creek (3) impairment, and is heavily forested, with some agricultural and urban type land uses. Scenario 2 predicts that the removal of all anthropogenic sources will result in less than 1% violations of the instantaneous standard and only 5% violations of the geometric mean standard. Scenarios 3 and 4 explore possible management scenarios, and predict that violations of the instantaneous standard can be reduced to under 10% with a 45% reduction in all land-based anthropogenic loads, and a 75% reduction in direct livestock loads. Scenario 6 predicts that a 53% reduction in land-based wildlife loads, 33% reduction in direct wildlife loads, along with 99% reductions in anthropogenic land loads and elimination of direct loads from livestock will be required to achieve 0% exceedances of the instantaneous and geometric mean standards.

Table 5.20 Allocation scenarios for bacterial concentration with current loading estimates in impairment #18, Swift Creek (2).

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	30.0	15.67
2	0	0	100	100	100	100	5.0	0.99
3	0	0	90	50	50	100	21.67	9.26
4*	0	0	50	45	45	100	26.67	10.03
5*	0	0	75	45	45	100	26.67	9.97
6**	33	53	100	99	99	100	0.00	0.00

* Indicates modeled water quality if upstream impairment #17, Swift Creek (1) is allocated to < 10% exceedances of instantaneous standard.
** Indicates modeled water quality if all upstream impairments are allocated to 0% exceedances of instantaneous standard.

Swift Creek (3) flows into the Appomattox River (3) impairment, and is heavily forested, with some agricultural and significant urban type land uses. Scenario 2 predicts that the removal of all anthropogenic sources will result in 1.15% violations of the instantaneous standard and only 5% violations of the geometric mean standard Scenarios 3 and 4 explore possible management scenarios, and predict that violations of the instantaneous standard can be reduced to under 10% with a 45% reduction in all land-based anthropogenic loads, and a 25% reduction in direct livestock loads. Scenario 6 predicts that a 59% reduction in land-based wildlife loads, 25% reduction in direct wildlife loads, along with 99% reductions in anthropogenic land loads and elimination of direct loads from livestock will be required to achieve 0% exceedances of the instantaneous and geometric mean standards.

Table 5.21 Allocation scenarios for bacterial concentration with current loading estimates in impairment #19, Swift Creek (3).

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	38.33	16.44
2	0	0	100	100	100	100	5.0	1.15
3	0	0	90	50	50	100	30.0	8.93
4*	0	0	90	40	40	100	30	10.14
5*	0	0	25	45	45	100	30	9.75
6**	25	59	100	99	99	100	0.0	0.0

* - Indicates modeled water quality if upstream impairment #18, Swift Creek (2) is allocated to < 0% exceedances of instantaneous standard.
** Indicates modeled water quality if all upstream impairments are allocated to 0% exceedances of instantaneous standard.

5.2.2.17 Appomattox (3)

The Appomattox (3) impairment drains the entire Appomattox River basin, and thus is influenced by all upstream load reductions in the watershed. Additionally, the lower reaches of this impairment are influenced by the pollutant concentration in the James River, as they are predicted to move into the Appomattox with incoming tides. Scenario 3 represents the conditions that are predicted at the outlet of the Appomattox River if all land uses in the Appomattox are subject to a management scenario of 90% reductions in direct livestock loads, and 50% reduction in all human related land loads. It is predicted that under this scenario the violation rate of the instantaneous standard will be 13.2%. Scenario 4 predicts that reducing all contributing impairments to violation rates below 10% instantaneous exceedances (Scenario 4) coupled with a 100% reduction in direct urban loads from the subwatersheds contributing to the Appomattox River (3) will reduce the rate of instantaneous standards violations to 5.38%. Further reductions in scenario 6 still result in a violation rate of 0.05%, equivalent to one violation. Scenario 7 predicts that a 80% reduction in land-based wildlife loads, 10% reduction in direct wildlife loads, along with 99% reductions in anthropogenic land loads and elimination of direct loads from livestock will be required to achieve 0% exceedances of the instantaneous and geometric mean standards.

Table 5.22 Allocation scenarios for bacterial concentration with current loading estimates in impairment #20, Appomattox River (3).

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access / Crops	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	GM > 126 cfu/ 100ml	Single Sample Exceeds 235 cfu/ 100ml
1	0	0	0	0	0	0	50.0	18.0
2	0	0	100	100	100	100	1.6	0.75
3	0	0	90	50	50	100	22.6	13.2
4*	0	0	0	0	0	100	3.22	5.38
6**	0	80	100	99	99	100	0.0	0.05
7**	10	80	100	99	99	100	0.0	0.0

* Indicates modeled water quality if all upstream impairments are allocated to < 10% exceedances of the instantaneous standard.
** Indicates modeled water quality if all upstream impairments are allocated to 0% exceedances of instantaneous standard.

Figures 5.2 through 5.23 contain graphs of the existing and allocated instantaneous *E. coli* concentrations for all the impairments in the Appomattox River basin. It may be noted that the existing curves are given in black, while the allocated values are overlaid in gray. The instantaneous values are average daily concentration as predicted by the water quality model.

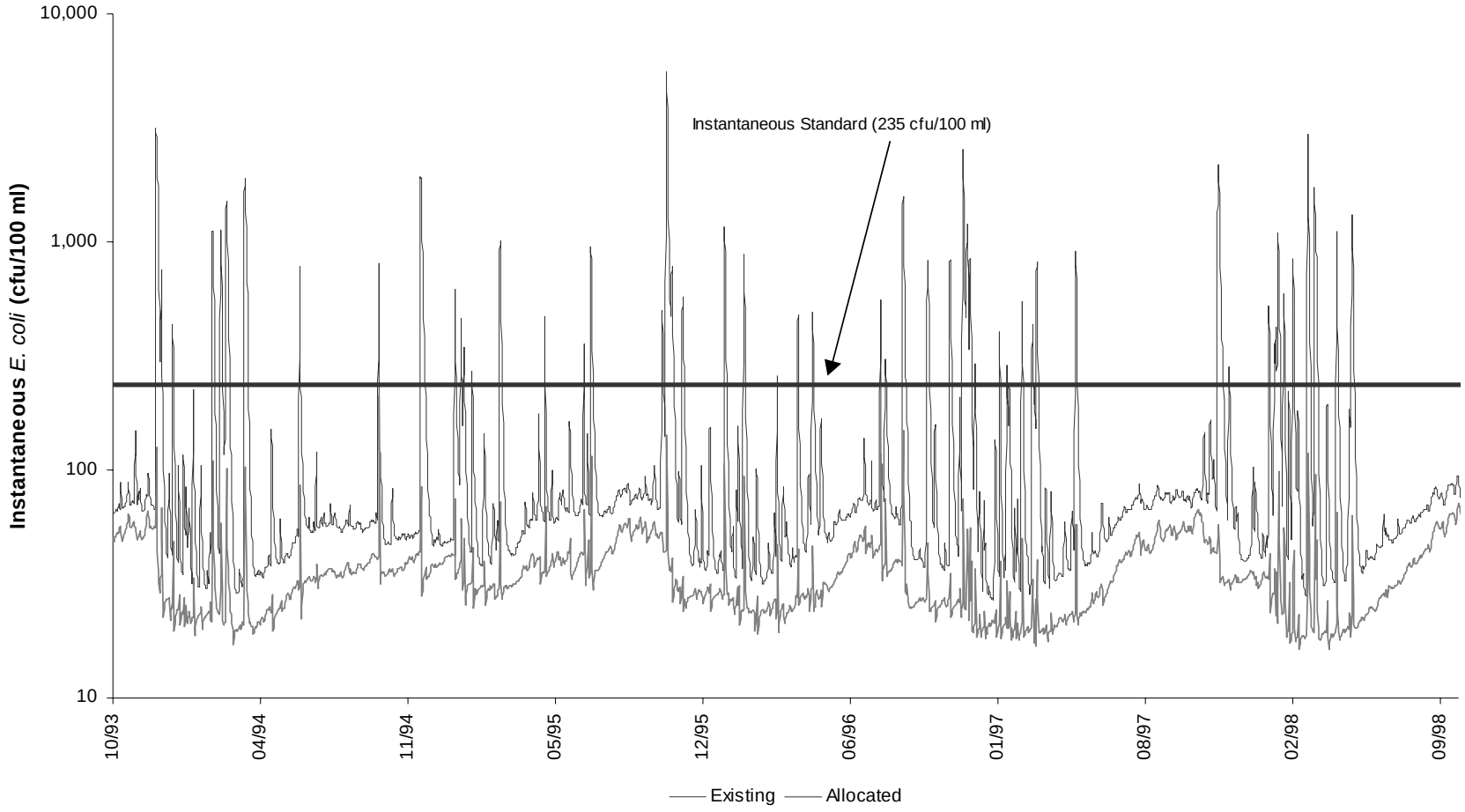

Figure 5.2 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 17, Spring Creek impairment.

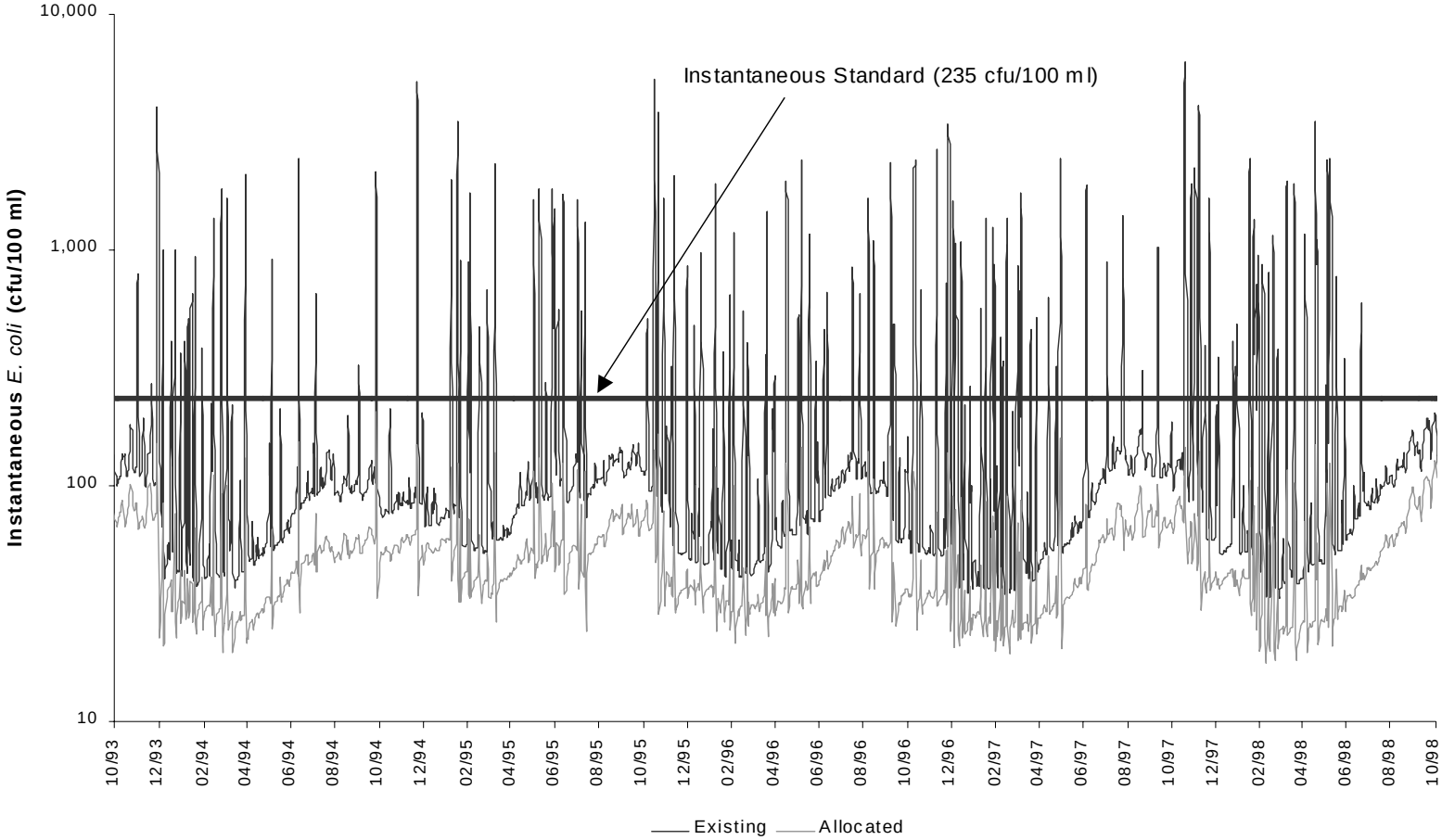

Figure 5.3 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 23, Appomattox River (1) impairment.

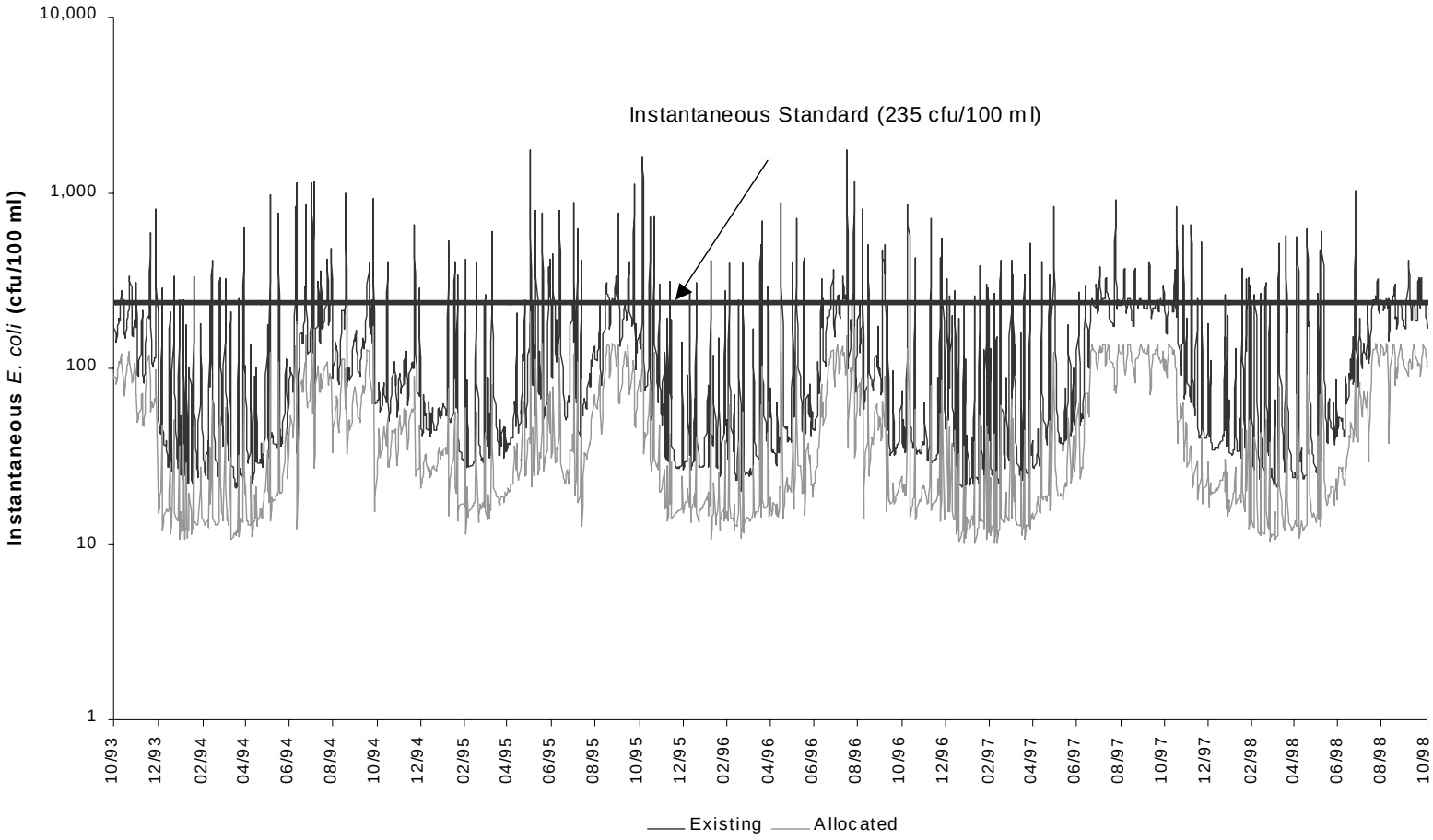

Figure 5.4 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 28, Briery Creek impairment.

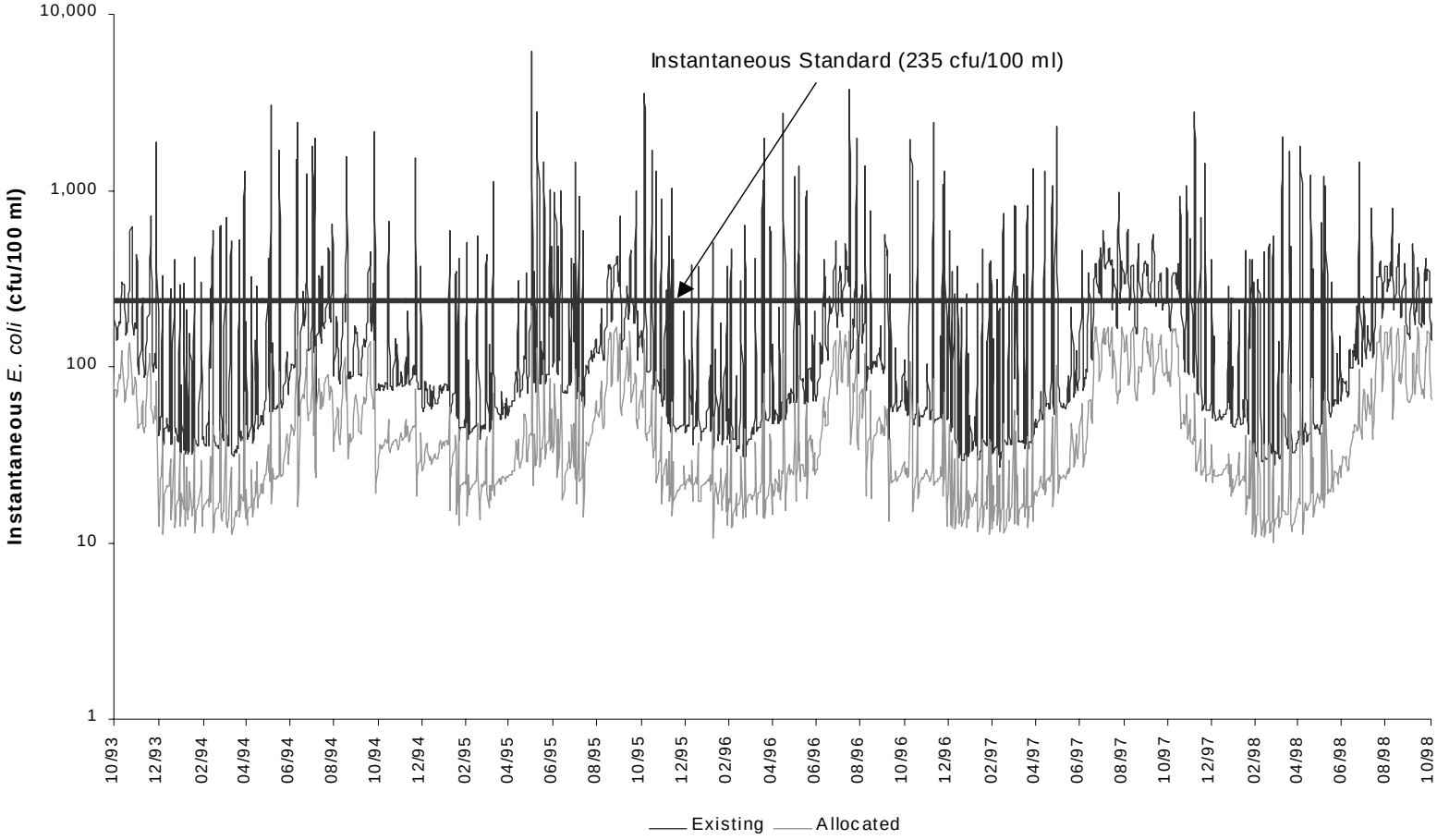

Figure 5.5 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 33, Bush River (1) impairment.

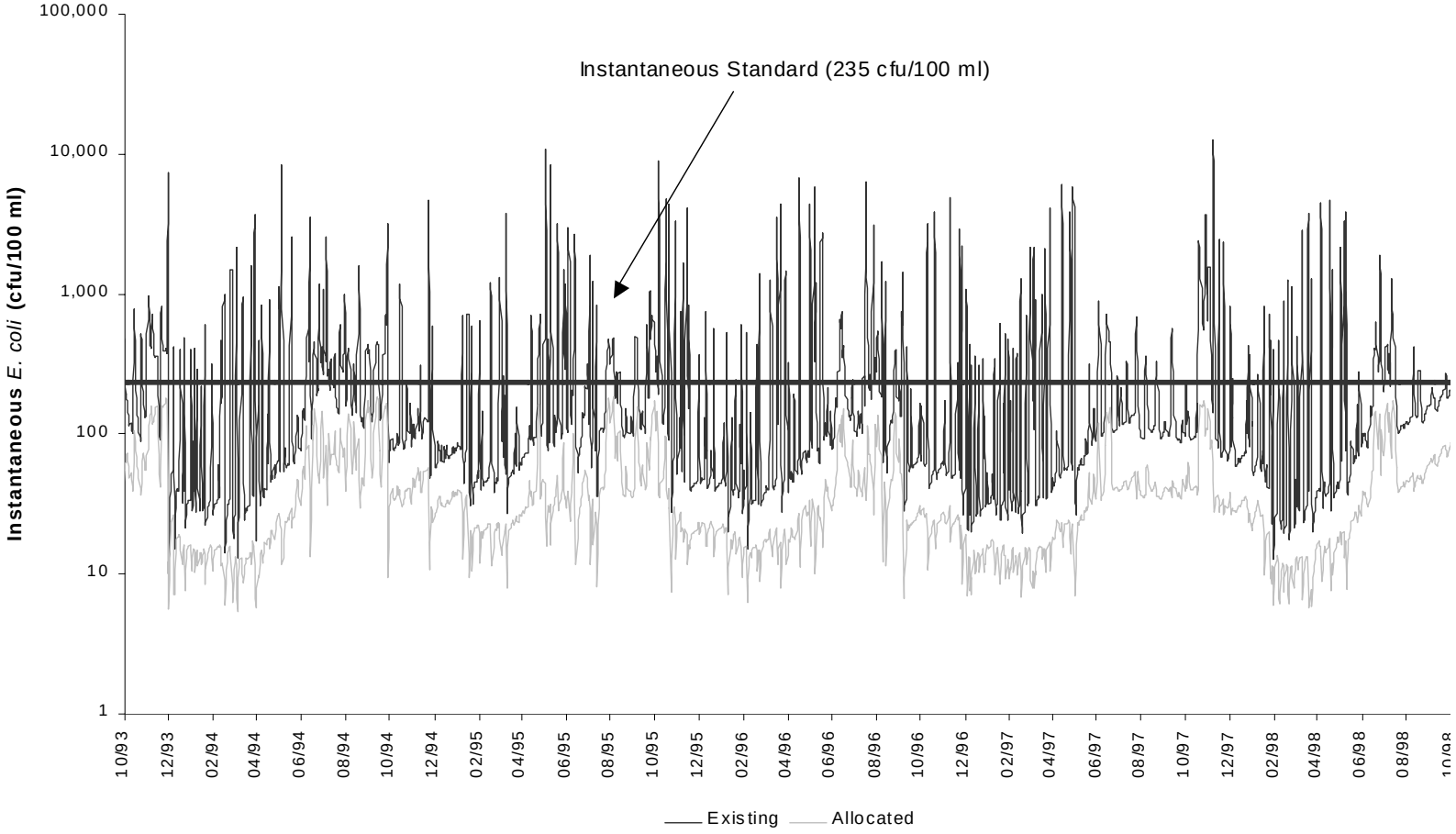

Figure 5.6 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 34, Little Sandy Creek impairment.

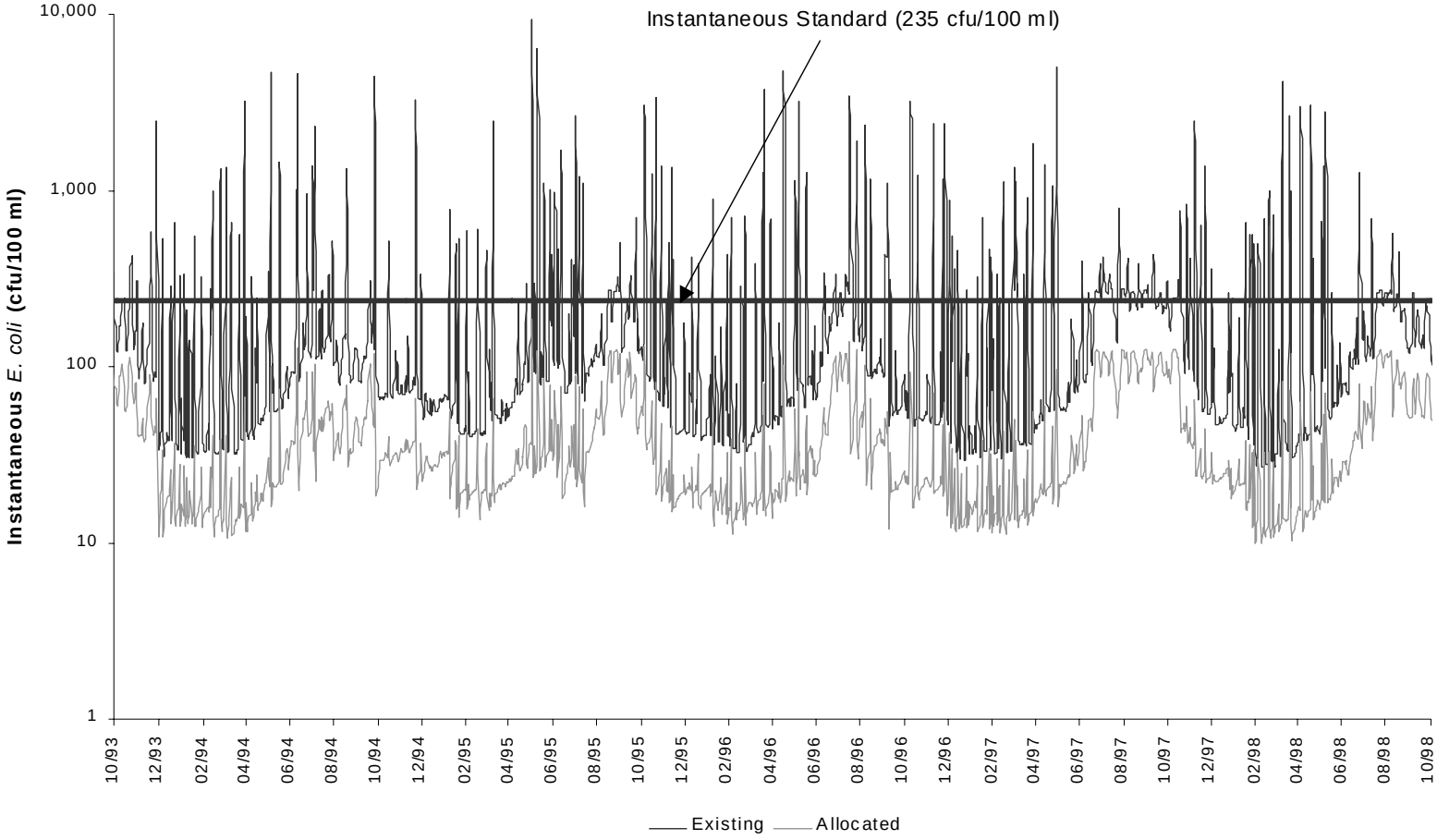

Figure 5.7 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 40, Bush River (2) impairment.

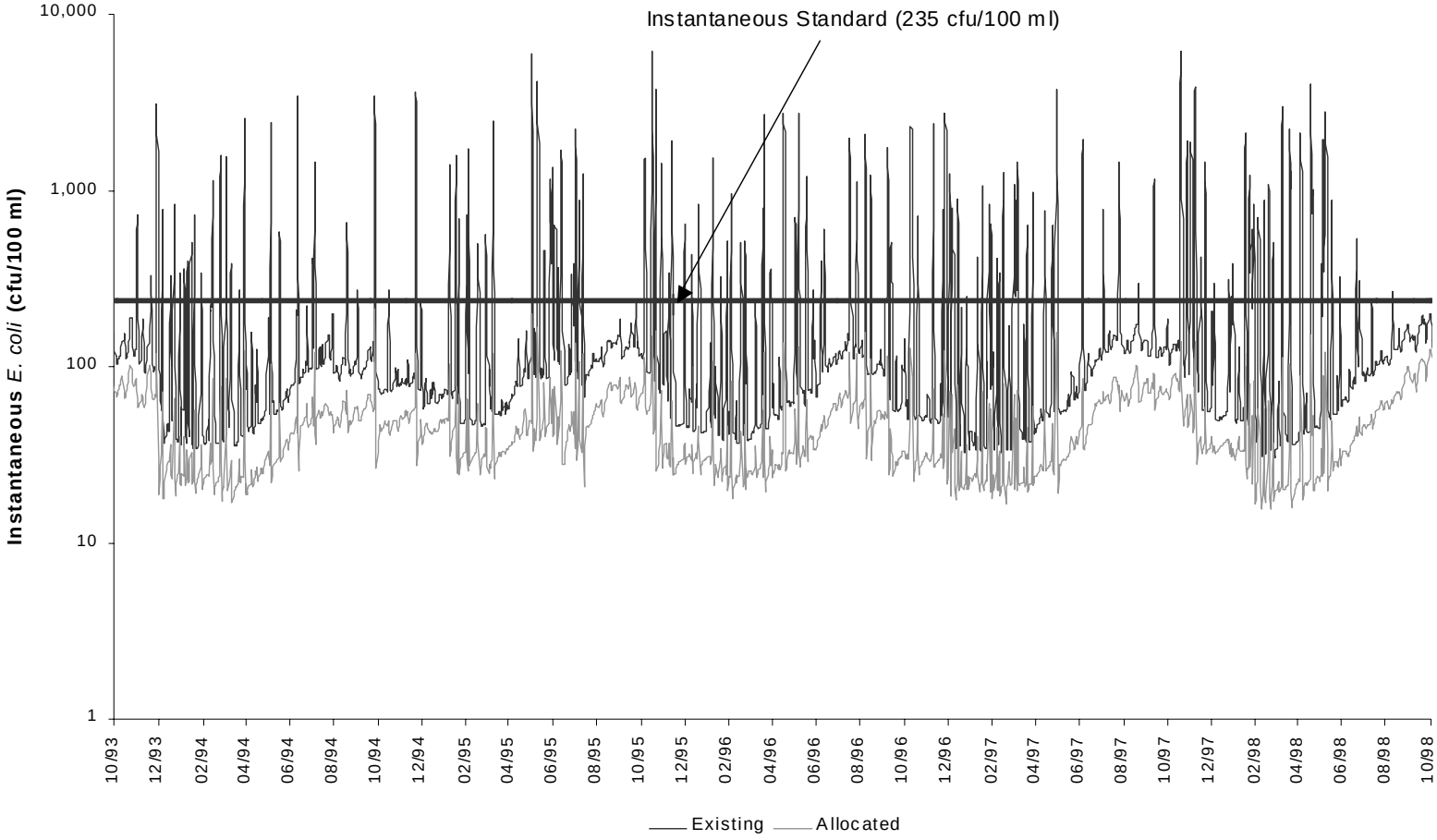

Figure 5.8 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 41, Appomattox River (1) impairment.

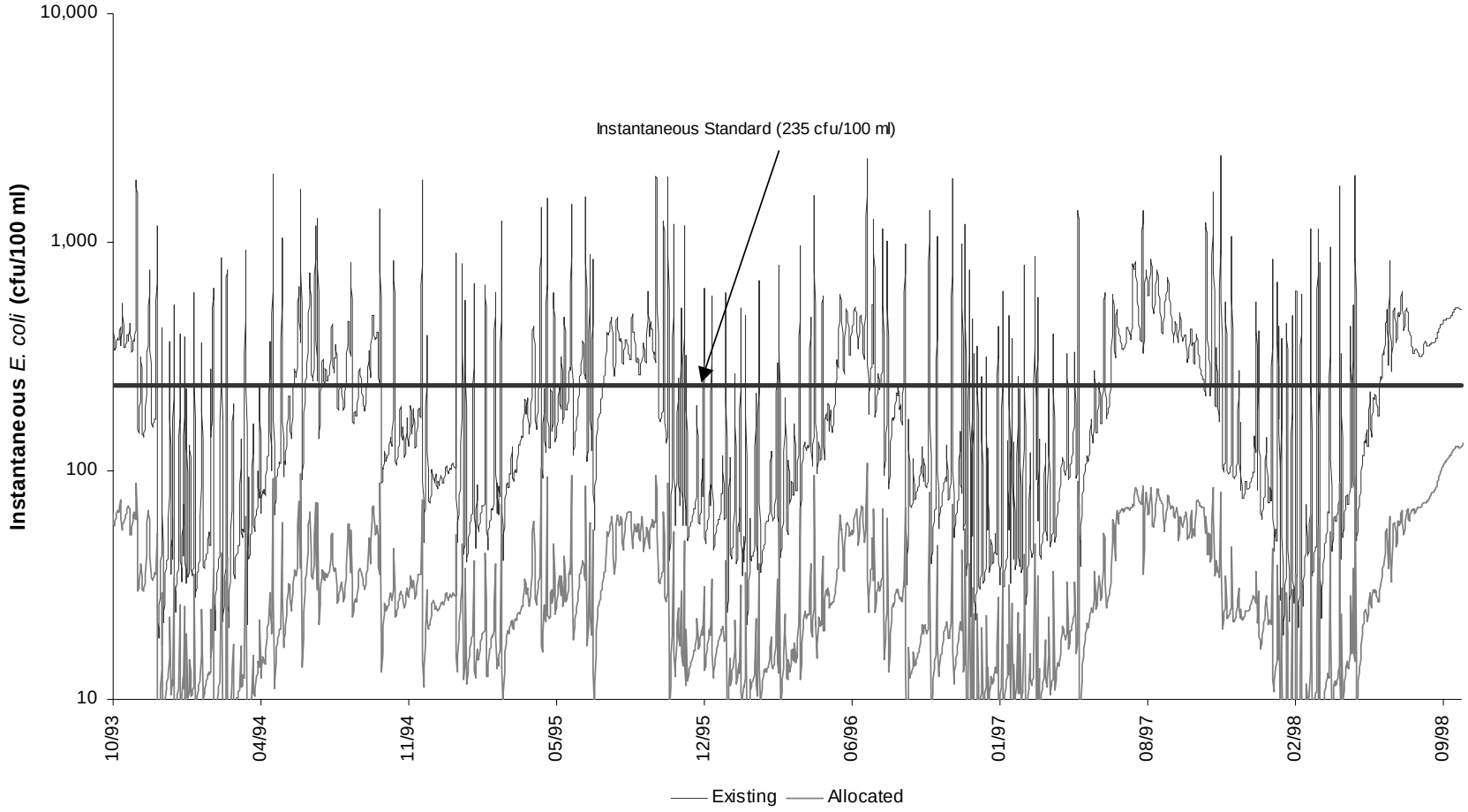

Figure 5.9 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 46, Saylers Creek impairment.

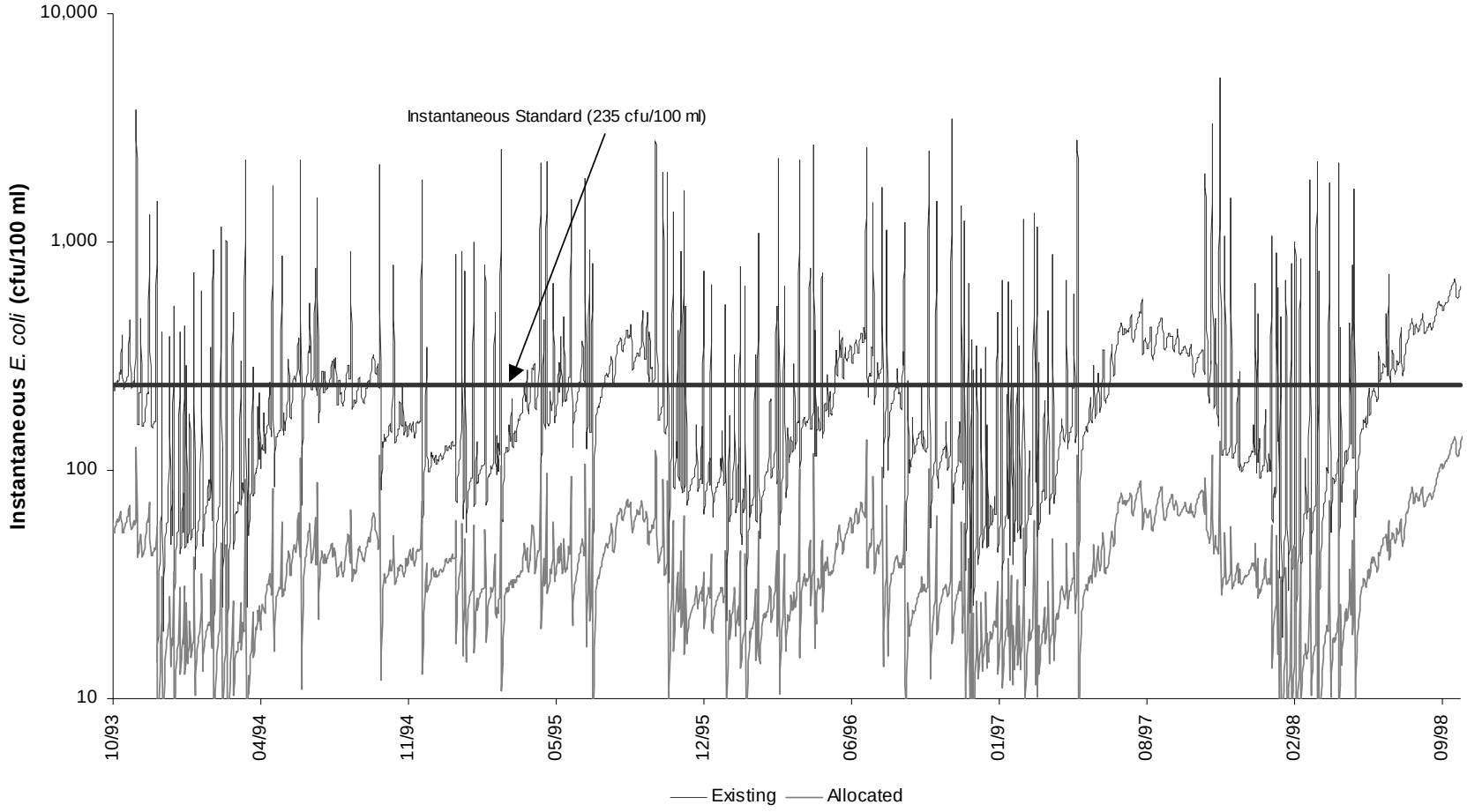

Figure 5.10 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 48, Angola Creek (1) impairment.

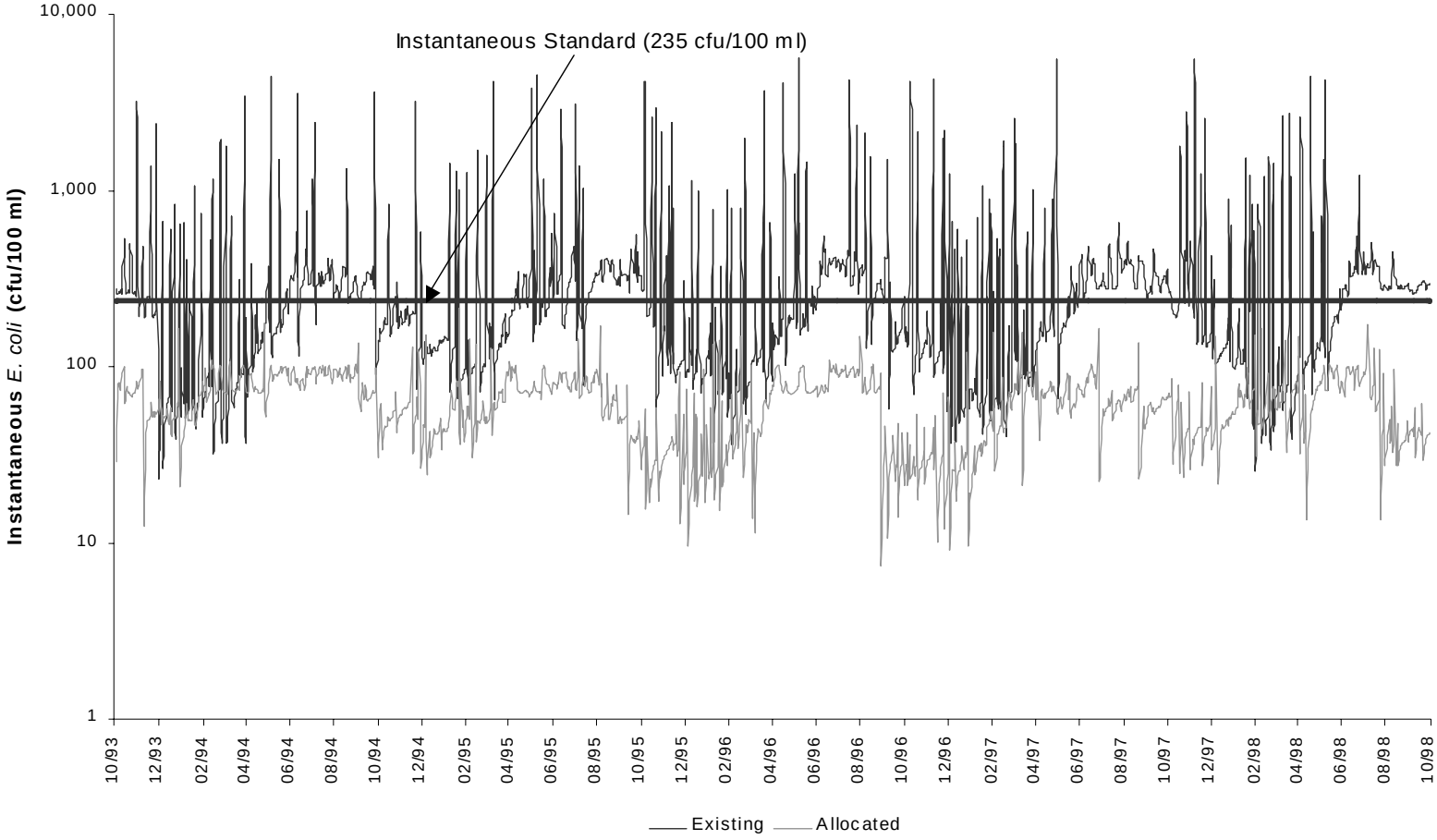

Figure 5.11 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 49, Angola Creek (2) impairment.

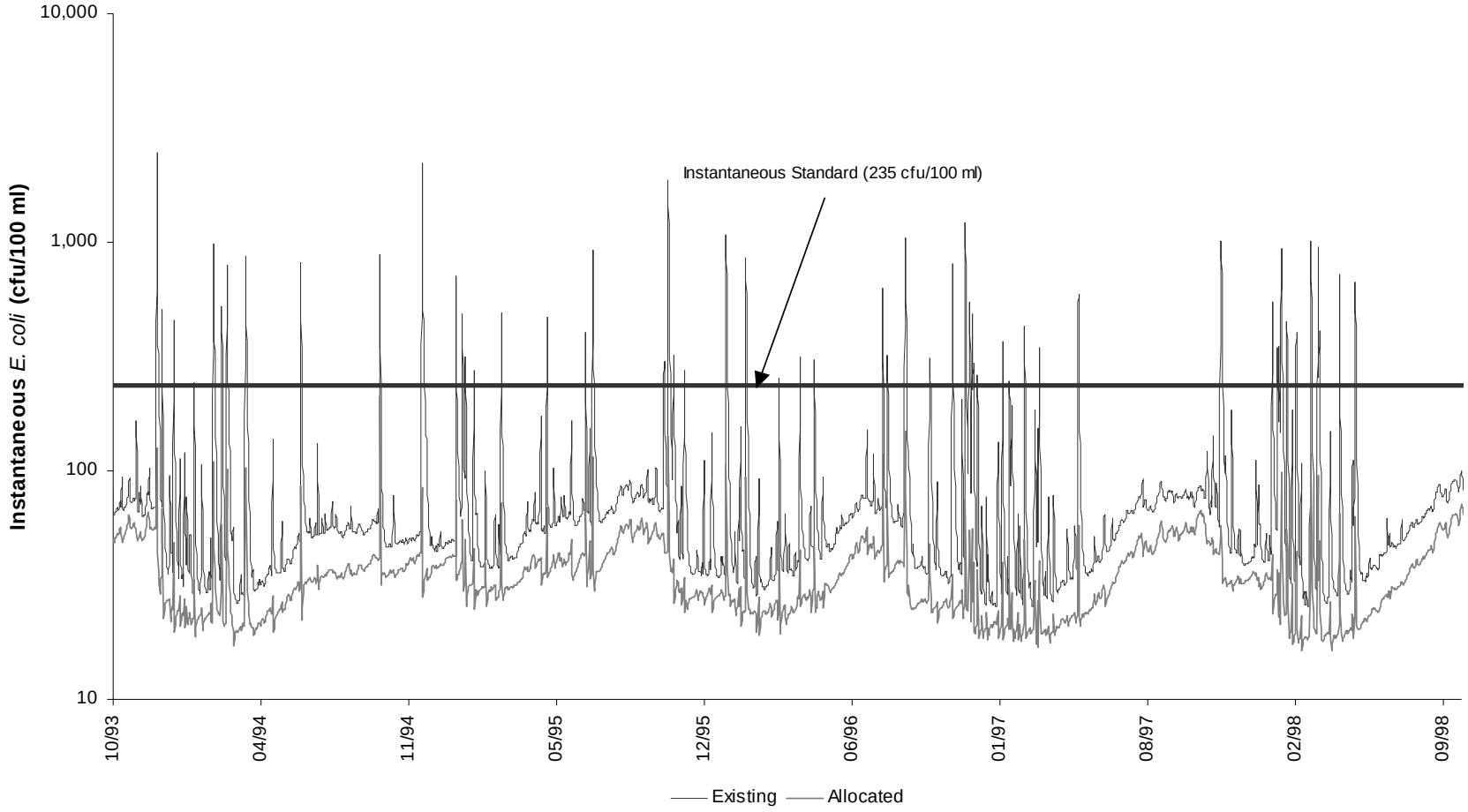

Figure 5.12 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 54, Horsepen Creek impairment.

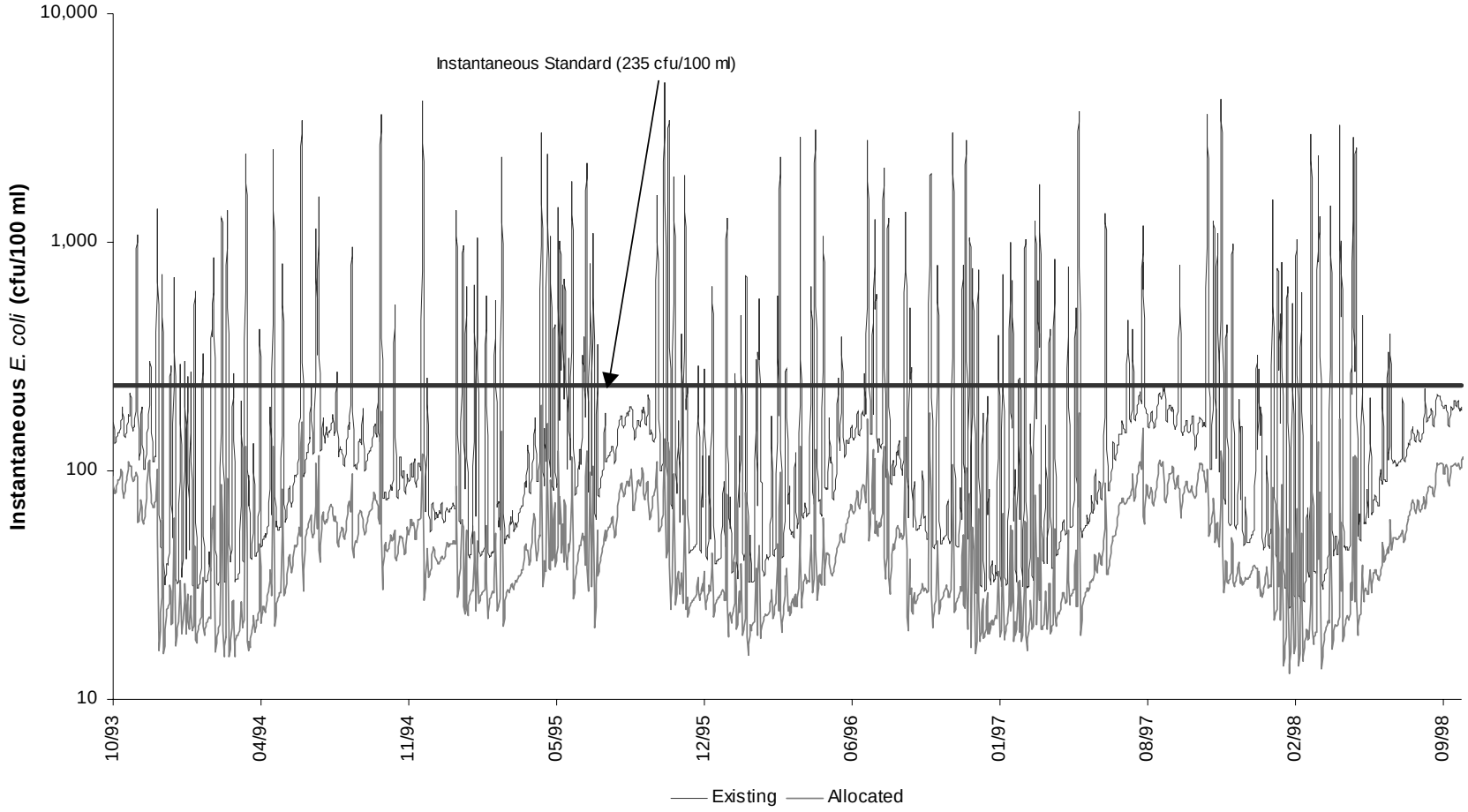

Figure 5.13 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 62, Appomattox River (1) impairment.

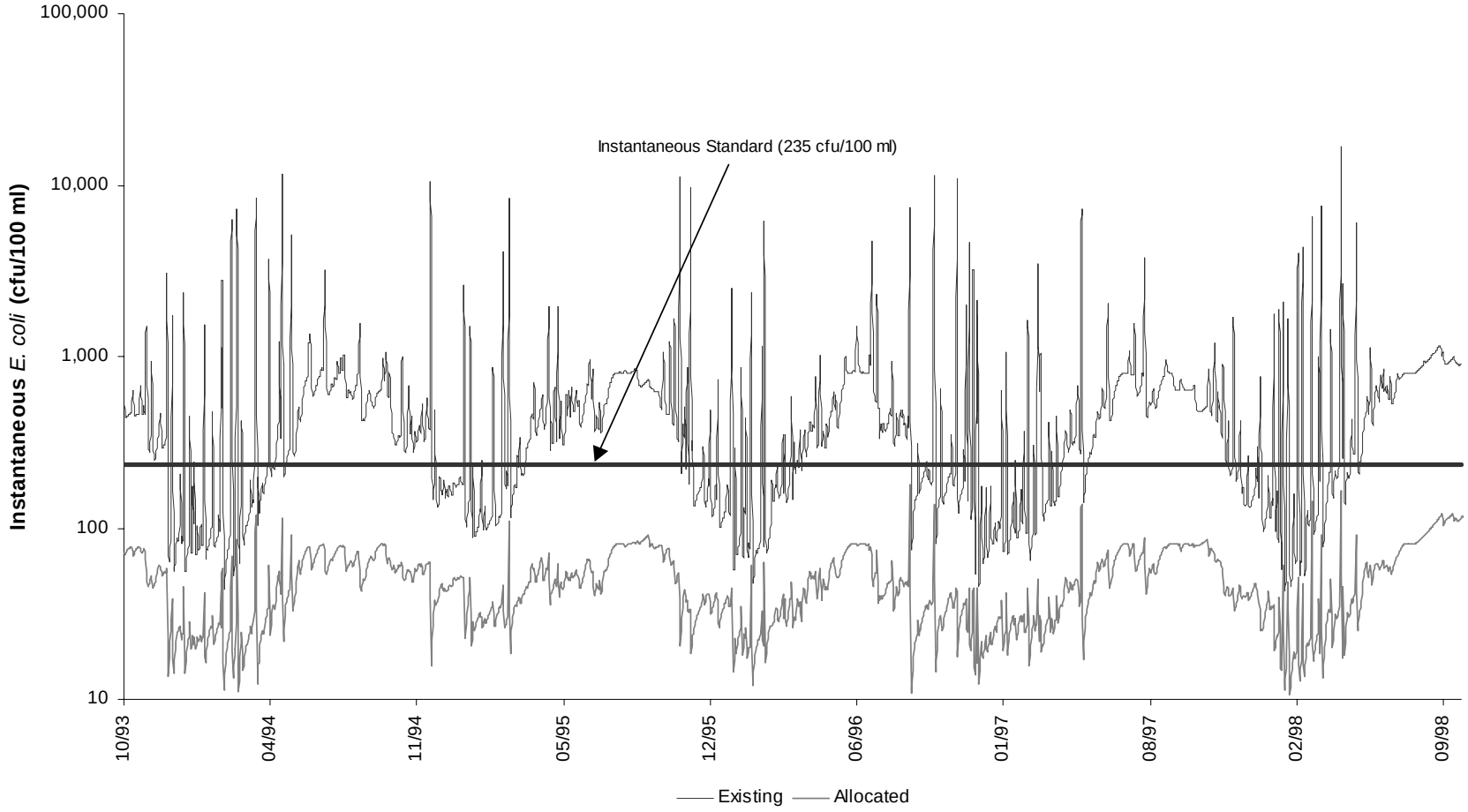

Figure 5.14 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 71, Nibbs Creek impairment.

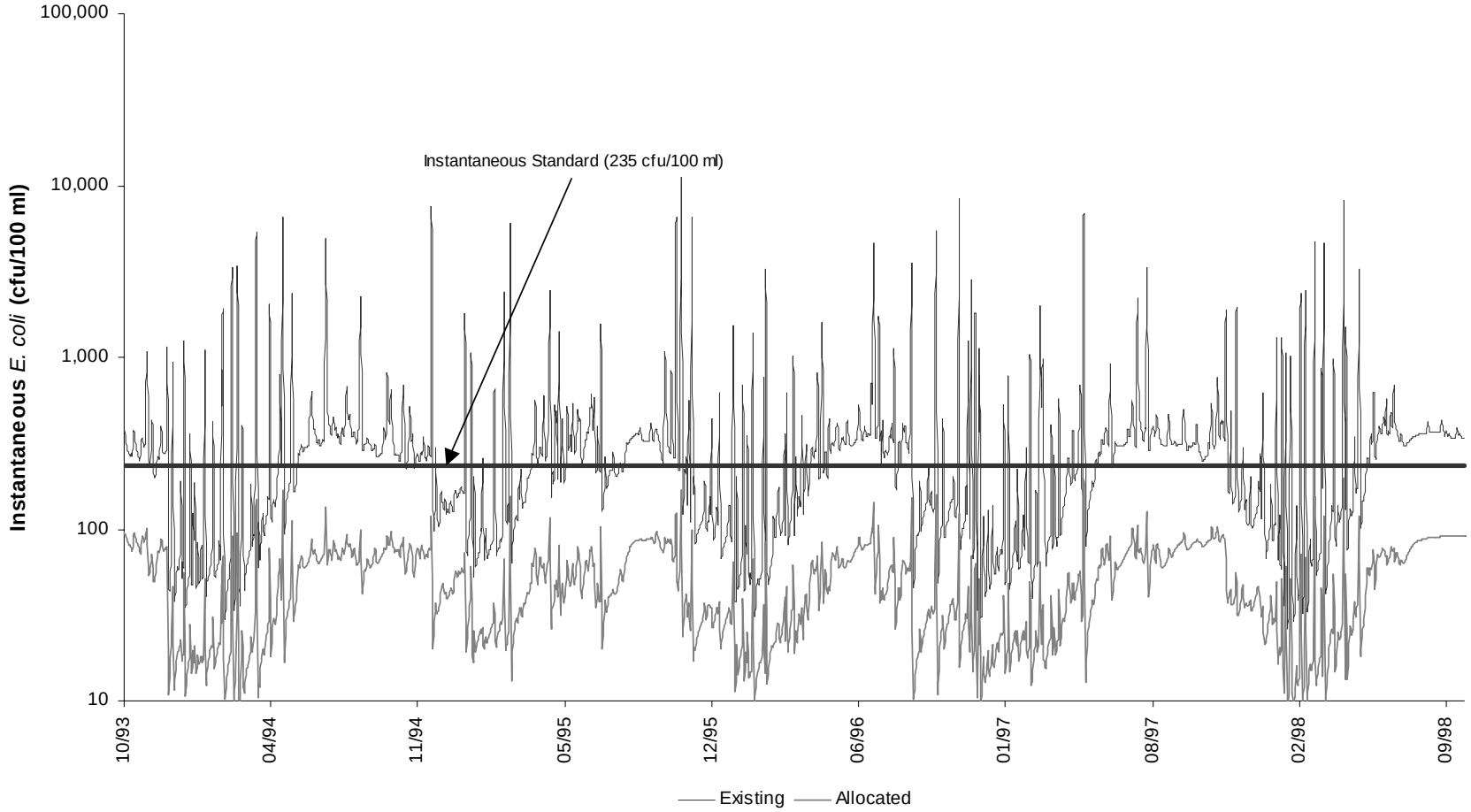

Figure 5.15 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 72, Flat Creek impairment.

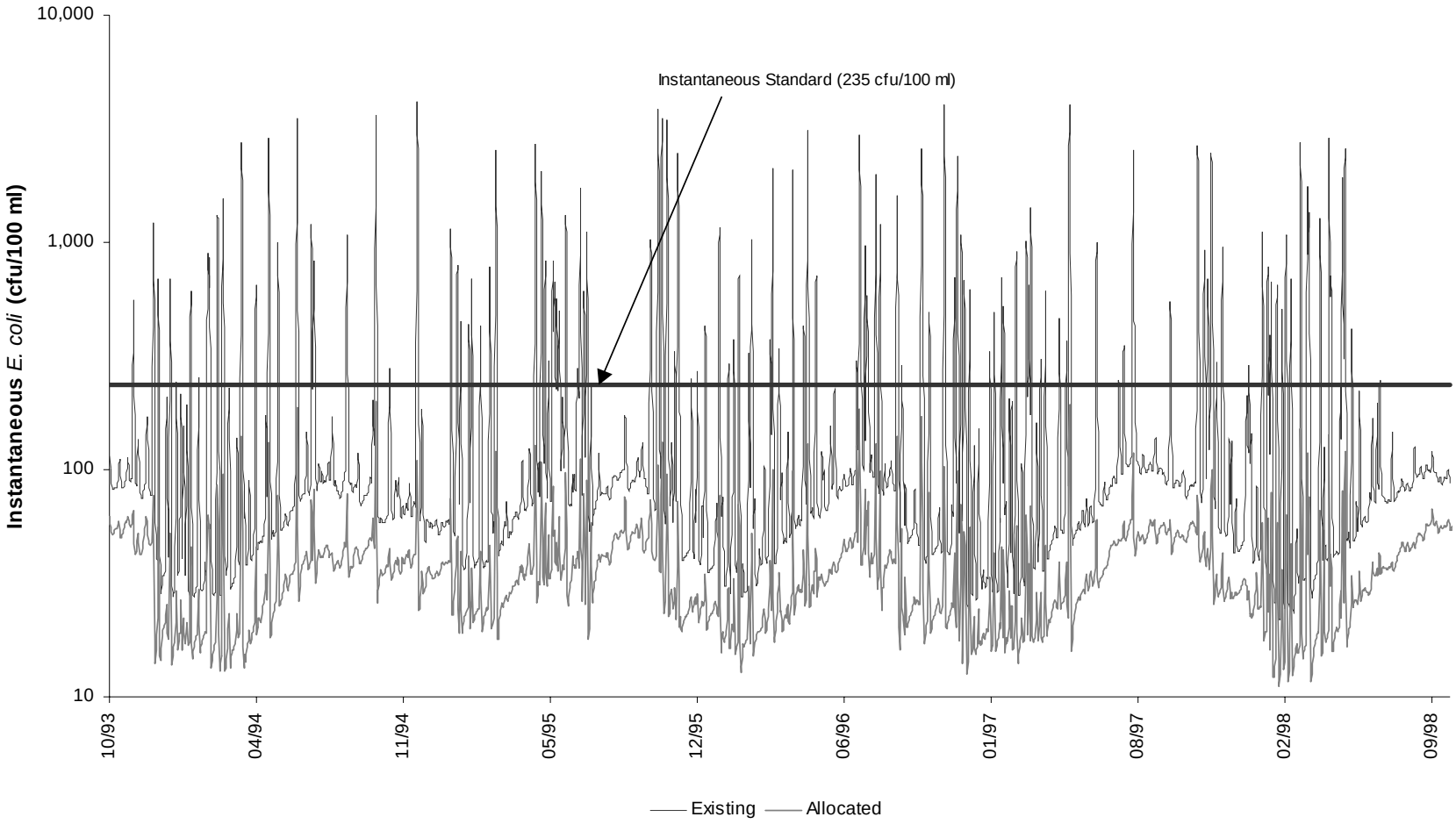

Figure 5.16 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 77, Appomattox River (1) impairment.

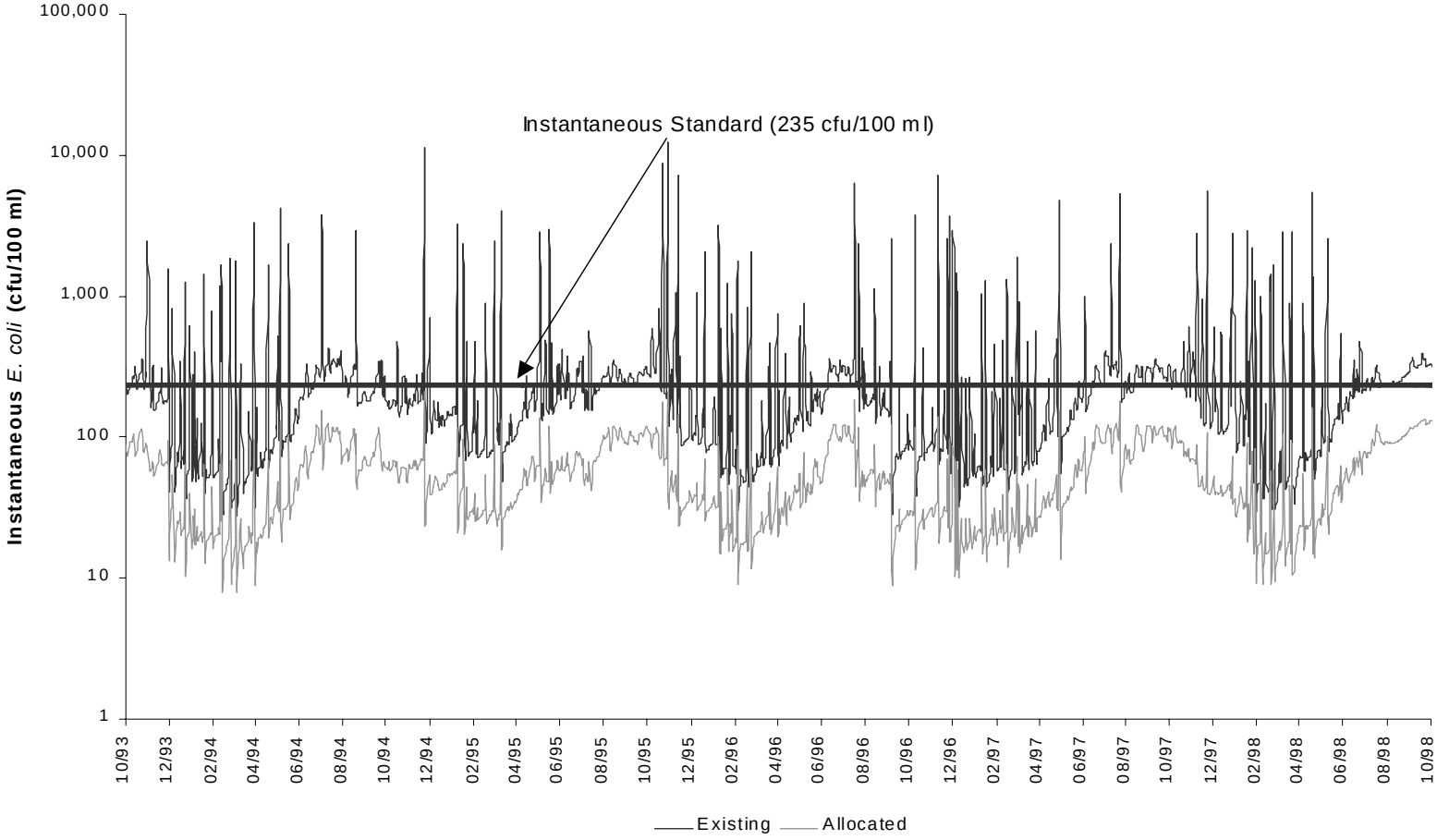

Figure 5.17 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 94, West Creek impairment.

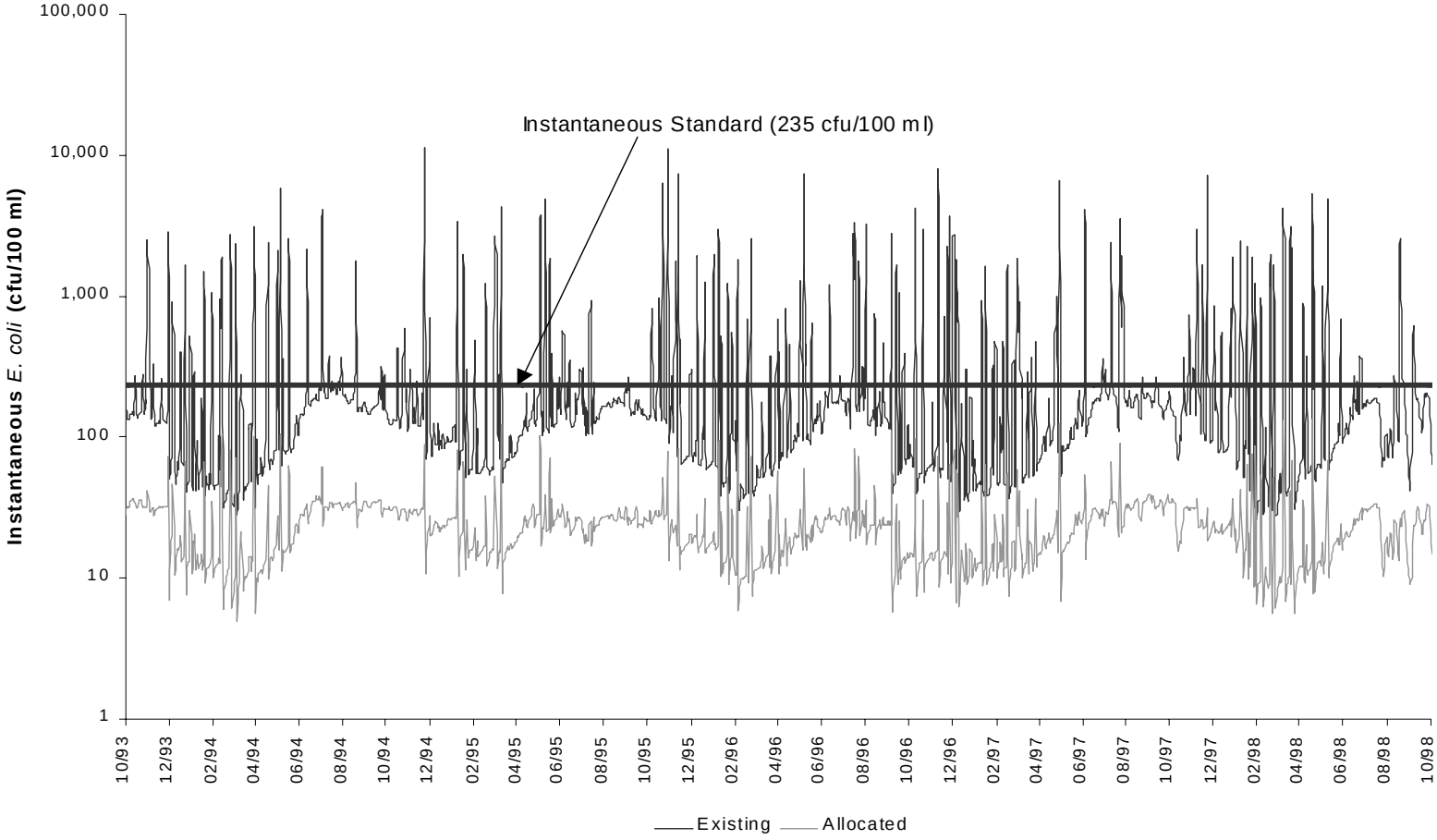

Figure 5.18 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 97, Deep Creek impairment.

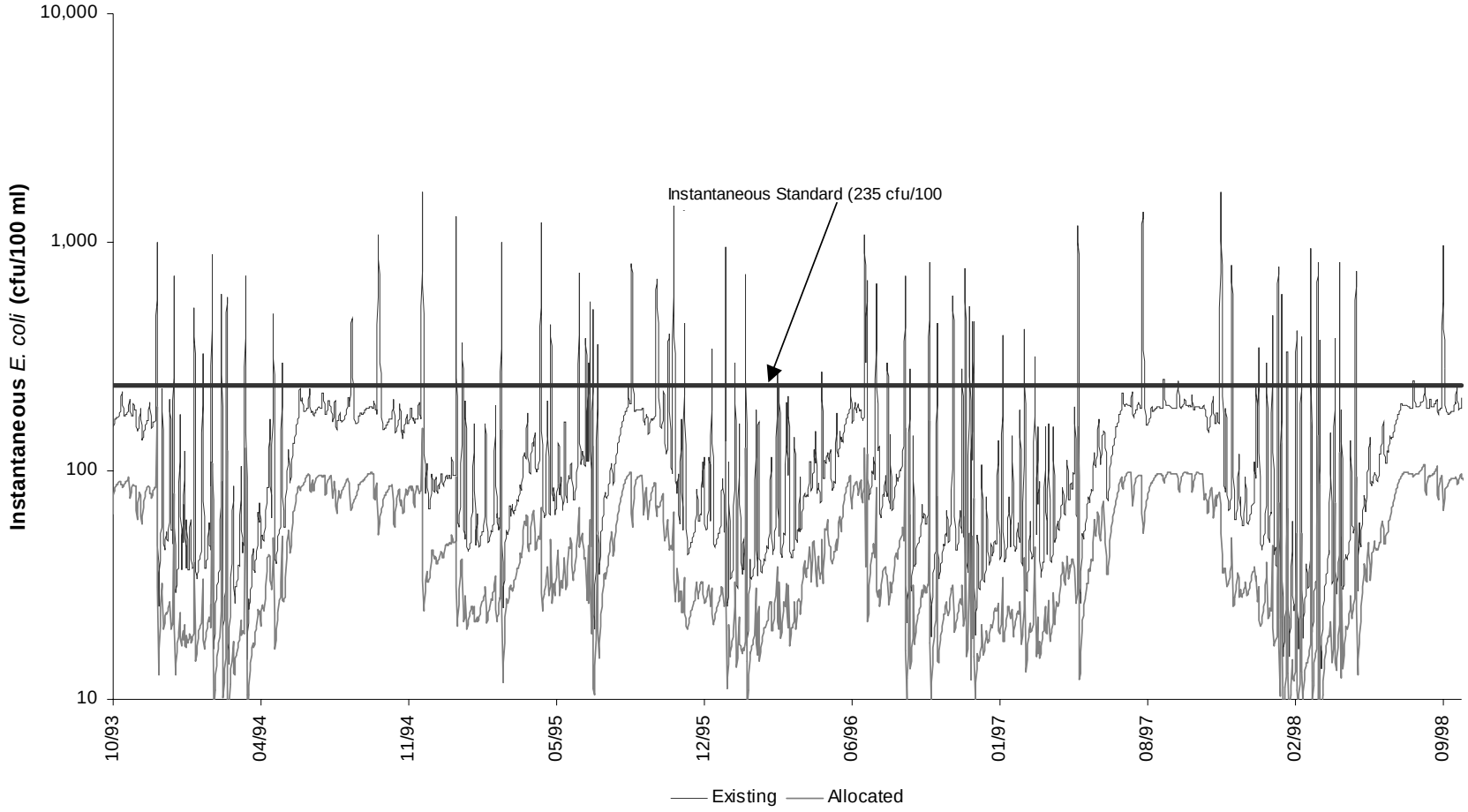

Figure 5.19 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 126, Swift Creek (1) impairment.

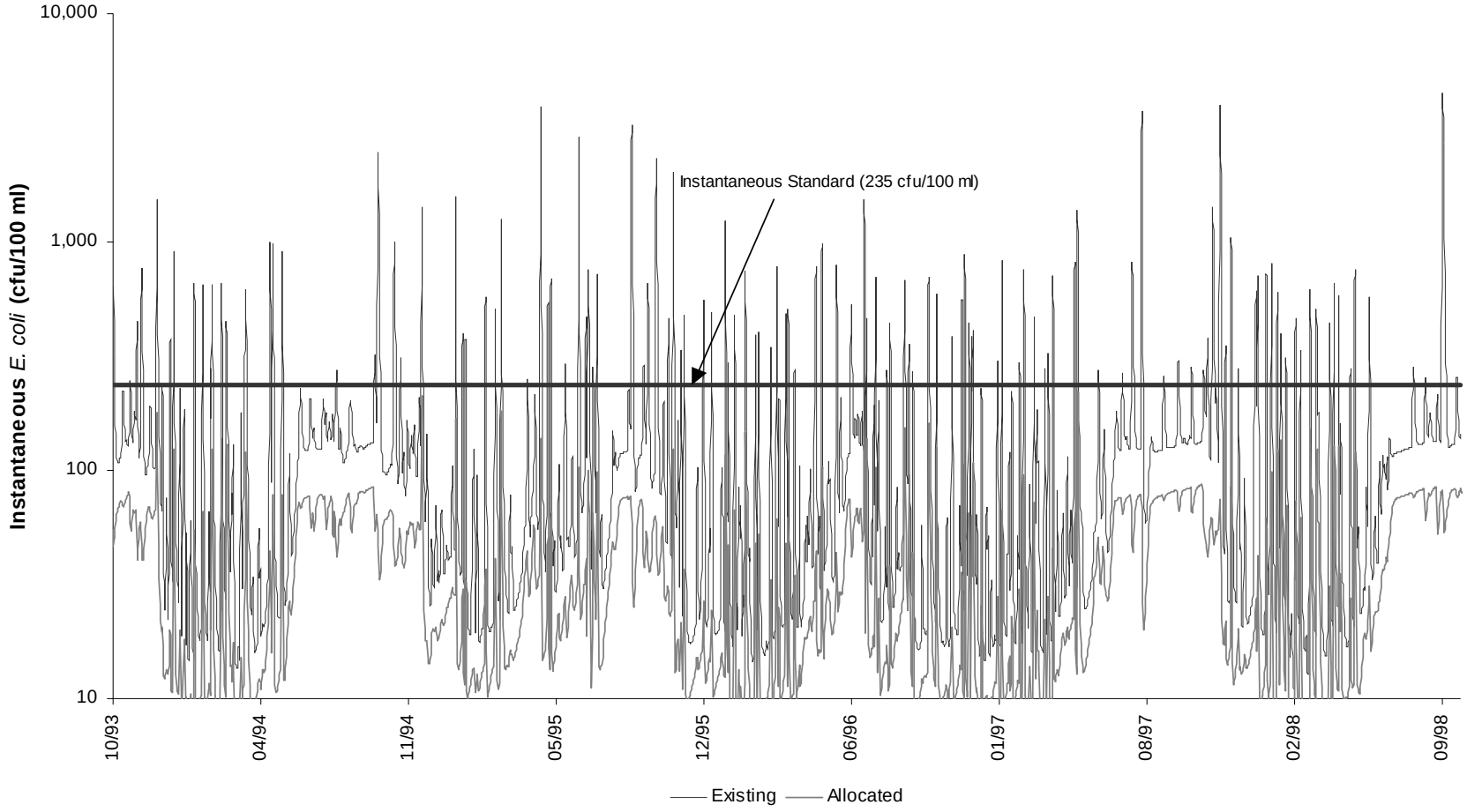

Figure 5.20 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 138, Swift Creek (2) impairment.

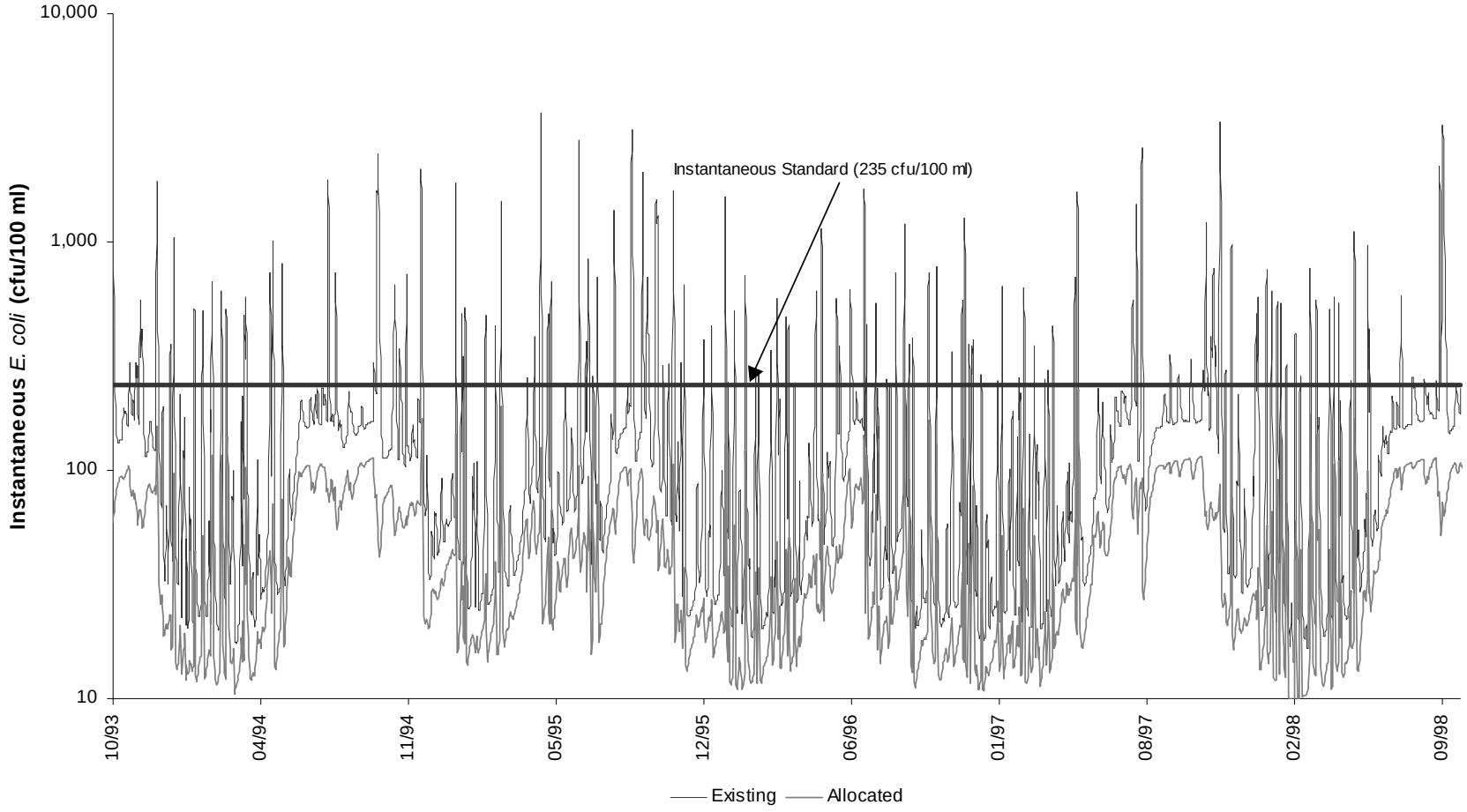

Figure 5.21 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 143, Swift Creek (3) impairment.

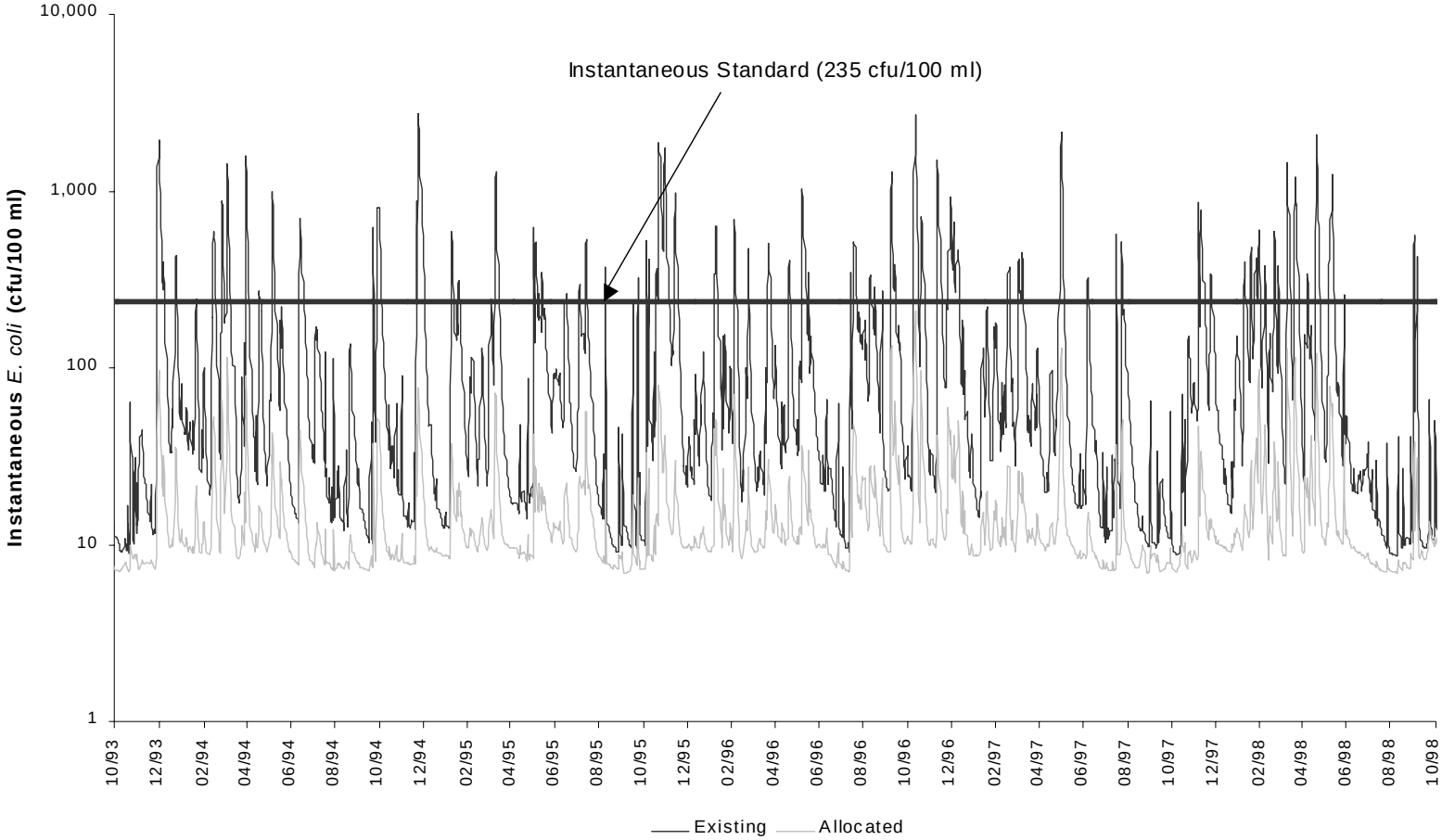

Figure 5.22 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 118, Appomattox River (2) impairment.

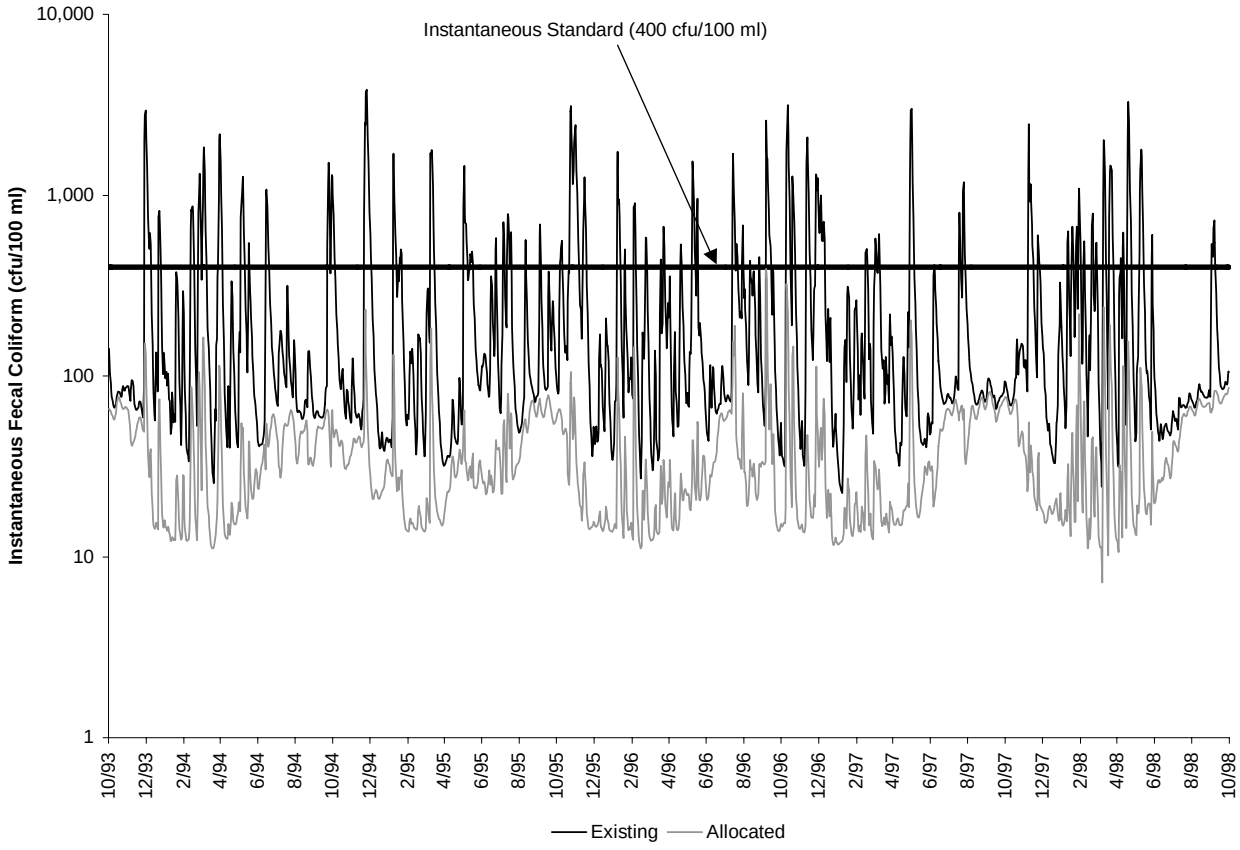

Figure 5.23 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 149, Appomattox River (3) impairment.

Figures 5.24 through 5.45 show the monthly geometric mean concentrations for existing and allocated conditions for all impairments in the Appomattox River basin. These graphs show existing conditions in black, with allocated conditions overlaid in gray. The monthly geometric mean is calculated from the daily average *E. coli* concentration predicted by the water quality model, and is grouped by calendar month.

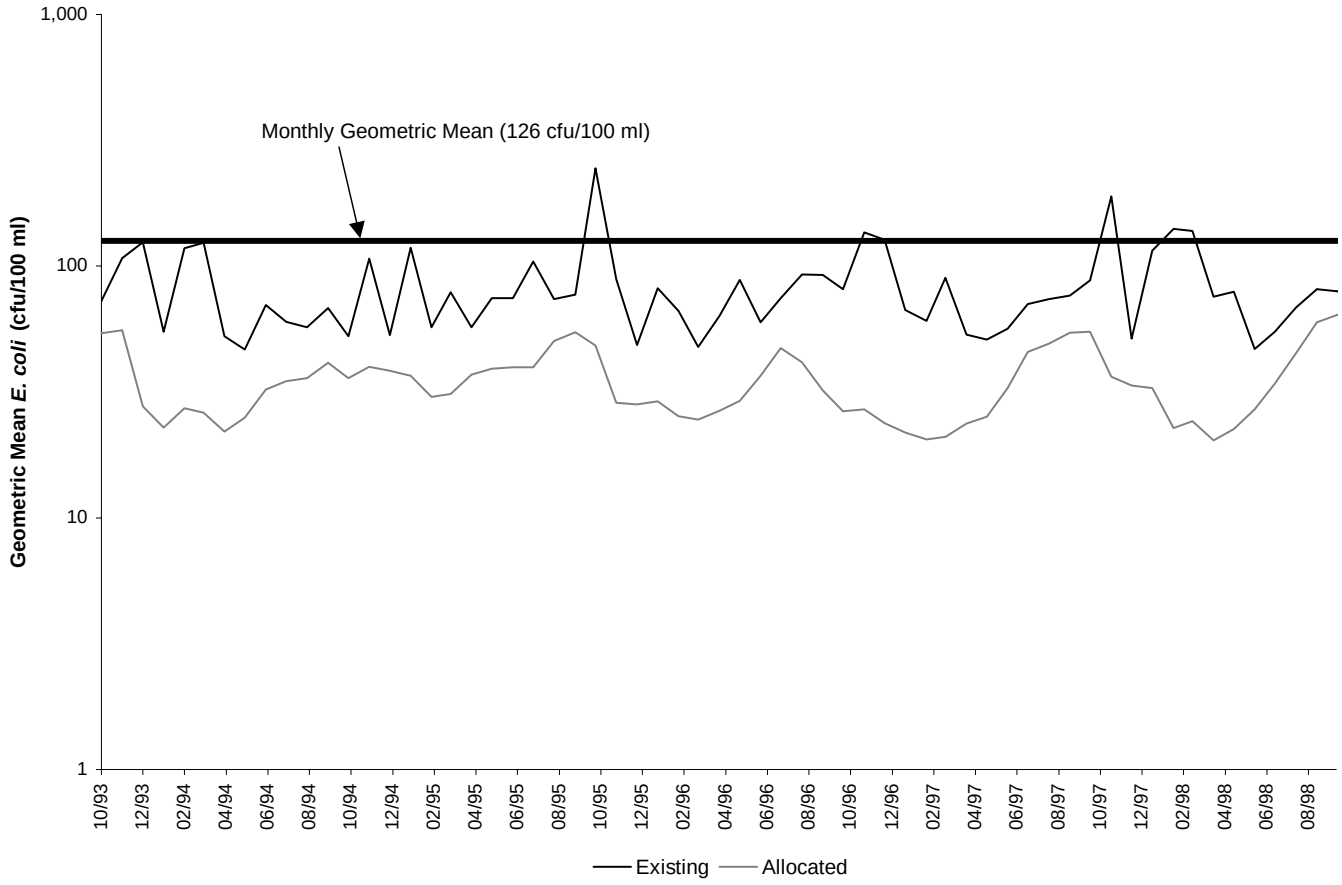

Figure 5.24 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 17, Spring Creek impairment.

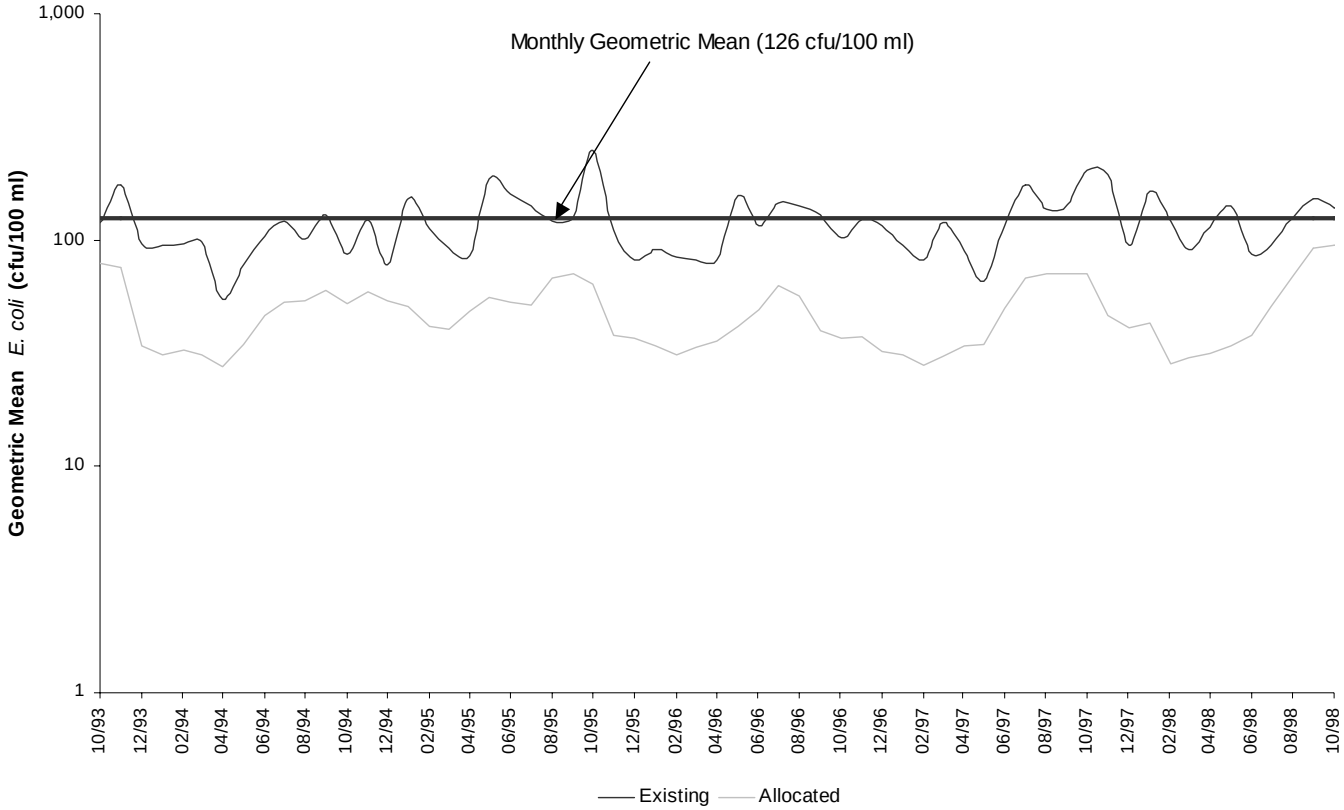

Figure 5.25 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 23, Appomattox River (1) impairment.

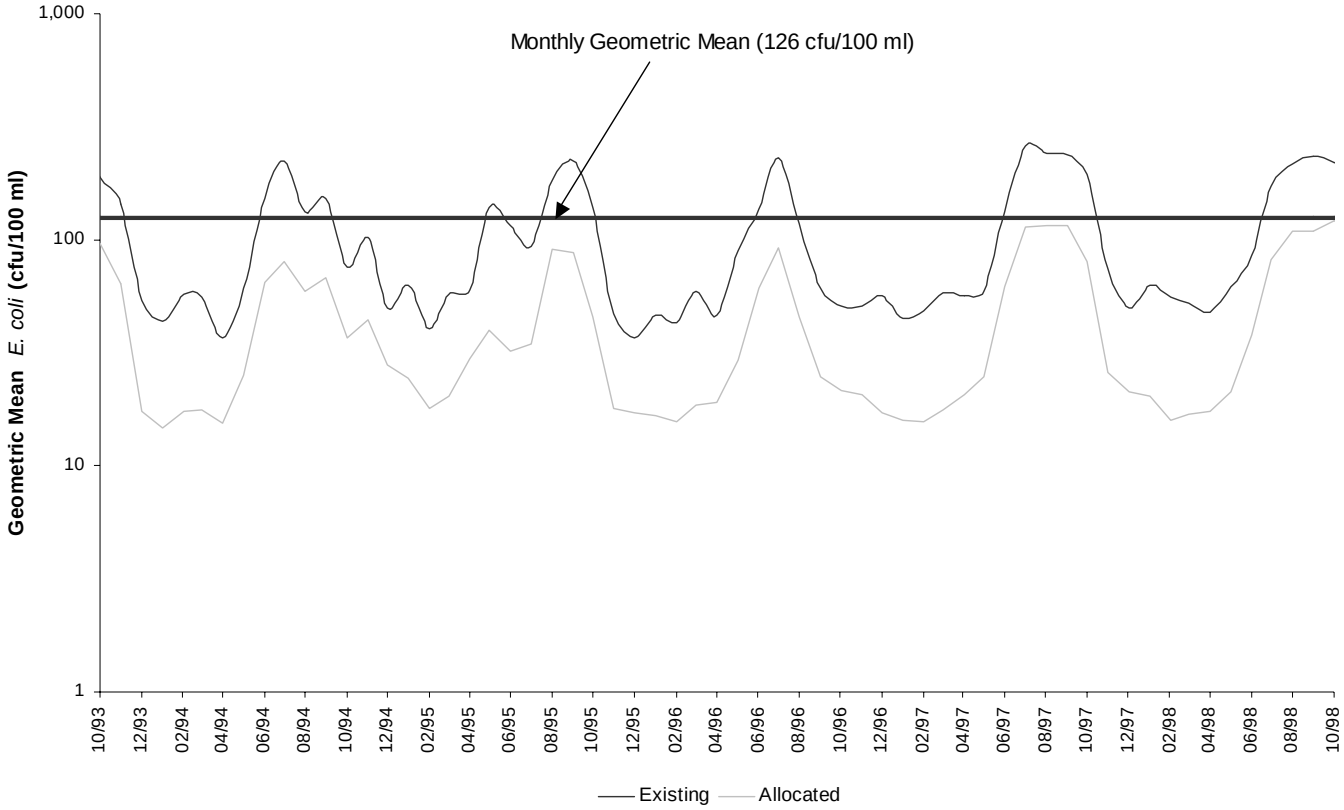

Figure 5.26 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 28, Briery Creek impairment.

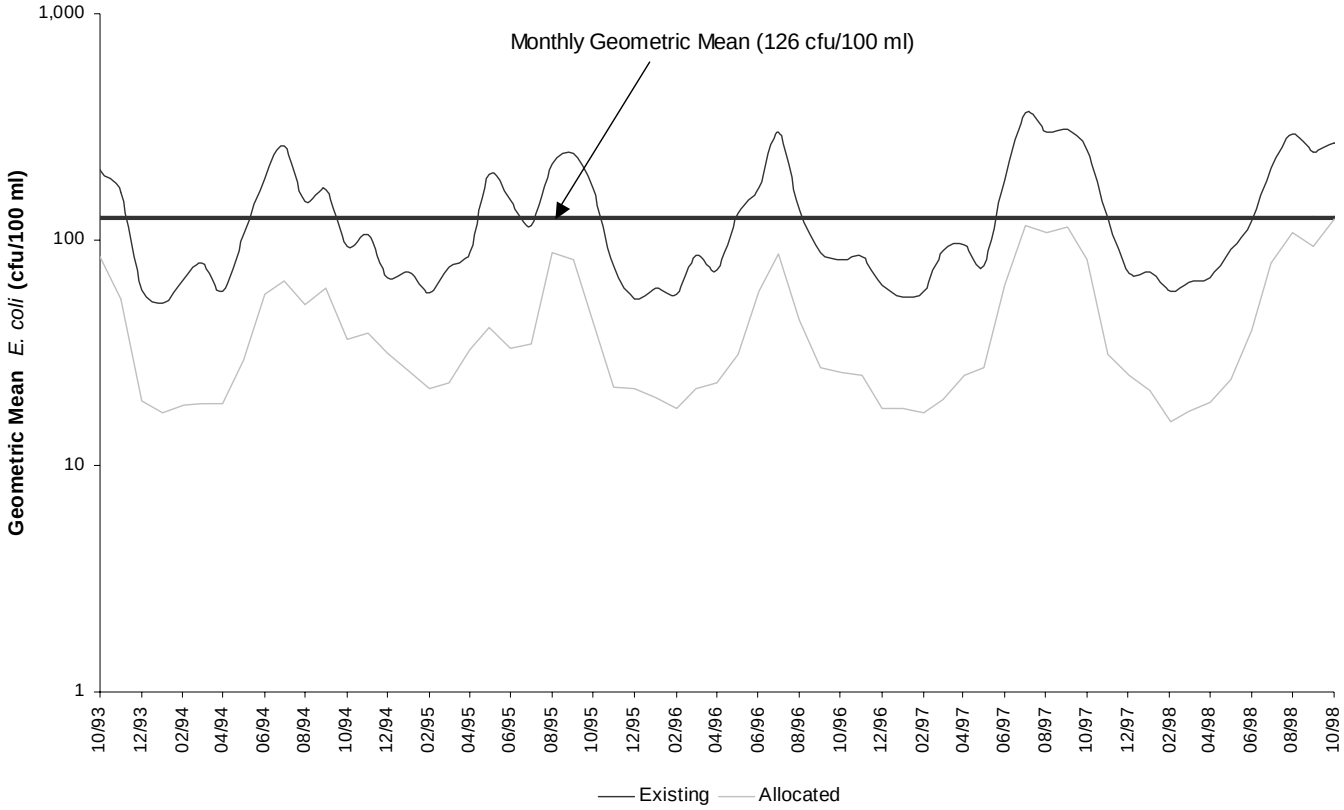

Figure 5.27 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 33, Bush River (1) impairment.

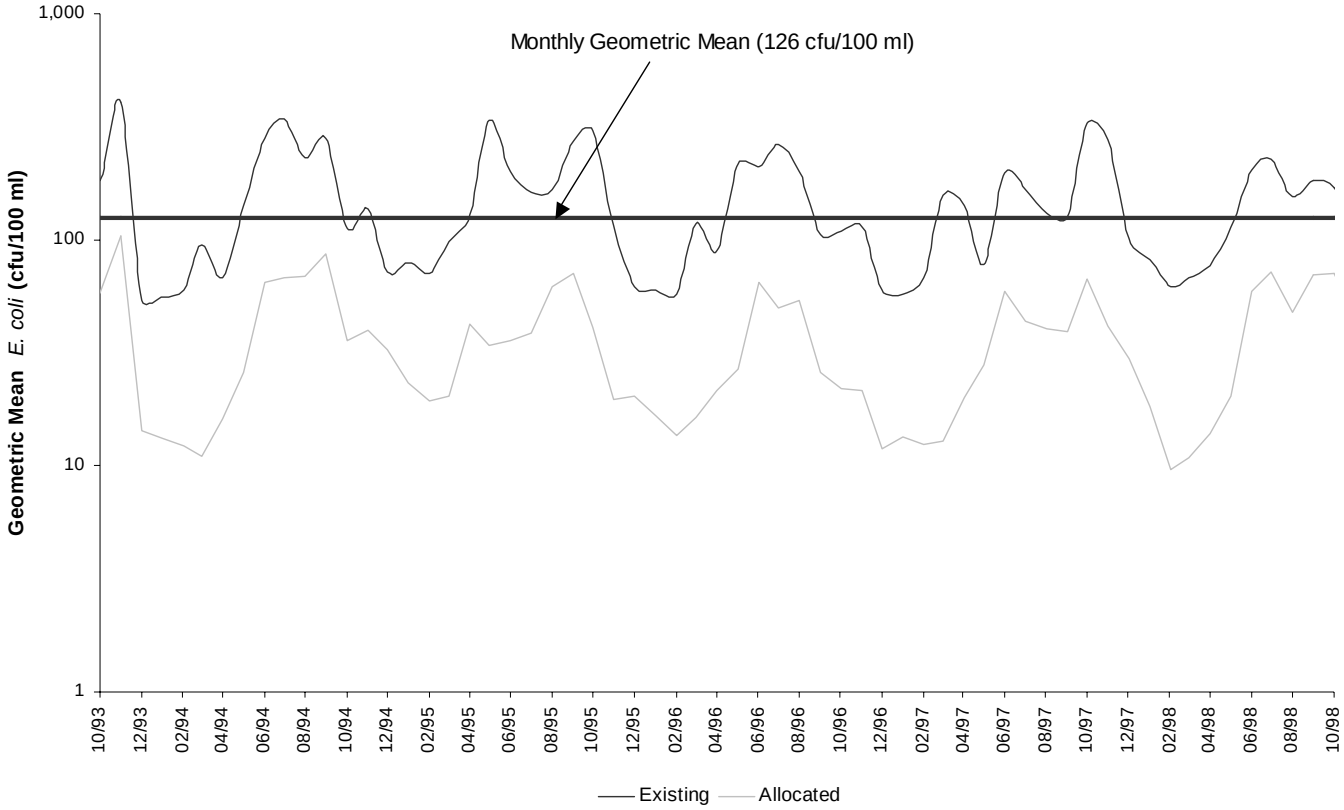

Figure 5.28 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 34, Little Sandy Creek impairment.

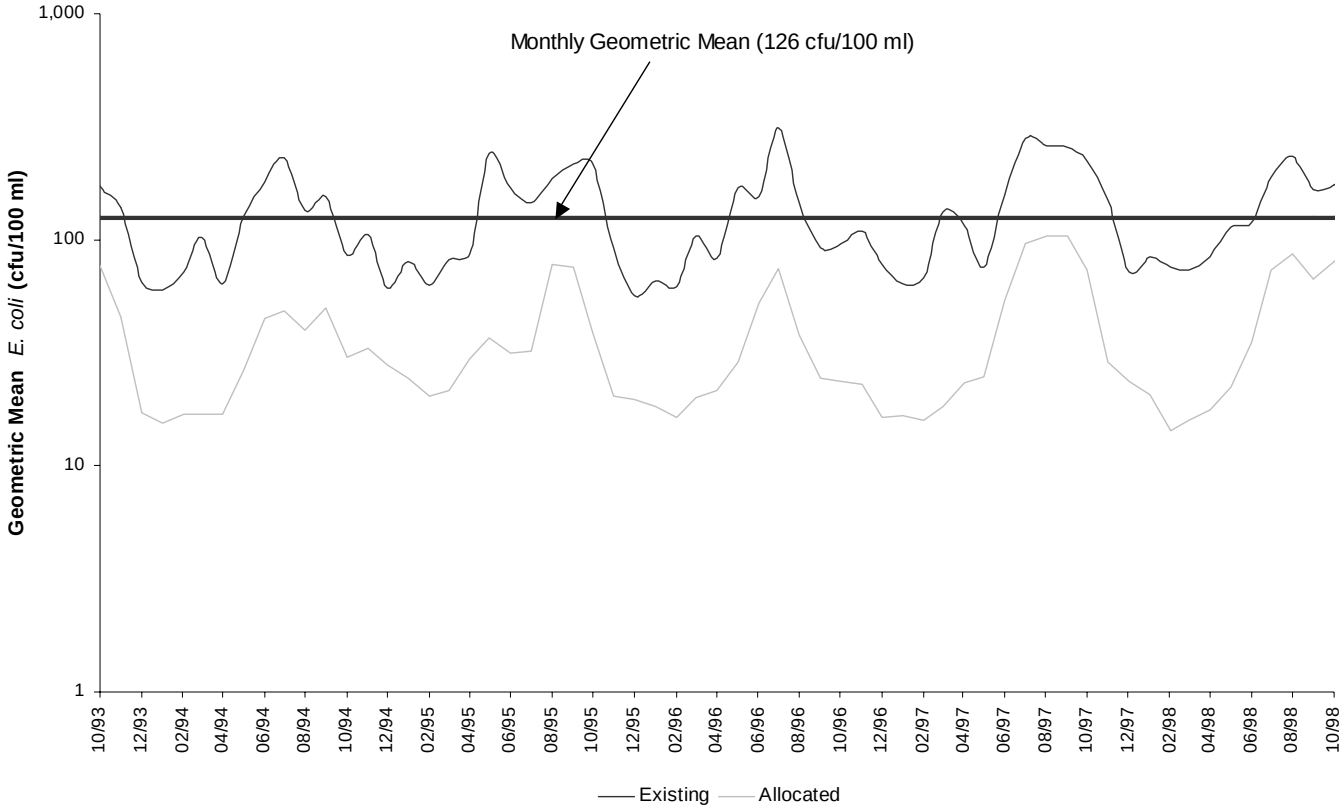

Figure 5.29 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 40, Bush River (2) impairment.

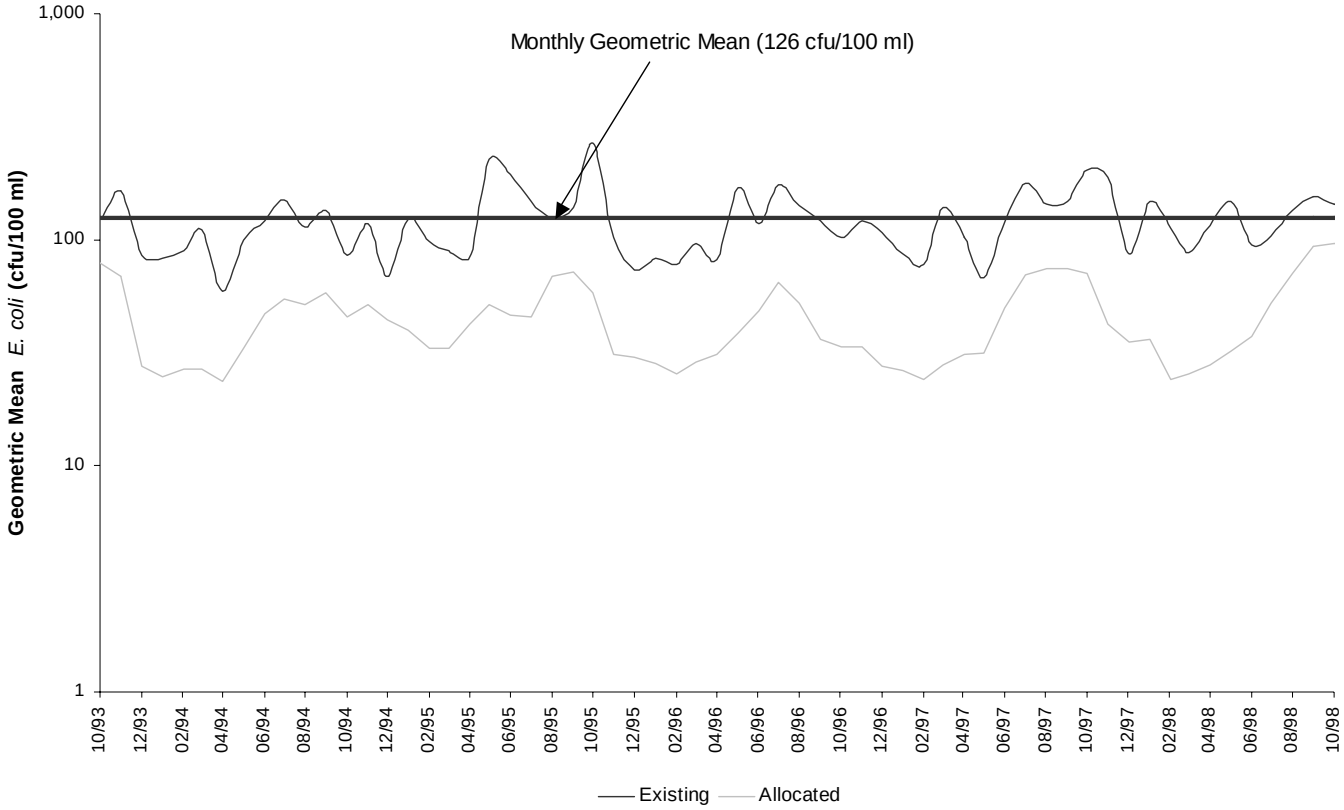

Figure 5.30 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 41, Appomattox River (1) impairment.

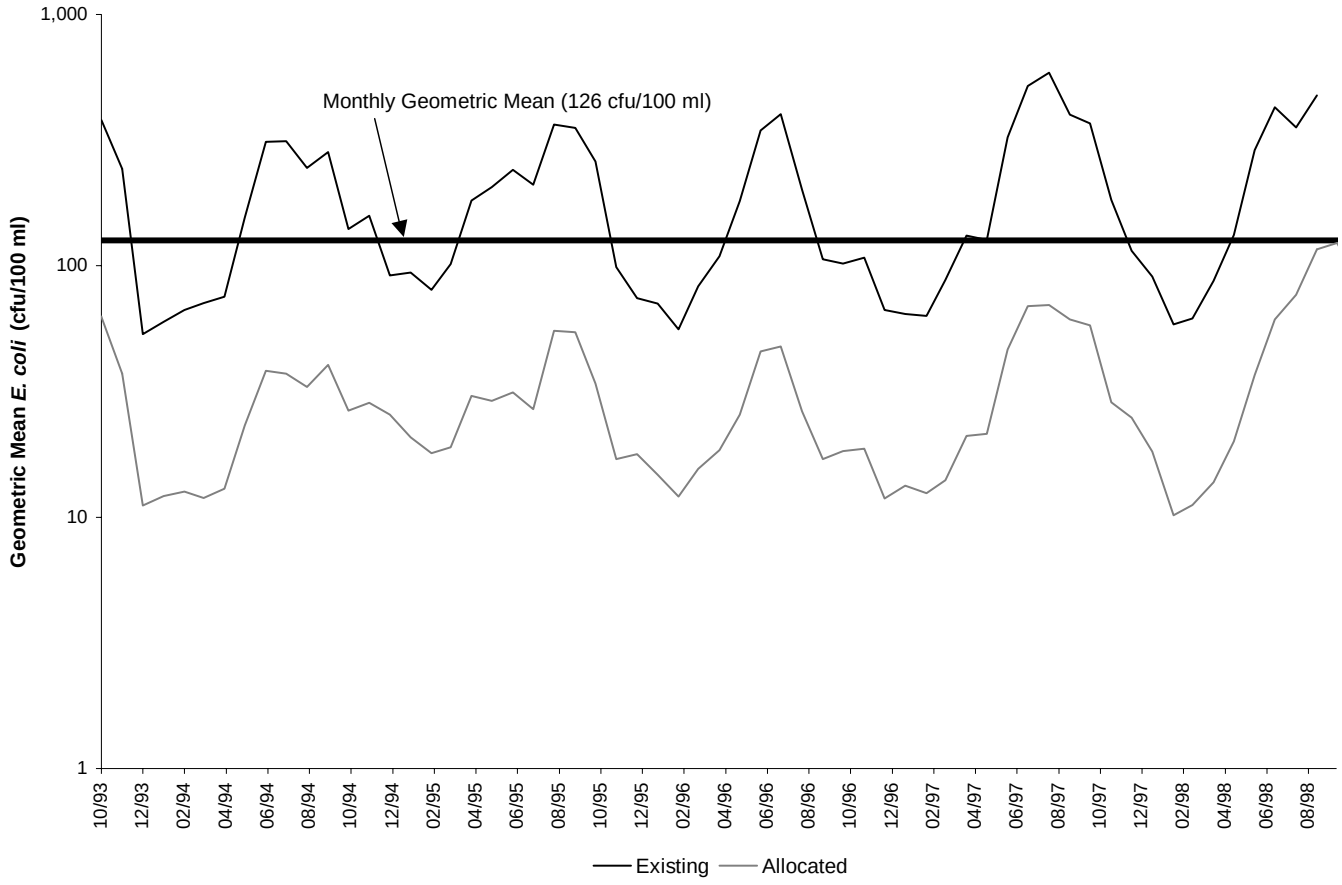

Figure 5.31 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 46, Saylers Creek impairment.

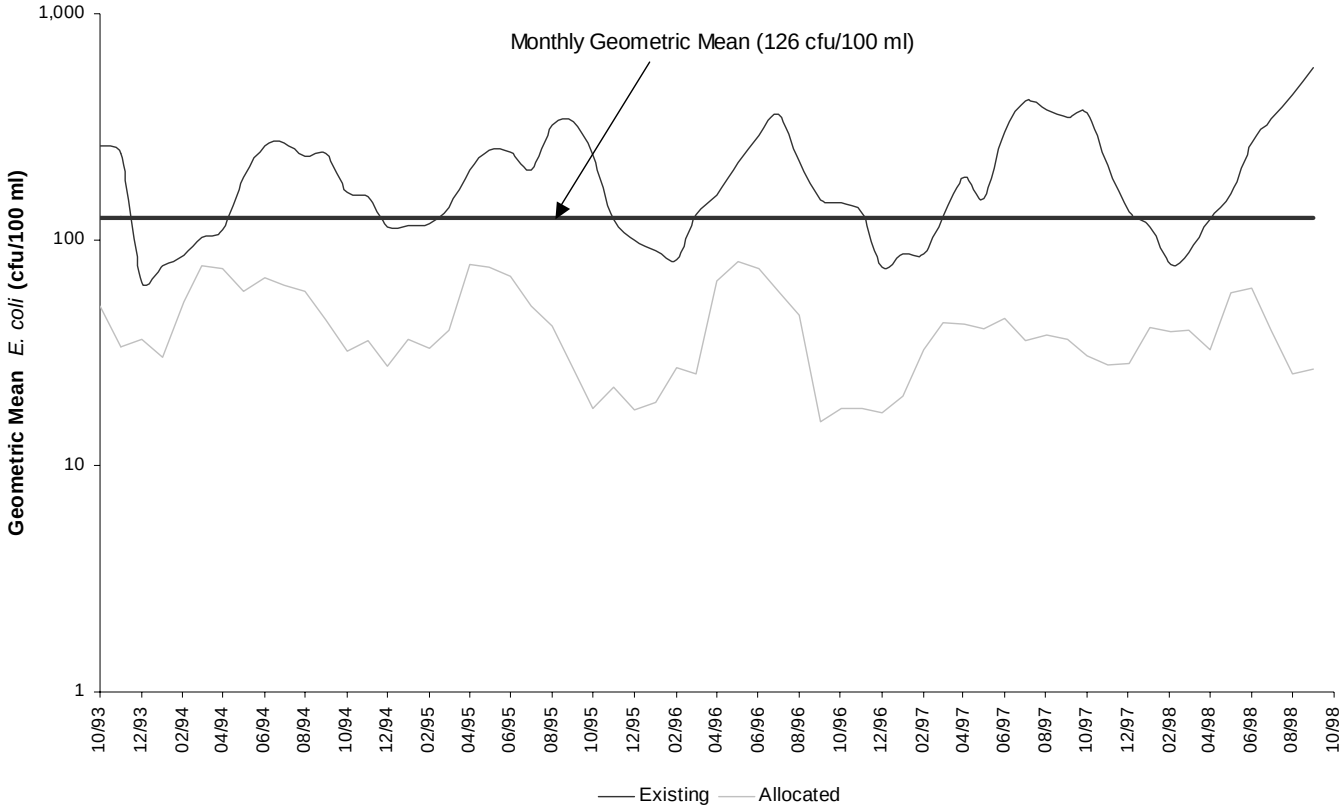

Figure 5.32 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 48, Angola Creek (1) impairment.

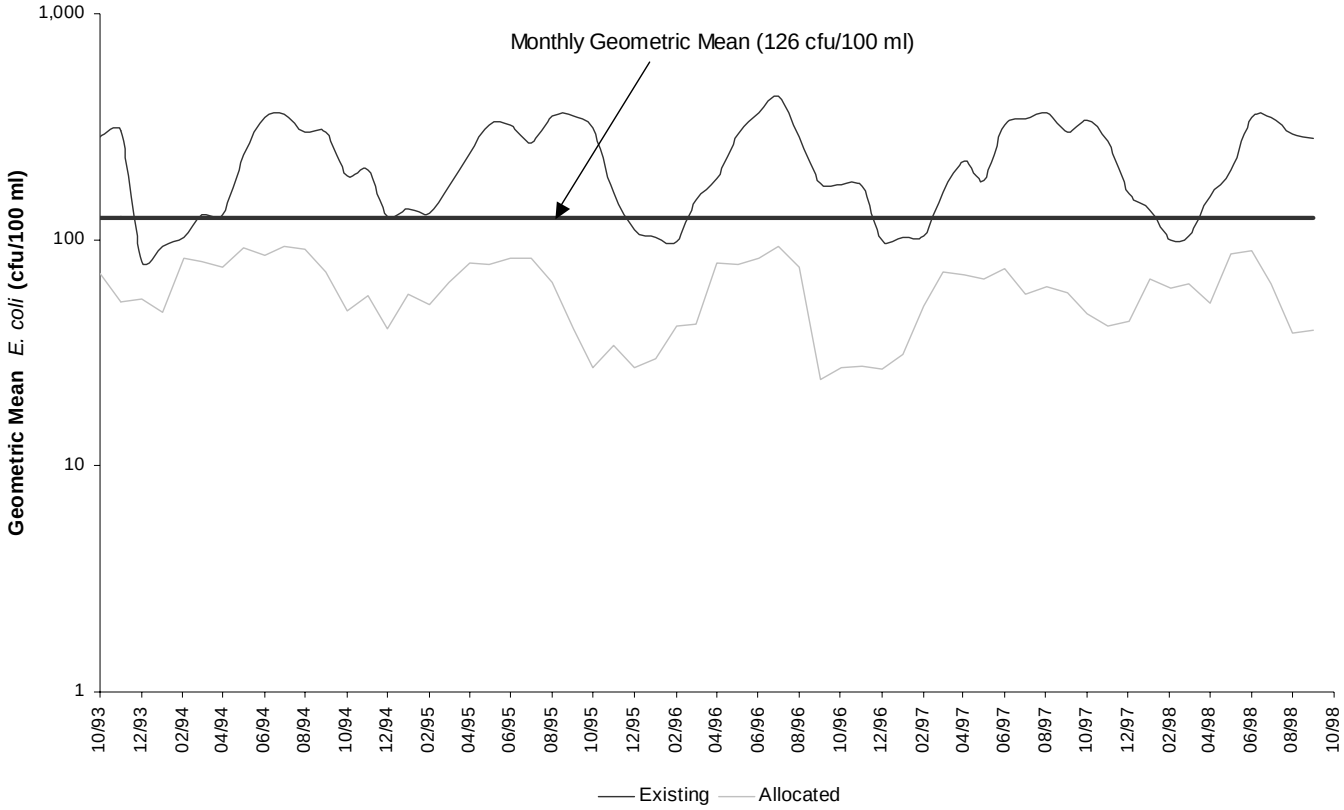

Figure 5.33 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 49, Angola Creek (2) impairment.

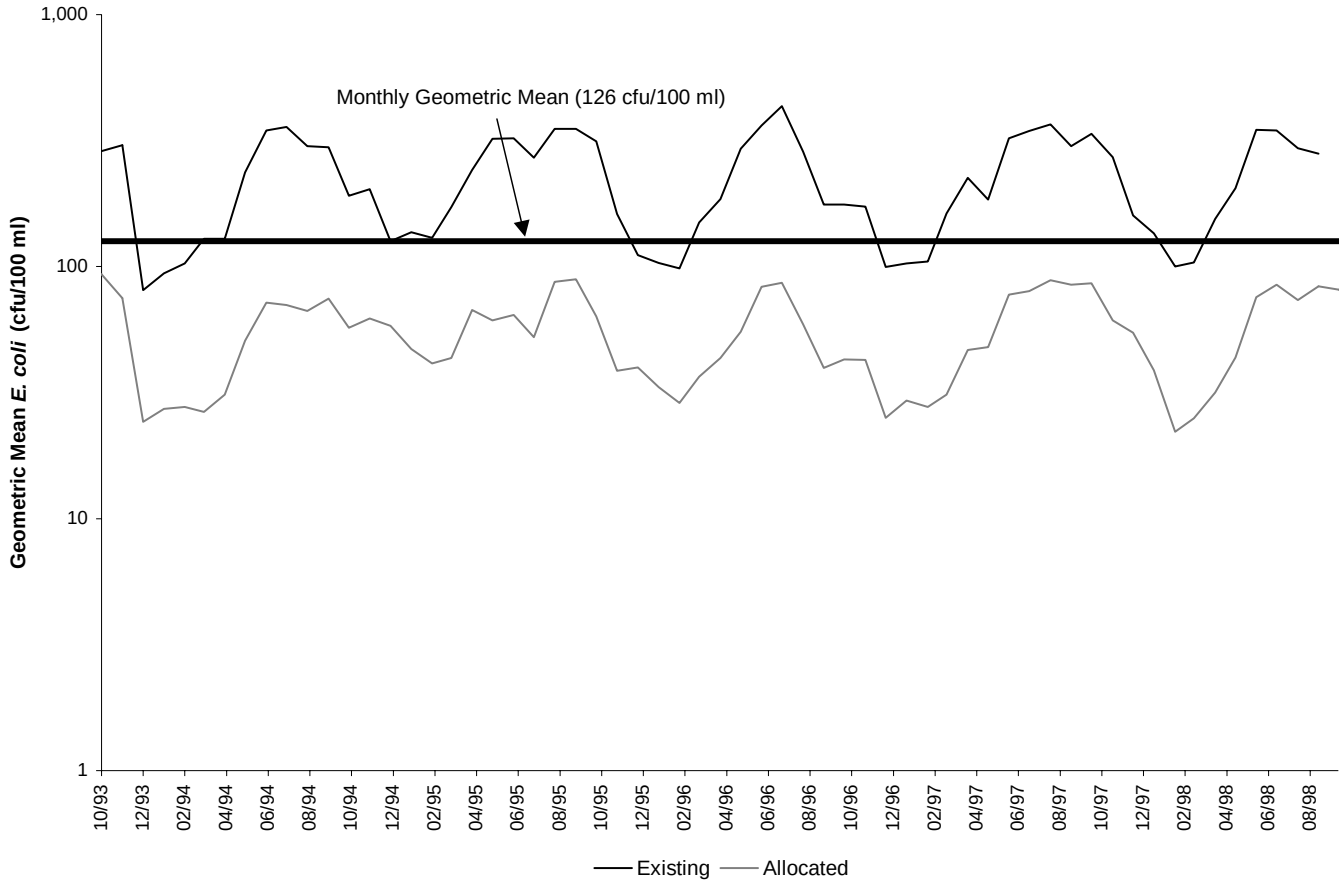

Figure 5.34 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 54, Horsepen Creek impairment.

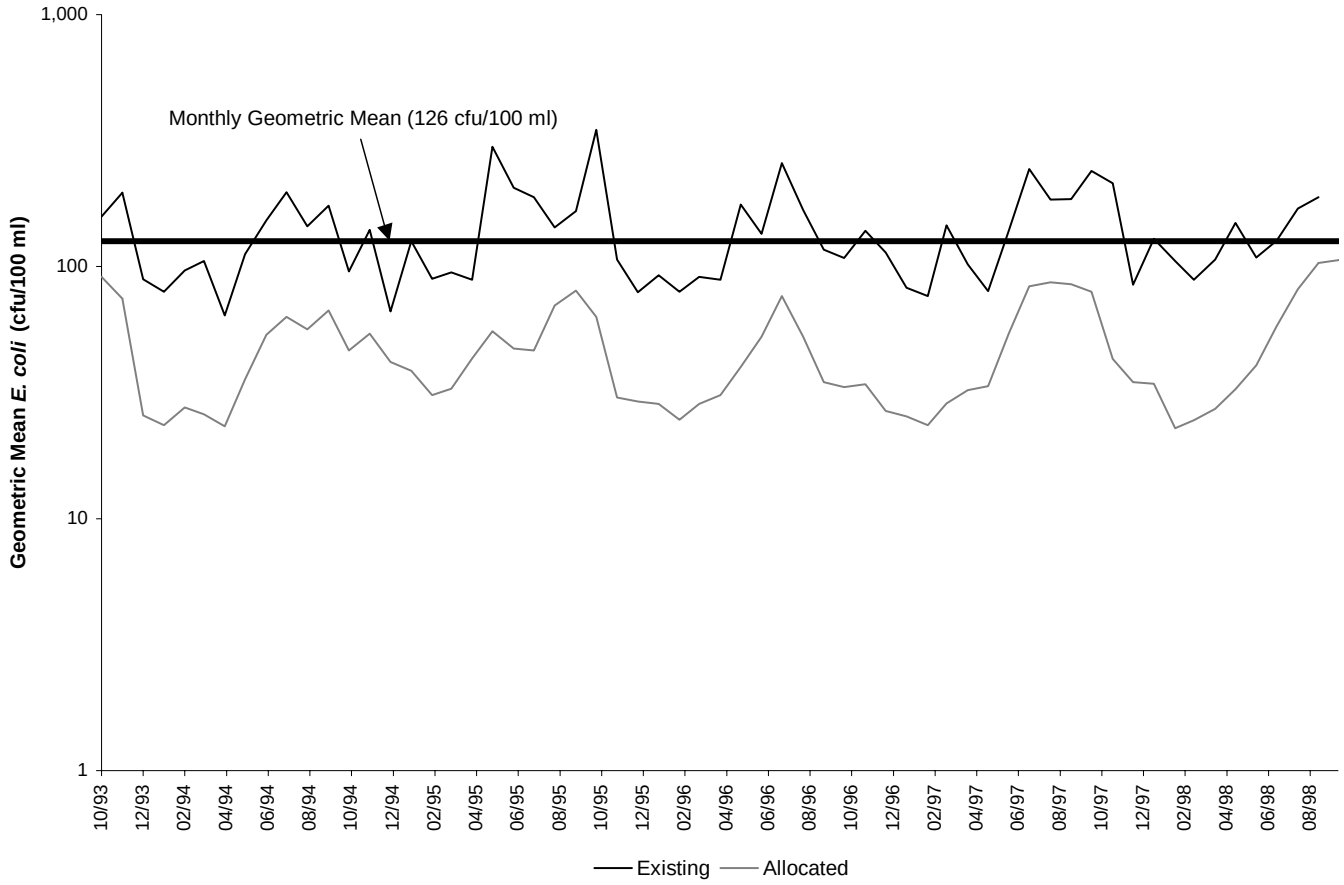

Figure 5.35 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 62, Appomattox River (1) impairment.

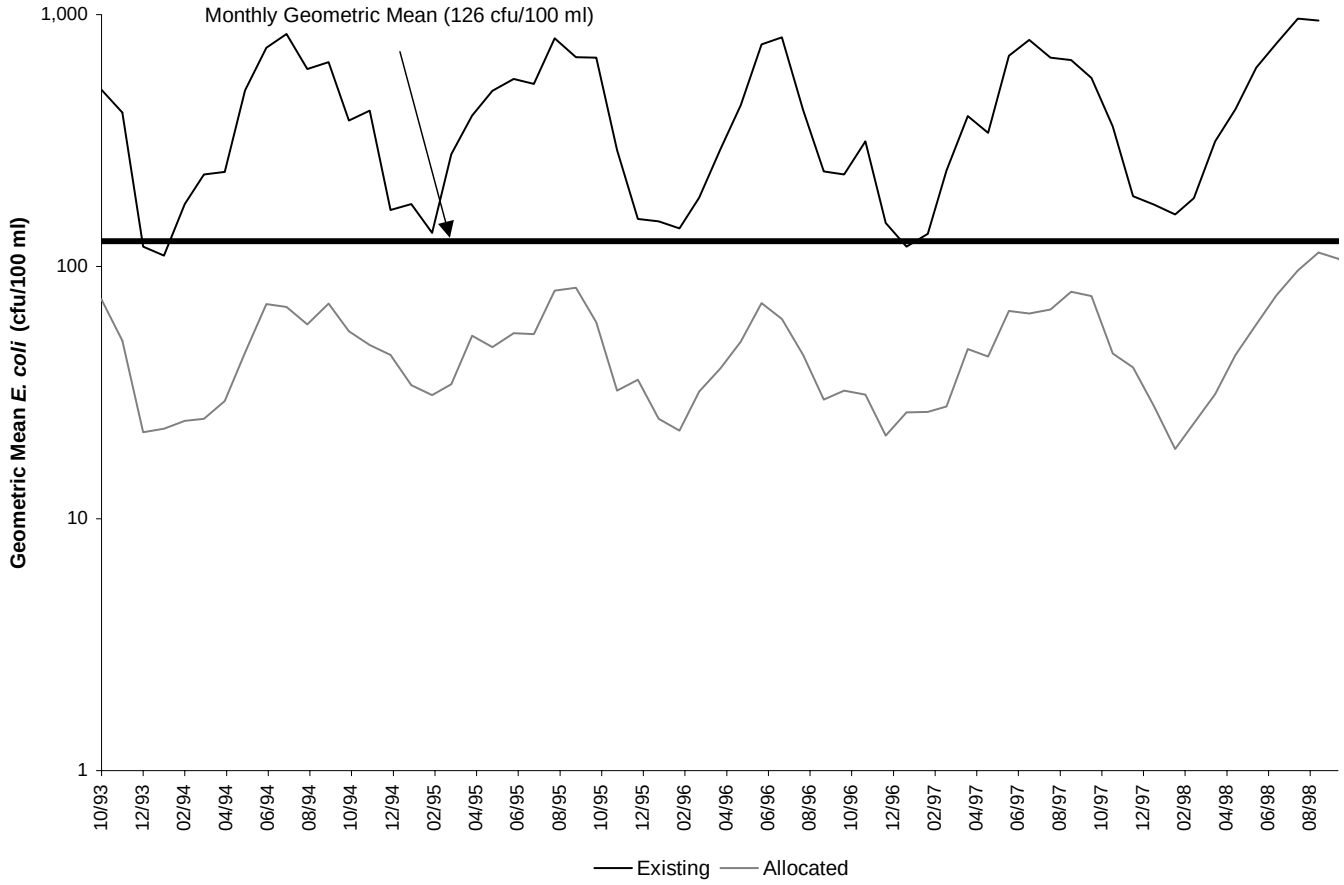

Figure 5.36 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 71, Nibbs Creek impairment.

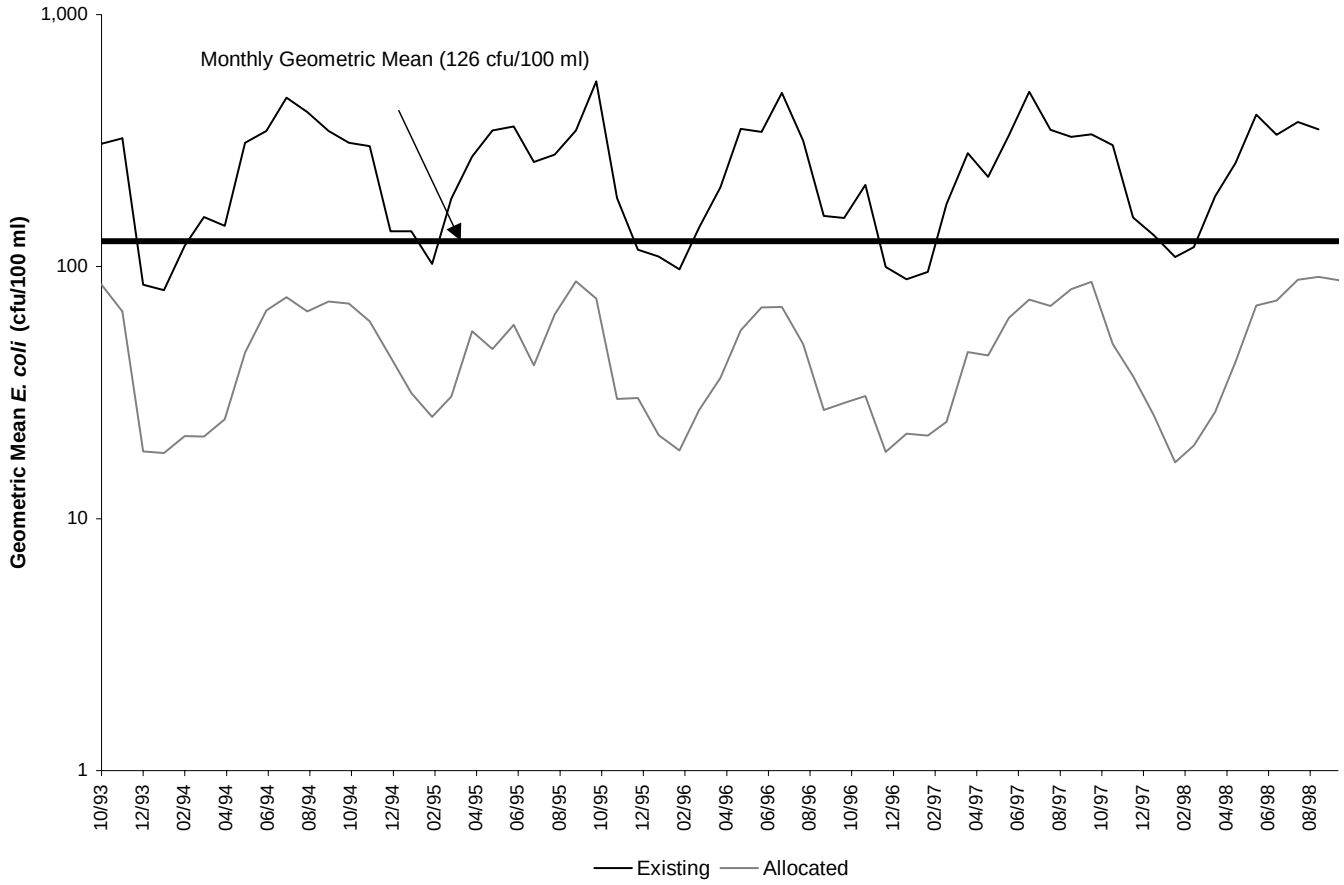

Figure 5.37 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 72, Flat Creek impairment.

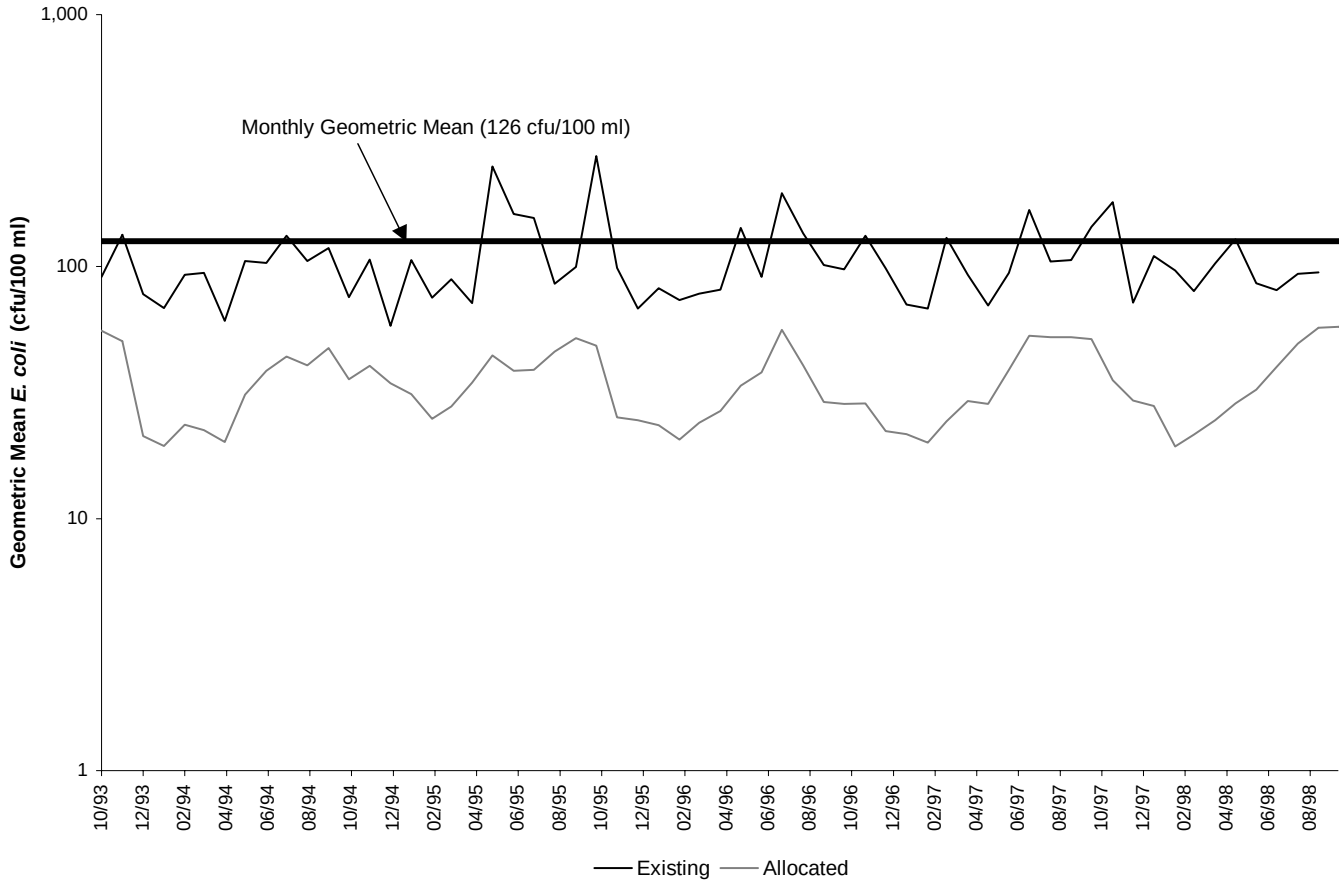

Figure 5.38 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 77, Appomattox River (1) impairment.

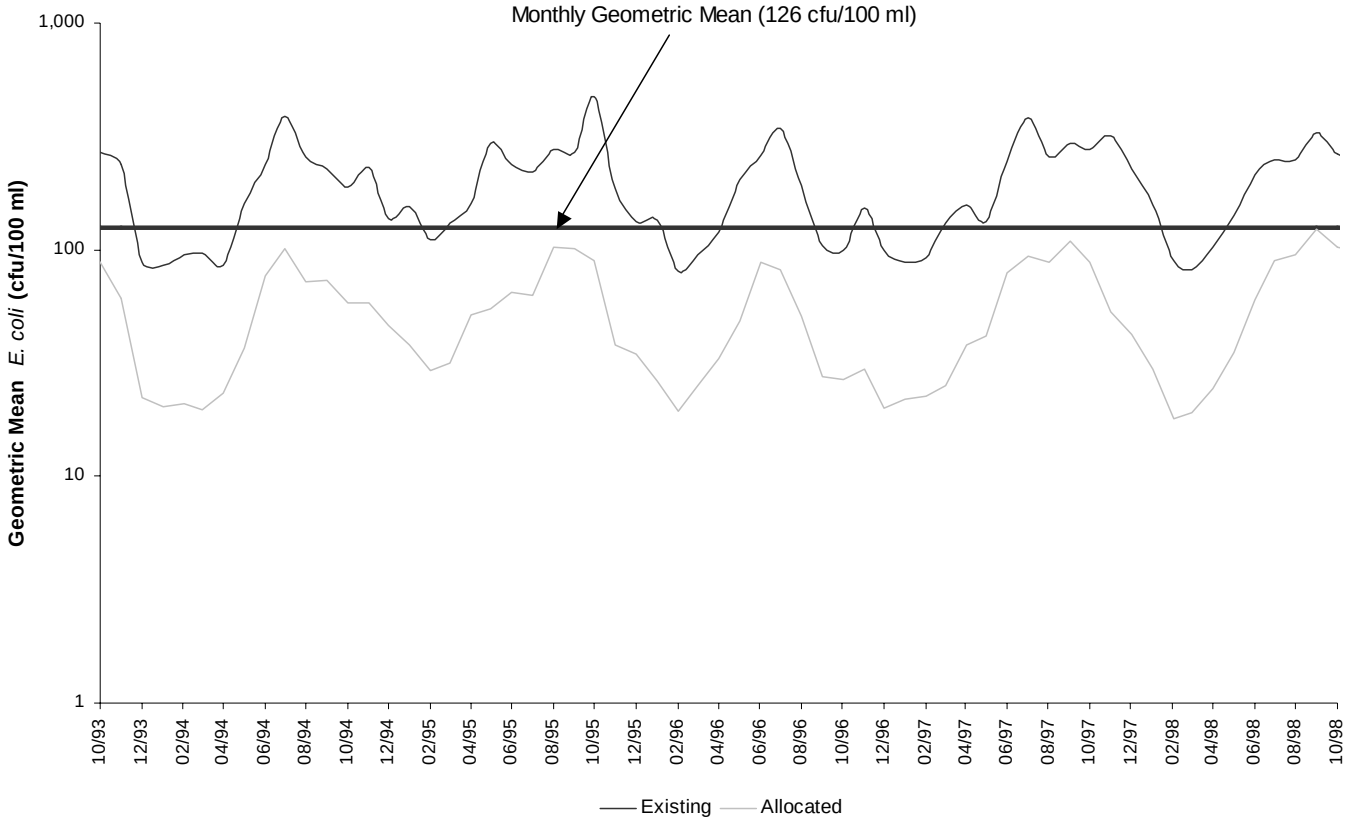

Figure 5.39 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 94, West Creek impairment.

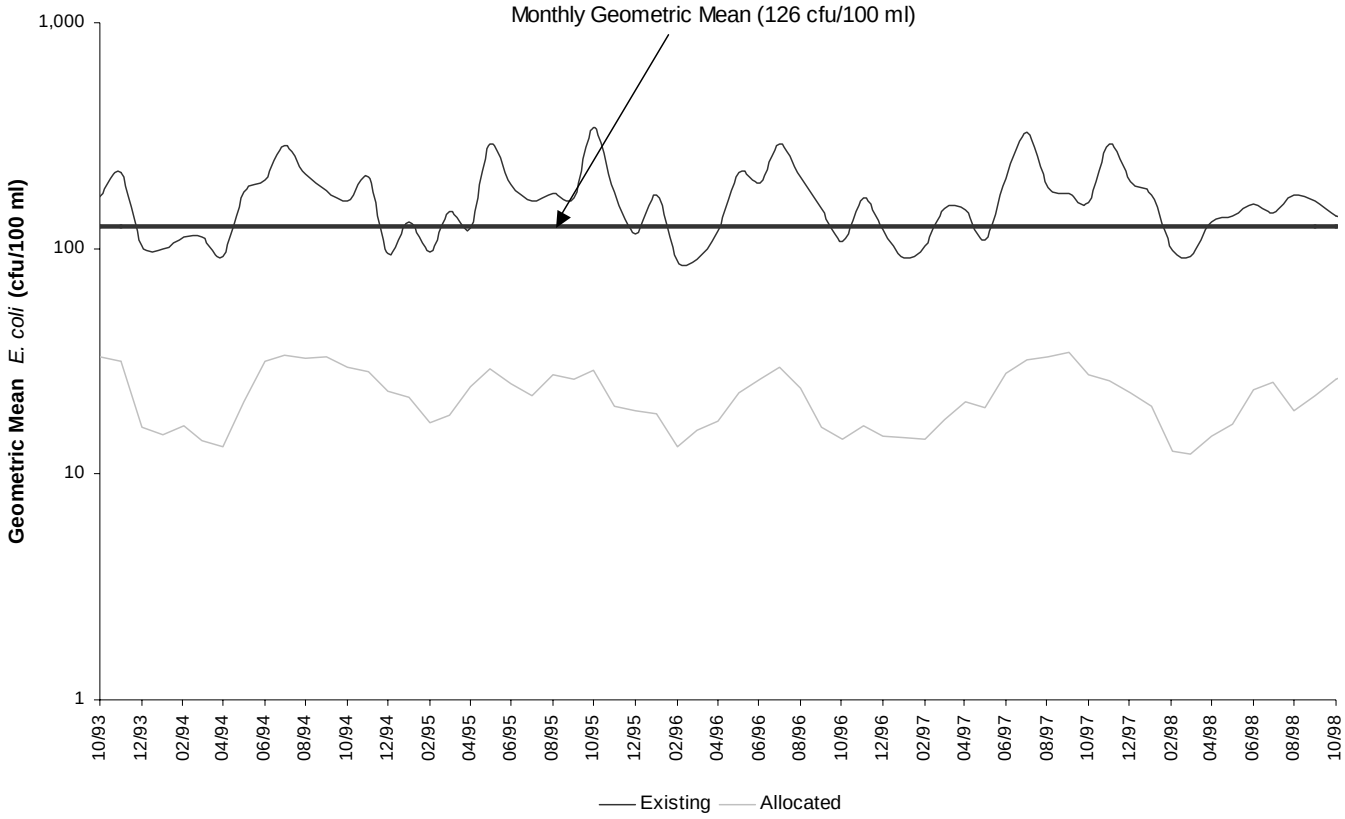

Figure 5.40 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 97, Deep Creek impairment.

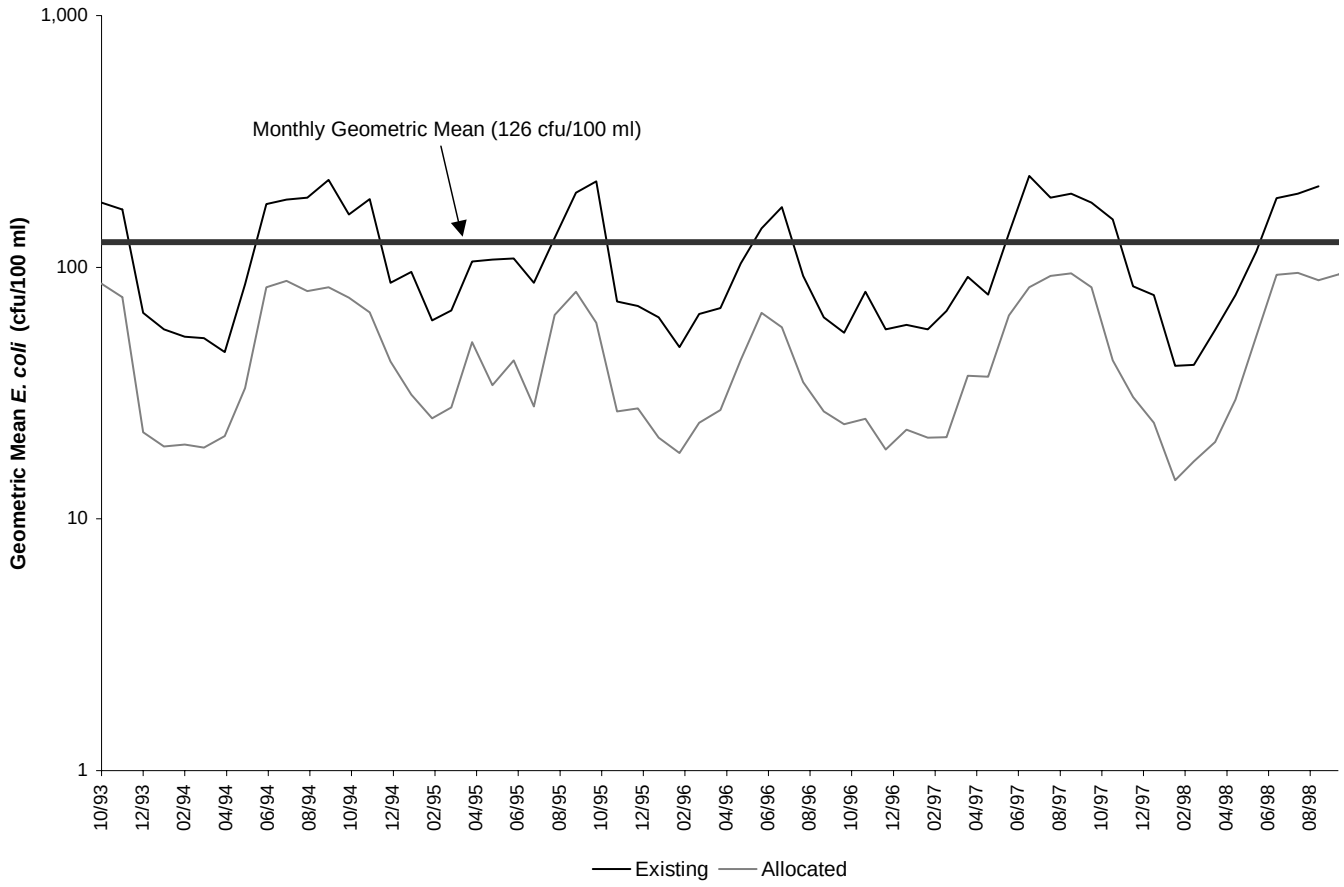

Figure 5.41 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 126, Swift Creek (1) impairment.

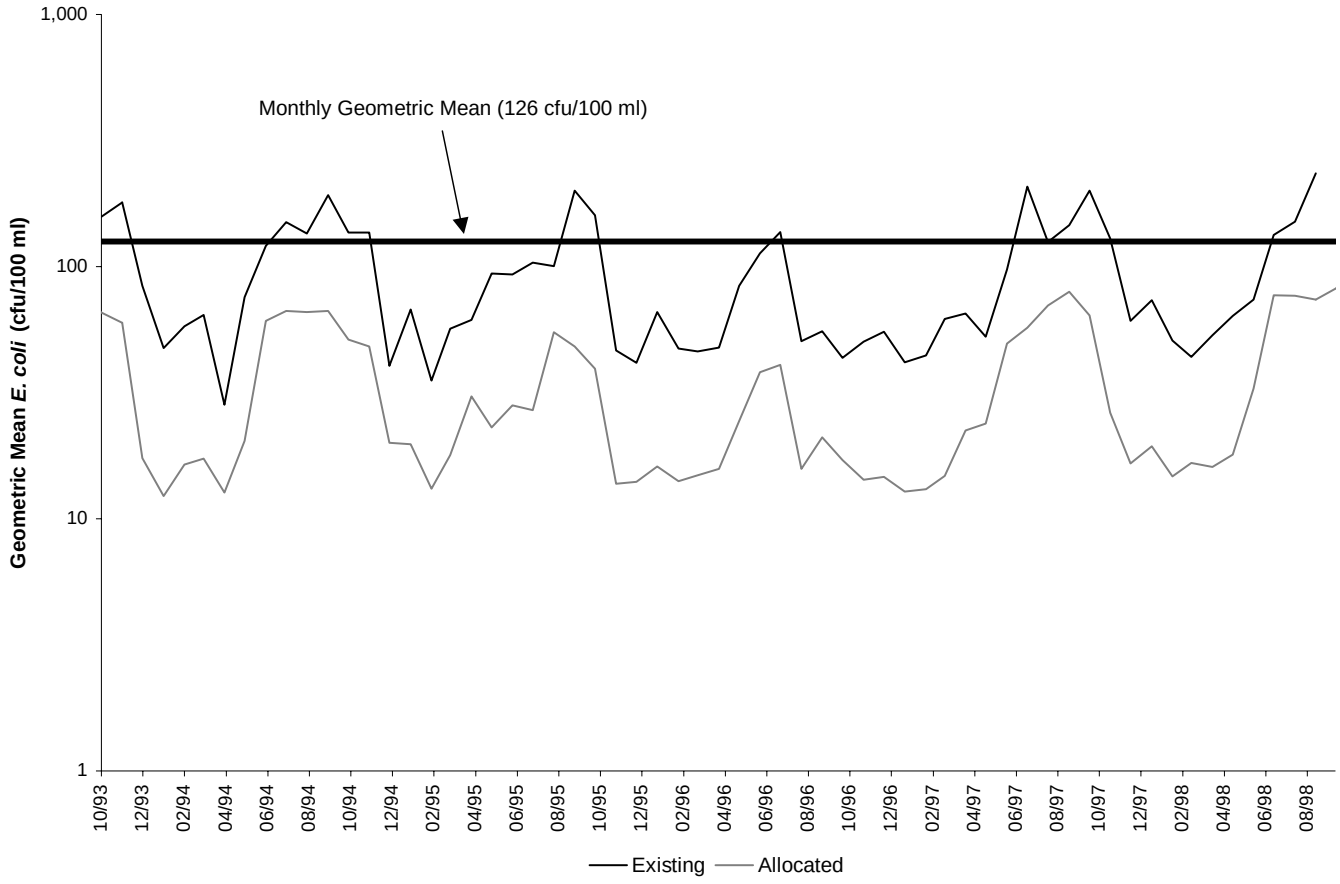

Figure 5.42 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 138, Swift Creek (2) impairment.

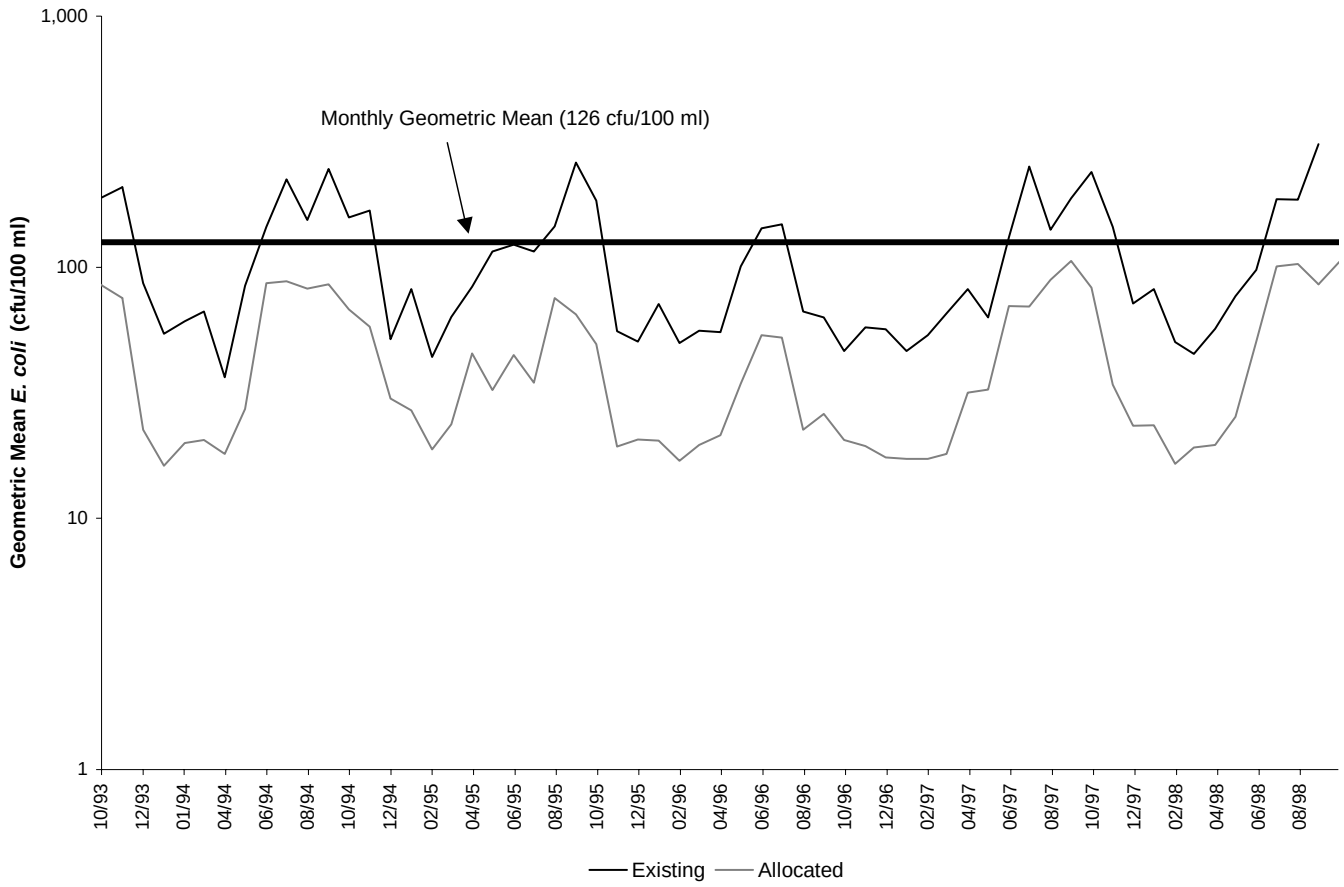

Figure 5.43 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 143, Swift Creek (3) impairment.

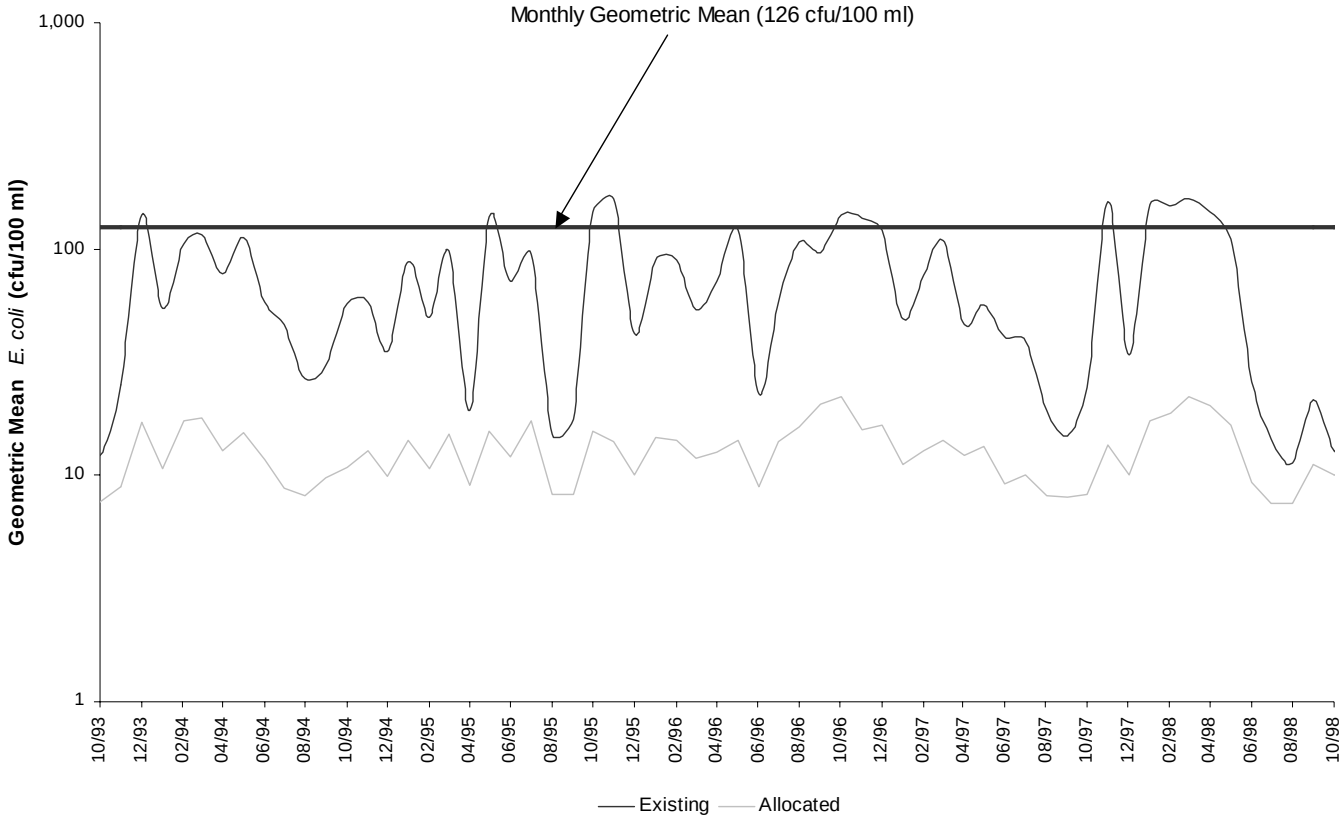

Figure 5.44 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 118, Appomattox River (2) impairment.

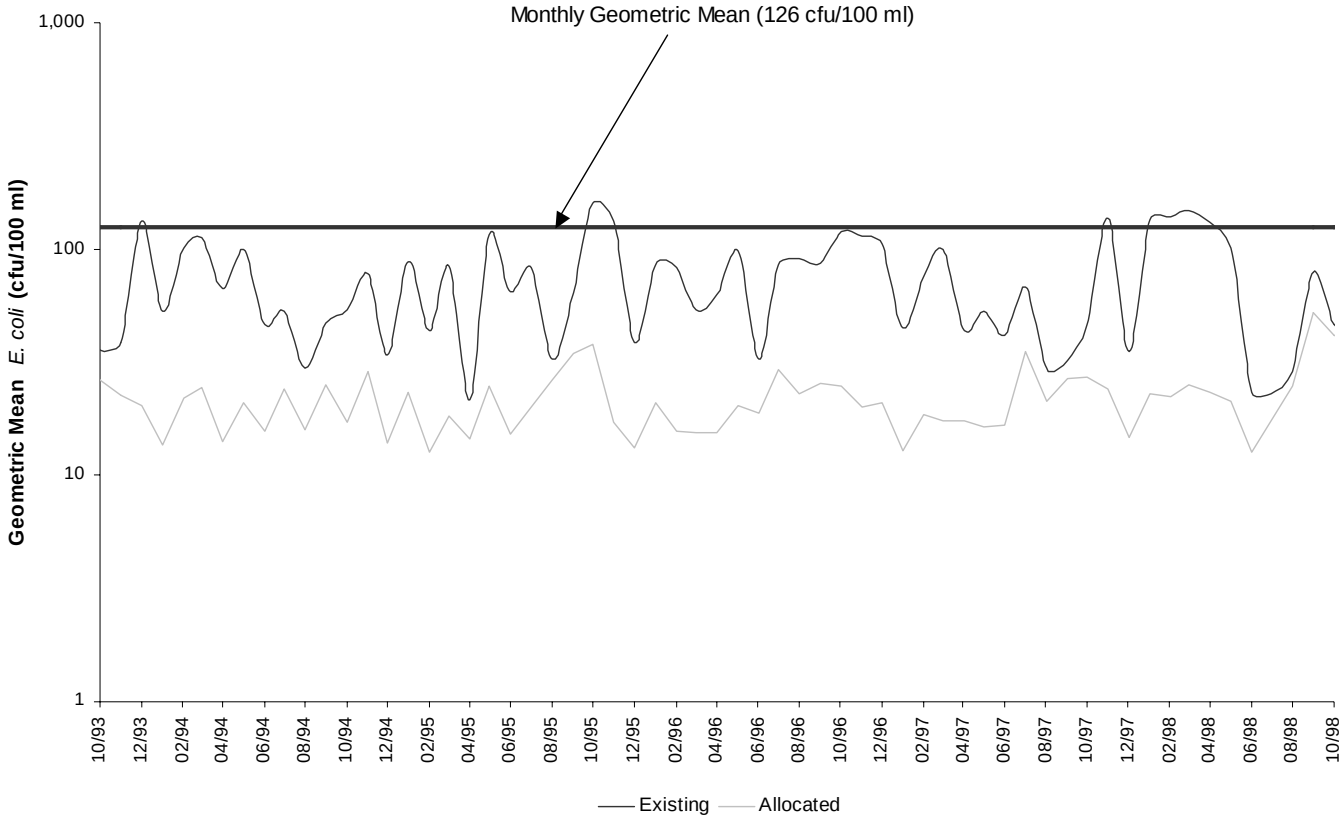

Figure 5.45 Existing and allocation scenarios of *E. coli* concentrations in subwatershed 149, Appomattox River (3)

Tables 5.23 through 5.43 contain the existing and allocated loads for all the impairments in the Appomattox River basin, reported as total annual coliforms for *E. coli* from both direct and land-based sources. The percent reduction needed to meet water quality is given in the final column of these tables. Table 5.44 is known as the TMDL table, which gives the number of coliforms of *E. coli* that can reach the stream in a given year, and still meet existing water quality standards. These figures are broken up into Waste Load Allocation (WLA), or the portion of these coliforms that may come from permitted discharge sources (including NPS sources under an MS4 permit) and Load Allocation (LA), or the portion of these coliforms that may come from the non-permitted non-point sources existing in the watershed.

Table 5.23 Land-based and Direct nonpoint source fecal coliform load reductions in the Spring Creek impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	2.36E+12	2.36E+10	99
Commercial	5.32E+11	5.32E+09	99
Cropland	1.04E+13	1.04E+11	99
Livestock	5.13E+13	5.13E+11	99
Pasture	9.44E+14	9.44E+12	99
Residential	2.88E+13	2.88E+11	99
Water	0.00E+00	0.00E+00	0
Wetlands	1.74E+14	5.21E+13	70
Woodland	5.44E+14	1.63E+14	70
Direct			
Human	1.85E+11	0.00E+00	100
Livestock	1.10E+13	0.00E+00	100
Wildlife	2.23E+13	2.23E+13	0

Table 5.24 Land-based and Direct nonpoint source fecal coliform load reductions in the Briery Creek impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	3.17E+12	3.17E+10	99
Commercial	7.76E+11	7.76E+09	99
Cropland	3.97E+12	3.97E+10	99
Pasture	5.78E+14	5.78E+12	99
Potential	3.16E+13	3.16E+11	99
Residential	9.40E+13	9.40E+11	99
Water	0.00E+00	0.00E+00	0
Wetlands	2.90E+14	6.37E+13	78
Woodland	8.74E+14	1.92E+14	78
Direct			
Human	6.81E+11	0.00E+00	100
Livestock	6.58E+12	0.00E+00	100
Wildlife	3.01E+13	1.86E+13	0

Table 5.25 Land-based and Direct nonpoint source fecal coliform load reductions in the Bush River (1) impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	2.50E+12	2.50E+10	99
Commercial	1.89E+12	1.89E+10	99
Cropland	3.71E+15	3.71E+13	99
Pasture	1.78E+15	1.78E+13	99
Potential	5.89E+13	5.89E+11	99
Residential	7.48E+13	7.48E+11	99
Water	0.00E+00	0.00E+00	0
Wetlands	6.15E+14	7.38E+13	88
Woodland	1.32E+14	1.58E+14	88
Direct			
Human	1.11E+12	0.00E+00	100
Livestock	2.04E+13	0.00E+00	100
Wildlife	5.06E+13	2.63E+13	0

Table 5.26 Land-based and Direct nonpoint source fecal coliform load reductions in the Little Sandy Creek impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	1.29E+12	1.29E+10	99.00%
Commercial	3.82E+11	3.82E+09	99.00%
Cropland	7.04E+15	1.41E+13	99.80%
Pasture	2.98E+15	5.97E+12	99.80%
Potential	9.42E+13	1.88E+11	99.80%
Residential	5.94E+12	5.94E+10	99.00%
Water	0.00E+00	0.00E+00	0.00%
Wetlands	7.97E+13	7.97E+11	99.00%
Woodland	2.00E+14	2.00E+12	99.00%
Direct			
Human	5.06E+10	0.00E+00	100.00%
Livestock	4.30E+13	0.00E+00	100.00%
Wildlife	7.98E+12	4.15E+12	48.00%

Table 5.27 Land-based and Direct nonpoint source fecal coliform load reductions in the Bush River (2) impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	5.40E+12	5.40E+10	99
Commercial	1.62E+12	1.62E+10	99
Cropland	3.74E+13	3.74E+13	99
Pasture	7.96E+14	7.96E+12	99
Potential	2.62E+13	2.62E+11	99
Residential	4.35E+13	4.35E+11	99
Water	0.00E+00	0.00E+00	0
Wetlands	3.68E+14	4.41E+13	88
Woodland	5.26E+14	6.31E+13	88
Direct			
Human	3.76E+11	0.00E+00	100
Livestock	7.22E+12	0.00E+00	100
Wildlife	2.68E+13	1.74E+13	35

Table 5.28 Land-based and Direct nonpoint source fecal coliform load reductions in the Saylers Creek impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	1.06E+12	1.06E+10	99
Commercial	1.42E+11	1.42E+09	99
Cropland	1.56E+15	1.56E+13	99
Pasture	1.38E+15	1.38E+13	99
Potential	5.62E+13	5.62E+11	99
Residential	3.91E+13	3.91E+11	99
Water	0.00E+00	0.00E+00	0
Wetlands	1.41E+14	2.83E+13	80
Woodland	3.76E+14	7.52E+13	80
Direct			
Human	2.45E+11	0.00E+00	100
Livestock	2.08E+13	0.00E+00	100
Wildlife	1.63E+13	7.33E+12	55

Table 5.29 Land-based and Direct nonpoint source fecal coliform load reductions in the Angola Creek (1) impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	1.90E+11	1.90E+09	99
Commercial	1.19E+10	1.19E+08	99
Cropland	5.22E+13	5.22E+11	99
Pasture	1.20E+15	1.20E+13	99
Potential	2.46E+13	2.46E+11	99
Residential	7.16E+12	7.16E+10	99
Water	0.00E+00	0.00E+00	0
Wetlands	3.70E+13	3.70E+12	90
Woodland	2.24E+14	2.24E+13	90
Direct			
Human	2.04E+11	0.00E+00	100
Livestock	8.76E+12	0.00E+00	100
Wildlife	5.92E+12	2.96E+12	50

Table 5.30 Land-based and Direct nonpoint source fecal coliform load reductions in the Angola Creek (2) impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	9.49E+11	9.49E+09	99
Commercial	1.25E+10	1.25E+08	99
Cropland	2.02E+15	2.02E+13	99
Pasture	9.71E+14	9.71E+12	99
Potential	3.82E+13	3.82E+11	99
Residential	5.07E+12	5.07E+10	99
Water	0.00E+00	0.00E+00	0
Wetlands	9.79E+13	4.90E+12	95
Woodland	1.06E+14	5.29E+12	95
Direct			
Human	9.09E+10	0.00E+00	100
Livestock	1.57E+13	0.00E+00	100
Wildlife	7.43E+12	7.43E+12	0

Table 5.31 Land-based and Direct nonpoint source fecal coliform load reductions in the Horsepen Creek impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	4.46E+11	4.46E+09	99
Commercial	0.00E+00	0.00E+00	99
Cropland	1.03E+15	1.03E+13	99
Pasture	4.12E+14	4.12E+12	99
Potential	1.29E+13	1.29E+11	99
Residential	5.42E+12	5.42E+10	99
Water	0.00E+00	0.00E+00	0
Wetlands	2.47E+13	2.47E+11	99
Woodland	1.37E+14	1.37E+12	99
Direct			
Human	4.38E+10	0.00E+00	100
Livestock	5.16E+12	0.00E+00	100
Wildlife	2.48E+12	9.42E+11	62

Table 5.32 Land-based and Direct nonpoint source fecal coliform load reductions in the Nibbs Creek impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	2.74E+12	0.00E+00	100
Commercial	1.47E+12	0.00E+00	100
Cropland	7.26E+15	0.00E+00	100
Pasture	2.98E+15	0.00E+00	100
Potential	1.10E+14	0.00E+00	100
Residential	5.57E+13	0.00E+00	100
Water	0.00E+00	0.00E+00	0
Wetlands	1.12E+14	3.36E+13	70
Woodland	4.76E+14	1.43E+14	70
Direct			
Human	7.77E+11	0.00E+00	100
Livestock	3.88E+13	0.00E+00	100
Wildlife	1.98E+13	1.58E+13	20

Table 5.33 Land-based and Direct nonpoint source fecal coliform load reductions in the Flat Creek impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	1.20E+13	1.20E+11	99
Commercial	3.23E+12	3.23E+10	99
Cropland	1.03E+16	1.03E+14	99
Pasture	8.66E+15	8.66E+13	99
Potential	1.82E+14	1.82E+12	99
Residential	1.35E+14	1.35E+12	99
Water	0.00E+00	0.00E+00	0
Wetlands	8.33E+14	1.67E+14	80
Woodland	2.45E+15	4.89E+14	80
Direct			
Human	1.50E+12	0.00E+00	100
Livestock	6.13E+13	0.00E+00	100
Wildlife	9.34E+13	4.58E+13	51

Table 5.34 Land-based and Direct nonpoint source fecal coliform load reductions in the Appomattox River (12a) impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	4.04E+13	4.04E+11	99
Commercial	2.21E+13	2.21E+11	99
Cropland	1.23E+16	1.23E+14	99
Livestock	5.33E+14	5.33E+12	99
Pasture	1.20E+16	1.20E+14	99
Residential	5.59E+14	5.59E+12	99
Water	0.00E+00	0.00E+00	0
Wetlands	1.35E+15	2.71E+14	80
Woodland	6.33E+15	1.27E+15	80
Direct			
Human	3.36E+12	0.00E+00	100
Livestock	1.59E+14	0.00E+00	100
Wildlife	2.09E+14	2.09E+14	0

Table 5.35 Land-based and Direct nonpoint source fecal coliform load reductions in the Appomattox River (12b) impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	1.94E+13	1.94E+11	99
Commercial	9.36E+11	9.36E+09	99
Cropland	1.49E+16	1.49E+14	99
Pasture	1.08E+16	1.08E+14	99
Potential	2.91E+14	2.91E+12	99
Residential	3.13E+14	3.13E+12	99
Water	0.00E+00	0.00E+00	0
Wetlands	1.68E+15	5.21E+14	69
Woodland	3.89E+15	1.21E+15	69
Direct			
Human	2.56E+12	0.00E+00	100
Livestock	1.09E+14	7.62E+12	93
Wildlife	1.46E+14	1.46E+14	0

Table 5.36 Land-based and Direct nonpoint source fecal coliform load reductions in the Appomattox River (12c) impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	1.32E+13	1.32E+11	99
Commercial	1.45E+13	1.45E+11	99
Cropland	1.62E+15	1.62E+13	99
Pasture	1.34E+15	1.34E+13	99
Potential	5.28E+13	5.28E+11	99
Residential	8.16E+13	8.16E+11	99
Water	0.00E+00	0.00E+00	0
Wetlands	3.27E+13	1.57E+13	52
Woodland	2.72E+15	1.31E+15	52
Direct			
Human	2.99E+11	0.00E+00	100
Livestock	1.32E+13	1.32E+13	0
Wildlife	6.04E+13	6.04E+13	0

Table 5.37 Land-based and Direct nonpoint source fecal coliform load reductions in the West Creek impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	4.23E+12	4.23E+10	99.00%
Commercial	6.57E+11	6.57E+09	99.00%
Cropland	3.21E+15	3.21E+13	99.00%
Pasture	1.43E+15	1.43E+13	99.00%
Potential	5.75E+13	5.75E+11	99.00%
Residential	5.29E+13	5.29E+11	99.00%
Water	0.00E+00	0.00E+00	0.00%
Wetlands	3.82E+14	4.21E+13	89.00%
Woodland	1.14E+15	1.25E+14	89.00%
Direct			
Human	6.07E+11	0.00E+00	100.00%
Livestock	1.98E+13	0.00E+00	100.00%
Wildlife	4.70E+13	1.79E+13	62.00%

Table 5.38 Land-based and Direct nonpoint source fecal coliform load reductions in the Deep Creek impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	2.14E+13	2.14E+11	99.00%
Commercial	2.48E+13	2.48E+11	99.00%
Cropland	1.11E+16	1.11E+14	99.00%
Pasture	6.27E+15	6.27E+13	99.00%
Potential	2.76E+14	2.76E+12	99.00%
Residential	2.07E+14	2.07E+12	99.00%
Water	0.00E+00	0.00E+00	0.00%
Wetlands	4.79E+14	2.40E+13	95.00%
Woodland	3.70E+15	1.85E+14	95.00%
Direct			
Human	1.94E+12	0.00E+00	100.00%
Livestock	1.01E+14	0.00E+00	100
Wildlife	1.04E+14	3.13E+13	70

Table 5.39 Land-based and Direct nonpoint source fecal coliform load reductions in the Appomattox River (2) impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	2.34E+13	9.38E+11	96
Commercial	1.46E+14	5.83E+12	96
Cropland	2.07E+16	8.26E+14	96
Pasture	7.57E+15	3.03E+14	96
Potential	3.13E+14	1.25E+13	96
Residential	7.61E+14	3.05E+13	96
Water	0.00E+00	0.00E+00	0
Wetlands	4.25E+13	4.25E+13	0
Woodland	5.32E+15	5.32E+15	0
Direct			
Human	1.69E+12	0.00E+00	100
Livestock	1.18E+14	1.18E+14	0
Wildlife	1.41E+14	1.41E+14	0

Table 5.40 Land-based and Direct nonpoint source fecal coliform load reductions in the Swift Creek (1) impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	2.22E+11	2.22E+09	99
Commercial	1.74E+12	1.74E+10	99
Cropland	2.08E+13	2.08E+11	99
Livestock	5.16E+12	5.16E+10	99
Pasture	1.59E+14	1.59E+12	99
Residential	8.62E+13	8.62E+11	99
Water	0.00E+00	0.00E+00	0
Wetlands	2.89E+13	7.51E+12	74
Woodland	1.11E+15	2.87E+14	74
Direct			
Human	2.04E+11	0.00E+00	100
Livestock	9.13E+11	0.00E+00	100
Wildlife	2.01E+13	9.84E+12	51

Table 5.41 Land-based and Direct nonpoint source fecal coliform load reductions in the Swift Creek (2) impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	4.26E+12	4.26E+10	99
Commercial	2.19E+13	2.19E+11	99
Cropland	5.10E+13	5.10E+11	99
Livestock	1.04E+13	1.04E+11	99
Pasture	2.79E+14	2.79E+12	99
Residential	1.01E+15	1.01E+13	99
Water	0.00E+00	0.00E+00	0
Wetlands	1.16E+13	5.45E+12	53
Woodland	1.83E+15	8.59E+14	53
Direct			
Human	8.05E+11	0.00E+00	100
Livestock	2.01E+12	0.00E+00	100
Wildlife	4.96E+13	3.32E+13	33

Table 5.42 Land-based and Direct nonpoint source fecal coliform load reductions in the Swift Creek (3) impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	5.65E+12	5.65E+10	99
Commercial	1.61E+13	1.61E+11	99
Cropland	4.10E+13	4.10E+11	99
Livestock	1.14E+13	1.14E+11	99
Pasture	3.93E+14	3.93E+12	99
Residential	3.50E+14	3.50E+12	99
Water	0.00E+00	0.00E+00	0
Wetlands	4.83E+13	1.98E+13	59
Woodland	1.60E+15	6.58E+14	59
Direct			
Human	5.34E+11	0.00E+00	100
Livestock	3.01E+12	0.00E+00	100
Wildlife	4.11E+13	3.08E+13	25

Table 5.43 Land-based and Direct nonpoint source fecal coliform load reductions in the Appomattox River (3) impairment for final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	2.52E+13	2.52E+11	99
Commercial	1.58E+14	1.58E+12	99
Cropland	9.54E+13	9.54E+11	99
Pasture	2.37E+14	2.37E+12	99
Potential	8.10E+12	8.10E+10	99
Residential	1.01E+15	1.01E+13	99
Water	0.00E+00	0.00E+00	0
Wetlands	9.01E+14	1.80E+14	80
Woodland	1.84E+15	3.67E+14	80
Direct			
Human	1.16E+12	0.00E+00	100
Livestock	0.00E+00	0.00E+00	100
Wildlife	8.02E+13	7.22E+13	10

Table 5.44 Average annual *E. coli* loads (cfu/year) modeled after TMDL allocation in the Appomattox River watershed impairments.

Impairment	WLA (cfu/year)	LA (cfu/year)	MOS	TMDL (cfu/year)
Angola Creek (1)	0.00E+00	6.76E+12		6.76E+12
Angola Creek (2)	0.00E+00	1.80E+13		1.80E+13
Appomattox River (1)	4.74E+12	6.86E+14		6.90E+14
Chesterfield --VA0088609	*6.64E+09*			
VAG402047	*1.75E+09*			
VAG404002	*1.75E+09*			
VAG404107	*1.75E+09*			
VAG404129	*1.75E+09*			
VAG404140	*1.75E+09*			
VAG404161	*1.75E+09*			
VA0083135	*4.18E+12*			
VAG407199	*1.75E+09*			
VAG407198	*1.75E+09*			
VAG404092	*1.75E+09*			
VA0057088	*0.00E+00*			
VA0089206	*0.00E+00*			
VA0086681	*5.24E+11*			
VA0020222	*1.15E+10*			
VA0089931	*0.00E+00*			
Appomattox River (2)	1.07E+13	5.90E+14		6.01E+14
Chesterfield --VA0088609	*2.07E+11*			
Colonial Heights –VAR040009	*1.74E+10*			
Petersburg –VAR040013	*1.31E+11*			
VAG402047	*1.75E+09*			
VAG404002	*1.75E+09*			
VAG404107	*1.75E+09*			
VAG404129	*1.75E+09*			
VAG404140	*1.75E+09*			
VAG404161	*1.75E+09*			
VA0083135	*4.18E+12*			
VAG407199	*1.75E+09*			
VAG407198	*1.75E+09*			
VAG404092	*1.75E+09*			
VA0057088	*0.00E+00*			
VA0089206	*0.00E+00*			
VA0086681	*5.24E+11*			
VA0020222	*1.15E+10*			
VA0089931	*0.00E+00*			
VA0020303	*8.71E+11*			
VA0090131	*0.00E+00*			
VA0023540	*2.62E+10*			
VA0005819	*4.70E+12*			
VA0059099	*0.00E+00*			
VA0089516	*0.00E+00*			

Implicit

Table 5.44 Average annual E. coli loads (cfu/year) modeled after TMDL allocation in the Appomattox River watershed impairments. (Continued)

Impairment	WLA (cfu/year)	LA (cfu/year)	MOS	TMDL (cfu/year)
Appomattox River (3)-tidal	6.87E+13	7.22E+14		7.91E+14
Chesterfield --VA0088609	*1.14E+13*			
Colonial Heights –VAR040009	*2.49E+12*			
Hopewell – VAR040015	*1.44E+12*			
Petersburg –VAR040013	*1.76E+12*			
VAG402047	*2.78E+09*			
VAG404002	*2.78E+09*			
VAG404107	*2.78E+09*			
VAG404129	*2.78E+09*			
VAG404140	*2.78E+09*			
VAG404161	*2.78E+09*			
VA0083135	*6.63E+12*			
VAG407199	*2.78E+09*			
VAG407198	*2.78E+09*			
VAG404092	*2.78E+09*			
VA0057088	*0.00E+00*			
VA0089206	*0.00E+00*			
VA0086681	*8.32E+11*			
VA0020222	*1.83E+10*			
VA0089931	*0.00E+00*			
VA0020303	*1.38E+12*			
VA0090131	*0.00E+00*			
VA0023540	*2.62E+10*			
VA0005819	*4.70E+12*			
VA0059099	*0.00E+00*			
VA0089516	*0.00E+00*			
VA0025437	*6.37E+13*			
VA0028258	*1.08E+11*			
VA0059161	*1.39E+12*			
VA0006254	*1.66E+10*			
VA0023426	*1.52E+11*			
VA0020206	*2.66E+10*			
VA0027561	*2.77E+10*			
VA0090344	*1.11E+11*			
Briery Creek	5.56E+09	3.84E+13		3.84E+13
VAG407198	*2.78E+09*			
VAG404092	*2.78E+09*			
Bush River (1)	5.56E+09	9.03E+13		9.03E+13
VAG407198	*2.78E+09*			
VAG404092	*2.78E+09*			
Bush River (2)	5.56E+09	1.10E+14		1.10E+14
VAG407198	*2.78E+09*			
VAG404092	*2.78E+09*			

Implicit

Table 5.44 Average annual E. coli loads (cfu/year) modeled after TMDL allocation in the Appomattox River watershed impairments. (Continued)

Impairment		WLA (cfu/year)	LA (cfu/year)	MOS	TMDL (cfu/year)
Deep Creek (FC)		1.38E+12	1.05E+14		1.06E+14
	VA0020303	1.38E+12			
	VA0090131	*0.00E+00*			
Flat Creek		8.32E+11	8.72E+13		8.80E+13
	VA0086681	8.32E+11			
Horsepen Creek		0.00E+00	4.44E+12		4.44E+12
Little Sandy Creek		0.00E+00	1.62E+12		1.62E+12
Nibbs Creek		8.32E+11	1.20E+13		1.29E+13
	VA0086681	8.32E+11			
Saylers Creek		0.00E+00	1.40E+13		1.40E+13
Spring Creek		0.00E+00	2.08E+13	*Implicit*	2.08E+13
Swift Creek (1)		8.37E+09	2.01E+13		2.01E+13
	Chesterfield --VA0088609	*8.37E+09*			
Swift Creek (2)		3.80E+11	8.38E+13		8.42E+13
	Chesterfield --VA0088609	*1.84E+11*			
	VA0006254	*1.66E+10*			
	VA0023426	*1.52E+11*			
	VA0020206	*2.66E+10*			
Swift Creek (3)		5.82E+11	1.28E+14		1.29E+14
	Chesterfield --VA0088609	*2.38E+11*			
	Colonial Heights –VAR040009	*1.03E+10*			
	VA0006254	*1.66E+10*			
	VA0023426	*1.52E+11*			
	VA0020206	*2.66E+10*			
	VA0027561	*2.77E+10*			
	VA0090344	*1.11E+11*			
West Creek		0.00E+00	3.91E+13		3.91E+13
	VA0090131	*0.00E+00*			

6. IMPLEMENTATION

The goal of this TMDL is to establish a three-step path that will lead to attainment of water quality standards. The first step in this process is to develop TMDLs that will result in meeting water quality standards. This report represents the culmination of that effort for the bacteria impairments on the Appomattox River. The second step is to develop a TMDL implementation plan. The final step is to implement the TMDL implementation plan, and to monitor stream water quality to determine if water quality standards are being attained.

Once a TMDL has been approved by EPA and the civilian State Water Control Board, measures must be taken to reduce pollution levels in the stream. These measures, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in 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 recent *Guidance Manual for Total Maximum Daily Load Implementation Plans*, published in July 2003 and available upon request from the VADEQ and VADCR TMDL project staff or at http://www.deq.state.va.us/tmdl/implans/ipguide.pdf. With successful completion of implementation plans, Virginia will be well on the way to restoring impaired waters and enhancing the value of this important resource. Additionally, development of an approved implementation plan will improve a locality's chances for obtaining financial and technical assistance during implementation.

6.1 Staged Implementation

In general, Virginia intends for the required 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 readily implentable BMPs that might be appropriate for controlling urban wash-off from parking lots and roads may include more restrictive ordinances to reduce fecal loads from pets, improved garbage collection and control, and improved street cleaning.

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

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

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

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

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

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

Watershed stakeholders will have opportunity to participate in the development of the TMDL implementation plan. 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 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 implementations 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 which exist in any model; 3) it provides a mechanism for developing public support; 4) it helps to ensure that the most cost-effective practices are implemented initially; and 5) it allows for the evaluation of the adequacy of the TMDL in achieving the water quality standard.

In general, the Commonwealth intends for the required reductions to be implemented in an iterative process that addresses the sources with the largest impact on water quality first. For example, the most promising management practice in agricultural areas of the watershed may be livestock exclusion from streams. This has been shown to be very effective in lowering fecal bacteria concentrations in streams, both from the cattle deposits themselves and from additional buffering in the riparian zone. Additionally, reducing the human bacteria loading from failing septic systems and straight pipes should be a focus during the first stage because of its health implications.

The goal of the Stage 1 scenarios is to reduce the bacteria loadings from controllable sources, excluding wildlife. The Stage 1 scenarios were generated with the same model setup as was used for the TMDL allocation scenarios. While specific Stage I goals for BMP implementation will be established as part of the implementation plan development process, one potential scenario is outlined below.

As presented in Chapter 5, scenarios were devised assuming reductions of 100% in all anthropogenic land-based loads, 100% reduction in sewer overflows and uncontrolled residential discharges, 100% reduction in direct livestock deposition, and a 0% reduction in wildlife direct and land-based loading to the stream. For all impairments, the model predicted violations of the water quality standards.

The Stage I water quality goal was to reduce the number of violations of the instantaneous standard in the impaired segments in the Appomattox River basin to less than 10%. Since many headwater reaches required reductions of greater than 75% of all land-based urban and agricultural loads to meet the 10% goal, these are considered to be unreasonable for a Stage I implementation. Therefore, management scenarios were chosen which required reductions equal to or less than 60% of any land based loads, and 100% of direct livestock loads. The model predictions for these stage I allocations are shown in Table 6.1.

Table 6.1 Reduction percentages for the Stage I implementation.

Impairment Name	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture / Livestock Access/ Cropland	NPS Res./ Urban	Straight Pipe/ Sewer Overflow	% Single Samples Exceeding 235 cfu/ 100ml
Spring Creek	0	0	90	50	50	100	2.04
Briery Creek	0	0	50	50	50	100	9.70
Bush River (1)	0	0	90	50	50	100	16.93
Little Sandy Creek	0	0	90	50	50	100	20.11
Bush River (2)	0	0	90	50	50	100	11.84
Saylers Creek	0	0	100	60	0	100	14.08
Angola Creek (1)	0	0	100	60	0	100	10.19
Angola Creek (2)	0	0	100	60	0	100	12.05
Horsepen Creek	0	0	100	60	50	100	27.78
Nibbs Creek	0	0	90	50	50	100	12.42
Flat Creek	0	0	90	50	50	100	12.6
Appomattox River (1a) (model segment 1)	0	0	90	50	50	100	10.44
Appomattox River (1b) (model segment 3)	0	0	100	60	0	100	12.11
Appomattox River (1c) (model segment 4)	0	0	90	50	50	100	14.03
West Creek	0	0	90	50	50	100	24.82
Deep Creek	0	0	90	50	50	100	24.71
Appomattox River (2)	0	0	90	50	50	100	11.89
Swift Creek (1)	0	0	90	25	25	100	5.86
Swift Creek (2)	0	0	75	45	45	100	9.97
Swift Creek (3)	0	0	25	45	45	100	9.75
Appomattox River (3)	0	0	0	50	50	100	5.38

Table 6.2 through Table 6.22 detail the load reductions required to meet the Stage I Implementation described in Table 6.1.

Table 6.2 Nonpoint source allocations in the Spring Creek impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	2.36E+12	1.18E+12	50%
Commercial	5.32E+11	2.66E+11	50%
Cropland	1.04E+13	5.19E+12	50%
Pasture	5.13E+13	2.56E+13	50%
Potential	9.44E+14	4.72E+14	50%
Residential	2.88E+13	1.44E+13	50%
Water	0.00E+00	0.00E+00	0%
Wetlands	1.74E+14	1.74E+14	0%
Woodland	5.44E+14	5.44E+14	0%
Direct			
Human	1.85E+11	0.00E+00	100%
Livestock	1.10E+13	1.10E+12	90%
Wildlife	2.23E+13	2.23E+13	0%

Table 6.3 Nonpoint source allocations in the Briery Creek impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	3.17E+12	1.59E+12	50%
Commercial	7.76E+11	3.88E+11	50%
Cropland	3.97E+12	1.99E+12	50%
Pasture	5.78E+14	2.89E+14	50%
Potential	3.16E+13	1.58E+13	50%
Residential	9.40E+13	4.70E+13	50%
Water	0.00E+00	0.00E+00	0%
Wetlands	2.90E+14	2.90E+14	0%
Woodland	8.74E+14	8.74E+14	0%
Direct			
Human	6.81E+11	0.00E+00	100%
Livestock	6.58E+12	3.29E+12	50%
Wildlife	3.01E+13	3.01E+13	0%

Table 6.4 Nonpoint source allocations in the Bush River (1) impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	2.50E+12	1.25E+12	50%
Commercial	1.89E+12	9.44E+11	50%
Cropland	3.71E+15	1.85E+15	50%
Pasture	1.78E+15	8.88E+14	50%
Potential	5.89E+13	2.95E+13	50%
Residential	7.48E+13	3.74E+13	50%
Water	0.00E+00	0.00E+00	0%
Wetlands	6.15E+14	6.15E+14	0%
Woodland	1.32E+15	1.32E+15	0%
Direct			
Human	1.11E+12	0.00E+00	100%
Livestock	2.04E+13	2.04E+12	90%
Wildlife	5.06E+13	5.06E+13	0%

Table 6.5 Nonpoint source allocations in the Little Sandy Creek impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	1.29E+12	6.43E+11	50%
Commercial	3.82E+11	1.91E+11	50%
Cropland	7.04E+15	3.52E+15	50%
Pasture	2.98E+15	1.49E+15	50%
Potential	9.42E+13	4.71E+13	50%
Residential	5.94E+12	2.97E+12	50%
Water	0.00E+00	0.00E+00	0%
Wetlands	7.97E+13	7.97E+13	0%
Woodland	2.00E+14	2.00E+14	0%
Direct			
Human	5.06E+10	0.00E+00	100%
Livestock	4.30E+13	4.30E+12	90%
Wildlife	7.98E+12	7.98E+12	0%

Table 6.6 Nonpoint source allocations in the Bush River (2) impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	5.40E+12	2.70E+12	50%
Commercial	1.62E+12	8.09E+11	50%
Cropland	3.74E+13	1.87E+13	50%
Pasture	7.96E+14	3.98E+14	50%
Potential	2.62E+13	1.31E+13	50%
Residential	4.35E+13	2.17E+13	50%
Water	0.00E+00	0.00E+00	0%
Wetlands	3.68E+14	3.68E+14	0%
Woodland	5.26E+14	5.26E+14	0%
Direct			
Human	3.76E+11	0.00E+00	100%
Livestock	7.22E+12	7.22E+11	90%
Wildlife	2.68E+13	2.68E+13	0%

Table 6.7 Nonpoint source allocations in the Saylers Creek impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based	1.06E+12	1.06E+12	0%
Barren	1.42E+11	1.42E+11	0%
Commercial	1.56E+15	6.25E+14	60%
Cropland	1.38E+15	5.51E+14	60%
Pasture	5.62E+13	2.25E+13	60%
Potential	3.91E+13	3.91E+13	0%
Residential	0.00E+00	0.00E+00	0%
Water	1.41E+14	1.41E+14	0%
Wetlands	3.76E+14	3.76E+14	0%
Woodland			
Direct	2.45E+11	0.00E+00	100%
Human	2.08E+13	0.00E+00	100%
Livestock	1.63E+13	1.63E+13	0%
Wildlife	1.06E+12	1.06E+12	0%

Table 6.8 Nonpoint source allocations in the Angola Creek (1) impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	1.90E+11	1.90E+11	0%
Commercial	1.19E+10	1.19E+10	0%
Cropland	5.22E+13	2.09E+13	60%
Pasture	1.20E+15	4.79E+14	60%
Potential	2.46E+13	9.83E+12	60%
Residential	7.16E+12	7.16E+12	0%
Water	0.00E+00	0.00E+00	0%
Wetlands	3.70E+13	3.70E+13	0%
Woodland	2.24E+14	2.24E+14	0%
Direct			
Human	2.04E+11	0.00E+00	100%
Livestock	8.76E+12	0.00E+00	100%
Wildlife	5.92E+12	5.92E+12	0%

Table 6.9 Nonpoint source allocations in the Angola Creek (2) impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	9.49E+11	9.49E+11	0%
Commercial	1.25E+10	1.25E+10	0%
Cropland	2.02E+15	8.08E+14	60%
Pasture	9.71E+14	3.88E+14	60%
Potential	3.82E+13	1.53E+13	60%
Residential	5.07E+12	5.07E+12	0%
Water	0.00E+00	0.00E+00	0%
Wetlands	9.79E+13	9.79E+13	0%
Woodland	1.06E+14	1.06E+14	0%
Direct			
Human	9.09E+10	0.00E+00	100%
Livestock	1.57E+13	0.00E+00	100%
Wildlife	7.43E+12	7.43E+12	0%

Table 6.10 Nonpoint source allocations in the Horsepen Creek impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	4.46E+11	2.23E+11	50%
Commercial	0.00E+00	0.00E+00	50%
Cropland	1.03E+15	4.10E+14	60%
Pasture	4.12E+14	1.65E+14	60%
Potential	1.29E+13	5.14E+12	60%
Residential	5.42E+12	2.71E+12	50%
Water	0.00E+00	0.00E+00	0%
Wetlands	2.47E+13	2.47E+13	0%
Woodland	1.37E+14	1.37E+14	0%
Direct			
Human	4.38E+10	0.00E+00	100%
Livestock	5.16E+12	0.00E+00	100%
Wildlife	2.48E+12	2.48E+12	0%

Table 6.11 Nonpoint source allocations in the Nibbs Creek impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	2.74E+12	1.37E+12	50%
Commercial	1.47E+12	7.33E+11	50%
Cropland	7.26E+15	3.63E+15	50%
Pasture	2.98E+15	1.49E+15	50%
Potential	1.10E+14	5.50E+13	50%
Residential	5.57E+13	2.79E+13	50%
Water	0.00E+00	0.00E+00	0%
Wetlands	1.12E+14	1.12E+14	0%
Woodland	4.76E+14	4.76E+14	0%
Direct			
Human	7.77E+11	0.00E+00	100%
Livestock	3.88E+13	3.88E+12	90%
Wildlife	1.98E+13	1.98E+13	0%

Table 6.12 Nonpoint source allocations in the Flat Creek impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	1.20E+13	5.99E+12	50%
Commercial	3.23E+12	1.62E+12	50%
Cropland	1.03E+16	5.16E+15	50%
Pasture	8.66E+15	4.33E+15	50%
Potential	1.82E+14	9.11E+13	50%
Residential	1.35E+14	6.74E+13	50%
Water	0.00E+00	0.00E+00	0%
Wetlands	8.33E+14	8.33E+14	0%
Woodland	2.45E+15	2.45E+15	0%
Direct			
Human	1.50E+12	0.00E+00	100%
Livestock	6.13E+13	6.13E+12	90%
Wildlife	9.34E+13	9.34E+13	0%

Table 6.13 Nonpoint source allocations in the Appomattox River (12a) impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	4.04E+13	2.02E+13	50%
Commercial	2.21E+13	1.10E+13	50%
Cropland	1.23E+16	6.13E+15	50%
Pasture	5.33E+14	2.67E+14	50%
Potential	1.20E+16	5.99E+15	50%
Residential	5.59E+14	2.80E+14	50%
Water	0.00E+00	0.00E+00	0%
Wetlands	1.35E+15	1.35E+15	0%
Woodland	6.33E+15	6.33E+15	0%
Direct			
Human	3.36E+12	0.00E+00	100%
Livestock	1.59E+14	1.59E+13	90%
Wildlife	2.09E+14	2.09E+14	0%

Table 6.14 Nonpoint source allocations in the Appomattox River (12b) impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	1.94E+13	1.94E+13	0%
Commercial	9.36E+11	9.36E+11	0%
Cropland	1.49E+16	5.97E+15	60%
Pasture	1.08E+16	4.33E+15	60%
Potential	2.91E+14	1.16E+14	60%
Residential	3.13E+14	3.13E+14	0%
Water	0.00E+00	0.00E+00	0%
Wetlands	1.68E+15	1.68E+15	0%
Woodland	3.89E+15	3.89E+15	0%
Direct			
Human	2.56E+12	0.00E+00	100%
Livestock	1.09E+14	0.00E+00	100%
Wildlife	1.46E+14	1.46E+14	0%

Table 6.15 Nonpoint source allocations in the Appomattox River (12c) impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	1.32E+13	6.61E+12	50%
Commercial	1.45E+13	7.23E+12	50%
Cropland	1.62E+15	8.12E+14	50%
Pasture	1.34E+15	6.69E+14	50%
Potential	5.28E+13	2.64E+13	50%
Residential	8.16E+13	4.08E+13	50%
Water	0.00E+00	0.00E+00	0%
Wetlands	3.27E+13	3.27E+13	0%
Woodland	2.72E+15	2.72E+15	0%
Direct			
Human	2.99E+11	0.00E+00	100%
Livestock	1.32E+13	1.32E+12	90%
Wildlife	6.04E+13	6.04E+13	0%

Table 6.16 Nonpoint source allocations in the West Creek impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	4.23E+12	2.12E+12	50%
Commercial	6.57E+11	3.28E+11	50%
Cropland	3.21E+15	1.61E+15	50%
Pasture	1.43E+15	7.15E+14	50%
Potential	5.75E+13	2.87E+13	50%
Residential	5.29E+13	2.65E+13	50%
Water	0.00E+00	0.00E+00	0%
Wetlands	3.82E+14	3.82E+14	0%
Woodland	1.14E+15	1.14E+15	0%
Direct			
Human	6.07E+11	0.00E+00	100%
Livestock	1.98E+13	1.98E+12	90%
Wildlife	4.70E+13	4.70E+13	0%

Table 6.17 Nonpoint source allocations in the Deep Creek impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	2.14E+13	1.07E+13	50%
Commercial	2.48E+13	1.24E+13	50%
Cropland	1.11E+16	5.55E+15	50%
Pasture	6.27E+15	3.13E+15	50%
Potential	2.76E+14	1.38E+14	50%
Residential	2.07E+14	1.04E+14	50%
Water	0.00E+00	0.00E+00	0%
Wetlands	4.79E+14	4.79E+14	0%
Woodland	3.70E+15	3.70E+15	0%
Direct			
Human	1.94E+12	0.00E+00	100%
Livestock	1.01E+14	1.01E+13	90%
Wildlife	1.04E+14	1.04E+14	0%

Table 6.18 Nonpoint source allocations in the Appomattox River (2) impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	2.34E+13	1.17E+13	50%
Commercial	1.46E+14	7.28E+13	50%
Cropland	2.07E+16	1.03E+16	50%
Pasture	7.57E+15	3.79E+15	50%
Potential	3.13E+14	1.56E+14	50%
Residential	7.61E+14	3.81E+14	50%
Water	0.00E+00	0.00E+00	0%
Wetlands	4.25E+13	4.25E+13	0%
Woodland	5.32E+15	5.32E+15	0%
Direct			
Human	1.69E+12	0.00E+00	100%
Livestock	1.18E+14	1.18E+13	90%
Wildlife	1.41E+14	1.41E+14	0%

Table 6.19 Nonpoint source allocations in the Swift Creek (1) impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	2.22E+11	1.66E+11	25%
Commercial	1.74E+12	1.31E+12	25%
Cropland	2.08E+13	1.56E+13	25%
Pasture	5.16E+12	3.87E+12	25%
Potential	1.59E+14	1.20E+14	25%
Residential	8.62E+13	6.46E+13	25%
Water	0.00E+00	0.00E+00	0%
Wetlands	2.89E+13	2.89E+13	0%
Woodland	1.11E+15	1.11E+15	0%
Direct			
Human	2.04E+11	0.00E+00	100%
Livestock	9.13E+11	9.13E+10	90%
Wildlife	2.01E+13	2.01E+13	0%

Table 6.20 Nonpoint source allocations in the Swift Creek (2) impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	4.26E+12	2.34E+12	45%
Commercial	2.19E+13	1.21E+13	45%
Cropland	5.10E+13	2.80E+13	45%
Pasture	1.04E+13	5.74E+12	45%
Potential	2.79E+14	1.53E+14	45%
Residential	1.01E+15	5.58E+14	45%
Water	0.00E+00	0.00E+00	0%
Wetlands	1.16E+13	1.16E+13	0%
Woodland	1.83E+15	1.83E+15	0%
Direct			
Human	8.05E+11	0.00E+00	100%
Livestock	2.01E+12	5.02E+11	75%
Wildlife	4.96E+13	4.96E+13	0%

Table 6.21 Nonpoint source allocations in the Swift Creek (3) impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	5.65E+12	3.11E+12	45%
Commercial	1.61E+13	8.85E+12	45%
Cropland	4.10E+13	2.26E+13	45%
Pasture	1.14E+13	6.26E+12	45%
Potential	3.93E+14	2.16E+14	45%
Residential	3.50E+14	1.93E+14	45%
Water	0.00E+00	0.00E+00	0%
Wetlands	4.83E+13	4.83E+13	0%
Woodland	1.60E+15	1.60E+15	0%
Direct			
Human	5.34E+11	0.00E+00	100%
Livestock	3.01E+12	2.26E+12	25%
Wildlife	4.11E+13	4.11E+13	0%

Table 6.22 Nonpoint source allocations in the Appomattox River (3) impairment for Stage I implementation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Barren	2.52E+13	1.26E+13	50%
Commercial	1.58E+14	7.88E+13	50%
Cropland	9.54E+13	4.77E+13	50%
Pasture	2.37E+14	1.19E+14	50%
Potential	8.10E+12	4.05E+12	50%
Residential	1.01E+15	5.04E+14	50%
Water	0.00E+00	0.00E+00	0%
Wetlands	9.01E+14	9.01E+14	0%
Woodland	1.84E+15	1.84E+15	0%
Direct			
Human	1.16E+12	0.00E+00	100%
Livestock	0.00E+00	0.00E+00	0%
Wildlife	8.02E+13	8.02E+13	0%

The development of the implementation plan is expected to be an iterative process, with monitoring data refining its final design. Subsequent refinements will be made as the progress toward meeting milestones and the expressed TMDL goals is assessed. As

practices are implemented, periodic analyses of water quality conditions will be conducted to evaluate the progress toward meeting end goals.

6.3 Reasonable Assurance for Implementation

6.3.1 Follow-up Monitoring

VADEQ will continue monitoring the Appomattox River watershed in accordance with its ambient monitoring program to evaluate reductions in fecal bacteria counts and the effectiveness of TMDL implementation in attainment of water quality standards.

The monitoring stations listed in Table 6.1 are trend stations and will continue to be monitored on a monthly basis. Watershed monitoring stations are designed to provide complete, census-based coverage of every watershed in Virginia. Two of the major data users in the Commonwealth (the Department of Environmental Quality and the Department of Conservation and Recreation) have indicated that this is an important function for ambient water quality monitoring.

Watershed stations are located at the mouth and within the watershed, based on a census siting scheme. The number of stations in the watershed is determined by the NPS priority ranking thus focusing our resources on known problem areas. Watersheds are monitored on a rotating basis such that, in the 6-year assessment cycle, all 493 watersheds are monitored. These stations will be sampled at a frequency of once every other month for a two-year period on a 6-year rotating basin basis.

Table 6.23 Ambient Trend Stations in the Appomattox Watershed

Station ID	Stream Name
2-APP001.53	Appomattox River
2-APP0050.23	Appomattox River
2-DPC005.20	Deep Creek
2-APP012.79	Appomattox River
2-APP085.85	Appomattox River
2-APP110.93	Appomattox River
2-APP118.04	Appomattox River
2-BFL011.03	Buffalo Creek

6.3.2 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. 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.

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

Once developed, VADEQ will take TMDL implementation plans to the State Water Control Board (SWCB) for approval as the plan for implemeting the pollutant allocations and reductions contained in the TMDLs. Also, VADEQ will request SWCB authorization to incorporate the TMDL implementation plan into the appropriate Water Quality Management Plan (WQMP) in accordance with the CWA's Section 303(e). In response to a Memorandum of Understanding (MOU) between EPA and VADEQ. Also, VADEQ submitted a draft Continuous Planning Process to EPA in which VADEQ 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.

6.3.3 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 Pollutant Discharge Elimination System (VPDES) Permit Regulation (9 VAC 25-31-10 et seq.). Section 9 VAC 25-31-120 describes the requirements for storm water 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…".

Part of the Appomattox River watershed is covered by Phase I and II VPDES permits. The Phase I permit was issued March 24, 2003 and expires March 23, 2008, VA0088609 owned by Chesterfield. The Phase II permits were issued December 2, 2002 and expire December 2, 2007 VAR040009 owned by Colonial Heights City, VAR040013 owned by Petersburg City and VAR040015 owned by Hopewell City for the small municipal separate storm sewer systems (MS-4s). The permits state, under Part II.A., that the "permittee must develop, implement, and enforce a storm water 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 storm water 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 Storm Water Management Program required in Part II be modified to implement the TMDL within a timeframe consistent with the TMDL."

For MS4/VPDES general permits, VADEQ expects revisions to the permittee's Stormwater Pollution Prevention Plans to specifically address the TMDL pollutants of concern. VADEQ anticipates that BMP effectiveness would be determined through

ambient in-stream monitoring. This is in accordance with recent EPA guidance (EPA Memorandum on TMDLs and Stormwater Permits, dated November 22, 2002). If future monitoring indicates no improvement in stream water quality, the permit could require the MS4 to expand or better tailor its BMPs to achieve the TMDL reductions. However, only failing to implement the required BMPs would be considered a violation of the permit. DEQ acknowledges that it may not be possible to meet the existing water quality standard because of the wildlife issue associated with a number of bacteria TMDLs (see section 6.4.5 below). At some future time, it may therefore become necessary to investigate the stream's use designation and adjust the water quality criteria through a Use Attainability Analysis. Any changes to the TMDL resulting from water quality standards change on Appomattox River would be reflected in the permittee's Stormwater Pollution Prevention Plan required by the MS4/VPDES permit.

Additional information on Virginia's Storm Water Phase 2 program and a downloadable menu of Best Management Practices and Measurable Goals Guidance can be found at http://www.deq.state.va.us/water/bmps.html.

6.3.4 Implementation Funding Sources

One potential source of funding for TMDL implementation is Section 319 of the Clean Water Act. Section 319 funding is a major source of funds for Virginia's Nonpoint Source Management Program. Other funding sources for implementation include the U.S. Department of Agriculture's Conservation Reserve Enhancement and Environmental Quality Incentive Programs, the Virginia State Revolving Loan Program, and the Virginia Water Quality Improvement Fund. 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.

6.3.5 Addressing Wildlife Contributions

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. As is the case for the

Appomattox River, 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.**

To address this issue, Virginia has proposed (during its recent 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 will become effective pending EPA approval and can be found at http://www.deq.state.va.us/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 bacterial 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.state.va.us/wqs/WQS03AUG.pdf.

Based on the above, EPA and Virginia have developed a process to address the wildlife issue. First in this process 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 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 6.1

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, a UAA may be initiated to reflect the presence of naturally high bacteria levels due to uncontrollable sources. In some cases, the effort may never have to go to the UAA phase because the water quality standard exceedances attributed to wildlife in the model may have been very small and infrequent and within the margin of error.

7. PUBLIC PARTICIPATION

The development of the Appomattox River TMDLs greatly benefited from public participation. This section details the involvement for the upper and lower watershed areas.

7.1 Upper Appomattox River Watershed

Table 7.1 details the public participation throughout the project. In addition to the three public meetings, there were three Technical Advisory Committee (TAC) meetings.

The first TAC meeting for the Upper Appomattox River took place on March 20, 2003. There were 12 attendees representing VADEQ, VADCR, James River Association, Clean Virginia Waterways, Prince Edward Utility, Town of Farmville, PFSWCD, VDH, Longwood College, and MapTech, Inc. The second TAC meeting for the Upper Appomattox River took place on October 1, 2003 and was attended by 11 people. There were also 11 people in attendance at the third TAC meeting, which took place on February 10, 2004.

Public meetings were advertised in the Farmville Herald and also published in the Virginia Register. The first public meeting took place on May 20, 2003 in the Johns Auditorium on the campus of Hampden-Sydney College in Hampden-Sydney, Virginia; 19 people attended. The meeting was publicized through direct mailing to local government agencies.

The second public meeting was held in the Crawley Forum at Hampden-Sydney College in Hampden-Sydney, Virginia on November 4, 2003 to discuss the source assessment input, BST, and model calibration data; 58 people attended. Copies of the presentation materials were available for public distribution. There was a 30 day-public comment period and no written comments were received.

The final public meeting was took place at the Farmville Train Station in Farmville, Virginia on March 4, 2004; 36 people (13 stakeholders, 17 agency, 6 MapTech) were in attendance. Topics discussed include: TMDL implementation, Secondary Contact Recreation, and Use Attainability Analysis. There was a 30 day-public comment period and two written comments were received.

Table 7.1 Public participation during TMDL development for the Upper Appomattox River watershed.

Date	Location	Attendance[1]	Type	Format
3/20/03	Old Farmville Bus Station Farmville, VA	12	1st TAC meeting	
5/20/03	Johns Auditorium Hampden-Sydney College Hampden-Sydney, VA		1st public meeting	Open to public at large
10/1/03	Old Farmville Bus Station Farmville, VA	11	2nd TAC meeting for Upper Appomattox	
11/4/03	Crawley Forum Hampden-Sydney College Hampden-Sydney, VA	58	2nd public meeting	Open to public at large
2/10/04	Old Farmville Train Station 510 West 3rd Street Farmville, VA	11	3rd TAC meeting	
3/4/04	Old Farmville Train Station 510 West 3rd Street Farmville, VA	36	Final public meeting	Open to public at large

[1]The number of attendants is estimated from sign up sheets provided at each meeting. These numbers are known to underestimate the actual attendance.

Public participation during the implementation plan development process will include the formation of stakeholders' committee and open public meetings. Public participation is critical to promote reasonable assurances that the implementation activities will occur. A stakeholders' committee will have the expressed purpose of formulating the TMDL implementation plan. The major stakeholders were identified during the development of this TMDL. The committee will consist of, but not be limited to, representatives from the Department of Environmental Quality, Department of Conservation and Recreation, Department of Health, local agricultural community, local urban community, and local governments. This committee will have responsibility for identifying corrective actions that are founded in practicality, establish a time line to insure expeditious

implementation, and set measurable goals and milestones for attaining water quality standards.

7.2 Lower Appomattox River Watershed

Table 7.2 details the public participation for the lower watershed area. The first TAC meeting for the Lower Appomattox River took place on March 24, 2003. There were 28 attendees representing government agencies and MapTech, Inc. The second TAC meeting for the Lower Appomattox River took place on October 6, 2003 and was attended by 11 people. There were 13 people in attendance at the third TAC meeting, which took place on February 11, 2004.

The first public meeting took place on May 21, 2003 at the Police Station in Chesterfield, Virginia; 19 people attended. The meeting was publicized through notice in the Virginia Register; information was also provided to the Crewe-Burkeville Journal, Progress Index (Petersburg), and Powhatan Today in the Community Calendar sections. In addition, the Amelia County extension agent did a mailing to agricultural producers in his coverage area.

The second public meeting was held at the Police Station in Chesterfield, Virginia on November 6, 2003 to discuss the source assessment input, BST, and model calibration data; 13 people attended. Copies of the presentation materials were available for public distribution. Public meetings were advertised in the Farmville Herald and also published in the Virginia Register. There was a 30 day-public comment period and no written comments were received.

Table 7.2 Public participation during TMDL development for the Lower Appomattox River watershed.

Date	Location	Attendance[1]	Type	Format
3/24/03	Chesterfield County Government Complex Chesterfield, VA 23832	28	1st TAC meeting	
5/21/03	Chesterfield County Police Bldg Gov't Complex Chesterfield, VA 23832	19	1st public meeting	Open to public at large
10/6/03	DEQ – Piedmont Regional Office 4949 A Cox Road Glenn Allen, VA 23060	11	2nd TAC meeting for Upper Appomattox	
11/6/03	Chesterfield County Police Bldg Gov't Complex Chesterfield, VA 23832	13	2nd public meeting	Open to public at large
2/11/04	Chesterfield Central Library 9501 Lori Road Chesterfield, VA 23832	13	3rd TAC meeting	
3/11/04	Chesterfield County Police Bldg Gov't Complex Chesterfield, VA 23832	17	3rd public meeting	Open to public at large
3/30/04	Chesterfield County Government Complex Chesterfield, VA 23832	13	4th TAC meeting	

[1]The number of attendants is estimated from sign up sheets provided at each meeting. These numbers are known to underestimate the actual attendance.

Public participation during the implementation plan development process will include the formation of stakeholders' committee and open public meetings. Public participation is critical to promote reasonable assurances that the implementation activities will occur. A stakeholders' committee will have the expressed purpose of formulating the TMDL implementation plan. The major stakeholders were identified during the development of this TMDL. The committee will consist of, but not be limited to, representatives from the

Department of Environmental Quality, Department of Conservation and Recreation, Department of Health, local agricultural community, local urban community, and local governments. This committee will have responsibility for identifying corrective actions that are founded in practicality, establish a time line to insure expeditious implementation, and set measurable goals and milestones for attaining water quality standards.

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GLOSSARY

Note: All entries in italics are taken from EPA (1998).

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

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

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

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

Antidegradation Policies. *Policies that are part of each states water quality standards. These policies are designed to protect water quality and provide a method of assessing activities that might affect the integrity of waterbodies.*

Aquatic ecosystem. *Complex of biotic and abiotic components of natural waters. The aquatic ecosystem is an ecological unit that includes the physical characteristics (such as flow or velocity and depth), the biological community of the water column and benthos, and the chemical characteristics such as dissolved solids, dissolved oxygen, and nutrients. Both living and nonliving components of the aquatic ecosystem interact and influence the properties and status of each component.*

Assimilative capacity. *The amount of contaminant load that can be discharged to a specific waterbody without exceeding water quality standards or criteria. Assimilative capacity is used to define the ability of a waterbody to naturally absorb and use a discharged substance without impairing water quality or harming aquatic life.*

Background levels. *Levels representing the chemical, physical, and biological conditions that would result from natural geomorphological processes such as weathering or dissolution.*

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

Bacterial decomposition. *Breakdown by oxidation, or decay, of organic matter by heterotrophic bacteria. Bacteria use the organic carbon in organic matter as the energy source for cell synthesis.*

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

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

Benthic organisms. *Organisms living in, or on, bottom substrates in aquatic ecosystems.*

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

Bioassessment. Evaluation of the condition of an ecosystem that uses biological surveys and other direct measurements of the resident biota. (2)

Biosolids. Biologically treated solids originating from municipal wastewater treatment plants.

Biometric. (Biological Metric) The study of biological phenomena by measurements and statistics.

Box and whisker plot. A graphical representation of the mean, lower quartile, upper quartile, upper limit, lower limit, and outliers of a data set.

Calibration. *The process of adjusting model parameters within physically defensible ranges until the resulting predictions give a best possible good fit to observed data.*

Causal analysis. A process in which data and other information are organized and evaluated using quantitative and logical techniques to determine the likely cause of an observed condition. (2)

Causal association. A correlation or other association between measures or observations of two entities or processes which occurs because of an underlying causal relationship. (2)

Causal mechanism. The process by which a cause induces an effect. (2)

Causal relationship. The relationship between a cause and its effect. (2)

Cause. 1. That which produces an effect (a general definition).

2. A stressor or set of stressors that occur at an intensity, duration and frequency of exposure that results in a change in the ecological condition (a SI-specific definition). (2)

Channel. *A natural stream that conveys water; a ditch or channel excavated for the flow of water.*

Chloride. *An atom of chlorine in solution; an ion bearing a single negative charge.*

Clean Water Act (CWA). *The Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972), Public Law 92-500, as amended by Public Law 96-483 and Public Law 97-117, 33 U.S.C. 1251 et seq. The Clean Water Act (CWA) contains a number of provisions to restore and maintain the quality of the nation's water resources. One of these provisions is Section 303(d), which establishes the TMDL program.*

Coefficient of determination. Represents the proportion of the total sample variability around y that is explained by the linear relationship between *y* and *x*. (In simple linear regression, it may also be computed as the square of the coefficient of correlation *r.)* (3)

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

Concentration-based limit. *A limit based on the relative strength of a pollutant in a waste stream, usually expressed in milligrams per liter (mg/L).*

Concentration-response model. A quantitative (usually statistical) model of the relationship between the concentration of a chemical to which a population or community of organisms is exposed and the frequency or magnitude of a biological response. (2)

Confluence. The point at which a river and its tributary flow together.

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

Continuous discharge. *A discharge that occurs without interruption throughout the operating hours of a facility, except for infrequent shutdowns for maintenance, process changes, or other similar activities.*

Conventional pollutants. *As specified under the Clean Water Act, conventional contaminants include suspended solids, coliform bacteria, high biochemical oxygen demand, pH, and oil and grease.*

Conveyance. A measure of the water carrying capacity of a channel section. It is directly proportional to the discharge in the channel section.

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

Cross-sectional area. *Wet area of a waterbody normal to the longitudinal component of the flow.*

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

Decay. *The gradual decrease in the amount of a given substance in a given system due to various sink processes including chemical and biological transformation, dissipation to other environmental media, or deposition into storage areas.*

Decomposition. *Metabolic breakdown of organic materials; the formation of by-products of decomposition releases energy and simple organic and inorganic compounds. See also* ***Respiration****.*

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

Deterministic model. *A model that does not include built-in variability: same input will always result in the same output.*

Dilution. *The addition of some quantity of less-concentrated liquid (water) that results in a decrease in the original concentration.*

Direct runoff. *Water that flows over the ground surface or through the ground directly into streams, rivers, and lakes.*

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

Discharge Monitoring Report (DMR). *Report of effluent characteristics submitted by a municipal or industrial facility that has been granted an NPDES discharge permit.*

Discharge permits (under NPDES). *A permit issued by the U.S. EPA or a state regulatory agency that sets specific limits on the type and amount of pollutants that a municipality or industry can discharge to a receiving water; it also includes a compliance schedule for achieving those limits. The permit process was established under the National Pollutant Discharge Elimination System, under provisions of the Federal Clean Water Act.*

Dispersion. *The spreading of chemical or biological constituents, including pollutants, in various directions at varying velocities depending on the differential in-stream flow characteristics.*

Diurnal. *Actions or processes that have a period or a cycle of approximately one tidal-day or are completed within a 24-hour period and that recur every 24 hours. Also, the occurrence of an activity/process during the day rather than the night.*

DNA. Deoxyribonucleic acid. The genetic material of cells and some viruses.

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

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

Dynamic model. *A mathematical formulation describing and simulating the physical behavior of a system or a process and its temporal variability.*

Dynamic simulation. *Modeling of the behavior of physical, chemical, and/or biological phenomena and their variations over time.*

Ecosystem. *An interactive system that includes the organisms of a natural community association together with their abiotic physical, chemical, and geochemical environment.*

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

Effluent guidelines. *The national effluent guidelines and standards specify the achievable effluent pollutant reduction that is attainable based upon the performance of treatment technologies employed within an industrial category. The National Effluent Guidelines Program was established with a phased approach whereby industry would first be required to meet interim limitations based on best practicable control technology currently available for existing sources (BPT). The second level of effluent limitations to be attained by industry was referred to as best available technology economically achievable (BAT), which was established primarily for the control of toxic pollutants.*

Effluent limitation. *Restrictions established by a state or EPA on quantities, rates, and concentrations in pollutant discharges.*

Empirical model. *Use of statistical techniques to discern patterns or relationships underlying observed or measured data for large sample sets. Does not account for physical dynamics of waterbodies.*

Endpoint. *An endpoint (or indicator/target) is a characteristic of an ecosystem that may be affected by exposure to a stressor. Assessment endpoints and measurement endpoints are two distinct types of endpoints commonly used by resource managers. An assessment endpoint is the formal expression of a valued environmental characteristic and should have societal relevance (an indicator). A measurement endpoint is the expression of an observed or measured response to a stress or disturbance. It is a measurable environmental characteristic that is related to the valued environmental characteristic chosen as the assessment endpoint. The numeric criteria that are part of traditional water quality standards are good examples of measurement endpoints (targets).*

Enhancement. *In the context of restoration ecology, any improvement of a structural or functional attribute.*

Evapotranspiration. The combined effects of evaporation and transpiration on the water balance. Evaporation is water loss into the atmosphere from soil and water surfaces. Transpiration is water loss into the atmosphere as part of the life cycle of plants.

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

Fate of pollutants. *Physical, chemical, and biological transformation in the nature and changes of the amount of a pollutant in an environmental system. Transformation processes are pollutant-specific. Because they have comparable kinetics, different formulations for each pollutant are not required.*

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

Feedlot. *A confined area for the controlled feeding of animals. Tends to concentrate large amounts of animal waste that cannot be absorbed by the soil and, hence, may be carried to nearby streams or lakes by rainfall runoff.*

First-order kinetics. *The type of relationship describing a dynamic reaction in which the rate of transformation of a pollutant is proportional to the amount of that pollutant in the environmental system.*

Flux. *Movement and transport of mass of any water quality constituent over a given period of time. Units of mass flux are mass per unit time.*

General Standard. A narrative standard that ensures the general health of state waters. All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life (9VAC25-260-20). (4)

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

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

Ground water. *The supply of fresh water found beneath the earths surface, usually in aquifers, which supply wells and springs. Because ground water is a major source of drinking water, there is growing concern over contamination from leaching agricultural or industrial pollutants and leaking underground storage tanks.*

HSPF. Hydrological Simulation Program – Fortran. A computer simulation tool used to mathematically model nonpoint source pollution sources and movement of pollutants in a watershed.

Hydrograph. *A graph showing variation of stage (depth) or discharge in a stream over a period of time.*

Hydrologic cycle. *The circuit of water movement from the atmosphere to the earth and its return to the atmosphere through various stages or processes, such as precipitation, interception, runoff, infiltration, storage, evaporation, and transpiration.*

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

Hyetograph. *Graph of rainfall rate versus time during a storm event.*

IMPLND. An impervious land segment in HSPF. It is used to model land covered by impervious materials, such as pavement.

Indicator. *A measurable quantity that can be used to evaluate the relationship between pollutant sources and their impact on water quality.*

Indicator organism. *An organism used to indicate the potential presence of other (usually pathogenic) organisms. Indicator organisms are usually associated with the other organisms, but are usually more easily sampled and measured.*

Indirect causation. The induction of effects through a series of cause-effect relationships, so that the impaired resource may not even be exposed to the initial cause. (2)

Indirect effects. Changes in a resource that are due to a series of cause-effect relationships rather than to direct exposure to a contaminant or other stressor. (2)

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

In situ. *In place; in situ measurements consist of measurements of components or processes in a full-scale system or a field, rather than in a laboratory.*

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

Isolate. An inbreeding biological population that is isolated from similar populations by physical or other means.

Leachate. *Water that collects contaminants as it trickles through wastes, pesticides, or fertilizers. Leaching can occur in farming areas, feedlots, and landfills and can result in hazardous substances entering surface water, ground water, or soil.*

Limits (upper and lower). The lower limit equals the lower quartile – 1.5x(upper quartile – lower quartile), and the upper limit equals the upper quartile + 1.5x(upper quartile – lower quartile). Values outside these limits are referred to as outliers.

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

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

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

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

Mass balance. *An equation that accounts for the flux of mass going into a defined area and the flux of mass leaving the defined area. The flux in must equal the flux out.*

Mass loading. *The quantity of a pollutant transported to a waterbody.*

Mathematical model. *A system of mathematical expressions that describe the spatial and temporal distribution of water quality constituents resulting from fluid transport and the one or more individual processes and interactions within some prototype aquatic ecosystem. A mathematical water quality model is used as the basis for waste load allocation evaluations.*

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

MGD. Million gallons per day. A unit of water flow, whether discharge or withdraw.

Mitigation. *Actions taken to avoid, reduce, or compensate for the effects of environmental damage. Among the broad spectrum of possible actions are those that restore, enhance, create, or replace damaged ecosystems.*

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

Mood's Median Test. A nonparametric (distribution-free) test used to test the equality of medians from two or more populations.

Multivariate Regression. A functional relationship between 1 dependent variable and multiple independent variables that are often empirically determined from data and are used especially to predict values of one variable when given values of the others.

Narrative criteria. *Nonquantitative guidelines that describe the desired water quality goals.*

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

Natural waters. *Flowing water within a physical system that has developed without human intervention, in which natural processes continue to take place.*

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

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

Numerical model. *Model that approximates a solution of governing partial differential equations, which describe a natural process. The approximation uses a numerical discretization of the space and time components of the system or process.*

Organic matter. *The organic fraction that includes plant and animal residue at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population. Commonly determined as the amount of organic material contained in a soil or water sample.*

Parameter. A numerical descriptive measure of a population. Since it is based on the observations of the population, its value is almost always unknown.

Peak runoff. *The highest value of the stage or discharge attained by a flood or storm event; also referred to as flood peak or peak discharge.*

PERLND. A pervious land segment in HSPF. It is used to model a particular land use segment within a subwatershed (*e.g*. pasture, urban land, or crop land).

Permit. *An authorization, license, or equivalent control document issued by EPA or an approved federal, state, or local agency to implement the requirements of an environmental regulation; e.g., a permit to operate a wastewater treatment plant or to operate a facility that may generate harmful emissions.*

Permit Compliance System (PCS). *Computerized management information system that contains data on NPDES permit-holding facilities. PCS keeps extensive records on more than 65,000 active water-discharge permits on sites located throughout the nation. PCS tracks permit, compliance, and enforcement status of NPDES facilities.*

Phased/staged approach. *Under the phased approach to TMDL development, load allocations and wasteload allocations are calculated using the best available data and information recognizing the need for additional monitoring data to accurately characterize sources and loadings. The phased approach is typically employed when nonpoint sources dominate. It provides for the implementation of load reduction strategies while collecting additional data.*

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

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

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

Postaudit. *A subsequent examination and verification of a model's predictive performance following implementation of an environmental control program.*

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

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

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

Quartile. The 25th, 50th, and 75th percentiles of a data set. A percentile (p) of a data set ordered by magnitude is the value that has at most p% of the measurements in the data set below it, and (100-p)% above it. The 50th quartile is also known as the median. The 25th and 75th quartiles are referred to as the lower and upper quartiles, respectively.

Raw sewage. *Untreated municipal sewage.*

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

Reserve capacity. *Pollutant loading rate set aside in determining stream waste load allocation, accounting for uncertainty and future growth.*

Residence time. *Length of time that a pollutant remains within a section of a stream or river. The residence time is determined by the streamflow and the volume of the river reach or the average stream velocity and the length of the river reach.*

Restoration. *Return of an ecosystem to a close approximation of its presumed condition prior to disturbance.*

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

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

Roughness coefficient. *A factor in velocity and discharge formulas representing the effects of channel roughness on energy losses in flowing water. Manning's "n" is a commonly used roughness coefficient.*

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

Seasonal Kendall test. A statistical tool used to test for trends in data, which is unaffected by seasonal cycles.

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

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

Simulation. *The use of mathematical models to approximate the observed behavior of a natural water system in response to a specific known set of input and forcing conditions. Models that have been validated, or verified, are then used to predict the response of a natural water system to changes in the input or forcing conditions.*

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

Source. An origination point, area, or entity that releases or emits a stressor. A source can alter the normal intensity, frequency, or duration of a natural attribute, whereby the attribute then becomes a stressor. (2)

Spatial segmentation. *A numerical discretization of the spatial component of a system into one or more dimensions; forms the basis for application of numerical simulation models.*

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

Standard. In reference to water quality (*e.g.* 200 cfu/100 ml geometric mean limit).

Standard deviation. A measure of the variability of a data set. The positive square root of the variance of a set of measurements.

Standard error. The standard deviation of a distribution of a sample statistic, esp. when the mean is used as the statistic.

Statistical significance. An indication that the differences being observed are not due to random error. The p-value indicates the probability that the differences are due to random error (i.e. a low p-value indicates statistical significance).

Steady-state model. *Mathematical model of fate and transport that uses constant values of input variables to predict constant values of receiving water quality concentrations. Model variables are treated as not changing with respect to time.*

Stepwise regression. All possible one-variable models of the form $E(y) = B_0 + B_1 x_1$ are fit and the "best" x1 is selected based on the t-test for B1. Next, two-variable models of the form $E(y) = B_0 + B_1 x_1 + B_2 x_i$ are fit (where x_i is the variable selected in the first step): the "second best" x_i is selected based on the test for B_2. The process continues in this fashion until no more "important" x's can be added to the model. (3)

Storm runoff. *Storm water runoff, snowmelt runoff, and surface runoff and drainage; rainfall that does not evaporate or infiltrate the ground because of impervious land surfaces or a soil infiltration rate lower than rainfall intensity, but instead flows onto adjacent land or into waterbodies or is routed into a drain or sewer system.*

Streamflow. *Discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word "streamflow" uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than "runoff" since streamflow may be applied to discharge whether or not it is affected by diversion or regulation.*

Stream Reach. A straight portion of a stream.

Stream restoration. *Various techniques used to replicate the hydrological, morphological, and ecological features that have been lost in a stream because of urbanization, farming, or other disturbance.*

Stressor. Any physical, chemical, or biological entity that can induce an adverse response. (2)

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

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

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

Technology-based standards. *Effluent limitations applicable to direct and indirect sources that are developed on a category-by-category basis using statutory factors, not including water quality effects.*

Timestep. An increment of time in modeling terms. The smallest unit of time used in a mathematical simulation model (*e.g*. 15-minutes, 1-hour, 1-day).

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

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

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

TRC. Total Residual Chlorine. A measure of the effectiveness of chlorinating treated waste water effluent.

Tributary. *A lower order-stream compared to a receiving waterbody. "Tributary to" indicates the largest stream into which the reported stream or tributary flows.*

Validation (of a model). *Process of determining how well the mathematical model's computer representation describes the actual behavior of the physical processes under investigation. A validated model will have also been tested to ascertain whether it accurately and correctly solves the equations being used to define the system simulation.*

Variance. A measure of the variability of a data set. The sum of the squared deviations (observation – mean) divided by (number of observations) – 1.

VADACS. Virginia Department of Agriculture and Consumer Services.

VADCR. Virginia Department of Conservation and Recreation.

VADEQ. Virginia Department of Environmental Quality.

VDH. Virginia Department of Health.

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

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

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

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

Water quality-based effluent limitations (WQBEL). *Effluent limitations applied to dischargers when technology-based limitations alone would cause violations of water quality standards. Usually WQBELs are applied to discharges into small streams.*

Water quality-based permit. *A permit with an effluent limit more stringent than one based on technology performance. Such limits might be necessary to protect the designated use of receiving waters (e.g., recreation, irrigation, industry, or water supply).*

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

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

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

WQIA. Water Quality Improvement Act.

APPENDIX A

FREQUENCY ANALYSIS OF WATER QUALITY SAMPLING DATA

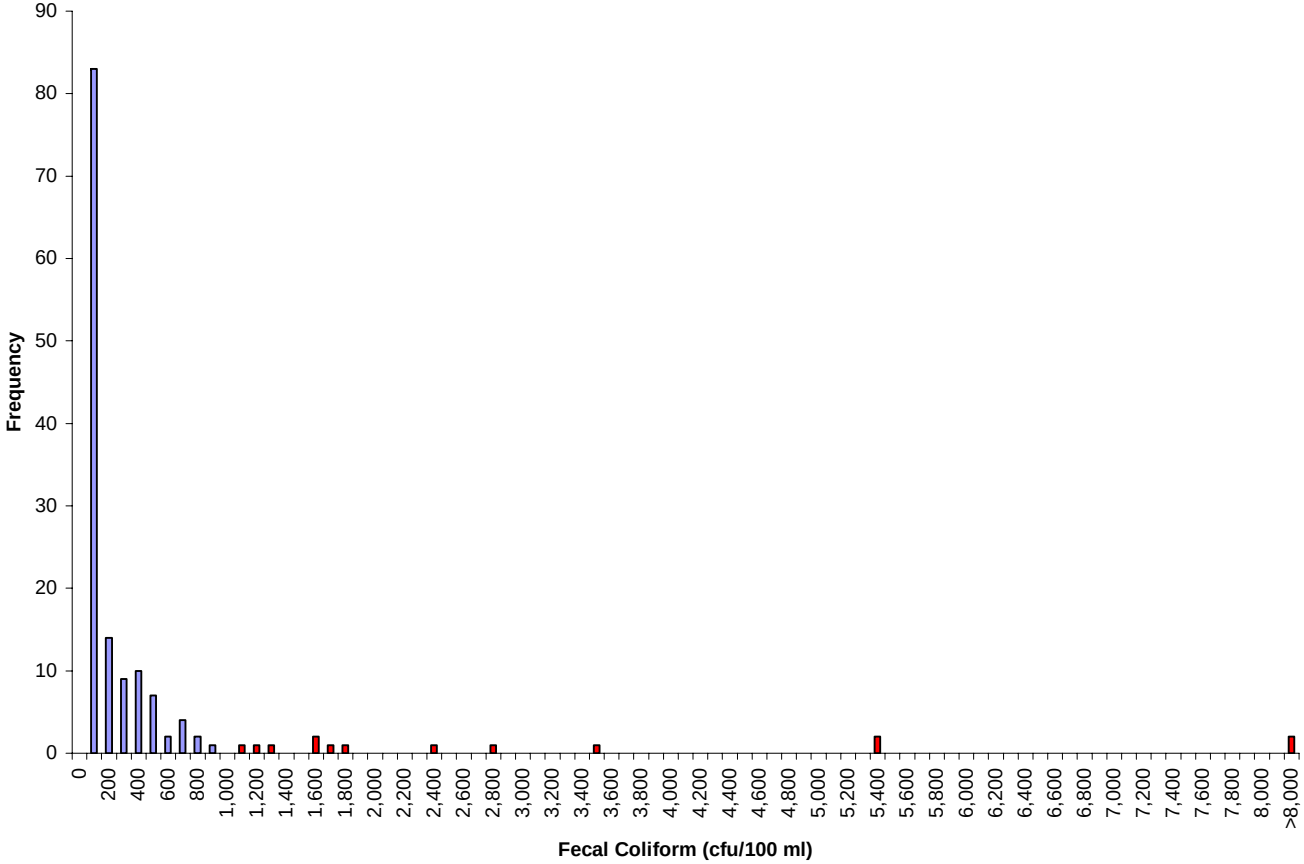

Figure A.1 Frequency analysis of fecal coliform concentrations at station 2APP001.53 in the Appomattox River impairment for period April 1990 to February 2003.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

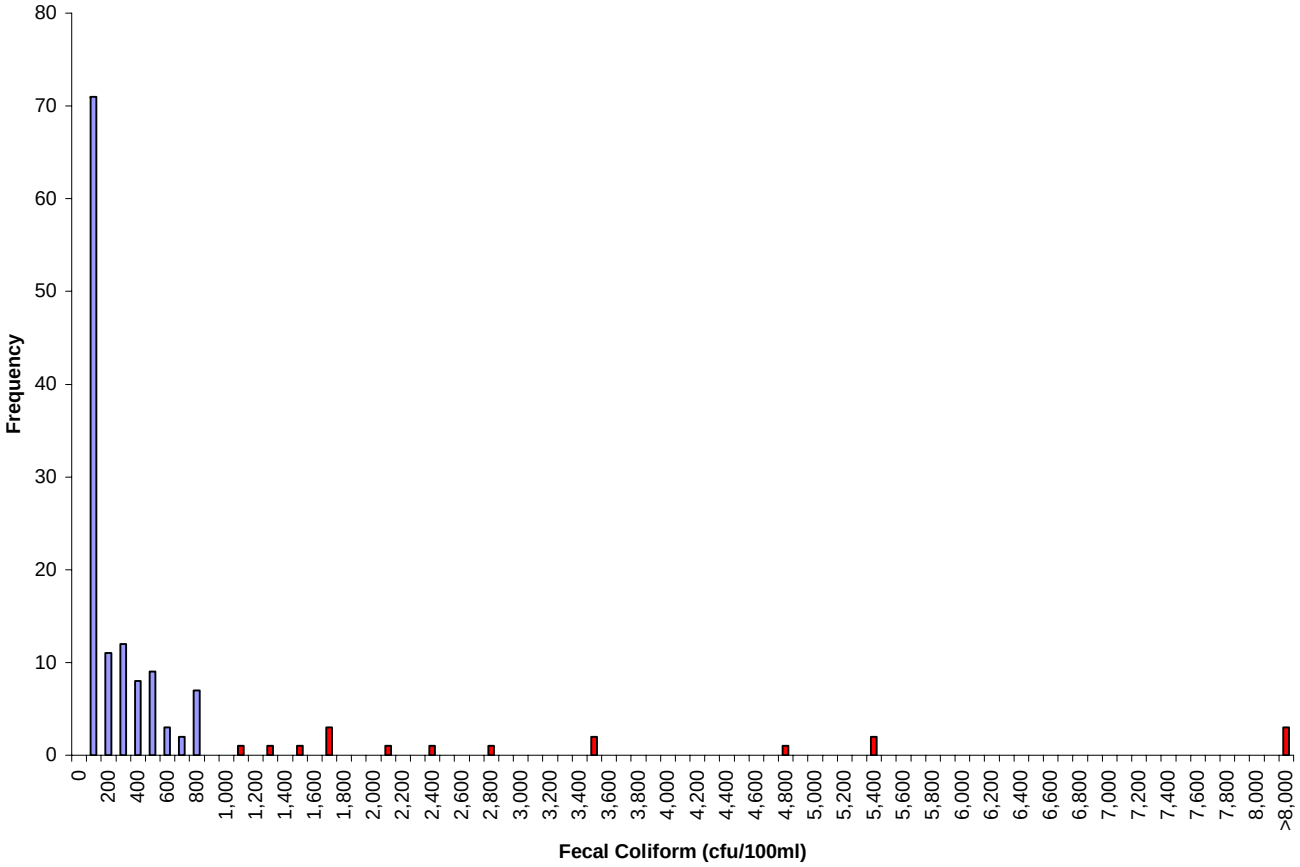

Figure A.2 Frequency analysis of fecal coliform concentrations at station 2APP012.79 in the Appomattox River impairment for period January 1990 to October 2002.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

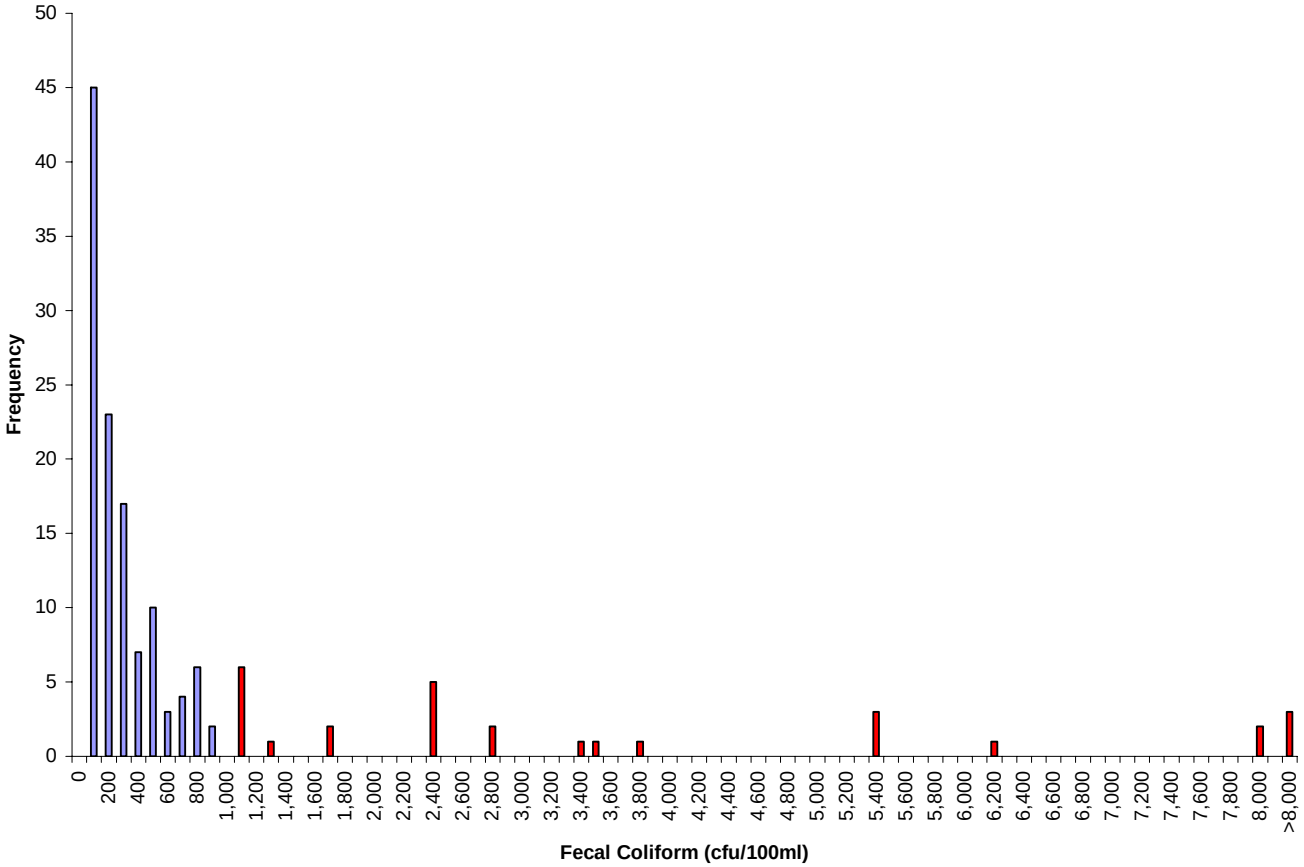

Figure A.3 Frequency analysis of fecal coliform concentrations at station 2APP050.23 in the Appomattox River impairment for period January 1990 to February 2003.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

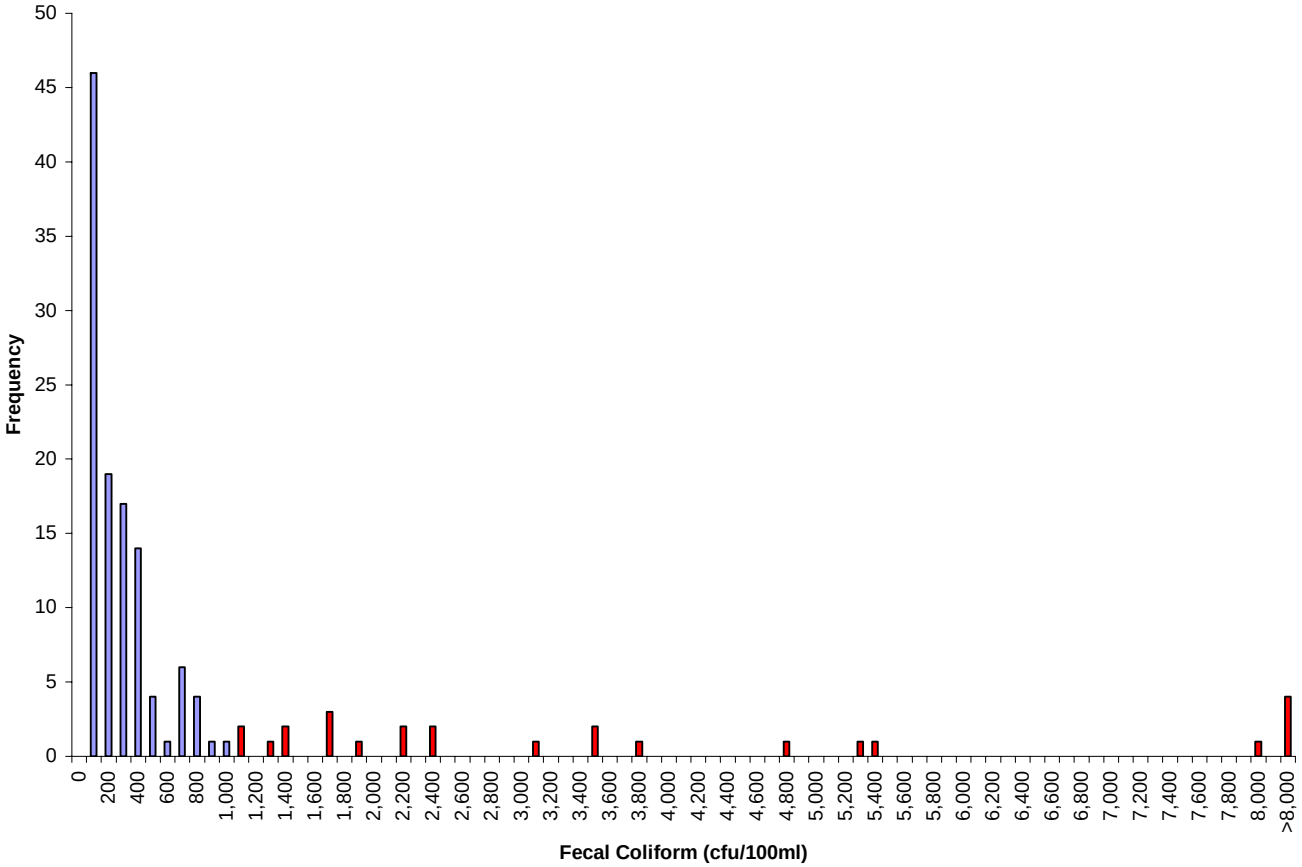

Figure A.4 Frequency analysis of fecal coliform concentrations at station 2APP090.12 in the Appomattox River impairment for period January 1990 to October 2002.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

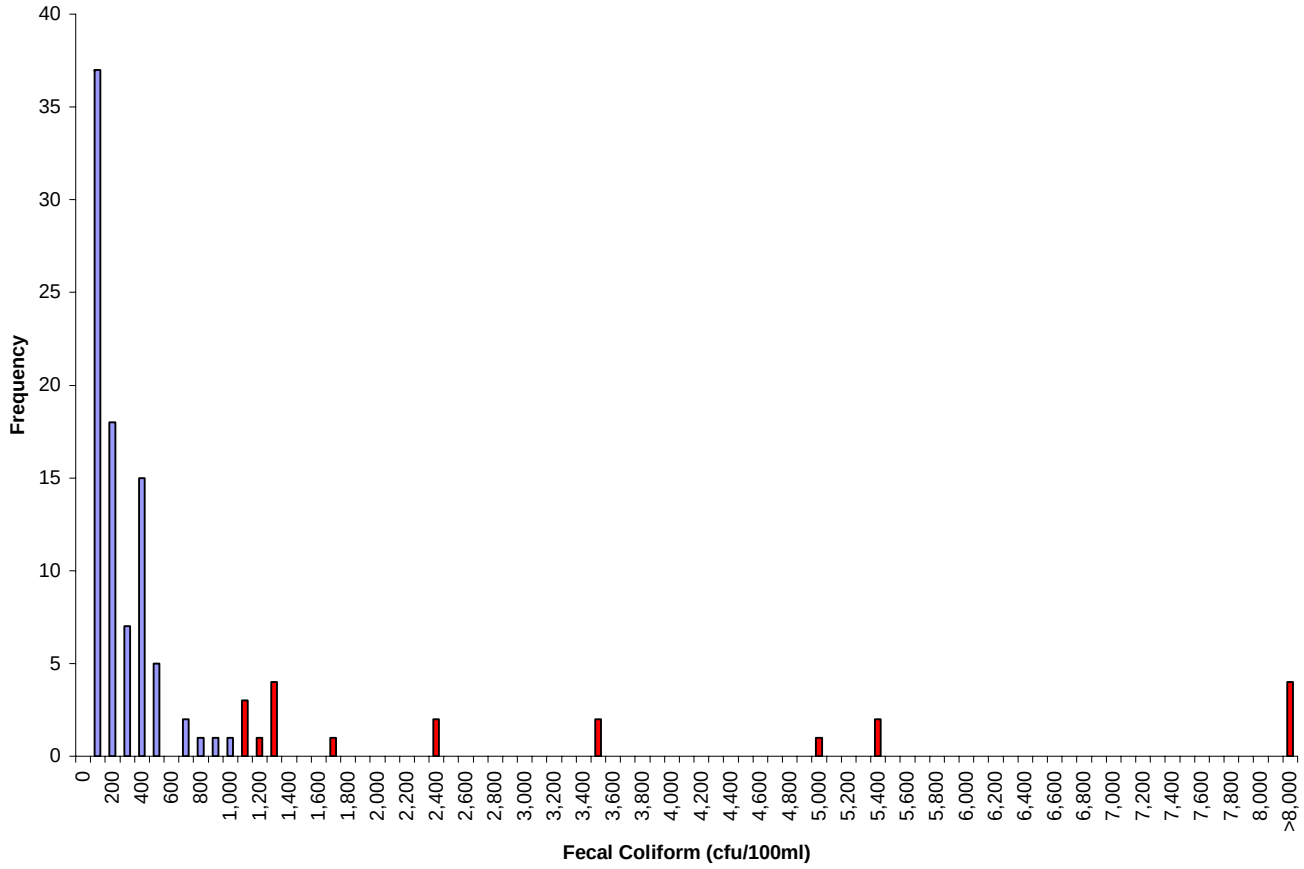

Figure A.5 Frequency analysis of fecal coliform concentrations at station 2APP118.04 in the Appomattox River impairment for period January 1990 to October 2002.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

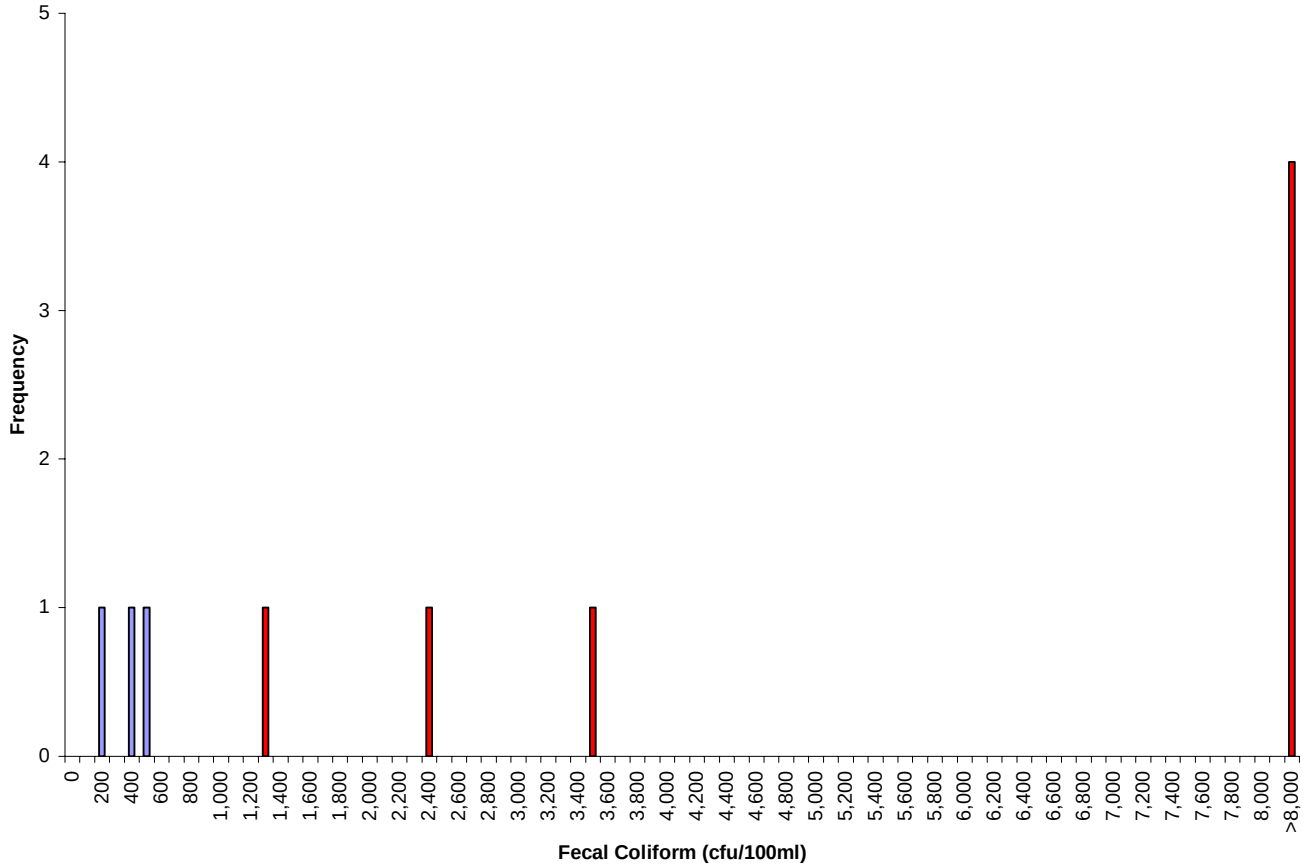

Figure A.6 Frequency analysis of fecal coliform concentrations at station 2ANG001.27 in the Appomattox River impairment for period April 1998 through August 2000.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

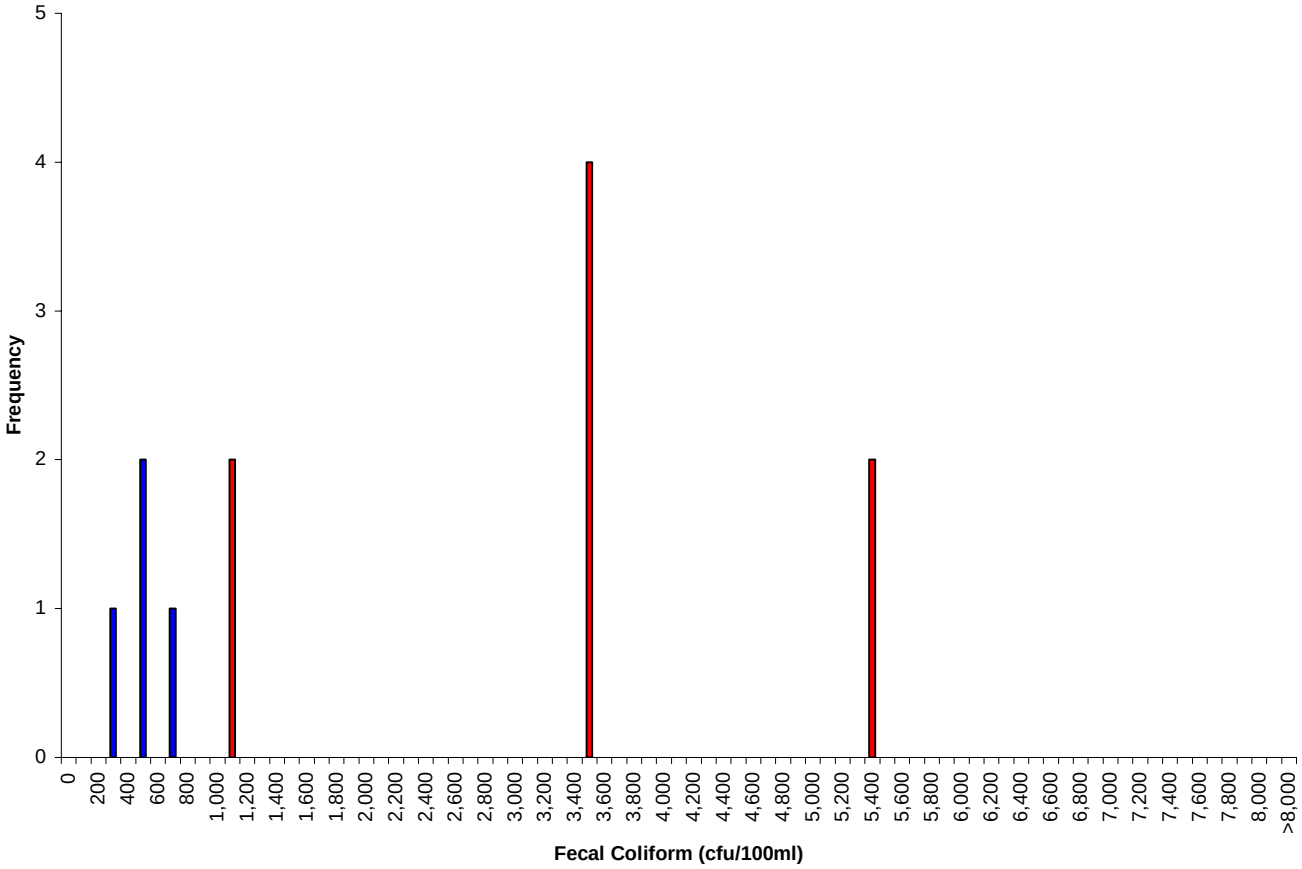

Figure A.7 Frequency analysis of fecal coliform concentrations at station 2ANG003.35 in the Appomattox River impairment for period April 1998 through August 2000.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

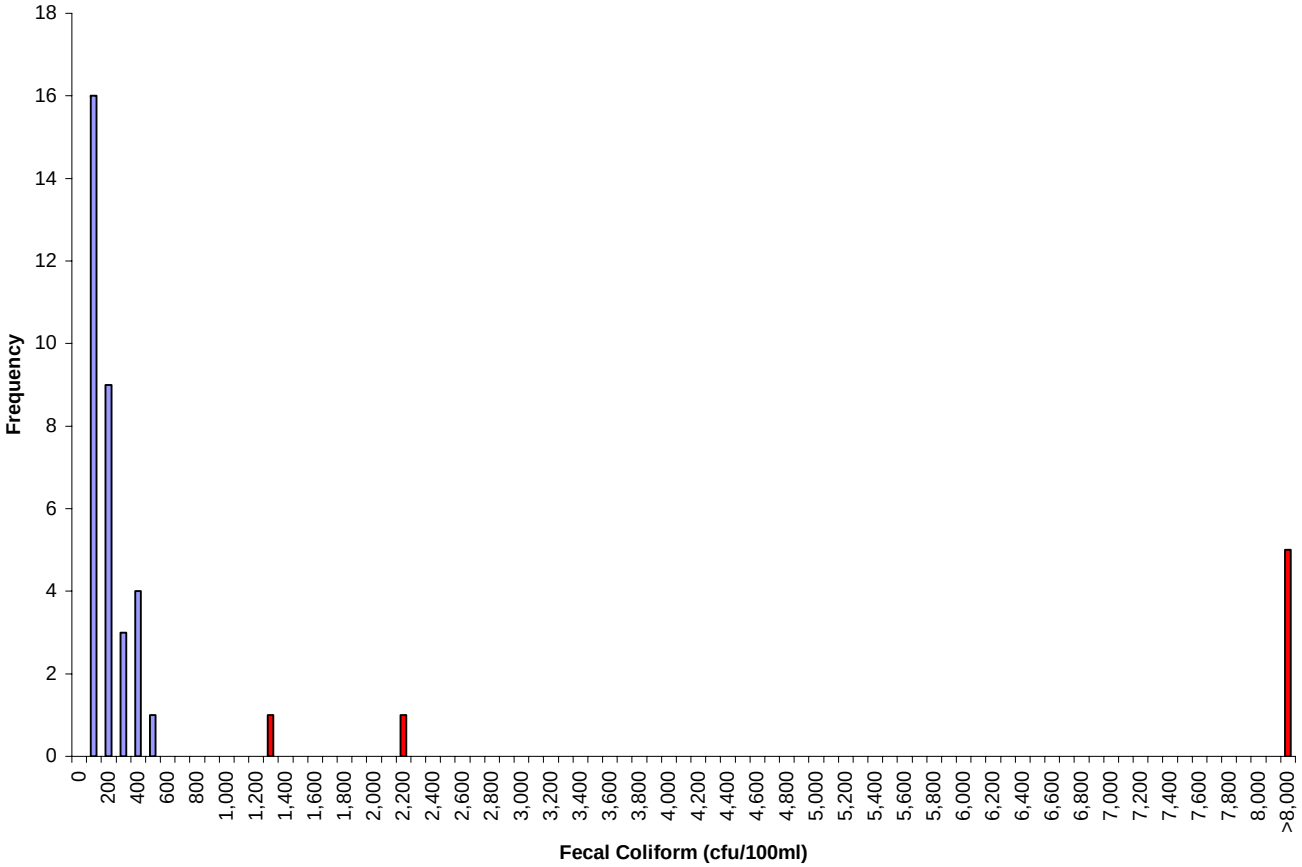

Figure A.8 Frequency analysis of fecal coliform concentrations at station 2BRI001.00 in the Appomattox River impairment for period August 1994 to November 2002.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

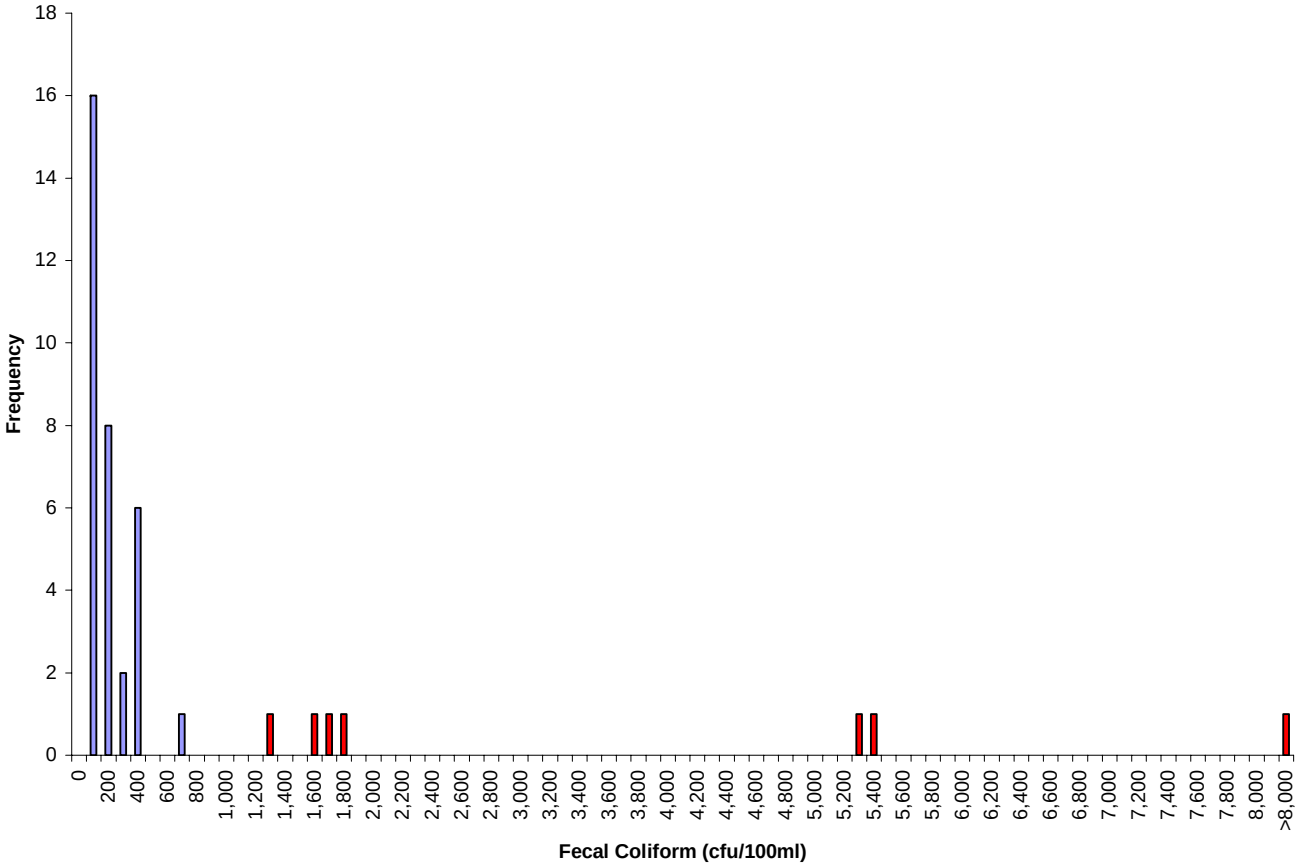

Figure A.9 Frequency analysis of fecal coliform concentrations at station 2BSR002.82 in the Appomattox River impairment for period August 1994 to November 2002.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

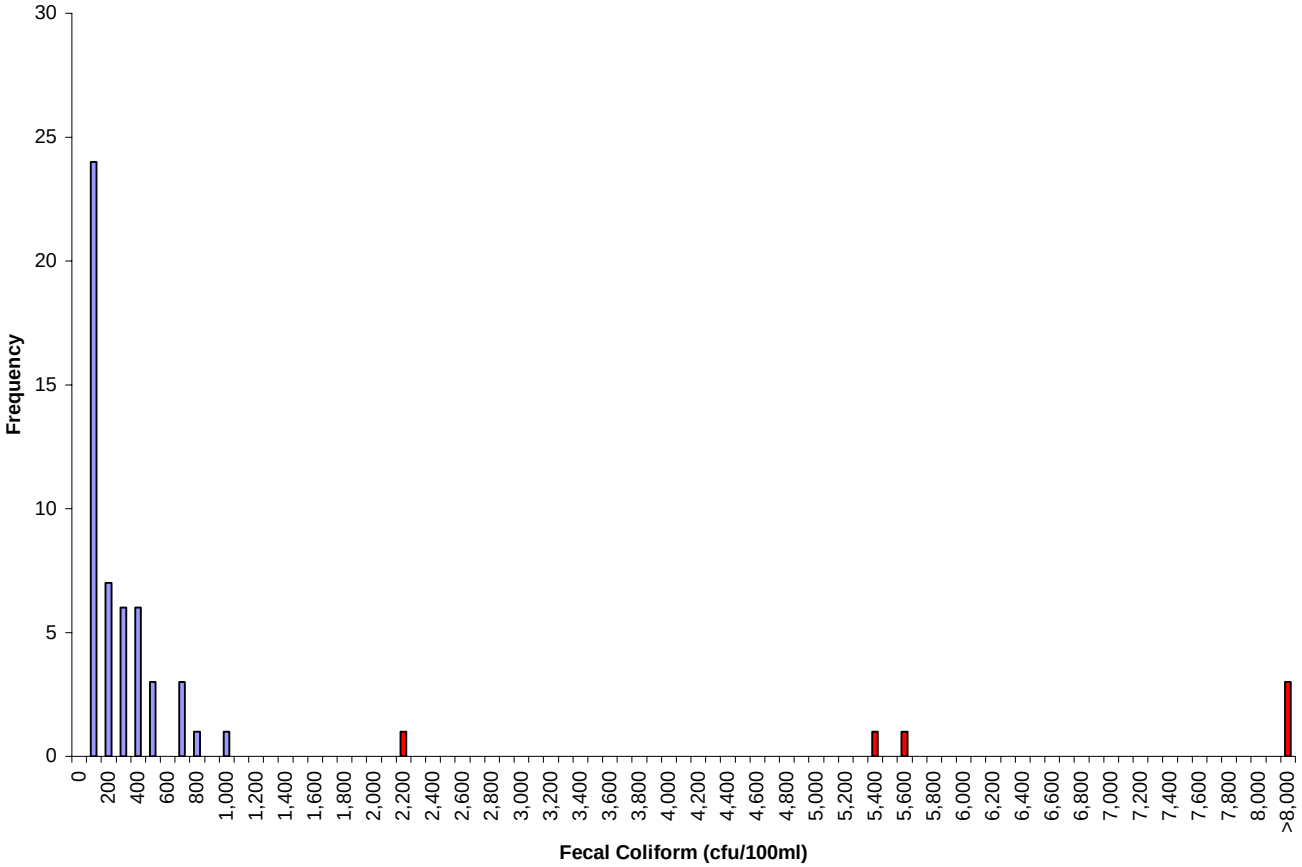

Figure A.10 Frequency analysis of fecal coliform concentrations at station 2DPC005.20 in the Appomattox River impairment for period October 1990 to November 2002.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

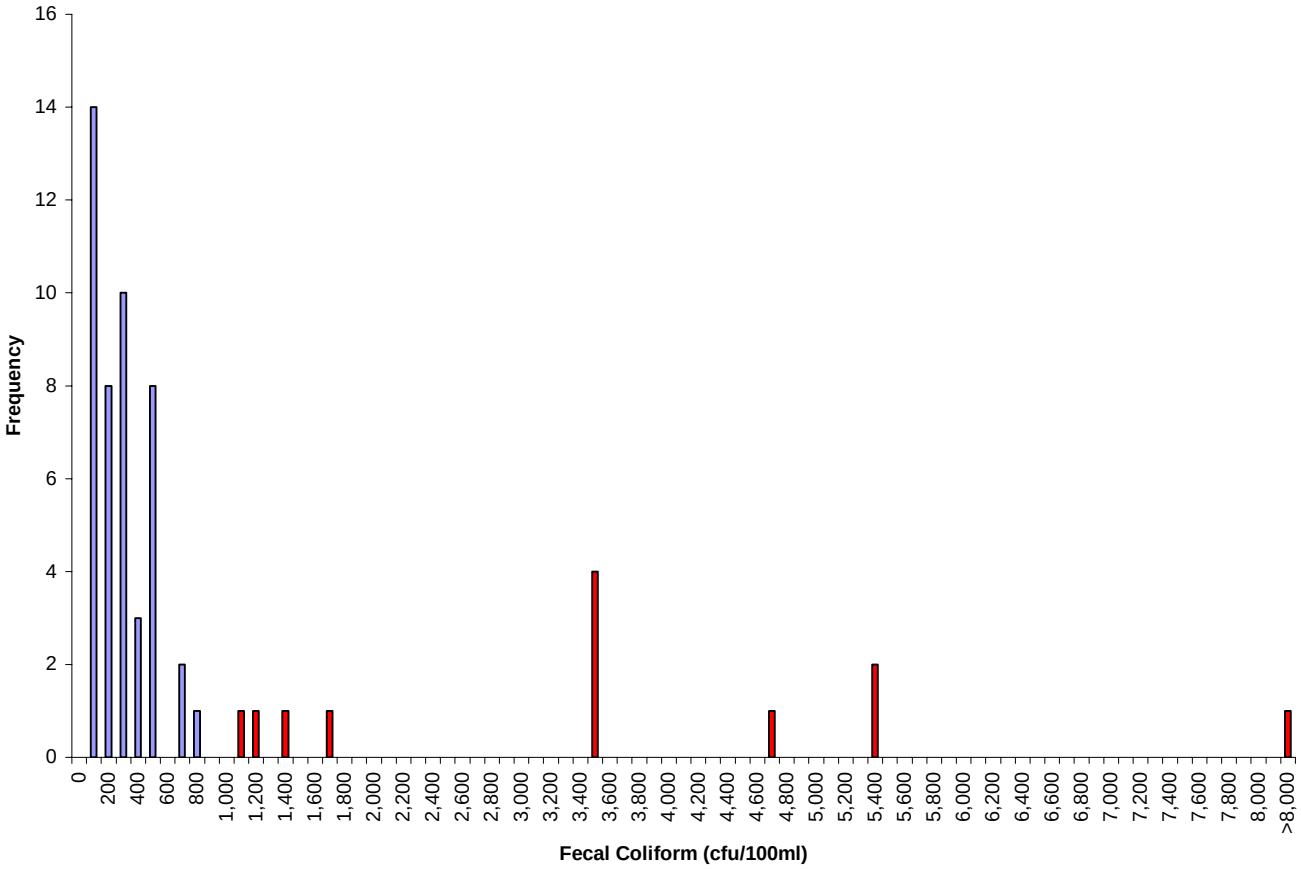

Figure A.11 Frequency analysis of fecal coliform concentrations at station 2FLA001.95 in the Appomattox River impairment for August 1990 to October 2002.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

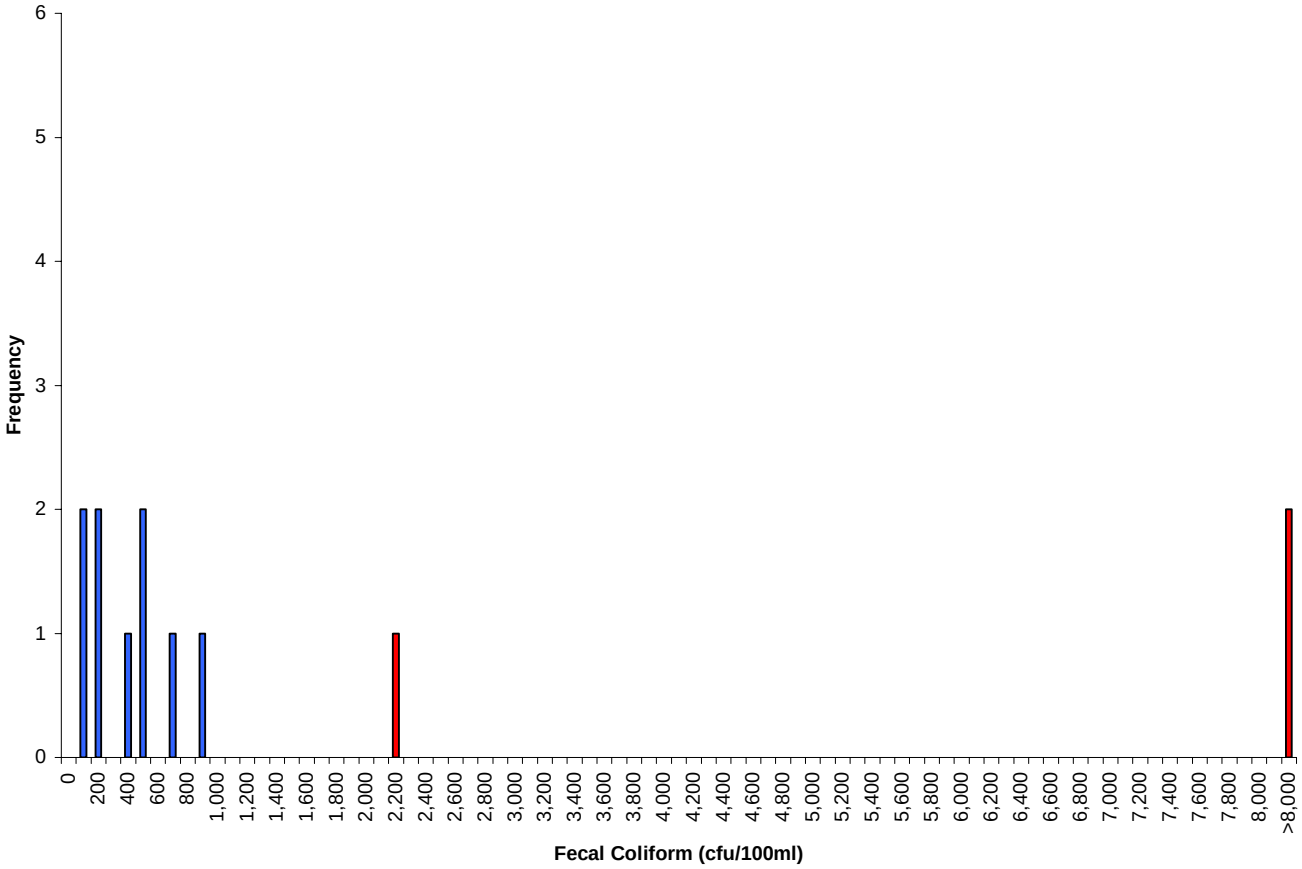

Figure A.12 Frequency analysis of fecal coliform concentrations at station 2HRP000.42 in the Appomattox River impairment for period October 1997 through August 2000.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

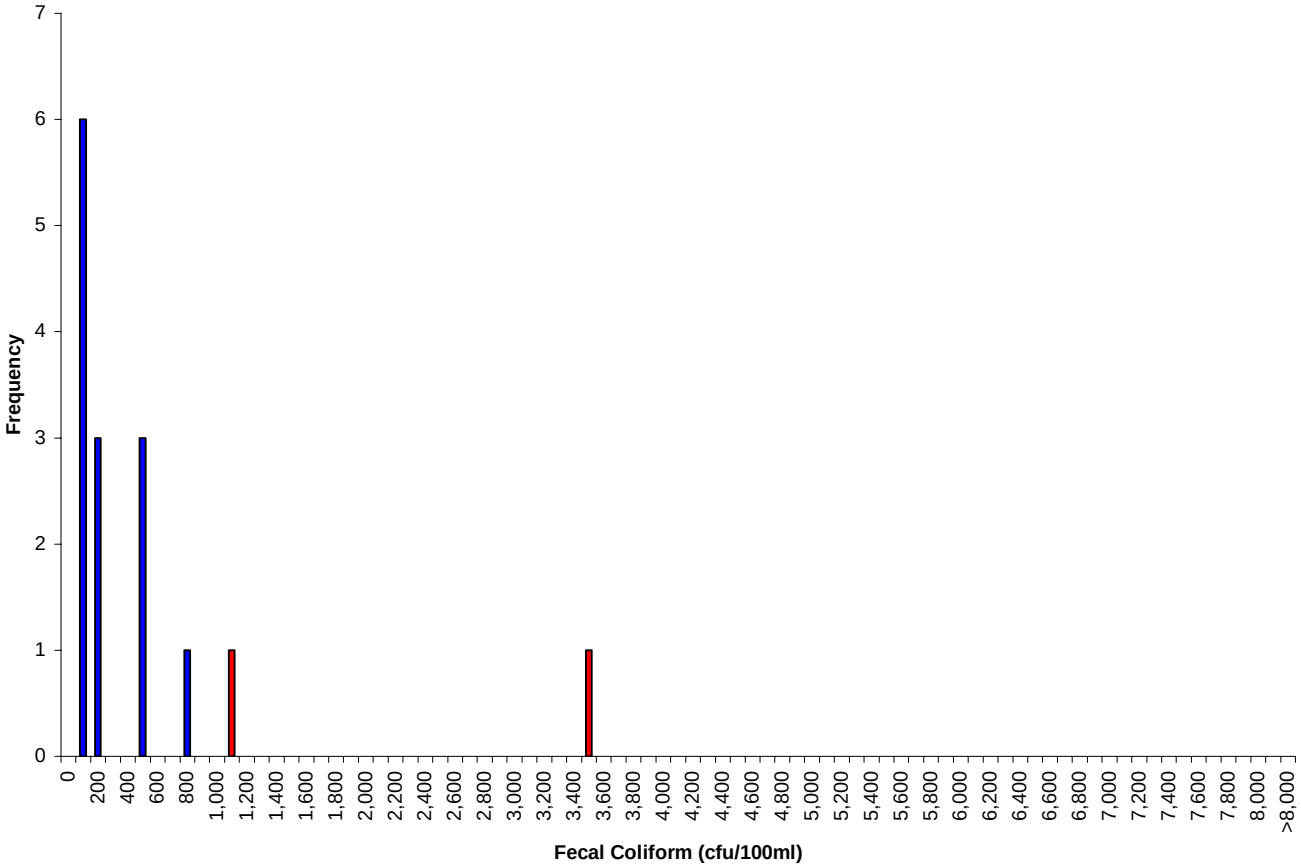

Figure A.13 Frequency analysis of fecal coliform concentrations at station 2LIT002.40 in the Appomattox River impairment for period October 1997 through August 2000.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

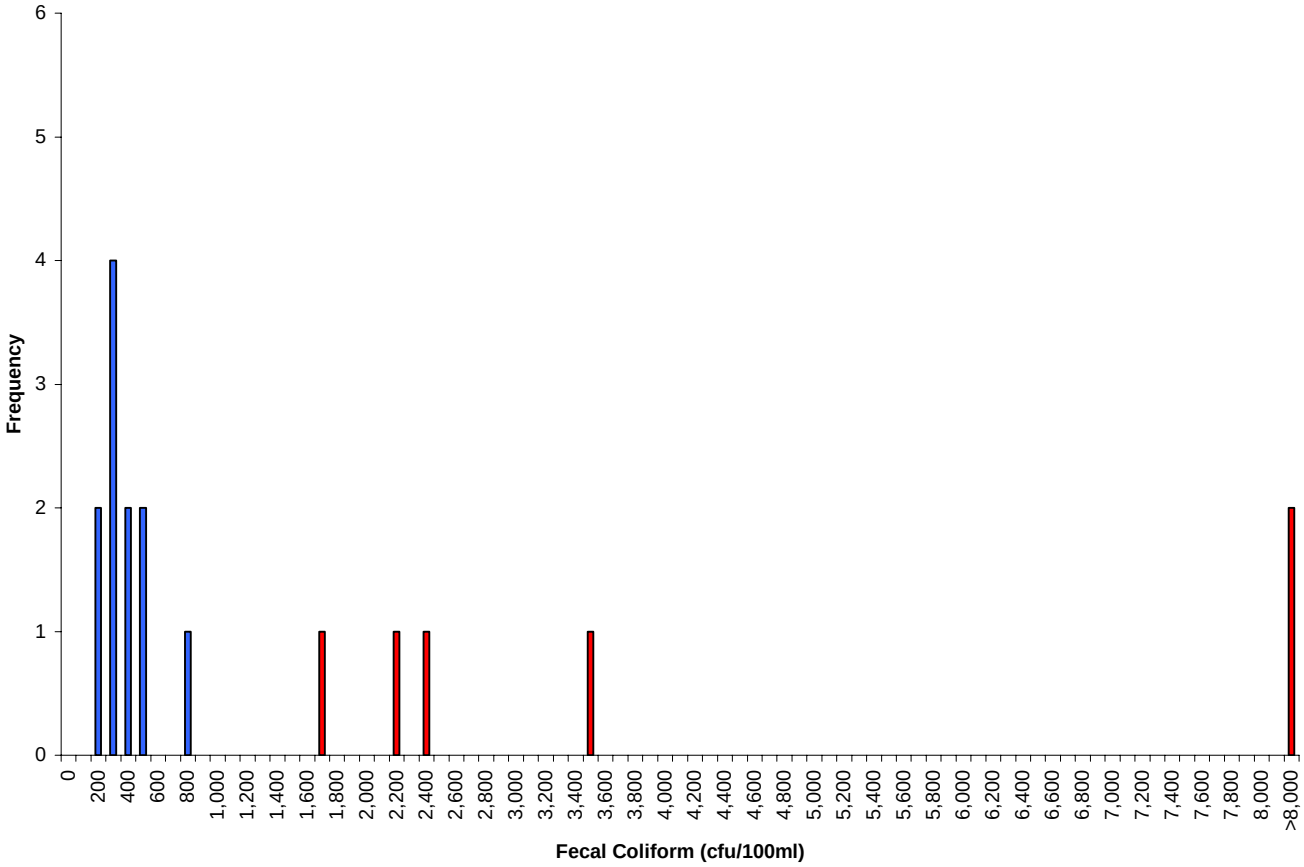

Figure A. 14 Frequency analysis of fecal coliform concentrations at station 2NBB001.54 in the Appomattox River impairment for period June 2000 to June 2002.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

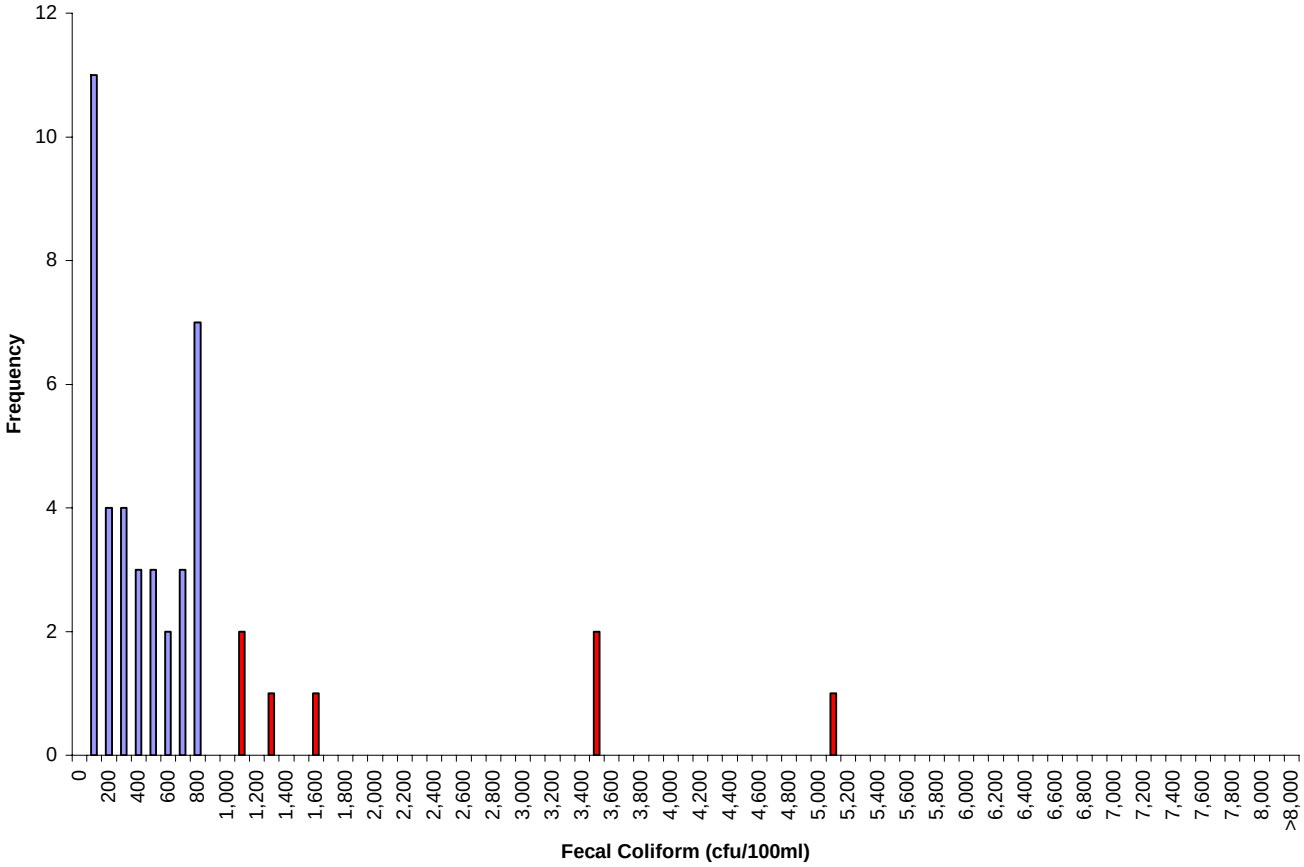

Figure A. 15 Frequency analysis of fecal coliform concentrations at station 2NBB003.65 in the Appomattox River impairment for period September 1994 to February 2003.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

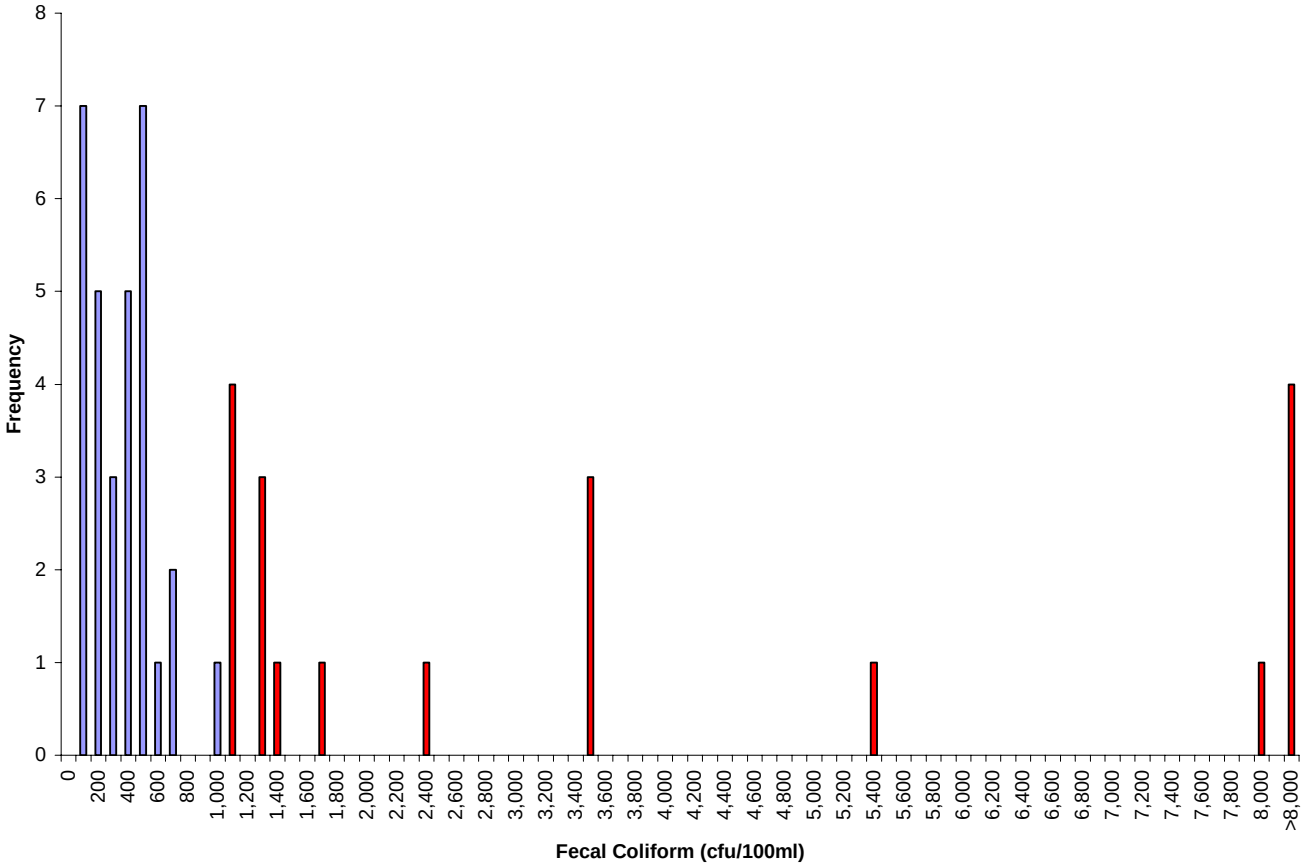

Figure A. 16 Frequency analysis of fecal coliform concentrations at station 2SYL001.26 in the Appomattox River impairment for period September 1990 to April 2001.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

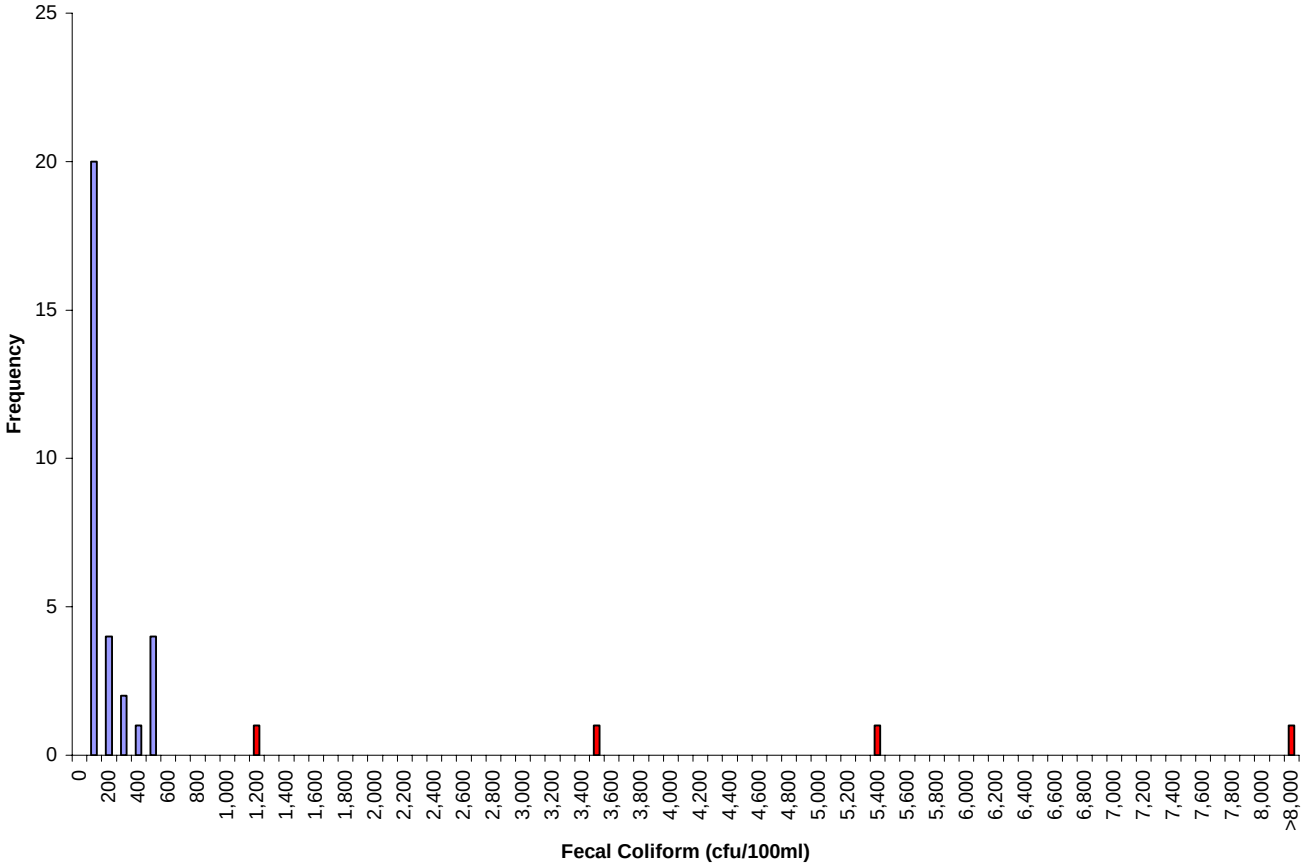

Figure A.17 Frequency analysis of fecal coliform concentrations at station 2SPA001.46 in the Appomattox River impairment for period July 1994 to April 2001.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

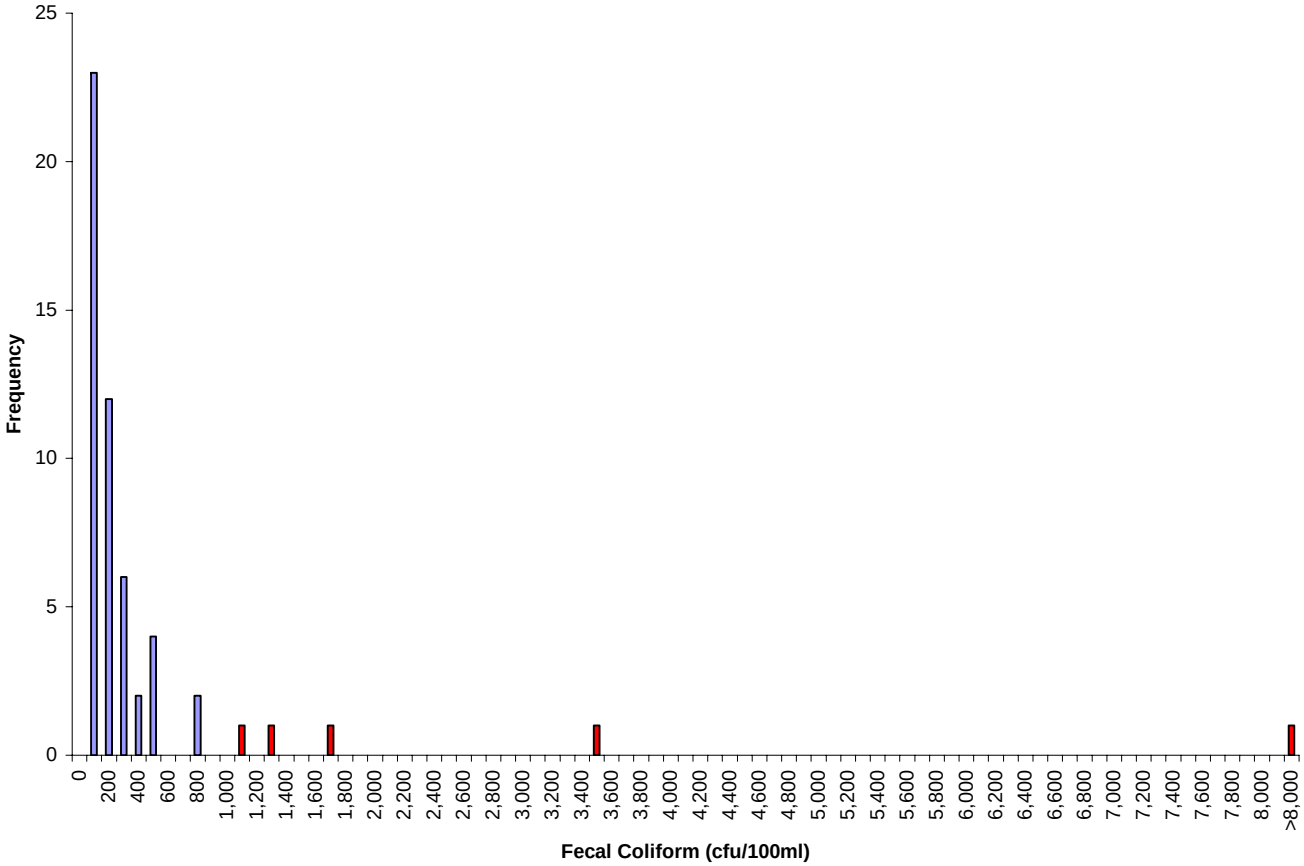

Figure A.18 Frequency analysis of fecal coliform concentrations at station 2SFT004.92 in the Appomattox River impairment for period January 1990 to March 2001.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

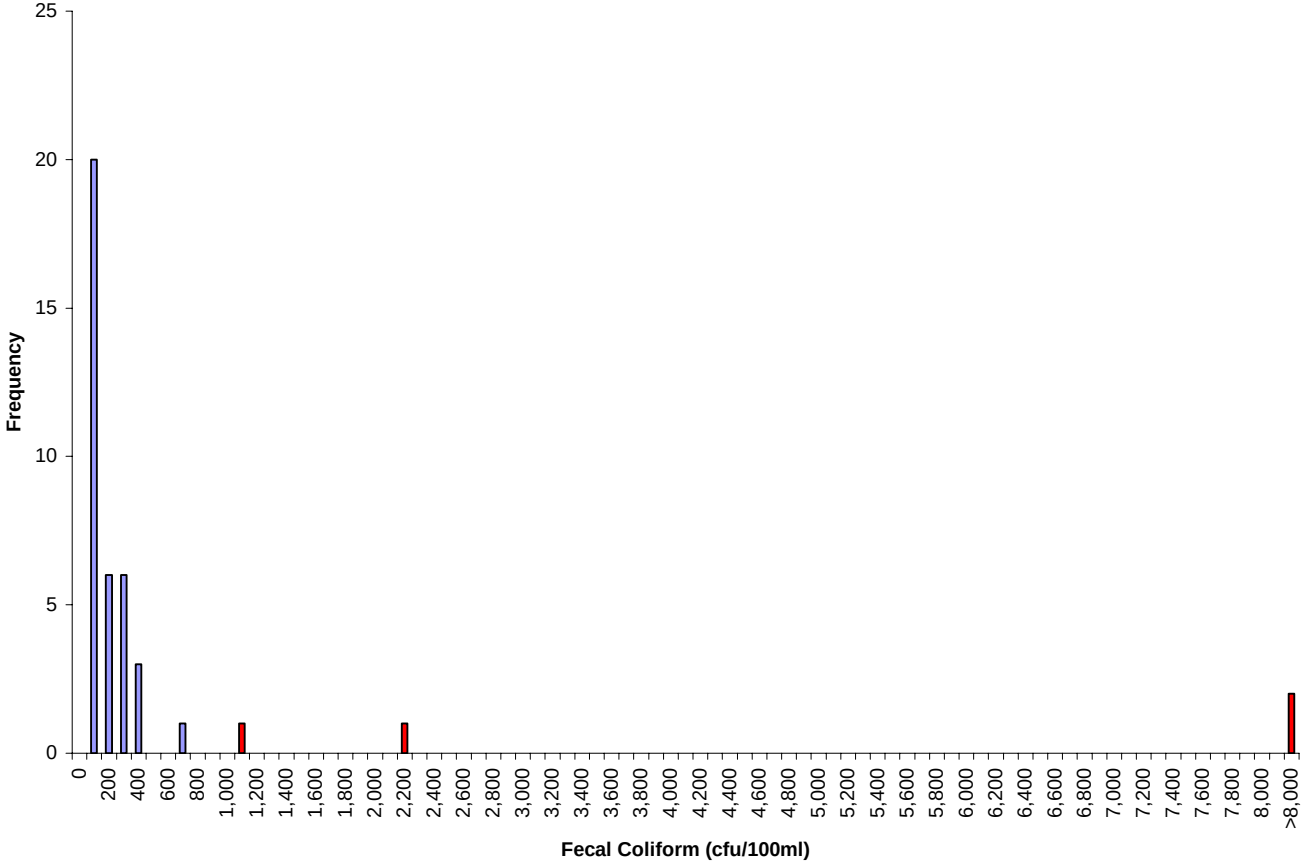

Figure A.19 Frequency analysis of fecal coliform concentrations at station 2SFT019.15 in the Appomattox River impairment for period January 1990 to June 1990 and July 1994 to March 2001.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

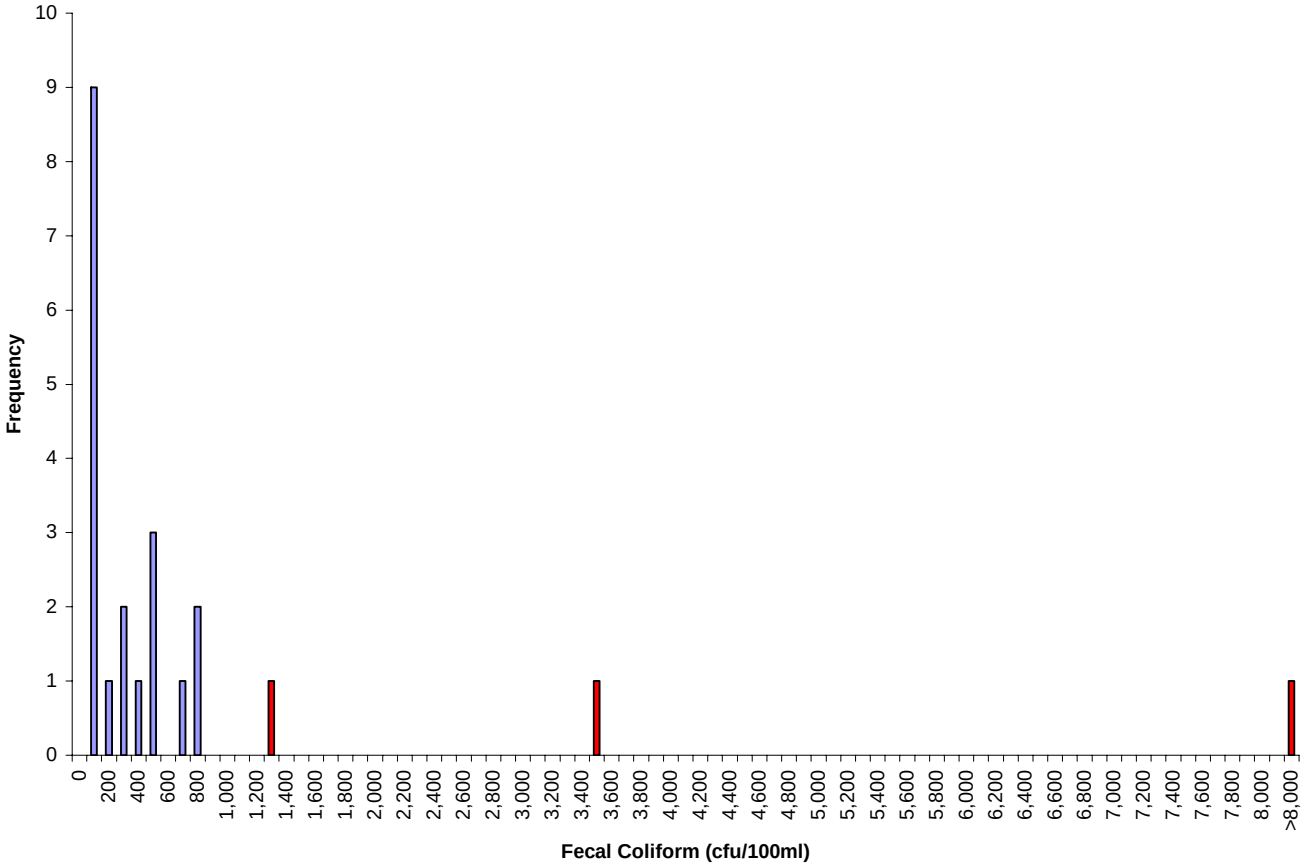

Figure A. 20 Frequency analysis of fecal coliform concentrations at station 2WET004.96 in the Appomattox River impairment for period July 1997 to March 2001.

*Red indicates a value which violates the listing standard of 1,000 cfu/100 ml.

APPENDIX B

FECAL COLIFORM LOADS IN EXISTING CONDITIONS

Table B.1 Current conditions (2003) of land applied fecal coliform load for Appomattox River (Segment 1) impairment (Subsheds 1-12,18-23,41,47,50-53,55-65,73-77).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	9.42E+08	4.17E+10	1.80E+11	2.80E+10	5.36E+10
February	9.42E+08	4.09E+10	2.14E+11	3.66E+10	6.05E+10
March	9.42E+08	3.92E+10	2.02E+12	5.50E+10	8.48E+10
April	9.42E+08	3.84E+10	2.02E+12	5.14E+10	1.13E+11
May	9.42E+08	3.76E+10	2.00E+12	3.73E+10	1.13E+11
June	9.42E+08	3.68E+10	8.72E+09	4.80E+10	1.37E+11
July	9.42E+08	3.51E+10	8.57E+09	4.82E+10	1.37E+11
August	9.42E+08	3.51E+10	8.57E+09	4.82E+10	1.37E+11
September	9.42E+08	3.51E+10	6.00E+11	4.30E+10	1.13E+11
October	9.42E+08	3.43E+10	2.01E+12	4.30E+10	8.48E+10
November	9.42E+08	3.51E+10	2.01E+12	3.93E+10	7.50E+10
December	9.42E+08	3.84E+10	1.80E+11	2.92E+10	5.36E+10

Table B.1 Current conditions (2003) of land applied fecal coliform load for Appomattox River (Segment 1) impairment (Subsheds 1-12,18-23,41,47,50-53,55-65,73-77) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	4.88E+11	0.00E+00	2.34E+10	5.96E+09
February	4.78E+11	0.00E+00	2.34E+10	5.96E+09
March	4.57E+11	0.00E+00	2.34E+10	5.96E+09
April	4.46E+11	0.00E+00	2.34E+10	5.96E+09
May	4.36E+11	0.00E+00	2.34E+10	5.96E+09
June	4.25E+11	0.00E+00	2.34E+10	5.96E+09
July	4.05E+11	0.00E+00	2.34E+10	5.96E+09
August	4.05E+11	0.00E+00	2.34E+10	5.96E+09
September	4.05E+11	0.00E+00	2.34E+10	5.96E+09
October	3.94E+11	0.00E+00	2.34E+10	5.96E+09
November	4.05E+11	0.00E+00	2.34E+10	5.96E+09
December	4.46E+11	0.00E+00	2.34E+10	5.96E+09

Table B.2 Current conditions (2003) of land applied fecal coliform load for Spring Creek impairment (Subsheds 13-17).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	1.64E+08	7.02E+07	3.49E+08	2.08E+09	8.50E+09
February	1.64E+08	7.02E+07	5.19E+08	2.73E+09	1.02E+10
March	1.64E+08	7.02E+07	1.14E+09	3.35E+09	1.34E+10
April	1.64E+08	7.02E+07	1.01E+09	3.17E+09	1.77E+10
May	1.64E+08	7.02E+07	5.08E+08	2.66E+09	1.77E+10
June	1.64E+08	7.02E+07	5.13E+08	2.64E+09	2.09E+10
July	1.64E+08	7.02E+07	5.08E+08	2.63E+09	2.09E+10
August	1.64E+08	7.02E+07	5.08E+08	2.63E+09	2.09E+10
September	1.64E+08	7.02E+07	6.77E+08	2.83E+09	1.77E+10
October	1.64E+08	7.02E+07	6.67E+08	2.86E+09	1.34E+10
November	1.64E+08	7.02E+07	6.77E+08	2.40E+09	1.10E+10
December	1.64E+08	7.02E+07	3.49E+08	2.08E+09	8.50E+09

Table B.2 Current conditions (2003) of land applied fecal coliform load for Spring Creek impairment (Subsheds 13-17) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	3.08E+10	0.00E+00	3.65E+09	7.12E+08
February	3.02E+10	0.00E+00	3.65E+09	7.12E+08
March	2.90E+10	0.00E+00	3.65E+09	7.12E+08
April	2.83E+10	0.00E+00	3.65E+09	7.12E+08
May	2.77E+10	0.00E+00	3.65E+09	7.12E+08
June	2.71E+10	0.00E+00	3.65E+09	7.12E+08
July	2.58E+10	0.00E+00	3.65E+09	7.12E+08
August	2.58E+10	0.00E+00	3.65E+09	7.12E+08
September	2.58E+10	0.00E+00	3.65E+09	7.12E+08
October	2.52E+10	0.00E+00	3.65E+09	7.12E+08
November	2.58E+10	0.00E+00	3.65E+09	7.12E+08
December	2.83E+10	0.00E+00	3.65E+09	7.12E+08

Table B.3 Current conditions (2003) of land applied fecal coliform load for Briery Creek impairment (Subsheds 24-28).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	1.72E+08	1.47E+08	5.40E+08	1.83E+09	3.33E+09
February	1.72E+08	1.47E+08	5.40E+08	2.18E+09	3.70E+09
March	1.72E+08	1.47E+08	5.40E+08	2.16E+09	4.38E+09
April	1.72E+08	1.47E+08	5.40E+08	2.14E+09	5.30E+09
May	1.72E+08	1.47E+08	5.40E+08	2.14E+09	5.30E+09
June	1.72E+08	1.47E+08	5.40E+08	2.12E+09	5.98E+09
July	1.72E+08	1.47E+08	5.40E+08	2.12E+09	5.98E+09
August	1.72E+08	1.47E+08	5.40E+08	2.12E+09	5.98E+09
September	1.72E+08	1.47E+08	5.40E+08	2.14E+09	5.30E+09
October	1.72E+08	1.47E+08	5.40E+08	2.16E+09	4.38E+09
November	1.72E+08	1.47E+08	5.40E+08	1.82E+09	3.86E+09
December	1.72E+08	1.47E+08	5.40E+08	1.83E+09	3.33E+09

Table B.3 Current conditions (2003) of land applied fecal coliform load for Briery Creek impairment (Subsheds 24-28) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	1.27E+10	0.00E+00	3.77E+09	7.76E+08
February	1.25E+10	0.00E+00	3.77E+09	7.76E+08
March	1.20E+10	0.00E+00	3.77E+09	7.76E+08
April	1.18E+10	0.00E+00	3.77E+09	7.76E+08
May	1.15E+10	0.00E+00	3.77E+09	7.76E+08
June	1.13E+10	0.00E+00	3.77E+09	7.76E+08
July	1.08E+10	0.00E+00	3.77E+09	7.76E+08
August	1.08E+10	0.00E+00	3.77E+09	7.76E+08
September	1.08E+10	0.00E+00	3.77E+09	7.76E+08
October	1.06E+10	0.00E+00	3.77E+09	7.76E+08
November	1.08E+10	0.00E+00	3.77E+09	7.76E+08
December	1.18E+10	0.00E+00	3.77E+09	7.76E+08

Table B.4 Current conditions (2003) of land applied fecal coliform load for Bush River (Segment 1) impairment (Subsheds 29-33).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	8.74E+07	2.20E+08	4.62E+10	3.09E+09	7.03E+09
February	8.74E+07	2.20E+08	5.42E+10	3.98E+09	7.64E+09
March	8.74E+07	2.20E+08	5.20E+11	5.42E+09	1.06E+10
April	8.74E+07	2.20E+08	5.20E+11	5.13E+09	1.40E+10
May	8.74E+07	2.20E+08	5.19E+11	4.03E+09	1.40E+10
June	8.74E+07	2.20E+08	9.32E+08	5.38E+09	1.70E+10
July	8.74E+07	2.20E+08	9.18E+08	5.40E+09	1.70E+10
August	8.74E+07	2.20E+08	9.18E+08	5.40E+09	1.70E+10
September	8.74E+07	2.20E+08	1.54E+11	4.49E+09	1.40E+10
October	8.74E+07	2.20E+08	5.19E+11	4.51E+09	1.06E+10
November	8.74E+07	2.20E+08	5.19E+11	4.00E+09	9.78E+09
December	8.74E+07	2.20E+08	4.62E+10	3.20E+09	7.03E+09

Table B.4 Current conditions (2003) of land applied fecal coliform load for Bush River (Segment 1) impairment (Subsheds 29-33) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	7.80E+09	0.00E+00	2.98E+09	5.98E+08
February	7.64E+09	0.00E+00	2.98E+09	5.98E+08
March	7.32E+09	0.00E+00	2.98E+09	5.98E+08
April	7.16E+09	0.00E+00	2.98E+09	5.98E+08
May	7.00E+09	0.00E+00	2.98E+09	5.98E+08
June	6.84E+09	0.00E+00	2.98E+09	5.98E+08
July	6.52E+09	0.00E+00	2.98E+09	5.98E+08
August	6.52E+09	0.00E+00	2.98E+09	5.98E+08
September	6.52E+09	0.00E+00	2.98E+09	5.98E+08
October	6.36E+09	0.00E+00	2.98E+09	5.98E+08
November	6.52E+09	0.00E+00	2.98E+09	5.98E+08
December	7.16E+09	0.00E+00	2.98E+09	5.98E+08

Table B.5 Current conditions (2003) of land applied fecal coliform load for Little Sandy Creek impairment (Subsheds 34-35).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	1.22E+08	8.50E+07	1.40E+11	4.52E+09	7.82E+09
February	1.22E+08	8.50E+07	1.65E+11	5.69E+09	8.13E+09
March	1.22E+08	8.50E+07	1.59E+12	9.20E+09	1.41E+10
April	1.22E+08	8.50E+07	1.59E+12	8.68E+09	2.02E+10
May	1.22E+08	8.50E+07	1.59E+12	6.14E+09	2.02E+10
June	1.22E+08	8.50E+07	9.86E+08	1.12E+10	2.61E+10
July	1.22E+08	8.50E+07	9.58E+08	1.13E+10	2.61E+10
August	1.22E+08	8.50E+07	9.58E+08	1.13E+10	2.61E+10
September	1.22E+08	8.50E+07	4.69E+11	7.31E+09	2.02E+10
October	1.22E+08	8.50E+07	1.59E+12	7.30E+09	1.41E+10
November	1.22E+08	8.50E+07	1.59E+12	6.95E+09	1.37E+10
December	1.22E+08	8.50E+07	1.40E+11	4.94E+09	7.82E+09

Table B.5 Current conditions (2003) of land applied fecal coliform load for Little Sandy Creek impairment (Subsheds 34-35) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	4.39E+09	0.00E+00	1.71E+09	2.44E+08
February	4.30E+09	0.00E+00	1.71E+09	2.44E+08
March	4.11E+09	0.00E+00	1.71E+09	2.44E+08
April	4.02E+09	0.00E+00	1.71E+09	2.44E+08
May	3.93E+09	0.00E+00	1.71E+09	2.44E+08
June	3.84E+09	0.00E+00	1.71E+09	2.44E+08
July	3.65E+09	0.00E+00	1.71E+09	2.44E+08
August	3.65E+09	0.00E+00	1.71E+09	2.44E+08
September	3.65E+09	0.00E+00	1.71E+09	2.44E+08
October	3.56E+09	0.00E+00	1.71E+09	2.44E+08
November	3.65E+09	0.00E+00	1.71E+09	2.44E+08
December	4.02E+09	0.00E+00	1.71E+09	2.44E+08

Table B.6 Current conditions (2003) of land applied fecal coliform load for Bush River (Segment 2) impairment (Subsheds 36-40).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	2.49E+08	1.68E+08	8.51E+08	1.95E+09	4.90E+09
February	2.49E+08	1.68E+08	1.36E+09	2.90E+09	5.51E+09
March	2.49E+08	1.68E+08	3.23E+09	4.78E+09	6.63E+09
April	2.49E+08	1.68E+08	2.82E+09	4.33E+09	8.13E+09
May	2.49E+08	1.68E+08	1.33E+09	2.81E+09	8.13E+09
June	2.49E+08	1.68E+08	1.34E+09	2.80E+09	9.26E+09
July	2.49E+08	1.68E+08	1.33E+09	2.79E+09	9.26E+09
August	2.49E+08	1.68E+08	1.33E+09	2.79E+09	9.26E+09
September	2.49E+08	1.68E+08	1.84E+09	3.33E+09	8.13E+09
October	2.49E+08	1.68E+08	1.80E+09	3.33E+09	6.63E+09
November	2.49E+08	1.68E+08	1.84E+09	2.93E+09	5.77E+09
December	2.49E+08	1.68E+08	8.51E+08	1.95E+09	4.90E+09

Table B.6 Current conditions (2003) of land applied fecal coliform load for Bush River (Segment 2) impairment (Subsheds 36-40) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	8.61E+09	0.00E+00	3.33E+09	5.88E+08
February	8.44E+09	0.00E+00	3.33E+09	5.88E+08
March	8.10E+09	0.00E+00	3.33E+09	5.88E+08
April	7.93E+09	0.00E+00	3.33E+09	5.88E+08
May	7.76E+09	0.00E+00	3.33E+09	5.88E+08
June	7.59E+09	0.00E+00	3.33E+09	5.88E+08
July	7.26E+09	0.00E+00	3.33E+09	5.88E+08
August	7.26E+09	0.00E+00	3.33E+09	5.88E+08
September	7.26E+09	0.00E+00	3.33E+09	5.88E+08
October	7.09E+09	0.00E+00	3.33E+09	5.88E+08
November	7.26E+09	0.00E+00	3.33E+09	5.88E+08
December	7.93E+09	0.00E+00	3.33E+09	5.88E+08

Table B.7 Current conditions (2003) of land applied fecal coliform load for Saylers Creek impairment (Subsheds 42-46).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	1.57E+08	4.76E+07	5.00E+10	3.99E+09	6.26E+09
February	1.57E+08	4.76E+07	5.83E+10	4.65E+09	7.15E+09
March	1.57E+08	4.76E+07	5.64E+11	4.66E+09	1.02E+10
April	1.57E+08	4.76E+07	5.64E+11	4.72E+09	1.37E+10
May	1.57E+08	4.76E+07	5.64E+11	4.79E+09	1.37E+10
June	1.57E+08	4.76E+07	2.83E+08	6.30E+09	1.67E+10
July	1.57E+08	4.76E+07	2.83E+08	6.35E+09	1.67E+10
August	1.57E+08	4.76E+07	2.83E+08	6.35E+09	1.67E+10
September	1.57E+08	4.76E+07	1.66E+11	4.89E+09	1.37E+10
October	1.57E+08	4.76E+07	5.64E+11	4.95E+09	1.02E+10
November	1.57E+08	4.76E+07	5.64E+11	4.22E+09	8.89E+09
December	1.57E+08	4.76E+07	5.00E+10	4.16E+09	6.26E+09

Table B.7 Current conditions (2003) of land applied fecal coliform load for Saylers Creek impairment (Subsheds 42-46) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	6.04E+10	0.00E+00	3.76E+09	6.39E+08
February	5.89E+10	0.00E+00	3.76E+09	6.39E+08
March	5.59E+10	0.00E+00	3.76E+09	6.39E+08
April	5.44E+10	0.00E+00	3.76E+09	6.39E+08
May	5.29E+10	0.00E+00	3.76E+09	6.39E+08
June	5.14E+10	0.00E+00	3.76E+09	6.39E+08
July	4.83E+10	0.00E+00	3.76E+09	6.39E+08
August	4.83E+10	0.00E+00	3.76E+09	6.39E+08
September	4.83E+10	0.00E+00	3.76E+09	6.39E+08
October	4.68E+10	0.00E+00	3.76E+09	6.39E+08
November	4.83E+10	0.00E+00	3.76E+09	6.39E+08
December	5.44E+10	0.00E+00	3.76E+09	6.39E+08

Table B.8 Current conditions (2003) of land applied fecal coliform load for Angola Creek (Segment 1) impairment (Subshed 48).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	1.99E+07	4.62E+07	7.73E+07	8.95E+08	1.89E+09
February	1.99E+07	4.62E+07	7.74E+08	1.80E+09	2.29E+09
March	1.99E+07	4.62E+07	3.34E+09	4.24E+09	3.02E+09
April	1.99E+07	4.62E+07	2.77E+09	3.68E+09	4.00E+09
May	1.99E+07	4.62E+07	7.29E+08	1.73E+09	4.00E+09
June	1.99E+07	4.62E+07	7.51E+08	1.73E+09	4.73E+09
July	1.99E+07	4.62E+07	7.29E+08	1.71E+09	4.73E+09
August	1.99E+07	4.62E+07	7.29E+08	1.71E+09	4.73E+09
September	1.99E+07	4.62E+07	1.42E+09	2.39E+09	4.00E+09
October	1.99E+07	4.62E+07	1.38E+09	2.37E+09	3.02E+09
November	1.99E+07	4.62E+07	1.42E+09	2.17E+09	2.45E+09
December	1.99E+07	4.62E+07	7.73E+07	8.95E+08	1.89E+09

Table B.8 Current conditions (2003) of land applied fecal coliform load for Angola Creek (Segment 1) impairment (Subshed 48) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	4.63E+10	0.00E+00	6.85E+08	1.53E+08
February	4.53E+10	0.00E+00	6.85E+08	1.53E+08
March	4.34E+10	0.00E+00	6.85E+08	1.53E+08
April	4.24E+10	0.00E+00	6.85E+08	1.53E+08
May	4.14E+10	0.00E+00	6.85E+08	1.53E+08
June	4.04E+10	0.00E+00	6.85E+08	1.53E+08
July	3.84E+10	0.00E+00	6.85E+08	1.53E+08
August	3.84E+10	0.00E+00	6.85E+08	1.53E+08
September	3.84E+10	0.00E+00	6.85E+08	1.53E+08
October	3.75E+10	0.00E+00	6.85E+08	1.53E+08
November	3.84E+10	0.00E+00	6.85E+08	1.53E+08
December	4.24E+10	0.00E+00	6.85E+08	1.53E+08

Table B.9 Current conditions (2003) of land applied fecal coliform load for Angola Creek (Segment 2) impairment (Subshed 49).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	1.61E+07	4.90E+07	1.46E+10	1.48E+09	3.19E+09
February	1.61E+07	4.90E+07	1.70E+10	1.65E+09	3.50E+09
March	1.61E+07	4.90E+07	1.65E+11	1.67E+09	5.68E+09
April	1.61E+07	4.90E+07	1.65E+11	1.72E+09	8.02E+09
May	1.61E+07	4.90E+07	1.65E+11	1.76E+09	8.02E+09
June	1.61E+07	4.90E+07	9.15E+07	2.67E+09	1.02E+10
July	1.61E+07	4.90E+07	9.15E+07	2.70E+09	1.02E+10
August	1.61E+07	4.90E+07	9.15E+07	2.70E+09	1.02E+10
September	1.61E+07	4.90E+07	4.85E+10	1.82E+09	8.02E+09
October	1.61E+07	4.90E+07	1.65E+11	1.84E+09	5.68E+09
November	1.61E+07	4.90E+07	1.65E+11	1.63E+09	5.24E+09
December	1.61E+07	4.90E+07	1.46E+10	1.58E+09	3.19E+09

Table B.9 Current conditions (2003) of land applied fecal coliform load for Angola Creek (Segment 2) impairment (Subshed 49) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	9.72E+08	0.00E+00	7.54E+08	1.46E+08
February	9.51E+08	0.00E+00	7.54E+08	1.46E+08
March	9.10E+08	0.00E+00	7.54E+08	1.46E+08
April	8.89E+08	0.00E+00	7.54E+08	1.46E+08
May	8.68E+08	0.00E+00	7.54E+08	1.46E+08
June	8.48E+08	0.00E+00	7.54E+08	1.46E+08
July	8.06E+08	0.00E+00	7.54E+08	1.46E+08
August	8.06E+08	0.00E+00	7.54E+08	1.46E+08
September	8.06E+08	0.00E+00	7.54E+08	1.46E+08
October	7.86E+08	0.00E+00	7.54E+08	1.46E+08
November	8.06E+08	0.00E+00	7.54E+08	1.46E+08
December	8.89E+08	0.00E+00	7.54E+08	1.46E+08

Table B.10 Current conditions (2003) of land applied fecal coliform load for Horsepen Creek impairment (Subshed 54).

	Barren (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	4.66E+07	7.29E+09	1.27E+09	2.05E+09
February	4.66E+07	8.79E+09	1.58E+09	2.05E+09
March	4.66E+07	8.26E+10	2.77E+09	3.61E+09
April	4.66E+07	8.23E+10	2.60E+09	5.14E+09
May	4.66E+07	8.14E+10	1.74E+09	5.14E+09
June	4.66E+07	4.38E+08	2.99E+09	6.70E+09
July	4.66E+07	4.28E+08	3.02E+09	6.70E+09
August	4.66E+07	4.28E+08	3.02E+09	6.70E+09
September	4.66E+07	2.46E+10	2.13E+09	5.14E+09
October	4.66E+07	8.17E+10	2.12E+09	3.61E+09
November	4.66E+07	8.17E+10	2.08E+09	3.61E+09
December	4.66E+07	7.29E+09	1.40E+09	2.05E+09

Table B.10 Current conditions (2003) of land applied fecal coliform load for Horsepen Creek impairment (Subshed 54) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	1.43E+10	0.00E+00	7.88E+08	2.01E+08
February	1.40E+10	0.00E+00	7.88E+08	2.01E+08
March	1.35E+10	0.00E+00	7.88E+08	2.01E+08
April	1.32E+10	0.00E+00	7.88E+08	2.01E+08
May	1.29E+10	0.00E+00	7.88E+08	2.01E+08
June	1.27E+10	0.00E+00	7.88E+08	2.01E+08
July	1.21E+10	0.00E+00	7.88E+08	2.01E+08
August	1.21E+10	0.00E+00	7.88E+08	2.01E+08
September	1.21E+10	0.00E+00	7.88E+08	2.01E+08
October	1.19E+10	0.00E+00	7.88E+08	2.01E+08
November	1.21E+10	0.00E+00	7.88E+08	2.01E+08
December	1.32E+10	0.00E+00	7.88E+08	2.01E+08

Table B.11 Current conditions (2003) of land applied fecal coliform load for Flat Creek impairment (Subsheds 66-68,72).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	5.62E+07	5.06E+08	1.39E+10	1.85E+09	4.59E+09
February	5.62E+07	5.06E+08	1.80E+10	3.76E+09	4.79E+09
March	5.62E+07	5.06E+08	1.64E+11	1.04E+10	6.91E+09
April	5.62E+07	5.06E+08	1.62E+11	8.99E+09	9.13E+09
May	5.62E+07	5.06E+08	1.57E+11	3.80E+09	9.13E+09
June	5.62E+07	5.06E+08	2.00E+09	5.01E+09	1.13E+10
July	5.62E+07	5.06E+08	1.95E+09	4.99E+09	1.13E+10
August	5.62E+07	5.06E+08	1.95E+09	4.99E+09	1.13E+10
September	5.62E+07	5.06E+08	4.93E+10	5.65E+09	9.13E+09
October	5.62E+07	5.06E+08	1.59E+11	5.56E+09	6.91E+09
November	5.62E+07	5.06E+08	1.59E+11	5.50E+09	6.62E+09
December	5.62E+07	5.06E+08	1.39E+10	1.97E+09	4.59E+09

Table B.11 Current conditions (2003) of land applied fecal coliform load for Flat Creek impairment (Subsheds 66-68,72) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	3.47E+11	0.00E+00	2.67E+09	6.11E+08
February	3.39E+11	0.00E+00	2.67E+09	6.11E+08
March	3.24E+11	0.00E+00	2.67E+09	6.11E+08
April	3.17E+11	0.00E+00	2.67E+09	6.11E+08
May	3.09E+11	0.00E+00	2.67E+09	6.11E+08
June	3.01E+11	0.00E+00	2.67E+09	6.11E+08
July	2.86E+11	0.00E+00	2.67E+09	6.11E+08
August	2.86E+11	0.00E+00	2.67E+09	6.11E+08
September	2.86E+11	0.00E+00	2.67E+09	6.11E+08
October	2.78E+11	0.00E+00	2.67E+09	6.11E+08
November	2.86E+11	0.00E+00	2.67E+09	6.11E+08
December	3.17E+11	0.00E+00	2.67E+09	6.11E+08

Table B.12 Current conditions (2003) of land applied fecal coliform load for Nibbs Creek impairment (Subsheds 69-71).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	1.15E+08	1.80E+08	3.68E+10	2.35E+09	3.97E+09
February	1.15E+08	1.80E+08	4.34E+10	2.86E+09	4.06E+09
March	1.15E+08	1.80E+08	4.17E+11	4.54E+09	6.35E+09
April	1.15E+08	1.80E+08	4.17E+11	4.31E+09	8.66E+09
May	1.15E+08	1.80E+08	4.15E+11	3.10E+09	8.66E+09
June	1.15E+08	1.80E+08	6.66E+08	5.07E+09	1.10E+10
July	1.15E+08	1.80E+08	6.51E+08	5.12E+09	1.10E+10
August	1.15E+08	1.80E+08	6.51E+08	5.12E+09	1.10E+10
September	1.15E+08	1.80E+08	1.23E+11	3.67E+09	8.66E+09
October	1.15E+08	1.80E+08	4.16E+11	3.66E+09	6.35E+09
November	1.15E+08	1.80E+08	4.16E+11	3.54E+09	6.22E+09
December	1.15E+08	1.80E+08	3.68E+10	2.57E+09	3.97E+09

Table B.12 Current conditions (2003) of land applied fecal coliform load for Nibbs Creek impairment (Subsheds 69-71) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	5.36E+09	0.00E+00	2.84E+09	4.58E+08
February	5.24E+09	0.00E+00	2.84E+09	4.58E+08
March	4.99E+09	0.00E+00	2.84E+09	4.58E+08
April	4.87E+09	0.00E+00	2.84E+09	4.58E+08
May	4.75E+09	0.00E+00	2.84E+09	4.58E+08
June	4.63E+09	0.00E+00	2.84E+09	4.58E+08
July	4.38E+09	0.00E+00	2.84E+09	4.58E+08
August	4.38E+09	0.00E+00	2.84E+09	4.58E+08
September	4.38E+09	0.00E+00	2.84E+09	4.58E+08
October	4.26E+09	0.00E+00	2.84E+09	4.58E+08
November	4.38E+09	0.00E+00	2.84E+09	4.58E+08
December	4.87E+09	0.00E+00	2.84E+09	4.58E+08

Table B.13 Current conditions (2003) of land applied fecal coliform load for Deep Creek impairment (Subsheds 78-90,95-97).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	3.25E+08	1.06E+10	3.34E+10	9.28E+09	1.76E+10
February	3.25E+08	1.06E+10	3.87E+10	1.06E+10	1.99E+10
March	3.25E+08	1.06E+10	3.63E+11	1.06E+10	2.80E+10
April	3.25E+08	1.06E+10	3.63E+11	1.08E+10	3.74E+10
May	3.25E+08	1.06E+10	3.63E+11	1.09E+10	3.74E+10
June	3.25E+08	1.06E+10	1.52E+09	1.46E+10	4.55E+10
July	3.25E+08	1.06E+10	1.52E+09	1.47E+10	4.55E+10
August	3.25E+08	1.06E+10	1.52E+09	1.47E+10	4.55E+10
September	3.25E+08	1.06E+10	1.08E+11	1.12E+10	3.74E+10
October	3.25E+08	1.06E+10	3.63E+11	1.13E+10	2.80E+10
November	3.25E+08	1.06E+10	3.63E+11	9.87E+09	2.47E+10
December	3.25E+08	1.06E+10	3.34E+10	9.69E+09	1.76E+10

Table B.13 Current conditions (2003) of land applied fecal coliform load for Deep Creek impairment (Subsheds 78-90,95-97) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	1.77E+11	0.00E+00	5.87E+09	2.73E+09
February	1.73E+11	0.00E+00	5.87E+09	2.73E+09
March	1.65E+11	0.00E+00	5.87E+09	2.73E+09
April	1.61E+11	0.00E+00	5.87E+09	2.73E+09
May	1.57E+11	0.00E+00	5.87E+09	2.73E+09
June	1.53E+11	0.00E+00	5.87E+09	2.73E+09
July	1.45E+11	0.00E+00	5.87E+09	2.73E+09
August	1.45E+11	0.00E+00	5.87E+09	2.73E+09
September	1.45E+11	0.00E+00	5.87E+09	2.73E+09
October	1.41E+11	0.00E+00	5.87E+09	2.73E+09
November	1.45E+11	0.00E+00	5.87E+09	2.73E+09
December	1.61E+11	0.00E+00	5.87E+09	2.73E+09

Table B.14 Current conditions (2003) of land applied fecal coliform load for West Creek impairment (Subsheds 91-94).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	8.01E+07	5.92E+07	9.74E+09	1.61E+09	3.86E+09
February	8.01E+07	5.92E+07	1.13E+10	1.71E+09	4.03E+09
March	8.01E+07	5.92E+07	1.07E+11	1.73E+09	6.14E+09
April	8.01E+07	5.92E+07	1.07E+11	1.78E+09	8.33E+09
May	8.01E+07	5.92E+07	1.07E+11	1.82E+09	8.33E+09
June	8.01E+07	5.92E+07	3.12E+08	2.72E+09	1.04E+10
July	8.01E+07	5.92E+07	3.12E+08	2.75E+09	1.04E+10
August	8.01E+07	5.92E+07	3.12E+08	2.75E+09	1.04E+10
September	8.01E+07	5.92E+07	3.17E+10	1.88E+09	8.33E+09
October	8.01E+07	5.92E+07	1.07E+11	1.90E+09	6.14E+09
November	8.01E+07	5.92E+07	1.07E+11	1.76E+09	5.89E+09
December	8.01E+07	5.92E+07	9.74E+09	1.71E+09	3.86E+09

Table B.14 Current conditions (2003) of land applied fecal coliform load for West Creek impairment (Subsheds 91-94) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	4.79E+10	0.00E+00	2.73E+09	7.47E+08
February	4.68E+10	0.00E+00	2.73E+09	7.47E+08
March	4.44E+10	0.00E+00	2.73E+09	7.47E+08
April	4.33E+10	0.00E+00	2.73E+09	7.47E+08
May	4.21E+10	0.00E+00	2.73E+09	7.47E+08
June	4.10E+10	0.00E+00	2.73E+09	7.47E+08
July	3.87E+10	0.00E+00	2.73E+09	7.47E+08
August	3.87E+10	0.00E+00	2.73E+09	7.47E+08
September	3.87E+10	0.00E+00	2.73E+09	7.47E+08
October	3.75E+10	0.00E+00	2.73E+09	7.47E+08
November	3.87E+10	0.00E+00	2.73E+09	7.47E+08
December	4.33E+10	0.00E+00	2.73E+09	7.47E+08

Table B.15 Current conditions (2003) of land applied fecal coliform load for Appomattox River (Segment 2) impairment (Subsheds 98-118).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	2.61E+08	4.73E+10	1.58E+10	7.52E+09	1.52E+10
February	2.61E+08	4.62E+10	1.81E+10	8.14E+09	1.66E+10
March	2.61E+08	4.39E+10	1.59E+11	8.21E+09	2.37E+10
April	2.61E+08	4.28E+10	1.59E+11	8.39E+09	3.15E+10
May	2.61E+08	4.17E+10	1.59E+11	8.55E+09	3.15E+10
June	2.61E+08	4.06E+10	1.97E+09	1.20E+10	3.86E+10
July	2.61E+08	3.84E+10	1.97E+09	1.21E+10	3.86E+10
August	2.61E+08	3.84E+10	1.97E+09	1.21E+10	3.86E+10
September	2.61E+08	3.84E+10	4.80E+10	8.77E+09	3.15E+10
October	2.61E+08	3.73E+10	1.59E+11	8.85E+09	2.37E+10
November	2.61E+08	3.84E+10	1.59E+11	8.08E+09	2.17E+10
December	2.61E+08	4.28E+10	1.58E+10	7.90E+09	1.52E+10

Table B.15 Current conditions (2003) of land applied fecal coliform load for Appomattox River (Segment 2) impairment (Subsheds 98-118) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	2.39E+11	0.00E+00	7.39E+09	3.30E+09
February	2.34E+11	0.00E+00	7.39E+09	3.30E+09
March	2.25E+11	0.00E+00	7.39E+09	3.30E+09
April	2.20E+11	0.00E+00	7.39E+09	3.30E+09
May	2.16E+11	0.00E+00	7.39E+09	3.30E+09
June	2.11E+11	0.00E+00	7.39E+09	3.30E+09
July	2.02E+11	0.00E+00	7.39E+09	3.30E+09
August	2.02E+11	0.00E+00	7.39E+09	3.30E+09
September	2.02E+11	0.00E+00	7.39E+09	3.30E+09
October	1.97E+11	0.00E+00	7.39E+09	3.30E+09
November	2.02E+11	0.00E+00	7.39E+09	3.30E+09
December	2.20E+11	0.00E+00	7.39E+09	3.30E+09

Table B.16 Current conditions (2003) of land applied fecal coliform load for Appomattox River (Segment 3 - Tidal) impairment (Subsheds 119-123,144-149).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	3.19E+08	2.93E+09	1.43E+09	1.62E+09	4.40E+09
February	3.19E+08	2.93E+09	1.43E+09	1.62E+09	4.40E+09
March	3.19E+08	2.93E+09	1.43E+09	1.62E+09	4.40E+09
April	3.19E+08	2.93E+09	1.43E+09	1.62E+09	4.40E+09
May	3.19E+08	2.93E+09	1.43E+09	1.62E+09	4.40E+09
June	3.19E+08	2.93E+09	1.43E+09	1.62E+09	4.40E+09
July	3.19E+08	2.93E+09	1.43E+09	1.62E+09	4.40E+09
August	3.19E+08	2.93E+09	1.43E+09	1.62E+09	4.40E+09
September	3.19E+08	2.93E+09	1.43E+09	1.62E+09	4.40E+09
October	3.19E+08	2.93E+09	1.43E+09	1.62E+09	4.40E+09
November	3.19E+08	2.93E+09	1.43E+09	1.62E+09	4.40E+09
December	3.19E+08	2.93E+09	1.43E+09	1.62E+09	4.40E+09

Table B.16 Current conditions (2003) of land applied fecal coliform load for Appomattox River (Segment 3 - Tidal) impairment (Subsheds 119-123,144-149) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	8.54E+09	0.00E+00	1.16E+10	2.63E+09
February	8.44E+09	0.00E+00	1.16E+10	2.63E+09
March	8.23E+09	0.00E+00	1.16E+10	2.63E+09
April	8.12E+09	0.00E+00	1.16E+10	2.63E+09
May	8.02E+09	0.00E+00	1.16E+10	2.63E+09
June	7.91E+09	0.00E+00	1.16E+10	2.63E+09
July	7.70E+09	0.00E+00	1.16E+10	2.63E+09
August	7.70E+09	0.00E+00	1.16E+10	2.63E+09
September	7.70E+09	0.00E+00	1.16E+10	2.63E+09
October	7.60E+09	0.00E+00	1.16E+10	2.63E+09
November	7.70E+09	0.00E+00	1.16E+10	2.63E+09
December	8.12E+09	0.00E+00	1.16E+10	2.63E+09

Table B.17 Current conditions (2003) of land applied fecal coliform load for Swift Creek (Segment 1) impairment (Subsheds 124-126).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	2.76E+07	2.76E+07	8.70E+08	6.86E+08	7.33E+08
February	2.76E+07	2.76E+07	8.70E+08	6.86E+08	8.02E+08
March	2.76E+07	2.76E+07	8.70E+08	6.86E+08	7.98E+08
April	2.76E+07	2.76E+07	8.70E+08	6.86E+08	7.93E+08
May	2.76E+07	2.76E+07	8.70E+08	6.86E+08	7.93E+08
June	2.76E+07	2.76E+07	8.70E+08	6.86E+08	7.89E+08
July	2.76E+07	2.76E+07	8.70E+08	6.86E+08	7.89E+08
August	2.76E+07	2.76E+07	8.70E+08	6.86E+08	7.89E+08
September	2.76E+07	2.76E+07	8.70E+08	6.86E+08	7.93E+08
October	2.76E+07	2.76E+07	8.70E+08	6.86E+08	7.98E+08
November	2.76E+07	2.76E+07	8.70E+08	6.86E+08	7.30E+08
December	2.76E+07	2.76E+07	8.70E+08	6.86E+08	7.33E+08

Table B.17 Current conditions (2003) of land applied fecal coliform load for Swift Creek (Segment 1) impairment (Subsheds 124-126) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	9.80E+08	4.90E+09	0.00E+00	2.36E+09
February	1.13E+09	4.81E+09	0.00E+00	2.36E+09
March	1.40E+09	4.63E+09	0.00E+00	2.36E+09
April	1.76E+09	4.53E+09	0.00E+00	2.36E+09
May	1.76E+09	4.44E+09	0.00E+00	2.36E+09
June	2.03E+09	4.35E+09	0.00E+00	2.36E+09
July	2.03E+09	4.16E+09	0.00E+00	2.36E+09
August	2.03E+09	4.16E+09	0.00E+00	2.36E+09
September	1.76E+09	4.16E+09	0.00E+00	2.36E+09
October	1.40E+09	4.07E+09	0.00E+00	2.36E+09
November	1.19E+09	4.16E+09	0.00E+00	2.36E+09
December	9.80E+08	4.53E+09	0.00E+00	2.36E+09

Table B.18 Current conditions (2003) of land applied fecal coliform load for Swift Creek (Segment 2) impairment (Subsheds 127-138).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	9.65E+07	2.02E+09	1.17E+09	2.21E+09	4.93E+09
February	9.65E+07	2.02E+09	1.17E+09	2.43E+09	5.49E+09
March	9.65E+07	2.02E+09	1.17E+09	2.42E+09	6.54E+09
April	9.65E+07	2.02E+09	1.17E+09	2.40E+09	7.93E+09
May	9.65E+07	2.02E+09	1.17E+09	2.40E+09	7.93E+09
June	9.65E+07	2.02E+09	1.17E+09	2.39E+09	8.98E+09
July	9.65E+07	2.02E+09	1.17E+09	2.39E+09	8.98E+09
August	9.65E+07	2.02E+09	1.17E+09	2.39E+09	8.98E+09
September	9.65E+07	2.02E+09	1.17E+09	2.40E+09	7.93E+09
October	9.65E+07	2.02E+09	1.17E+09	2.42E+09	6.54E+09
November	9.65E+07	2.02E+09	1.17E+09	2.21E+09	5.73E+09
December	9.65E+07	2.02E+09	1.17E+09	2.21E+09	4.93E+09

Table B.18 Current conditions (2003) of land applied fecal coliform load for Swift Creek (Segment 2) impairment (Subsheds 127-138) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	1.61E+10	0.00E+00	3.32E+09	1.59E+09
February	1.60E+10	0.00E+00	3.32E+09	1.59E+09
March	1.56E+10	0.00E+00	3.32E+09	1.59E+09
April	1.54E+10	0.00E+00	3.32E+09	1.59E+09
May	1.52E+10	0.00E+00	3.32E+09	1.59E+09
June	1.50E+10	0.00E+00	3.32E+09	1.59E+09
July	1.47E+10	0.00E+00	3.32E+09	1.59E+09
August	1.47E+10	0.00E+00	3.32E+09	1.59E+09
September	1.47E+10	0.00E+00	3.32E+09	1.59E+09
October	1.45E+10	0.00E+00	3.32E+09	1.59E+09
November	1.47E+10	0.00E+00	3.32E+09	1.59E+09
December	1.54E+10	0.00E+00	3.32E+09	1.59E+09

Table B.19 Current conditions (2003) of land applied fecal coliform load for Swift Creek (Segment 3) impairment (Subsheds 139-143).

	Barren (cfu/ac*day)	Commercial (cfu/ac*day)	Cropland (cfu/ac*day)	Pasture (cfu/ac*day)	Livestock Access (cfu/ac*day)
January	6.30E+07	7.75E+08	6.26E+08	1.18E+09	2.90E+09
February	6.30E+07	7.75E+08	6.26E+08	1.32E+09	3.10E+09
March	6.30E+07	7.75E+08	6.26E+08	1.31E+09	3.48E+09
April	6.30E+07	7.75E+08	6.26E+08	1.30E+09	3.98E+09
May	6.30E+07	7.75E+08	6.26E+08	1.30E+09	3.98E+09
June	6.30E+07	7.75E+08	6.26E+08	1.29E+09	4.36E+09
July	6.30E+07	7.75E+08	6.26E+08	1.29E+09	4.36E+09
August	6.30E+07	7.75E+08	6.26E+08	1.29E+09	4.36E+09
September	6.30E+07	7.75E+08	6.26E+08	1.30E+09	3.98E+09
October	6.30E+07	7.75E+08	6.26E+08	1.31E+09	3.48E+09
November	6.30E+07	7.75E+08	6.26E+08	1.18E+09	3.19E+09
December	6.30E+07	7.75E+08	6.26E+08	1.18E+09	2.90E+09

Table B.19 Current conditions (2003) of land applied fecal coliform load for Swift Creek (Segment 3) impairment (Subsheds 139-143) (cont).

	Residential (cfu/ac*day)	Water (cfu/ac*day)	Wetlands (cfu/ac*day)	Woodland (cfu/ac*day)
January	1.54E+10	0.00E+00	2.78E+09	9.26E+08
February	1.51E+10	0.00E+00	2.78E+09	9.26E+08
March	1.45E+10	0.00E+00	2.78E+09	9.26E+08
April	1.42E+10	0.00E+00	2.78E+09	9.26E+08
May	1.40E+10	0.00E+00	2.78E+09	9.26E+08
June	1.37E+10	0.00E+00	2.78E+09	9.26E+08
July	1.31E+10	0.00E+00	2.78E+09	9.26E+08
August	1.31E+10	0.00E+00	2.78E+09	9.26E+08
September	1.31E+10	0.00E+00	2.78E+09	9.26E+08
October	1.28E+10	0.00E+00	2.78E+09	9.26E+08
November	1.31E+10	0.00E+00	2.78E+09	9.26E+08
December	1.42E+10	0.00E+00	2.78E+09	9.26E+08

Table B.20 Monthly, directly deposited fecal coliform loads in each reach of the Appomattox River (Segment 1) impairment (Subsheds 1-12,18-23,41,47,50-53,55-65,73-77).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
1	Human	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08
	Livestock	2.53E+10	2.92E+10	4.72E+10	6.74E+10	6.74E+10	8.54E+10
	Wildlife	2.741E+10	2.741E+10	2.741E+10	2.741E+10	2.741E+10	2.741E+10
2	Human	1.88E+08	1.88E+08	1.88E+08	1.88E+08	1.88E+08	1.88E+08
	Livestock	5.59E+09	7.27E+09	1.04E+10	1.45E+10	1.45E+10	1.77E+10
	Wildlife	1.825E+10	1.825E+10	1.825E+10	1.825E+10	1.825E+10	1.825E+10
3	Human	7.54E+07	7.54E+07	7.54E+07	7.54E+07	7.54E+07	7.54E+07
	Livestock	9.32E+09	1.21E+10	1.73E+10	2.42E+10	2.42E+10	2.94E+10
	Wildlife	2.437E+10	2.437E+10	2.437E+10	2.437E+10	2.437E+10	2.437E+10
4	Human	3.67E+08	3.67E+08	3.67E+08	3.67E+08	3.67E+08	3.67E+08
	Livestock	1.91E+10	2.19E+10	3.57E+10	5.10E+10	5.10E+10	6.48E+10
	Wildlife	2.815E+10	2.815E+10	2.815E+10	2.815E+10	2.815E+10	2.815E+10
5	Human	4.09E+08	4.09E+08	4.09E+08	4.09E+08	4.09E+08	4.09E+08
	Livestock	4.43E+09	5.76E+09	8.22E+09	1.15E+10	1.15E+10	1.40E+10
	Wildlife	2.059E+10	2.059E+10	2.059E+10	2.059E+10	2.059E+10	2.059E+10
6	Human	2.25E+08	2.25E+08	2.25E+08	2.25E+08	2.25E+08	2.25E+08
	Livestock	5.71E+09	7.42E+09	1.06E+10	1.48E+10	1.48E+10	1.80E+10
	Wildlife	3.657E+10	3.657E+10	3.657E+10	3.657E+10	3.657E+10	3.657E+10
7	Human	3.95E+07	3.95E+07	3.95E+07	3.95E+07	3.95E+07	3.95E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.474E+10	1.474E+10	1.474E+10	1.474E+10	1.474E+10	1.474E+10
8	Human	4.76E+07	4.76E+07	4.76E+07	4.76E+07	4.76E+07	4.76E+07
	Livestock	3.44E+09	3.55E+09	6.47E+09	9.41E+09	9.41E+09	1.23E+10
	Wildlife	1.144E+10	1.144E+10	1.144E+10	1.144E+10	1.144E+10	1.144E+10
9	Human	2.04E+08	2.04E+08	2.04E+08	2.04E+08	2.04E+08	2.04E+08
	Livestock	4.92E+09	6.14E+09	8.77E+09	1.23E+10	1.23E+10	1.49E+10
	Wildlife	2.313E+10	2.313E+10	2.313E+10	2.313E+10	2.313E+10	2.313E+10
10	Human	6.00E+08	6.00E+08	6.00E+08	6.00E+08	6.00E+08	6.00E+08
	Livestock	3.05E+10	3.52E+10	5.69E+10	8.14E+10	8.14E+10	1.03E+11
	Wildlife	5.191E+10	5.191E+10	5.191E+10	5.191E+10	5.191E+10	5.191E+10
11	Human	1.23E+09	1.23E+09	1.23E+09	1.23E+09	1.23E+09	1.23E+09
	Livestock	2.10E+10	2.73E+10	3.89E+10	5.45E+10	5.45E+10	6.62E+10
	Wildlife	5.901E+10	5.901E+10	5.901E+10	5.901E+10	5.901E+10	5.901E+10
12	Human	1.36E+09	1.36E+09	1.36E+09	1.36E+09	1.36E+09	1.36E+09
	Livestock	7.57E+09	9.84E+09	1.41E+10	1.97E+10	1.97E+10	2.39E+10
	Wildlife	5.518E+10	5.518E+10	5.518E+10	5.518E+10	5.518E+10	5.518E+10
18	Human	3.19E+08	3.19E+08	3.19E+08	3.19E+08	3.19E+08	3.19E+08
	Livestock	3.84E+10	3.86E+10	6.88E+10	9.97E+10	9.97E+10	1.30E+11
	Wildlife	3.644E+10	3.644E+10	3.644E+10	3.644E+10	3.644E+10	3.644E+10
19	Human	2.72E+08	2.72E+08	2.72E+08	2.72E+08	2.72E+08	2.72E+08
	Livestock	1.75E+09	2.27E+09	3.25E+09	4.54E+09	4.54E+09	5.52E+09
	Wildlife	2.614E+10	2.614E+10	2.614E+10	2.614E+10	2.614E+10	2.614E+10

Table B.20 Monthly, directly deposited fecal coliform loads in each reach of the Appomattox River (Segment 1) impairment (Subsheds 1-12,18-23,41,47,50-53,55-65,73-77) (cont).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
20	Human	4.01E+08	4.01E+08	4.01E+08	4.01E+08	4.01E+08	4.01E+08
	Livestock	5.83E+08	7.57E+08	1.08E+09	1.51E+09	1.51E+09	1.84E+09
	Wildlife	1.474E+10	1.474E+10	1.474E+10	1.474E+10	1.474E+10	1.474E+10
21	Human	1.49E+09	1.49E+09	1.49E+09	1.49E+09	1.49E+09	1.49E+09
	Livestock	1.63E+10	2.12E+10	3.03E+10	4.24E+10	4.24E+10	5.15E+10
	Wildlife	9.345E+10	9.345E+10	9.345E+10	9.345E+10	9.345E+10	9.345E+10
22	Human	3.86E+08	3.86E+08	3.86E+08	3.86E+08	3.86E+08	3.86E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	6.705E+09	6.705E+09	6.705E+09	6.705E+09	6.705E+09	6.705E+09
23	Human	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09
	Livestock	4.66E+09	6.06E+09	8.65E+09	1.21E+10	1.21E+10	1.47E+10
	Wildlife	2.463E+10	2.463E+10	2.463E+10	2.463E+10	2.463E+10	2.463E+10
41	Human	9.93E+08	9.93E+08	9.93E+08	9.93E+08	9.93E+08	9.93E+08
	Livestock	6.87E+09	8.94E+09	1.28E+10	1.79E+10	1.79E+10	2.17E+10
	Wildlife	2.95E+10	2.95E+10	2.95E+10	2.95E+10	2.95E+10	2.95E+10
47	Human	1.01E+08	1.01E+08	1.01E+08	1.01E+08	1.01E+08	1.01E+08
	Livestock	4.66E+08	6.06E+08	8.65E+08	1.21E+09	1.21E+09	1.47E+09
	Wildlife	1.081E+10	1.081E+10	1.081E+10	1.081E+10	1.081E+10	1.081E+10
50	Human	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08
	Livestock	3.05E+10	3.05E+10	5.73E+10	8.37E+10	8.37E+10	1.11E+11
	Wildlife	1.772E+10	1.772E+10	1.772E+10	1.772E+10	1.772E+10	1.772E+10
51	Human	5.16E+08	5.16E+08	5.16E+08	5.16E+08	5.16E+08	5.16E+08
	Livestock	1.40E+09	1.82E+09	2.60E+09	3.63E+09	3.63E+09	4.41E+09
	Wildlife	2.506E+10	2.506E+10	2.506E+10	2.506E+10	2.506E+10	2.506E+10
52	Human	1.22E+08	1.22E+08	1.22E+08	1.22E+08	1.22E+08	1.22E+08
	Livestock	9.32E+08	1.21E+09	1.73E+09	2.42E+09	2.42E+09	2.94E+09
	Wildlife	1.137E+10	1.137E+10	1.137E+10	1.137E+10	1.137E+10	1.137E+10
53	Human	7.67E+08	7.67E+08	7.67E+08	7.67E+08	7.67E+08	7.67E+08
	Livestock	6.76E+09	8.78E+09	1.25E+10	1.76E+10	1.76E+10	2.13E+10
	Wildlife	2.788E+10	2.788E+10	2.788E+10	2.788E+10	2.788E+10	2.788E+10
55	Human	9.22E+08	9.22E+08	9.22E+08	9.22E+08	9.22E+08	9.22E+08
	Livestock	9.79E+09	1.27E+10	1.82E+10	2.54E+10	2.54E+10	3.09E+10
	Wildlife	3.149E+10	3.149E+10	3.149E+10	3.149E+10	3.149E+10	3.149E+10
56	Human	6.78E+08	6.78E+08	6.78E+08	6.78E+08	6.78E+08	6.78E+08
	Livestock	6.46E+09	7.68E+09	1.23E+10	1.78E+10	1.78E+10	2.24E+10
	Wildlife	4.275E+10	4.275E+10	4.275E+10	4.275E+10	4.275E+10	4.275E+10
57	Human	4.54E+08	4.54E+08	4.54E+08	4.54E+08	4.54E+08	4.54E+08
	Livestock	1.40E+09	1.82E+09	2.60E+09	3.63E+09	3.63E+09	4.41E+09
	Wildlife	3.446E+10	3.446E+10	3.446E+10	3.446E+10	3.446E+10	3.446E+10
58	Human	5.38E+08	5.38E+08	5.38E+08	5.38E+08	5.38E+08	5.38E+08
	Livestock	2.33E+09	3.03E+09	4.33E+09	6.06E+09	6.06E+09	7.36E+09
	Wildlife	4.605E+10	4.605E+10	4.605E+10	4.605E+10	4.605E+10	4.605E+10

Table B.20 Monthly, directly deposited fecal coliform loads in each reach of the Appomattox River (Segment 1) impairment (Subsheds 1-12,18-23,41,47,50-53,55-65,73-77) (cont).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
59	Human	4.99E+08	4.99E+08	4.99E+08	4.99E+08	4.99E+08	4.99E+08
	Livestock	2.23E+10	2.26E+10	4.20E+10	6.11E+10	6.11E+10	8.05E+10
	Wildlife	3.422E+10	3.422E+10	3.422E+10	3.422E+10	3.422E+10	3.422E+10
60	Human	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08
	Livestock	1.80E+10	1.98E+10	3.38E+10	4.86E+10	4.86E+10	6.26E+10
	Wildlife	2.752E+10	2.752E+10	2.752E+10	2.752E+10	2.752E+10	2.752E+10
61	Human	7.07E+08	7.07E+08	7.07E+08	7.07E+08	7.07E+08	7.07E+08
	Livestock	3.50E+09	4.54E+09	6.49E+09	9.09E+09	9.09E+09	1.10E+10
	Wildlife	4.276E+10	4.276E+10	4.276E+10	4.276E+10	4.276E+10	4.276E+10
62	Human	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08
	Livestock	2.12E+10	2.21E+10	3.98E+10	5.78E+10	5.78E+10	7.55E+10
	Wildlife	1.788E+10	1.788E+10	1.788E+10	1.788E+10	1.788E+10	1.788E+10
63	Human	4.33E+07	4.33E+07	4.33E+07	4.33E+07	4.33E+07	4.33E+07
	Livestock	2.33E+08	3.03E+08	4.33E+08	6.06E+08	6.06E+08	7.36E+08
	Wildlife	3.13E+09	3.13E+09	3.13E+09	3.13E+09	3.13E+09	3.13E+09
64	Human	1.46E+08	1.46E+08	1.46E+08	1.46E+08	1.46E+08	1.46E+08
	Livestock	2.33E+09	3.03E+09	4.33E+09	6.06E+09	6.06E+09	7.36E+09
	Wildlife	3.016E+10	3.016E+10	3.016E+10	3.016E+10	3.016E+10	3.016E+10
65	Human	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07
	Livestock	5.83E+08	7.57E+08	1.08E+09	1.51E+09	1.51E+09	1.84E+09
	Wildlife	1.059E+10	1.059E+10	1.059E+10	1.059E+10	1.059E+10	1.059E+10
73	Human	1.61E+08	1.61E+08	1.61E+08	1.61E+08	1.61E+08	1.61E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	2.251E+10	2.251E+10	2.251E+10	2.251E+10	2.251E+10	2.251E+10
74	Human	2.07E+08	2.07E+08	2.07E+08	2.07E+08	2.07E+08	2.07E+08
	Livestock	1.25E+10	1.34E+10	2.33E+10	3.37E+10	3.37E+10	4.36E+10
	Wildlife	4.227E+10	4.227E+10	4.227E+10	4.227E+10	4.227E+10	4.227E+10
75	Human	2.61E+07	2.61E+07	2.61E+07	2.61E+07	2.61E+07	2.61E+07
	Livestock	5.83E+08	7.57E+08	1.08E+09	1.51E+09	1.51E+09	1.84E+09
	Wildlife	2.212E+10	2.212E+10	2.212E+10	2.212E+10	2.212E+10	2.212E+10
76	Human	1.77E+08	1.77E+08	1.77E+08	1.77E+08	1.77E+08	1.77E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	2.689E+10	2.689E+10	2.689E+10	2.689E+10	2.689E+10	2.689E+10
77	Human	2.84E+07	2.84E+07	2.84E+07	2.84E+07	2.84E+07	2.84E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	7.857E+09	7.857E+09	7.857E+09	7.857E+09	7.857E+09	7.857E+09

Table B.20 Monthly, directly deposited fecal coliform loads in each reach of the Appomattox River (Segment 1) impairment (Subsheds 1-12,18-23,41,47,50-53,55-65,73-77) (cont).

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
1	Human	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08
	Livestock	8.54E+10	8.54E+10	6.74E+10	4.72E+10	4.16E+10	2.53E+10
	Wildlife	2.741E+10	2.741E+10	2.741E+10	2.741E+10	2.741E+10	2.741E+10
2	Human	1.88E+08	1.88E+08	1.88E+08	1.88E+08	1.88E+08	1.88E+08
	Livestock	1.77E+10	1.77E+10	1.45E+10	1.04E+10	7.99E+09	5.59E+09
	Wildlife	1.825E+10	1.825E+10	1.825E+10	1.825E+10	1.825E+10	1.825E+10
3	Human	7.54E+07	7.54E+07	7.54E+07	7.54E+07	7.54E+07	7.54E+07
	Livestock	2.94E+10	2.94E+10	2.42E+10	1.73E+10	1.33E+10	9.32E+09
	Wildlife	2.437E+10	2.437E+10	2.437E+10	2.437E+10	2.437E+10	2.437E+10
4	Human	3.67E+08	3.67E+08	3.67E+08	3.67E+08	3.67E+08	3.67E+08
	Livestock	6.48E+10	6.48E+10	5.10E+10	3.57E+10	3.17E+10	1.91E+10
	Wildlife	2.815E+10	2.815E+10	2.815E+10	2.815E+10	2.815E+10	2.815E+10
5	Human	4.09E+08	4.09E+08	4.09E+08	4.09E+08	4.09E+08	4.09E+08
	Livestock	1.40E+10	1.40E+10	1.15E+10	8.22E+09	6.32E+09	4.43E+09
	Wildlife	2.059E+10	2.059E+10	2.059E+10	2.059E+10	2.059E+10	2.059E+10
6	Human	2.25E+08	2.25E+08	2.25E+08	2.25E+08	2.25E+08	2.25E+08
	Livestock	1.80E+10	1.80E+10	1.48E+10	1.06E+10	8.16E+09	5.71E+09
	Wildlife	3.657E+10	3.657E+10	3.657E+10	3.657E+10	3.657E+10	3.657E+10
7	Human	3.95E+07	3.95E+07	3.95E+07	3.95E+07	3.95E+07	3.95E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.474E+10	1.474E+10	1.474E+10	1.474E+10	1.474E+10	1.474E+10
8	Human	4.76E+07	4.76E+07	4.76E+07	4.76E+07	4.76E+07	4.76E+07
	Livestock	1.23E+10	1.23E+10	9.41E+09	6.47E+09	6.32E+09	3.44E+09
	Wildlife	1.144E+10	1.144E+10	1.144E+10	1.144E+10	1.144E+10	1.144E+10
9	Human	2.04E+08	2.04E+08	2.04E+08	2.04E+08	2.04E+08	2.04E+08
	Livestock	1.49E+10	1.49E+10	1.23E+10	8.77E+09	7.02E+09	4.92E+09
	Wildlife	2.313E+10	2.313E+10	2.313E+10	2.313E+10	2.313E+10	2.313E+10
10	Human	6.00E+08	6.00E+08	6.00E+08	6.00E+08	6.00E+08	6.00E+08
	Livestock	1.03E+11	1.03E+11	8.14E+10	5.69E+10	5.02E+10	3.05E+10
	Wildlife	5.191E+10	5.191E+10	5.191E+10	5.191E+10	5.191E+10	5.191E+10
11	Human	1.23E+09	1.23E+09	1.23E+09	1.23E+09	1.23E+09	1.23E+09
	Livestock	6.62E+10	6.62E+10	5.45E+10	3.89E+10	3.00E+10	2.10E+10
	Wildlife	5.901E+10	5.901E+10	5.901E+10	5.901E+10	5.901E+10	5.901E+10
12	Human	1.36E+09	1.36E+09	1.36E+09	1.36E+09	1.36E+09	1.36E+09
	Livestock	2.39E+10	2.39E+10	1.97E+10	1.41E+10	1.08E+10	7.57E+09
	Wildlife	5.518E+10	5.518E+10	5.518E+10	5.518E+10	5.518E+10	5.518E+10
18	Human	3.19E+08	3.19E+08	3.19E+08	3.19E+08	3.19E+08	3.19E+08
	Livestock	1.30E+11	1.30E+11	9.97E+10	6.88E+10	6.87E+10	3.84E+10
	Wildlife	3.644E+10	3.644E+10	3.644E+10	3.644E+10	3.644E+10	3.644E+10
19	Human	2.72E+08	2.72E+08	2.72E+08	2.72E+08	2.72E+08	2.72E+08
	Livestock	5.52E+09	5.52E+09	4.54E+09	3.25E+09	2.50E+09	1.75E+09
	Wildlife	2.614E+10	2.614E+10	2.614E+10	2.614E+10	2.614E+10	2.614E+10

Table B.20 Monthly, directly deposited fecal coliform loads in each reach of the Appomattox River (Segment 1) impairment (Subsheds 1-12,18-23,41,47,50-53,55-65,73-77) (cont).

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
20	Human	4.01E+08	4.01E+08	4.01E+08	4.01E+08	4.01E+08	4.01E+08
	Livestock	1.84E+09	1.84E+09	1.51E+09	1.08E+09	8.32E+08	5.83E+08
	Wildlife	1.474E+10	1.474E+10	1.474E+10	1.474E+10	1.474E+10	1.474E+10
21	Human	1.49E+09	1.49E+09	1.49E+09	1.49E+09	1.49E+09	1.49E+09
	Livestock	5.15E+10	5.15E+10	4.24E+10	3.03E+10	2.33E+10	1.63E+10
	Wildlife	9.345E+10	9.345E+10	9.345E+10	9.345E+10	9.345E+10	9.345E+10
22	Human	3.86E+08	3.86E+08	3.86E+08	3.86E+08	3.86E+08	3.86E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	6.705E+09	6.705E+09	6.705E+09	6.705E+09	6.705E+09	6.705E+09
23	Human	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09
	Livestock	1.47E+10	1.47E+10	1.21E+10	8.65E+09	6.66E+09	4.66E+09
	Wildlife	2.463E+10	2.463E+10	2.463E+10	2.463E+10	2.463E+10	2.463E+10
41	Human	9.93E+08	9.93E+08	9.93E+08	9.93E+08	9.93E+08	9.93E+08
	Livestock	2.17E+10	2.17E+10	1.79E+10	1.28E+10	9.82E+09	6.87E+09
	Wildlife	2.95E+10	2.95E+10	2.95E+10	2.95E+10	2.95E+10	2.95E+10
47	Human	1.01E+08	1.01E+08	1.01E+08	1.01E+08	1.01E+08	1.01E+08
	Livestock	1.47E+09	1.47E+09	1.21E+09	8.65E+08	6.66E+08	4.66E+08
	Wildlife	1.081E+10	1.081E+10	1.081E+10	1.081E+10	1.081E+10	1.081E+10
50	Human	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08
	Livestock	1.11E+11	1.11E+11	8.37E+10	5.73E+10	5.73E+10	3.05E+10
	Wildlife	1.772E+10	1.772E+10	1.772E+10	1.772E+10	1.772E+10	1.772E+10
51	Human	5.16E+08	5.16E+08	5.16E+08	5.16E+08	5.16E+08	5.16E+08
	Livestock	4.41E+09	4.41E+09	3.63E+09	2.60E+09	2.00E+09	1.40E+09
	Wildlife	2.506E+10	2.506E+10	2.506E+10	2.506E+10	2.506E+10	2.506E+10
52	Human	1.22E+08	1.22E+08	1.22E+08	1.22E+08	1.22E+08	1.22E+08
	Livestock	2.94E+09	2.94E+09	2.42E+09	1.73E+09	1.33E+09	9.32E+08
	Wildlife	1.137E+10	1.137E+10	1.137E+10	1.137E+10	1.137E+10	1.137E+10
53	Human	7.67E+08	7.67E+08	7.67E+08	7.67E+08	7.67E+08	7.67E+08
	Livestock	2.13E+10	2.13E+10	1.76E+10	1.25E+10	9.65E+09	6.76E+09
	Wildlife	2.788E+10	2.788E+10	2.788E+10	2.788E+10	2.788E+10	2.788E+10
55	Human	9.22E+08	9.22E+08	9.22E+08	9.22E+08	9.22E+08	9.22E+08
	Livestock	3.09E+10	3.09E+10	2.54E+10	1.82E+10	1.40E+10	9.79E+09
	Wildlife	3.149E+10	3.149E+10	3.149E+10	3.149E+10	3.149E+10	3.149E+10
56	Human	6.78E+08	6.78E+08	6.78E+08	6.78E+08	6.78E+08	6.78E+08
	Livestock	2.24E+10	2.24E+10	1.78E+10	1.23E+10	1.06E+10	6.46E+09
	Wildlife	4.275E+10	4.275E+10	4.275E+10	4.275E+10	4.275E+10	4.275E+10
57	Human	4.54E+08	4.54E+08	4.54E+08	4.54E+08	4.54E+08	4.54E+08
	Livestock	4.41E+09	4.41E+09	3.63E+09	2.60E+09	2.00E+09	1.40E+09
	Wildlife	3.446E+10	3.446E+10	3.446E+10	3.446E+10	3.446E+10	3.446E+10
58	Human	5.38E+08	5.38E+08	5.38E+08	5.38E+08	5.38E+08	5.38E+08
	Livestock	7.36E+09	7.36E+09	6.06E+09	4.33E+09	3.33E+09	2.33E+09
	Wildlife	4.605E+10	4.605E+10	4.605E+10	4.605E+10	4.605E+10	4.605E+10

Table B.20 Monthly, directly deposited fecal coliform loads in each reach of the Appomattox River (Segment 1) impairment (Subsheds 1-12,18-23,41,47,50-53,55-65,73-77) (cont).

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
59	Human	4.99E+08	4.99E+08	4.99E+08	4.99E+08	4.99E+08	4.99E+08
	Livestock	8.05E+10	8.05E+10	6.11E+10	4.20E+10	4.16E+10	2.23E+10
	Wildlife	3.422E+10	3.422E+10	3.422E+10	3.422E+10	3.422E+10	3.422E+10
60	Human	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08
	Livestock	6.26E+10	6.26E+10	4.86E+10	3.38E+10	3.13E+10	1.80E+10
	Wildlife	2.752E+10	2.752E+10	2.752E+10	2.752E+10	2.752E+10	2.752E+10
61	Human	7.07E+08	7.07E+08	7.07E+08	7.07E+08	7.07E+08	7.07E+08
	Livestock	1.10E+10	1.10E+10	9.09E+09	6.49E+09	4.99E+09	3.50E+09
	Wildlife	4.276E+10	4.276E+10	4.276E+10	4.276E+10	4.276E+10	4.276E+10
62	Human	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08
	Livestock	7.55E+10	7.55E+10	5.78E+10	3.98E+10	3.86E+10	2.12E+10
	Wildlife	1.788E+10	1.788E+10	1.788E+10	1.788E+10	1.788E+10	1.788E+10
63	Human	4.33E+07	4.33E+07	4.33E+07	4.33E+07	4.33E+07	4.33E+07
	Livestock	7.36E+08	7.36E+08	6.06E+08	4.33E+08	3.33E+08	2.33E+08
	Wildlife	3.13E+09	3.13E+09	3.13E+09	3.13E+09	3.13E+09	3.13E+09
64	Human	1.46E+08	1.46E+08	1.46E+08	1.46E+08	1.46E+08	1.46E+08
	Livestock	7.36E+09	7.36E+09	6.06E+09	4.33E+09	3.33E+09	2.33E+09
	Wildlife	3.016E+10	3.016E+10	3.016E+10	3.016E+10	3.016E+10	3.016E+10
65	Human	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07
	Livestock	1.84E+09	1.84E+09	1.51E+09	1.08E+09	8.32E+08	5.83E+08
	Wildlife	1.059E+10	1.059E+10	1.059E+10	1.059E+10	1.059E+10	1.059E+10
73	Human	1.61E+08	1.61E+08	1.61E+08	1.61E+08	1.61E+08	1.61E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	2.251E+10	2.251E+10	2.251E+10	2.251E+10	2.251E+10	2.251E+10
74	Human	2.07E+08	2.07E+08	2.07E+08	2.07E+08	2.07E+08	2.07E+08
	Livestock	4.36E+10	4.36E+10	3.37E+10	2.33E+10	2.19E+10	1.25E+10
	Wildlife	4.227E+10	4.227E+10	4.227E+10	4.227E+10	4.227E+10	4.227E+10
75	Human	2.61E+07	2.61E+07	2.61E+07	2.61E+07	2.61E+07	2.61E+07
	Livestock	1.84E+09	1.84E+09	1.51E+09	1.08E+09	8.32E+08	5.83E+08
	Wildlife	2.212E+10	2.212E+10	2.212E+10	2.212E+10	2.212E+10	2.212E+10
76	Human	1.77E+08	1.77E+08	1.77E+08	1.77E+08	1.77E+08	1.77E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	2.689E+10	2.689E+10	2.689E+10	2.689E+10	2.689E+10	2.689E+10
77	Human	2.84E+07	2.84E+07	2.84E+07	2.84E+07	2.84E+07	2.84E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	7.857E+09	7.857E+09	7.857E+09	7.857E+09	7.857E+09	7.857E+09

Table B.21 Monthly, directly deposited fecal coliform loads in each reach of the Spring Creek impairment (Subsheds 13-17).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
13	Human	1.71E+08	1.71E+08	1.71E+08	1.71E+08	1.71E+08	1.71E+08
	Livestock	4.66E+09	6.06E+09	8.65E+09	1.21E+10	1.21E+10	1.47E+10
	Wildlife	2.014E+10	2.014E+10	2.014E+10	2.014E+10	2.014E+10	2.014E+10
14	Human	6.15E+07	6.15E+07	6.15E+07	6.15E+07	6.15E+07	6.15E+07
	Livestock	2.68E+09	3.48E+09	4.98E+09	6.97E+09	6.97E+09	8.46E+09
	Wildlife	6.552E+09	6.552E+09	6.552E+09	6.552E+09	6.552E+09	6.552E+09
15	Human	2.25E+08	2.25E+08	2.25E+08	2.25E+08	2.25E+08	2.25E+08
	Livestock	3.50E+09	4.54E+09	6.49E+09	9.09E+09	9.09E+09	1.10E+10
	Wildlife	1.492E+10	1.492E+10	1.492E+10	1.492E+10	1.492E+10	1.492E+10
16	Human	3.82E+07	3.82E+07	3.82E+07	3.82E+07	3.82E+07	3.82E+07
	Livestock	1.75E+09	2.27E+09	3.25E+09	4.54E+09	4.54E+09	5.52E+09
	Wildlife	9.7E+09	9.7E+09	9.7E+09	9.7E+09	9.7E+09	9.7E+09
17	Human	1.19E+07	1.19E+07	1.19E+07	1.19E+07	1.19E+07	1.19E+07
	Livestock	1.40E+09	1.82E+09	2.60E+09	3.63E+09	3.63E+09	4.41E+09
	Wildlife	9.844E+09	9.844E+09	9.844E+09	9.844E+09	9.844E+09	9.844E+09

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
13	Human	1.71E+08	1.71E+08	1.71E+08	1.71E+08	1.71E+08	1.71E+08
	Livestock	1.47E+10	1.47E+10	1.21E+10	8.65E+09	6.66E+09	4.66E+09
	Wildlife	2.014E+10	2.014E+10	2.014E+10	2.014E+10	2.014E+10	2.014E+10
14	Human	6.15E+07	6.15E+07	6.15E+07	6.15E+07	6.15E+07	6.15E+07
	Livestock	8.46E+09	8.46E+09	6.97E+09	4.98E+09	3.83E+09	2.68E+09
	Wildlife	6.552E+09	6.552E+09	6.552E+09	6.552E+09	6.552E+09	6.552E+09
15	Human	2.25E+08	2.25E+08	2.25E+08	2.25E+08	2.25E+08	2.25E+08
	Livestock	1.10E+10	1.10E+10	9.09E+09	6.49E+09	4.99E+09	3.50E+09
	Wildlife	1.492E+10	1.492E+10	1.492E+10	1.492E+10	1.492E+10	1.492E+10
16	Human	3.82E+07	3.82E+07	3.82E+07	3.82E+07	3.82E+07	3.82E+07
	Livestock	5.52E+09	5.52E+09	4.54E+09	3.25E+09	2.50E+09	1.75E+09
	Wildlife	9.7E+09	9.7E+09	9.7E+09	9.7E+09	9.7E+09	9.7E+09
17	Human	1.19E+07	1.19E+07	1.19E+07	1.19E+07	1.19E+07	1.19E+07
	Livestock	4.41E+09	4.41E+09	3.63E+09	2.60E+09	2.00E+09	1.40E+09
	Wildlife	9.844E+09	9.844E+09	9.844E+09	9.844E+09	9.844E+09	9.844E+09

Table B.22 Monthly, directly deposited fecal coliform loads in each reach of the Briery Creek impairment (Subsheds 24-28).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
24	Human	3.68E+08	3.68E+08	3.68E+08	3.68E+08	3.68E+08	3.68E+08
	Livestock	4.66E+09	6.06E+09	8.65E+09	1.21E+10	1.21E+10	1.47E+10
	Wildlife	3.271E+10	3.271E+10	3.271E+10	3.271E+10	3.271E+10	3.271E+10
25	Human	3.45E+08	3.45E+08	3.45E+08	3.45E+08	3.45E+08	3.45E+08
	Livestock	1.40E+09	1.82E+09	2.60E+09	3.63E+09	3.63E+09	4.41E+09
	Wildlife	1.243E+10	1.243E+10	1.243E+10	1.243E+10	1.243E+10	1.243E+10
26	Human	1.03E+09	1.03E+09	1.03E+09	1.03E+09	1.03E+09	1.03E+09
	Livestock	1.17E+09	1.51E+09	2.16E+09	3.03E+09	3.03E+09	3.68E+09
	Wildlife	1.891E+10	1.891E+10	1.891E+10	1.891E+10	1.891E+10	1.891E+10
27	Human	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Livestock	1.17E+09	1.51E+09	2.16E+09	3.03E+09	3.03E+09	3.68E+09
	Wildlife	4.669E+09	4.669E+09	4.669E+09	4.669E+09	4.669E+09	4.669E+09
28	Human	1.23E+08	1.23E+08	1.23E+08	1.23E+08	1.23E+08	1.23E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.376E+10	1.376E+10	1.376E+10	1.376E+10	1.376E+10	1.376E+10

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
24	Human	3.68E+08	3.68E+08	3.68E+08	3.68E+08	3.68E+08	3.68E+08
	Livestock	1.47E+10	1.47E+10	1.21E+10	8.65E+09	6.66E+09	4.66E+09
	Wildlife	3.271E+10	3.271E+10	3.271E+10	3.271E+10	3.271E+10	3.271E+10
25	Human	3.45E+08	3.45E+08	3.45E+08	3.45E+08	3.45E+08	3.45E+08
	Livestock	4.41E+09	4.41E+09	3.63E+09	2.60E+09	2.00E+09	1.40E+09
	Wildlife	1.243E+10	1.243E+10	1.243E+10	1.243E+10	1.243E+10	1.243E+10
26	Human	1.03E+09	1.03E+09	1.03E+09	1.03E+09	1.03E+09	1.03E+09
	Livestock	3.68E+09	3.68E+09	3.03E+09	2.16E+09	1.66E+09	1.17E+09
	Wildlife	1.891E+10	1.891E+10	1.891E+10	1.891E+10	1.891E+10	1.891E+10
27	Human	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Livestock	3.68E+09	3.68E+09	3.03E+09	2.16E+09	1.66E+09	1.17E+09
	Wildlife	4.669E+09	4.669E+09	4.669E+09	4.669E+09	4.669E+09	4.669E+09
28	Human	1.23E+08	1.23E+08	1.23E+08	1.23E+08	1.23E+08	1.23E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.376E+10	1.376E+10	1.376E+10	1.376E+10	1.376E+10	1.376E+10

Table B.23 Monthly, directly deposited fecal coliform loads in each reach of the Bush River (Segment 1) impairment (Subsheds 29-33).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
29	Human	2.08E+09	2.08E+09	2.08E+09	2.08E+09	2.08E+09	2.08E+09
	Livestock	4.66E+09	6.06E+09	8.65E+09	1.21E+10	1.21E+10	1.47E+10
	Wildlife	6.292E+10	6.292E+10	6.292E+10	6.292E+10	6.292E+10	6.292E+10
30	Human	2.07E+08	2.07E+08	2.07E+08	2.07E+08	2.07E+08	2.07E+08
	Livestock	2.33E+09	3.03E+09	4.33E+09	6.06E+09	6.06E+09	7.36E+09
	Wildlife	3.565E+10	3.565E+10	3.565E+10	3.565E+10	3.565E+10	3.565E+10
31	Human	6.63E+08	6.63E+08	6.63E+08	6.63E+08	6.63E+08	6.63E+08
	Livestock	1.67E+10	1.71E+10	3.14E+10	4.56E+10	4.56E+10	5.98E+10
	Wildlife	2.804E+10	2.804E+10	2.804E+10	2.804E+10	2.804E+10	2.804E+10
32	Human	7.84E+07	7.84E+07	7.84E+07	7.84E+07	7.84E+07	7.84E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	5.736E+09	5.736E+09	5.736E+09	5.736E+09	5.736E+09	5.736E+09
33	Human	7.37E+06	7.37E+06	7.37E+06	7.37E+06	7.37E+06	7.37E+06
	Livestock	1.17E+09	1.51E+09	2.16E+09	3.03E+09	3.03E+09	3.68E+09
	Wildlife	6.415E+09	6.415E+09	6.415E+09	6.415E+09	6.415E+09	6.415E+09

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
29	Human	2.08E+09	2.08E+09	2.08E+09	2.08E+09	2.08E+09	2.08E+09
	Livestock	1.47E+10	1.47E+10	1.21E+10	8.65E+09	6.66E+09	4.66E+09
	Wildlife	6.292E+10	6.292E+10	6.292E+10	6.292E+10	6.292E+10	6.292E+10
30	Human	2.07E+08	2.07E+08	2.07E+08	2.07E+08	2.07E+08	2.07E+08
	Livestock	7.36E+09	7.36E+09	6.06E+09	4.33E+09	3.33E+09	2.33E+09
	Wildlife	3.565E+10	3.565E+10	3.565E+10	3.565E+10	3.565E+10	3.565E+10
31	Human	6.63E+08	6.63E+08	6.63E+08	6.63E+08	6.63E+08	6.63E+08
	Livestock	5.98E+10	5.98E+10	4.56E+10	3.14E+10	3.08E+10	1.67E+10
	Wildlife	2.804E+10	2.804E+10	2.804E+10	2.804E+10	2.804E+10	2.804E+10
32	Human	7.84E+07	7.84E+07	7.84E+07	7.84E+07	7.84E+07	7.84E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	5.736E+09	5.736E+09	5.736E+09	5.736E+09	5.736E+09	5.736E+09
33	Human	7.37E+06	7.37E+06	7.37E+06	7.37E+06	7.37E+06	7.37E+06
	Livestock	3.68E+09	3.68E+09	3.03E+09	2.16E+09	1.66E+09	1.17E+09
	Wildlife	6.415E+09	6.415E+09	6.415E+09	6.415E+09	6.415E+09	6.415E+09

Table B.24 Monthly, directly deposited fecal coliform loads in each reach of the Little Sandy Creek impairment (Subsheds 34-35).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
34	Human	3.19E+07	3.19E+07	3.19E+07	3.19E+07	3.19E+07	3.19E+07
	Livestock	1.98E+09	2.57E+09	3.68E+09	5.15E+09	5.15E+09	6.25E+09
	Wildlife	1.319E+10	1.319E+10	1.319E+10	1.319E+10	1.319E+10	1.319E+10
35	Human	1.07E+08	1.07E+08	1.07E+08	1.07E+08	1.07E+08	1.07E+08
	Livestock	4.92E+10	5.04E+10	9.25E+10	1.35E+11	1.35E+11	1.77E+11
	Wildlife	8.692E+09	8.692E+09	8.692E+09	8.692E+09	8.692E+09	8.692E+09

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
34	Human	3.19E+07	3.19E+07	3.19E+07	3.19E+07	3.19E+07	3.19E+07
	Livestock	6.25E+09	6.25E+09	5.15E+09	3.68E+09	2.83E+09	1.98E+09
	Wildlife	1.319E+10	1.319E+10	1.319E+10	1.319E+10	1.319E+10	1.319E+10
35	Human	1.07E+08	1.07E+08	1.07E+08	1.07E+08	1.07E+08	1.07E+08
	Livestock	1.77E+11	1.77E+11	1.35E+11	9.25E+10	9.08E+10	4.92E+10
	Wildlife	8.692E+09	8.692E+09	8.692E+09	8.692E+09	8.692E+09	8.692E+09

Table B.25 Monthly, directly deposited fecal coliform loads in each reach of the Bush River (Segment 2) impairment (Subsheds 36-40).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
36	Human	4.03E+08	4.03E+08	4.03E+08	4.03E+08	4.03E+08	4.03E+08
	Livestock	4.66E+09	6.06E+09	8.65E+09	1.21E+10	1.21E+10	1.47E+10
	Wildlife	3.599E+10	3.599E+10	3.599E+10	3.599E+10	3.599E+10	3.599E+10
37	Human	8.50E+07	8.50E+07	8.50E+07	8.50E+07	8.50E+07	8.50E+07
	Livestock	4.66E+08	6.06E+08	8.65E+08	1.21E+09	1.21E+09	1.47E+09
	Wildlife	5.474E+09	5.474E+09	5.474E+09	5.474E+09	5.474E+09	5.474E+09
38	Human	2.84E+08	2.84E+08	2.84E+08	2.84E+08	2.84E+08	2.84E+08
	Livestock	1.40E+09	1.82E+09	2.60E+09	3.63E+09	3.63E+09	4.41E+09
	Wildlife	9.379E+09	9.379E+09	9.379E+09	9.379E+09	9.379E+09	9.379E+09
39	Human	2.47E+08	2.47E+08	2.47E+08	2.47E+08	2.47E+08	2.47E+08
	Livestock	1.51E+09	1.97E+09	2.81E+09	3.94E+09	3.94E+09	4.78E+09
	Wildlife	1.969E+10	1.969E+10	1.969E+10	1.969E+10	1.969E+10	1.969E+10
40	Human	1.04E+07	1.04E+07	1.04E+07	1.04E+07	1.04E+07	1.04E+07
	Livestock	1.17E+09	1.51E+09	2.16E+09	3.03E+09	3.03E+09	3.68E+09
	Wildlife	3.044E+09	3.044E+09	3.044E+09	3.044E+09	3.044E+09	3.044E+09

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
36	Human	4.03E+08	4.03E+08	4.03E+08	4.03E+08	4.03E+08	4.03E+08
	Livestock	1.47E+10	1.47E+10	1.21E+10	8.65E+09	6.66E+09	4.66E+09
	Wildlife	3.599E+10	3.599E+10	3.599E+10	3.599E+10	3.599E+10	3.599E+10
37	Human	8.50E+07	8.50E+07	8.50E+07	8.50E+07	8.50E+07	8.50E+07
	Livestock	1.47E+09	1.47E+09	1.21E+09	8.65E+08	6.66E+08	4.66E+08
	Wildlife	5.474E+09	5.474E+09	5.474E+09	5.474E+09	5.474E+09	5.474E+09
38	Human	2.84E+08	2.84E+08	2.84E+08	2.84E+08	2.84E+08	2.84E+08
	Livestock	4.41E+09	4.41E+09	3.63E+09	2.60E+09	2.00E+09	1.40E+09
	Wildlife	9.379E+09	9.379E+09	9.379E+09	9.379E+09	9.379E+09	9.379E+09
39	Human	2.47E+08	2.47E+08	2.47E+08	2.47E+08	2.47E+08	2.47E+08
	Livestock	4.78E+09	4.78E+09	3.94E+09	2.81E+09	2.16E+09	1.51E+09
	Wildlife	1.969E+10	1.969E+10	1.969E+10	1.969E+10	1.969E+10	1.969E+10
40	Human	1.04E+07	1.04E+07	1.04E+07	1.04E+07	1.04E+07	1.04E+07
	Livestock	3.68E+09	3.68E+09	3.03E+09	2.16E+09	1.66E+09	1.17E+09
	Wildlife	3.044E+09	3.044E+09	3.044E+09	3.044E+09	3.044E+09	3.044E+09

Table B.26 Monthly, directly deposited fecal coliform loads in each reach of the Saylers Creek impairment (Subsheds 42-46).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
42	Human	1.38E+08	1.38E+08	1.38E+08	1.38E+08	1.38E+08	1.38E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	5.411E+09	5.411E+09	5.411E+09	5.411E+09	5.411E+09	5.411E+09
43	Human	2.01E+08	2.01E+08	2.01E+08	2.01E+08	2.01E+08	2.01E+08
	Livestock	1.75E+09	2.27E+09	3.25E+09	4.54E+09	4.54E+09	5.52E+09
	Wildlife	8.263E+09	8.263E+09	8.263E+09	8.263E+09	8.263E+09	8.263E+09
44	Human	4.69E+07	4.69E+07	4.69E+07	4.69E+07	4.69E+07	4.69E+07
	Livestock	1.30E+10	1.42E+10	2.44E+10	3.52E+10	3.52E+10	4.55E+10
	Wildlife	4.975E+09	4.975E+09	4.975E+09	4.975E+09	4.975E+09	4.975E+09
45	Human	2.85E+08	2.85E+08	2.85E+08	2.85E+08	2.85E+08	2.85E+08
	Livestock	9.90E+09	1.29E+10	1.84E+10	2.57E+10	2.57E+10	3.13E+10
	Wildlife	2.267E+10	2.267E+10	2.267E+10	2.267E+10	2.267E+10	2.267E+10
46	Human	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Livestock	1.17E+09	1.51E+09	2.16E+09	3.03E+09	3.03E+09	3.68E+09
	Wildlife	3.295E+09	3.295E+09	3.295E+09	3.295E+09	3.295E+09	3.295E+09

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
42	Human	1.38E+08	1.38E+08	1.38E+08	1.38E+08	1.38E+08	1.38E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	5.411E+09	5.411E+09	5.411E+09	5.411E+09	5.411E+09	5.411E+09
43	Human	2.01E+08	2.01E+08	2.01E+08	2.01E+08	2.01E+08	2.01E+08
	Livestock	5.52E+09	5.52E+09	4.54E+09	3.25E+09	2.50E+09	1.75E+09
	Wildlife	8.263E+09	8.263E+09	8.263E+09	8.263E+09	8.263E+09	8.263E+09
44	Human	4.69E+07	4.69E+07	4.69E+07	4.69E+07	4.69E+07	4.69E+07
	Livestock	4.55E+10	4.55E+10	3.52E+10	2.44E+10	2.28E+10	1.30E+10
	Wildlife	4.975E+09	4.975E+09	4.975E+09	4.975E+09	4.975E+09	4.975E+09
45	Human	2.85E+08	2.85E+08	2.85E+08	2.85E+08	2.85E+08	2.85E+08
	Livestock	3.13E+10	3.13E+10	2.57E+10	1.84E+10	1.41E+10	9.90E+09
	Wildlife	2.267E+10	2.267E+10	2.267E+10	2.267E+10	2.267E+10	2.267E+10
46	Human	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Livestock	3.68E+09	3.68E+09	3.03E+09	2.16E+09	1.66E+09	1.17E+09
	Wildlife	3.295E+09	3.295E+09	3.295E+09	3.295E+09	3.295E+09	3.295E+09

Table B.27 Monthly, directly deposited fecal coliform loads in each reach of the Angola Creek (Segment 1) impairment (Subshed 48).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
48	Human	5.59E+08	5.59E+08	5.59E+08	5.59E+08	5.59E+08	5.59E+08
	Livestock	1.12E+10	1.45E+10	2.08E+10	2.91E+10	2.91E+10	3.53E+10
	Wildlife	1.623E+10	1.623E+10	1.623E+10	1.623E+10	1.623E+10	1.623E+10

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
48	Human	5.59E+08	5.59E+08	5.59E+08	5.59E+08	5.59E+08	5.59E+08
	Livestock	3.53E+10	3.53E+10	2.91E+10	2.08E+10	1.60E+10	1.12E+10
	Wildlife	1.623E+10	1.623E+10	1.623E+10	1.623E+10	1.623E+10	1.623E+10

Table B.28 Monthly, directly deposited fecal coliform loads in each reach of the Angola Creek (Segment 2) impairment (Subshed 49).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
49	Human	2.49E+08	2.49E+08	2.49E+08	2.49E+08	2.49E+08	2.49E+08
	Livestock	1.91E+10	2.11E+10	3.57E+10	5.13E+10	5.13E+10	6.59E+10
	Wildlife	2.036E+10	2.036E+10	2.036E+10	2.036E+10	2.036E+10	2.036E+10

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
49	Human	2.49E+08	2.49E+08	2.49E+08	2.49E+08	2.49E+08	2.49E+08
	Livestock	6.59E+10	6.59E+10	5.13E+10	3.57E+10	3.28E+10	1.91E+10
	Wildlife	2.036E+10	2.036E+10	2.036E+10	2.036E+10	2.036E+10	2.036E+10

Table B.29 Monthly, directly deposited fecal coliform loads in each reach of the Horsepen Creek impairment (Subshed 54).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
54	Human	1.20E+08	1.20E+08	1.20E+08	1.20E+08	1.20E+08	1.20E+08
	Livestock	6.10E+09	6.10E+09	1.15E+10	1.67E+10	1.67E+10	2.21E+10
	Wildlife	6.786E+09	6.786E+09	6.786E+09	6.786E+09	6.786E+09	6.786E+09

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
54	Human	1.20E+08	1.20E+08	1.20E+08	1.20E+08	1.20E+08	1.20E+08
	Livestock	2.21E+10	2.21E+10	1.67E+10	1.15E+10	1.15E+10	6.10E+09
	Wildlife	6.786E+09	6.786E+09	6.786E+09	6.786E+09	6.786E+09	6.786E+09

Table B.30 Monthly, directly deposited fecal coliform loads in each reach of the Flat Creek impairment (Subsheds 66-68,72).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
66	Human	8.17E+08	8.17E+08	8.17E+08	8.17E+08	8.17E+08	8.17E+08
	Livestock	4.43E+10	4.51E+10	8.33E+10	1.21E+11	1.21E+11	1.60E+11
	Wildlife	6.794E+10	6.794E+10	6.794E+10	6.794E+10	6.794E+10	6.794E+10
67	Human	2.06E+09	2.06E+09	2.06E+09	2.06E+09	2.06E+09	2.06E+09
	Livestock	2.91E+09	3.79E+09	5.41E+09	7.57E+09	7.57E+09	9.20E+09
	Wildlife	9.494E+10	9.494E+10	9.494E+10	9.494E+10	9.494E+10	9.494E+10
68	Human	9.17E+08	9.17E+08	9.17E+08	9.17E+08	9.17E+08	9.17E+08
	Livestock	2.18E+10	2.32E+10	4.08E+10	5.90E+10	5.90E+10	7.66E+10
	Wildlife	6.76E+10	6.76E+10	6.76E+10	6.76E+10	6.76E+10	6.76E+10
72	Human	3.11E+08	3.11E+08	3.11E+08	3.11E+08	3.11E+08	3.11E+08
	Livestock	4.43E+09	5.76E+09	8.22E+09	1.15E+10	1.15E+10	1.40E+10
	Wildlife	2.529E+10	2.529E+10	2.529E+10	2.529E+10	2.529E+10	2.529E+10

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
66	Human	8.17E+08	8.17E+08	8.17E+08	8.17E+08	8.17E+08	8.17E+08
	Livestock	1.60E+11	1.60E+11	1.21E+11	8.33E+10	8.22E+10	4.43E+10
	Wildlife	6.794E+10	6.794E+10	6.794E+10	6.794E+10	6.794E+10	6.794E+10
67	Human	2.06E+09	2.06E+09	2.06E+09	2.06E+09	2.06E+09	2.06E+09
	Livestock	9.20E+09	9.20E+09	7.57E+09	5.41E+09	4.16E+09	2.91E+09
	Wildlife	9.494E+10	9.494E+10	9.494E+10	9.494E+10	9.494E+10	9.494E+10
68	Human	9.17E+08	9.17E+08	9.17E+08	9.17E+08	9.17E+08	9.17E+08
	Livestock	7.66E+10	7.66E+10	5.90E+10	4.08E+10	3.88E+10	2.18E+10
	Wildlife	6.76E+10	6.76E+10	6.76E+10	6.76E+10	6.76E+10	6.76E+10
72	Human	3.11E+08	3.11E+08	3.11E+08	3.11E+08	3.11E+08	3.11E+08
	Livestock	1.40E+10	1.40E+10	1.15E+10	8.22E+09	6.32E+09	4.43E+09
	Wildlife	2.529E+10	2.529E+10	2.529E+10	2.529E+10	2.529E+10	2.529E+10

Table B.31 Monthly, directly deposited fecal coliform loads in each reach of the Nibbs Creek impairment (Subsheds 69-71).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
69	Human	8.56E+08	8.56E+08	8.56E+08	8.56E+08	8.56E+08	8.56E+08
	Livestock	1.17E+09	1.51E+09	2.16E+09	3.03E+09	3.03E+09	3.68E+09
	Wildlife	1.806E+10	1.806E+10	1.806E+10	1.806E+10	1.806E+10	1.806E+10
70	Human	5.20E+08	5.20E+08	5.20E+08	5.20E+08	5.20E+08	5.20E+08
	Livestock	2.06E+10	2.13E+10	3.87E+10	5.63E+10	5.63E+10	7.37E+10
	Wildlife	1.254E+10	1.254E+10	1.254E+10	1.254E+10	1.254E+10	1.254E+10
71	Human	7.53E+08	7.53E+08	7.53E+08	7.53E+08	7.53E+08	7.53E+08
	Livestock	2.44E+10	2.44E+10	4.59E+10	6.70E+10	6.70E+10	8.84E+10
	Wildlife	2.368E+10	2.368E+10	2.368E+10	2.368E+10	2.368E+10	2.368E+10

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
69	Human	8.56E+08	8.56E+08	8.56E+08	8.56E+08	8.56E+08	8.56E+08
	Livestock	3.68E+09	3.68E+09	3.03E+09	2.16E+09	1.66E+09	1.17E+09
	Wildlife	1.806E+10	1.806E+10	1.806E+10	1.806E+10	1.806E+10	1.806E+10
70	Human	5.20E+08	5.20E+08	5.20E+08	5.20E+08	5.20E+08	5.20E+08
	Livestock	7.37E+10	7.37E+10	5.63E+10	3.87E+10	3.77E+10	2.06E+10
	Wildlife	1.254E+10	1.254E+10	1.254E+10	1.254E+10	1.254E+10	1.254E+10
71	Human	7.53E+08	7.53E+08	7.53E+08	7.53E+08	7.53E+08	7.53E+08
	Livestock	8.84E+10	8.84E+10	6.70E+10	4.59E+10	4.59E+10	2.44E+10
	Wildlife	2.368E+10	2.368E+10	2.368E+10	2.368E+10	2.368E+10	2.368E+10

Table B.32 Monthly, directly deposited fecal coliform loads in each reach of the Deep Creek impairment (Subsheds 78-90,95-97).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
78	Human	2.07E+08	2.07E+08	2.07E+08	2.07E+08	2.07E+08	2.07E+08
	Livestock	9.32E+09	1.21E+10	1.73E+10	2.42E+10	2.42E+10	2.94E+10
	Wildlife	2.072E+10	2.072E+10	2.072E+10	2.072E+10	2.072E+10	2.072E+10
79	Human	7.85E+07	7.85E+07	7.85E+07	7.85E+07	7.85E+07	7.85E+07
	Livestock	4.66E+09	6.06E+09	8.65E+09	1.21E+10	1.21E+10	1.47E+10
	Wildlife	1.061E+10	1.061E+10	1.061E+10	1.061E+10	1.061E+10	1.061E+10
80	Human	4.76E+07	4.76E+07	4.76E+07	4.76E+07	4.76E+07	4.76E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.487E+09	1.487E+09	1.487E+09	1.487E+09	1.487E+09	1.487E+09
81	Human	6.30E+07	6.30E+07	6.30E+07	6.30E+07	6.30E+07	6.30E+07
	Livestock	6.99E+08	9.09E+08	1.30E+09	1.82E+09	1.82E+09	2.21E+09
	Wildlife	8.303E+09	8.303E+09	8.303E+09	8.303E+09	8.303E+09	8.303E+09
82	Human	4.21E+08	4.21E+08	4.21E+08	4.21E+08	4.21E+08	4.21E+08
	Livestock	2.53E+10	2.74E+10	4.74E+10	6.84E+10	6.84E+10	8.84E+10
	Wildlife	3.201E+10	3.201E+10	3.201E+10	3.201E+10	3.201E+10	3.201E+10
83	Human	2.51E+06	2.51E+06	2.51E+06	2.51E+06	2.51E+06	2.51E+06
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	8.016E+09	8.016E+09	8.016E+09	8.016E+09	8.016E+09	8.016E+09
84	Human	4.96E+08	4.96E+08	4.96E+08	4.96E+08	4.96E+08	4.96E+08
	Livestock	3.50E+09	4.54E+09	6.49E+09	9.09E+09	9.09E+09	1.10E+10
	Wildlife	1.443E+10	1.443E+10	1.443E+10	1.443E+10	1.443E+10	1.443E+10
85	Human	1.93E+08	1.93E+08	1.93E+08	1.93E+08	1.93E+08	1.93E+08
	Livestock	9.32E+08	1.21E+09	1.73E+09	2.42E+09	2.42E+09	2.94E+09
	Wildlife	6.528E+09	6.528E+09	6.528E+09	6.528E+09	6.528E+09	6.528E+09
86	Human	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09
	Livestock	2.15E+10	2.46E+10	4.01E+10	5.74E+10	5.74E+10	7.29E+10
	Wildlife	4.222E+10	4.222E+10	4.222E+10	4.222E+10	4.222E+10	4.222E+10
87	Human	5.45E+08	5.45E+08	5.45E+08	5.45E+08	5.45E+08	5.45E+08
	Livestock	2.65E+10	2.89E+10	4.95E+10	7.14E+10	7.14E+10	9.21E+10
	Wildlife	3.077E+10	3.077E+10	3.077E+10	3.077E+10	3.077E+10	3.077E+10
88	Human	2.49E+08	2.49E+08	2.49E+08	2.49E+08	2.49E+08	2.49E+08
	Livestock	4.54E+09	5.91E+09	8.44E+09	1.18E+10	1.18E+10	1.43E+10
	Wildlife	3.512E+10	3.512E+10	3.512E+10	3.512E+10	3.512E+10	3.512E+10
89	Human	5.72E+05	5.72E+05	5.72E+05	5.72E+05	5.72E+05	5.72E+05
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	2.749E+09	2.749E+09	2.749E+09	2.749E+09	2.749E+09	2.749E+09
90	Human	1.45E+07	1.45E+07	1.45E+07	1.45E+07	1.45E+07	1.45E+07
	Livestock	2.10E+09	2.73E+09	3.89E+09	5.45E+09	5.45E+09	6.62E+09
	Wildlife	1.236E+10	1.236E+10	1.236E+10	1.236E+10	1.236E+10	1.236E+10
95	Human	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07
	Livestock	2.18E+10	2.29E+10	4.09E+10	5.93E+10	5.93E+10	7.73E+10
	Wildlife	1.649E+10	1.649E+10	1.649E+10	1.649E+10	1.649E+10	1.649E+10

Table B.32 Monthly, directly deposited fecal coliform loads in each reach of the Deep Creek impairment (Subsheds 78-90,95-97) (cont).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
96	Human	7.36E+08	7.36E+08	7.36E+08	7.36E+08	7.36E+08	7.36E+08
	Livestock	2.80E+09	3.63E+09	5.19E+09	7.27E+09	7.27E+09	8.83E+09
	Wildlife	3.724E+10	3.724E+10	3.724E+10	3.724E+10	3.724E+10	3.724E+10
97	Human	4.18E+08	4.18E+08	4.18E+08	4.18E+08	4.18E+08	4.18E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	6.874E+09	6.874E+09	6.874E+09	6.874E+09	6.874E+09	6.874E+09

Table B.32 Monthly, directly deposited fecal coliform loads in each reach of the Deep Creek impairment (Subsheds 78-90,95-97) (cont).

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
78	Human	2.07E+08	2.07E+08	2.07E+08	2.07E+08	2.07E+08	2.07E+08
	Livestock	2.94E+10	2.94E+10	2.42E+10	1.73E+10	1.33E+10	9.32E+09
	Wildlife	2.072E+10	2.072E+10	2.072E+10	2.072E+10	2.072E+10	2.072E+10
79	Human	7.85E+07	7.85E+07	7.85E+07	7.85E+07	7.85E+07	7.85E+07
	Livestock	1.47E+10	1.47E+10	1.21E+10	8.65E+09	6.66E+09	4.66E+09
	Wildlife	1.061E+10	1.061E+10	1.061E+10	1.061E+10	1.061E+10	1.061E+10
80	Human	4.76E+07	4.76E+07	4.76E+07	4.76E+07	4.76E+07	4.76E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.487E+09	1.487E+09	1.487E+09	1.487E+09	1.487E+09	1.487E+09
81	Human	6.30E+07	6.30E+07	6.30E+07	6.30E+07	6.30E+07	6.30E+07
	Livestock	2.21E+09	2.21E+09	1.82E+09	1.30E+09	9.99E+08	6.99E+08
	Wildlife	8.303E+09	8.303E+09	8.303E+09	8.303E+09	8.303E+09	8.303E+09
82	Human	4.21E+08	4.21E+08	4.21E+08	4.21E+08	4.21E+08	4.21E+08
	Livestock	8.84E+10	8.84E+10	6.84E+10	4.74E+10	4.44E+10	2.53E+10
	Wildlife	3.201E+10	3.201E+10	3.201E+10	3.201E+10	3.201E+10	3.201E+10
83	Human	2.51E+06	2.51E+06	2.51E+06	2.51E+06	2.51E+06	2.51E+06
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	8.016E+09	8.016E+09	8.016E+09	8.016E+09	8.016E+09	8.016E+09
84	Human	4.96E+08	4.96E+08	4.96E+08	4.96E+08	4.96E+08	4.96E+08
	Livestock	1.10E+10	1.10E+10	9.09E+09	6.49E+09	4.99E+09	3.50E+09
	Wildlife	1.443E+10	1.443E+10	1.443E+10	1.443E+10	1.443E+10	1.443E+10
85	Human	1.93E+08	1.93E+08	1.93E+08	1.93E+08	1.93E+08	1.93E+08
	Livestock	2.94E+09	2.94E+09	2.42E+09	1.73E+09	1.33E+09	9.32E+08
	Wildlife	6.528E+09	6.528E+09	6.528E+09	6.528E+09	6.528E+09	6.528E+09
86	Human	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09
	Livestock	7.29E+10	7.29E+10	5.74E+10	4.01E+10	3.56E+10	2.15E+10
	Wildlife	4.222E+10	4.222E+10	4.222E+10	4.222E+10	4.222E+10	4.222E+10
87	Human	5.45E+08	5.45E+08	5.45E+08	5.45E+08	5.45E+08	5.45E+08
	Livestock	9.21E+10	9.21E+10	7.14E+10	4.95E+10	4.61E+10	2.65E+10
	Wildlife	3.077E+10	3.077E+10	3.077E+10	3.077E+10	3.077E+10	3.077E+10
88	Human	2.49E+08	2.49E+08	2.49E+08	2.49E+08	2.49E+08	2.49E+08
	Livestock	1.43E+10	1.43E+10	1.18E+10	8.44E+09	6.49E+09	4.54E+09
	Wildlife	3.512E+10	3.512E+10	3.512E+10	3.512E+10	3.512E+10	3.512E+10
89	Human	5.72E+05	5.72E+05	5.72E+05	5.72E+05	5.72E+05	5.72E+05
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	2.749E+09	2.749E+09	2.749E+09	2.749E+09	2.749E+09	2.749E+09
90	Human	1.45E+07	1.45E+07	1.45E+07	1.45E+07	1.45E+07	1.45E+07
	Livestock	6.62E+09	6.62E+09	5.45E+09	3.89E+09	3.00E+09	2.10E+09
	Wildlife	1.236E+10	1.236E+10	1.236E+10	1.236E+10	1.236E+10	1.236E+10
95	Human	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07
	Livestock	7.73E+10	7.73E+10	5.93E+10	4.09E+10	3.94E+10	2.18E+10
	Wildlife	1.649E+10	1.649E+10	1.649E+10	1.649E+10	1.649E+10	1.649E+10

Table B.32 Monthly, directly deposited fecal coliform loads in each reach of the Deep Creek impairment (Subsheds 78-90,95-97) (cont).

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
96	Human	7.36E+08	7.36E+08	7.36E+08	7.36E+08	7.36E+08	7.36E+08
	Livestock	8.83E+09	8.83E+09	7.27E+09	5.19E+09	3.99E+09	2.80E+09
	Wildlife	3.724E+10	3.724E+10	3.724E+10	3.724E+10	3.724E+10	3.724E+10
97	Human	4.18E+08	4.18E+08	4.18E+08	4.18E+08	4.18E+08	4.18E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	6.874E+09	6.874E+09	6.874E+09	6.874E+09	6.874E+09	6.874E+09

Table B.33 Monthly, directly deposited fecal coliform loads in each reach of the West Creek impairment (Subsheds 91-94).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
91	Human	5.49E+08	5.49E+08	5.49E+08	5.49E+08	5.49E+08	5.49E+08
	Livestock	2.30E+10	2.44E+10	4.31E+10	6.23E+10	6.23E+10	8.10E+10
	Wildlife	4.212E+10	4.212E+10	4.212E+10	4.212E+10	4.212E+10	4.212E+10
92	Human	4.49E+08	4.49E+08	4.49E+08	4.49E+08	4.49E+08	4.49E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	3.063E+10	3.063E+10	3.063E+10	3.063E+10	3.063E+10	3.063E+10
93	Human	6.05E+08	6.05E+08	6.05E+08	6.05E+08	6.05E+08	6.05E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	3.032E+10	3.032E+10	3.032E+10	3.032E+10	3.032E+10	3.032E+10
94	Human	5.92E+07	5.92E+07	5.92E+07	5.92E+07	5.92E+07	5.92E+07
	Livestock	9.32E+08	1.21E+09	1.73E+09	2.42E+09	2.42E+09	2.94E+09
	Wildlife	2.542E+10	2.542E+10	2.542E+10	2.542E+10	2.542E+10	2.542E+10

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
91	Human	5.49E+08	5.49E+08	5.49E+08	5.49E+08	5.49E+08	5.49E+08
	Livestock	8.10E+10	8.10E+10	6.23E+10	4.31E+10	4.11E+10	2.30E+10
	Wildlife	4.212E+10	4.212E+10	4.212E+10	4.212E+10	4.212E+10	4.212E+10
92	Human	4.49E+08	4.49E+08	4.49E+08	4.49E+08	4.49E+08	4.49E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	3.063E+10	3.063E+10	3.063E+10	3.063E+10	3.063E+10	3.063E+10
93	Human	6.05E+08	6.05E+08	6.05E+08	6.05E+08	6.05E+08	6.05E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	3.032E+10	3.032E+10	3.032E+10	3.032E+10	3.032E+10	3.032E+10
94	Human	5.92E+07	5.92E+07	5.92E+07	5.92E+07	5.92E+07	5.92E+07
	Livestock	2.94E+09	2.94E+09	2.42E+09	1.73E+09	1.33E+09	9.32E+08
	Wildlife	2.542E+10	2.542E+10	2.542E+10	2.542E+10	2.542E+10	2.542E+10

Table B.34 Monthly, directly deposited fecal coliform loads in each reach of the Appomattox River (Segment 2) impairment (Subsheds 98-118).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
98	Human	1.65E+08	1.65E+08	1.65E+08	1.65E+08	1.65E+08	1.65E+08
	Livestock	4.28E+10	4.64E+10	8.01E+10	1.15E+11	1.15E+11	1.49E+11
	Wildlife	4.564E+10	4.564E+10	4.564E+10	4.564E+10	4.564E+10	4.564E+10
99	Human	3.47E+07	3.47E+07	3.47E+07	3.47E+07	3.47E+07	3.47E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.998E+09	1.998E+09	1.998E+09	1.998E+09	1.998E+09	1.998E+09
100	Human	2.51E+08	2.51E+08	2.51E+08	2.51E+08	2.51E+08	2.51E+08
	Livestock	9.32E+08	1.21E+09	1.73E+09	2.42E+09	2.42E+09	2.94E+09
	Wildlife	2.303E+10	2.303E+10	2.303E+10	2.303E+10	2.303E+10	2.303E+10
101	Human	4.78E+07	4.78E+07	4.78E+07	4.78E+07	4.78E+07	4.78E+07
	Livestock	2.33E+08	3.03E+08	4.33E+08	6.06E+08	6.06E+08	7.36E+08
	Wildlife	1.425E+10	1.425E+10	1.425E+10	1.425E+10	1.425E+10	1.425E+10
102	Human	4.14E+08	4.14E+08	4.14E+08	4.14E+08	4.14E+08	4.14E+08
	Livestock	1.05E+09	1.36E+09	1.95E+09	2.73E+09	2.73E+09	3.31E+09
	Wildlife	2.081E+10	2.081E+10	2.081E+10	2.081E+10	2.081E+10	2.081E+10
103	Human	2.11E+08	2.11E+08	2.11E+08	2.11E+08	2.11E+08	2.11E+08
	Livestock	9.32E+08	1.21E+09	1.73E+09	2.42E+09	2.42E+09	2.94E+09
	Wildlife	5.986E+09	5.986E+09	5.986E+09	5.986E+09	5.986E+09	5.986E+09
104	Human	2.42E+07	2.42E+07	2.42E+07	2.42E+07	2.42E+07	2.42E+07
	Livestock	1.17E+08	1.51E+08	2.16E+08	3.03E+08	3.03E+08	3.68E+08
	Wildlife	2.458E+09	2.458E+09	2.458E+09	2.458E+09	2.458E+09	2.458E+09
105	Human	9.00E+07	9.00E+07	9.00E+07	9.00E+07	9.00E+07	9.00E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	3.124E+10	3.124E+10	3.124E+10	3.124E+10	3.124E+10	3.124E+10
106	Human	6.77E+08	6.77E+08	6.77E+08	6.77E+08	6.77E+08	6.77E+08
	Livestock	4.66E+08	6.06E+08	8.65E+08	1.21E+09	1.21E+09	1.47E+09
	Wildlife	1.516E+10	1.516E+10	1.516E+10	1.516E+10	1.516E+10	1.516E+10
107	Human	9.97E+05	9.97E+05	9.97E+05	9.97E+05	9.97E+05	9.97E+05
	Livestock	2.33E+08	3.03E+08	4.33E+08	6.06E+08	6.06E+08	7.36E+08
	Wildlife	5.018E+09	5.018E+09	5.018E+09	5.018E+09	5.018E+09	5.018E+09
108	Human	3.18E+08	3.18E+08	3.18E+08	3.18E+08	3.18E+08	3.18E+08
	Livestock	2.33E+08	3.03E+08	4.33E+08	6.06E+08	6.06E+08	7.36E+08
	Wildlife	1.06E+10	1.06E+10	1.06E+10	1.06E+10	1.06E+10	1.06E+10
109	Human	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	2.582E+09	2.582E+09	2.582E+09	2.582E+09	2.582E+09	2.582E+09
110	Human	1.24E+09	1.24E+09	1.24E+09	1.24E+09	1.24E+09	1.24E+09
	Livestock	4.70E+10	4.83E+10	8.83E+10	1.28E+11	1.28E+11	1.68E+11
	Wildlife	8.624E+10	8.624E+10	8.624E+10	8.624E+10	8.624E+10	8.624E+10
111	Human	9.70E+07	9.70E+07	9.70E+07	9.70E+07	9.70E+07	9.70E+07
	Livestock	6.99E+08	9.09E+08	1.30E+09	1.82E+09	1.82E+09	2.21E+09
	Wildlife	8.255E+09	8.255E+09	8.255E+09	8.255E+09	8.255E+09	8.255E+09

Table B.34 Monthly, directly deposited fecal coliform loads in each reach of the Appomattox River (Segment 2) impairment (Subsheds 98-118) (cont).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
112	Human	2.34E+08	2.34E+08	2.34E+08	2.34E+08	2.34E+08	2.34E+08
	Livestock	4.66E+08	6.06E+08	8.65E+08	1.21E+09	1.21E+09	1.47E+09
	Wildlife	2.236E+10	2.236E+10	2.236E+10	2.236E+10	2.236E+10	2.236E+10
113	Human	3.88E+08	3.88E+08	3.88E+08	3.88E+08	3.88E+08	3.88E+08
	Livestock	4.48E+10	4.55E+10	8.42E+10	1.23E+11	1.23E+11	1.61E+11
	Wildlife	2.3E+10	2.3E+10	2.3E+10	2.3E+10	2.3E+10	2.3E+10
114	Human	6.83E+07	6.83E+07	6.83E+07	6.83E+07	6.83E+07	6.83E+07
	Livestock	2.33E+08	3.03E+08	4.33E+08	6.06E+08	6.06E+08	7.36E+08
	Wildlife	2.168E+10	2.168E+10	2.168E+10	2.168E+10	2.168E+10	2.168E+10
115	Human	2.75E+08	2.75E+08	2.75E+08	2.75E+08	2.75E+08	2.75E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.414E+10	1.414E+10	1.414E+10	1.414E+10	1.414E+10	1.414E+10
116	Human	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	5.771E+09	5.771E+09	5.771E+09	5.771E+09	5.771E+09	5.771E+09
117	Human	4.32E+07	4.32E+07	4.32E+07	4.32E+07	4.32E+07	4.32E+07
	Livestock	9.32E+08	1.21E+09	1.73E+09	2.42E+09	2.42E+09	2.94E+09
	Wildlife	1.918E+10	1.918E+10	1.918E+10	1.918E+10	1.918E+10	1.918E+10
118	Human	4.79E+07	4.79E+07	4.79E+07	4.79E+07	4.79E+07	4.79E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	7.952E+09	7.952E+09	7.952E+09	7.952E+09	7.952E+09	7.952E+09

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
98	Human	1.65E+08	1.65E+08	1.65E+08	1.65E+08	1.65E+08	1.65E+08
	Livestock	1.49E+11	1.49E+11	1.15E+11	8.01E+10	7.48E+10	4.28E+10
	Wildlife	4.564E+10	4.564E+10	4.564E+10	4.564E+10	4.564E+10	4.564E+10
99	Human	3.47E+07	3.47E+07	3.47E+07	3.47E+07	3.47E+07	3.47E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.998E+09	1.998E+09	1.998E+09	1.998E+09	1.998E+09	1.998E+09
100	Human	2.51E+08	2.51E+08	2.51E+08	2.51E+08	2.51E+08	2.51E+08
	Livestock	2.94E+09	2.94E+09	2.42E+09	1.73E+09	1.33E+09	9.32E+08
	Wildlife	2.303E+10	2.303E+10	2.303E+10	2.303E+10	2.303E+10	2.303E+10
101	Human	4.78E+07	4.78E+07	4.78E+07	4.78E+07	4.78E+07	4.78E+07
	Livestock	7.36E+08	7.36E+08	6.06E+08	4.33E+08	3.33E+08	2.33E+08
	Wildlife	1.425E+10	1.425E+10	1.425E+10	1.425E+10	1.425E+10	1.425E+10
102	Human	4.14E+08	4.14E+08	4.14E+08	4.14E+08	4.14E+08	4.14E+08
	Livestock	3.31E+09	3.31E+09	2.73E+09	1.95E+09	1.50E+09	1.05E+09
	Wildlife	2.081E+10	2.081E+10	2.081E+10	2.081E+10	2.081E+10	2.081E+10
103	Human	2.11E+08	2.11E+08	2.11E+08	2.11E+08	2.11E+08	2.11E+08
	Livestock	2.94E+09	2.94E+09	2.42E+09	1.73E+09	1.33E+09	9.32E+08
	Wildlife	5.986E+09	5.986E+09	5.986E+09	5.986E+09	5.986E+09	5.986E+09

Table B.34 Monthly, directly deposited fecal coliform loads in each reach of the Appomattox River (Segment 2) impairment (Subsheds 98-118) (cont).

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
104	Human	2.42E+07	2.42E+07	2.42E+07	2.42E+07	2.42E+07	2.42E+07
	Livestock	3.68E+08	3.68E+08	3.03E+08	2.16E+08	1.66E+08	1.17E+08
	Wildlife	2.458E+09	2.458E+09	2.458E+09	2.458E+09	2.458E+09	2.458E+09
105	Human	9.00E+07	9.00E+07	9.00E+07	9.00E+07	9.00E+07	9.00E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	3.124E+10	3.124E+10	3.124E+10	3.124E+10	3.124E+10	3.124E+10
106	Human	6.77E+08	6.77E+08	6.77E+08	6.77E+08	6.77E+08	6.77E+08
	Livestock	1.47E+09	1.47E+09	1.21E+09	8.65E+08	6.66E+08	4.66E+08
	Wildlife	1.516E+10	1.516E+10	1.516E+10	1.516E+10	1.516E+10	1.516E+10
107	Human	9.97E+05	9.97E+05	9.97E+05	9.97E+05	9.97E+05	9.97E+05
	Livestock	7.36E+08	7.36E+08	6.06E+08	4.33E+08	3.33E+08	2.33E+08
	Wildlife	5.018E+09	5.018E+09	5.018E+09	5.018E+09	5.018E+09	5.018E+09
108	Human	3.18E+08	3.18E+08	3.18E+08	3.18E+08	3.18E+08	3.18E+08
	Livestock	7.36E+08	7.36E+08	6.06E+08	4.33E+08	3.33E+08	2.33E+08
	Wildlife	1.06E+10	1.06E+10	1.06E+10	1.06E+10	1.06E+10	1.06E+10
109	Human	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	2.582E+09	2.582E+09	2.582E+09	2.582E+09	2.582E+09	2.582E+09
110	Human	1.24E+09	1.24E+09	1.24E+09	1.24E+09	1.24E+09	1.24E+09
	Livestock	1.68E+11	1.68E+11	1.28E+11	8.83E+10	8.64E+10	4.70E+10
	Wildlife	8.624E+10	8.624E+10	8.624E+10	8.624E+10	8.624E+10	8.624E+10
111	Human	9.70E+07	9.70E+07	9.70E+07	9.70E+07	9.70E+07	9.70E+07
	Livestock	2.21E+09	2.21E+09	1.82E+09	1.30E+09	9.99E+08	6.99E+08
	Wildlife	8.255E+09	8.255E+09	8.255E+09	8.255E+09	8.255E+09	8.255E+09
112	Human	2.34E+08	2.34E+08	2.34E+08	2.34E+08	2.34E+08	2.34E+08
	Livestock	1.47E+09	1.47E+09	1.21E+09	8.65E+08	6.66E+08	4.66E+08
	Wildlife	2.236E+10	2.236E+10	2.236E+10	2.236E+10	2.236E+10	2.236E+10
113	Human	3.88E+08	3.88E+08	3.88E+08	3.88E+08	3.88E+08	3.88E+08
	Livestock	1.61E+11	1.61E+11	1.23E+11	8.42E+10	8.33E+10	4.48E+10
	Wildlife	2.3E+10	2.3E+10	2.3E+10	2.3E+10	2.3E+10	2.3E+10
114	Human	6.83E+07	6.83E+07	6.83E+07	6.83E+07	6.83E+07	6.83E+07
	Livestock	7.36E+08	7.36E+08	6.06E+08	4.33E+08	3.33E+08	2.33E+08
	Wildlife	2.168E+10	2.168E+10	2.168E+10	2.168E+10	2.168E+10	2.168E+10
115	Human	2.75E+08	2.75E+08	2.75E+08	2.75E+08	2.75E+08	2.75E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.414E+10	1.414E+10	1.414E+10	1.414E+10	1.414E+10	1.414E+10
116	Human	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	5.771E+09	5.771E+09	5.771E+09	5.771E+09	5.771E+09	5.771E+09
117	Human	4.32E+07	4.32E+07	4.32E+07	4.32E+07	4.32E+07	4.32E+07
	Livestock	2.94E+09	2.94E+09	2.42E+09	1.73E+09	1.33E+09	9.32E+08
	Wildlife	1.918E+10	1.918E+10	1.918E+10	1.918E+10	1.918E+10	1.918E+10

Table B.34 Monthly, directly deposited fecal coliform loads in each reach of the Appomattox River (Segment 2) impairment (Subsheds 98-118) (cont).

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
118	Human	4.79E+07	4.79E+07	4.79E+07	4.79E+07	4.79E+07	4.79E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	7.952E+09	7.952E+09	7.952E+09	7.952E+09	7.952E+09	7.952E+09

Table B.35 Monthly, directly deposited fecal coliform loads in each reach of the Appomattox River (Segment 3 - Tidal) impairment (Subsheds 119-123,144-149).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
119	Human	7.91E+08	7.91E+08	7.91E+08	7.91E+08	7.91E+08	7.91E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	2.023E+10	2.023E+10	2.023E+10	2.023E+10	2.023E+10	2.023E+10
120	Human	6.20E+08	6.20E+08	6.20E+08	6.20E+08	6.20E+08	6.20E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	2.603E+10	2.603E+10	2.603E+10	2.603E+10	2.603E+10	2.603E+10
121	Human	6.76E+05	6.76E+05	6.76E+05	6.76E+05	6.76E+05	6.76E+05
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	9.761E+09	9.761E+09	9.761E+09	9.761E+09	9.761E+09	9.761E+09
122	Human	2.41E+08	2.41E+08	2.41E+08	2.41E+08	2.41E+08	2.41E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.738E+10	1.738E+10	1.738E+10	1.738E+10	1.738E+10	1.738E+10
123	Human	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.544E+10	1.544E+10	1.544E+10	1.544E+10	1.544E+10	1.544E+10
144	Human	1.47E+08	1.47E+08	1.47E+08	1.47E+08	1.47E+08	1.47E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.83E+10	1.83E+10	1.83E+10	1.83E+10	1.83E+10	1.83E+10
145	Human	1.90E+06	1.90E+06	1.90E+06	1.90E+06	1.90E+06	1.90E+06
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	3.561E+10	3.561E+10	3.561E+10	3.561E+10	3.561E+10	3.561E+10
146	Human	8.33E+05	8.33E+05	8.33E+05	8.33E+05	8.33E+05	8.33E+05
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.888E+10	1.888E+10	1.888E+10	1.888E+10	1.888E+10	1.888E+10
147	Human	9.99E+08	9.99E+08	9.99E+08	9.99E+08	9.99E+08	9.99E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	2.443E+10	2.443E+10	2.443E+10	2.443E+10	2.443E+10	2.443E+10
148	Human	5.30E+06	5.30E+06	5.30E+06	5.30E+06	5.30E+06	5.30E+06
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	7.499E+09	7.499E+09	7.499E+09	7.499E+09	7.499E+09	7.499E+09
149	Human	3.57E+08	3.57E+08	3.57E+08	3.57E+08	3.57E+08	3.57E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	2.625E+10	2.625E+10	2.625E+10	2.625E+10	2.625E+10	2.625E+10

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
119	Human	7.91E+08	7.91E+08	7.91E+08	7.91E+08	7.91E+08	7.91E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	2.023E+10	2.023E+10	2.023E+10	2.023E+10	2.023E+10	2.023E+10
120	Human	6.20E+08	6.20E+08	6.20E+08	6.20E+08	6.20E+08	6.20E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	2.603E+10	2.603E+10	2.603E+10	2.603E+10	2.603E+10	2.603E+10

Table B.35 Monthly, directly deposited fecal coliform loads in each reach of the Appomattox River (Segment 3 - Tidal) impairment (Subsheds 119-123,144-149) (cont).

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
121	Human	6.76E+05	6.76E+05	6.76E+05	6.76E+05	6.76E+05	6.76E+05
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	9.761E+09	9.761E+09	9.761E+09	9.761E+09	9.761E+09	9.761E+09
122	Human	2.41E+08	2.41E+08	2.41E+08	2.41E+08	2.41E+08	2.41E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.738E+10	1.738E+10	1.738E+10	1.738E+10	1.738E+10	1.738E+10
123	Human	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.544E+10	1.544E+10	1.544E+10	1.544E+10	1.544E+10	1.544E+10
144	Human	1.47E+08	1.47E+08	1.47E+08	1.47E+08	1.47E+08	1.47E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.83E+10	1.83E+10	1.83E+10	1.83E+10	1.83E+10	1.83E+10
145	Human	1.90E+06	1.90E+06	1.90E+06	1.90E+06	1.90E+06	1.90E+06
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	3.561E+10	3.561E+10	3.561E+10	3.561E+10	3.561E+10	3.561E+10
146	Human	8.33E+05	8.33E+05	8.33E+05	8.33E+05	8.33E+05	8.33E+05
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.888E+10	1.888E+10	1.888E+10	1.888E+10	1.888E+10	1.888E+10
147	Human	9.99E+08	9.99E+08	9.99E+08	9.99E+08	9.99E+08	9.99E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	2.443E+10	2.443E+10	2.443E+10	2.443E+10	2.443E+10	2.443E+10
148	Human	5.30E+06	5.30E+06	5.30E+06	5.30E+06	5.30E+06	5.30E+06
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	7.499E+09	7.499E+09	7.499E+09	7.499E+09	7.499E+09	7.499E+09
149	Human	3.57E+08	3.57E+08	3.57E+08	3.57E+08	3.57E+08	3.57E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	2.625E+10	2.625E+10	2.625E+10	2.625E+10	2.625E+10	2.625E+10

Table B.36 Monthly, directly deposited fecal coliform loads in each reach of the Swift Creek (Segment 1) impairment (Subsheds 124-126).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
124	Human	5.07E+08	5.07E+08	5.07E+08	5.07E+08	5.07E+08	5.07E+08
	Livestock	9.32E+08	1.21E+09	1.73E+09	2.42E+09	2.42E+09	2.94E+09
	Wildlife	4.059E+10	4.059E+10	4.059E+10	4.059E+10	4.059E+10	4.059E+10
125	Human	3.89E+07	3.89E+07	3.89E+07	3.89E+07	3.89E+07	3.89E+07
	Livestock	2.33E+08	3.03E+08	4.33E+08	6.06E+08	6.06E+08	7.36E+08
	Wildlife	2.111E+09	2.111E+09	2.111E+09	2.111E+09	2.111E+09	2.111E+09
126	Human	1.29E+07	1.29E+07	1.29E+07	1.29E+07	1.29E+07	1.29E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.237E+10	1.237E+10	1.237E+10	1.237E+10	1.237E+10	1.237E+10

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
124	Human	5.07E+08	5.07E+08	5.07E+08	5.07E+08	5.07E+08	5.07E+08
	Livestock	2.94E+09	2.94E+09	2.42E+09	1.73E+09	1.33E+09	9.32E+08
	Wildlife	4.059E+10	4.059E+10	4.059E+10	4.059E+10	4.059E+10	4.059E+10
125	Human	3.89E+07	3.89E+07	3.89E+07	3.89E+07	3.89E+07	3.89E+07
	Livestock	7.36E+08	7.36E+08	6.06E+08	4.33E+08	3.33E+08	2.33E+08
	Wildlife	2.111E+09	2.111E+09	2.111E+09	2.111E+09	2.111E+09	2.111E+09
126	Human	1.29E+07	1.29E+07	1.29E+07	1.29E+07	1.29E+07	1.29E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.237E+10	1.237E+10	1.237E+10	1.237E+10	1.237E+10	1.237E+10

Table B.37 Monthly, directly deposited fecal coliform loads in each reach of the Swift Creek (Segment 2) impairment (Subsheds 127-138).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
127	Human	2.67E+08	2.67E+08	2.67E+08	2.67E+08	2.67E+08	2.67E+08
	Livestock	4.66E+08	6.06E+08	8.65E+08	1.21E+09	1.21E+09	1.47E+09
	Wildlife	2.922E+10	2.922E+10	2.922E+10	2.922E+10	2.922E+10	2.922E+10
128	Human	7.01E+05	7.01E+05	7.01E+05	7.01E+05	7.01E+05	7.01E+05
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	3.025E+09	3.025E+09	3.025E+09	3.025E+09	3.025E+09	3.025E+09
129	Human	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Livestock	4.66E+08	6.06E+08	8.65E+08	1.21E+09	1.21E+09	1.47E+09
	Wildlife	1.919E+10	1.919E+10	1.919E+10	1.919E+10	1.919E+10	1.919E+10
130	Human	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	8.607E+09	8.607E+09	8.607E+09	8.607E+09	8.607E+09	8.607E+09
131	Human	6.00E+06	6.00E+06	6.00E+06	6.00E+06	6.00E+06	6.00E+06
	Livestock	5.83E+08	7.57E+08	1.08E+09	1.51E+09	1.51E+09	1.84E+09
	Wildlife	9.237E+09	9.237E+09	9.237E+09	9.237E+09	9.237E+09	9.237E+09
132	Human	4.68E+08	4.68E+08	4.68E+08	4.68E+08	4.68E+08	4.68E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.13E+10	1.13E+10	1.13E+10	1.13E+10	1.13E+10	1.13E+10
133	Human	1.31E+08	1.31E+08	1.31E+08	1.31E+08	1.31E+08	1.31E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	6.985E+09	6.985E+09	6.985E+09	6.985E+09	6.985E+09	6.985E+09
134	Human	5.93E+08	5.93E+08	5.93E+08	5.93E+08	5.93E+08	5.93E+08
	Livestock	5.83E+08	7.57E+08	1.08E+09	1.51E+09	1.51E+09	1.84E+09
	Wildlife	1.693E+10	1.693E+10	1.693E+10	1.693E+10	1.693E+10	1.693E+10
135	Human	6.49E+08	6.49E+08	6.49E+08	6.49E+08	6.49E+08	6.49E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.402E+10	1.402E+10	1.402E+10	1.402E+10	1.402E+10	1.402E+10
136	Human	2.17E+07	2.17E+07	2.17E+07	2.17E+07	2.17E+07	2.17E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	229082359	229082359	229082359	229082359	229082359	229082359
137	Human	6.53E+07	6.53E+07	6.53E+07	6.53E+07	6.53E+07	6.53E+07
	Livestock	1.17E+08	1.51E+08	2.16E+08	3.03E+08	3.03E+08	3.68E+08
	Wildlife	5.853E+09	5.853E+09	5.853E+09	5.853E+09	5.853E+09	5.853E+09
138	Human	2.44E+05	2.44E+05	2.44E+05	2.44E+05	2.44E+05	2.44E+05
	Livestock	3.50E+08	4.54E+08	6.49E+08	9.09E+08	9.09E+08	1.10E+09
	Wildlife	1.114E+10	1.114E+10	1.114E+10	1.114E+10	1.114E+10	1.114E+10

Table B.37 Monthly, directly deposited fecal coliform loads in each reach of the Swift Creek (Segment 2) impairment (Subsheds 127-138) (cont).

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
127	Human	2.67E+08	2.67E+08	2.67E+08	2.67E+08	2.67E+08	2.67E+08
	Livestock	1.47E+09	1.47E+09	1.21E+09	8.65E+08	6.66E+08	4.66E+08
	Wildlife	2.922E+10	2.922E+10	2.922E+10	2.922E+10	2.922E+10	2.922E+10
128	Human	7.01E+05	7.01E+05	7.01E+05	7.01E+05	7.01E+05	7.01E+05
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	3.025E+09	3.025E+09	3.025E+09	3.025E+09	3.025E+09	3.025E+09
129	Human	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Livestock	1.47E+09	1.47E+09	1.21E+09	8.65E+08	6.66E+08	4.66E+08
	Wildlife	1.919E+10	1.919E+10	1.919E+10	1.919E+10	1.919E+10	1.919E+10
130	Human	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	8.607E+09	8.607E+09	8.607E+09	8.607E+09	8.607E+09	8.607E+09
131	Human	6.00E+06	6.00E+06	6.00E+06	6.00E+06	6.00E+06	6.00E+06
	Livestock	1.84E+09	1.84E+09	1.51E+09	1.08E+09	8.32E+08	5.83E+08
	Wildlife	9.237E+09	9.237E+09	9.237E+09	9.237E+09	9.237E+09	9.237E+09
132	Human	4.68E+08	4.68E+08	4.68E+08	4.68E+08	4.68E+08	4.68E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.13E+10	1.13E+10	1.13E+10	1.13E+10	1.13E+10	1.13E+10
133	Human	1.31E+08	1.31E+08	1.31E+08	1.31E+08	1.31E+08	1.31E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	6.985E+09	6.985E+09	6.985E+09	6.985E+09	6.985E+09	6.985E+09
134	Human	5.93E+08	5.93E+08	5.93E+08	5.93E+08	5.93E+08	5.93E+08
	Livestock	1.84E+09	1.84E+09	1.51E+09	1.08E+09	8.32E+08	5.83E+08
	Wildlife	1.693E+10	1.693E+10	1.693E+10	1.693E+10	1.693E+10	1.693E+10
135	Human	6.49E+08	6.49E+08	6.49E+08	6.49E+08	6.49E+08	6.49E+08
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.402E+10	1.402E+10	1.402E+10	1.402E+10	1.402E+10	1.402E+10
136	Human	2.17E+07	2.17E+07	2.17E+07	2.17E+07	2.17E+07	2.17E+07
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	229082359	229082359	229082359	229082359	229082359	229082359
137	Human	6.53E+07	6.53E+07	6.53E+07	6.53E+07	6.53E+07	6.53E+07
	Livestock	3.68E+08	3.68E+08	3.03E+08	2.16E+08	1.66E+08	1.17E+08
	Wildlife	5.853E+09	5.853E+09	5.853E+09	5.853E+09	5.853E+09	5.853E+09
138	Human	2.44E+05	2.44E+05	2.44E+05	2.44E+05	2.44E+05	2.44E+05
	Livestock	1.10E+09	1.10E+09	9.09E+08	6.49E+08	4.99E+08	3.50E+08
	Wildlife	1.114E+10	1.114E+10	1.114E+10	1.114E+10	1.114E+10	1.114E+10

Table B.38 Monthly, directly deposited fecal coliform loads in each reach of the Swift Creek (Segment 3) impairment (Subsheds 139-143).

Reach	Source	Jan cfu/day	Feb cfu/day	Mar cfu/day	Apr cfu/day	May cfu/day	Jun cfu/day
139	Human	1.11E+09	1.11E+09	1.11E+09	1.11E+09	1.11E+09	1.11E+09
	Livestock	9.32E+08	1.21E+09	1.73E+09	2.42E+09	2.42E+09	2.94E+09
	Wildlife	4.505E+10	4.505E+10	4.505E+10	4.505E+10	4.505E+10	4.505E+10
140	Human	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Livestock	5.83E+08	7.57E+08	1.08E+09	1.51E+09	1.51E+09	1.84E+09
	Wildlife	1.408E+10	1.408E+10	1.408E+10	1.408E+10	1.408E+10	1.408E+10
141	Human	1.24E+08	1.24E+08	1.24E+08	1.24E+08	1.24E+08	1.24E+08
	Livestock	1.86E+09	2.42E+09	3.46E+09	4.85E+09	4.85E+09	5.89E+09
	Wildlife	3.368E+10	3.368E+10	3.368E+10	3.368E+10	3.368E+10	3.368E+10
142	Human	2.24E+08	2.24E+08	2.24E+08	2.24E+08	2.24E+08	2.24E+08
	Livestock	4.66E+08	6.06E+08	8.65E+08	1.21E+09	1.21E+09	1.47E+09
	Wildlife	8.03E+09	8.03E+09	8.03E+09	8.03E+09	8.03E+09	8.03E+09
143	Human	9.23E+06	9.23E+06	9.23E+06	9.23E+06	9.23E+06	9.23E+06
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.193E+10	1.193E+10	1.193E+10	1.193E+10	1.193E+10	1.193E+10

Reach	Source	Jul cfu/day	Aug cfu/day	Sep cfu/day	Oct cfu/day	Nov cfu/day	Dec cfu/day
139	Human	1.11E+09	1.11E+09	1.11E+09	1.11E+09	1.11E+09	1.11E+09
	Livestock	2.94E+09	2.94E+09	2.42E+09	1.73E+09	1.33E+09	9.32E+08
	Wildlife	4.505E+10	4.505E+10	4.505E+10	4.505E+10	4.505E+10	4.505E+10
140	Human	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Livestock	1.84E+09	1.84E+09	1.51E+09	1.08E+09	8.32E+08	5.83E+08
	Wildlife	1.408E+10	1.408E+10	1.408E+10	1.408E+10	1.408E+10	1.408E+10
141	Human	1.24E+08	1.24E+08	1.24E+08	1.24E+08	1.24E+08	1.24E+08
	Livestock	5.89E+09	5.89E+09	4.85E+09	3.46E+09	2.66E+09	1.86E+09
	Wildlife	3.368E+10	3.368E+10	3.368E+10	3.368E+10	3.368E+10	3.368E+10
142	Human	2.24E+08	2.24E+08	2.24E+08	2.24E+08	2.24E+08	2.24E+08
	Livestock	1.47E+09	1.47E+09	1.21E+09	8.65E+08	6.66E+08	4.66E+08
	Wildlife	8.03E+09	8.03E+09	8.03E+09	8.03E+09	8.03E+09	8.03E+09
143	Human	9.23E+06	9.23E+06	9.23E+06	9.23E+06	9.23E+06	9.23E+06
	Livestock	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Wildlife	1.193E+10	1.193E+10	1.193E+10	1.193E+10	1.193E+10	1.193E+10

Table B.39 Existing annual loads from land-based sources for the Appomattox River (Segment 1) impairment (Subsheds 1-12,18-23,41,47,50-53,55-65,73-77).

Source	Barren (cfu/yr)	Commercial (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets									
Dogs	0.00E+00	4.98E+12	0.00E+00	0.00E+00	0.00E+00	5.14E+14	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	1.29E+07	0.00E+00	0.00E+00	0.00E+00	1.33E+09	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	4.98E+12	0.00E+00	0.00E+00	0.00E+00	5.14E+14	0.00E+00	0.00E+00	0.00E+00
Human									
Failed Septic	0.00E+00	3.97E+12	0.00E+00	0.00E+00	0.00E+00	4.33E+14	0.00E+00	0.00E+00	0.00E+00
Livestock									
Dairy	0.00E+00	0.00E+00	1.93E+16	5.49E+15	3.24E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	0.00E+00	6.34E+15	3.30E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	2.11E+13	1.17E+12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	0.00E+00	3.61E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	3.15E+14	3.21E+15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	1.97E+16	1.54E+16	6.55E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife									
Raccoon	2.65E+13	1.81E+13	1.25E+14	1.28E+15	4.09E+13	1.26E+13	0.00E+00	7.18E+14	6.30E+15
Muskrat	1.78E+13	8.66E+12	3.84E+13	4.42E+14	1.60E+14	5.06E+12	0.00E+00	2.05E+15	4.76E+15
Deer	2.23E+13	9.06E+11	2.51E+13	2.58E+14	7.20E+12	4.74E+12	0.00E+00	5.51E+13	1.55E+15
Turkey	1.75E+09	1.94E+08	3.99E+09	3.90E+10	8.86E+08	9.05E+08	0.00E+00	2.40E+10	5.04E+11
Goose	5.16E+10	9.68E+09	3.65E+10	3.28E+11	8.35E+10	1.54E+10	0.00E+00	1.02E+12	2.71E+12
Duck	4.65E+08	8.54E+07	3.29E+08	2.96E+09	7.53E+08	1.38E+08	0.00E+00	9.23E+09	2.44E+10
Unquantifiable	6.66E+12	2.77E+12	1.88E+13	1.98E+14	2.08E+13	2.24E+12	0.00E+00	2.82E+14	1.26E+15
Total	7.33E+13	3.04E+13	2.07E+14	2.18E+15	2.29E+14	2.47E+13	0.00E+00	3.10E+15	1.39E+16

Table B.40 Existing annual loads from land-based sources for the Spring Creek impairment (Subsheds 13-17).

Source	Barren (cfu/yr)	Commercial (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets									
Dogs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.73E+13	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.47E+07	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.73E+13	0.00E+00	0.00E+00	0.00E+00
Human									
Failed Septic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.46E+13	0.00E+00	0.00E+00	0.00E+00
Livestock									
Dairy	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	0.00E+00	4.74E+14	2.56E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	0.00E+00	1.62E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	1.98E+12	4.96E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	1.98E+12	5.40E+14	2.56E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife									
Raccoon	1.12E+12	4.81E+11	5.16E+12	9.59E+13	3.74E+12	2.71E+11	0.00E+00	3.36E+13	3.25E+14
Muskrat	6.91E+11	0.00E+00	1.30E+12	2.84E+13	1.47E+13	0.00E+00	0.00E+00	1.15E+14	2.44E+14
Deer	3.47E+11	2.43E+10	8.69E+11	1.73E+13	3.93E+11	1.14E+11	0.00E+00	1.76E+12	4.77E+13
Turkey	8.02E+07	1.11E+07	1.82E+08	3.53E+09	9.21E+07	2.54E+07	0.00E+00	1.09E+09	3.11E+10
Goose	2.47E+09	0.00E+00	9.69E+08	1.57E+10	7.18E+09	1.33E+07	0.00E+00	5.81E+10	1.34E+11
Duck	2.23E+07	0.00E+00	8.74E+06	1.41E+08	6.48E+07	1.20E+05	0.00E+00	5.24E+08	1.21E+09
Unquantifiable	2.16E+11	5.06E+10	7.33E+11	1.42E+13	1.88E+12	3.84E+10	0.00E+00	1.51E+13	6.17E+13
Total	2.38E+12	5.56E+11	8.07E+12	1.56E+14	2.07E+13	4.23E+11	0.00E+00	1.66E+14	6.79E+14

Table B.41 Existing annual loads from land-based sources for the Briery Creek impairment (Subsheds 24-28).

Source	Barren (cfu/yr)	Commercial (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets									
Dogs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.20E+13	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.34E+08	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.20E+13	0.00E+00	0.00E+00	0.00E+00
Human									
Failed Septic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.95E+13	0.00E+00	0.00E+00	0.00E+00
Livestock									
Dairy	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	0.00E+00	2.85E+14	1.53E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	0.00E+00	1.06E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	2.95E+14	1.53E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife									
Raccoon	1.04E+12	6.51E+11	2.34E+12	7.31E+13	2.68E+12	1.65E+12	0.00E+00	6.06E+13	4.90E+14
Muskrat	4.64E+11	0.00E+00	4.10E+11	2.68E+13	1.05E+13	2.73E+11	0.00E+00	2.05E+14	2.83E+14
Deer	1.37E+12	6.62E+10	6.85E+11	3.30E+13	1.54E+12	2.56E+12	0.00E+00	3.83E+12	1.27E+14
Turkey	6.14E+07	6.59E+06	7.41E+07	1.71E+09	4.33E+07	1.09E+08	0.00E+00	1.72E+09	3.45E+10
Goose	9.86E+08	2.67E+07	3.73E+08	1.87E+10	5.65E+09	1.00E+09	0.00E+00	1.02E+11	1.60E+11
Duck	8.89E+06	2.40E+05	3.36E+06	1.69E+08	5.09E+07	9.01E+06	0.00E+00	9.16E+08	1.44E+09
Unquantifiable	2.87E+11	7.18E+10	3.44E+11	1.33E+13	1.47E+12	4.49E+11	0.00E+00	2.70E+13	9.00E+13
Total	3.16E+12	7.89E+11	3.78E+12	1.46E+14	1.62E+13	4.94E+12	0.00E+00	2.96E+14	9.90E+14

Table B.42 Existing annual loads from land-based sources for the Bush River (Segment 1) impairment (Subsheds 29-33).

Source	Barren (cfu/yr)	Commercial (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets									
Dogs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.25E+13	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E+08	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.25E+13	0.00E+00	0.00E+00	0.00E+00
Human									
Failed Septic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.33E+13	0.00E+00	0.00E+00	0.00E+00
Livestock									
Dairy	0.00E+00	0.00E+00	1.82E+15	5.13E+14	3.02E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	0.00E+00	3.24E+14	1.75E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	7.60E+14	4.23E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	0.00E+00	1.51E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	5.75E+12	2.48E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	2.59E+15	1.14E+15	4.77E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife									
Raccoon	1.32E+12	1.51E+12	4.77E+12	9.20E+13	1.95E+12	5.65E+11	0.00E+00	1.49E+14	8.18E+14
Muskrat	3.82E+11	1.64E+11	2.29E+12	2.59E+13	7.97E+12	0.00E+00	0.00E+00	4.02E+14	4.77E+14
Deer	5.54E+11	6.76E+10	6.98E+11	1.61E+13	1.96E+11	2.00E+11	0.00E+00	8.75E+12	1.16E+14
Turkey	1.23E+08	3.19E+07	1.39E+08	2.97E+09	3.87E+07	5.79E+07	0.00E+00	4.88E+09	6.68E+10
Goose	2.40E+09	1.60E+08	1.80E+09	2.35E+10	4.48E+09	4.40E+08	0.00E+00	1.98E+11	2.64E+11
Duck	2.16E+07	1.44E+06	1.62E+07	2.12E+08	4.04E+07	3.96E+06	0.00E+00	1.78E+09	2.38E+09
Unquantifiable	2.26E+11	1.74E+11	7.77E+11	1.34E+13	1.01E+12	7.66E+10	0.00E+00	5.60E+13	1.41E+14
Total	2.48E+12	1.91E+12	8.54E+12	1.47E+14	1.11E+13	8.42E+11	0.00E+00	6.16E+14	1.55E+15

Table B.43 Existing annual loads from land-based sources for the Little Sandy Creek impairment (Subsheds 34-35).

Source	Barren (cfu/yr)	Commercial (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets									
Dogs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.10E+12	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.01E+06	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.10E+12	0.00E+00	0.00E+00	0.00E+00
Human									
Failed Septic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.79E+12	0.00E+00	0.00E+00	0.00E+00
Livestock									
Dairy	0.00E+00	0.00E+00	5.25E+15	1.50E+15	8.92E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	0.00E+00	2.06E+14	1.11E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	7.60E+14	4.23E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	0.00E+00	5.58E+12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	9.44E+12	2.86E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	6.02E+15	2.04E+15	1.00E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife									
Raccoon	3.94E+11	3.40E+11	8.91E+11	3.64E+13	8.95E+11	1.61E+11	0.00E+00	1.52E+13	1.25E+14
Muskrat	7.37E+11	0.00E+00	1.37E+11	1.47E+13	2.68E+12	5.46E+10	0.00E+00	5.73E+13	6.84E+13
Deer	3.79E+10	1.32E+10	1.80E+11	5.57E+12	8.71E+10	3.87E+10	0.00E+00	8.56E+11	1.80E+13
Turkey	1.53E+07	6.39E+06	3.79E+07	1.11E+09	2.19E+07	1.08E+07	0.00E+00	5.43E+08	1.14E+10
Goose	2.03E+09	2.67E+07	1.73E+08	1.02E+10	1.60E+09	1.73E+08	0.00E+00	2.81E+10	3.55E+10
Duck	1.83E+07	2.40E+05	1.56E+06	9.23E+07	1.44E+07	1.56E+06	0.00E+00	2.53E+08	3.20E+08
Unquantifiable	1.17E+11	3.53E+10	1.21E+11	5.66E+12	3.66E+11	2.55E+10	0.00E+00	7.34E+12	2.11E+13
Total	1.29E+12	3.89E+11	1.33E+12	6.23E+13	4.02E+12	2.80E+11	0.00E+00	8.07E+13	2.32E+14

Table B.44 Existing annual loads from land-based sources for the Bush River (Segment 2) impairment (Subsheds 36-40).

Source	Barren (cfu/yr)	Commercial (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets									
Dogs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.18E+13	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.62E+07	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.18E+13	0.00E+00	0.00E+00	0.00E+00
Human									
Failed Septic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E+13	0.00E+00	0.00E+00	0.00E+00
Livestock									
Dairy	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	0.00E+00	3.12E+14	1.68E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	0.00E+00	1.12E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	1.76E+13	1.51E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	1.76E+13	4.75E+14	1.68E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife									
Raccoon	2.12E+12	1.32E+12	5.98E+12	7.51E+13	1.50E+12	1.03E+12	0.00E+00	7.80E+13	3.49E+14
Muskrat	2.46E+12	1.09E+11	2.51E+12	1.94E+13	7.04E+12	6.01E+11	0.00E+00	2.41E+14	2.14E+14
Deer	3.10E+11	6.26E+10	9.72E+11	1.17E+13	1.39E+11	2.68E+11	0.00E+00	3.81E+12	4.44E+13
Turkey	9.31E+07	2.29E+07	1.96E+08	2.36E+09	3.05E+07	6.84E+07	0.00E+00	2.38E+09	2.81E+10
Goose	5.04E+09	2.93E+08	2.08E+09	1.53E+10	3.97E+09	1.21E+09	0.00E+00	1.23E+11	1.26E+11
Duck	4.54E+07	2.64E+06	1.87E+07	1.38E+08	3.58E+07	1.09E+07	0.00E+00	1.10E+09	1.13E+09
Unquantifiable	4.89E+11	1.49E+11	9.47E+11	1.06E+13	8.69E+11	1.90E+11	0.00E+00	3.23E+13	6.07E+13
Total	5.38E+12	1.64E+12	1.04E+13	1.17E+14	9.56E+12	2.09E+12	0.00E+00	3.55E+14	6.68E+14

Table B.45 Existing annual loads from land-based sources for the Saylers Creek impairment (Subsheds 42-46).

Source	Barren (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets								
Dogs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.04E+13	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.27E+07	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.04E+13	0.00E+00	0.00E+00	0.00E+00
Human								
Failed Septic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E+13	0.00E+00	0.00E+00	0.00E+00
Livestock								
Dairy	0.00E+00	1.09E+15	3.08E+14	1.82E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	5.65E+14	3.05E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	5.58E+11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	1.09E+15	8.74E+14	4.86E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife								
Raccoon	6.42E+11	3.73E+12	7.47E+13	1.48E+12	1.12E+11	0.00E+00	2.95E+13	2.53E+14
Muskrat	1.39E+11	1.39E+11	1.44E+13	5.33E+12	0.00E+00	0.00E+00	9.77E+13	1.76E+14
Deer	1.74E+11	7.81E+11	1.34E+13	1.60E+11	3.15E+10	0.00E+00	1.62E+12	3.36E+13
Turkey	4.98E+07	1.63E+08	2.81E+09	3.67E+07	1.16E+07	0.00E+00	1.06E+09	2.20E+10
Goose	9.97E+08	5.98E+08	1.55E+10	3.15E+09	0.00E+00	0.00E+00	4.70E+10	1.01E+11
Duck	8.99E+06	5.39E+06	1.39E+08	2.84E+07	0.00E+00	0.00E+00	4.24E+08	9.14E+08
Unquantifiable	9.56E+10	4.65E+11	1.03E+13	6.97E+11	1.44E+10	0.00E+00	1.29E+13	4.63E+13
Total	1.05E+12	5.11E+12	1.13E+14	7.67E+12	1.58E+11	0.00E+00	1.42E+14	5.09E+14

Table B.46 Existing annual loads from land-based sources for the Angola Creek (Segment 1) impairment (Subshed 48).

Source	Barren (cfu/yr)	Commercial (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets									
Dogs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.89E+12	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.01E+07	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.89E+12	0.00E+00	0.00E+00	0.00E+00
Human									
Failed Septic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.15E+12	0.00E+00	0.00E+00	0.00E+00
Livestock									
Dairy	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	0.00E+00	3.79E+14	2.04E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	0.00E+00	4.46E+12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	3.43E+13	4.21E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	3.43E+13	8.05E+14	2.04E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife									
Raccoon	1.12E+11	1.09E+10	2.34E+12	3.11E+13	6.17E+11	0.00E+00	0.00E+00	8.07E+12	7.79E+13
Muskrat	2.78E+10	0.00E+00	4.44E+11	9.63E+12	3.11E+12	0.00E+00	0.00E+00	2.44E+13	6.96E+13
Deer	3.11E+10	0.00E+00	3.33E+11	4.28E+12	5.42E+10	3.26E+08	0.00E+00	3.85E+11	8.39E+12
Turkey	8.01E+06	0.00E+00	7.18E+07	8.59E+08	1.63E+07	0.00E+00	0.00E+00	2.52E+08	5.52E+09
Goose	3.32E+08	0.00E+00	6.91E+08	1.01E+10	1.66E+09	0.00E+00	0.00E+00	1.18E+10	4.56E+10
Duck	3.00E+06	0.00E+00	6.23E+06	9.14E+07	1.50E+07	0.00E+00	0.00E+00	1.07E+08	4.11E+08
Unquantifiable	1.72E+10	1.09E+09	3.11E+11	4.50E+12	3.78E+11	3.26E+07	0.00E+00	3.29E+12	1.56E+13
Total	1.89E+11	1.20E+10	3.43E+12	4.95E+13	4.16E+12	3.58E+08	0.00E+00	3.62E+13	1.72E+14

Table B.47 Existing annual loads from land-based sources for the Angola Creek (Segment 2) impairment (Subshed 49).

Source	Barren (cfu/yr)	Commercial (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets									
Dogs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E+12	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.28E+06	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E+12	0.00E+00	0.00E+00	0.00E+00
Human									
Failed Septic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.29E+12	0.00E+00	0.00E+00	0.00E+00
Livestock									
Dairy	0.00E+00	0.00E+00	1.46E+15	4.09E+14	2.41E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	0.00E+00	2.33E+14	1.26E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	0.00E+00	3.91E+12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	1.46E+15	6.46E+14	3.67E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife									
Raccoon	5.62E+11	1.09E+10	1.44E+12	2.65E+13	5.22E+11	1.16E+11	0.00E+00	1.86E+13	7.54E+13
Muskrat	1.39E+11	0.00E+00	6.11E+11	1.28E+13	1.14E+12	2.22E+11	0.00E+00	6.45E+13	5.69E+13
Deer	1.67E+11	6.51E+08	2.02E+11	3.77E+12	4.30E+10	2.04E+10	0.00E+00	7.63E+11	7.89E+12
Turkey	4.07E+07	1.10E+05	4.08E+07	7.48E+08	9.87E+06	5.48E+06	0.00E+00	4.72E+08	5.15E+09
Goose	6.11E+08	0.00E+00	3.85E+08	9.50E+09	7.71E+08	1.86E+08	0.00E+00	3.12E+10	3.56E+10
Duck	5.51E+06	0.00E+00	3.47E+06	8.57E+07	6.95E+06	1.68E+06	0.00E+00	2.82E+08	3.21E+08
Unquantifiable	8.68E+10	1.15E+09	2.26E+11	4.31E+12	1.70E+11	3.59E+10	0.00E+00	8.39E+12	1.40E+13
Total	9.55E+11	1.27E+10	2.48E+12	4.74E+13	1.87E+12	3.95E+11	0.00E+00	9.22E+13	1.54E+14

Table B.48 Existing annual loads from land-based sources for the Horsepen Creek impairment (Subshed 54).

Source	Barren (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets								
Dogs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.32E+12	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.59E+06	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.32E+12	0.00E+00	0.00E+00	0.00E+00
Human								
Failed Septic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.18E+12	0.00E+00	0.00E+00	0.00E+00
Livestock								
Dairy	0.00E+00	7.29E+14	2.05E+14	1.20E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	3.91E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	9.37E+12	6.43E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	7.38E+14	2.69E+14	1.20E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife								
Raccoon	8.71E+10	1.26E+12	9.02E+12	1.60E+11	7.25E+09	0.00E+00	4.43E+12	4.42E+13
Muskrat	0.00E+00	1.39E+11	1.72E+12	3.61E+11	0.00E+00	0.00E+00	1.52E+13	2.63E+13
Deer	3.14E+11	2.17E+12	1.47E+13	2.23E+11	1.90E+10	0.00E+00	2.44E+12	5.48E+13
Turkey	5.35E+06	3.37E+07	2.32E+08	3.74E+06	6.79E+05	0.00E+00	1.17E+08	2.64E+09
Goose	0.00E+00	2.39E+08	1.67E+09	2.79E+08	0.00E+00	0.00E+00	7.28E+09	1.33E+10
Duck	0.00E+00	2.16E+06	1.51E+07	2.52E+06	0.00E+00	0.00E+00	6.57E+07	1.20E+08
Unquantifiable	4.01E+10	3.56E+11	2.55E+12	7.44E+10	2.62E+09	0.00E+00	2.21E+12	1.25E+13
Total	4.41E+11	3.92E+12	2.80E+13	8.18E+11	2.89E+10	0.00E+00	2.43E+13	1.38E+14

Table B.49 Existing annual loads from land-based sources for the Flat Creek impairment (Subsheds 66-68,72).

Source	Barren (cfu/yr)	Commercial (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets									
Dogs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.09E+13	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.83E+08	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.09E+13	0.00E+00	0.00E+00	0.00E+00
Human									
Failed Septic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.55E+13	0.00E+00	0.00E+00	0.00E+00
Livestock									
Dairy	0.00E+00	0.00E+00	6.85E+15	1.96E+15	1.16E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	0.00E+00	4.94E+14	2.66E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	0.00E+00	3.63E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	2.53E+14	3.22E+15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	7.11E+15	5.71E+15	1.43E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife									
Raccoon	5.99E+12	2.47E+12	3.12E+13	3.01E+14	6.82E+12	8.17E+11	0.00E+00	1.67E+14	1.24E+15
Muskrat	2.61E+12	3.46E+11	5.04E+12	7.61E+13	2.79E+13	2.66E+11	0.00E+00	5.84E+14	1.00E+15
Deer	2.08E+12	1.06E+11	5.11E+12	4.94E+13	6.77E+11	2.45E+11	0.00E+00	8.22E+12	1.58E+14
Turkey	5.24E+08	4.14E+07	1.01E+09	1.03E+10	1.75E+08	7.17E+07	0.00E+00	5.30E+09	1.05E+11
Goose	5.84E+09	9.48E+08	6.16E+09	6.75E+10	1.53E+10	9.74E+08	0.00E+00	2.86E+11	5.43E+11
Duck	5.27E+07	8.55E+06	5.55E+07	6.09E+08	1.38E+08	8.78E+06	0.00E+00	2.58E+09	4.90E+09
Unquantifiable	1.07E+12	2.92E+11	4.13E+12	4.26E+13	3.54E+12	1.33E+11	0.00E+00	7.60E+13	2.40E+14
Total	1.18E+13	3.21E+12	4.54E+13	4.69E+14	3.90E+13	1.46E+12	0.00E+00	8.36E+14	2.64E+15

Table B.50 Existing annual loads from land-based sources for the Nibbs Creek impairment (Subsheds 69-71).

Source	Barren (cfu/yr)	Commercial (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets									
Dogs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.84E+13	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.34E+07	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.84E+13	0.00E+00	0.00E+00	0.00E+00
Human									
Failed Septic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.75E+13	0.00E+00	0.00E+00	0.00E+00
Livestock									
Dairy	0.00E+00	0.00E+00	5.10E+15	1.43E+15	8.43E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	0.00E+00	1.87E+14	6.39E+12	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	0.00E+00	9.49E+12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	1.46E+13	3.23E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	5.12E+15	1.95E+15	9.07E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife									
Raccoon	1.12E+12	1.14E+12	7.19E+12	1.27E+14	3.69E+12	5.11E+11	0.00E+00	1.85E+13	2.30E+14
Muskrat	1.12E+12	4.26E+11	2.03E+12	4.35E+13	1.35E+13	1.87E+11	0.00E+00	8.46E+13	2.15E+14
Deer	2.28E+11	4.03E+10	1.01E+12	1.71E+13	3.09E+11	1.28E+11	0.00E+00	6.98E+11	2.49E+13
Turkey	4.61E+07	1.69E+07	1.98E+08	3.44E+09	7.10E+07	3.29E+07	0.00E+00	4.12E+08	1.64E+10
Goose	2.13E+09	2.86E+08	2.25E+09	3.11E+10	7.17E+09	3.12E+08	0.00E+00	4.12E+10	1.19E+11
Duck	1.92E+07	2.58E+06	2.03E+07	2.80E+08	6.46E+07	2.81E+06	0.00E+00	3.72E+08	1.07E+09
Unquantifiable	2.47E+11	1.60E+11	1.02E+12	1.88E+13	1.75E+12	8.26E+10	0.00E+00	1.04E+13	4.70E+13
Total	2.72E+12	1.76E+12	1.12E+13	2.07E+14	1.93E+13	9.08E+11	0.00E+00	1.14E+14	5.17E+14

Table B.51 Existing annual loads from land-based sources for the Deep Creek impairment (Subsheds 78-90,95-97).

Source	Barren (cfu/yr)	Commercial (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets									
Dogs	0.00E+00	1.48E+13	0.00E+00	0.00E+00	0.00E+00	1.30E+14	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	3.83E+07	0.00E+00	0.00E+00	0.00E+00	3.36E+08	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	1.48E+13	0.00E+00	0.00E+00	0.00E+00	1.30E+14	0.00E+00	0.00E+00	0.00E+00
Human									
Failed Septic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.59E+13	0.00E+00	0.00E+00	0.00E+00
Livestock									
Dairy	0.00E+00	0.00E+00	7.87E+15	2.21E+15	1.30E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	0.00E+00	2.06E+15	1.05E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	0.00E+00	4.41E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	1.25E+14	1.33E+15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	8.00E+15	5.64E+15	2.35E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife									
Raccoon	7.78E+12	6.97E+12	4.70E+13	3.38E+14	9.80E+12	2.81E+12	0.00E+00	1.02E+14	1.46E+15
Muskrat	7.74E+12	2.29E+12	2.40E+13	9.00E+13	3.79E+13	3.65E+11	0.00E+00	3.30E+14	1.41E+15
Deer	3.73E+12	4.16E+11	1.12E+13	1.23E+14	1.01E+12	3.24E+12	0.00E+00	1.16E+13	2.84E+14
Turkey	6.22E+08	8.41E+07	1.60E+09	1.18E+10	2.50E+08	2.20E+08	0.00E+00	3.62E+09	1.23E+11
Goose	2.41E+10	5.13E+09	2.06E+10	1.01E+11	2.21E+10	1.74E+09	0.00E+00	1.68E+11	8.18E+11
Duck	2.17E+08	4.63E+07	1.85E+08	9.13E+08	1.99E+08	1.57E+07	0.00E+00	1.51E+09	7.37E+09
Unquantifiable	1.93E+12	9.69E+11	8.22E+12	5.51E+13	4.88E+12	6.42E+11	0.00E+00	4.44E+13	3.15E+14
Total	2.12E+13	1.07E+13	9.04E+13	6.06E+14	5.36E+13	7.06E+12	0.00E+00	4.88E+14	3.47E+15

Table B.52 Existing annual loads from land-based sources for the West Creek impairment (Subsheds 91-94).

Source	Barren (cfu/yr)	Commercial (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets									
Dogs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.59E+13	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.70E+07	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.59E+13	0.00E+00	0.00E+00	0.00E+00
Human									
Failed Septic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.76E+13	0.00E+00	0.00E+00	0.00E+00
Livestock									
Dairy	0.00E+00	0.00E+00	2.19E+15	6.14E+14	3.61E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	0.00E+00	2.58E+14	1.02E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	0.00E+00	1.17E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	9.19E+12	7.52E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	2.20E+15	9.59E+14	4.63E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife									
Raccoon	2.02E+12	5.70E+11	1.22E+13	1.23E+14	2.31E+12	2.18E+11	0.00E+00	6.22E+13	5.61E+14
Muskrat	1.17E+12	0.00E+00	3.00E+12	3.26E+13	7.51E+12	0.00E+00	0.00E+00	2.73E+14	5.41E+14
Deer	6.79E+11	3.32E+10	1.89E+12	1.96E+13	2.80E+11	7.78E+10	0.00E+00	3.16E+12	6.48E+13
Turkey	1.42E+08	9.88E+06	3.87E+08	4.09E+09	6.52E+07	2.06E+07	0.00E+00	1.69E+09	4.40E+10
Goose	4.64E+09	4.27E+08	5.05E+09	3.78E+10	4.59E+09	1.16E+08	0.00E+00	1.36E+11	3.05E+11
Duck	4.18E+07	3.85E+06	4.56E+07	3.41E+08	4.14E+07	1.05E+06	0.00E+00	1.23E+09	2.75E+09
Unquantifiable	3.88E+11	6.03E+10	1.71E+12	1.75E+13	1.01E+12	2.96E+10	0.00E+00	3.39E+13	1.17E+14
Total	4.26E+12	6.64E+11	1.88E+13	1.92E+14	1.11E+13	3.26E+11	0.00E+00	3.73E+14	1.28E+15

Table B.53 Existing annual loads from land-based sources for the Appomattox River (Segment 2) impairment (Subsheds 98-118).

Source	Barren (cfu/yr)	Commercial (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets									
Dogs	0.00E+00	1.67E+13	0.00E+00	0.00E+00	0.00E+00	5.79E+14	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	4.32E+07	0.00E+00	0.00E+00	0.00E+00	1.50E+09	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	1.67E+13	0.00E+00	0.00E+00	0.00E+00	5.79E+14	0.00E+00	0.00E+00	0.00E+00
Human									
Failed Septic	0.00E+00	3.60E+13	0.00E+00	0.00E+00	0.00E+00	1.70E+14	0.00E+00	0.00E+00	0.00E+00
Livestock									
Dairy	0.00E+00	0.00E+00	1.39E+16	3.89E+15	2.29E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	0.00E+00	8.88E+14	4.60E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	0.00E+00	8.71E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	3.04E+13	9.62E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	1.39E+16	4.96E+15	2.75E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife									
Raccoon	1.05E+13	4.14E+13	9.80E+13	3.73E+14	9.57E+12	1.30E+13	0.00E+00	8.82E+12	2.76E+15
Muskrat	4.22E+12	4.56E+13	3.66E+13	9.31E+13	2.89E+13	1.03E+13	0.00E+00	3.06E+13	2.33E+15
Deer	6.36E+12	7.59E+11	1.93E+13	6.62E+13	1.18E+12	2.92E+12	0.00E+00	3.24E+11	4.41E+14
Turkey	8.66E+08	2.58E+08	3.28E+09	1.18E+10	2.38E+08	3.91E+08	0.00E+00	1.14E+08	2.32E+11
Goose	1.96E+10	4.83E+10	3.86E+10	1.05E+11	1.75E+10	2.68E+10	0.00E+00	2.77E+10	1.29E+12
Duck	1.77E+08	4.36E+08	3.48E+08	9.48E+08	1.58E+08	2.42E+08	0.00E+00	2.50E+08	1.16E+10
Unquantifiable	2.11E+12	8.79E+12	1.54E+13	5.32E+13	3.97E+12	2.63E+12	0.00E+00	3.98E+12	5.53E+14
Total	2.32E+13	9.67E+13	1.69E+14	5.85E+14	4.37E+13	2.89E+13	0.00E+00	4.38E+13	6.08E+15

Table B.54 Existing annual loads from land-based sources for the Appomattox River (Segment 3 - tidal) impairment (Subsheds 119-123,144-149).

Source	Barren (cfu/yr)	Commercial (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets									
Dogs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.05E+14	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.08E+09	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.05E+14	0.00E+00	0.00E+00	0.00E+00
Human									
Failed Septic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.68E+14	0.00E+00	0.00E+00	0.00E+00
Livestock									
Dairy	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	0.00E+00	4.52E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	4.52E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife									
Raccoon	6.31E+12	6.64E+13	4.32E+13	9.07E+13	1.42E+12	2.27E+13	0.00E+00	1.21E+14	6.06E+14
Muskrat	1.05E+13	7.00E+13	1.88E+13	2.66E+13	5.87E+12	1.71E+13	0.00E+00	6.72E+14	7.23E+14
Deer	6.22E+12	3.09E+12	2.07E+13	2.53E+13	2.61E+11	1.71E+13	0.00E+00	2.82E+13	2.40E+14
Turkey	1.80E+08	2.32E+08	1.06E+09	2.19E+09	2.80E+07	9.45E+08	0.00E+00	3.09E+09	3.20E+10
Goose	4.17E+10	5.56E+10	1.36E+10	1.99E+10	3.08E+09	3.32E+10	0.00E+00	3.10E+11	3.84E+11
Duck	3.76E+08	5.01E+08	1.23E+08	1.79E+08	2.77E+07	2.99E+08	0.00E+00	2.80E+09	3.46E+09
Unquantifiable	2.31E+12	1.40E+13	8.28E+12	1.43E+13	7.55E+11	5.69E+12	0.00E+00	8.21E+13	1.57E+14
Total	2.54E+13	1.54E+14	9.10E+13	1.57E+14	8.31E+12	6.26E+13	0.00E+00	9.04E+14	1.73E+15

Table B.55 Existing annual loads from land-based sources for the Swift Creek (Segment 1) impairment (Subsheds 124-126).

Source	Commercial (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets								
Dogs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.21E+13	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E+08	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.21E+13	0.00E+00	0.00E+00	0.00E+00
Human								
Failed Septic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.18E+13	0.00E+00	0.00E+00	0.00E+00
Livestock								
Dairy	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	3.95E+13	2.13E+12	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	1.62E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	5.57E+13	2.13E+12	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife								
Raccoon	2.94E+11	9.81E+12	2.88E+13	6.55E+11	1.37E+12	0.00E+00	4.33E+12	2.98E+14
Muskrat	1.13E+12	7.98E+12	7.76E+12	1.93E+12	7.76E+11	0.00E+00	2.16E+13	3.17E+14
Deer	8.01E+10	1.50E+12	3.75E+13	6.99E+10	2.99E+12	0.00E+00	2.01E+11	2.69E+14
Turkey	1.88E+06	3.11E+08	6.63E+08	1.63E+07	7.93E+07	0.00E+00	1.00E+08	1.63E+10
Goose	1.57E+09	6.99E+09	1.05E+10	1.06E+09	2.71E+09	0.00E+00	1.13E+10	1.73E+11
Duck	1.42E+07	6.30E+07	9.48E+07	9.52E+06	2.44E+07	0.00E+00	1.01E+08	1.56E+09
Unquantifiable	1.50E+11	1.93E+12	7.40E+12	2.65E+11	5.14E+11	0.00E+00	2.61E+12	8.84E+13
Total	1.65E+12	2.12E+13	8.14E+13	2.92E+12	5.65E+12	0.00E+00	2.87E+13	9.72E+14

Table B.56 Existing annual loads from land-based sources for the Swift Creek (Segment 2) impairment (Subsheds 127-138).

Source	Barren (cfu/yr)	Commercial (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets									
Dogs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.30E+14	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.15E+09	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.30E+14	0.00E+00	0.00E+00	0.00E+00
Human									
Failed Septic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.76E+14	0.00E+00	0.00E+00	0.00E+00
Livestock									
Dairy	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	0.00E+00	8.70E+13	4.69E+12	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	0.00E+00	4.07E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	1.28E+14	4.69E+12	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife									
Raccoon	2.03E+12	1.19E+13	3.29E+13	5.86E+13	1.41E+12	1.03E+13	0.00E+00	2.62E+12	1.02E+15
Muskrat	8.76E+11	1.11E+13	1.73E+13	1.56E+13	3.75E+12	1.18E+13	0.00E+00	7.63E+12	7.58E+14
Deer	9.40E+11	3.08E+11	4.96E+12	1.05E+13	1.66E+11	2.92E+12	0.00E+00	1.62E+11	1.53E+14
Turkey	1.55E+08	1.54E+08	1.02E+09	2.01E+09	3.65E+07	7.75E+08	0.00E+00	6.83E+07	8.52E+10
Goose	5.62E+09	1.25E+10	2.31E+10	2.36E+10	2.38E+09	1.91E+10	0.00E+00	8.54E+09	4.55E+11
Duck	5.06E+07	1.13E+08	2.09E+08	2.12E+08	2.15E+07	1.72E+08	0.00E+00	7.70E+07	4.10E+09
Unquantifiable	3.85E+11	2.33E+12	5.52E+12	8.48E+12	5.33E+11	2.50E+12	0.00E+00	1.04E+12	1.93E+14
Total	4.24E+12	2.56E+13	6.07E+13	9.32E+13	5.86E+12	2.75E+13	0.00E+00	1.15E+13	2.13E+15

Table B.57 Existing annual loads from land-based sources for the Swift Creek (Segment 3) impairment (Subsheds 139-143).

Source	Barren (cfu/yr)	Commercial (cfu/yr)	Cropland (cfu/yr)	Pasture (cfu/yr)	Livestock Access (cfu/yr)	Residential (cfu/yr)	Water (cfu/yr)	Wetlands (cfu/yr)	Woodland (cfu/yr)
Pets									
Dogs	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+14	0.00E+00	0.00E+00	0.00E+00
Cats	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.16E+08	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+14	0.00E+00	0.00E+00	0.00E+00
Human									
Failed Septic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E+14	0.00E+00	0.00E+00	0.00E+00
Livestock									
Dairy	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beef	0.00E+00	0.00E+00	0.00E+00	1.30E+14	7.03E+12	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Swine	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Horse	0.00E+00	0.00E+00	0.00E+00	5.25E+13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Poultry	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	1.83E+14	7.03E+12	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wildlife									
Raccoon	2.31E+12	4.92E+12	2.56E+13	8.15E+13	1.24E+12	2.52E+12	0.00E+00	8.47E+12	8.05E+14
Muskrat	2.00E+12	1.03E+13	9.24E+12	1.73E+13	2.83E+12	2.38E+12	0.00E+00	3.50E+13	6.61E+14
Deer	7.66E+11	8.89E+10	3.30E+12	1.09E+13	1.41E+11	5.45E+11	0.00E+00	3.63E+11	8.98E+13
Turkey	1.33E+08	1.67E+07	6.82E+08	2.23E+09	4.15E+07	8.68E+07	0.00E+00	1.98E+08	5.36E+10
Goose	7.91E+09	8.92E+09	1.22E+10	2.28E+10	1.90E+09	6.84E+09	0.00E+00	2.01E+10	3.89E+11
Duck	7.13E+07	8.04E+07	1.10E+08	2.06E+08	1.71E+07	6.17E+07	0.00E+00	1.81E+08	3.51E+09
Unquantifiable	5.08E+11	1.53E+12	3.82E+12	1.10E+13	4.21E+11	5.45E+11	0.00E+00	4.39E+12	1.56E+14
Total	5.59E+12	1.68E+13	4.20E+13	1.21E+14	4.63E+12	5.99E+12	0.00E+00	4.83E+13	1.71E+15

Table B.58 Existing annual loads from direct-deposition sources for the Appomattox River (Segment 1) impairment (Subsheds 1-12,18-23,41,47,50-53,55-65,73-77).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	6.23E+12
Total	6.23E+12
Livestock	
Dairy	1.08E+16
Beef	2.86E+15
Swine	0.00E+00
Horse	1.55E+14
Poultry	1.51E+15
Total	1.53E+16
Wildlife	
Raccoon	2.14E+13
Muskrat	3.50E+14
Beaver	6.33E+11
Deer	9.63E+11
Turkey	2.72E+08
Goose	1.17E+11
Duck	1.61E+09
Total	3.73E+14

Table B.59 Existing annual loads from direct-deposition sources for the Spring Creek impairment (Subsheds 13-17).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	1.85E+11
Total	1.85E+11
Livestock	
Dairy	0.00E+00
Beef	2.14E+14
Swine	0.00E+00
Horse	6.94E+12
Poultry	2.21E+13
Total	2.43E+14
Wildlife	
Raccoon	1.17E+12
Muskrat	1.91E+13
Beaver	3.05E+10
Deer	3.43E+10
Turkey	1.51E+07
Goose	6.18E+09
Duck	8.47E+07
Total	2.03E+13

Table B.60 Existing annual loads from direct-deposition sources for the Briery Creek impairment (Subsheds 24-28).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	6.81E+11
Total	6.81E+11
Livestock	
Dairy	0.00E+00
Beef	1.29E+14
Swine	0.00E+00
Horse	4.54E+12
Poultry	0.00E+00
Total	1.33E+14
Wildlife	
Raccoon	1.59E+12
Muskrat	2.56E+13
Beaver	5.07E+10
Deer	8.51E+10
Turkey	2.05E+07
Goose	8.86E+09
Duck	1.21E+08
Total	2.74E+13

Table B.61 Existing annual loads from direct-deposition sources for the Bush River (Segment 1) impairment (Subsheds 29-33).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	1.11E+12
Total	1.11E+12
Livestock	
Dairy	1.01E+15
Beef	1.46E+14
Swine	0.00E+00
Horse	6.46E+12
Poultry	1.09E+14
Total	1.62E+15
Wildlife	
Raccoon	2.68E+12
Muskrat	4.32E+13
Beaver	7.99E+10
Deer	7.13E+10
Turkey	3.53E+07
Goose	1.30E+10
Duck	1.79E+08
Total	4.60E+13

Table B.62 Existing annual loads from direct-deposition sources for the Little Sandy Creek impairment (Subsheds 34-35).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	5.06E+10
Total	5.06E+10
Livestock	
Dairy	2.93E+15
Beef	9.28E+13
Swine	0.00E+00
Horse	2.39E+12
Poultry	1.27E+14
Total	3.50E+15
Wildlife	
Raccoon	4.48E+11
Muskrat	6.78E+12
Beaver	1.26E+10
Deer	1.24E+10
Turkey	5.50E+06
Goose	2.04E+09
Duck	2.79E+07
Total	7.26E+12

Table B.63 Existing annual loads from direct-deposition sources for the Bush River (Segment 2) impairment (Subsheds 36-40).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	3.76E+11
Total	3.76E+11
Livestock	
Dairy	0.00E+00
Beef	1.41E+14
Swine	0.00E+00
Horse	4.78E+12
Poultry	7.24E+13
Total	2.18E+14
Wildlife	
Raccoon	1.29E+12
Muskrat	2.30E+13
Beaver	4.10E+10
Deer	3.09E+10
Turkey	1.48E+07
Goose	7.57E+09
Duck	1.04E+08
Total	2.44E+13

Table B.64 Existing annual loads from direct-deposition sources for the Saylers Creek impairment (Subsheds 42-46).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	2.45E+11
Total	2.45E+11
Livestock	
Dairy	6.08E+14
Beef	2.55E+14
Swine	0.00E+00
Horse	2.39E+11
Poultry	0.00E+00
Total	8.64E+14
Wildlife	
Raccoon	9.12E+11
Muskrat	1.38E+13
Beaver	2.41E+10
Deer	2.49E+10
Turkey	1.10E+07
Goose	4.62E+09
Duck	6.33E+07
Total	1.48E+13

Table B.65 Existing annual loads from direct-deposition sources for the Angola Creek (Segment 1) impairment (Subshed 48).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	2.04E+11
Total	2.04E+11
Livestock	
Dairy	0.00E+00
Beef	1.71E+14
Swine	0.00E+00
Horse	1.91E+12
Poultry	1.95E+14
Total	3.68E+14
Wildlife	
Raccoon	3.01E+11
Muskrat	5.07E+12
Beaver	9.06E+09
Deer	6.74E+09
Turkey	3.37E+06
Goose	2.01E+09
Duck	2.76E+07
Total	5.39E+12

Table B.66 Existing annual loads from direct-deposition sources for the Angola Creek (Segment 2) impairment (Subshed 49).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	9.09E+10
Total	9.09E+10
Livestock	
Dairy	8.11E+14
Beef	1.05E+14
Swine	0.00E+00
Horse	1.67E+12
Poultry	0.00E+00
Total	9.18E+14
Wildlife	
Raccoon	3.09E+11
Muskrat	6.43E+12
Beaver	8.04E+09
Deer	6.44E+09
Turkey	3.24E+06
Goose	2.15E+09
Duck	2.94E+07
Total	6.76E+12

Table B.67 Existing annual loads from direct-deposition sources for the Horsepen Creek impairment (Subshed 54).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	4.38E+10
Total	4.38E+10
Livestock	
Dairy	4.05E+14
Beef	0.00E+00
Swine	0.00E+00
Horse	1.68E+04
Poultry	3.16E+13
Total	4.37E+14
Wildlife	
Raccoon	1.48E+11
Muskrat	2.06E+12
Beaver	3.40E+09
Deer	3.74E+10
Turkey	1.96E+06
Goose	5.87E+08
Duck	8.04E+06
Total	2.25E+12

Table B.68 Existing annual loads from direct-deposition sources for the Flat Creek impairment (Subsheds 66-68,72).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	1.50E+12
Total	1.50E+12
Livestock	
Dairy	3.83E+15
Beef	2.23E+14
Swine	0.00E+00
Horse	1.55E+13
Poultry	1.49E+15
Total	5.55E+15
Wildlife	
Raccoon	4.39E+12
Muskrat	7.34E+13
Beaver	1.33E+11
Deer	1.12E+11
Turkey	5.42E+07
Goose	2.44E+10
Duck	3.34E+08
Total	7.81E+13

Table B.69 Existing annual loads from direct-deposition sources for the Nibbs Creek impairment (Subsheds 69-71).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	7.77E+11
Total	7.77E+11
Livestock	
Dairy	2.84E+15
Beef	8.27E+13
Swine	0.00E+00
Horse	4.07E+12
Poultry	1.45E+14
Total	3.07E+15
Wildlife	
Raccoon	9.77E+11
Muskrat	1.55E+13
Beaver	2.82E+10
Deer	2.23E+10
Turkey	1.03E+07
Goose	5.32E+09
Duck	7.29E+07
Total	1.66E+13

Table B.70 Existing annual loads from direct-deposition sources for the Deep Creek impairment (Subsheds 78-90,95-97).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	1.94E+12
Total	1.94E+12
Livestock	
Dairy	4.38E+15
Beef	9.27E+14
Swine	0.00E+00
Horse	1.89E+13
Poultry	6.22E+14
Total	5.95E+15
Wildlife	
Raccoon	4.53E+12
Muskrat	8.95E+13
Beaver	1.52E+11
Deer	2.20E+11
Turkey	6.32E+07
Goose	3.13E+10
Duck	4.29E+08
Total	9.45E+13

Table B.71 Existing annual loads from direct-deposition sources for the West Creek impairment (Subsheds 91-94).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	6.07E+11
Total	6.07E+11
Livestock	
Dairy	1.22E+15
Beef	1.15E+14
Swine	0.00E+00
Horse	5.02E+12
Poultry	3.62E+13
Total	1.37E+15
Wildlife	
Raccoon	1.75E+12
Muskrat	4.06E+13
Beaver	6.07E+10
Deer	4.53E+10
Turkey	2.34E+07
Goose	1.30E+10
Duck	1.78E+08
Total	4.25E+13

Table B.72 Existing annual loads from direct-deposition sources for the Appomattox River (Segment 2) impairment (Subsheds 98-118).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	1.69E+12
Total	1.69E+12
Livestock	
Dairy	7.70E+15
Beef	4.00E+14
Swine	0.00E+00
Horse	3.73E+13
Poultry	5.43E+13
Total	8.19E+15
Wildlife	
Raccoon	8.24E+12
Muskrat	1.30E+14
Beaver	2.22E+11
Deer	2.69E+11
Turkey	1.00E+08
Goose	5.29E+10
Duck	7.25E+08
Total	1.38E+14

Table B.73 Existing annual loads from direct-deposition sources for the Appomattox River (Segment 3 - tidal) impairment (Subsheds 119-123,144-149).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	1.16E+12
Total	1.16E+12
Livestock	
Dairy	0.00E+00
Beef	0.00E+00
Swine	0.00E+00
Horse	1.94E+13
Poultry	0.00E+00
Total	1.94E+13
Wildlife	
Raccoon	2.43E+12
Muskrat	7.57E+13
Beaver	1.56E+11
Deer	1.71E+11
Turkey	2.03E+07
Goose	2.71E+10
Duck	3.71E+08
Total	7.84E+13

Table B.74 Existing annual loads from direct-deposition sources for the Swift Creek (Segment 1) impairment (Subsheds 124-126).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	2.04E+11
Total	2.04E+11
Livestock	
Dairy	0.00E+00
Beef	1.79E+13
Swine	0.00E+00
Horse	6.94E+12
Poultry	0.00E+00
Total	2.48E+13
Wildlife	
Raccoon	8.62E+11
Muskrat	1.72E+13
Beaver	2.57E+10
Deer	1.56E+11
Turkey	1.04E+07
Goose	5.82E+09
Duck	7.97E+07
Total	1.83E+13

Table B.75 Existing annual loads from direct-deposition sources for the Swift Creek (Segment 2) impairment (Subsheds 127-138).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	8.04E+11
Total	8.04E+11
Livestock	
Dairy	0.00E+00
Beef	3.93E+13
Swine	0.00E+00
Horse	1.75E+13
Poultry	0.00E+00
Total	5.67E+13
Wildlife	
Raccoon	2.86E+12
Muskrat	4.20E+13
Beaver	6.15E+10
Deer	8.64E+10
Turkey	3.79E+07
Goose	2.12E+10
Duck	2.91E+08
Total	4.50E+13

Table B.76 Existing annual loads from direct-deposition sources for the Swift Creek (Segment 3) impairment (Subsheds 139-143).

Source	Fecal Coliform Load (cfu/yr)
Human	
Straight Pipes	5.34E+11
Total	5.34E+11
Livestock	
Dairy	0.00E+00
Beef	5.89E+13
Swine	0.00E+00
Horse	2.25E+13
Poultry	0.00E+00
Total	8.14E+13
Wildlife	
Raccoon	2.34E+12
Muskrat	3.50E+13
Beaver	6.34E+10
Deer	5.30E+10
Turkey	2.85E+07
Goose	1.31E+10
Duck	1.79E+08
Total	3.74E+13

APPENDIX C

ADDITIONAL TABLES AND FIGURES
MODEL CALIBRATION AND VALIDATION

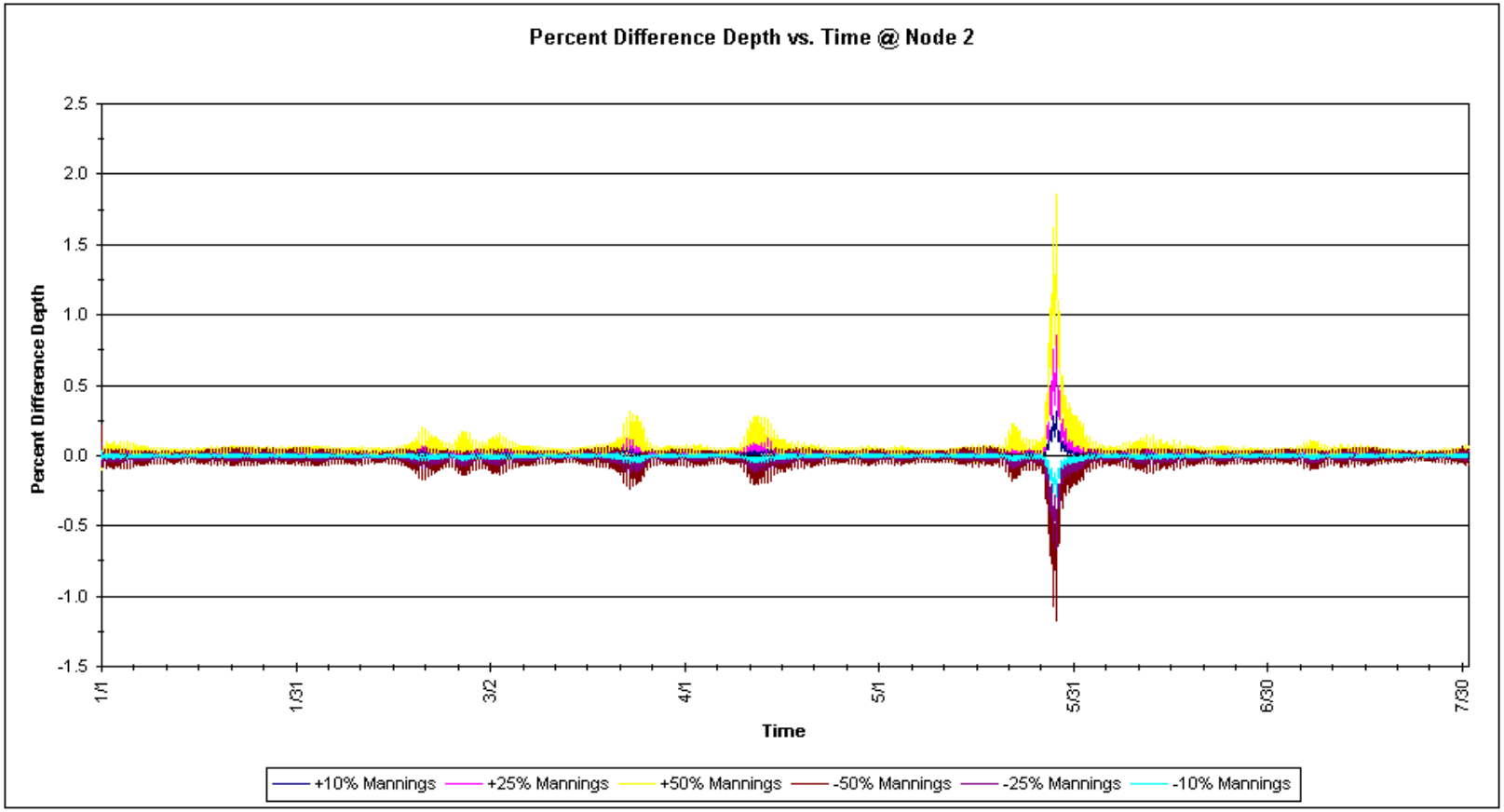

Figure C.1 Percent Change in Simulated Tidal Segment Water Depth vs. Percent Change in Manning's Roughness Coefficient.

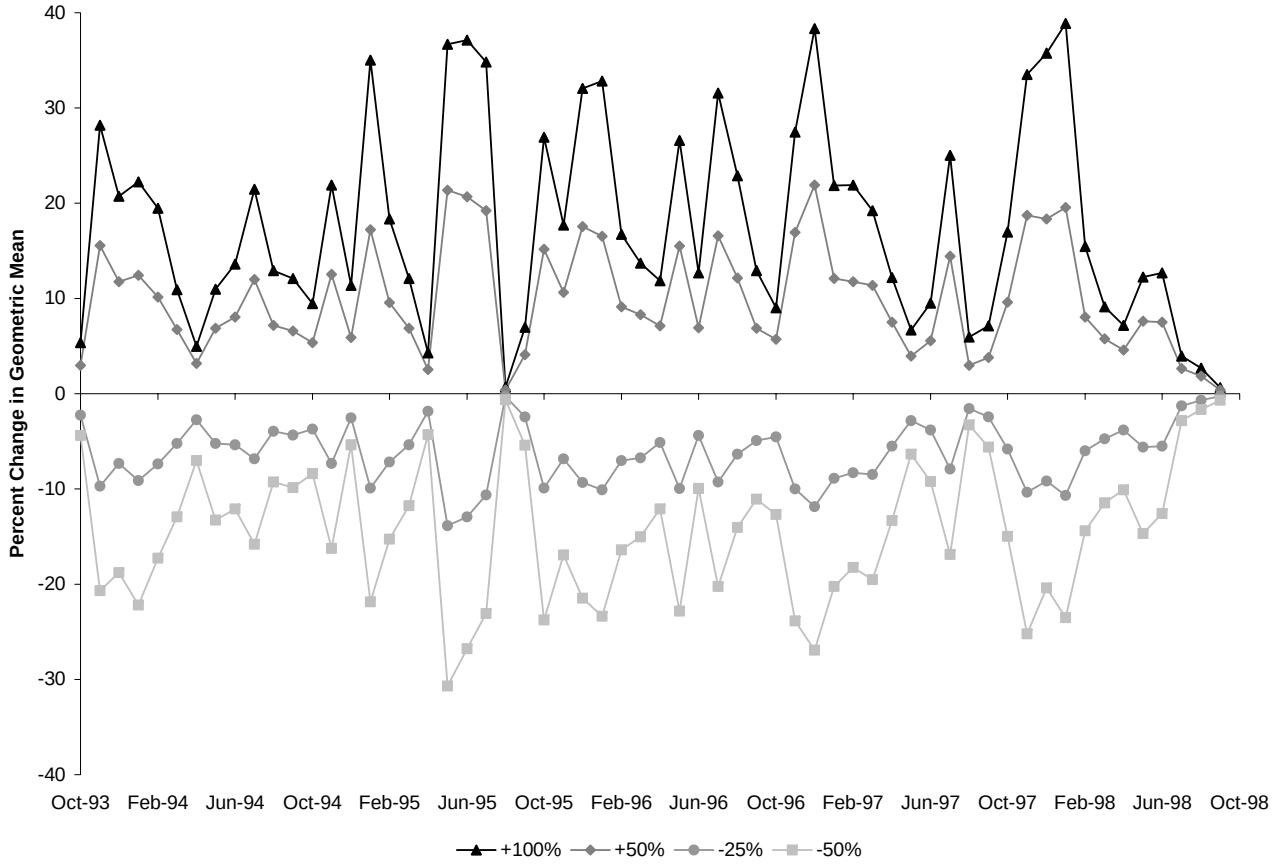

Figure C.2 Results of sensitivity analysis on 30-day, geometric-mean concentrations in the Appomattox River watershed, as affected by changes in maximum FC accumulation on land (MON-SQOLIM).

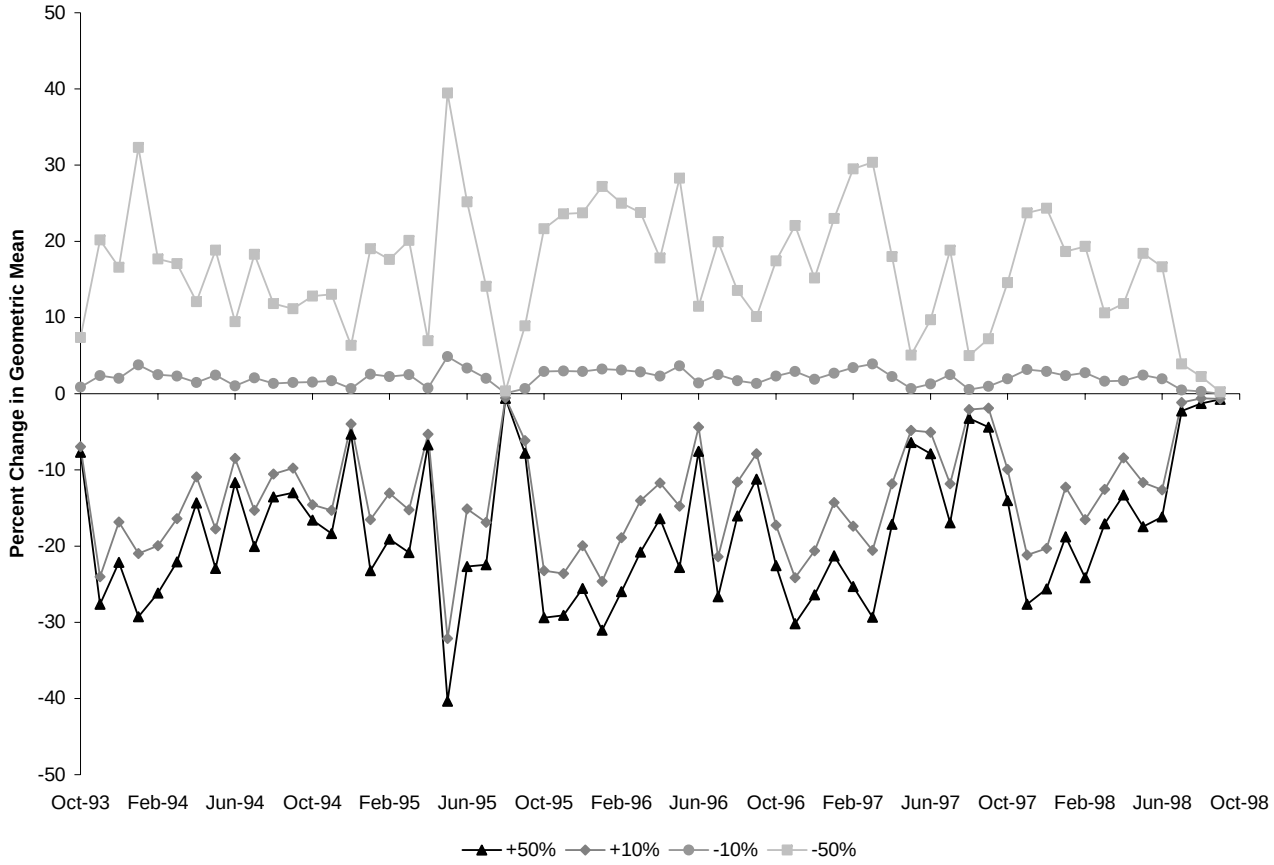

Figure C.3 Results of sensitivity analysis on 30-day, geometric-mean concentrations in the Appomattox River watershed, as affected by changes in the wash-off rate for FC on land surfaces (WSQOP).

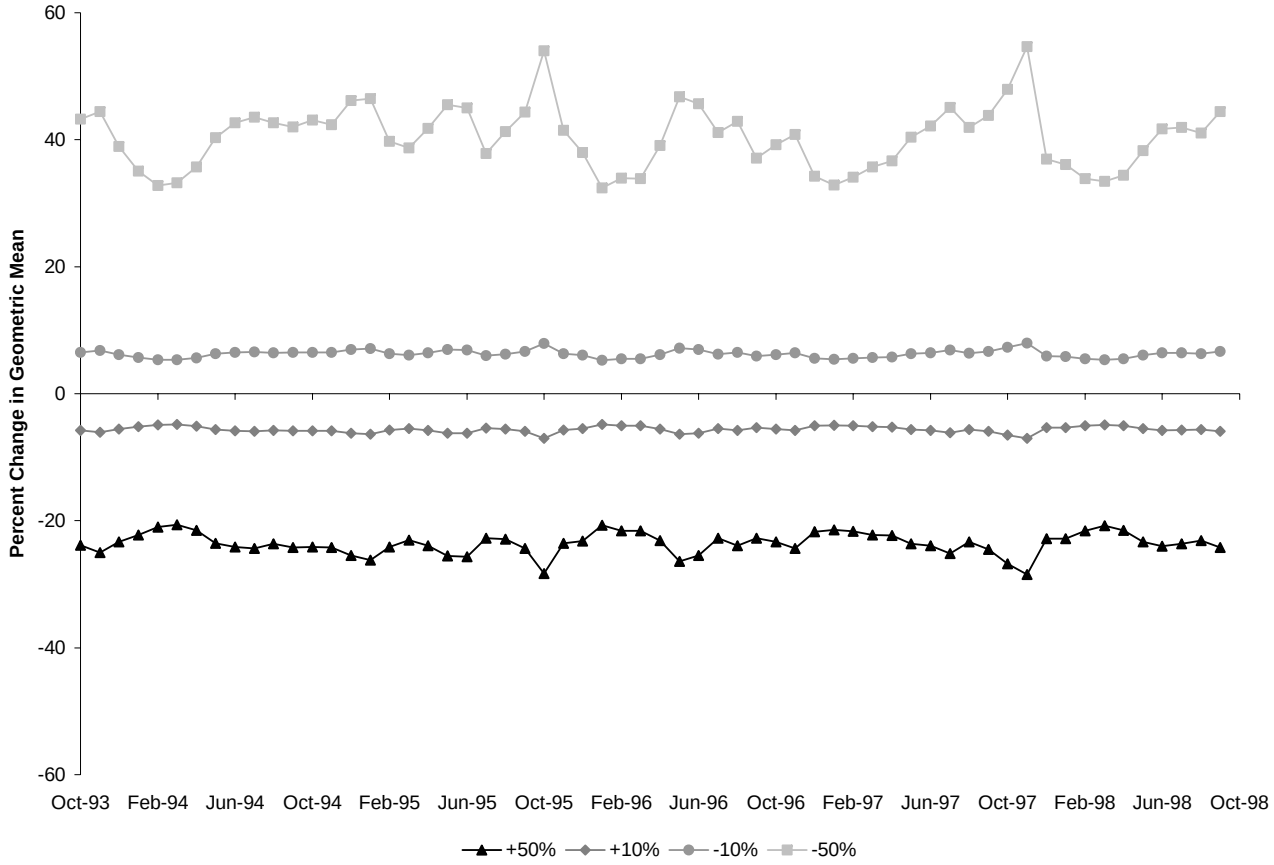

Figure C.4 Results of sensitivity analysis on 30-day, geometric-mean concentrations in the Appomattox River watershed, as affected by changes in the in-stream first-order decay rate (FSTDEC).

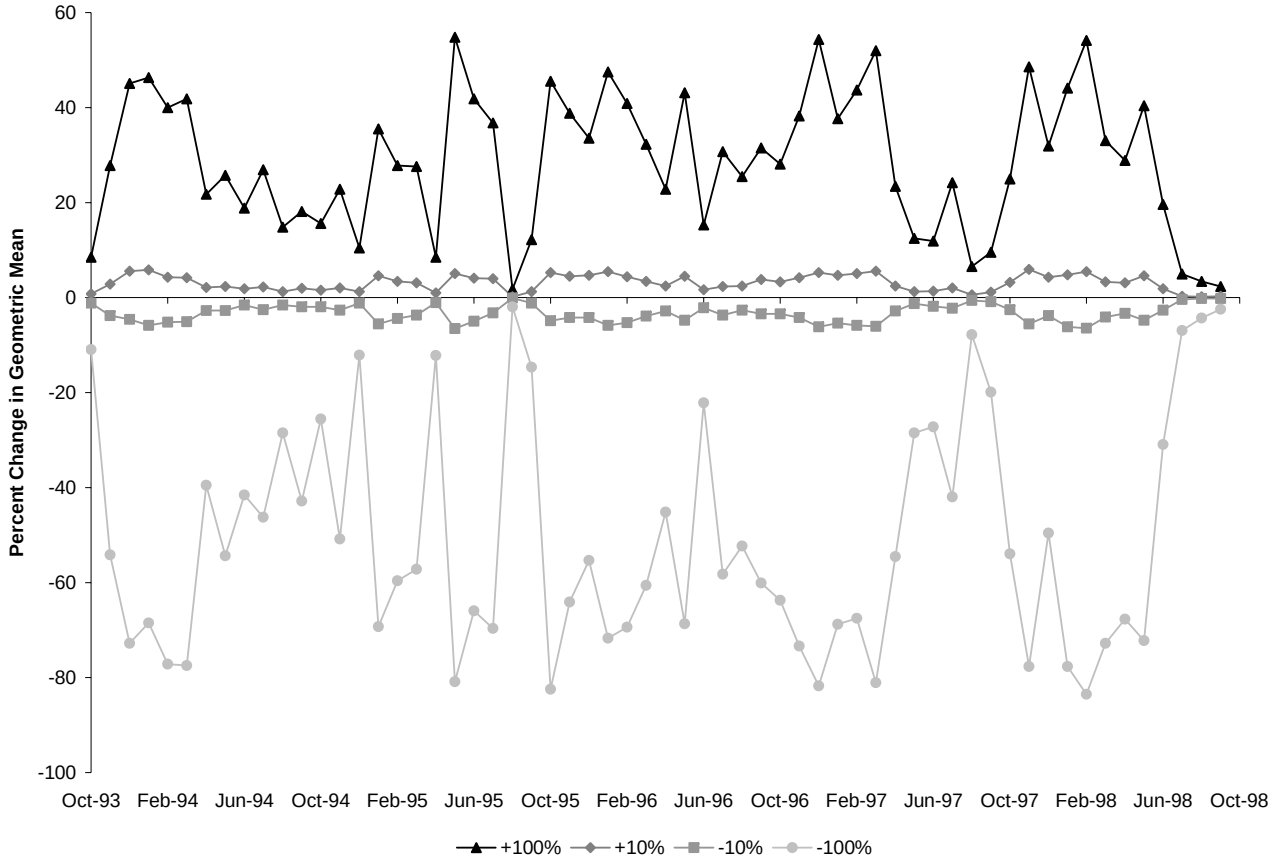

Figure C.5 Results of sensitivity analysis on calendar month geometric-mean concentrations in the Appomattox River watershed, as affected by changes in land-based loadings.

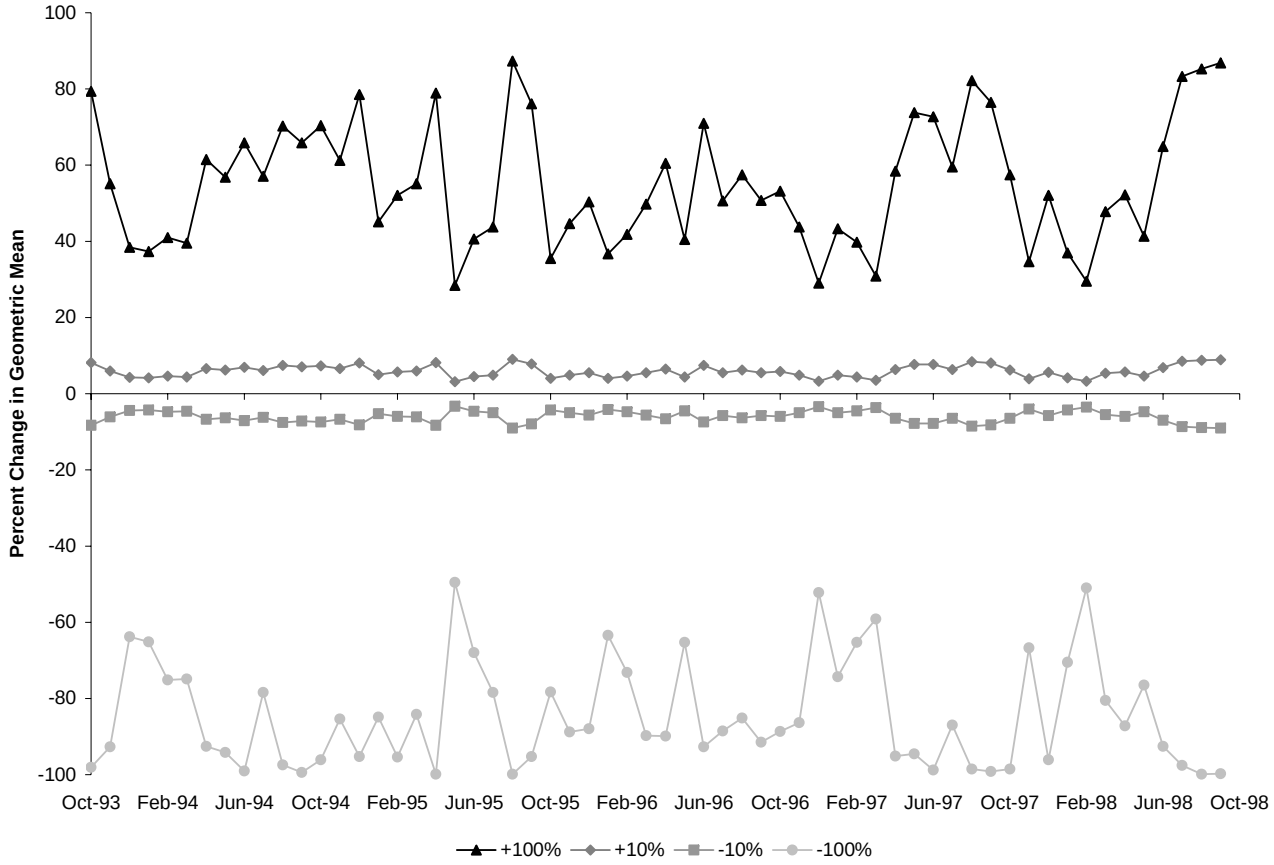

Figure C.6 Results of sensitivity analysis on 30-day geometric-mean concentrations in the Appomattox River watershed, as affected by changes in loadings from direct nonpoint sources.

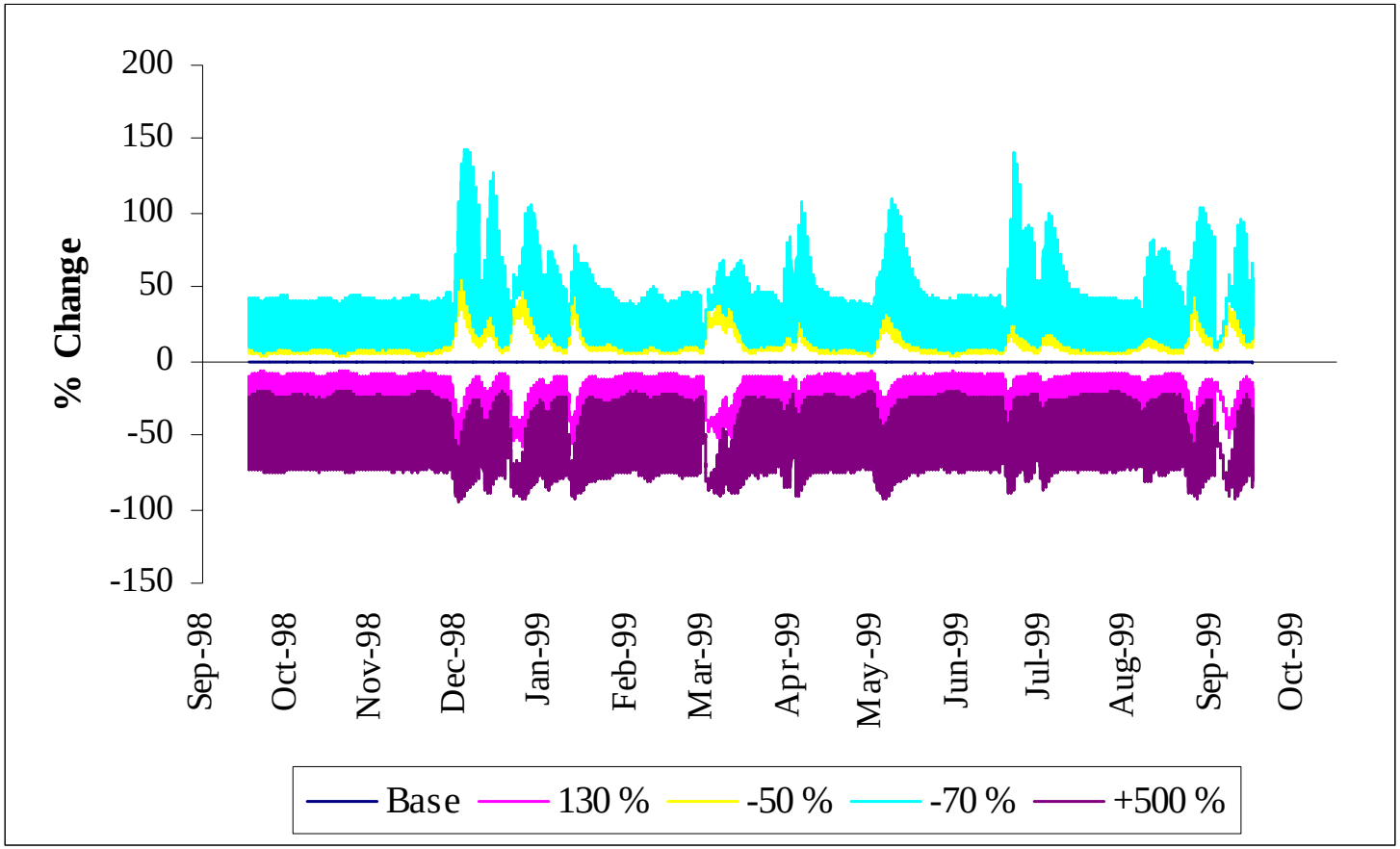

Figure C.7 Percent Change in Fecal Coliform concentration vs. Percent Change in first order decay coefficient in the WASP model.

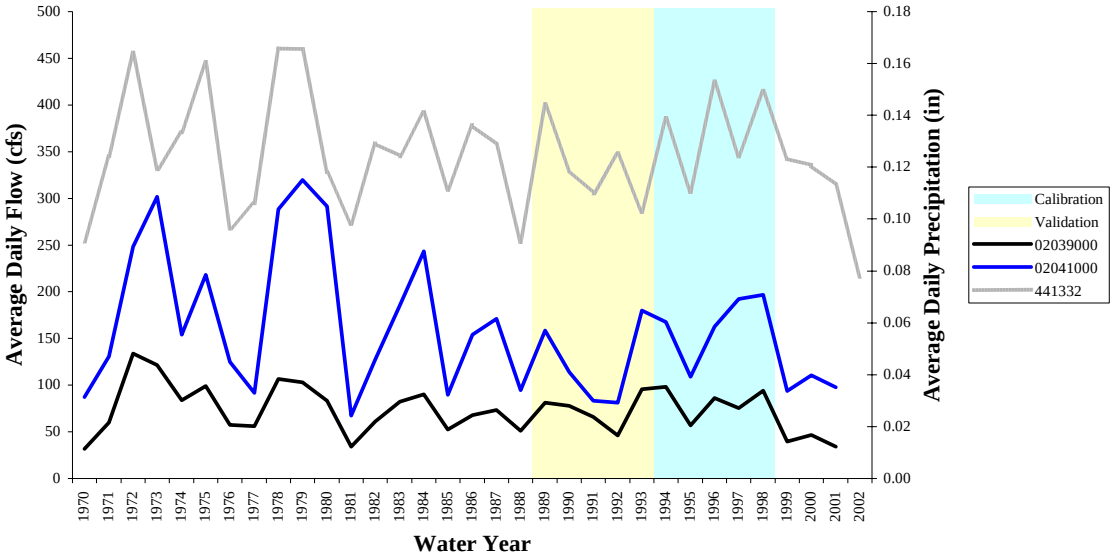

Figure C.8 Annual Historical Flow (USGS Stations 02039000 and 02041000) and Precipitation (Station 441332) Data

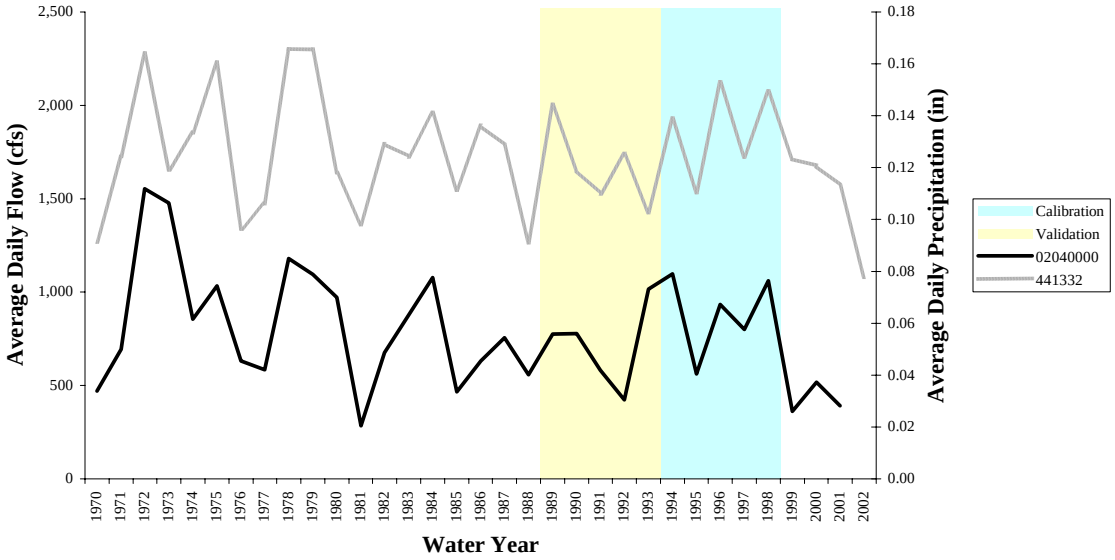

Figure C.9 Annual Historical Flow (USGS Station 02040000) and Precipitation (Station 441332) Data

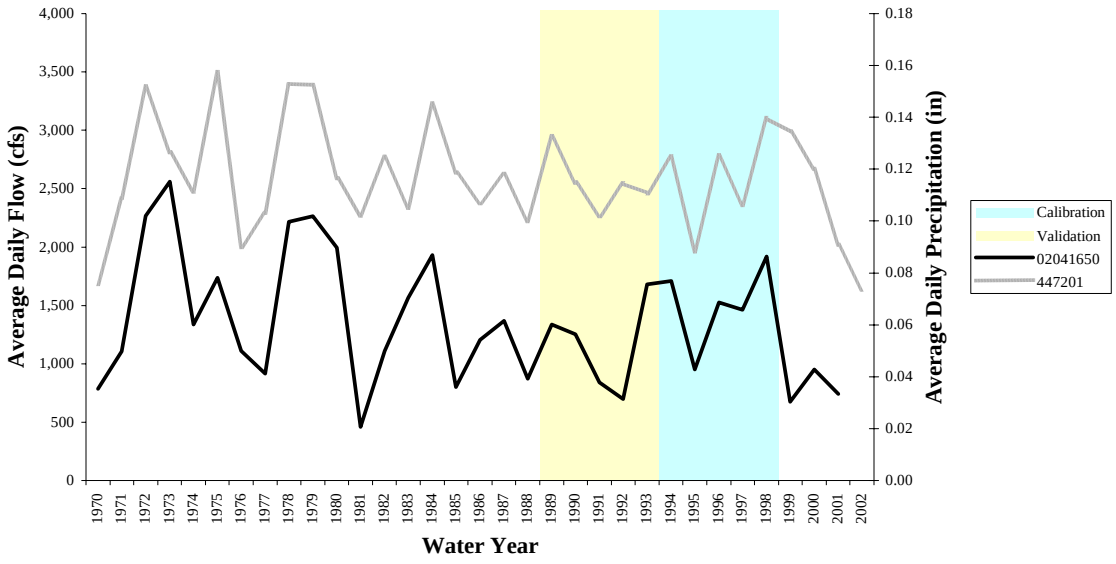

Figure C.10 Annual Historical Flow (USGS Station 02041650) and Precipitation (Station 447201) Data

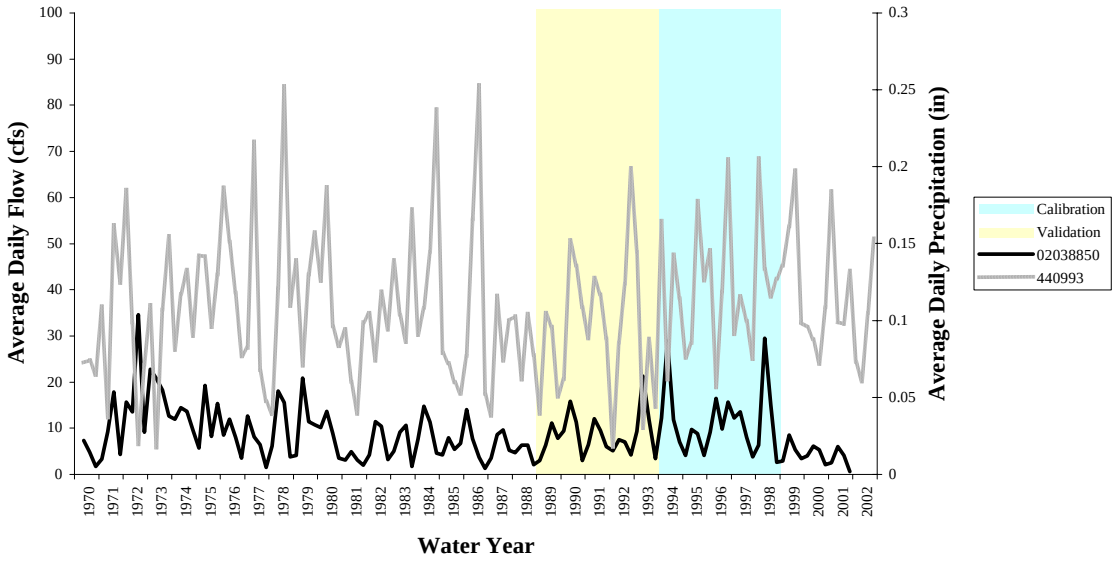

Figure C.11 Seasonal Historical Flow (USGS Station 02038850) and Precipitation (Station 440993) Data

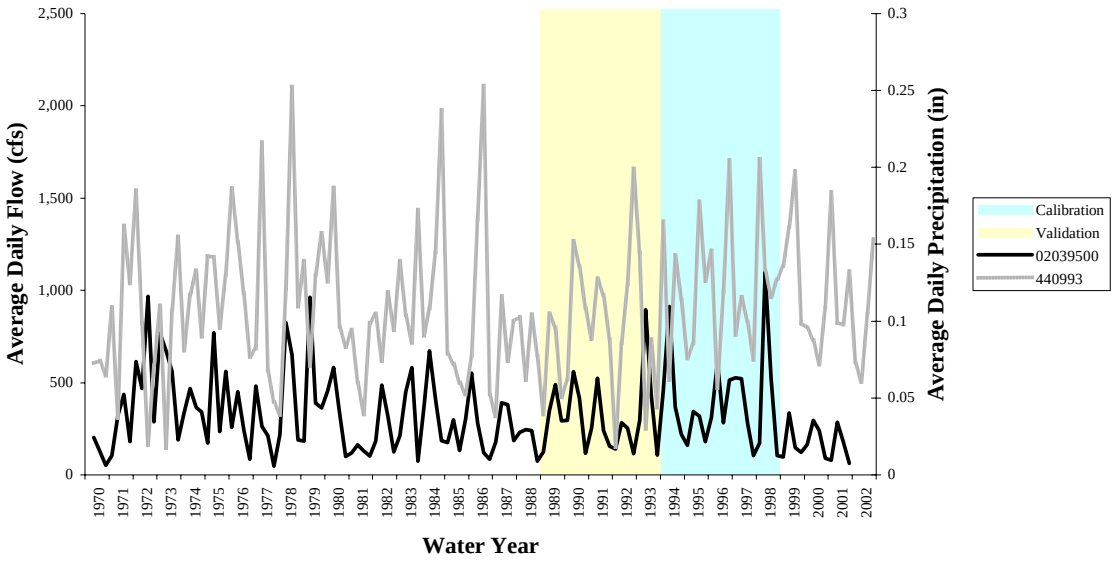

Figure C.12 Seasonal Historical Flow (USGS Station 020395000) and Precipitation (Station 440993) Data

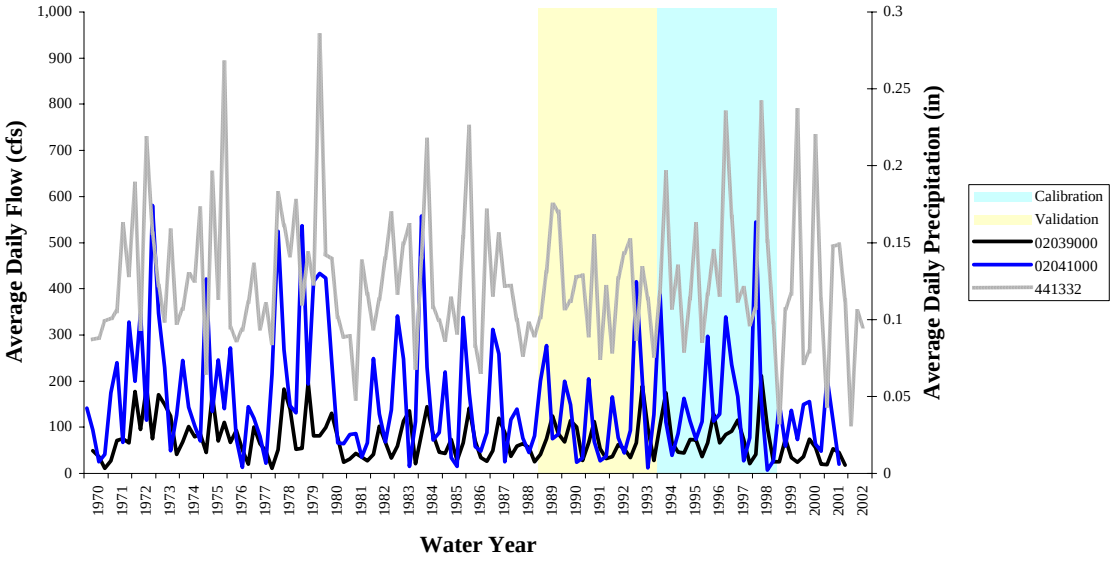

Figure C.13 Seasonal Historical Flow (USGS Stations 02039000 and 02041000) and Precipitation (Station 441332) Data

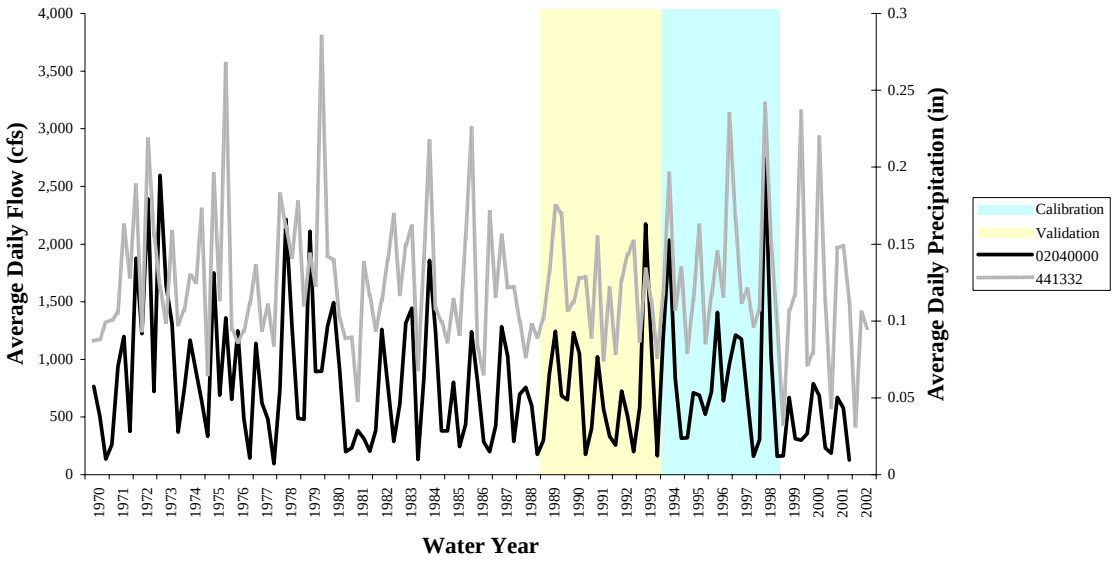

Figure C.14 Seasonal Historical Flow (USGS Station 02040000) and Precipitation (Station 441332) Data

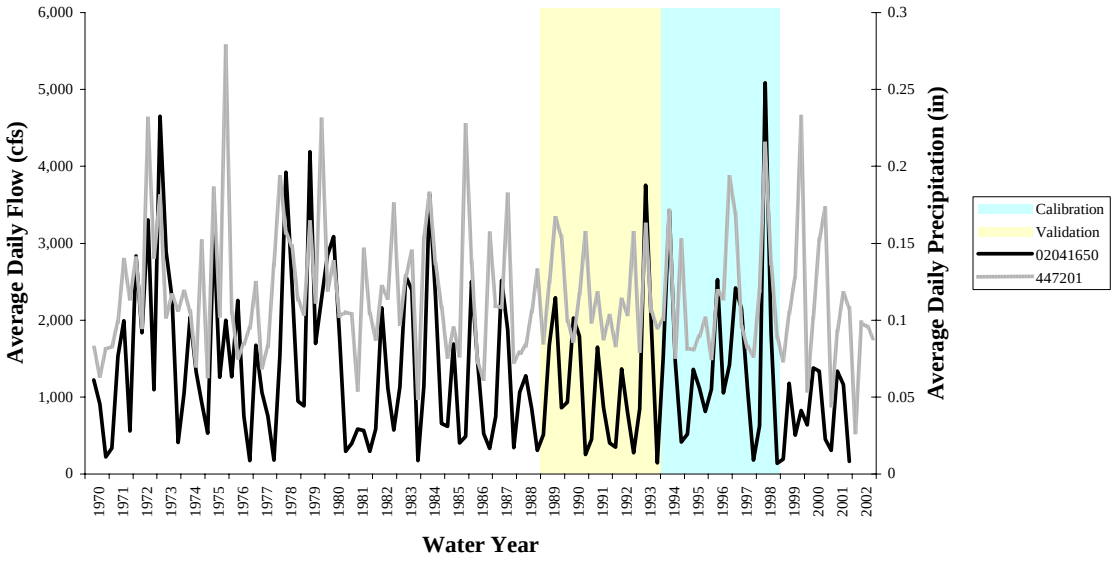

Figure C.15 Seasonal Historical Flow (USGS Station 02041650) and Precipitation (Station 447201) Data

Table C.1 Hydrology calibration criteria and model performance for period 10/1/1993 through 9/30/1998 at gaging station USGS02039000 on Buffalo Creek (model segment 1, subshed 20).

Criterion	Observed	Modeled	Error
Total In-stream Flow:	78.57	83.53	6.31%
Upper 10% Flow Values:	32.90	31.20	-5.17%
Lower 50% Flow Values:	15.91	17.30	8.77%
Winter Flow Volume	33.35	35.48	6.38%
Spring Flow Volume	18.12	19.60	8.17%
Summer Flow Volume	10.30	10.40	1.05%
Fall Flow Volume	16.81	18.05	7.38%
Total Storm Volume	63.23	66.37	4.97%
Winter Storm Volume	29.55	31.23	5.66%
Spring Storm Volume	14.29	15.31	7.15%
Summer Storm Volume	6.45	6.09	-5.55%
Fall Storm Volume	12.94	13.74	6.21%

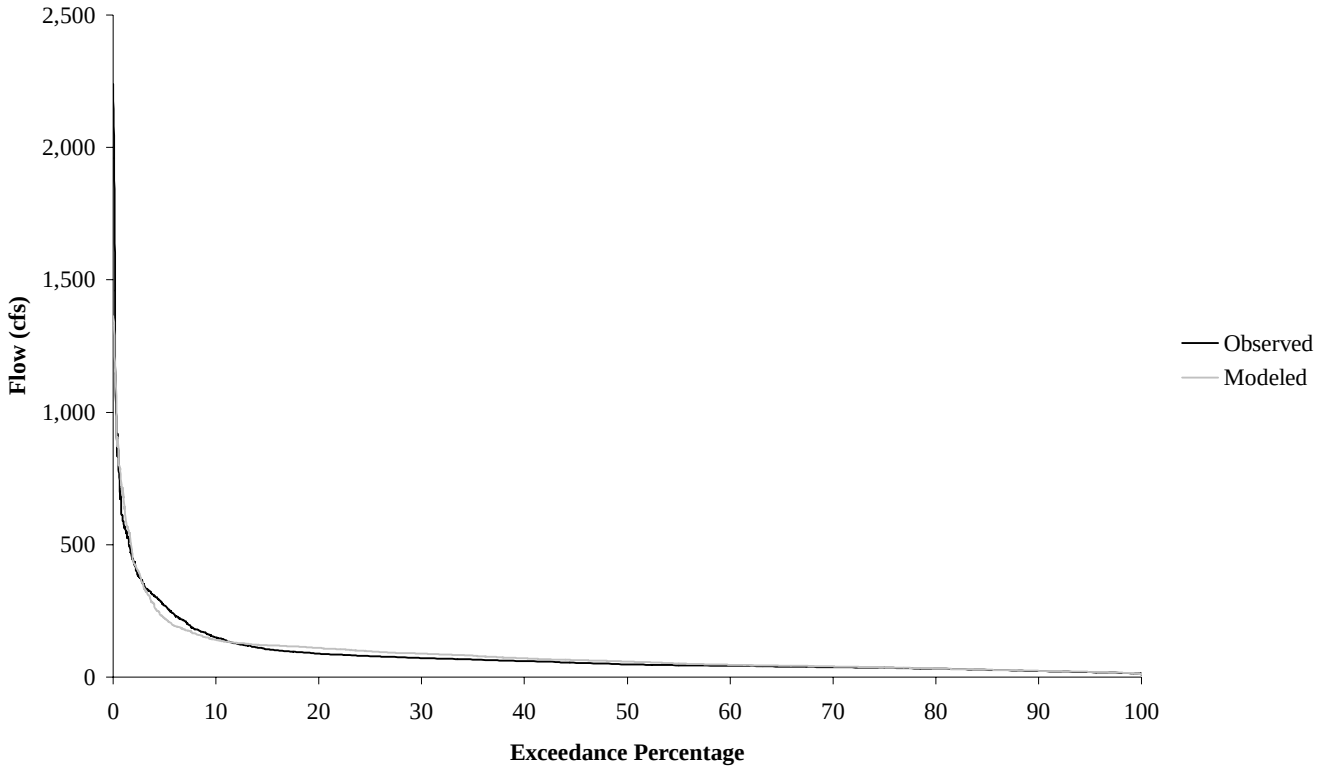

Figure C.16 Buffalo Creek flow duration at gage station USGS02039000 for calibration period 10/1/1993 through 9/30/1998 (model segment 1, subshed 20).

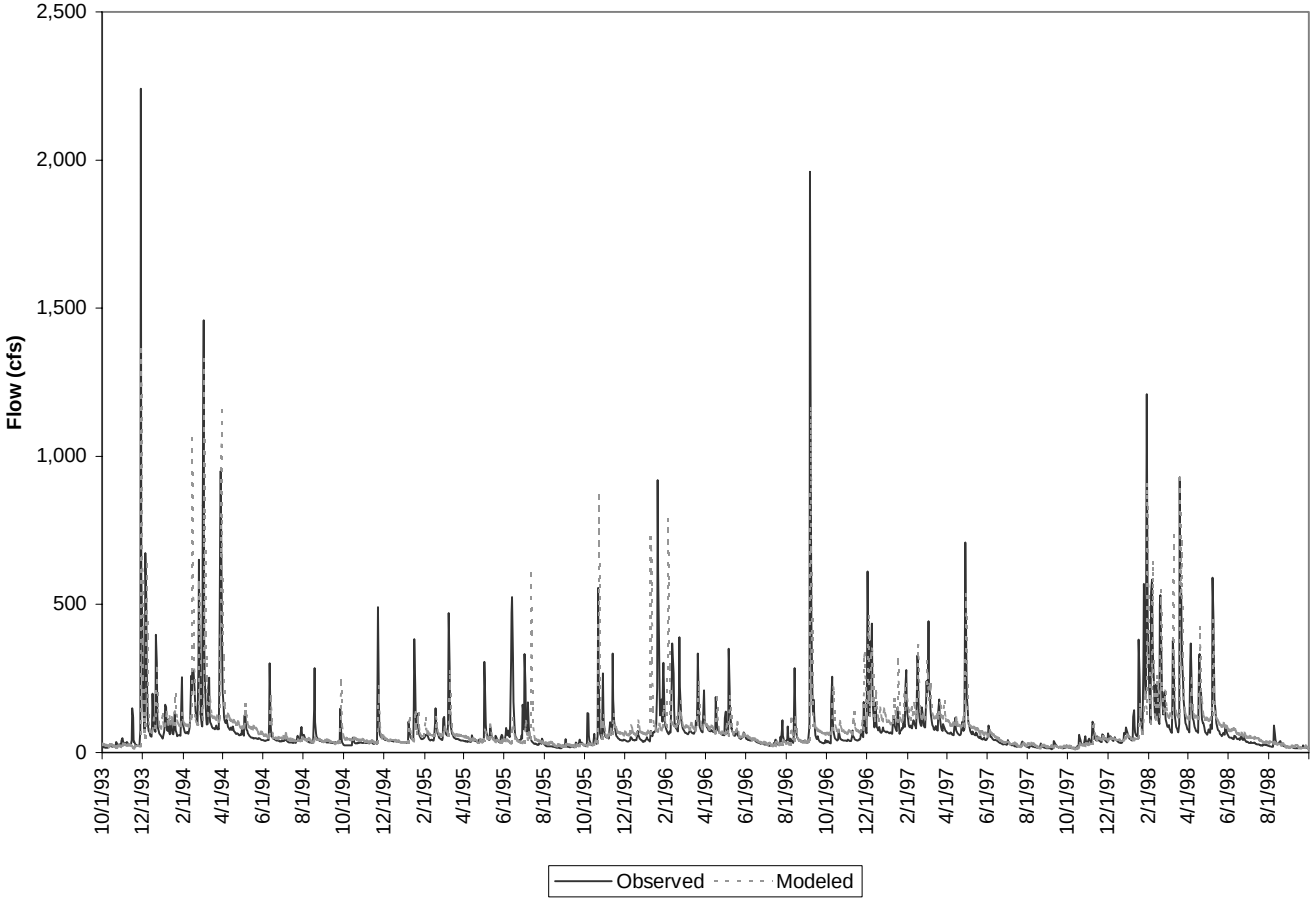

Figure C.17 Calibration results for period 10/1/1993 through 9/30/1998 at gage station USGS02039000 on Buffalo Creek (model segment 1, subshed 20)

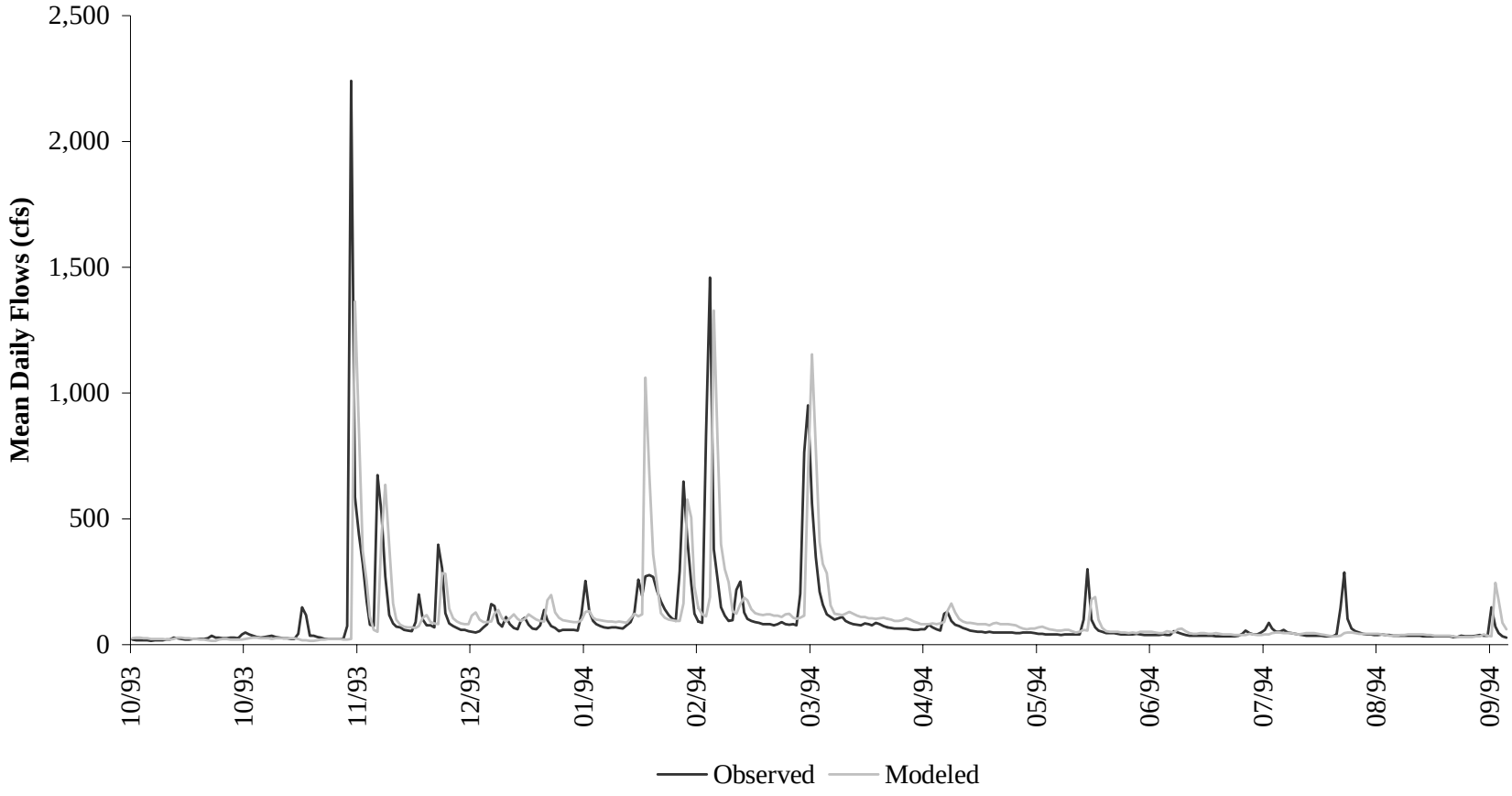

Figure C.18 Calibration results for period 10/01/93 through 09/30/94 for USGS Station 02039000

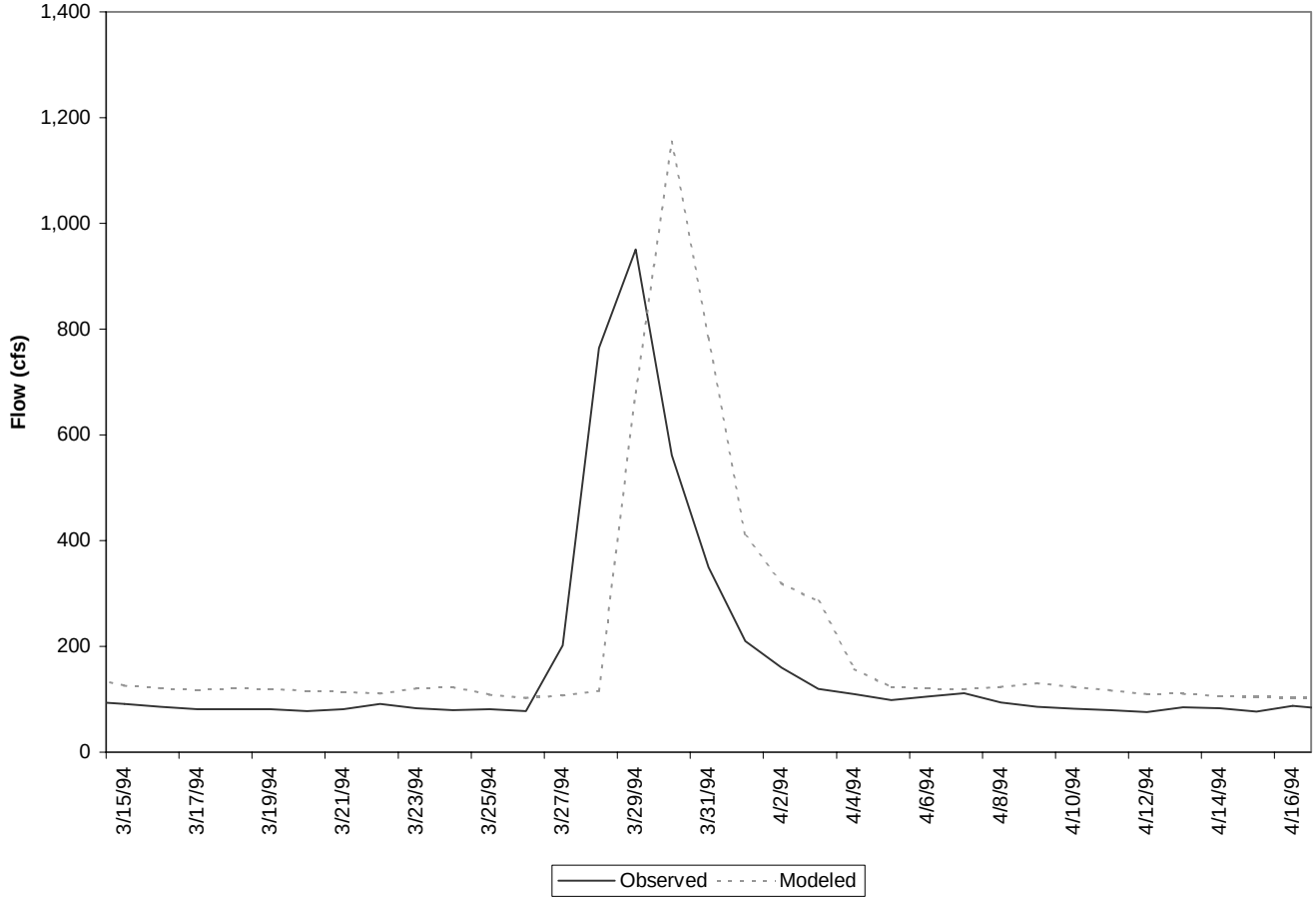

Figure C.19 Calibration results for a single storm event at gage station USGS02039000 on Buffalo Creek (model segment 1, subshed 20)

Table C.2 Hydrology calibration criteria and model performance for period 10/1/1993 through 9/30/1998 at gaging station USGS02040000 on Appomattox River (model segment 3, subshed 62).

Criterion	Observed	Modeled	Error
Total In-stream Flow:	83.31	85.18	2.25%
Upper 10% Flow Values:	38.40	36.31	-5.45%
Lower 50% Flow Values:	11.68	11.77	0.81%
Winter Flow Volume	37.42	40.07	7.08%
Spring Flow Volume	18.05	17.30	-4.15%
Summer Flow Volume	10.06	8.60	-14.57%
Fall Flow Volume	17.77	19.21	8.10%
Total Storm Volume	74.20	78.32	5.55%
Winter Storm Volume	35.16	38.37	9.11%
Spring Storm Volume	15.78	15.59	-1.21%
Summer Storm Volume	7.78	6.89	-11.51%
Fall Storm Volume	15.48	17.48	12.94%

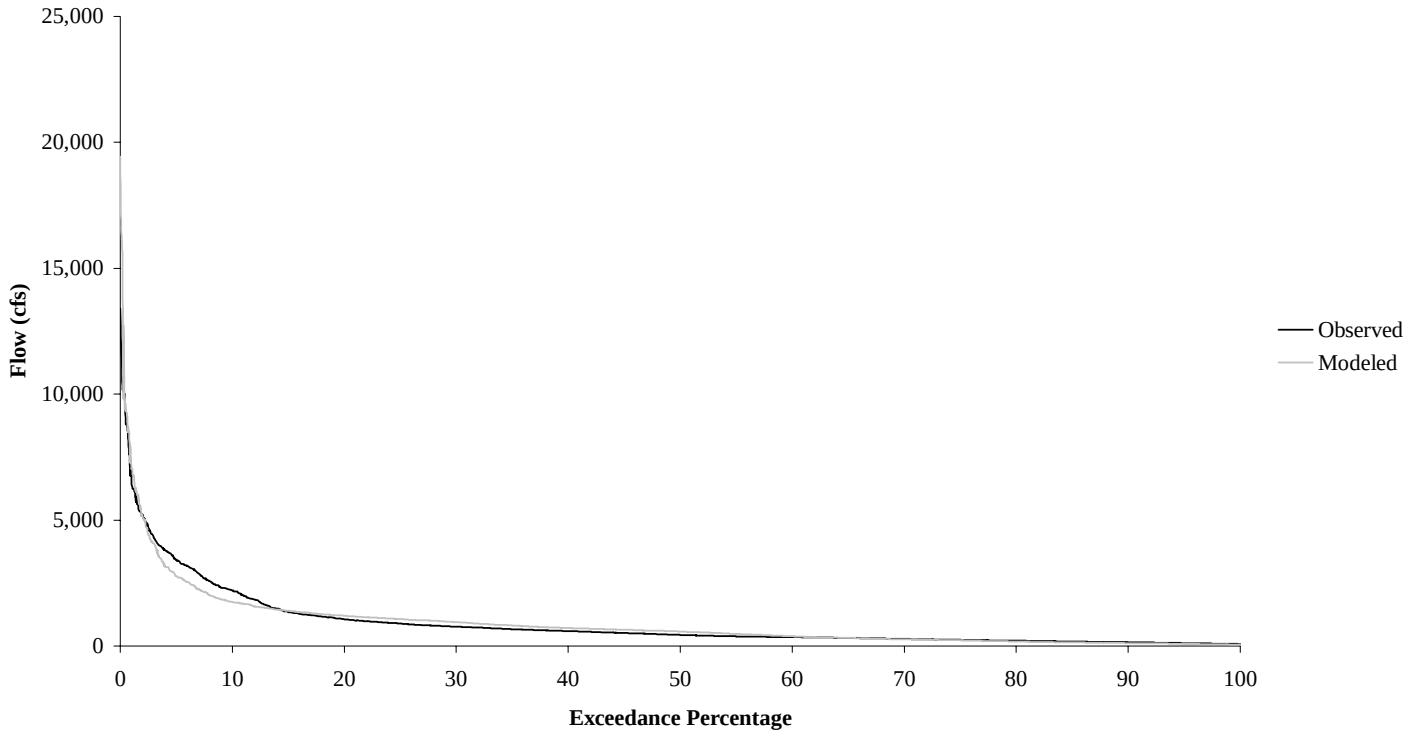

Figure C.20 Appomattox River flow duration at gage station USGS02040000 for calibration period 10/1/1993 through 9/30/1998 (model segment 3, subshed 62).

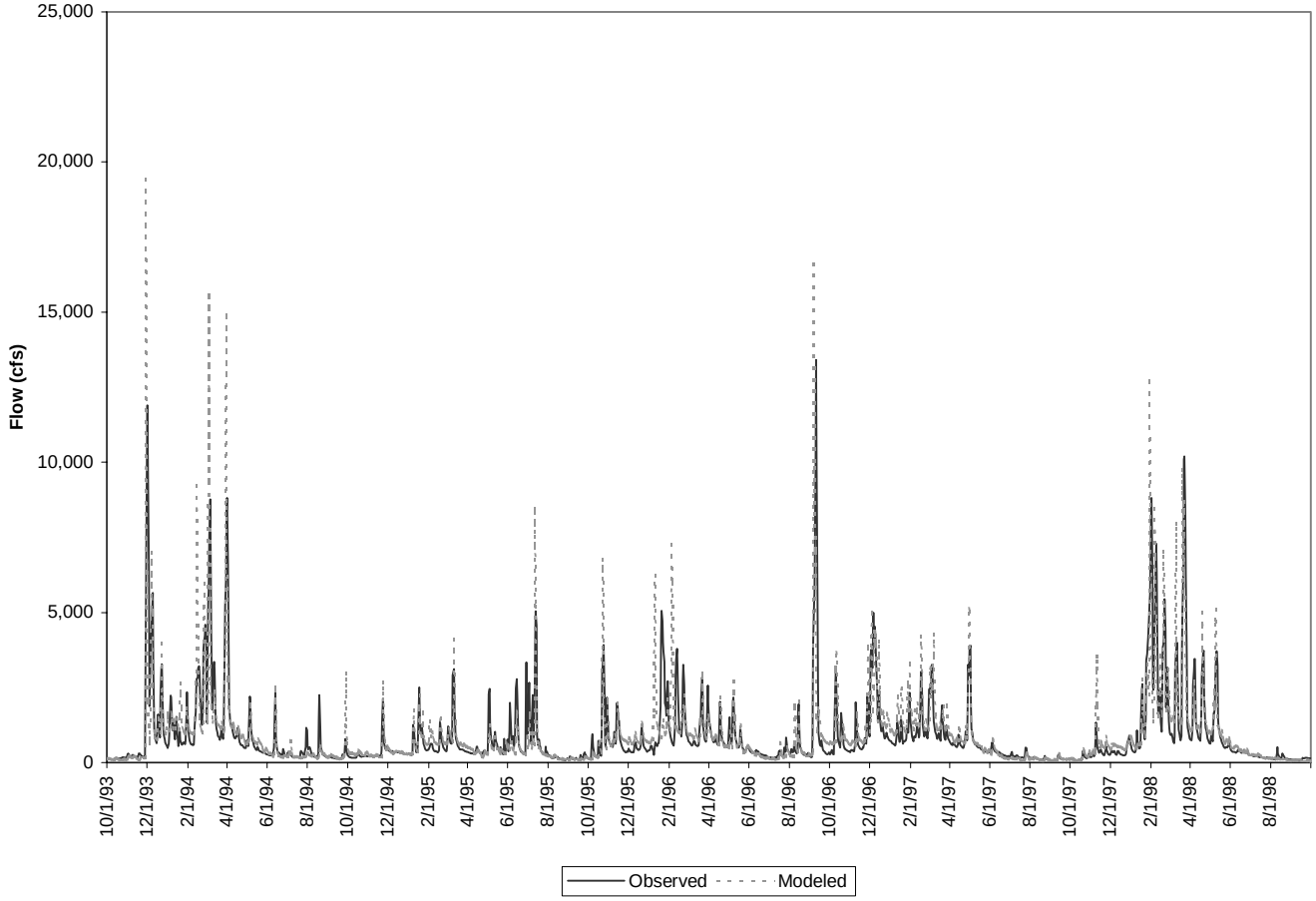

Figure C.21 Calibration results for period 10/1/1993 through 9/30/1998 at gage station USGS02040000 on Appomattox River (model segment 3, subshed 62)

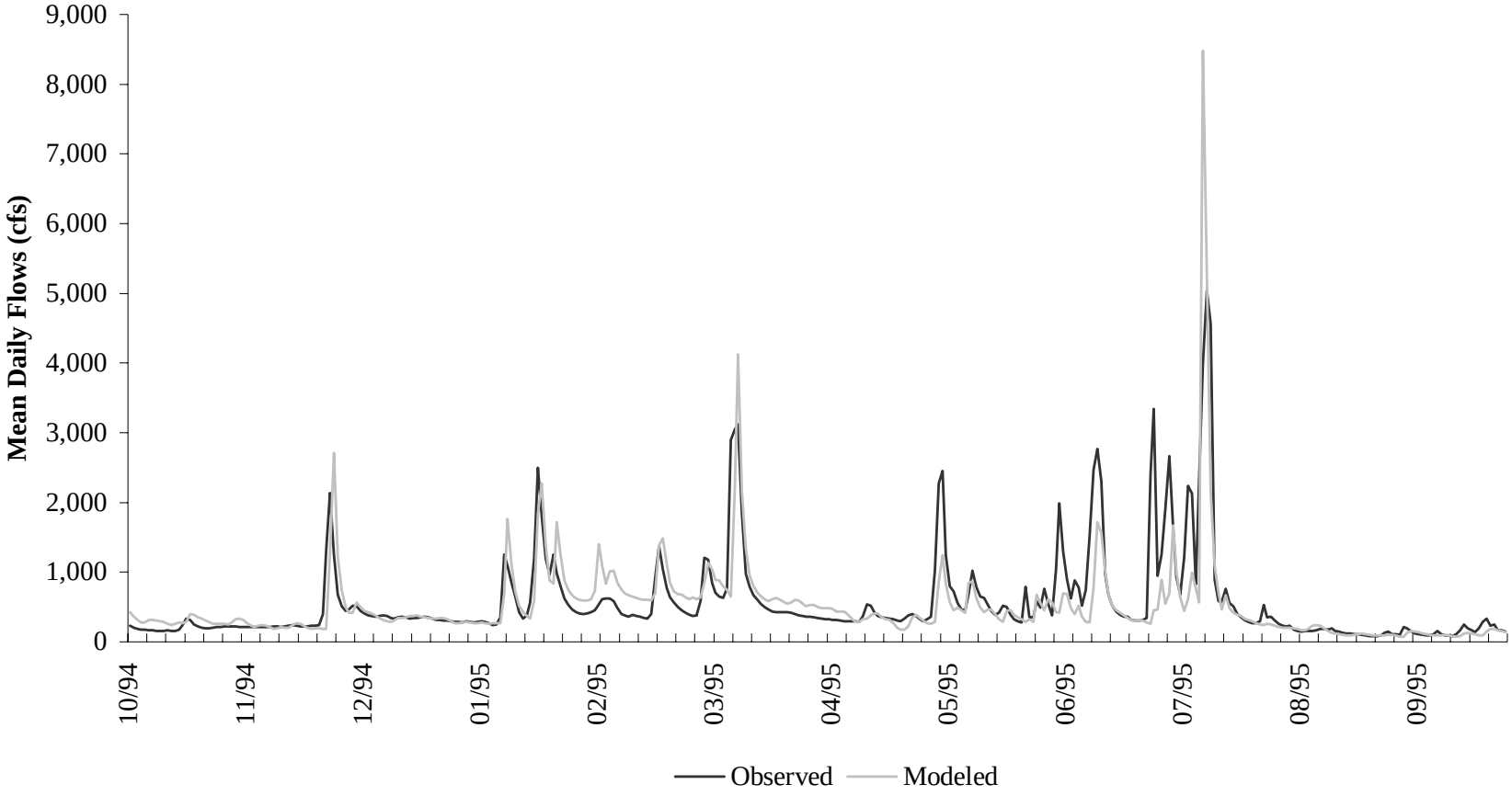

Figure C.22 Calibration results for period 10/01/94 through 09/30/95 for USGS Station 02040000.

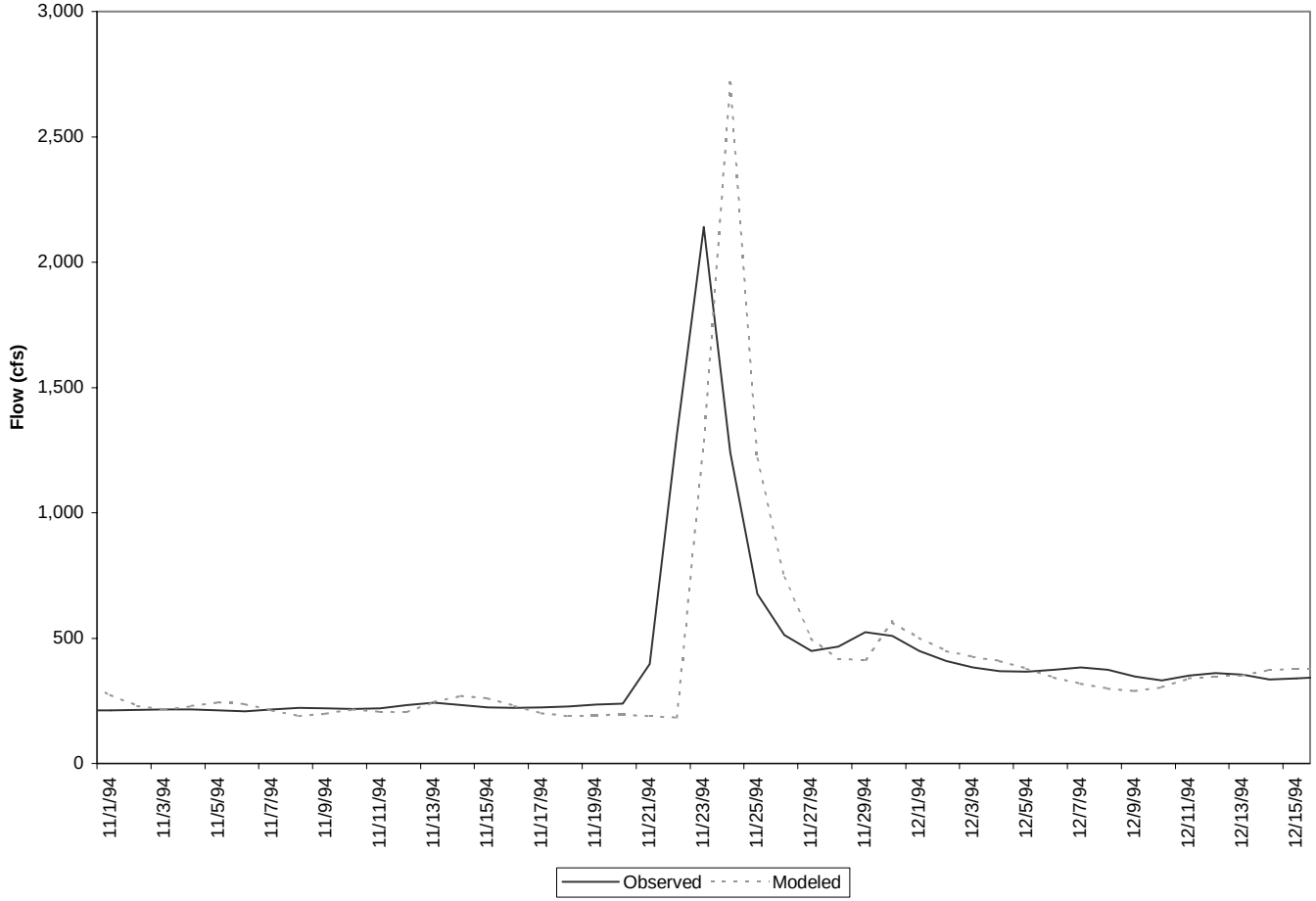

Figure C.23 Calibration results for a single storm event at gage station USGS02040000 on Appomattox River (model segment 3, subshed 62)

Table C.3 Hydrology calibration criteria and model performance for period 10/1/1993 through 9/30/1998 at gaging station USGS02041000 on Deep Creek (model segment 5, subshed 95).

Criterion	Observed	Modeled	Error
Total In-stream Flow:	53.98	58.10	7.63%
Upper 10% Flow Values:	27.27	25.77	-5.49%
Lower 50% Flow Values:	6.03	6.12	1.58%
Winter Flow Volume	26.38	28.56	8.24%
Spring Flow Volume	10.79	11.43	5.85%
Summer Flow Volume	4.58	4.84	5.72%
Fall Flow Volume	12.22	13.28	8.62%
Total Storm Volume	52.58	57.72	9.78%
Winter Storm Volume	26.04	28.46	9.32%
Spring Storm Volume	10.44	11.33	8.49%
Summer Storm Volume	4.23	4.74	12.13%
Fall Storm Volume	11.87	13.18	11.05%

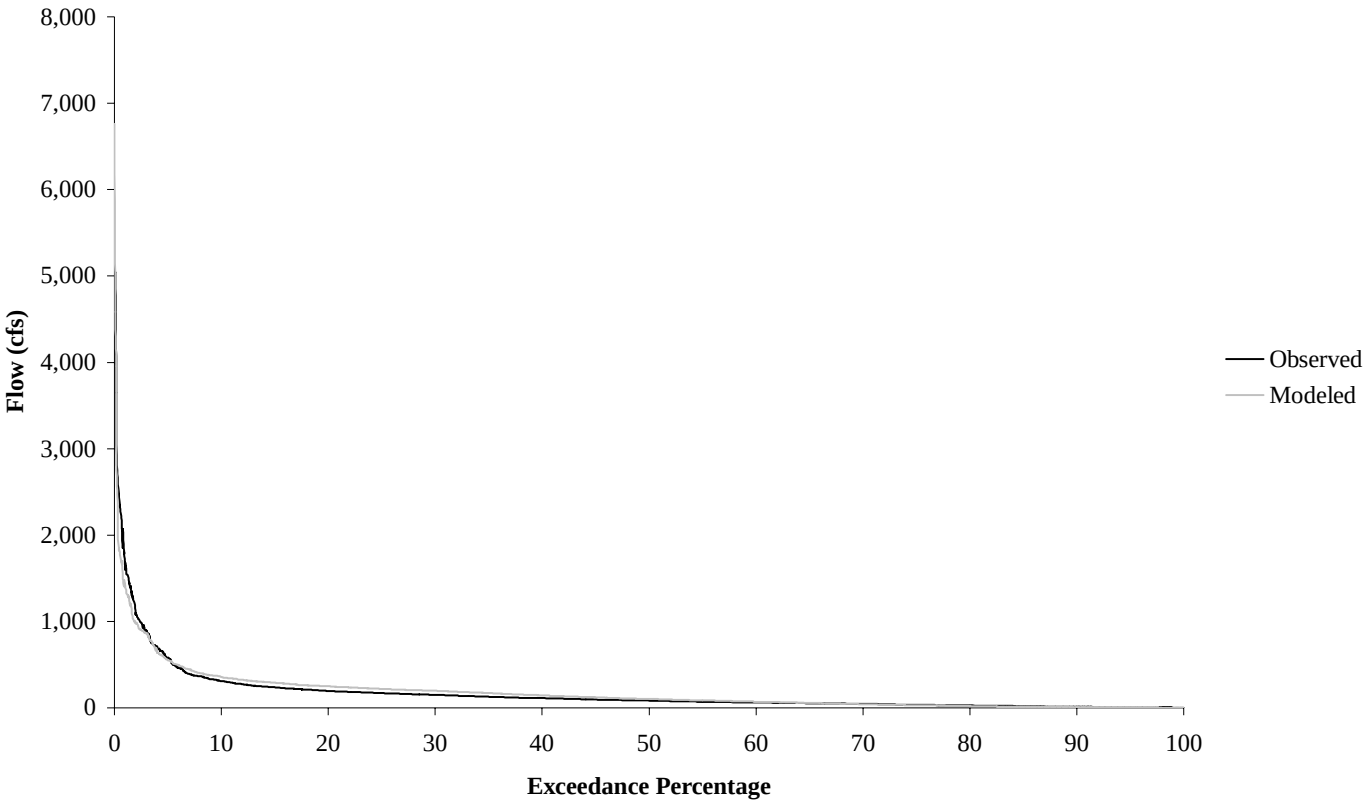

Figure C.24 Deep Creek flow duration at gage station USGS02041000 for calibration period 10/1/1993 through 9/30/1998 (model segment 5, subshed 95).

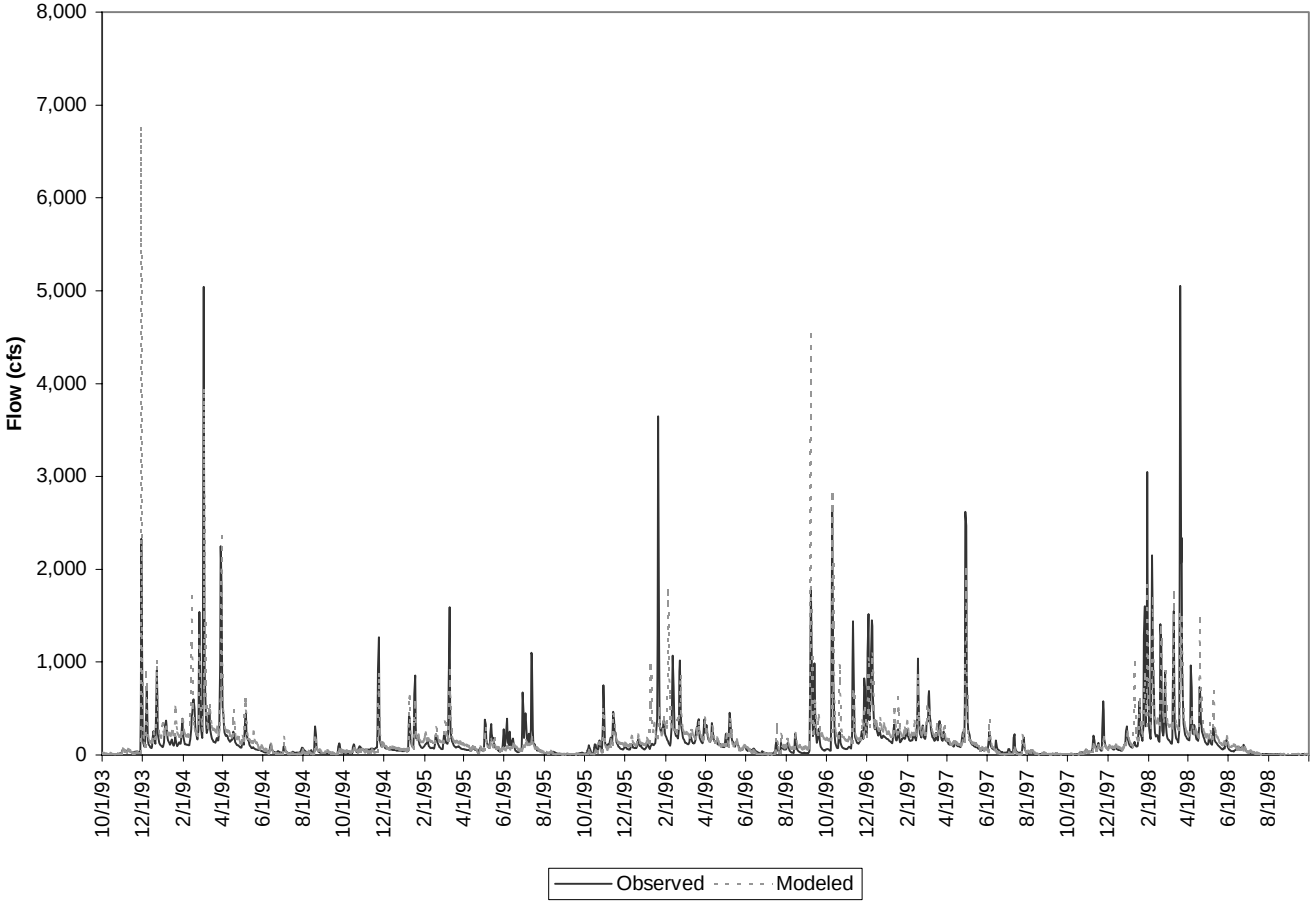

Figure C.25 Calibration results for period 10/1/1993 through 9/30/1998 at gage station USGS02041000 on Deep Creek (model segment 5, subshed 95)

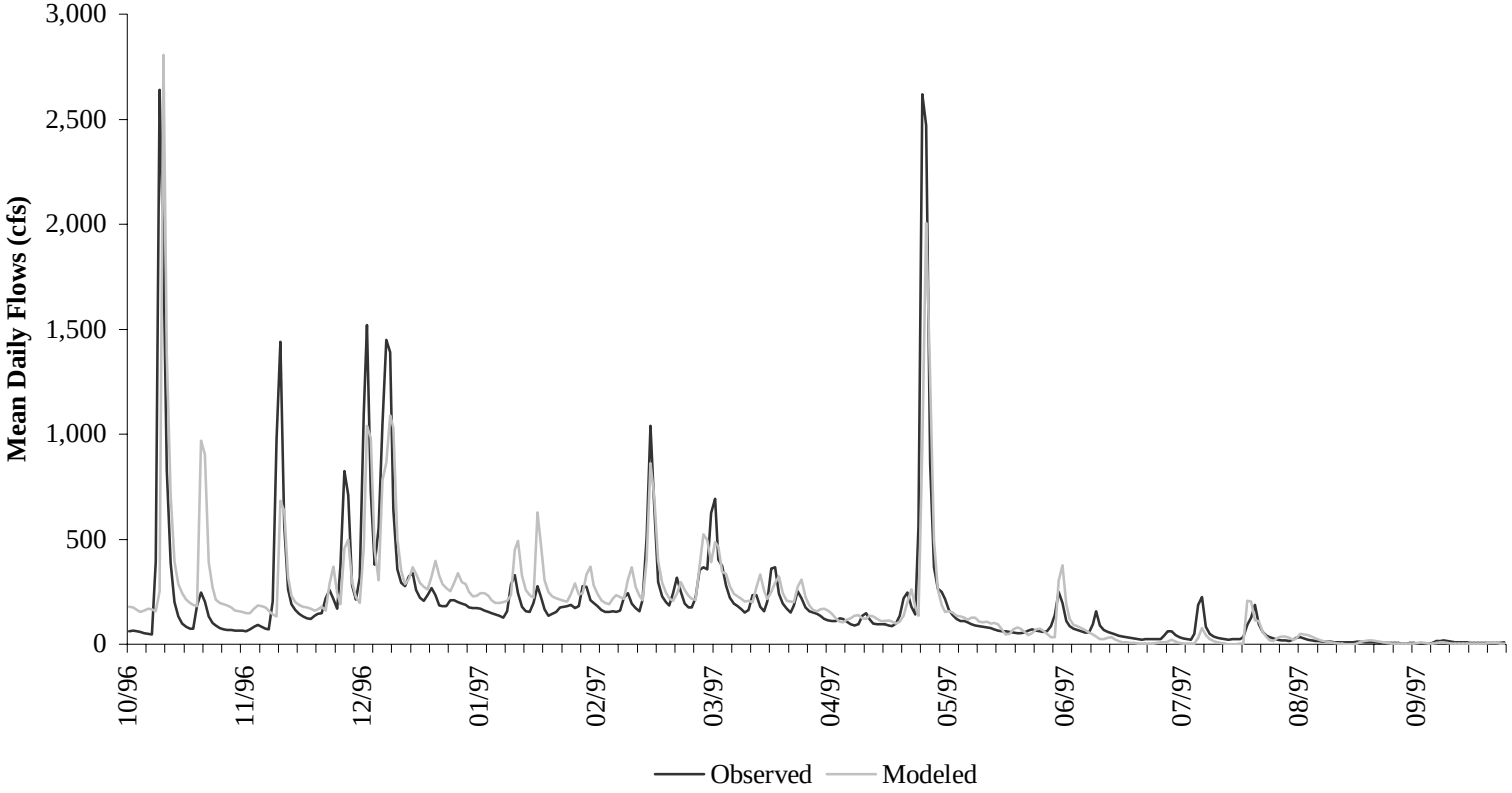

Figure C.26 Calibration results for water year period 10/01/96 through 09/30/97 for USGS Station 02041000.

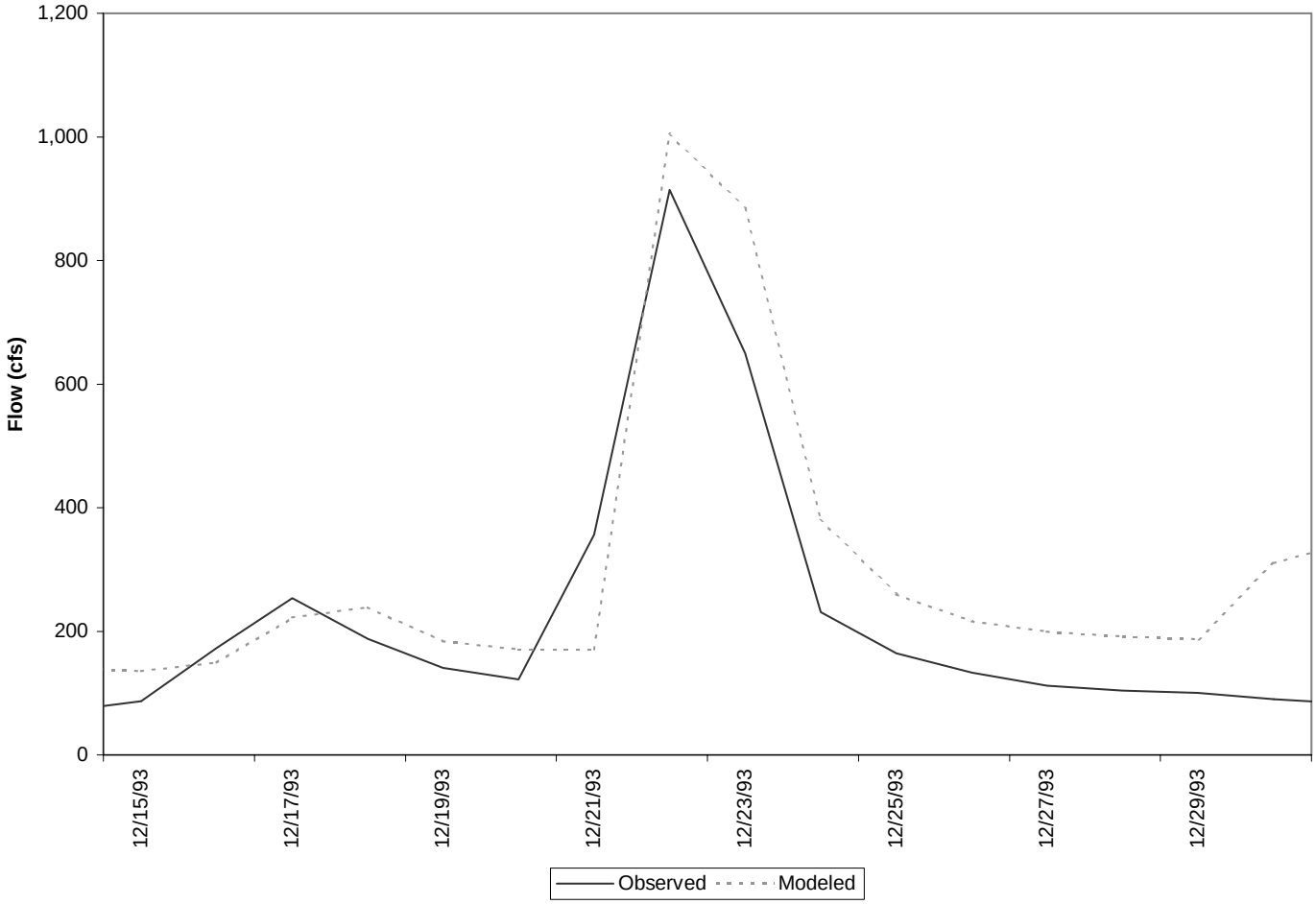

Figure C.27 Calibration results for a single storm event at gage station USGS02041000 on Deep Creek (model segment 5, subshed 95)

Table C.4 Hydrology calibration criteria and model performance for period 10/1/1993 through 9/30/1998 at gaging station USGS02041650 on Appomattox River (model segment 7, subshed 115).

Criterion	Observed	Modeled	Error
Total In-stream Flow:	76.01	78.03	2.66%
Upper 10% Flow Values:	34.51	32.38	-6.17%
Lower 50% Flow Values:	8.87	9.34	5.35%
Winter Flow Volume	36.22	37.91	4.68%
Spring Flow Volume	16.53	15.47	-6.39%
Summer Flow Volume	7.55	7.33	-2.94%
Fall Flow Volume	15.71	17.32	10.22%
Total Storm Volume	72.06	73.41	1.87%
Winter Storm Volume	35.24	36.76	4.33%
Spring Storm Volume	15.54	14.32	-7.88%
Summer Storm Volume	6.56	6.18	-5.81%
Fall Storm Volume	14.72	16.15	9.69%

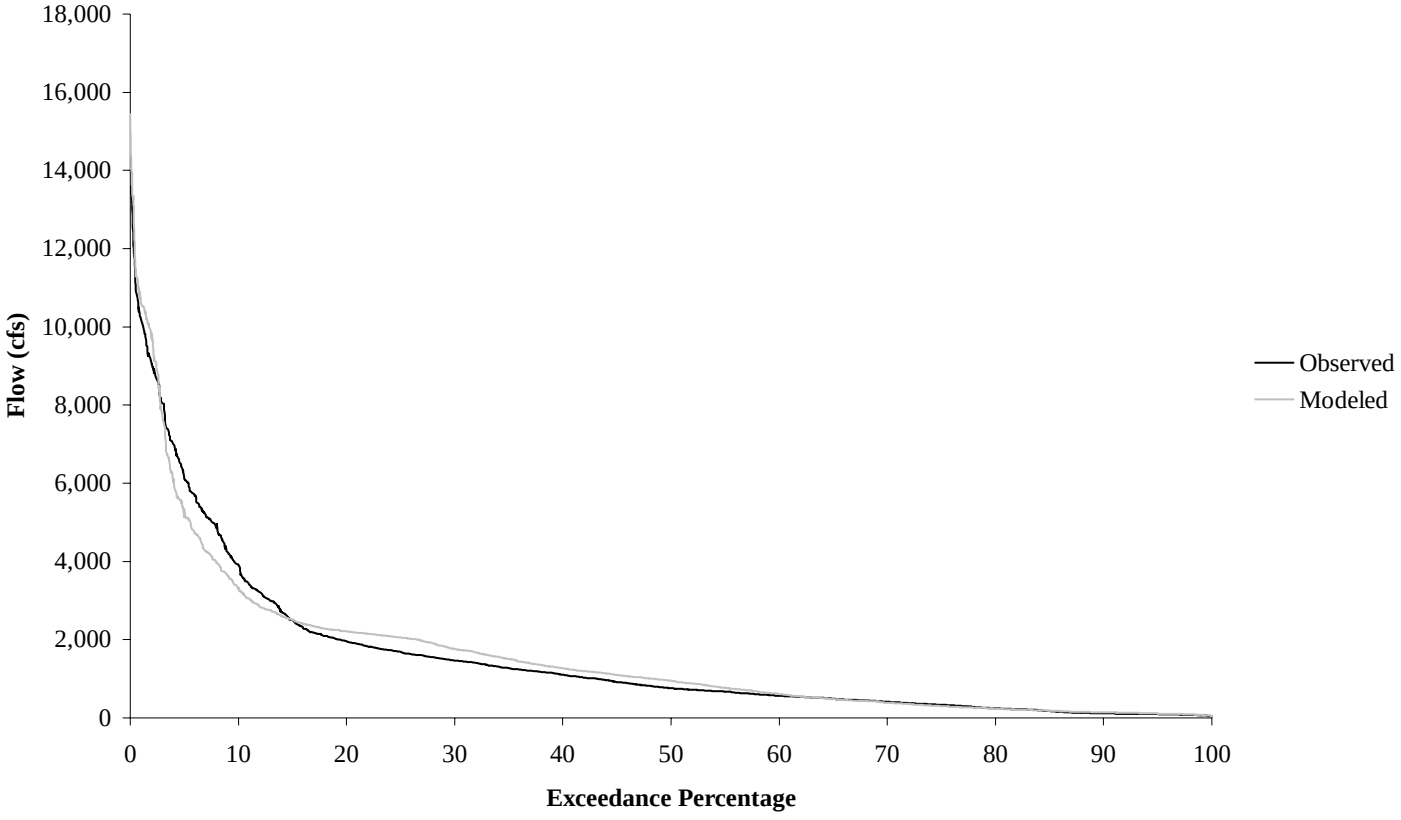

Figure C.28 Appomattox River flow duration at gage station USGS02041650 for calibration period 10/1/1993 through 9/30/1998 (model segment 7, subshed 115).

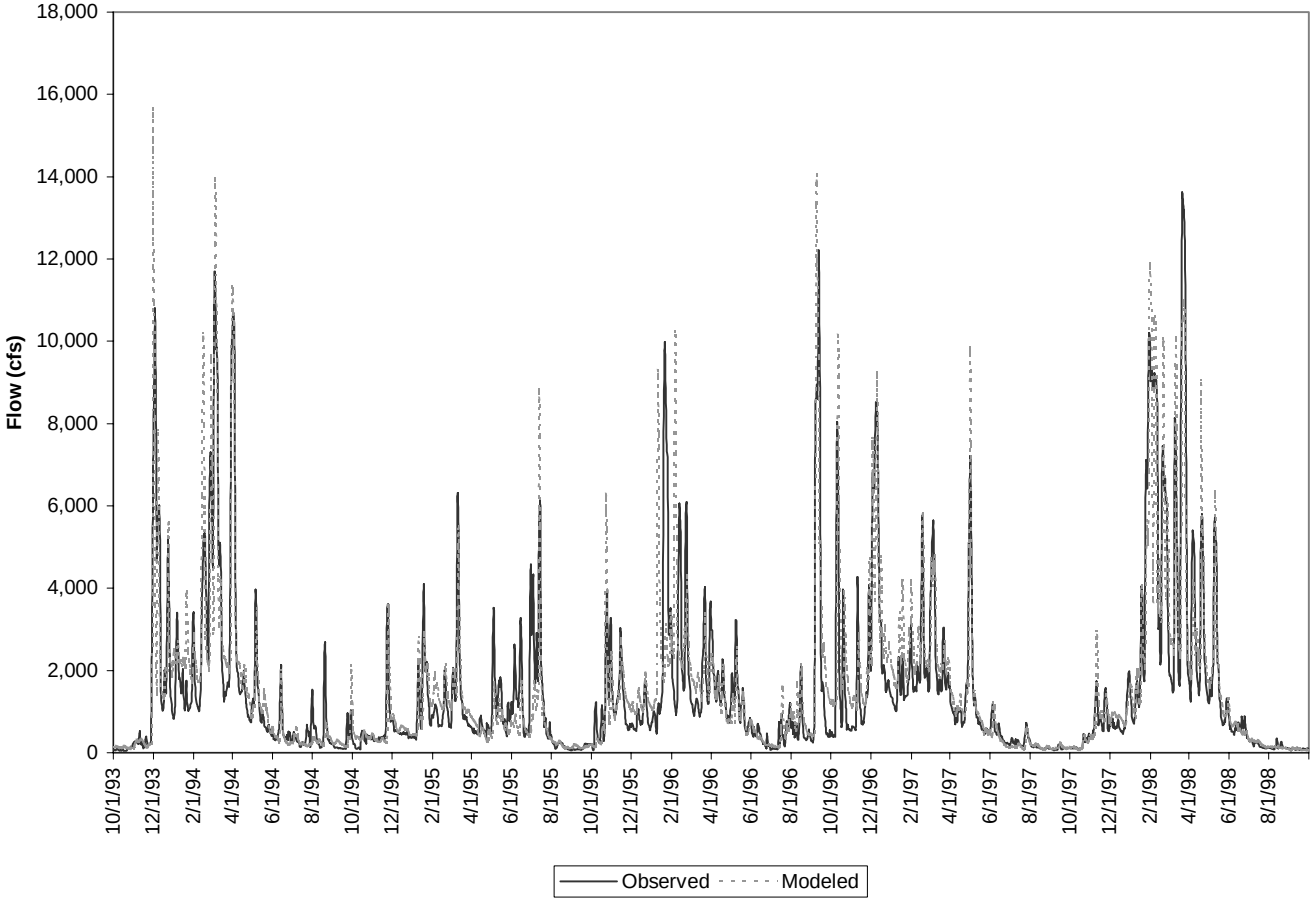

Figure C.29 Calibration results for period 10/1/1993 through 9/30/1998 at gage station USGS02041650 on Appomattox River (model segment 7, subshed 115)

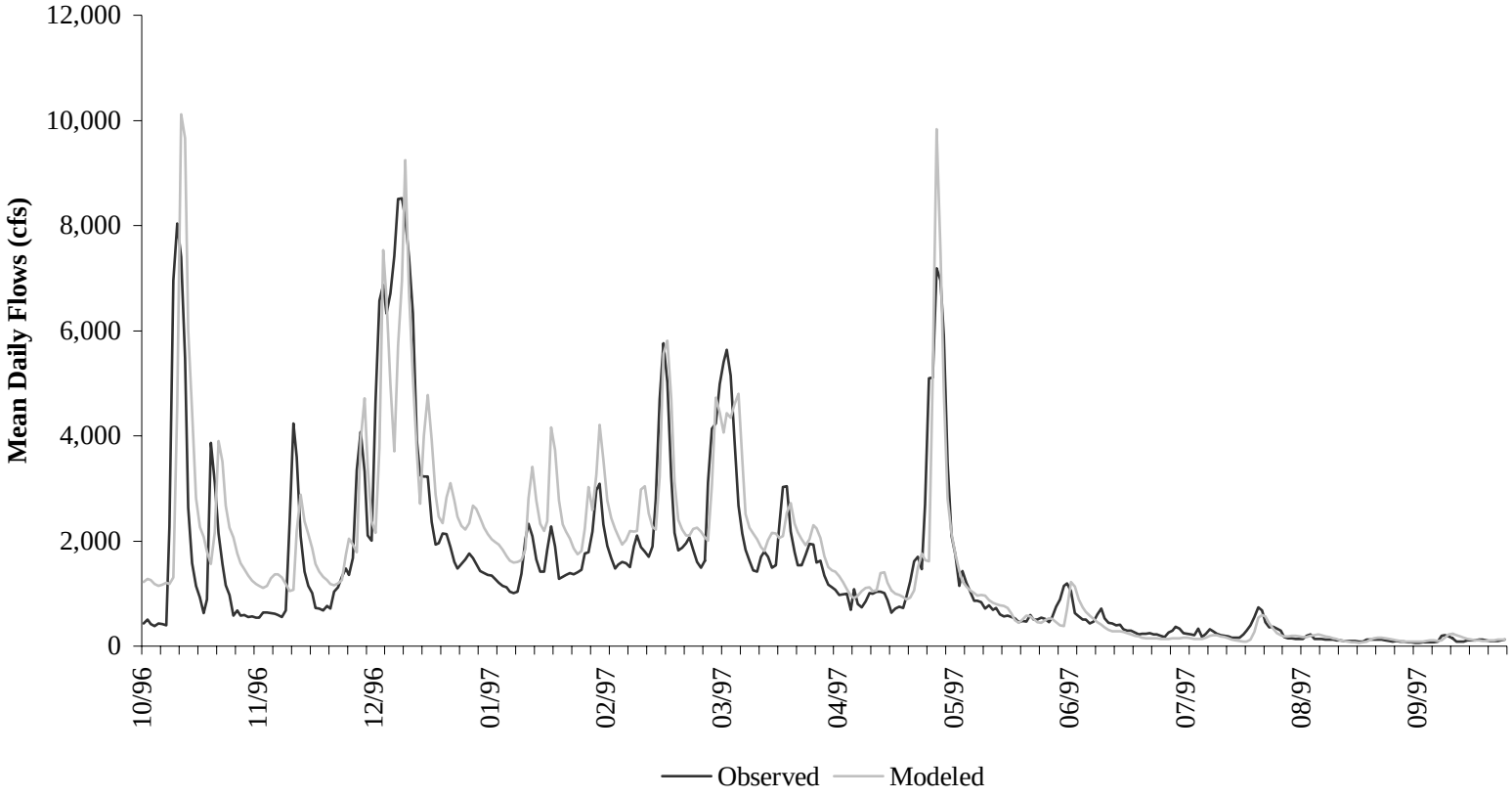

Figure C.30 Calibration results for water year period 10/01/96 through 09/30/97 for USGS Station 02041650.

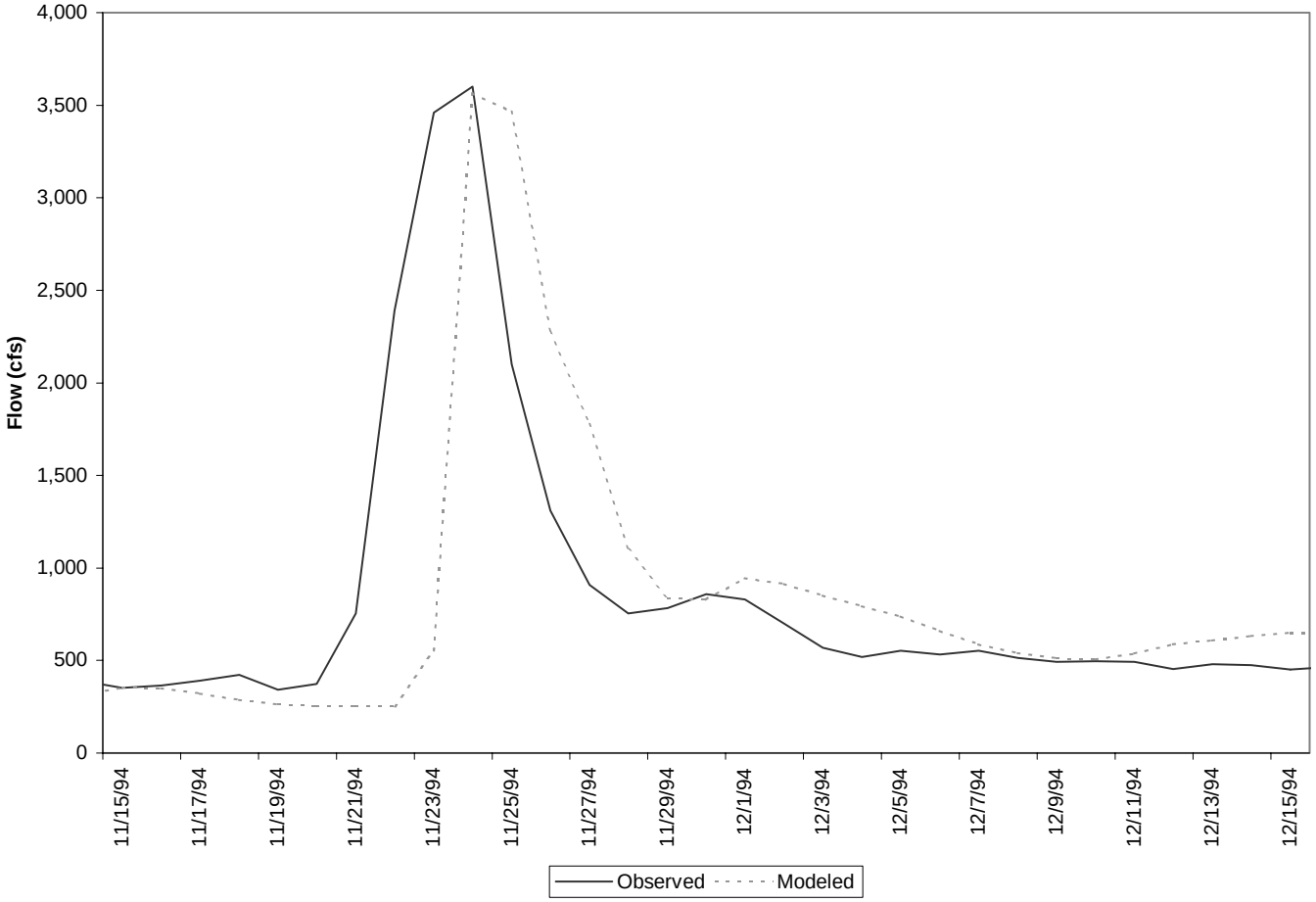

Figure C.31 Calibration results for a single storm event at gage station USGS02041650 on Appomattox River (model segment 7, subshed 115)

Table C.5 Hydrology validation criteria and model performance for period 10/1/1988 through 9/30/1993 at gaging station USGS02039000 on Buffalo Creek (model segment 1, subshed 20).

Criterion	Observed	Modeled	Error
Total In-stream Flow:	70.26	67.00	-4.64%
Upper 10% Flow Values:	27.02	24.87	-7.97%
Lower 50% Flow Values:	15.52	12.81	-17.42%
Winter Flow Volume	26.26	24.95	-5.01%
Spring Flow Volume	20.53	23.02	12.12%
Summer Flow Volume	10.03	8.35	-16.78%
Fall Flow Volume	13.43	10.68	-20.47%
Total Storm Volume	53.03	59.03	11.32%
Winter Storm Volume	21.99	22.96	4.42%
Spring Storm Volume	16.22	21.01	29.57%
Summer Storm Volume	5.74	6.38	11.29%
Fall Storm Volume	9.08	8.66	-4.57%

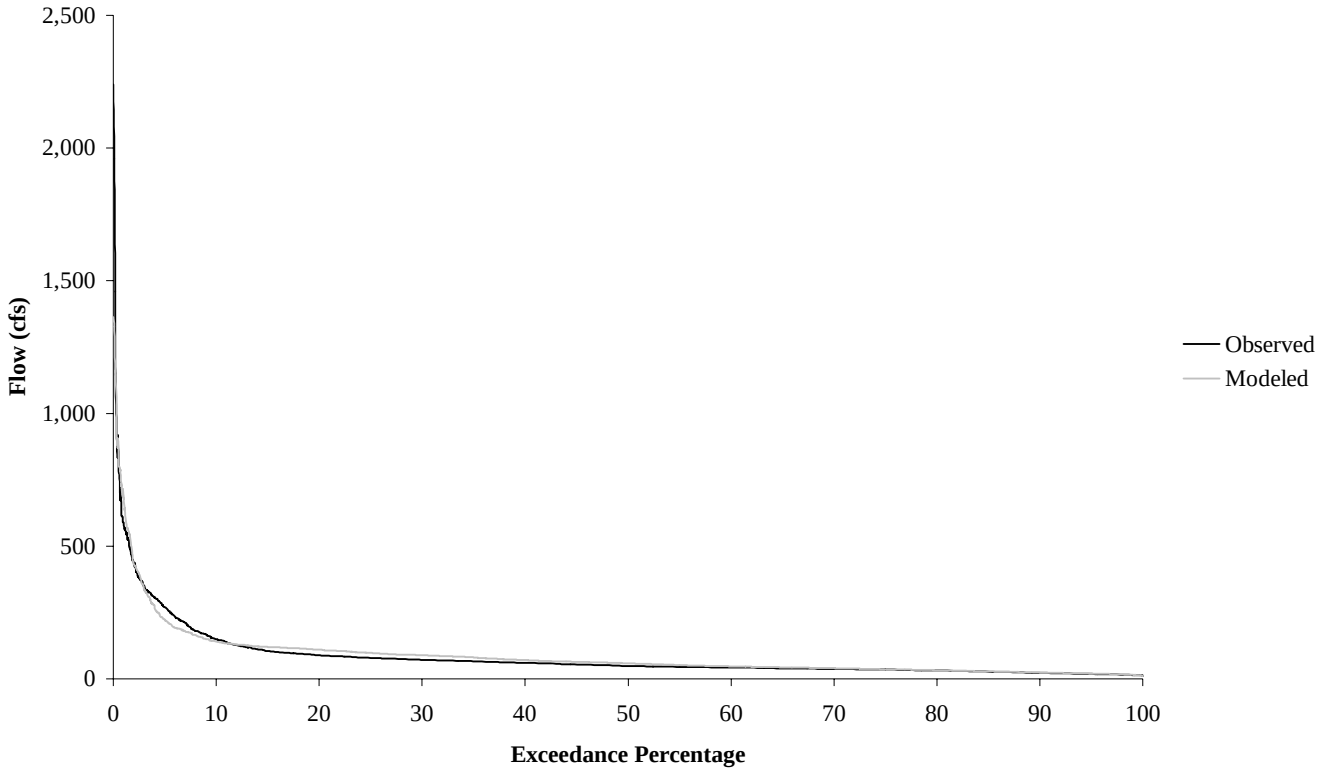

Figure C.32 Buffalo Creek flow duration at gage station USGS02039000 for validation period 10/1/1988 through 9/30/1993 (model segment 1, subshed 20).

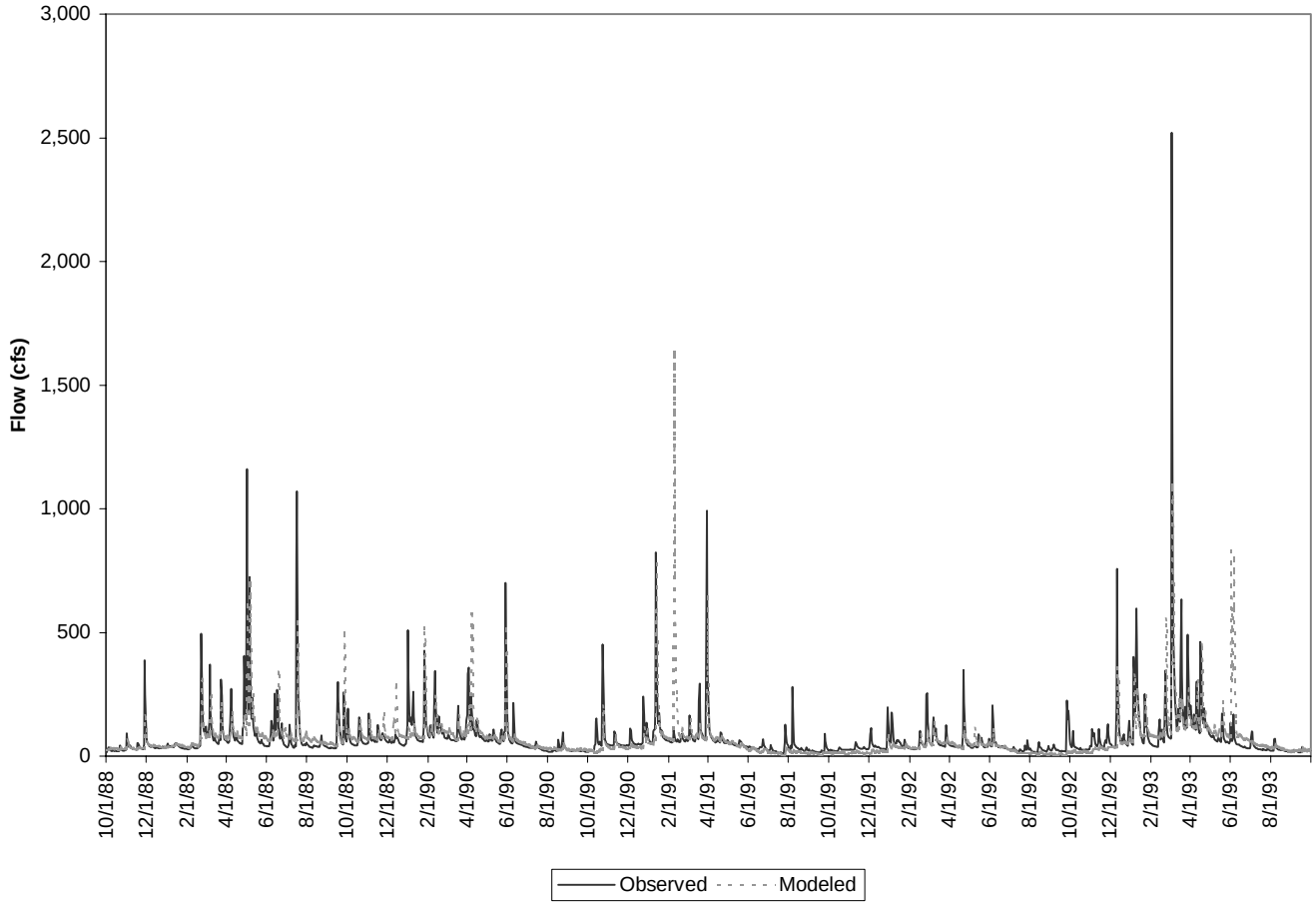

Figure C.33 Validation results for period 10/1/1988 through 9/30/1993 at gage station USGS02039000 on Buffalo Creek (model segment 1, subshed 20)

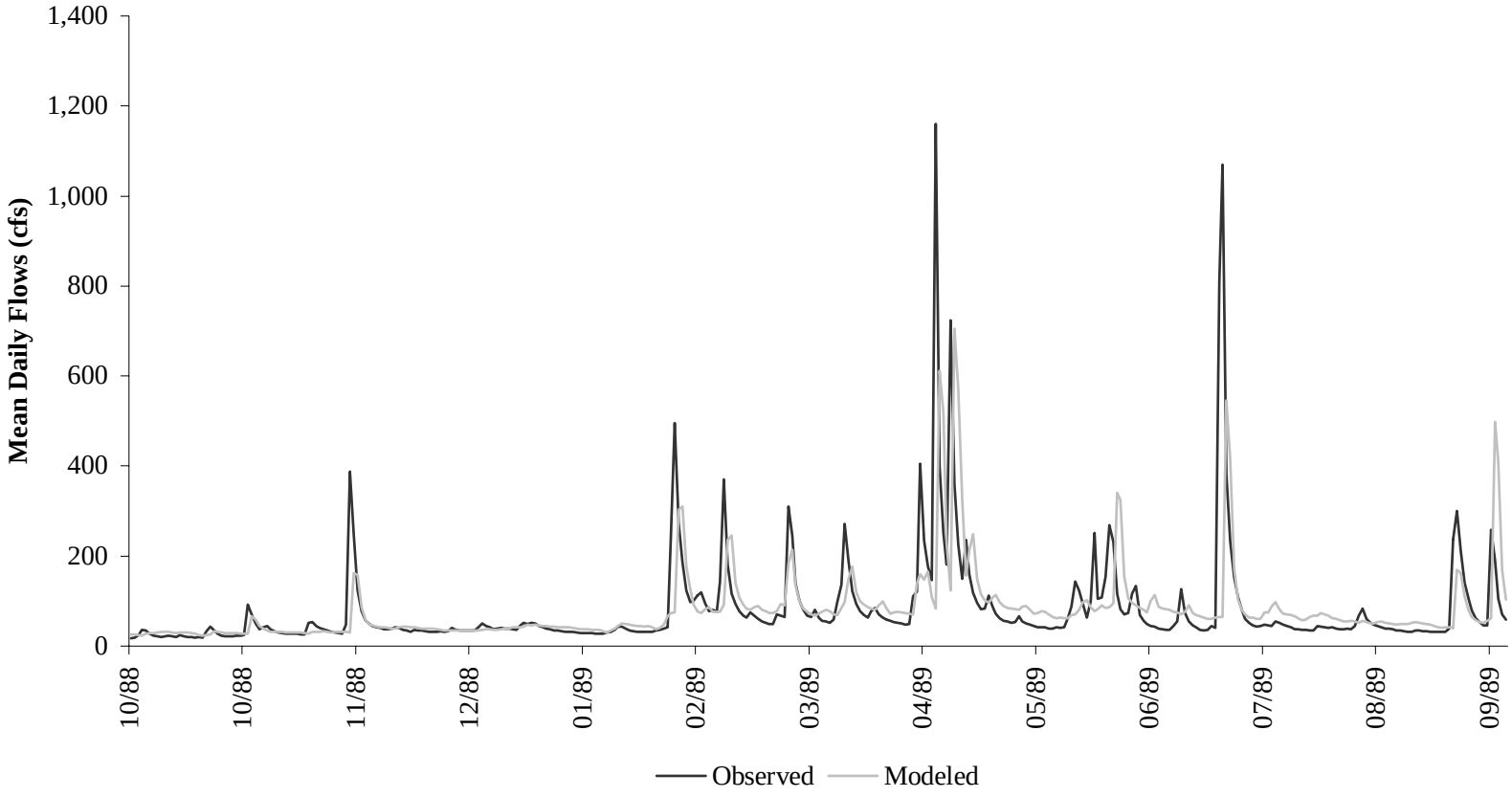

Figure C.34 Validation results for period 10/01/88 through 09/30/89 for USGS Station 02039000.

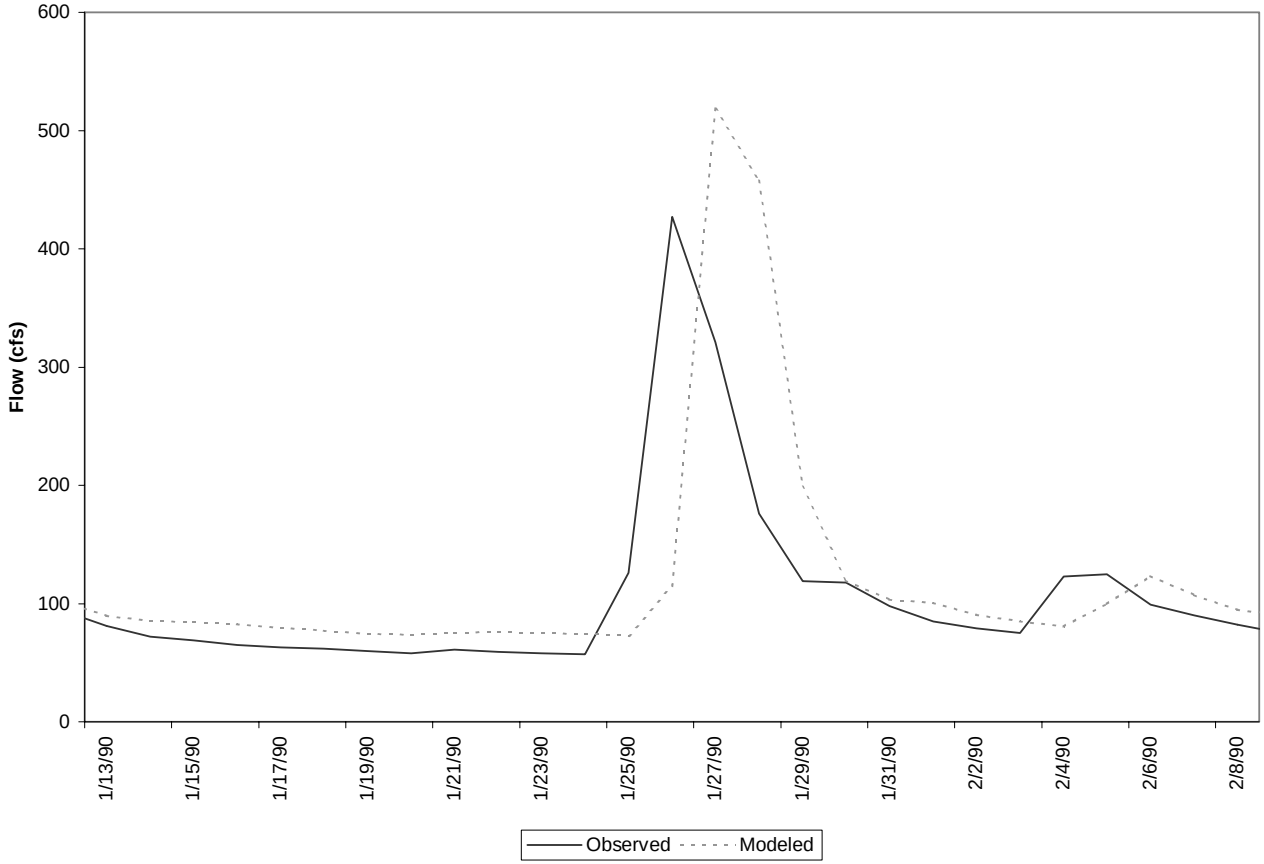

Figure C.35 Validation results for a single storm event at gage station USGS02039000 on Buffalo Creek (model segment 1, subshed 20)

Table C.6 Hydrology validation criteria and model performance for period 10/1/1988 through 9/30/1993 at gaging station USGS02040000 on Appomattox River (model segment 3, subshed 62).

Criterion	Observed	Modeled	Error
Total In-stream Flow:	66.82	69.19	3.54%
Upper 10% Flow Values:	28.15	28.08	-0.26%
Lower 50% Flow Values:	10.28	10.04	-2.34%
Winter Flow Volume	27.92	28.81	3.20%
Spring Flow Volume	21.13	23.17	9.68%
Summer Flow Volume	7.40	6.18	-16.58%
Fall Flow Volume	10.37	11.03	6.32%
Total Storm Volume	58.20	63.74	9.52%
Winter Storm Volume	25.79	27.46	6.49%
Spring Storm Volume	18.98	21.81	14.93%
Summer Storm Volume	5.23	4.82	-7.88%
Fall Storm Volume	8.20	9.65	17.66%

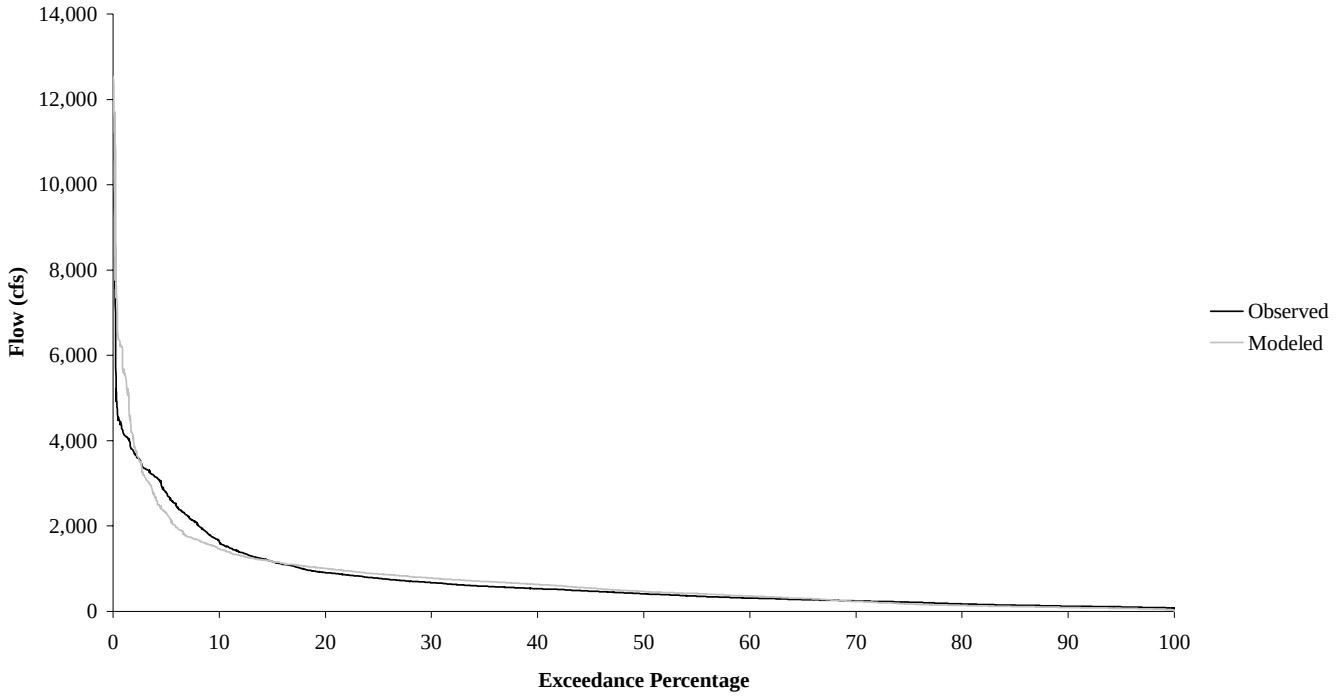

Figure C.36 Appomattox River flow duration at gage station USGS02040000 for validation period 10/1/1988 through 9/30/1993 (model segment 3, subshed 62).

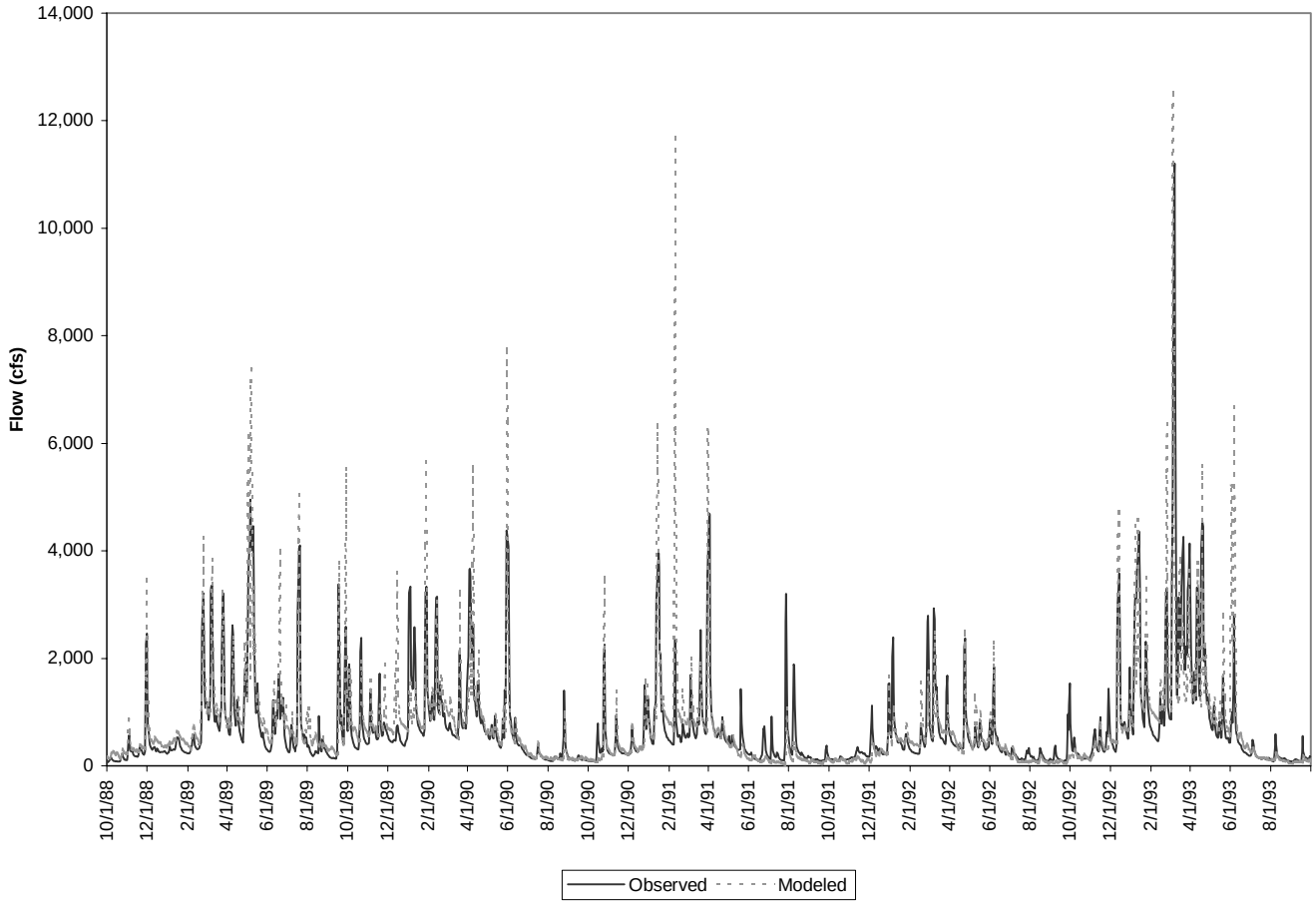

Figure C.37 Validation results for period 10/1/1988 through 9/30/1993 at gage station USGS02040000 on Appomattox River (model segment 3, subshed 62)

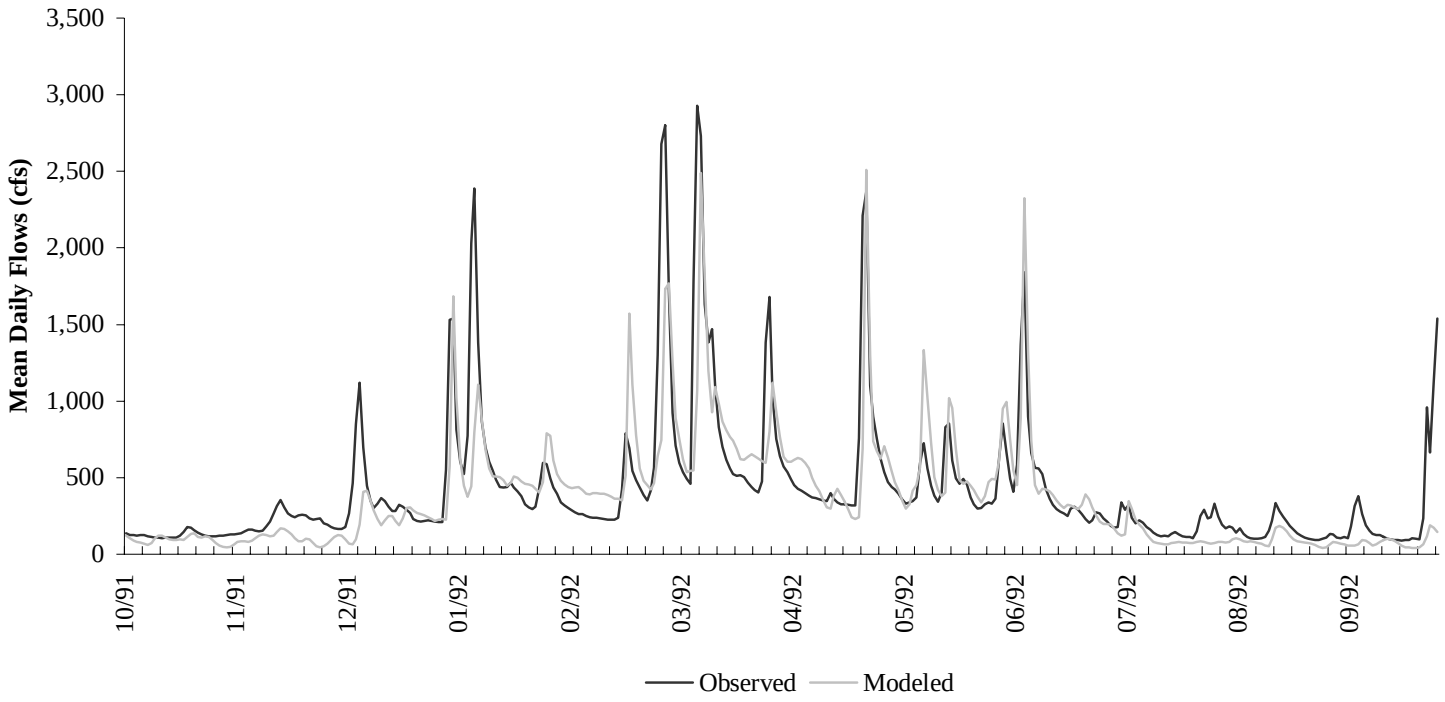

Figure C.38 Validation results for water year period 10/01/91 through 09/30/92 for USGS Station 02040000.

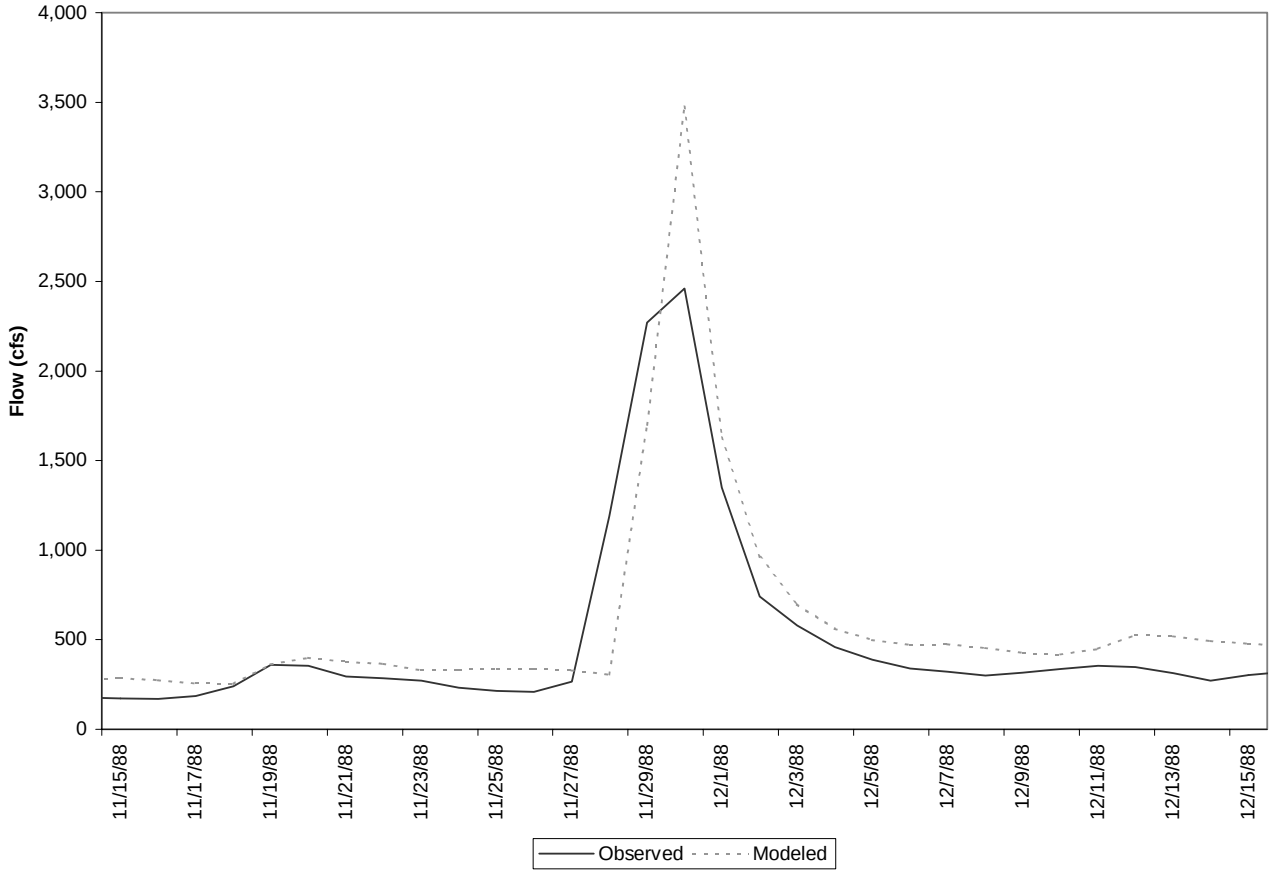

Figure C.39 Validation results for a single storm event at gage station USGS02040000 on Appomattox River (model segment 3, subshed 62)

Table C.7 Hydrology validation criteria and model performance for period 10/1/1988 through 9/30/1993 at gaging station USGS02041000 on Deep Creek (model segment 5, subshed 95).

Criterion	Observed	Modeled	Error
Total In-stream Flow:	40.17	43.68	8.76%
Upper 10% Flow Values:	19.53	18.77	-3.87%
Lower 50% Flow Values:	4.88	5.07	3.76%
Winter Flow Volume	19.14	20.20	5.54%
Spring Flow Volume	12.59	14.90	18.43%
Summer Flow Volume	3.00	2.37	-21.21%
Fall Flow Volume	5.44	6.21	14.27%
Total Storm Volume	39.48	43.52	10.23%
Winter Storm Volume	18.97	20.16	6.28%
Spring Storm Volume	12.41	14.86	19.74%
Summer Storm Volume	2.84	2.33	-17.95%
Fall Storm Volume	5.27	6.17	17.25%

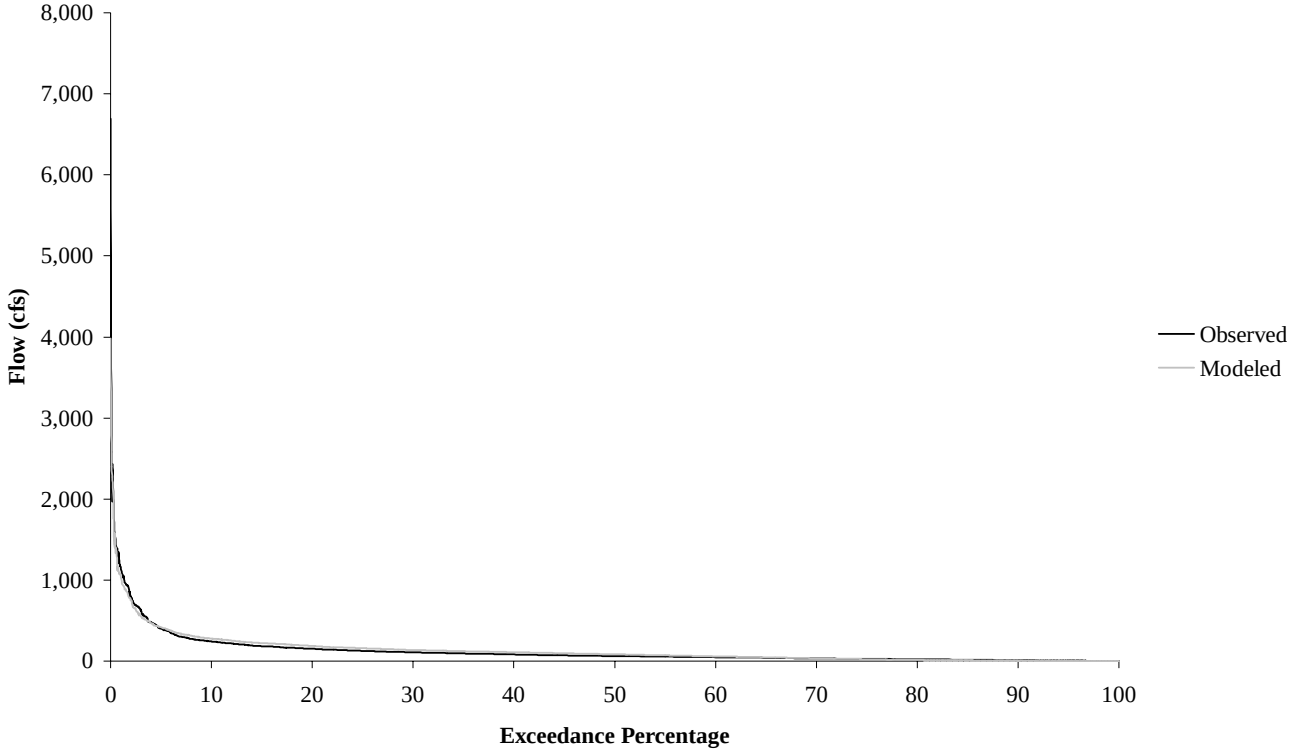

Figure C.40 Deep Creek flow duration at gage station USGS02041000 for validation period 10/1/1988 through 9/30/1993 (model segment 5, subshed 95).

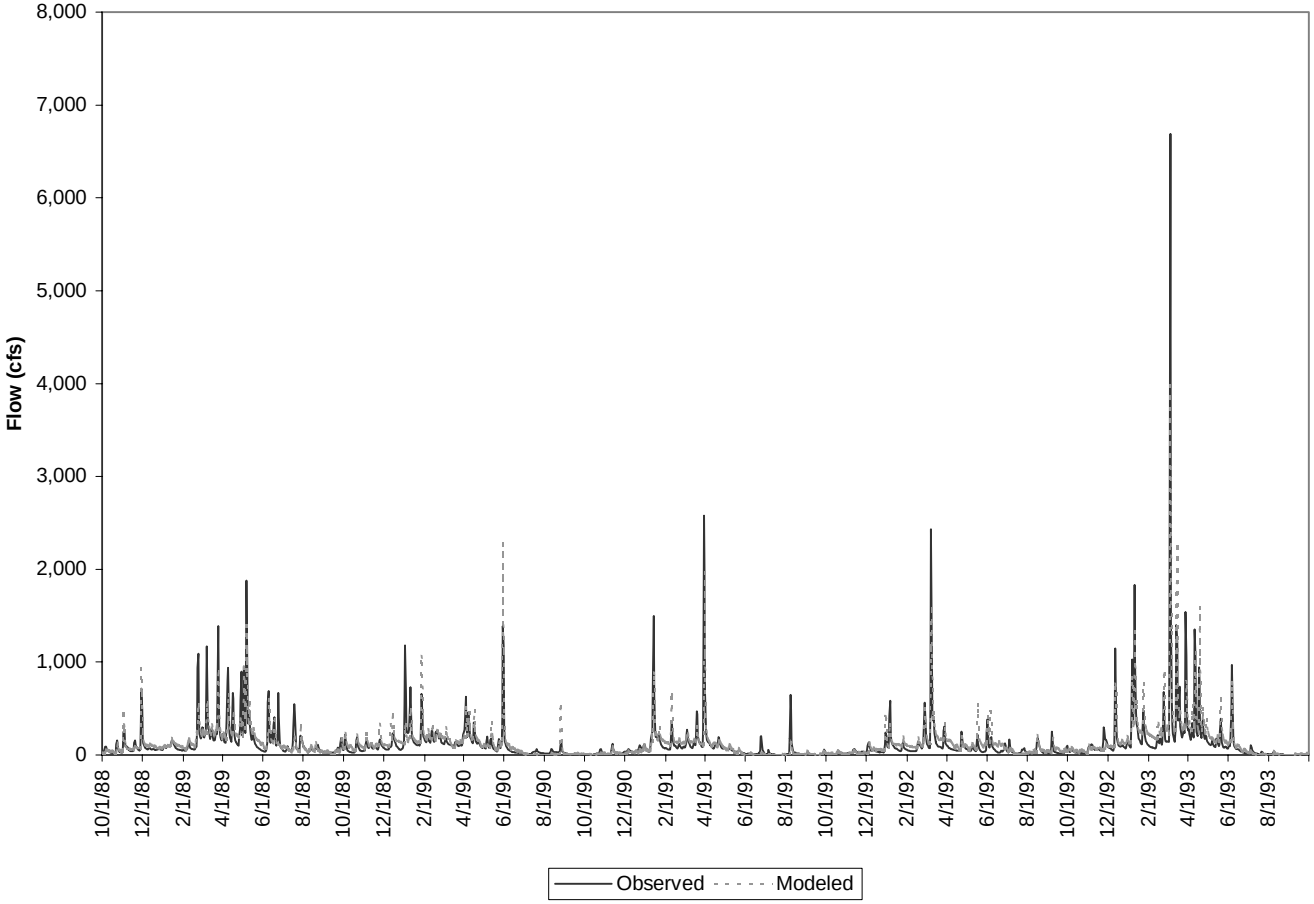

Figure C.41 Validation results for period 10/1/1988 through 9/30/1993 at gage station USGS02041000 on Deep Creek (model segment 5, subshed 95)

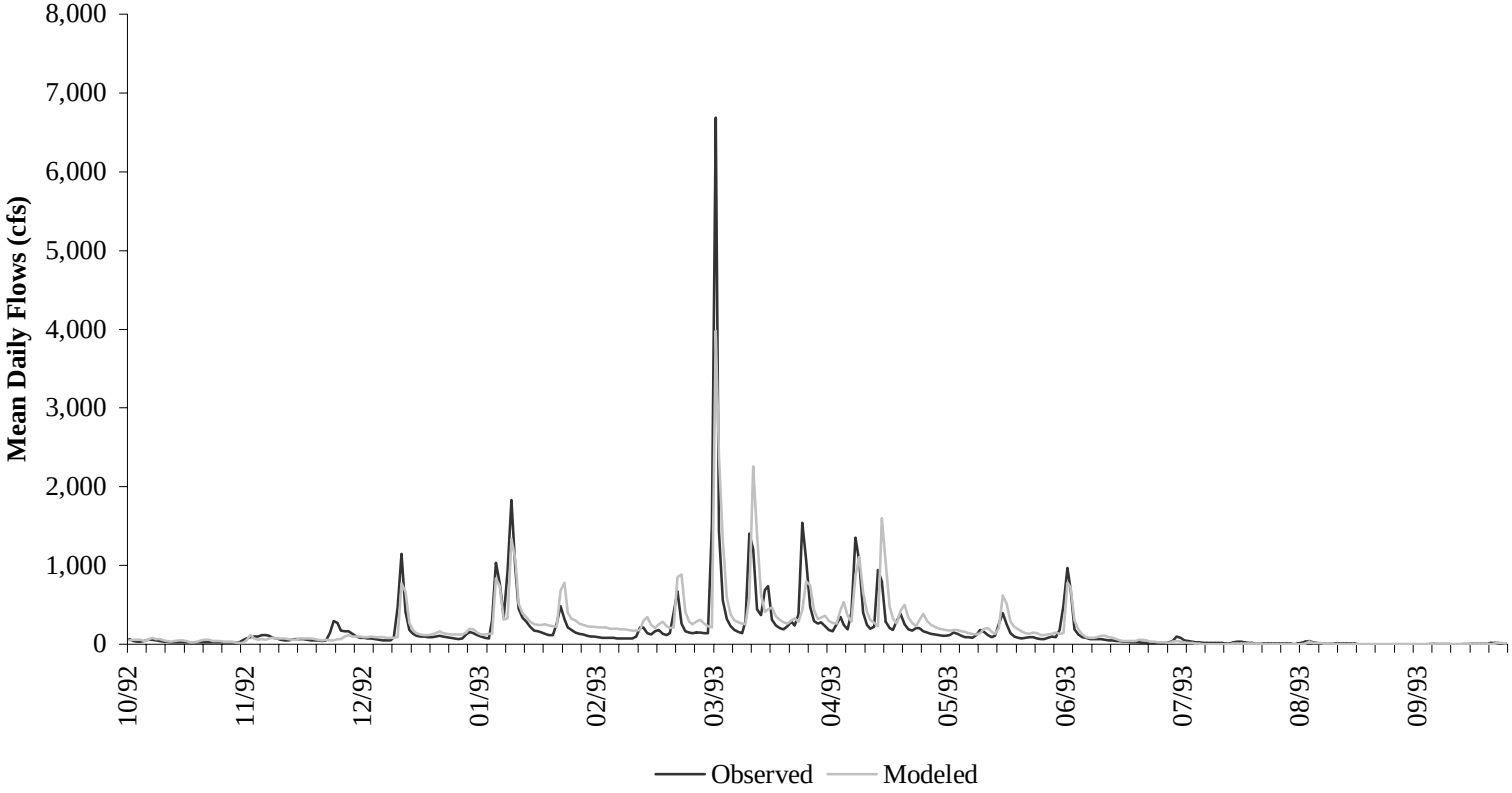

Figure C.42 Validation results for water year period 10/01/92 through 09/30/93 for USGS Station 02041000.

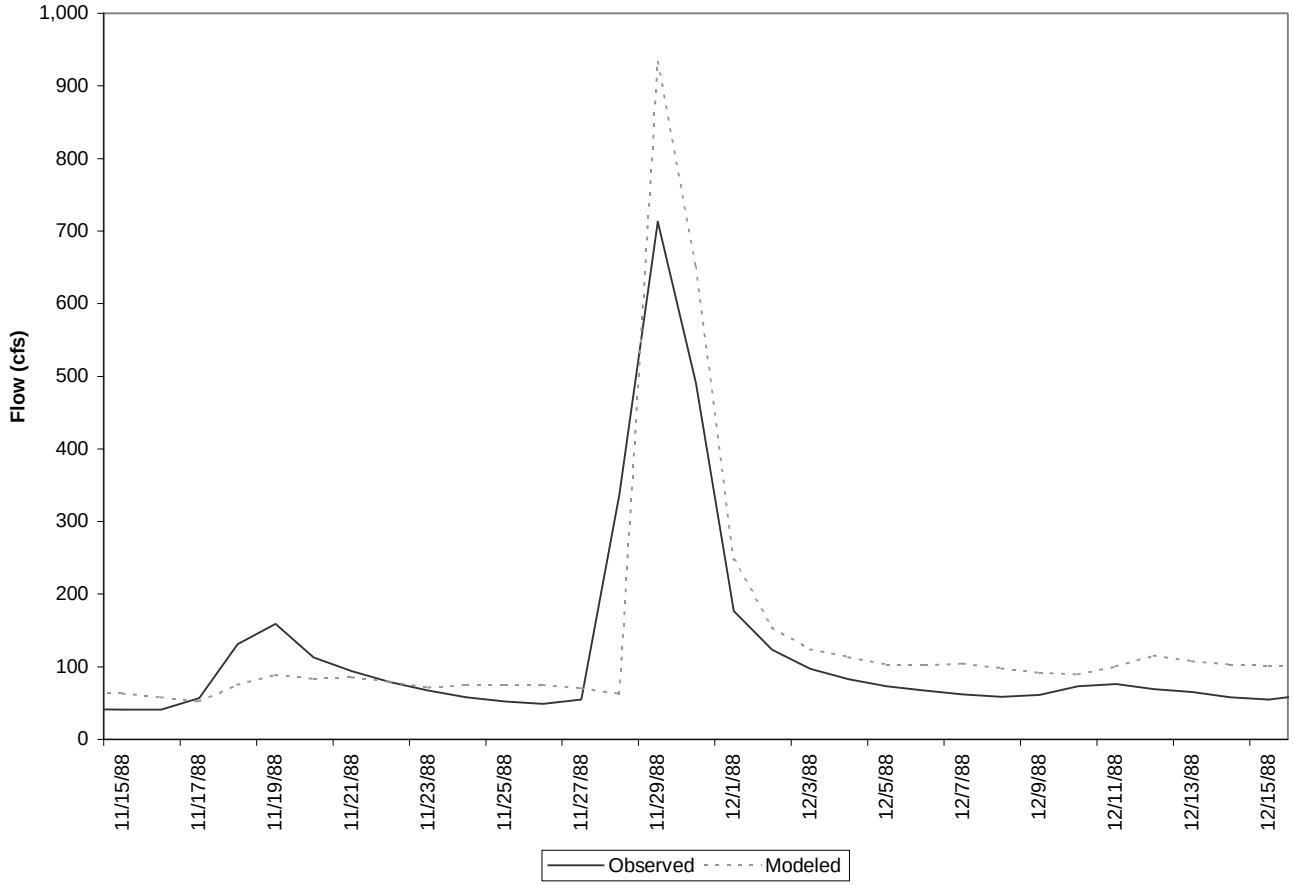

Figure C.43 Validation results for a single storm event at gage station USGS02041000 on Deep Creek (model segment 5, subshed 95)

Table C.8 Hydrology validation criteria and model performance for period 10/1/1988 through 9/30/1993 at gaging station USGS02041650 on Appomattox River (model segment 7, subshed 115).

Criterion	Observed	Modeled	Error
Total In-stream Flow:	58.26	58.93	1.16%
Upper 10% Flow Values:	26.00	23.06	-11.32%
Lower 50% Flow Values:	7.68	7.66	-0.27%
Winter Flow Volume	26.07	26.08	0.04%
Spring Flow Volume	19.39	20.32	4.78%
Summer Flow Volume	4.94	3.99	-19.27%
Fall Flow Volume	7.86	8.55	8.79%
Total Storm Volume	53.31	54.97	3.11%
Winter Storm Volume	24.84	25.09	1.03%
Spring Storm Volume	18.15	19.33	6.47%
Summer Storm Volume	3.72	3.00	-19.20%
Fall Storm Volume	6.61	7.55	14.26%

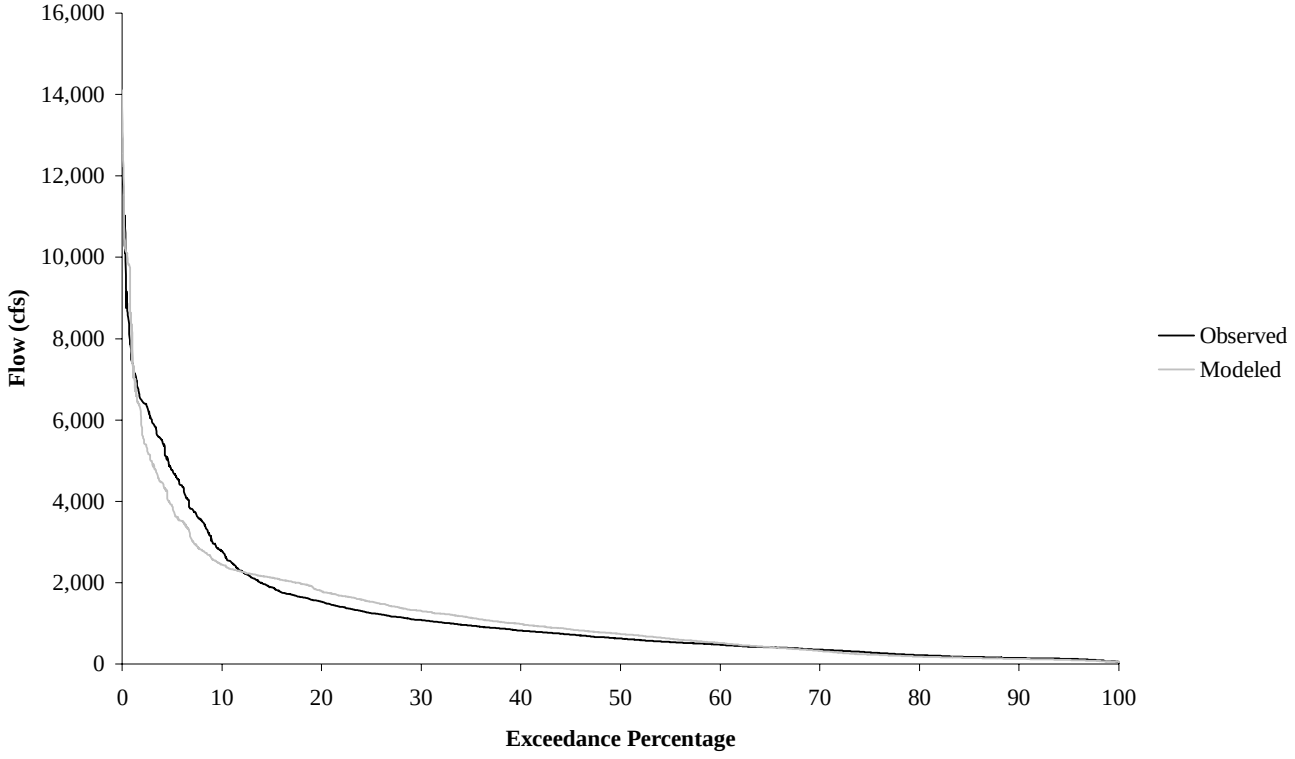

Figure C.44 Appomattox River flow duration at gage station USGS02041650 for validation period 10/1/1988 through 9/30/1993 (model segment 7, subshed 115).

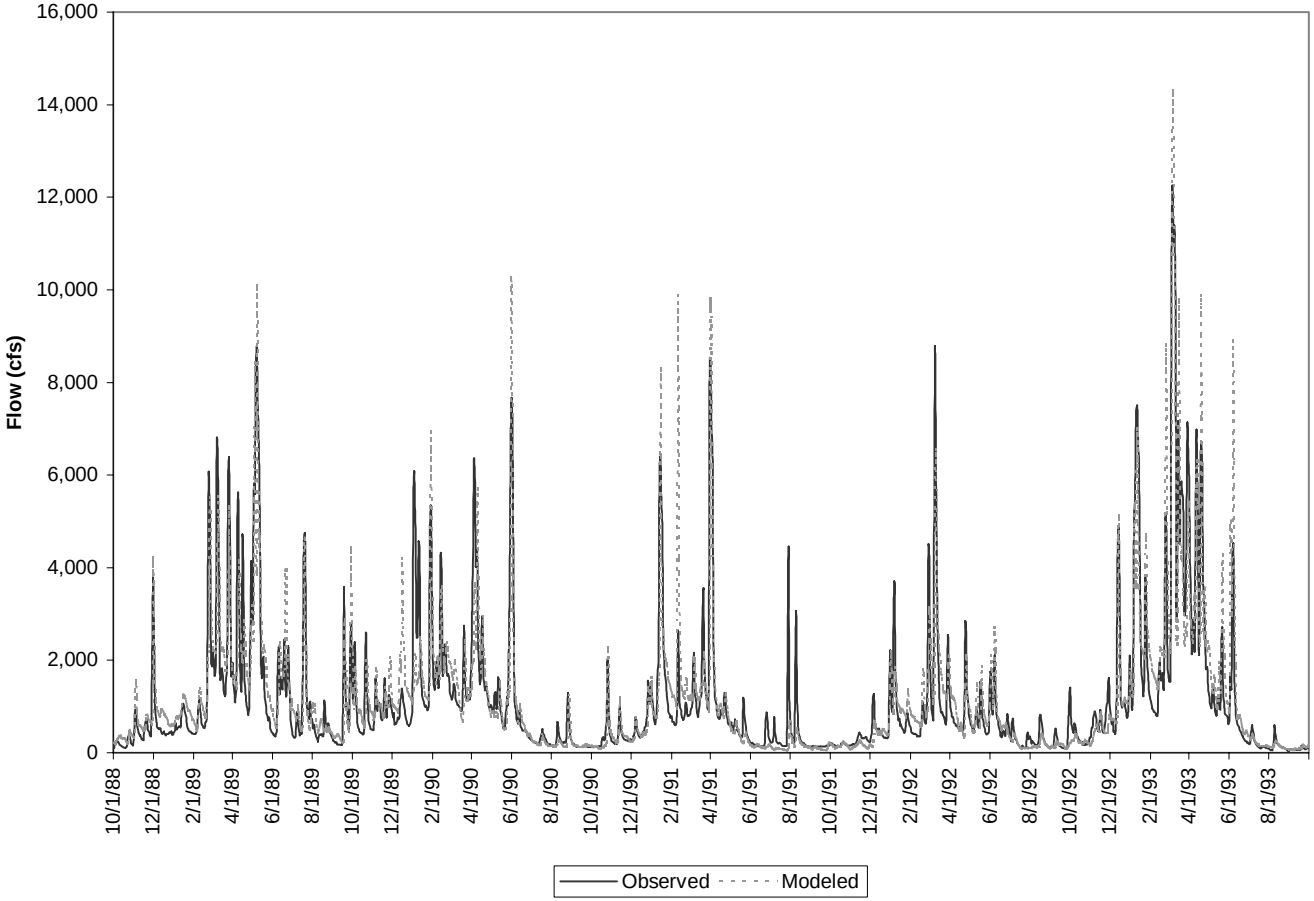

Figure C.45 Validation results for period 10/1/1988 through 9/30/1993 at gage station USGS02041650 on Appomattox River (model segment 7, subshed 115)

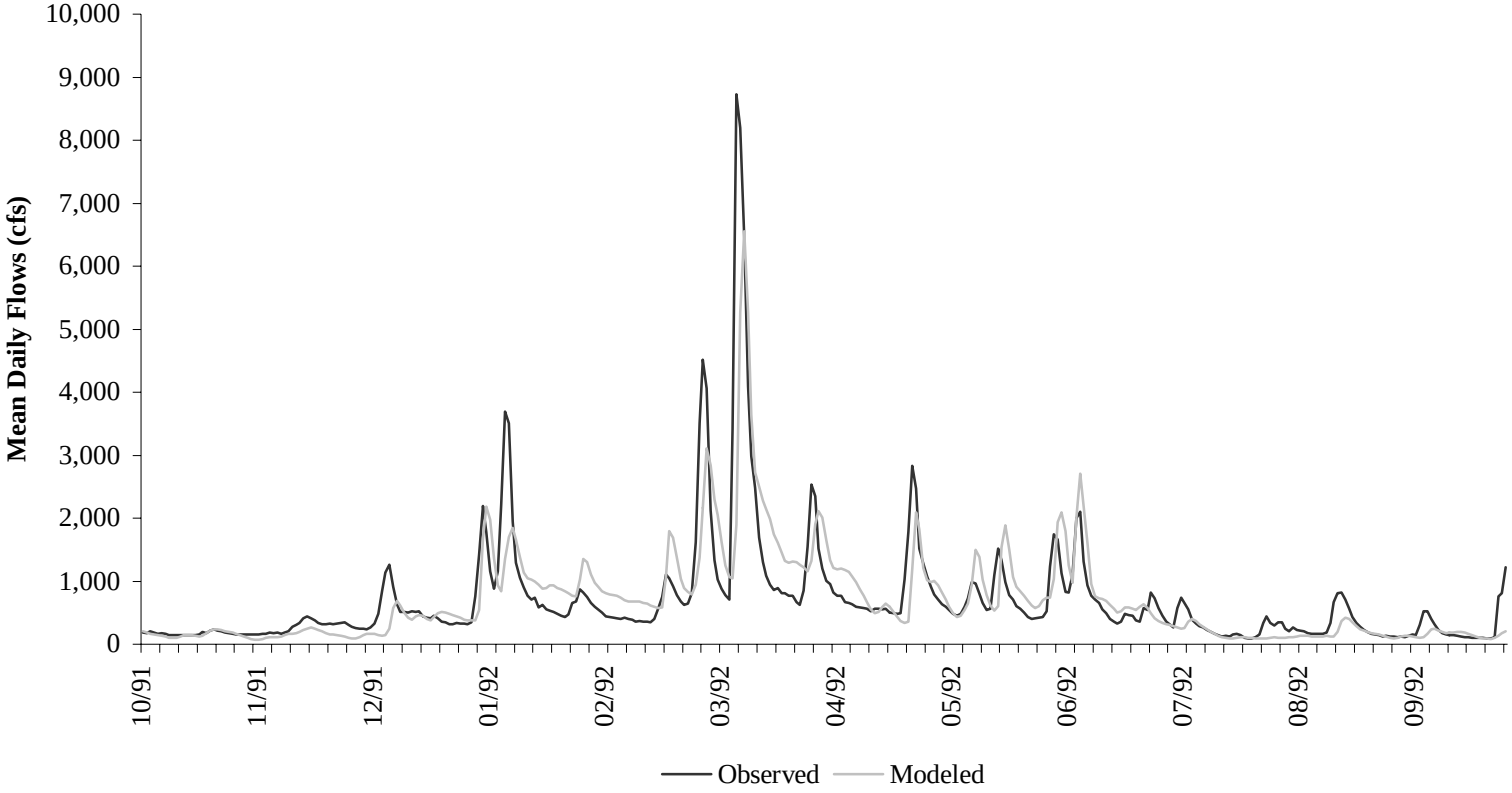

Figure C.46 Validation results for water year period 10/01/91 through 09/30/92 for USGS Station 02041650.

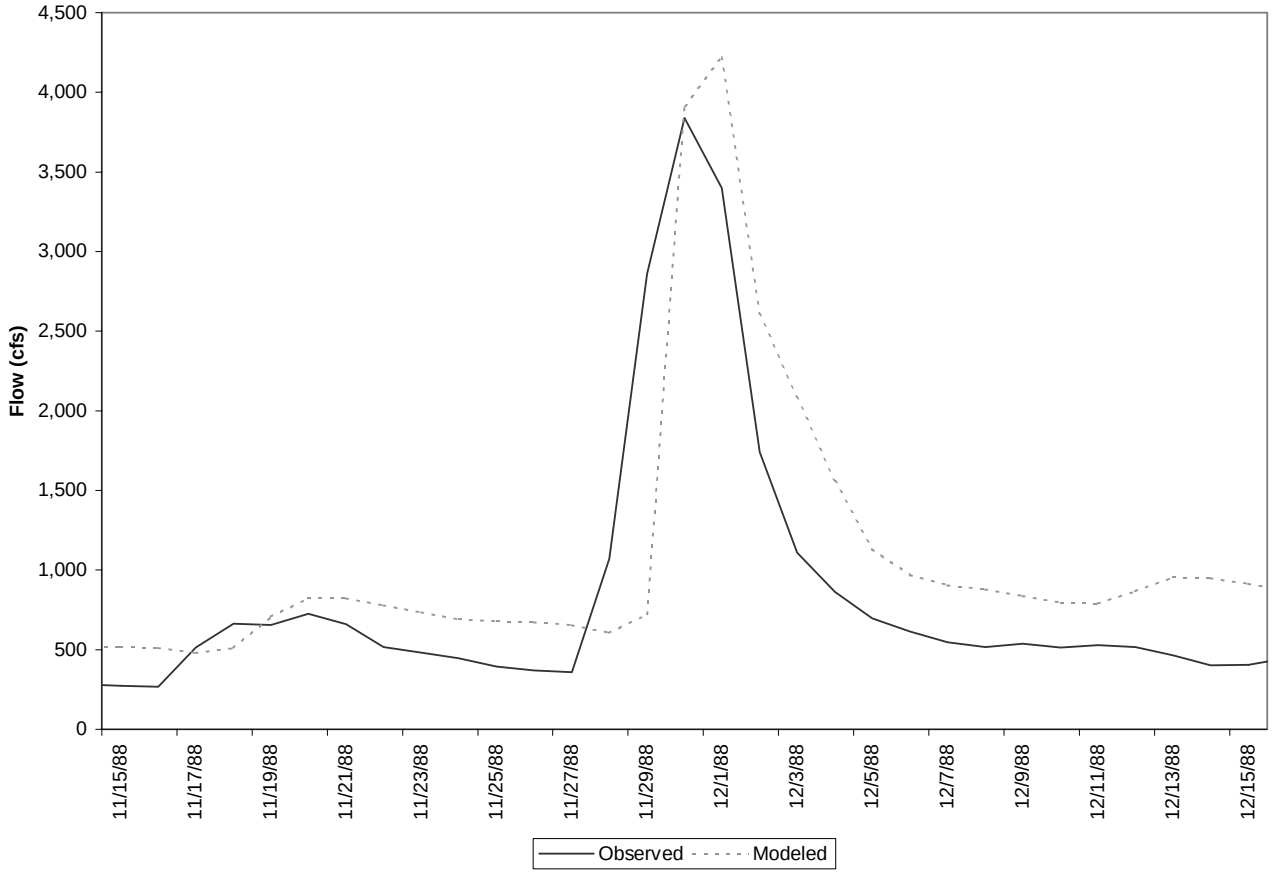

Figure C.47 Validation results for a single storm event at gage station USGS02041650 on Appomattox River (model segment 7, subshed 115)

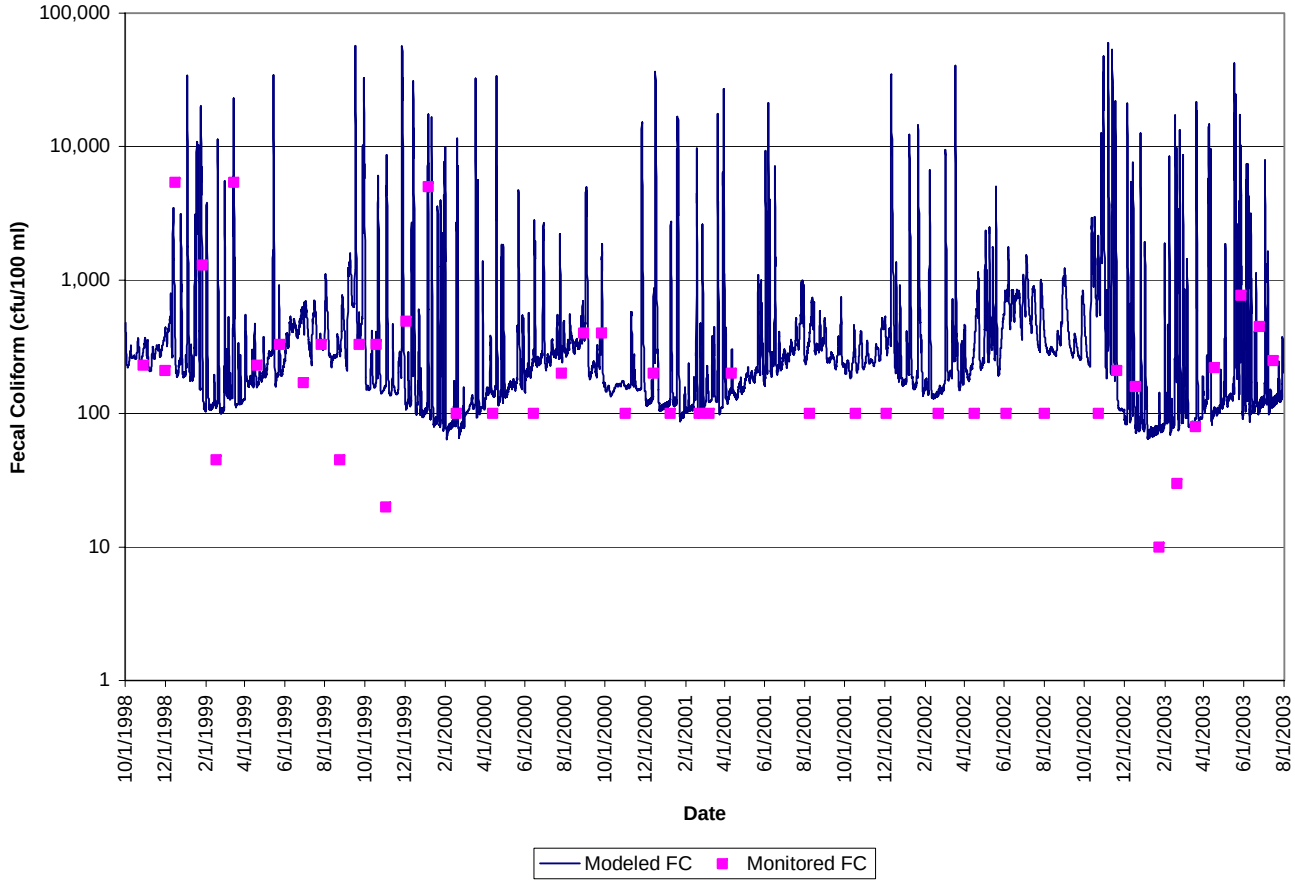

Figure C.48 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 1, subshed 11

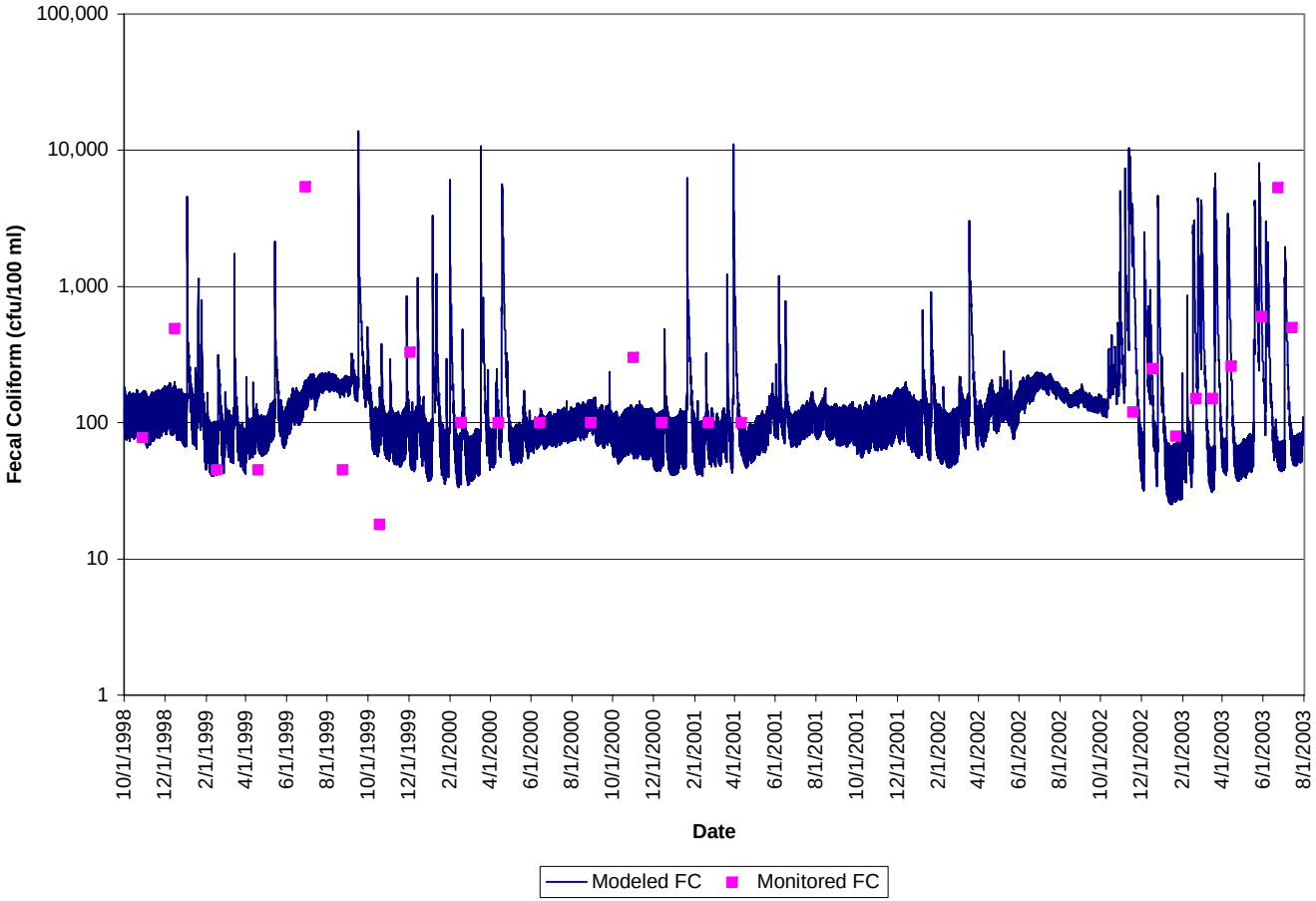

Figure C.49 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 1, subshed 17

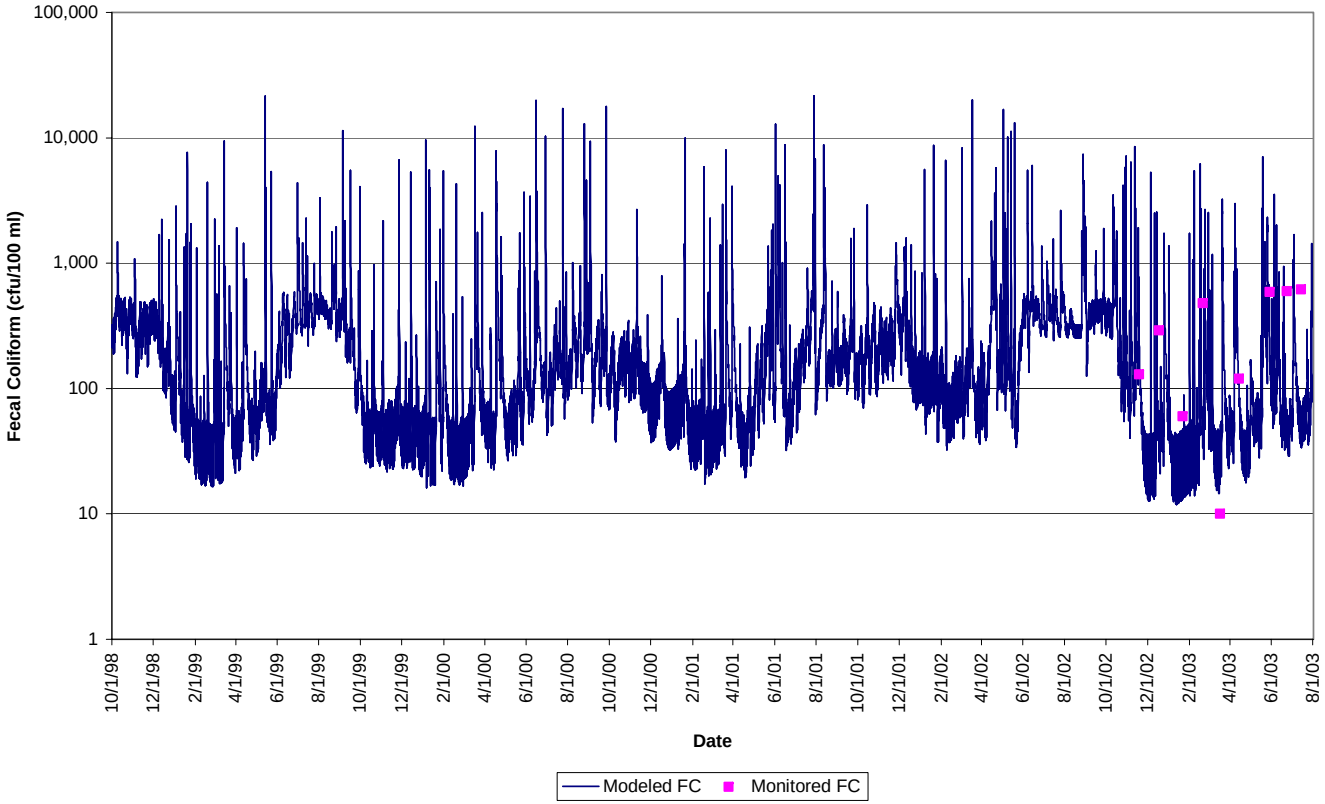

Figure C.50 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 2, subshed 27

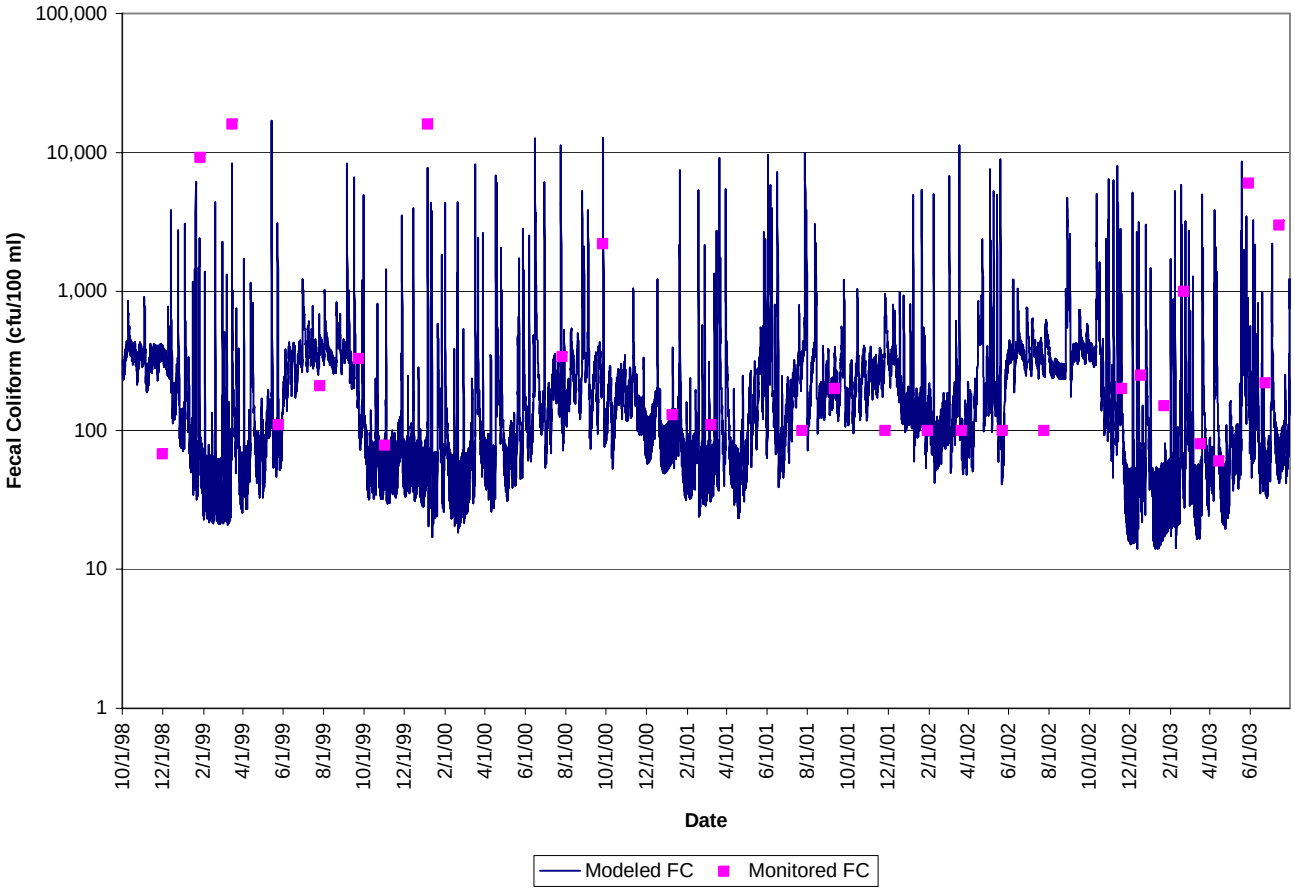

Figure C.51 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 2, subshed 28

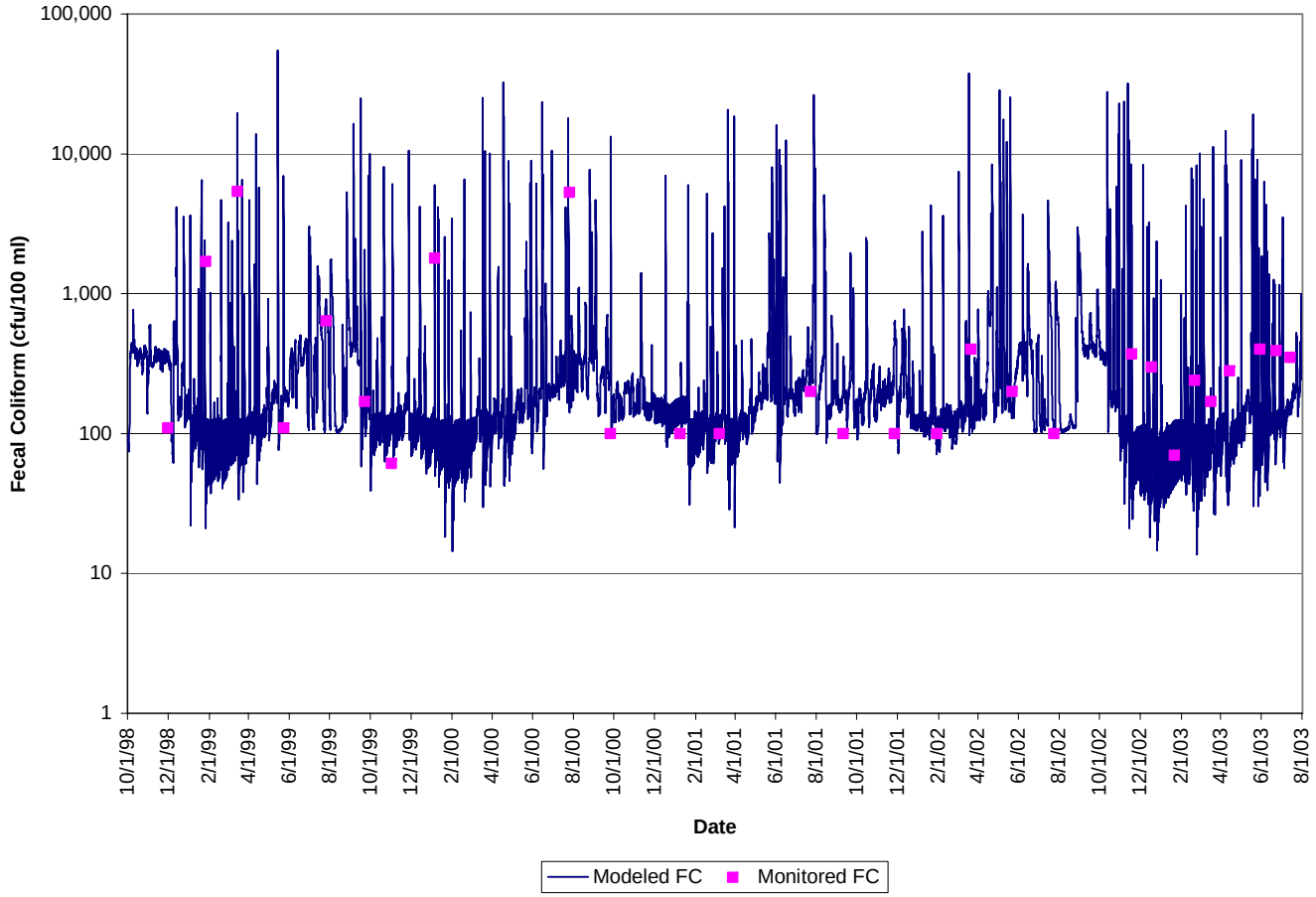

Figure C.52 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 2, subshed 32

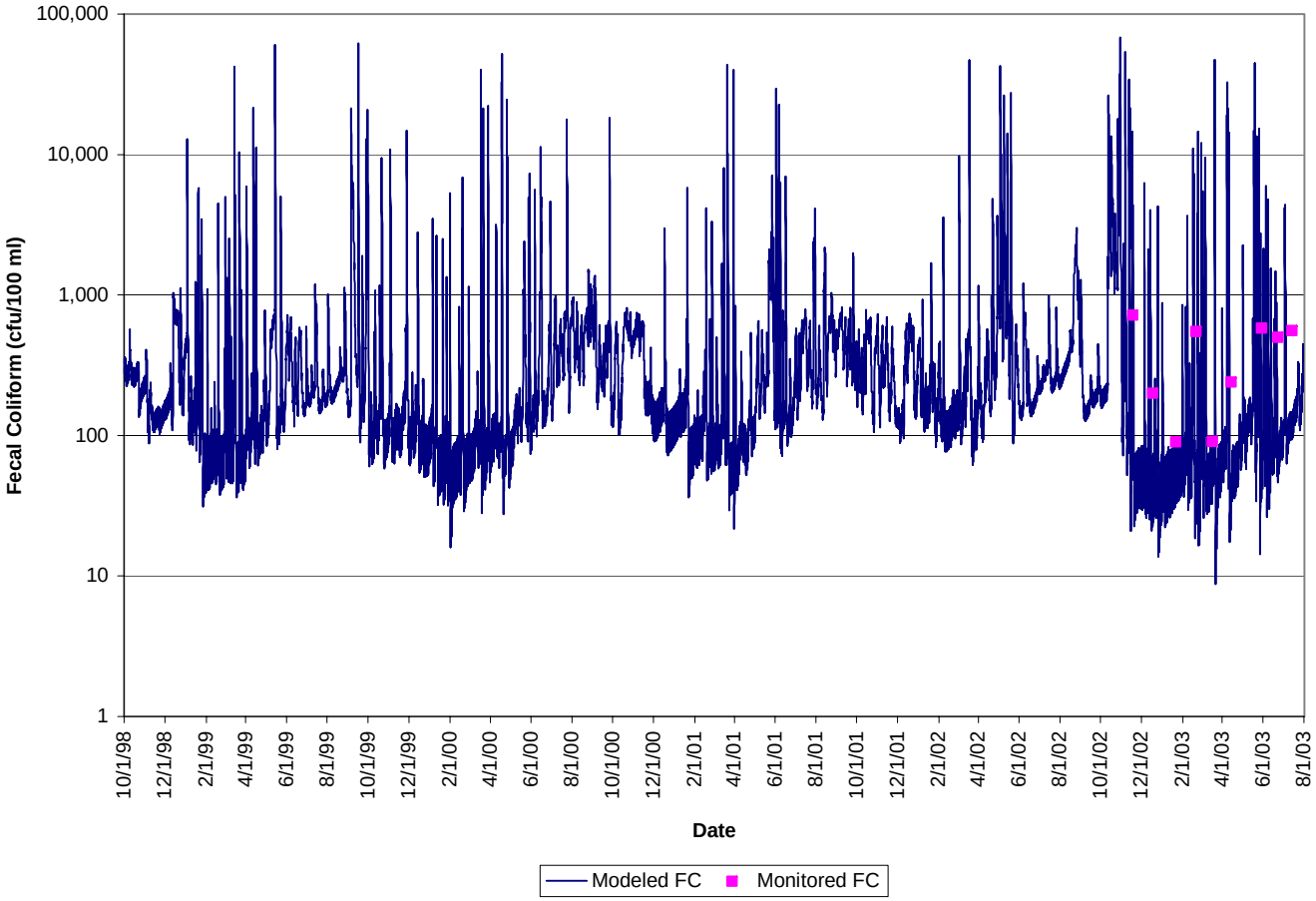

Figure C.53 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 2, subshed 34

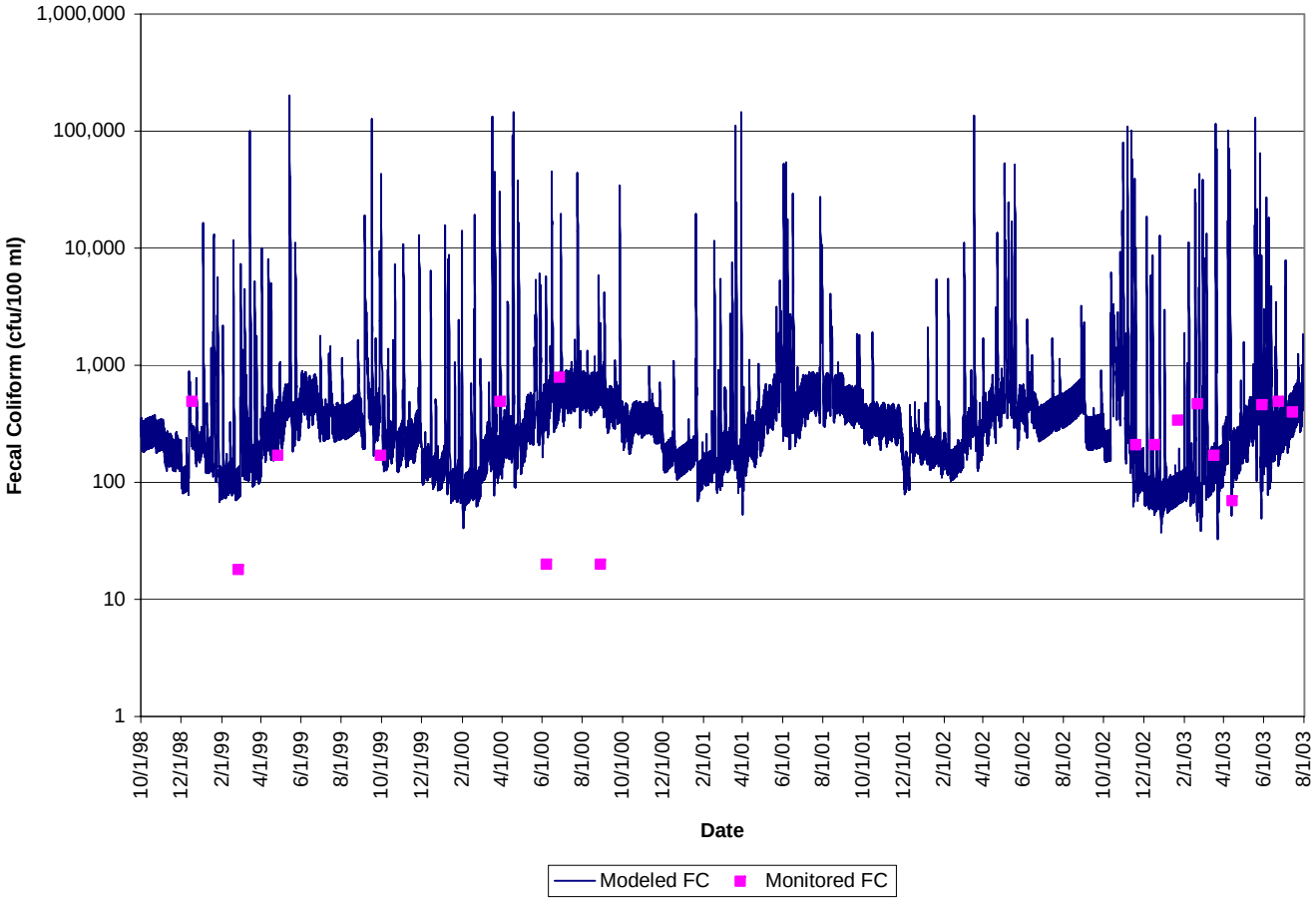

Figure C.54 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 2, subshed 35

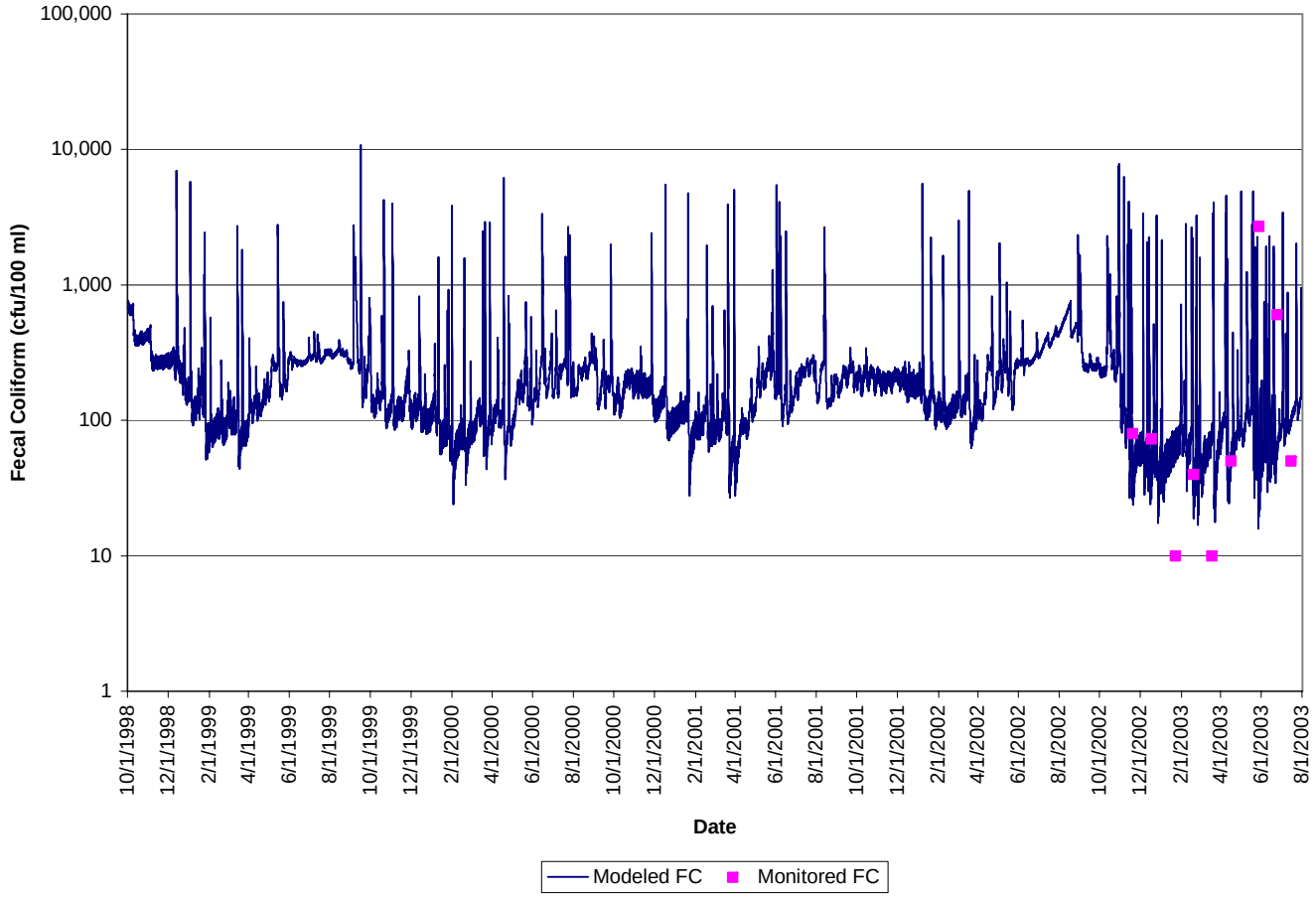

Figure C.55 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 3, subshed 43

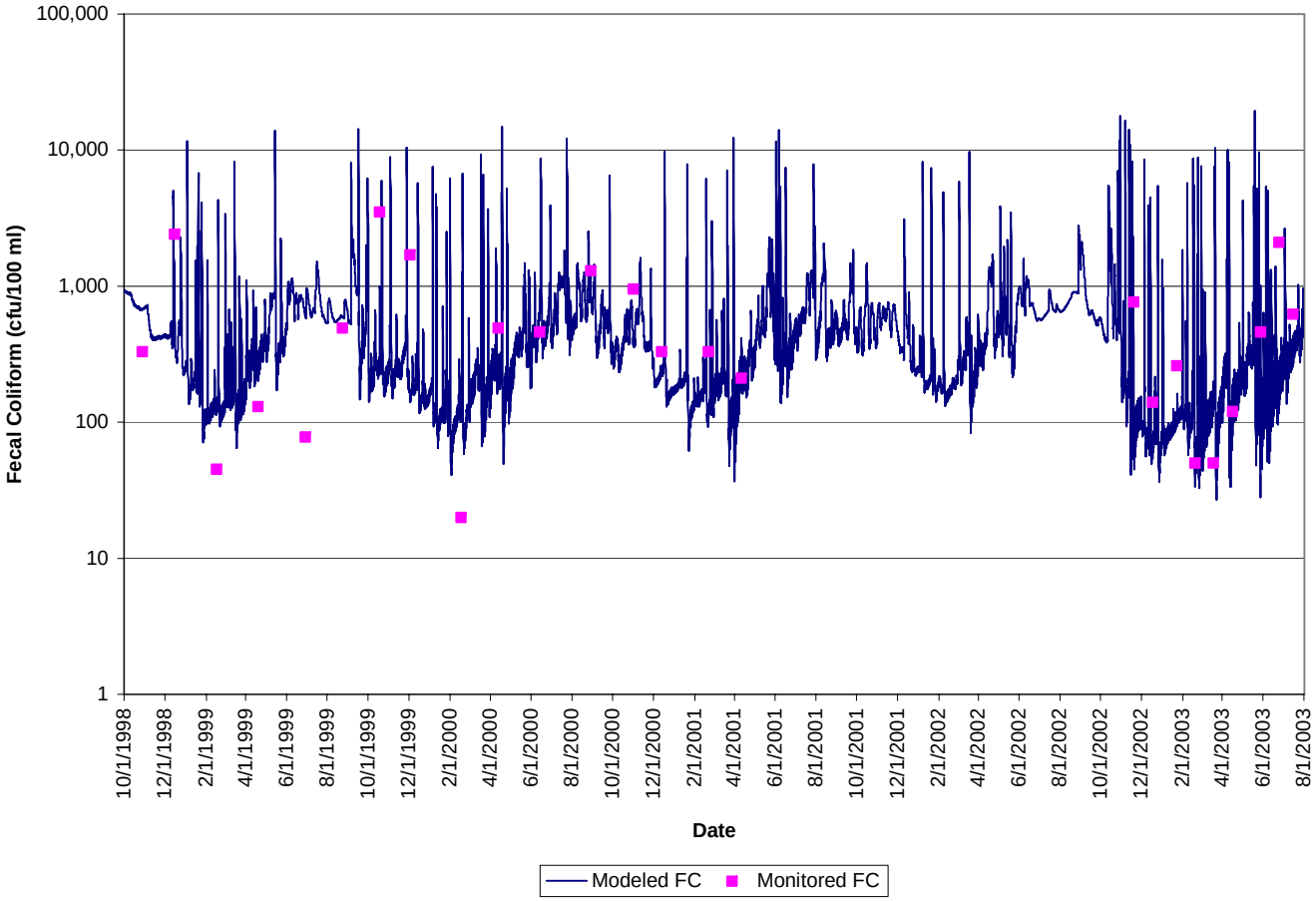

Figure C.56 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 3, subshed 46

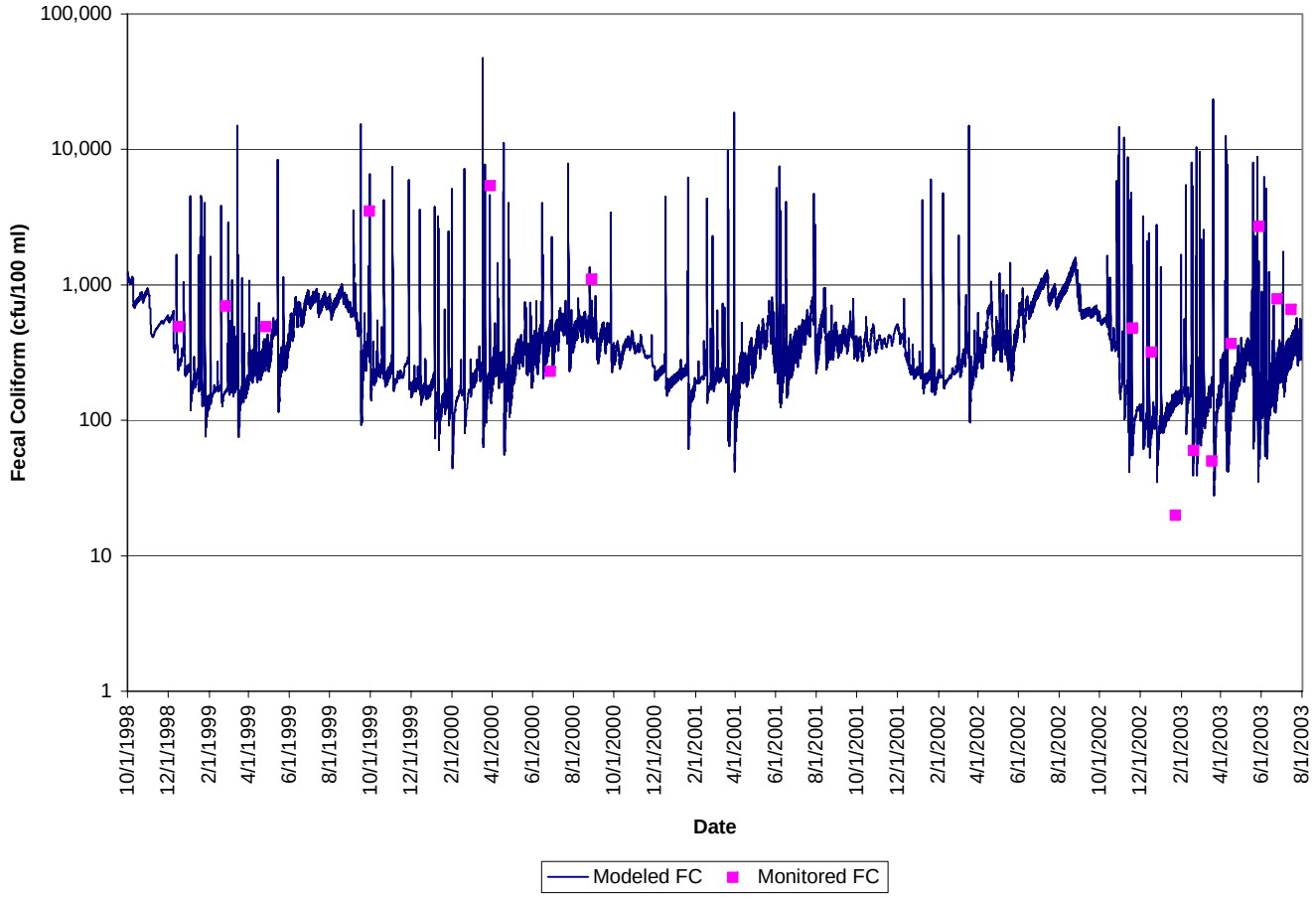

Figure C.57 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 3, subshed 48

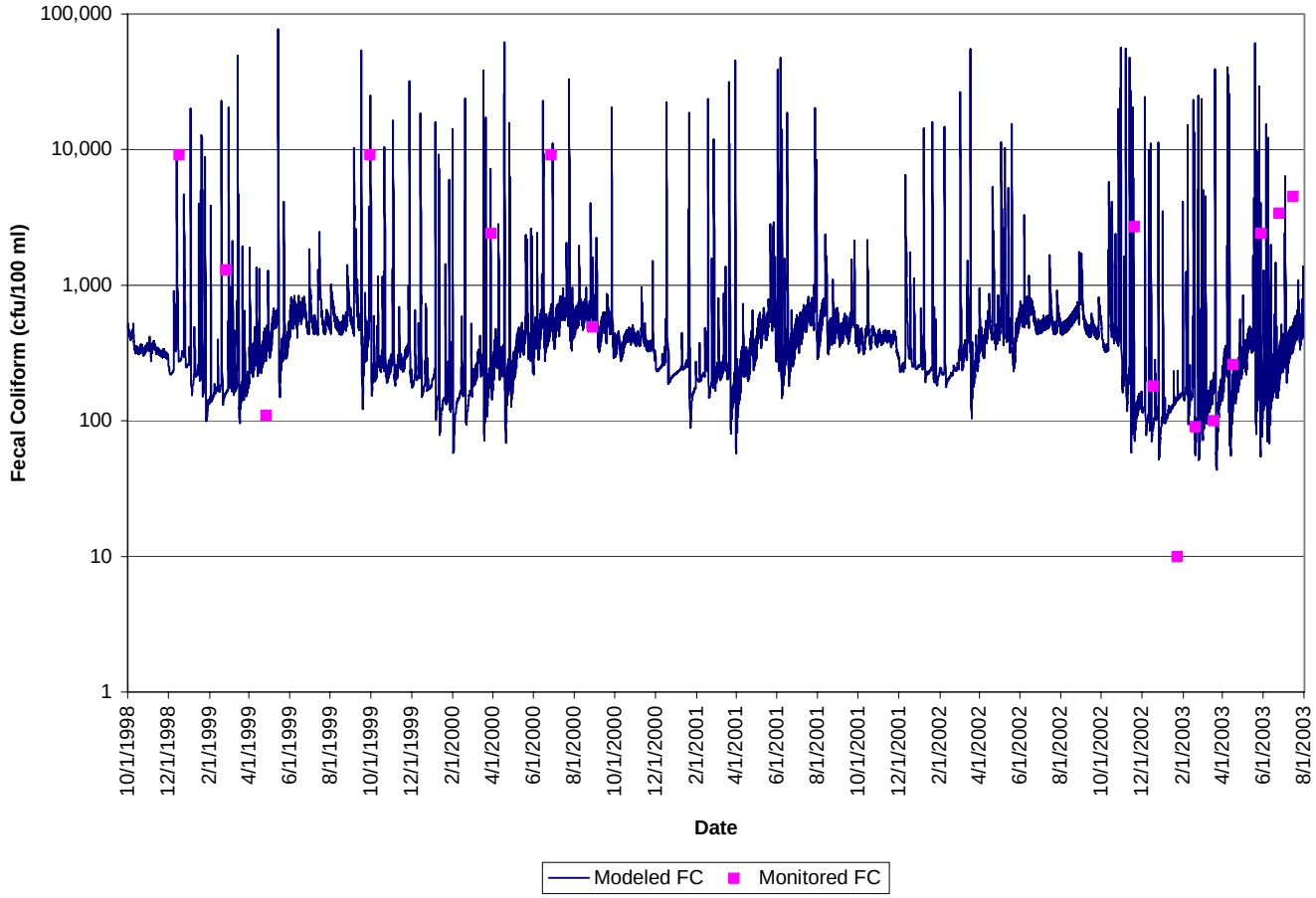

Figure C.58 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 3, subshed 49

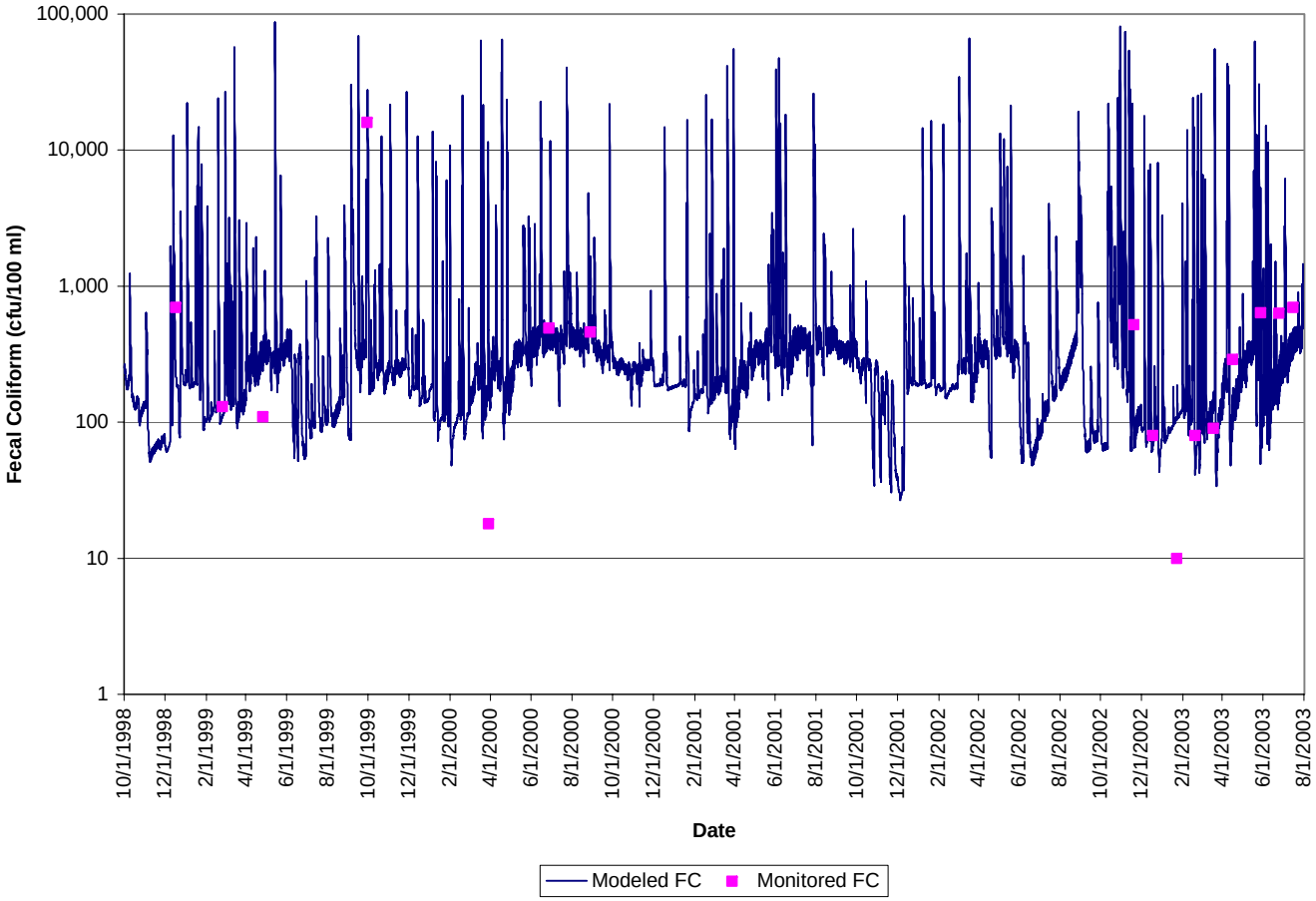

Figure C.59 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 3, subshed 54

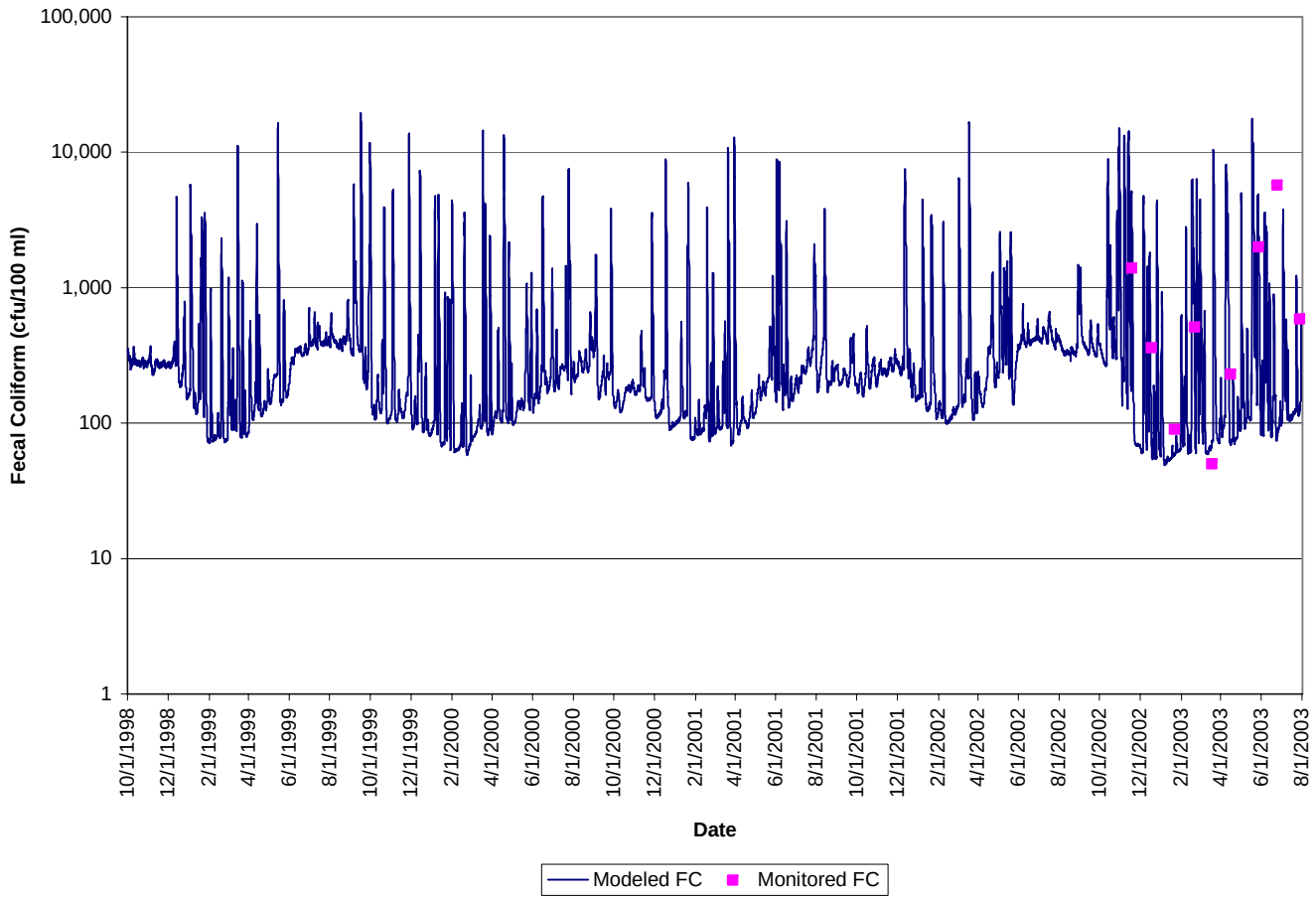

Figure C.60 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 3, subshed 59

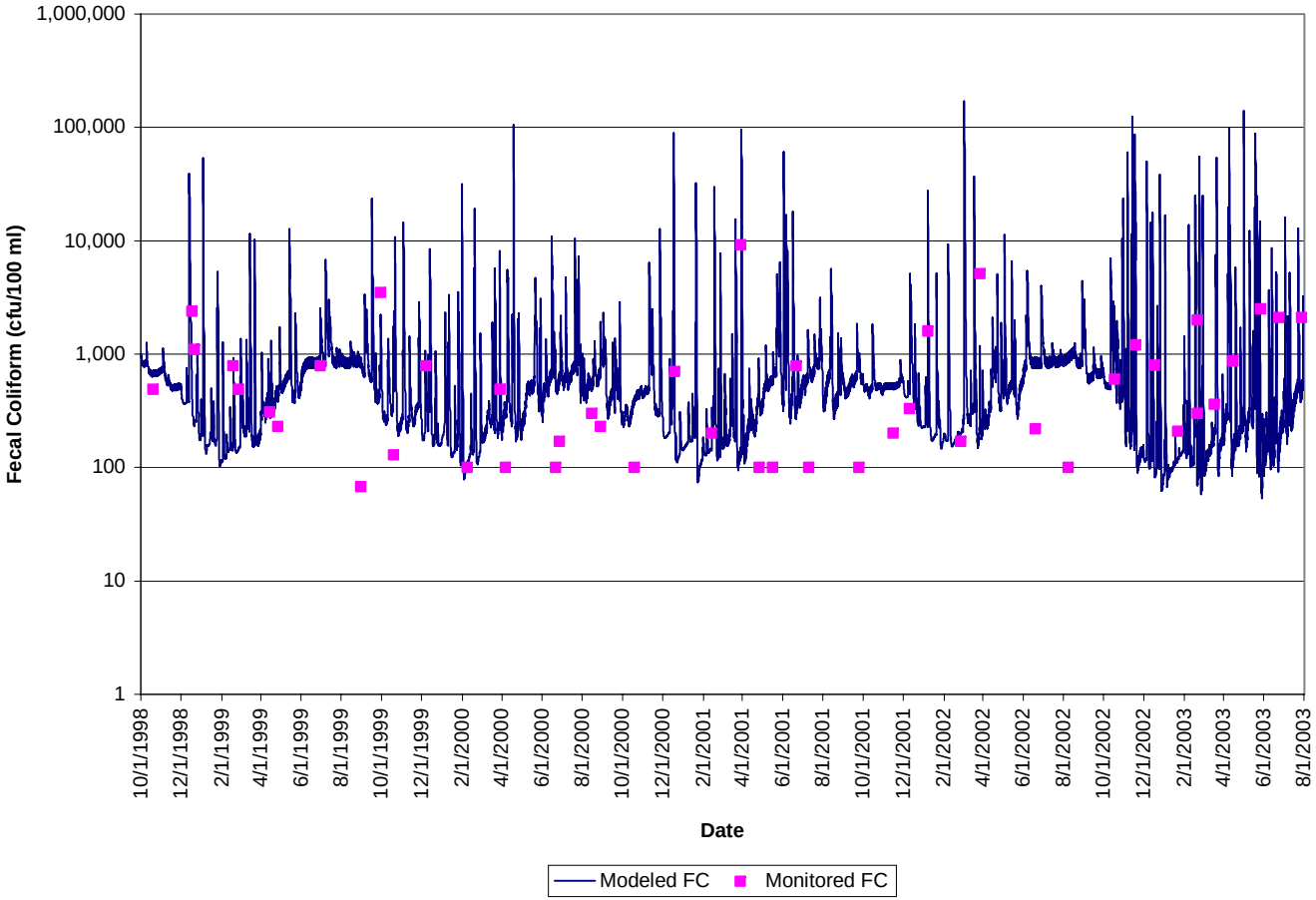

Figure C.61 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 4, subshed 71

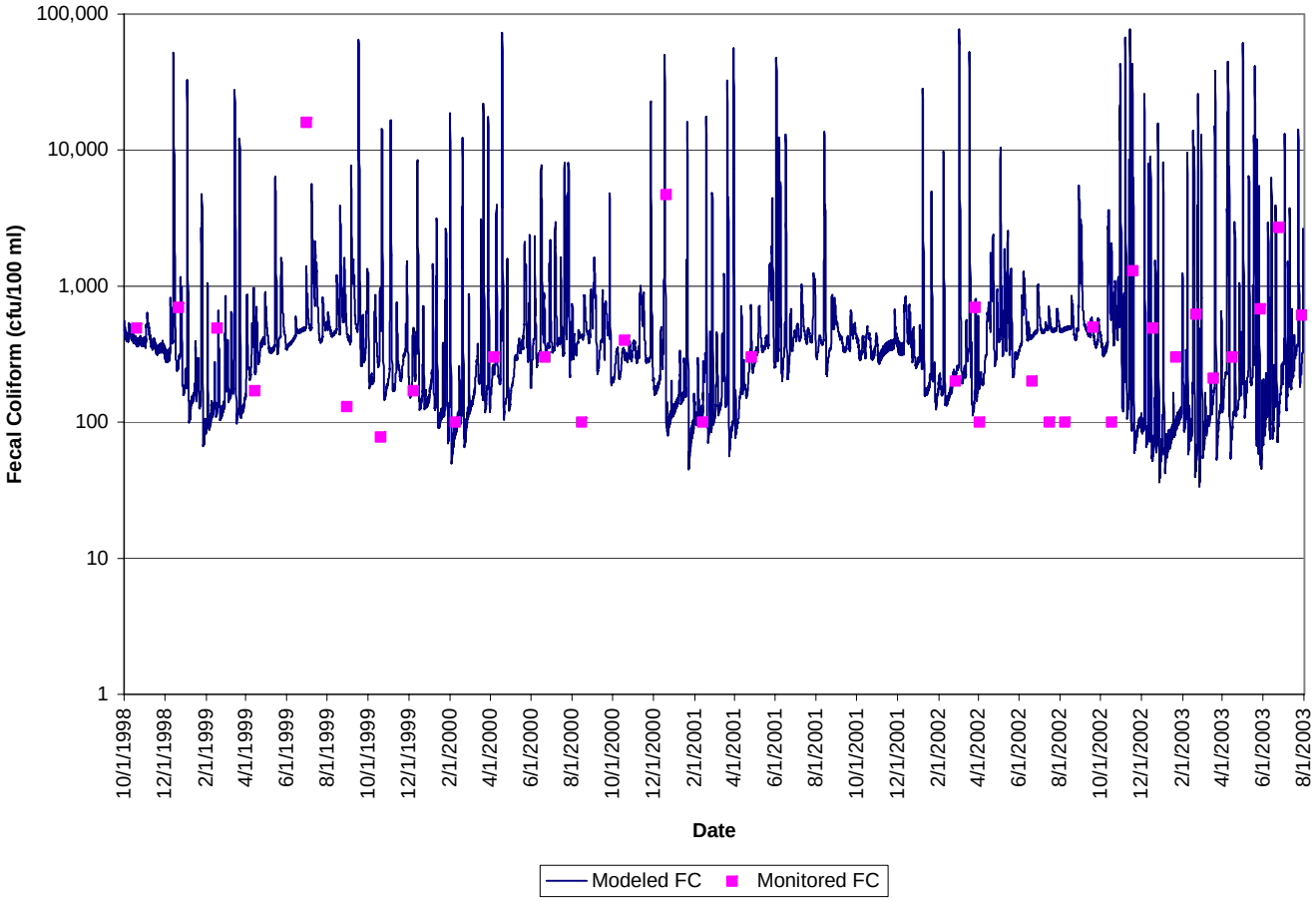

Figure C.62 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 4, subshed 72

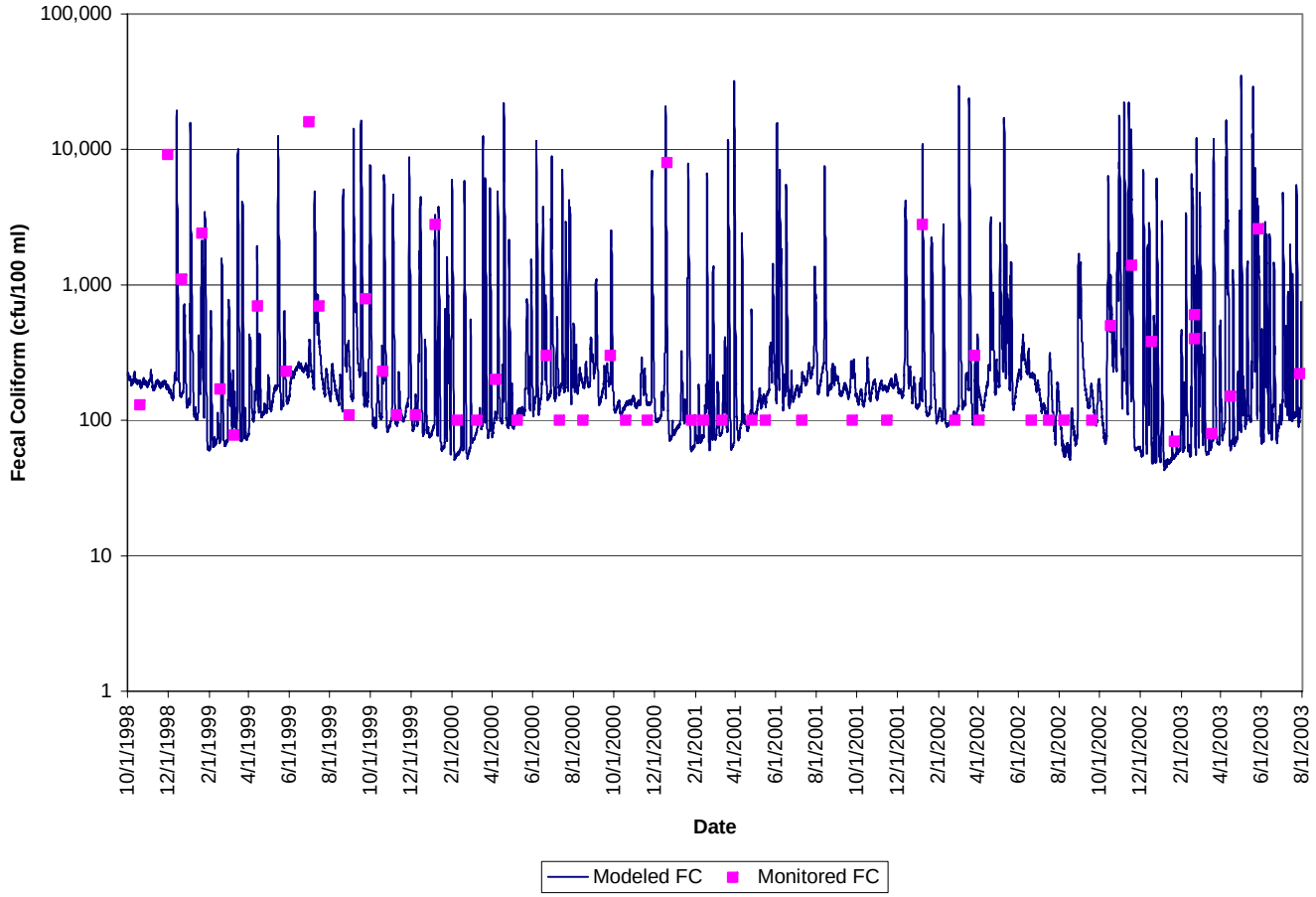

Figure C.63 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 4, subshed 73

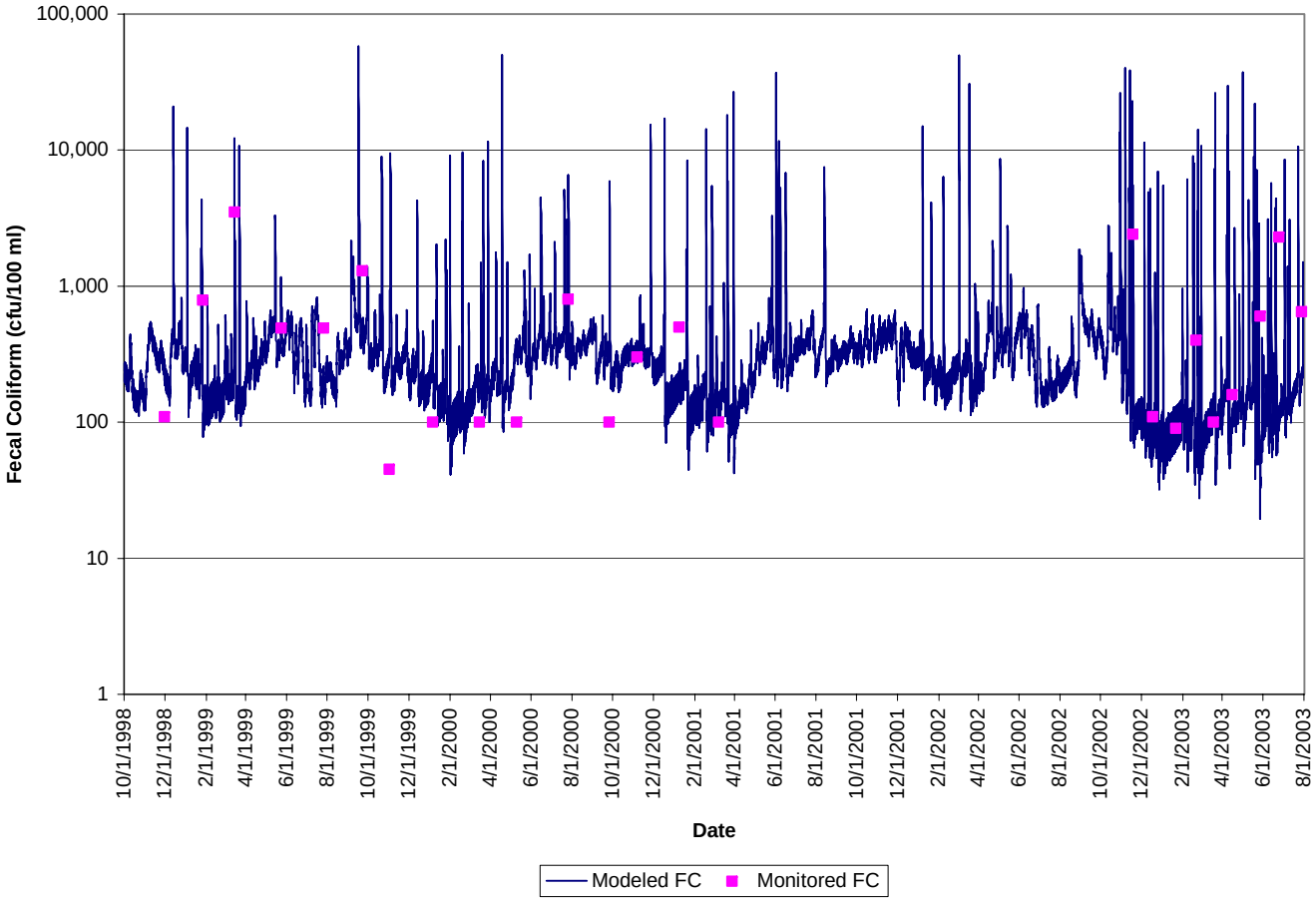

Figure C.64 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 5, subshed 93

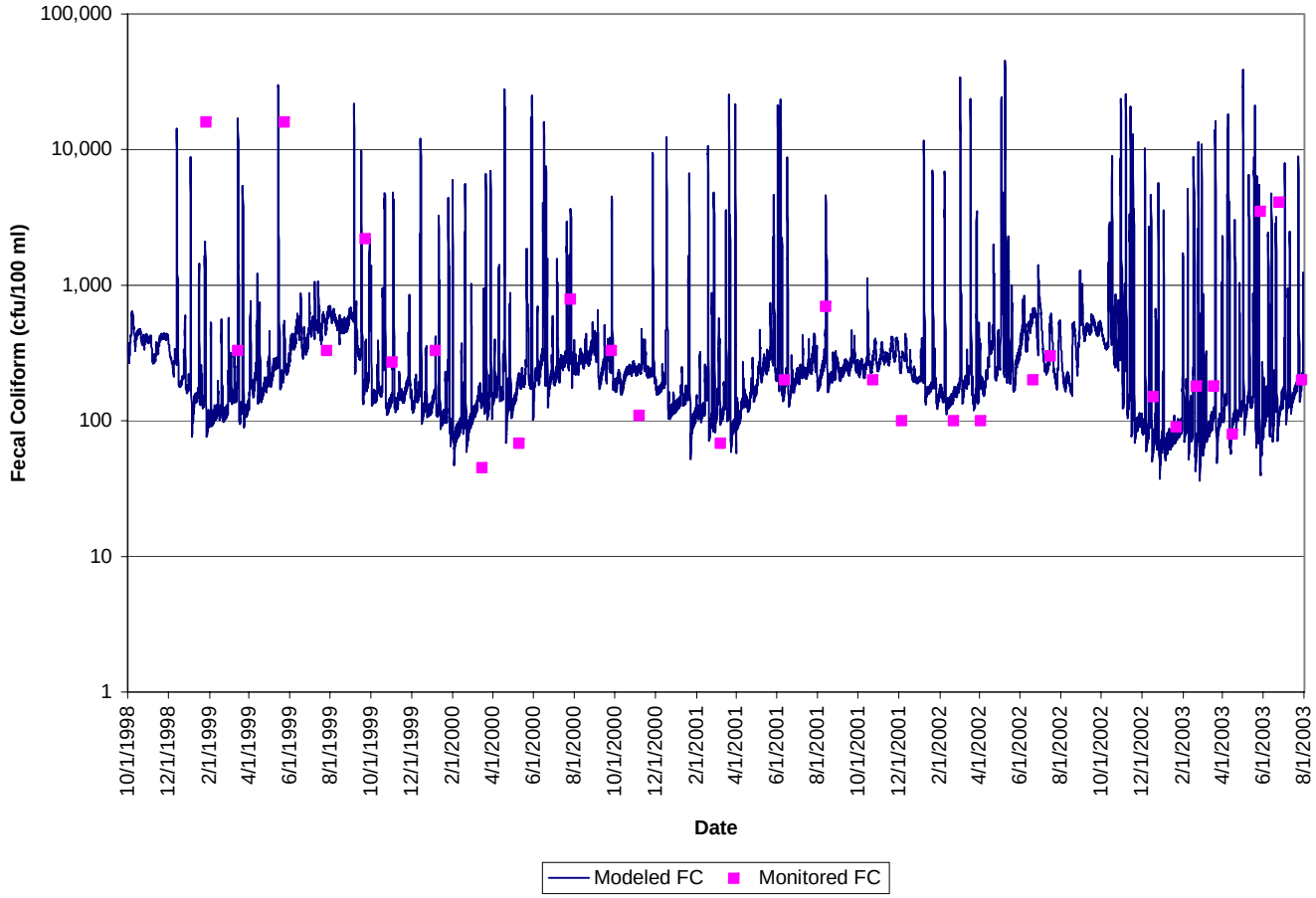

Figure C.65 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 5, subshed 95

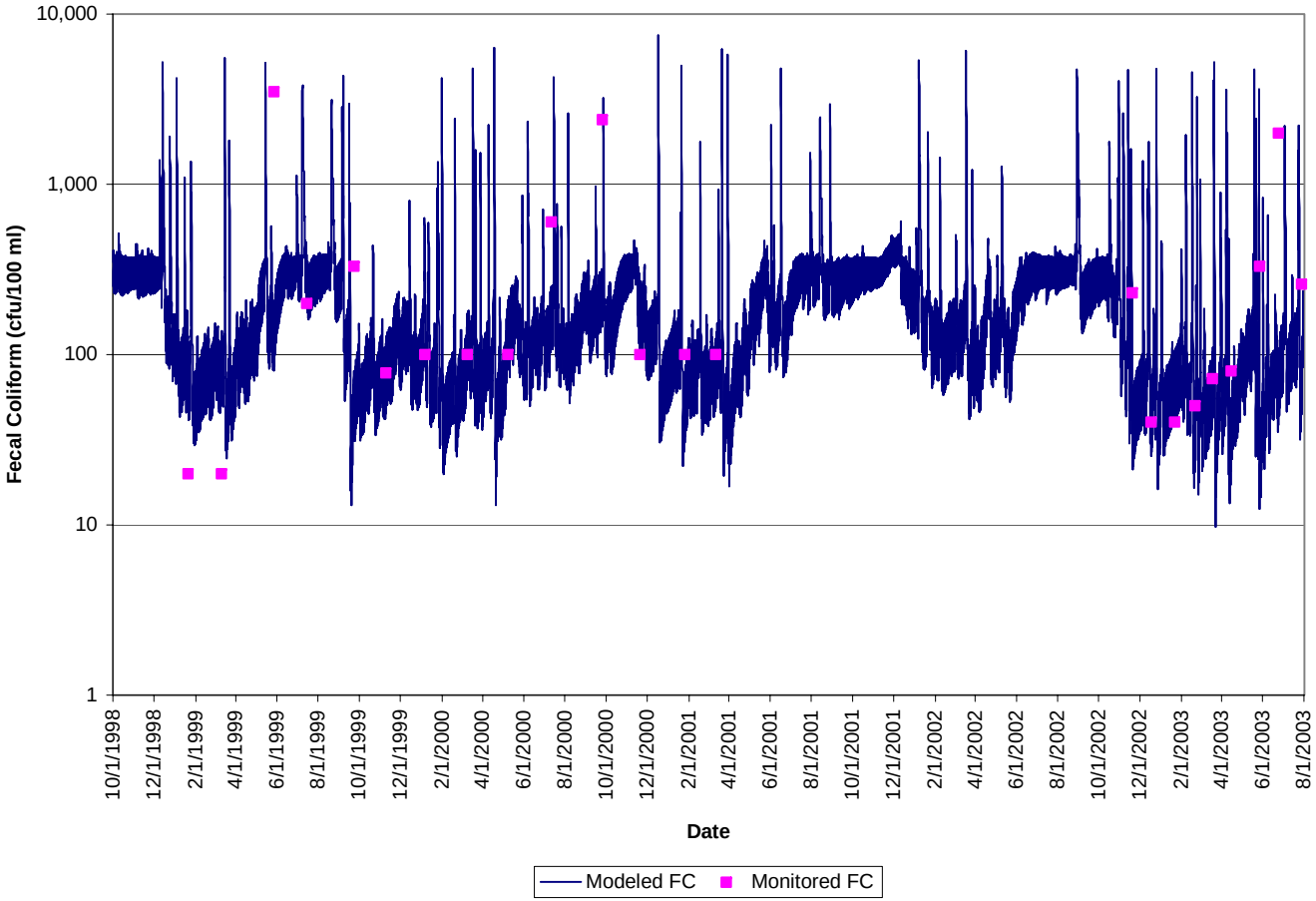

Figure C.66 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 6, subshed 126

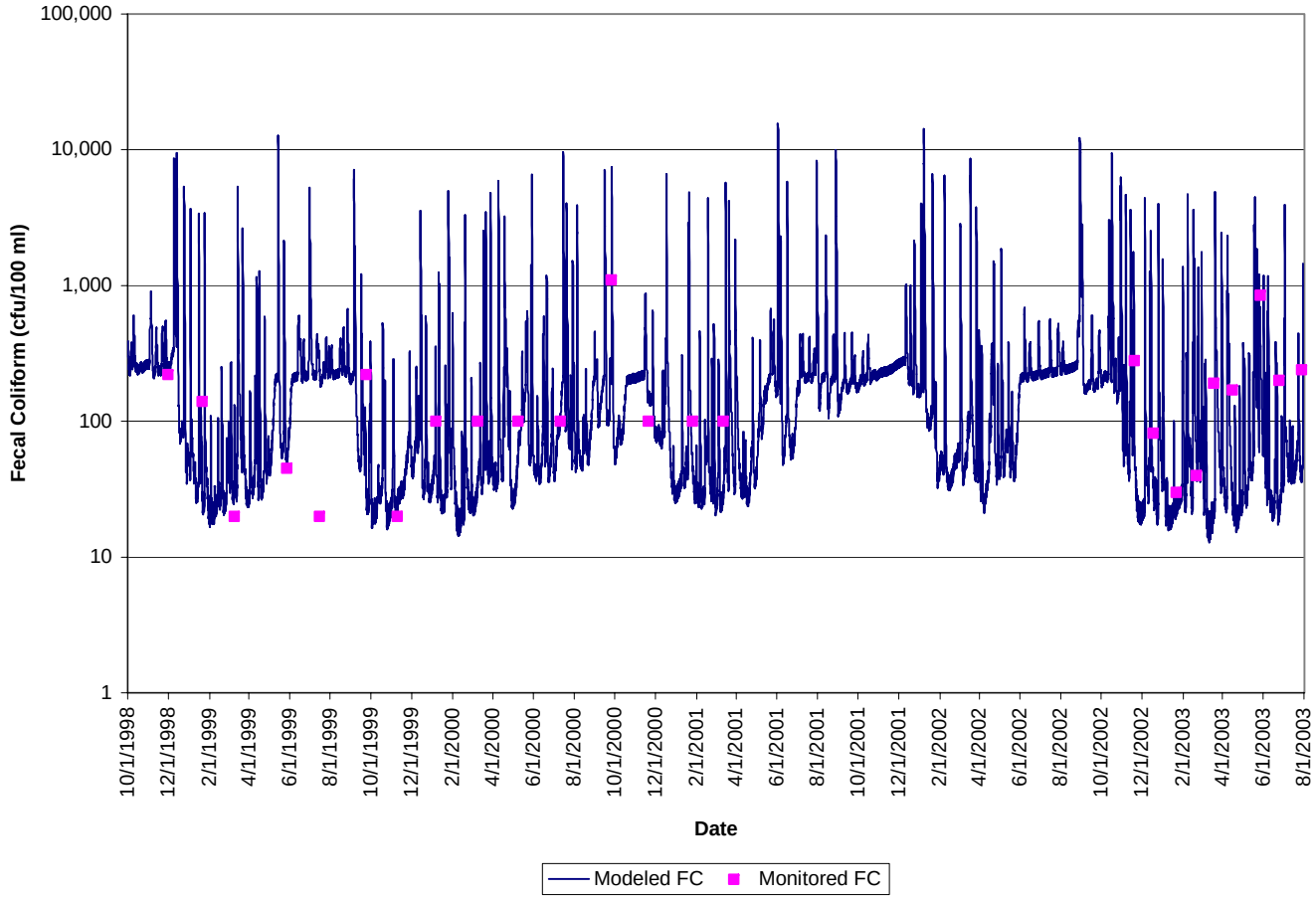

Figure C.67 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 6, subshed 137

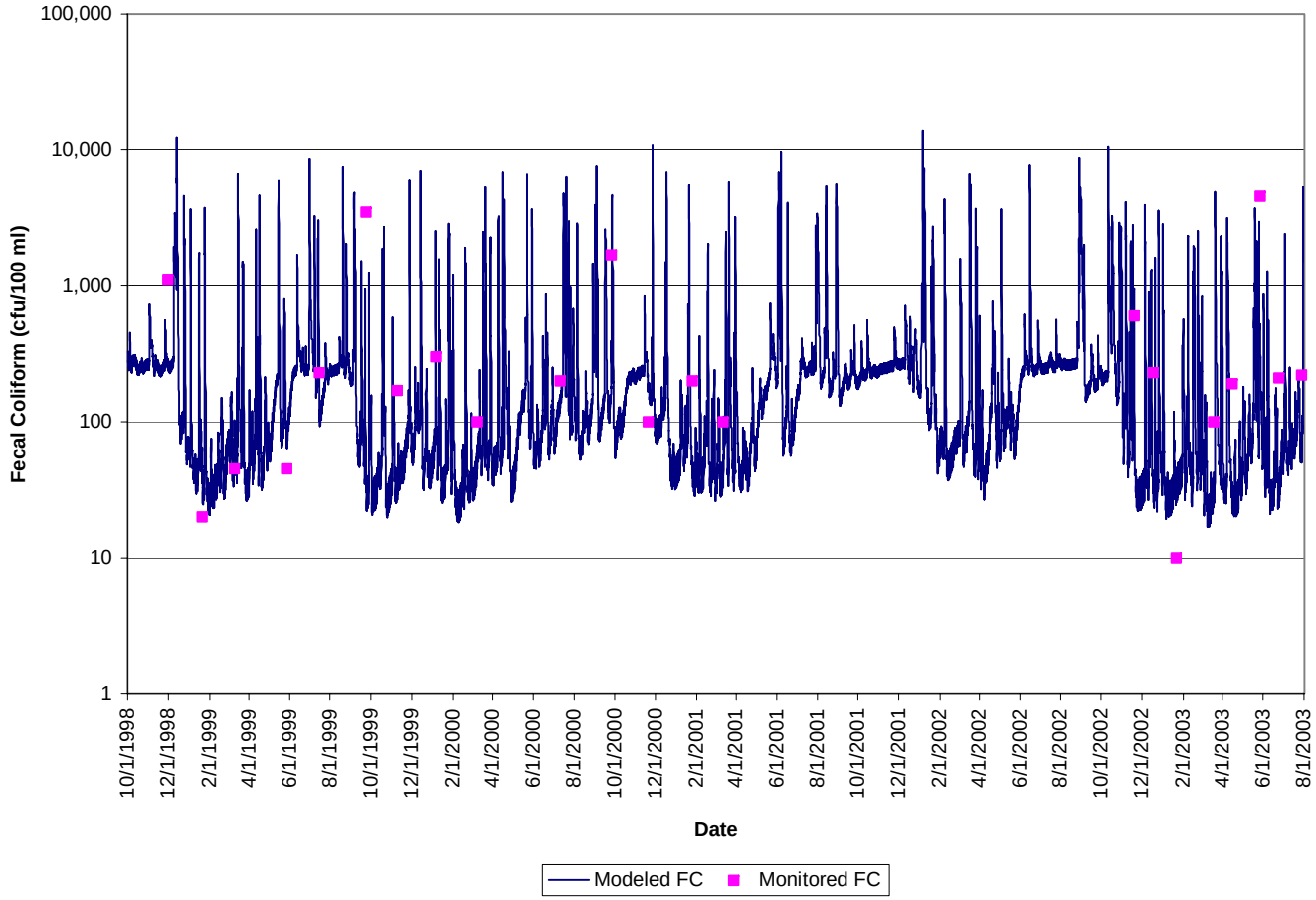

Figure C.68 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 6, subshed 143

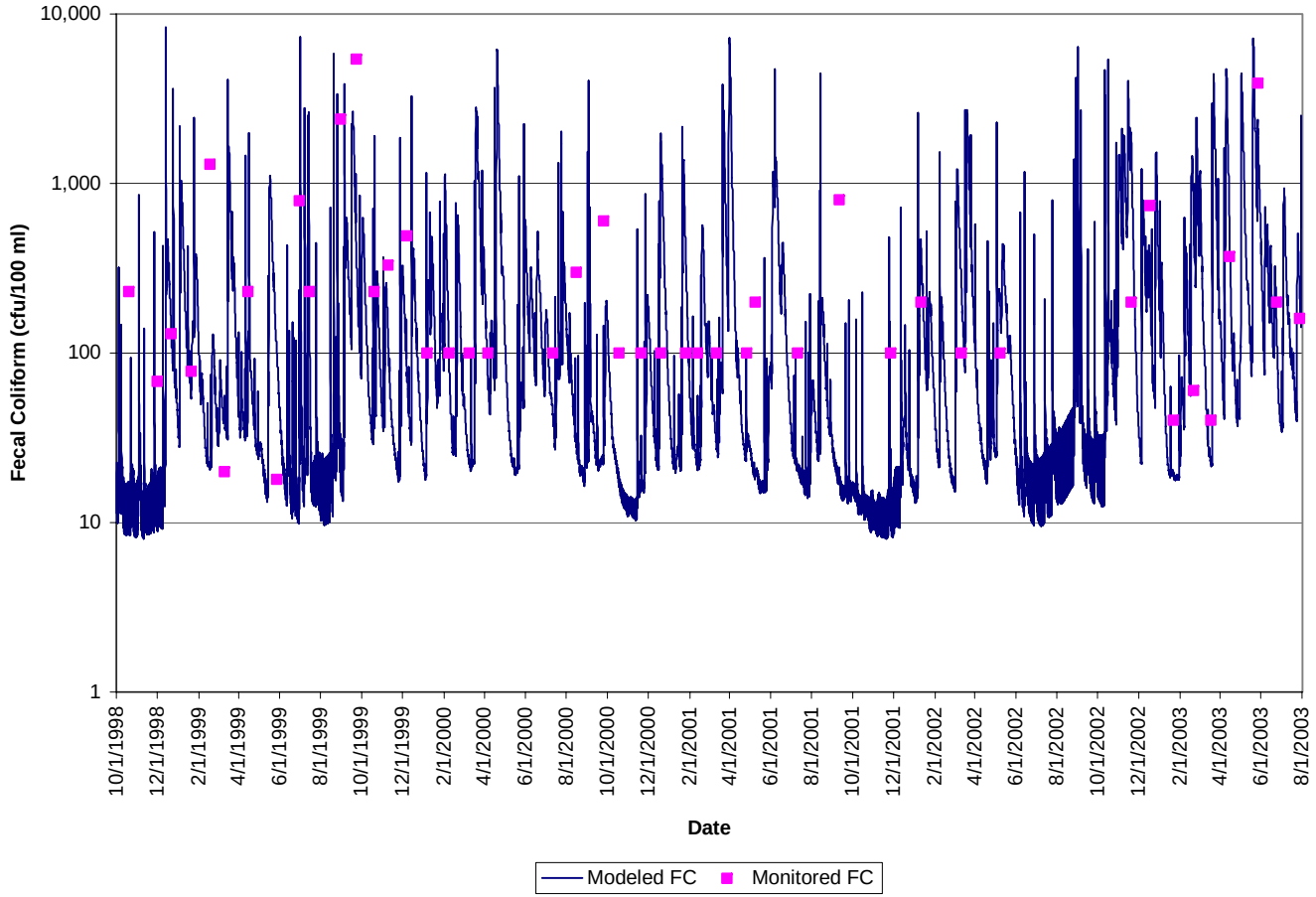

Figure C.69 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 7, subshed 118

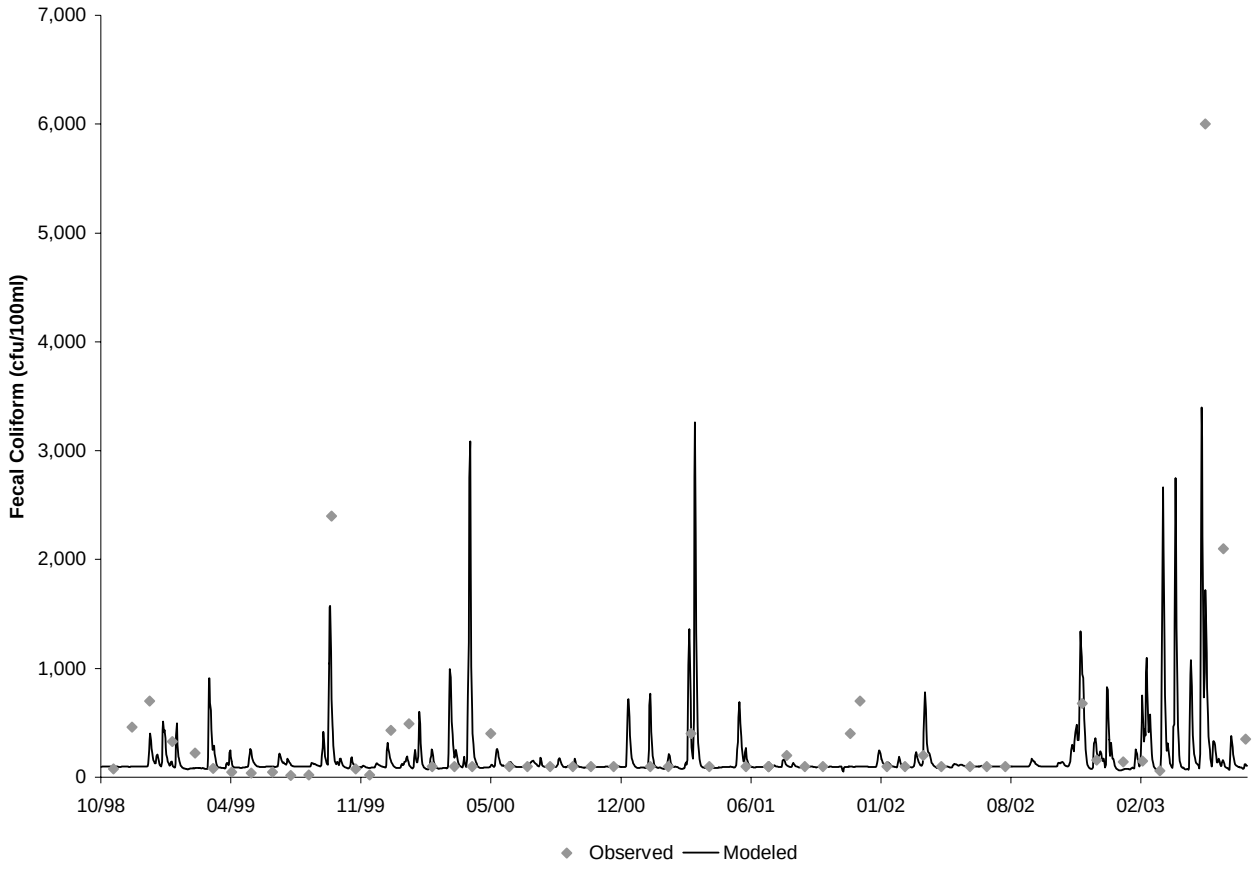

Figure C.70 Quality Calibration results for period 10/1/1998 to 7/30/2003 Model Segment 7, subshed 149

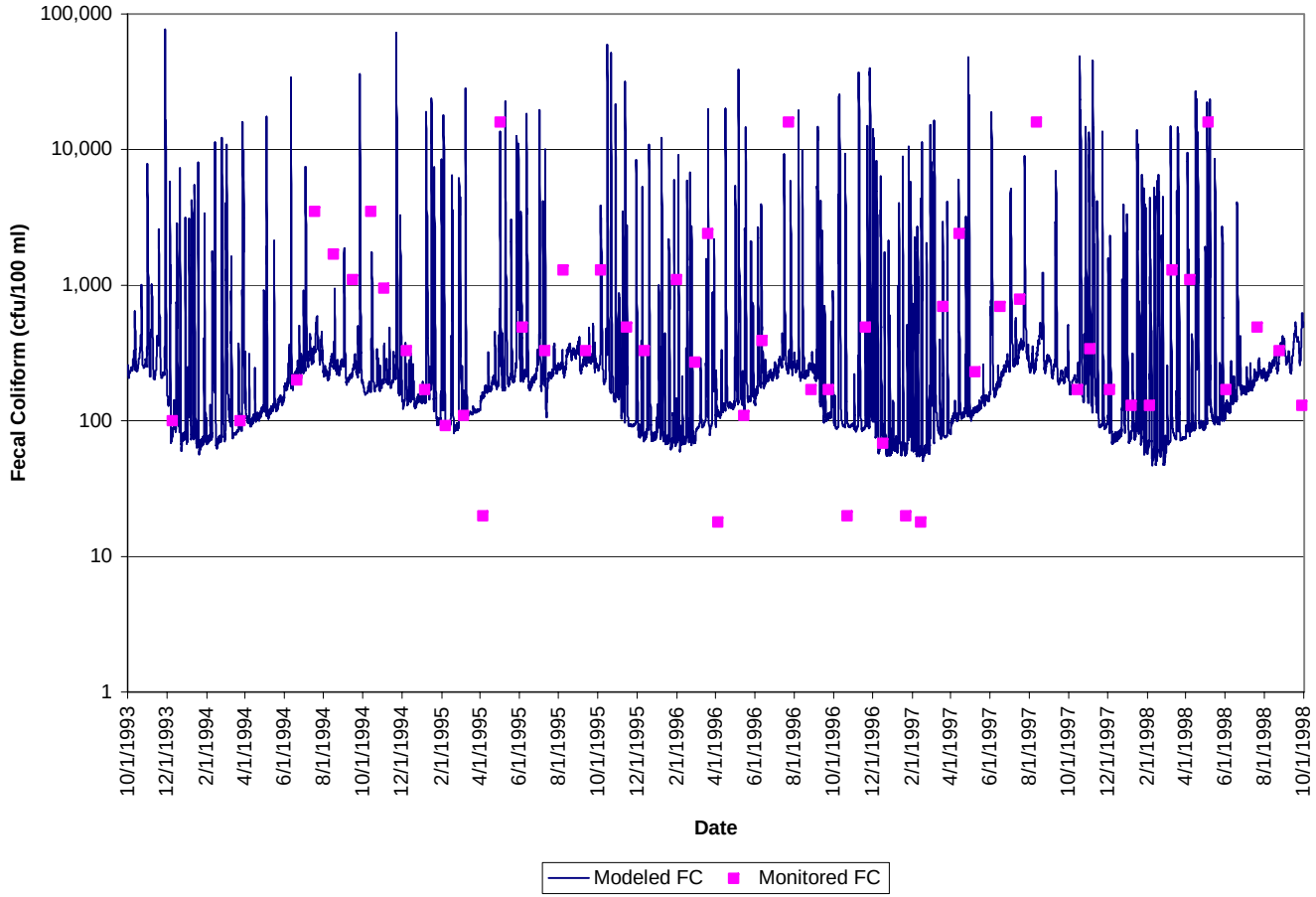

Figure C.71 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 1, subshed 11

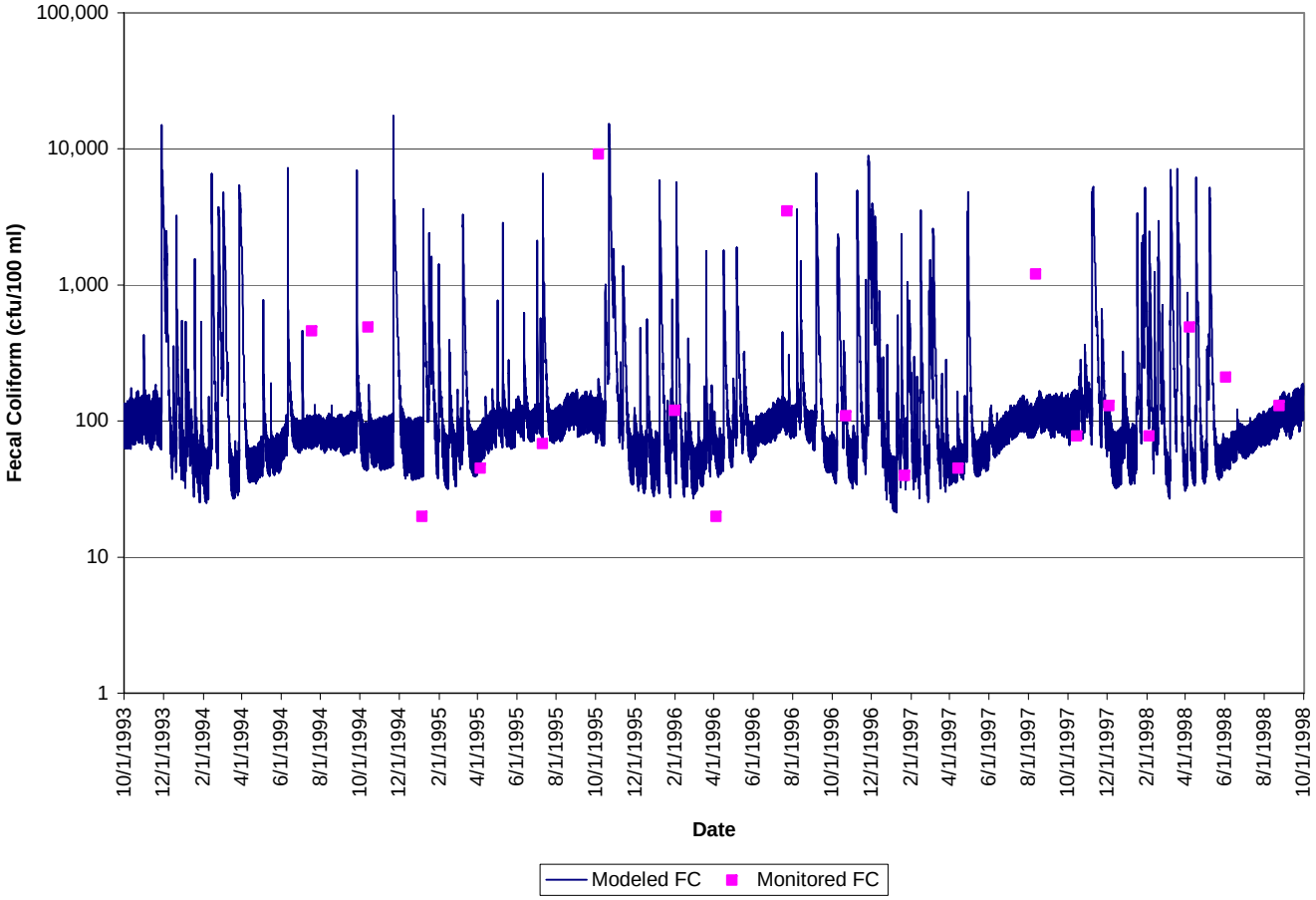

Figure C.72 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 1, subshed 17

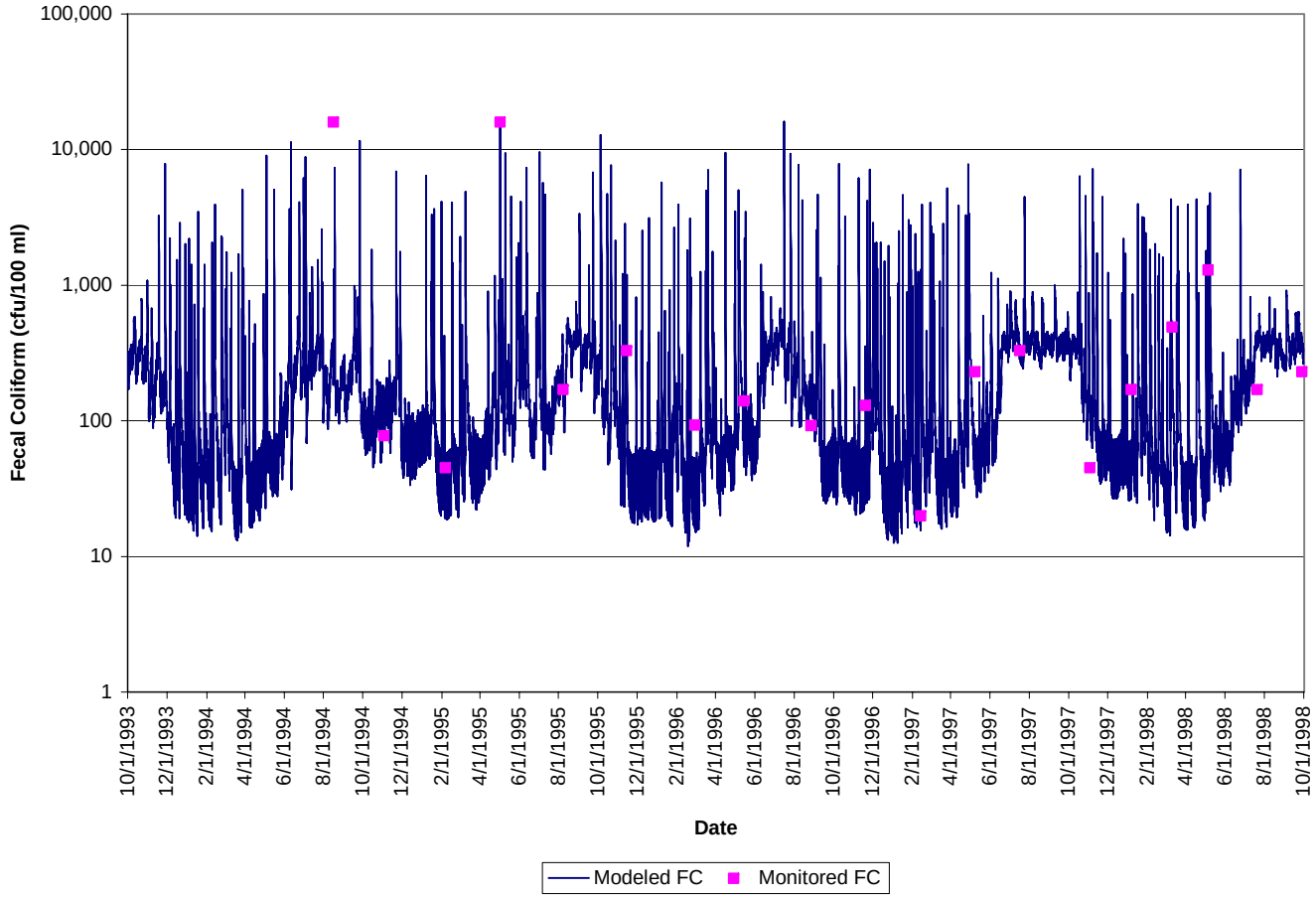

Figure C.73 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 2, subshed 28

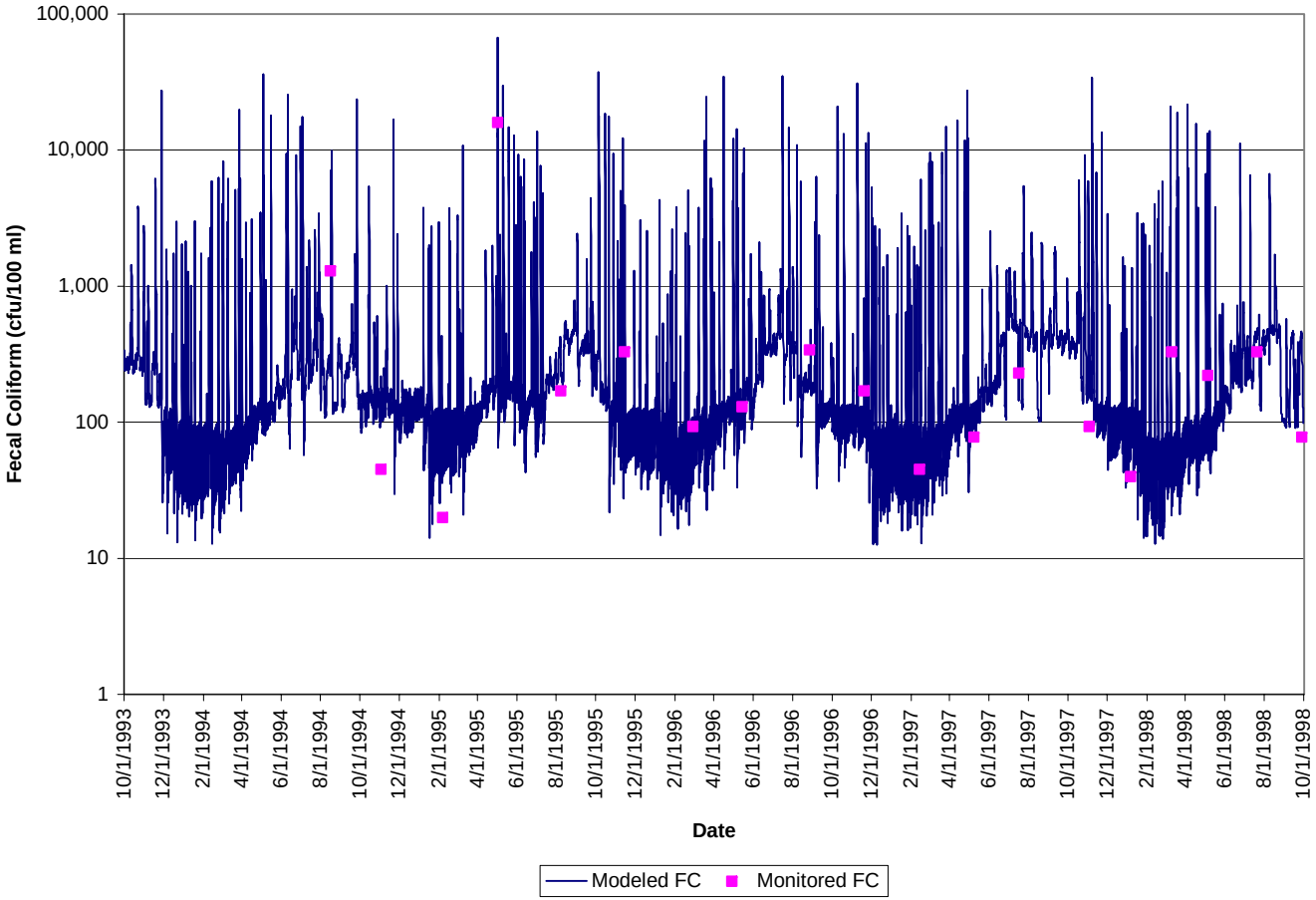

Figure C.74 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 2, subshed 32

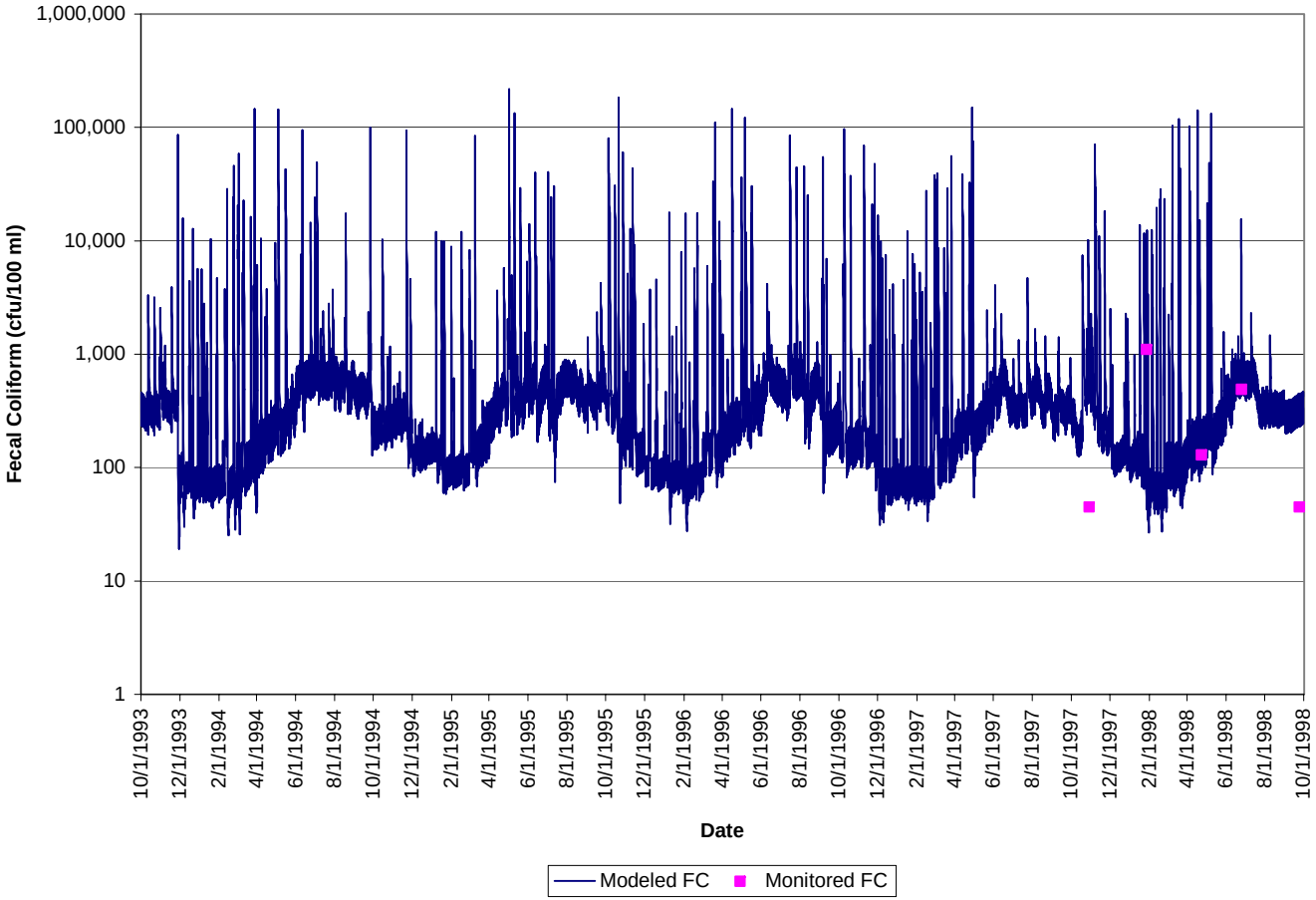

Figure C.75 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 2, subshed 35

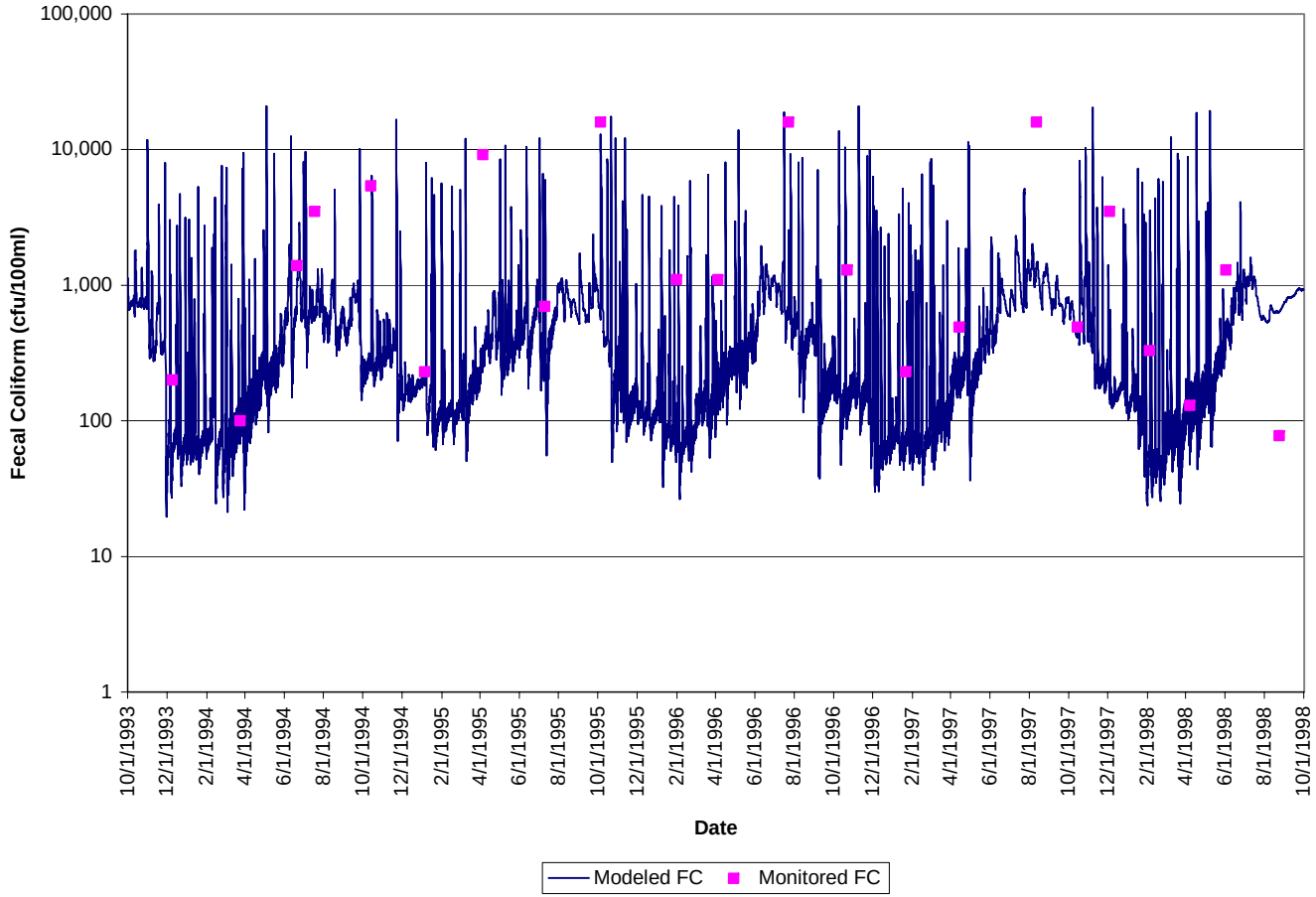

Figure C.76 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 3, subshed 46

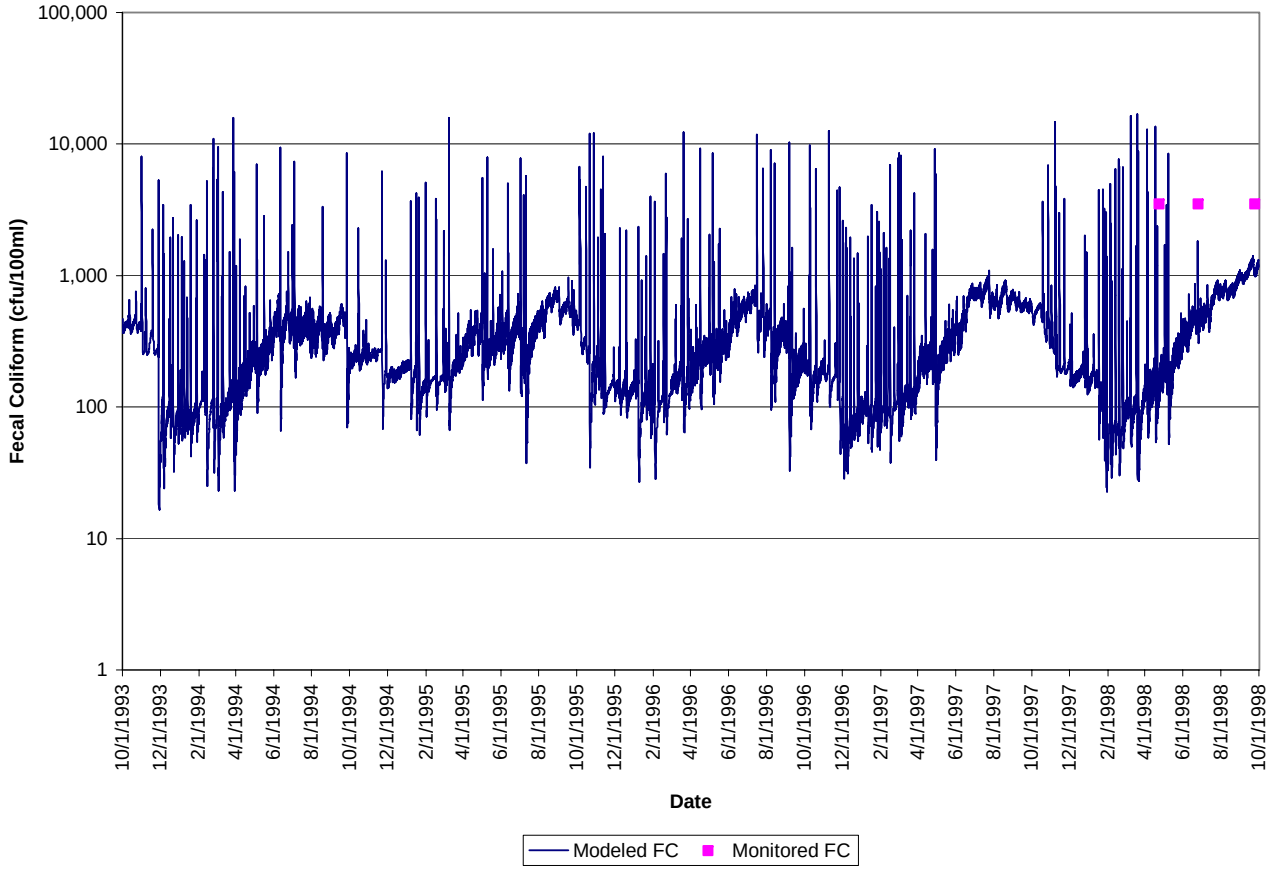

Figure C.77 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 3, subshed 48

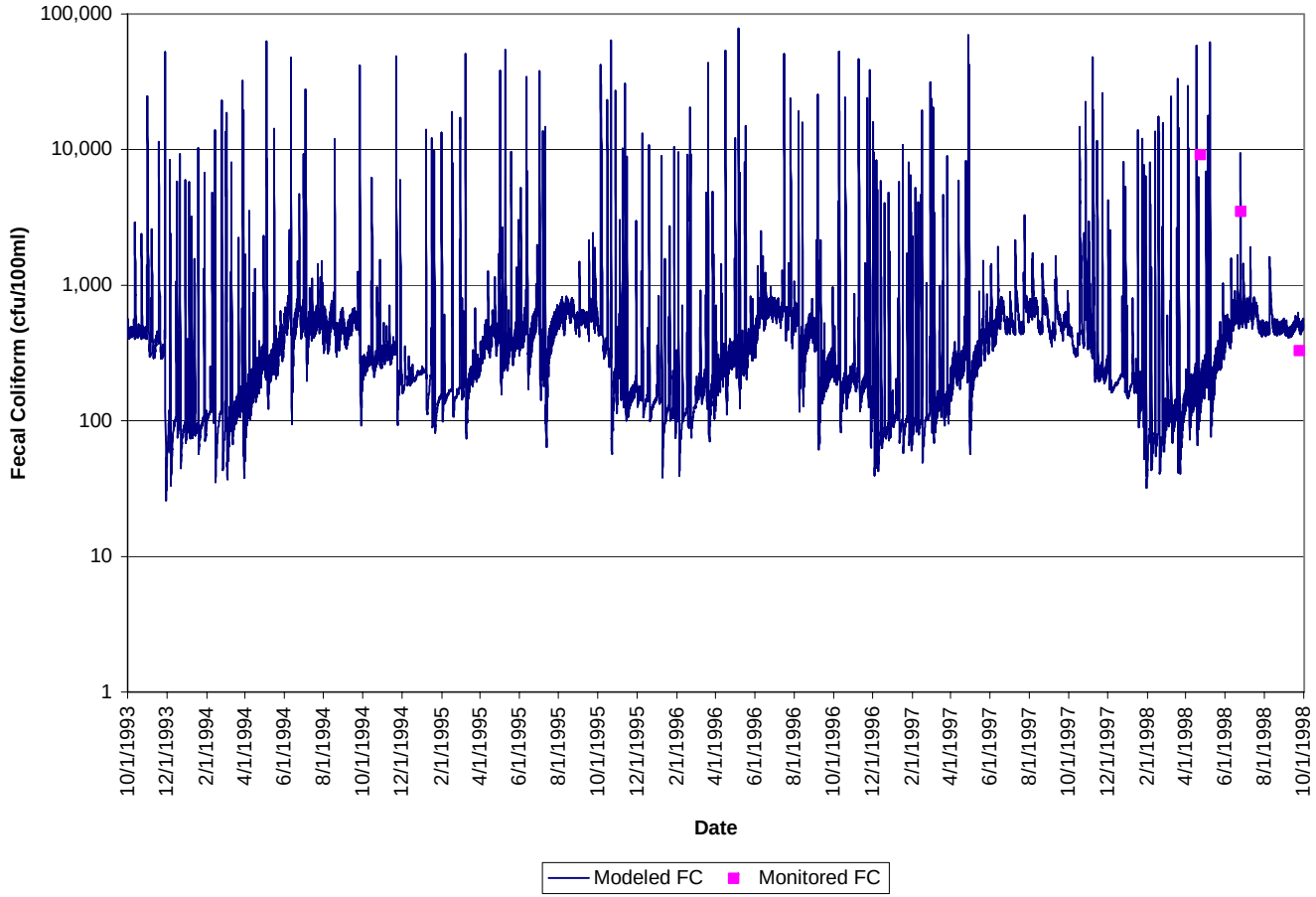

Figure C.78 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 3, subshed 49

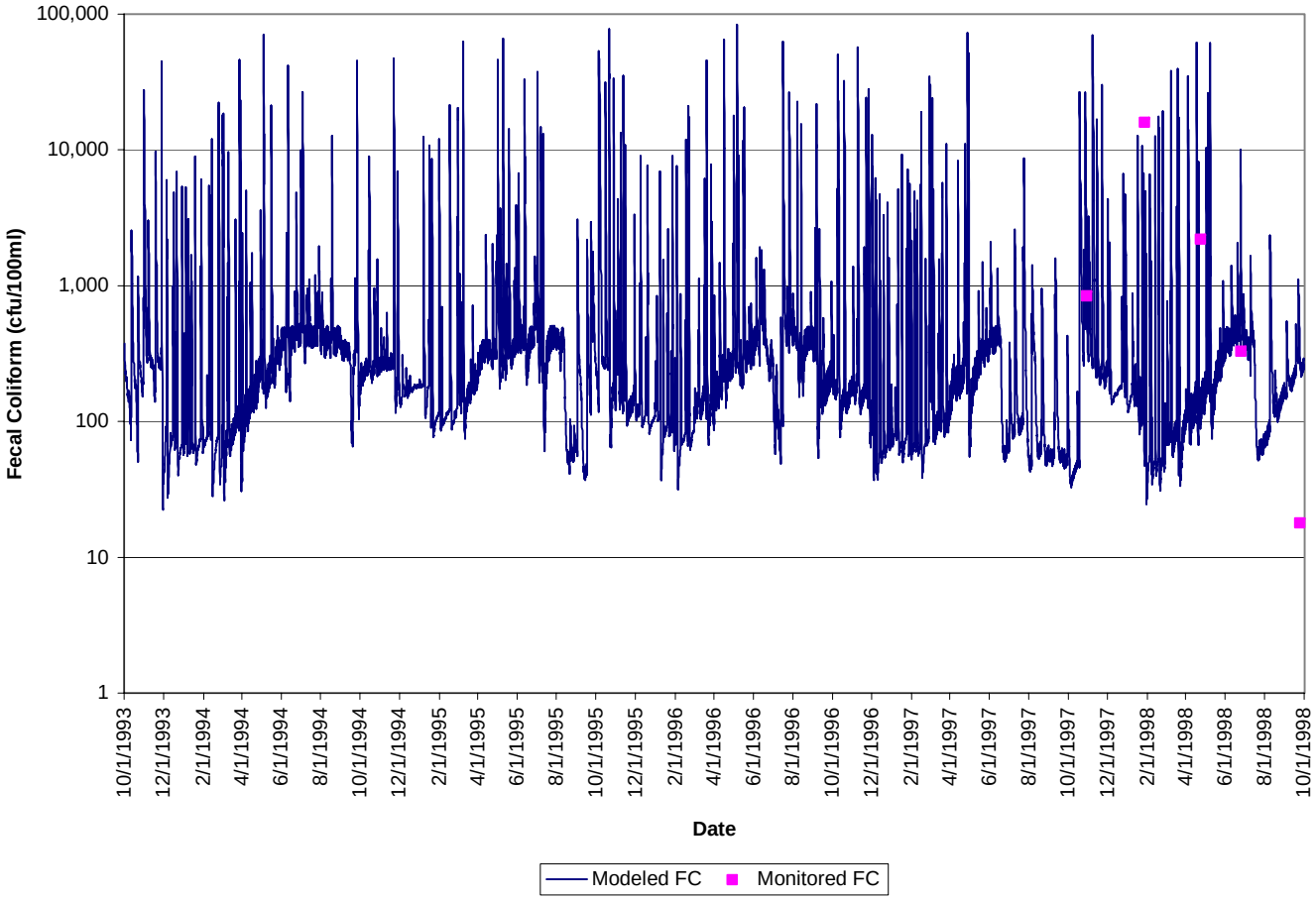

Figure C.79 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 3, subshed 54

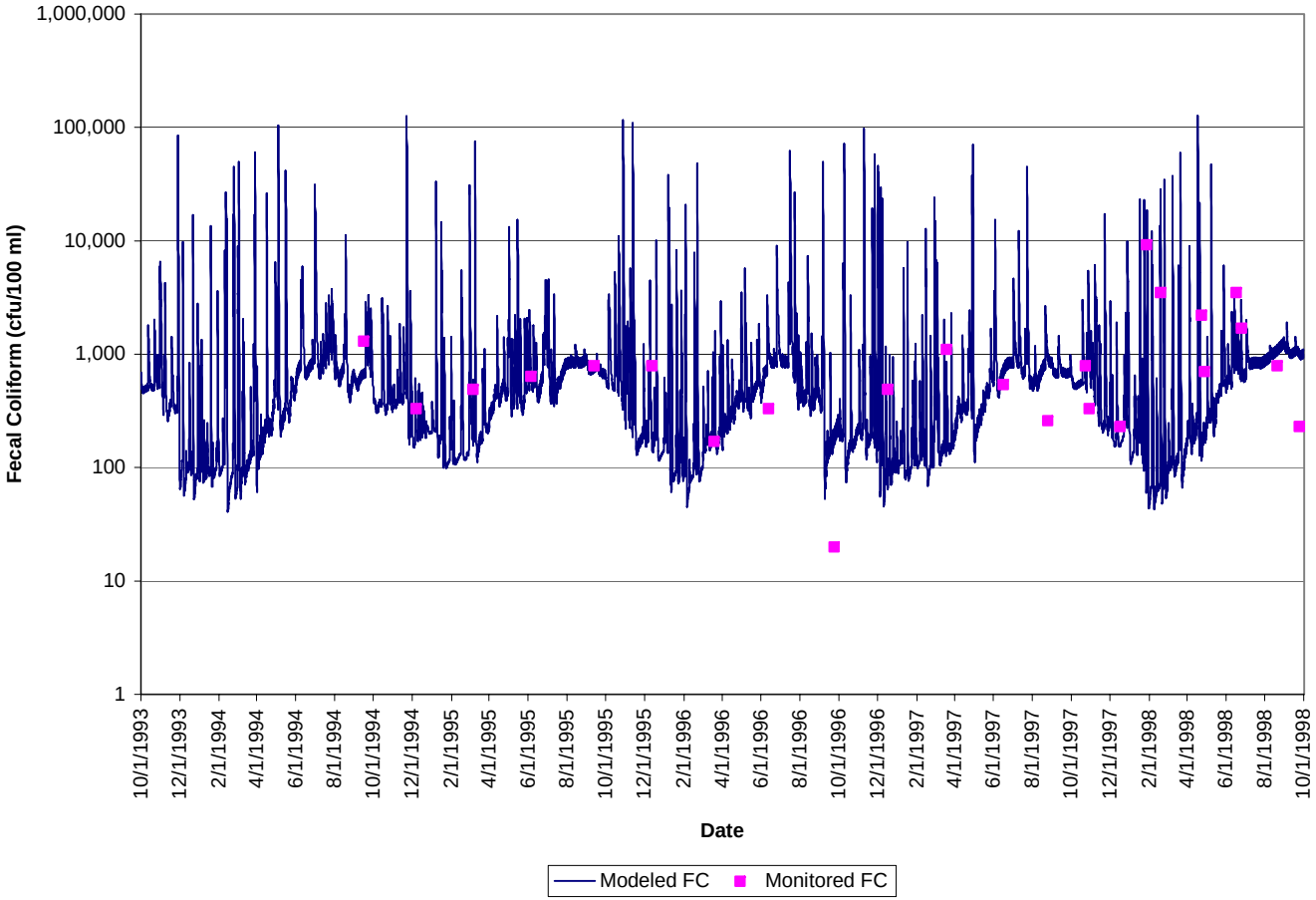

Figure C.80 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 4, subshed 71

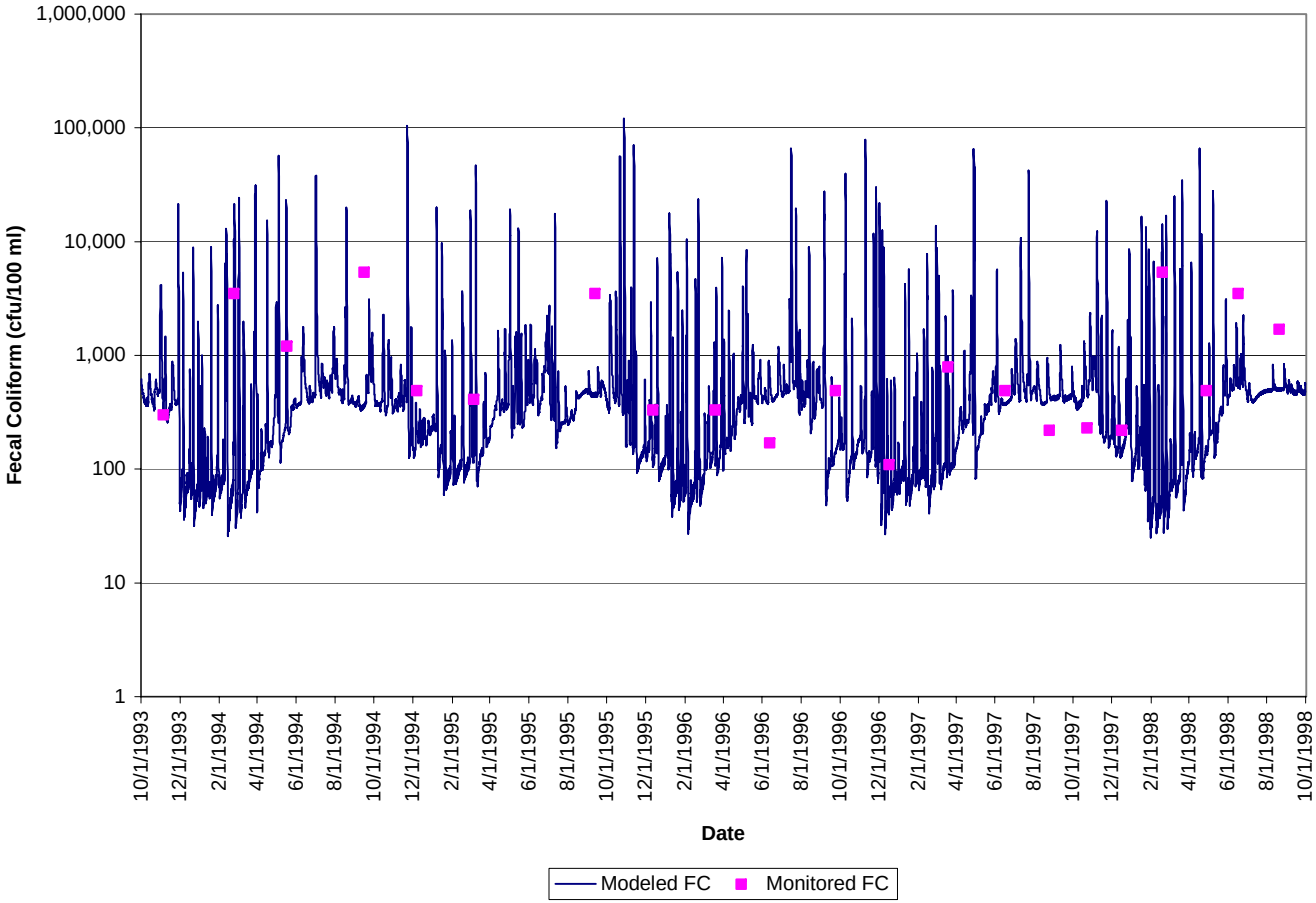

Figure C.81 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 4, subshed 72

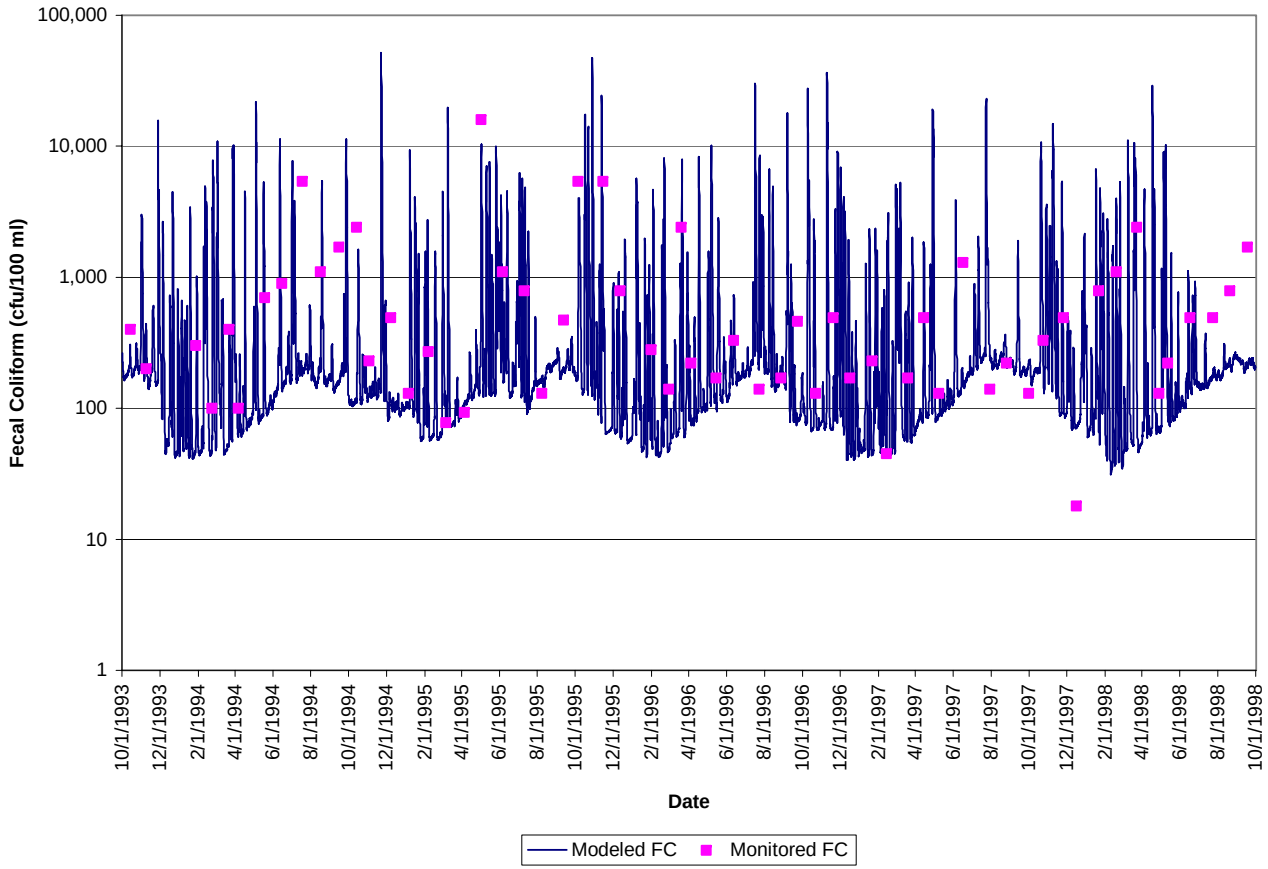

Figure C.82 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 4, subshed 73

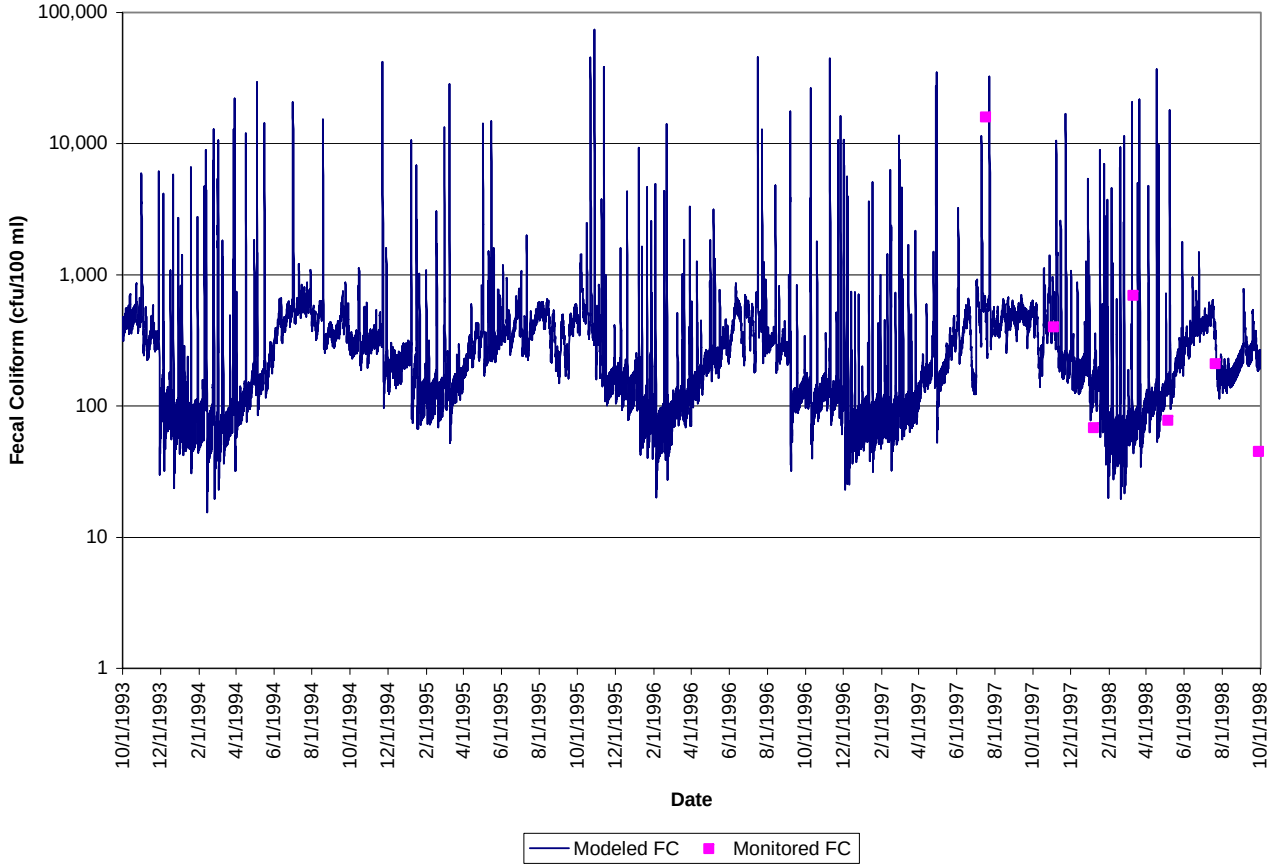

Figure C.83 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 5, subshed 93

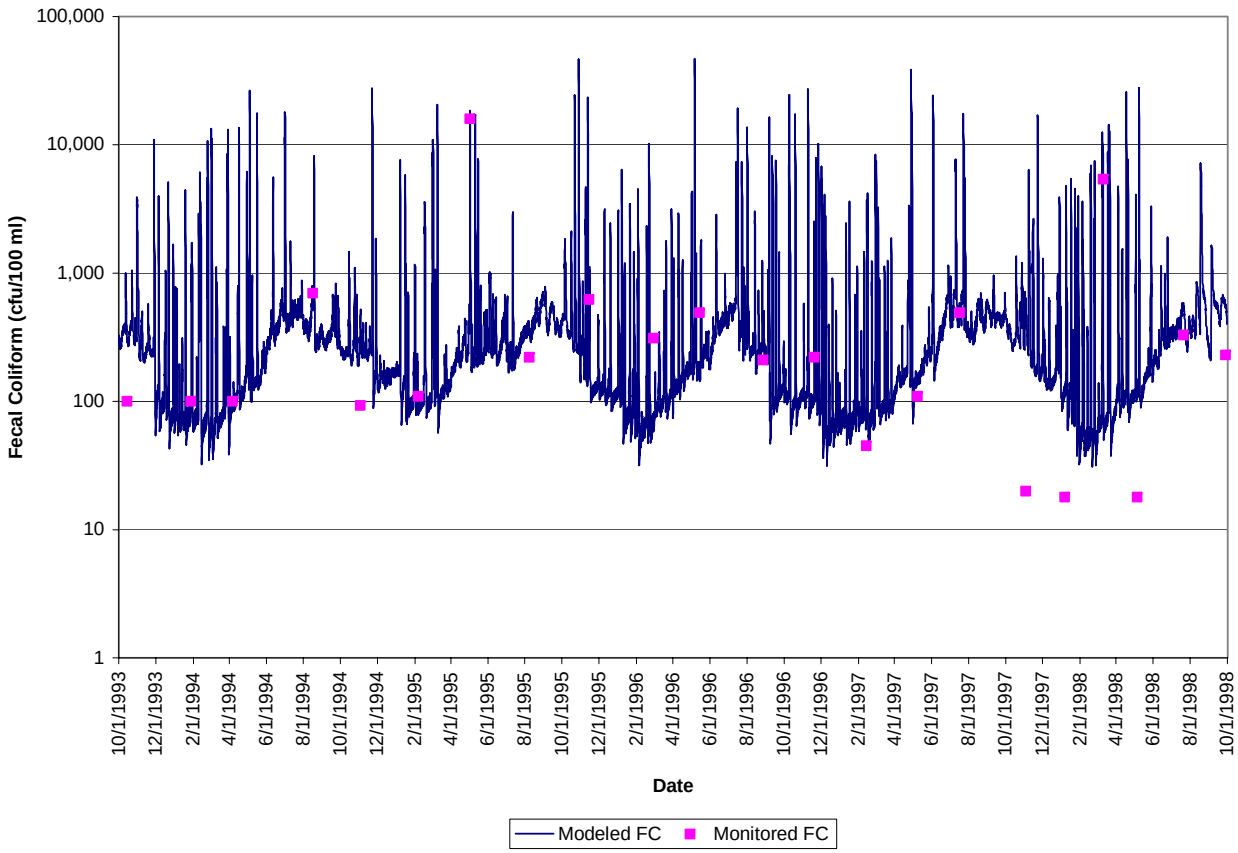

Figure C.84 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 5, subshed 95

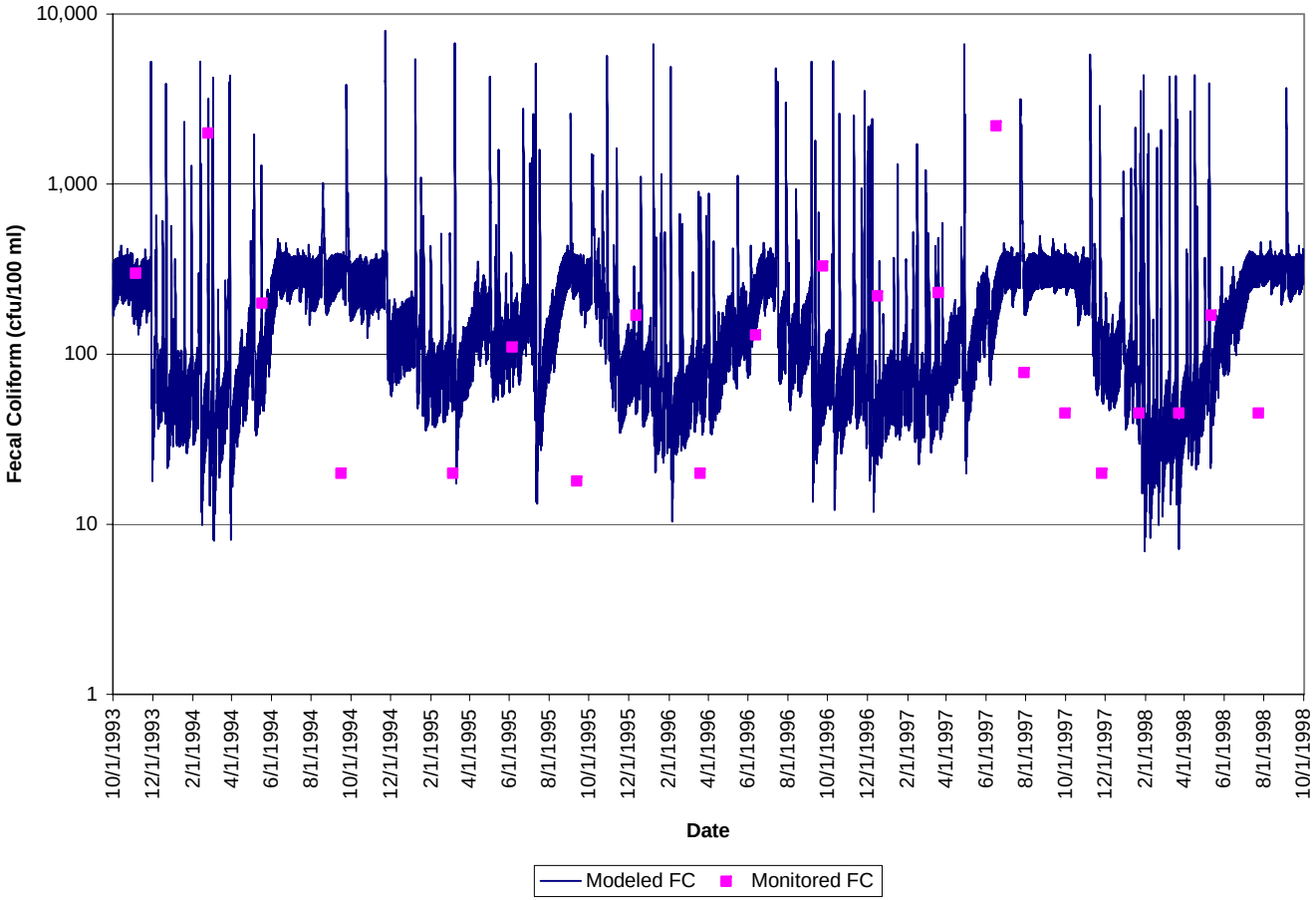

Figure C.85 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 6, subshed 126

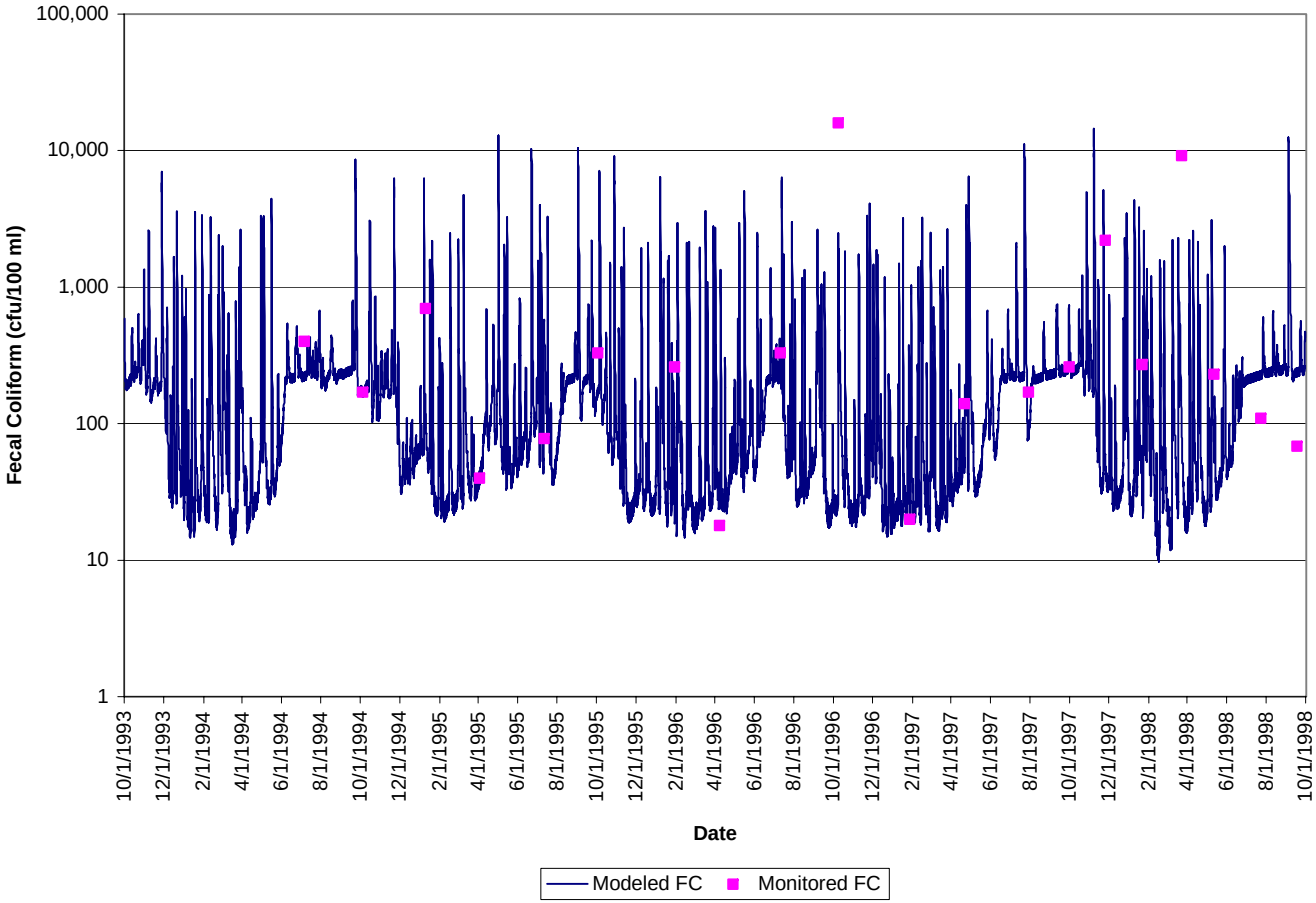

Figure C.86 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 6, subshed 137

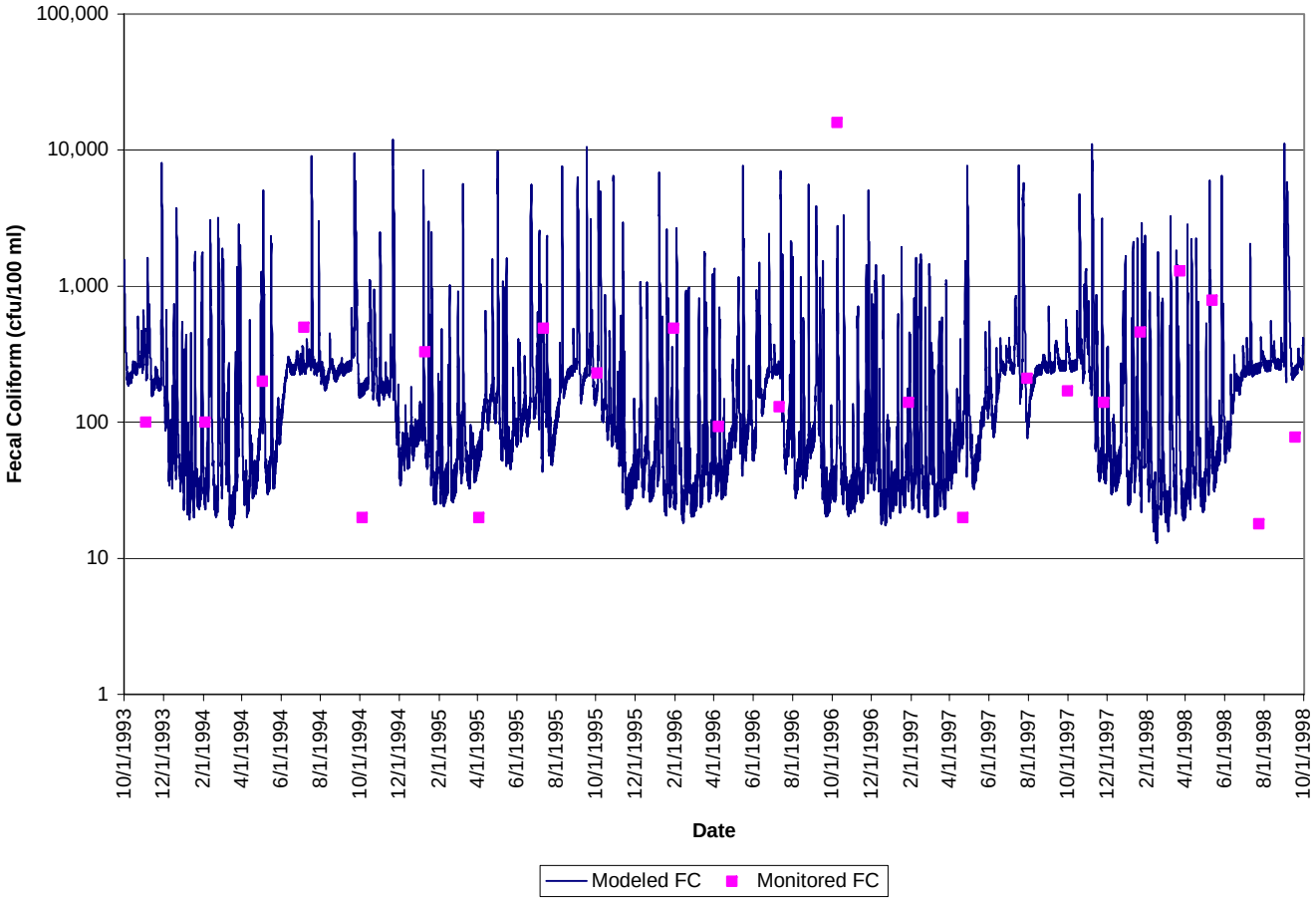

Figure C.87 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 6, subshed 143

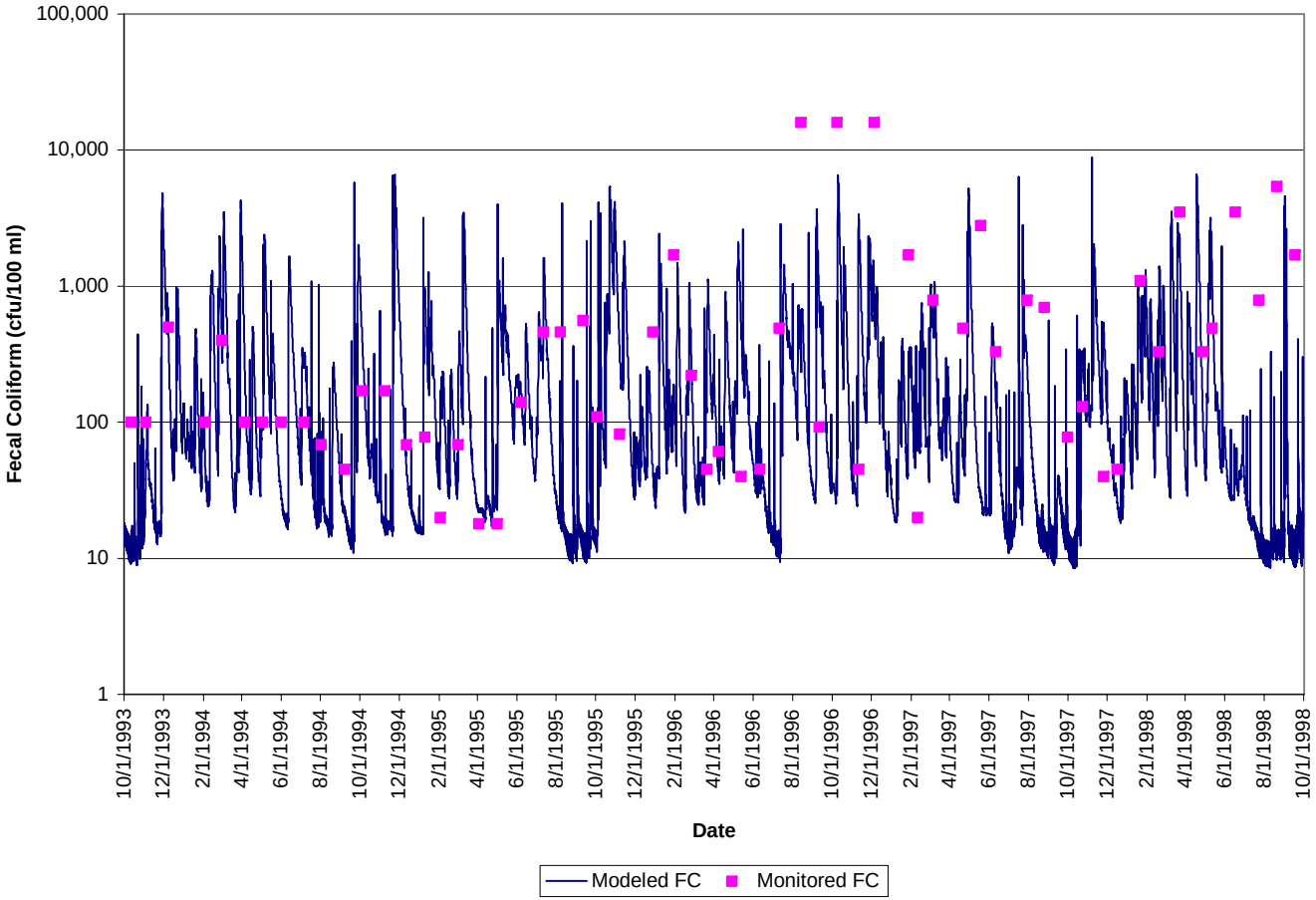

Figure C.88 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 7, subshed 118

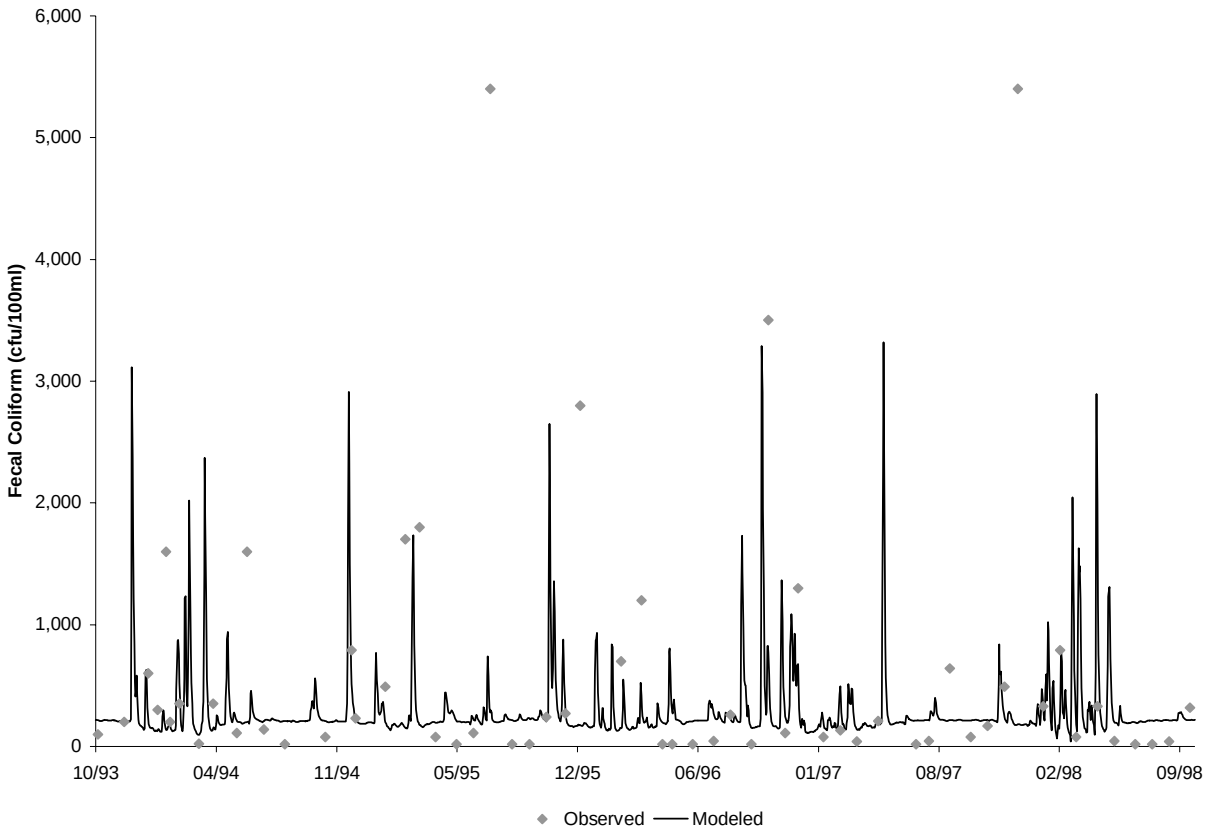

Figure C.89 Quality Validation results for period 10/1/1993 to 9/30/1998 Model Segment 7, subshed 149.