Bacteria Total Maximum Daily Load Development for Three Creek, Flat Swamp, Tarrara Creek, Mill Swamp, and Darden Mill Run in Southampton, Sussex, Greensville, Brunswick Counties and the City of Emporia, Virginia

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Executive Summary

Background

The Three Creek (K26, K27) watershed is located in Brunswick, Greensville, Sussex, and Southampton Counties and the City of Emporia. The Mill Swamp (K28) and Darden Mill Run (K30) watersheds are located in Southampton County. Darden Mill Run flows into Mill Creek; Mill Creek, Three Creek, and Mill Swamp flow into the Nottoway River (USGS Hydrologic Unit Code 03010201). Nottoway River discharges into the Chowan River near the North Carolina state line. The Flat Swamp (K13) and Tarrara Creek (K13) watersheds are also located in Southampton County; Flat Swamp flows into Tarrara Creek, which flows into an unnamed swamp, which discharges to the Meherrin River (USGS Hydrologic Unit Code 03010204) near the North Carolina state line. The Meherrin River also flows into the Chowan River. The Chowan River flows into the Albemarle Sound in North Carolina. The watershed areas are: Three Creek, 139,731 acres; Mill Swamp, 15,853 acres; Darden Mill Run, 17,781 acres; Flat Swamp, 23,682 acres; and Tarrara Creek (exclusive of Flat Swamp), 20,819 acres.

A portion of Three Creek (part of K27R-02-BAC) was first listed as impaired on Virginia's *2002 303(d) Report on Impaired Waters* due to water quality violations of the fecal coliform bacteria standard. Flat Swamp (K13R-02-BAC) and Darden Mill Run (K30R-01-BAC) were first listed as impaired on Virginia's *Final 2004 305(b)/303(d) Water Quality Assessment Integrated Report* due to water quality violations of the fecal coliform bacteria standard. Mill Swamp (K28R-01-BAC) and two segments of Three Creek (K26R-02-BAC and the remainder of K27R-02-BAC) were first listed as impaired on Virginia's *Final 2006 305(b)/303(d) Water Quality Assessment Integrated Report* due to water quality violations of the fecal coliform and *E. coli* standards, respectively. Tarrara Creek (K13R-01-BAC) and one segment of Three Creek (K26R-03-BAC) were first listed as impaired on Virginia's *Final 2008 305(b)/303(d) Water Quality Assessment Integrated Report* due to water quality violations of the *E. coli* standard (VADEQ, 2010).

All of these impaired segments have been assessed as not supporting the Clean Water Act's Primary Contact Recreational Use Goal.

This document describes the Total Maximum Daily Loads (TMDL) for bacteria that were developed for the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds in order to remedy the bacteria water quality impairments. The TMDLs were developed for the water quality standard for bacteria, which states that the calendar-month geometric mean concentration of *E. coli* shall not exceed 126 cfu/100 mL. A glossary of terms used in the development of this TMDL is listed in Appendix A.

Sources of Bacteria

There are three large and two small point sources with permits to discharge bacteria into the Three Creek watershed; no point sources discharging bacteria exist in the remaining study areas. However, the majority of the bacteria load originates from nonpoint sources. The nonpoint sources of bacteria originate from livestock, wildlife, pets, and humans. Significant bacteria loads come from wildlife directly depositing feces in the stream. Livestock directly depositing bacteria on the land surface also contribute a significant amount of bacteria to the stream during large storm events. Wildlife contribute bacteria loadings to the stream and all land surfaces, in accordance with the habitat range for each species. Household pets contribute a small amount of bacteria to residential areas, while hunt club dogs contribute bacteria to swamps and forests. The amounts of bacteria produced in different locations (e.g., streams, pasture, forest) were estimated on a monthly basis to account for seasonal variability in wildlife behavior and livestock production and practices. Livestock management and production factors, such as the fraction of time livestock spend in streams, were considered on a monthly basis. These sources of bacteria can be summarized in two ways. First, Table ES. 1 through Table ES. 4 summarize the bacteria **produced** in each location (stream, cropland, pasture, residential, and forest). Land-deposited sources of bacteria undergo die-off and must be transported by runoff from rainfall events into the stream. Direct-deposited sources enter the stream immediately without die-off and without the need for a rainfall event. The relative contributions given in Table ES. 5 through Table ES. 11 reflect the

contributions from each source to the bacteria **surviving** in-stream at the outlet of each impaired segment. These surviving bacteria are quantified through modeling (see next section) that takes into account the varied fate and transport processes and represents the fraction of in-stream bacteria attributable to each source for each impaired stream segment. Because the bacteria deposited directly to the stream are subject to less die-off than land deposited sources and do not require a rainfall event to be transferred to the stream, the directly deposited sources compose a higher percentage of surviving bacteria than they do of the overall number of bacteria produced in the watershed.

Table ES. 1. Estimated annual fecal coliform loadings to the stream and the various land use categories for existing conditions in the Three Creek watershed.

Source	Fecal coliform loading ($x10^{12}$ cfu/yr)	Percent of total loading
Direct loading to streams		
Livestock in stream	13	<1%
Hunt Club washoff	2	<1%
Wildlife in stream	327	3%
Point Sources	<1	<1%
Loading to land surfaces		
Cropland†	627	6%
Pasture	7,810	71%
Residential	593	5%
Forest	1,454	13%
Wetlands	128	1%
Total	**10,954**	

† Includes an average 3.15 x 10^{10} cfu/year from biosolids

Table ES. 2. Estimated annual fecal coliform loadings to the stream and the various land use categories for existing conditions in the Flat Swamp and Tarrara Creek watersheds.

Source	Fecal coliform loading ($x10^{12}$ cfu/yr)	Percent of total loading
Direct loading to streams		
Livestock in stream	24	<1%
Hunt Club washoff	1	<1%
Wildlife in stream	137	2%
Straight pipes	2	<1%
Loading to land surfaces		
Cropland	350	4%
Pasture	6,669	85%
Residential	154	2%
Forest	417	5%
Wetlands	47	1%
Total	**7,801**	

Table ES. 3. Estimated annual fecal coliform loadings to the stream and the various land use categories for existing conditions in the Mill Swamp watershed.

Source	Fecal coliform loading ($x10^{12}$ cfu/yr)	Percent of total loading
Direct loading to streams		
Livestock in stream	<1	<1%
Hunt Club washoff	<1	<1%
Wildlife in stream	41	7%
Straight pipes	4	1%
Loading to land surfaces		
Cropland	79	13%
Pasture	259	43%
Residential	64	11%
Forest	146	24%
Wetlands	8	1%
Total	**601**	

Table ES. 4. Estimated annual fecal coliform loadings to the stream and the various land use categories for existing conditions in the Darden Mill Run watershed.

Source	Fecal coliform loading ($x10^{12}$ cfu/yr)	Percent of total loading
Direct loading to streams		
Livestock in stream	10	<1%
Hunt Club washoff	<1	<1%
Wildlife in stream	48	1%
Loading to land surfaces		
Cropland	140	4%
Pasture	3,106	87%
Residential	88	2%
Forest	159	4%
Wetlands	10	<1%
Total	**3,561**	

Table ES. 5. Relative contributions of different *E. coli* sources to the overall *E. coli* concentration for existing conditions in Darden Mill Run.

Source	Mean Daily *E. coli* Concentration by Source, cfu/100 mL	Relative Contribution by Source
Direct nonpoint source loadings to the stream from wildlife	157	70%
Nonpoint source loadings from pervious land segments	41	18%
Direct nonpoint source loadings to the stream from livestock	22	10%
Interflow and groundwater contribution	3	1%
Direct nonpoint source loadings to the stream from hunt clubs	1	<1%
Straight-pipe discharges to stream	<1	<1%
Nonpoint source loadings from impervious land segments	<1	<1%
All Sources	224	

Table ES. 6. Relative contributions of different *E. coli* sources to the overall *E. coli* concentration for existing conditions in Mill Swamp.

Source	Mean Daily *E. coli* Concentration by Source, cfu/100 mL	Relative Contribution by Source
Direct nonpoint source loadings to the stream from wildlife	37	67%
Nonpoint source loadings from pervious land segments	9	15%
Straight-pipe discharges to stream	7	12%
Interflow and groundwater contribution	2	3%
Direct nonpoint source loadings to the stream from livestock	1	1%
Direct nonpoint source loadings to the stream from hunt clubs	<1	<1%
Nonpoint source loadings from impervious land segments	<1	<1%
All Sources	55	

Table ES. 7. Relative contributions of different *E. coli* sources to the overall *E. coli* concentration for existing conditions in Tarrara Creek.

Source	Mean Daily *E. coli* Concentration by Source, cfu/100 mL	Relative Contribution by Source
Direct nonpoint source loadings to the stream from wildlife	253	12%
Straight-pipe discharges to stream	1865[‡]	85%
Nonpoint source loadings from pervious land segments	34	2%
Direct nonpoint source loadings to the stream from livestock	31	1%
Interflow and groundwater contribution	7	<1%
Direct nonpoint source loadings to the stream from hunt clubs	2	<1%
Nonpoint source loadings from impervious land segments	<1	<1%
All Sources	2192[‡]	

[‡]These numbers appear high because the straight pipe contributions that come in near the outlet become extremely concentrated during times of low flow in dry months. A flow-weighted average (that gives more weight to higher flow events and little weight to low flow conditions) gives a straight pipe contribution of 3 cfu/100 mL, 1.4% of the overall flow-weighted average of 212 cfu/100 mL. These high numbers tell us that during low flow conditions the straight pipe contributions will dominate the total bacteria concentration in the stream and cause violations of the water quality criteria.

Table ES. 8. Relative contributions of different *E. coli* sources to the overall *E. coli* concentration for existing conditions in Flat Swamp.

Source	Mean Daily *E. coli* Concentration by Source, cfu/100 mL	Relative Contribution by Source
Direct nonpoint source loadings to the stream from wildlife	203	75%
Nonpoint source loadings from pervious land segments	42	16%
Interflow and groundwater contribution	13	5%
Direct nonpoint source loadings to the stream from livestock	9	3%
Direct nonpoint source loadings to the stream from hunt clubs	2	<1%
Straight-pipe discharges to stream	<1	<1%
Nonpoint source loadings from impervious land segments	<1	<1%
All Sources	269	

Table ES. 9. Relative contributions of different *E. coli* sources to the overall *E. coli* concentration for existing conditions in Three Creek (K27R-02, sub-watershed 1).

Source	Mean Daily *E. coli* Concentration by Source, cfu/100 mL	Relative Contribution by Source
Direct nonpoint source loadings to the stream from wildlife	56	81%
Nonpoint source loadings from pervious land segments	8	11%
Direct nonpoint source loadings to the stream from livestock	4	6%
Interflow and groundwater contribution	1	1%
Straight-pipe discharges to stream	<1	<1%
Nonpoint source loadings from impervious land segments	<1	<1%
Direct nonpoint source loadings to the stream from hunt clubs	<1	<1%
Biosolids	<1	<1%
All Sources	69	

Table ES. 10. Relative contributions of different *E. coli* sources to the overall *E. coli* concentration for existing conditions in Three Creek (K26R-02, sub-watershed 20).

Source	Mean Daily *E. coli* Concentration by Source, cfu/100 mL	Relative Contribution by Source
Direct nonpoint source loadings to the stream from wildlife	172	91%
Direct nonpoint source loadings to the stream from livestock	11	6%
Nonpoint source loadings from pervious land segments	5	3%
Interflow and groundwater contribution	1	<1%
Straight-pipe discharges to stream	<1	<1%
Nonpoint source loadings from impervious land segments	<1	<1%
Direct nonpoint source loadings to the stream from hunt clubs	1	<1%
All Sources	190	

Table ES. 11. Relative contributions of different *E. coli* sources to the overall *E. coli* concentration for existing conditions in Three Creek (K26R-03, sub-watershed 30).

Source	Mean Daily *E. coli* Concentration by Source, cfu/100 mL	Relative Contribution by Source
Direct nonpoint source loadings to the stream from wildlife	110	83%
Nonpoint source loadings from pervious land segments	17	12%
Direct nonpoint source loadings to the stream from livestock	3	2%
Interflow and groundwater contribution	2	1%
Direct nonpoint source loadings to the stream from hunt clubs	1	<1%
Straight-pipe discharges to stream	<1	<1%
Nonpoint source loadings from impervious land segments	<1	<1%
All Sources	133	

Modeling

The Hydrological Simulation Program – FORTRAN (HSPF) (Bicknell *et al.*, 2001) was used to simulate the fate and transport of fecal coliform bacteria in the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds. HSPF is a continuous model that can represent fate and transport of pollutants on both the land surface and in the stream. As recommended by VADEQ, water quality modeling was conducted with fecal coliform inputs, and then a translator equation was used to convert the output to *E. coli* for the final TMDLs. To identify localized sources of fecal coliform within the watershed, the Three Creek watershed was divided into 37 sub-watersheds, the Darden Mill Run watershed into 11 sub-watersheds, the Mill Swamp watershed into 9 sub-watersheds, the Flat Swamp watershed into 12 sub-watersheds, and the Tarrara Creek watershed (exclusive of Flat Swamp) into 9 sub-watersheds based on homogeneity of land use, stream network connectivity, and monitoring station locations.

As continuous flow data for these creeks were not available, the hydrology component of HSPF was calibrated for surrogate watersheds. Based on the similarities in relative distance, watershed size, distribution of land use, and hydrologic soil group

between the impaired watersheds and the Blackwater River watershed in Prince George, Surry, Sussex, and Dinwiddie Counties and the City of Petersburg, the Blackwater River watershed was selected as the surrogate watershed for the majority of the impaired watershed area. Because the headwaters of the Three Creek watershed lie in the Piedmont Ecoregion (rather than the Coastal Plain Ecoregion that surrounds the remaining area), North Meherrin River in Lunenburg, Charlotte, and Prince Edward Counties was selected as the surrogate watershed for the upstream area of Three Creek in the Piedmont Ecoregion. The hydrologic parameters for Blackwater River were originally calibrated in the Chowan Basin TMDL (VADEQ, 2005) and were recalibrated for this TMDL to meet more stringent criteria and take advantage of new features available in HSPF that were not available at the time of the original project. The hydrologic parameters for the North Meherrin River watershed were calibrated as a part of this project. The calibrated parameters from each surrogate model were transferred to the corresponding land uses in the impaired watersheds. The remaining hydrologic parameters, those that have a direct relation to physical characteristics of the watershed (e.g., land slope), were obtained from digital maps of the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds.

The water quality component of the HSPF model was calibrated and validated for Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek at stations 5ATRE008.48, 5ATRE016.02, 5ATRE022.05, 5ATRE026.75, 5ATRE038.07, 5ADMR008.42, 5AMSP000.16, 5AFTS002.93, and 5ATRR002.50 for periods corresponding to the period of record for each station, ranging between 1990 and 2009. Where less than five years of data were available for a given station, validation was not conducted. Inputs to the model included fecal coliform loadings on land and in the stream. A comparison of simulated and observed bacteria concentrations in the stream indicated that the model adequately simulated the fate and transport of fecal bacteria.

Existing Conditions

Contributions from various sources in the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds were represented in HSPF to establish the existing conditions for a representative 5-year period that included both

low and high-flow conditions. This 5-year period used meteorological data from 1991, 1993, 1998, 2002, and 2004 to represent the appropriate range of conditions. Monthly bacteria loadings to different land use categories were calculated for each sub-watershed. Direct seasonal bacteria loadings to streams by cattle on pastures with stream access were calculated for each stream segment. Bacteria loadings to streams and land by wildlife were estimated for several species. Bacteria loadings to land from failing septic systems and directly to the stream from straight pipes were estimated based on communication with Department of Health personnel and suitability of soils. Bacteria contributions from pet and hunting dog waste were also considered. Meteorological data were paired with bacterial loading and land use data for existing conditions to establish this baseline scenario. Results from the calibrated HSPF model showed routine high signatures from wildlife direct deposit, with some additional contributions from straight pipes, livestock direct deposit, and overland flow. In most watersheds, contributions from wildlife direct deposit alone (without any other source of bacteria) violated the geometric mean criterion.

Allocation Scenarios

Different source reduction scenarios were evaluated to identify implementable scenarios that meet the calendar-month geometric mean *E. coli* criterion (126 cfu/100 mL) with zero violations. These scenarios were conducted using the same meteorological data used to establish existing conditions. The bacteria loadings used in modeling correspond to anticipated and permitted future conditions for the Darden Mill Run, Mill Swamp, Flat Swamp, Tarrara Creek, and Three Creek watersheds. These future conditions differed from existing conditions in that confined animal feeding operations, biosolids applications, and permitted point source dischargers were represented in the model at their maximum permitted limits. The reductions required for each impaired segment to meet the applicable water quality criterion are presented in Table ES. 12. In several segments reductions in wildlife contributions are required; note that in these cases, these are the minimum wildlife reductions needed to attain the criteria under the critical conditions, even if all other bacteria sources were completely eliminated. The critical conditions for most of these watersheds are times of very low

flow. The lower reductions needed from anthropogenic sources are because the wildlife contribute the overwhelming majority of bacteria, coupled with the fact that anthropogenic sources tend to be larger contributors under periods of high flow than under the low flow conditions that were critical for these watersheds. Three large and two small point sources currently discharge at or below their permit requirements; therefore, the proposed scenarios require load reductions only for nonpoint sources of fecal coliform. Details on the loads to be reduced from each source are given in Table ES. 13 through Table ES. 26.

Table ES. 12. Required fecal coliform loading reductions (%) to meet the *E. coli* standard.

Impaired Segment	Cattle Direct Deposit	Loads from Pasture	Loads from Cropland	Straight Pipes & Failing Septics	Loads from Residential Areas	Hunt Club 'Direct Deposit'	Wildlife Direct Deposit
Darden Mill Run	95	0	0	100	0	75	65
Mill Swamp	0	0	0	100	0	0	0
Flat Swamp	0	35	35	100	35	0	85
Tarrara Creek†	75	0	0	100	0	0	90
Three Creek (K26R-03)	75	75	75	100	75	55	50
Three Creek (K26R-02)‡	90	0	0	100	0	45	85
Three Creek (K27R-02)¶	0	0	0	100	0	0	0

†These reductions are applied to the drainage area for Tarrara Creek not included in the drainage area for Flat Swamp and incorporate the Flat Swamp reductions on the Flat Swamp drainage area.

‡ These reductions are applied to the drainage area for Three Creek (K26R-02) not included in the drainage area for Three Creek (K26R-03) and incorporate the Three Creek (K26R-03) reductions on the Three Creek (K26R-03) drainage area.

¶ These reductions are applied to the drainage area for Three Creek (K27R-02) not included in the drainage area for Three Creek (K26R-03) or Three Creek (K26R-02) and incorporate the Three Creek (K26R-03) reductions on the Three Creek (K26R-03) drainage area and the Three Creek (K26R-02) reductions on the Three Creek (K26R-02) drainage area.

Table ES. 13. Estimated annual nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for the TMDL allocation scenario for Darden Mill Run.

Land use category	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)	Percent of total land deposited load from nonpoint sources	TMDL nonpoint source allocation load ($x10^{12}$ cfu/yr)	Percent Reduction from Baseline Load
Cropland	148	4	148	0
Pasture	3,106	88	3,106	0
Residential - septics	35	1	0	100
Residential - other	53	2	53	0
Forest – wildlife	135	4	135	0
Forest – hunt clubs	24	1	24	0
Wetlands – wildlife	7	<1	7	0
Wetlands – hunt clubs	2	<1	2	0
Total	3,510		3,475	1

Table ES. 14. Estimated annual nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for the TMDL allocation scenario for Mill Swamp.

Land use category	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)	Percent of total land deposited load from nonpoint sources	TMDL nonpoint source allocation load ($x10^{12}$ cfu/yr)	Percent Reduction from Baseline Load
Cropland	79	14	79	0
Pasture	259	47	259	0
Residential - septics	15	3	0	100
Residential - other	49	9	49	0
Forest – wildlife	124	22	124	0
Forest – hunt clubs	22	4	22	0
Wetlands – wildlife	5	1	5	0
Wetlands – hunt clubs	2	<1	2	0
Total	555		540	3

Table ES. 15. Estimated annual nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for the TMDL allocation scenario for Flat Swamp.

Land use category	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)	Percent of total land deposited load from nonpoint sources	TMDL nonpoint source allocation load ($x10^{12}$ cfu/yr)	Percent Reduction from Baseline Load
Cropland - biosolids	2,084	38	1,355	35
Cropland - other	125	2	81	35
Pasture	2,969	54	1,930	35
Residential - septics	17	<1	0	100
Residential - other	35	<1	23	35
Forest – wildlife	201	4	201	0
Forest – hunt clubs	33	1	33	0
Wetlands – wildlife	19	<1	19	0
Wetlands – hunt clubs	4	<1	4	0
Total	5,483		3,646	34

Table ES. 16. Estimated annual nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for the TMDL allocation scenario for Tarrara Creek.

Land use category	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)†	Percent of total land deposited load from nonpoint sources	TMDL nonpoint source allocation load ($x10^{12}$ cfu/yr)†	Percent Reduction from Baseline Load
Cropland - biosolids	45	1	45	0
Cropland - other	226	5	226	0
Pasture	3,691	86	3,691	0
Residential - septics	15	<1	0	100
Residential - other	87	2	87	0
Forest – wildlife	157	4	157	0
Forest – hunt clubs	26	1	26	0
Wetlands – wildlife	20	<1	20	0
Wetlands – hunt clubs	4	<1	4	0
Total	4,271		4,256	<1

† Exclusive of Flat Swamp loads

Table ES. 17. Estimated annual nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for the TMDL allocation scenario for Three Creek (K26R-03, sub-watershed 30).

Land use category	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)	Percent of total land deposited load from nonpoint sources	TMDL nonpoint source allocation load ($x10^{12}$ cfu/yr)	Percent Reduction from Baseline Load
Cropland	20	1	5	75
Pasture	2,093	85	523	75
Residential – septics	26	2	0	100
Residential – other	61	2	15	75
Forest – wildlife	227	9	227	0
Forest – hunt clubs	34	1	34	0
Wetlands – wildlife	1	<1	1	0
Wetlands – hunt clubs	0.3	<1	0.3	0
Total	2,462		805	67

Table ES. 18. Estimated annual nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for the TMDL allocation scenario for Three Creek (K26R-02, sub-watershed 20).

Land use category	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)†	Percent of total land deposited load from nonpoint sources	TMDL nonpoint source allocation load ($x10^{12}$ cfu/yr)†	Percent Reduction from Baseline Load
Cropland	134	7	134	0
Pasture	957	52	957	0
Residential - septics	64	4	0	100
Residential - other	222	12	222	0
Forest – wildlife	356	20	356	0
Forest – hunt clubs	36	2	36	0
Wetlands – wildlife	49	3	49	0
Wetlands – hunt clubs	6	<1	6	0
Total	1,824		1,760	4

†Exclusive of K26R-03 loads

Table ES. 19. Estimated annual nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for the TMDL allocation scenario for Three Creek (K27R-02, sub-watershed 1).

Land use category	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)†	Percent of total land deposited load from nonpoint sources	TMDL nonpoint source allocation load ($x10^{12}$ cfu/yr)†	Percent Reduction from Baseline Load
Cropland - biosolids	706	10	706	0
Cropland - other	465	7	465	0
Pasture	4,760	68	4,760	0
Residential – septics	48	1	0	100
Residential – other	172	2	172	0
Forest – wildlife	701	10	701	0
Forest – hunt clubs	99	1	99	0
Wetlands – wildlife	60	1	60	0
Wetlands – hunt clubs	12	<1	12	0
Total	7,023		6,975	1

†Exclusive of K26R-03 and K26R-02 loads

Table ES. 20. Estimated annual direct nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for the TMDL allocation scenario for Darden Mill Run.

Source	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)	Percent of total direct deposited load from direct nonpoint source	TMDL direct nonpoint source allocation load ($x10^{12}$ cfu/yr)	Percent Reduction from Baseline Load
Livestock in Streams	10	17	0.5	95
Straight Pipes	0	0	0	100
Wildlife in Streams	48	83	17	65
Washoff from Hunt Clubs	0.3	<1	0.08	75
Total	58.3		17.6	70

Table ES. 21. Estimated annual direct nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for the TMDL allocation scenario for Mill Swamp.

Source	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)	Percent of total direct deposited load from direct nonpoint source	TMDL direct nonpoint source allocation load ($x10^{12}$ cfu/yr)	Percent Reduction from Baseline Load
Livestock in Streams	0.3	1	0.3	0
Straight Pipes	4	9	0	100
Wildlife in Streams	41	90	41	0
Washoff from Hunt Clubs	0.2	<1	0.2	0
Total	45.5		41.5	9

Table ES. 22. Estimated annual direct nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for the TMDL allocation scenario for Flat Swamp.

Source	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)	Percent of total direct deposited load from direct nonpoint source	TMDL direct nonpoint source allocation load ($x10^{12}$ cfu/yr)	Percent Reduction from Baseline Load
Livestock in Streams	8	10	8	0
Straight Pipes	<1	<1	0	100
Wildlife in Streams	73	90	11	85
Washoff from Hunt Clubs	0.4	<1	0.4	0
Total	81.4		19.4	76

Table ES. 23. Estimated annual direct nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for the TMDL allocation scenario for Tarrara Creek.

Source	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)†	Percent of total direct deposited load from direct nonpoint source	TMDL direct nonpoint source allocation load ($x10^{12}$ cfu/yr)†	Percent Reduction from Baseline Load
Livestock in Streams	16	19	4	75
Straight Pipes	2	2	0	100
Wildlife in Streams	64	78	6.4	90
Washoff from Hunt Clubs	0.3	<1	0.3	0
Total	82.3		10.7	87

† Excludes loads from Flat Swamp

Table ES. 24. Estimated annual direct nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for the TMDL allocation scenario for Three Creek (K26R-03, sub-watershed 30).

Source	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)	Percent of total direct deposited load from direct nonpoint source	TMDL direct nonpoint source allocation load ($x10^{12}$ cfu/yr)	Percent Reduction from Baseline Load
Livestock in Streams	1	2	0.3	75
Straight Pipes	0	0	0	100
Wildlife in Streams	43	97	21.5	50
Washoff from Hunt Clubs	0.3	1	0.14	55
Total	44.3		21.9	51

Table ES. 25. Estimated annual direct nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for the TMDL allocation scenario for Three Creek (K26R-02, sub-watershed 20).

Source	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)†	Percent of total direct deposited load from direct nonpoint source	TMDL direct nonpoint source allocation load ($x10^{12}$ cfu/yr)†	Percent Reduction from Baseline Load
Livestock in Streams	2	2	0.2	90
Straight Pipes	0	0	0	100
Wildlife in Streams	103	98	15.5	85
Washoff from Hunt Clubs	0.4	<1	0.2	45
Total	105.4		15.9	85

† Exclusive of K26R-03 loads

Table ES. 26. Estimated annual direct nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for the TMDL allocation scenario for Three Creek (K27R-02, sub-watershed 1).

Source	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)†	Percent of total direct deposited load from direct nonpoint source	TMDL direct nonpoint source allocation load ($x10^{12}$ cfu/yr)†	Percent Reduction from Baseline Load
Livestock in Streams	10	5	10	0
Straight Pipes	0	0	0	100
Wildlife in Streams	181	94	181	0
Washoff from Hunt Clubs	1	1	1	0
Total	192		192	0

† Exclusive of K26R-03 and K26R-02 loads

The TMDL was determined as the average annual *E. coli* load at the watershed outlets for the chosen allocation scenarios. The WLAs for Darden Mill Run and Mill Swamp were determined as approximately 1% of the total TMDL load to allow for future growth in permitted facilities. No modeled future growth will be included in this bacterial TMDL for Flat Swamp and Tarrara Creek due to the hydrologic nature of the swamp water (with significant evaporative losses during low flows) and the significant wildlife bacterial loading component in those watersheds. New permitted bacteria sources will be evaluated on an individual basis for Flat Swamp and Tarrara Creek. It may be

considered appropriate to permit new facilities in the Flat Swamp and Tarrara Creek watersheds at the bacteria water quality standard criteria for *E. coli*, 126 cfu/L. In consideration of factors presented in this bacteria TMDL for Flat Swamp and Tarrara Creek, EPA Region 3 TMDL staff are in agreement with this approach.

The WLAs for the three segments of Three Creek were obtained by first taking the product of the permitted point sources' *E. coli* discharge concentrations and allowable annual discharges, and adding a load five times this amount as an allocation for potential future permits. The LAs were then determined as the TMDL-WLA. The margin of safety for all of these TMDLs was implicit and achieved through conservative assumptions of bacteria loading and management practices as detailed throughout this report. Equation ES.1 was used to calculate the TMDL allocations shown in Table ES. 27 through Table ES. 33.

$$TMDL = \Sigma WLA + \Sigma LA + MOS \qquad [ES.1]$$

where:

WLA = wasteload allocation (point source contributions);

LA = load allocation (nonpoint source contributions); and

MOS = margin of safety.

Table ES. 27. Estimated annual *E. coli* loadings (cfu/yr) at the watershed outlet used for the Darden Mill Run bacteria TMDL.

Parameter	ΣWLA	ΣLA	MOS*	TMDL
E. coli	4.10×10^{11}	410.17×10^{11}	--	414.27×10^{11}

*Implicit MOS

Table ES. 28. Estimated annual *E. coli* loadings (cfu/yr) at the watershed outlet used for the Mill Swamp bacteria TMDL.

Parameter	ΣWLA	ΣLA	MOS*	TMDL
E. coli	1.93×10^{11}	192.60×10^{11}	--	194.53×10^{11}

*Implicit MOS

Table ES. 29. Estimated annual *E. coli* loadings (cfu/yr) at the watershed outlet used for the Flat Swamp bacteria TMDL.

Parameter	ΣWLA‡	ΣLA	MOS*	TMDL
E. coli	--	378.2×10^{11}	--	378.2×10^{11}

*Implicit MOS

‡New permitted bacteria sources will be evaluated on an individual basis for Flat Swamp

Table ES. 30. Estimated annual *E. coli* loadings (cfu/yr) at the watershed outlet used for the Tarrara Creek bacteria TMDL.

Parameter	ΣWLA[‡]	ΣLA	MOS[*]	TMDL
E. coli	--	657.7×10^{11}	--	657.7×10^{11}

[*]Implicit MOS
[‡]New permitted bacteria sources will be evaluated on an individual basis for Tarrara Creek

Table ES. 31. Estimated annual *E. coli* loadings (cfu/yr) at the watershed outlet used for the Three Creek (K26R-03) bacteria TMDL.

Parameter	ΣWLA	ΣLA	MOS[*]	TMDL
E. coli	0.05×10^{11}	445.06×10^{11}	--	445.11×10^{11}

[*]Implicit MOS

Table ES. 32. Estimated annual *E. coli* loadings (cfu/yr) at the watershed outlet used for the Three Creek (K26R-02) bacteria TMDL.

Parameter	ΣWLA	ΣLA	MOS[*]	TMDL
E. coli	95.39×10^{11}	156.91×10^{11}	--	252.30×10^{11}

[*]Implicit MOS

Table ES. 33. Estimated annual *E. coli* loadings (cfu/yr) at the watershed outlet used for the Three Creek (K27R-02) bacteria TMDL.

Parameter	ΣWLA	ΣLA	MOS[*]	TMDL
E. coli	142.5×10^{11}	755.49×10^{11}	--	897.99×10^{11}

[*]Implicit MOS

Transitional Scenario

The implementation of a transitional scenario, or Stage 1 implementation, will allow for an evaluation of the effectiveness of management practices and accuracy of model assumptions through data collection. Stage 1 implementation was developed with a target of a 10.5% violation rate of the instantaneous *E. coli* water quality criterion (235 cfu/100 mL) and no reductions in wildlife sources. However, the former goal could not be reached in some of the watersheds without wildlife reductions; for those watersheds, the Stage 1 scenario simply removes the wildlife reductions called for in the TMDL. The Stage 1 scenarios are given in Table ES. 34 for each impaired segment. Hunt Club 'Direct Deposit' represents washoff from hosing down dog kennels at hunt clubs.

Table ES. 34. Allocation scenarios for Stage 1 TMDL implementation for the Darden Mill Run, Mill Swamp, Flat Swamp, Tarrara Creek, and Three Creek watersheds.

Impaired Segment	Single Sample Criterion Percent Violation	Required Fecal Coliform Loading Reductions to Meet the Stage 1 Goal, %					
		Livestock Direct Deposit	Loads from Pasture	Loads from Cropland	Straight Pipes & Failing Septics	Hunt Club 'Direct Deposit'	Non-Human Loads from Residential Areas
Darden Mill Run	27	95	0	0	100	75	0
Mill Swamp	1	0	0	0	100	0	0
Flat Swamp	37	0	35	35	100	0	35
Tarrara Creek†	39	75	0	0	100	0	0
Three Creek (K26R-03)	8	0	0	0	100	0	0
Three Creek (K26R-02)‡	27	90	0	0	100	45	0
Three Creek (K27R-02)¶	1	0	0	0	100	0	0

†These reductions are applied to the drainage area for Tarrara Creek not included in the drainage area for Flat Swamp and incorporate the Flat Swamp reductions on the Flat Swamp drainage area.
‡These reductions are applied to the drainage area for Three Creek (K26R-02) not included in the drainage area for Three Creek (K26R-03) and incorporate the Three Creek (K26R-03) reductions on the Three Creek (K26R-03) drainage area.
¶These reductions are applied to the drainage area for Three Creek (K27R-02) not included in the drainage area for Three Creek (K26R-03) or Three Creek (K26R-02) and incorporate the Three Creek (K26R-03) reductions on the Three Creek (K26R-03) drainage area and the Three Creek (K26R-02) reductions on the Three Creek (K26R-02) drainage area.

Implementation

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

The hydrologic nature of the swamp waters in this TMDL and the significant wildlife bacterial loading component impacted the modeling results for these watersheds. The model shows that wildlife are major contributors to the bacteria concentrations, nearly to the exclusion of all other sources (Section 5.2), and

furthermore that the evaporative losses over the swamp surface during critical low flow periods may cause noticeable increased concentrations of bacteria. New permitted bacteria sources will be evaluated on an individual basis. No use change will be pursued at this time; however, it may be appropriate to do so in the future, and efforts to develop this bacteria TMDL and an associated Natural Conditions report for dissolved oxygen provide the basis for such evaluation. In consideration of factors presented in this bacteria TMDL for Darden Mill Run, Mill Swamp, Flat Swamp, Tarrara Creek, and Three Creek, EPA Region 3 TMDL staff are in agreement with this approach.

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

Public Participation

Public participation was solicited at every stage of TMDL development in order to receive inputs from stakeholders and to apprise the stakeholders of the progress made. In March 2011, members of the Center for Watershed Studies at Virginia Tech traveled to Emporia for a two-day trip around the impaired watersheds to become acquainted with them. Throughout the process, personnel from Virginia Tech contacted stakeholders and local agency personnel via telephone, email, and in person to acquire their input. Two public meetings were held to inform stakeholders of the TMDL process and solicit feedback. These were held on May 19, 2011 at Capron Elementary School and February 15, 2012 at the Board of Supervisors Room for Southampton County in Courtland, VA. Two Technical Advisory Committee meetings were also held, on June 28, 2011 and January 23, 2012 at the Board of Supervisors Room for Southampton County. These meetings provided a forum for a group of interested stakeholders and agency personnel to provide detailed feedback on the estimates and methods used in these TMDLs. More details on public participation can be found in Chapter 7.

1 Introduction

1.1 Background

1.1.1 TMDL Definition and Regulatory Information

Section 303(d) of the Federal Clean Water Act and the U.S. Environmental Protection Agency's (USEPA) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to identify water bodies that violate state water quality standards and to develop Total Maximum Daily Loads (TMDLs) for such water bodies. A TMDL reflects the total pollutant loading a water body can receive and still meet water quality standards. A TMDL establishes the maximum allowable pollutant loading from both point and nonpoint sources for a water body, allocates the load among the pollutant contributors, and provides a framework for taking actions to restore water quality.

1.1.2 Impairment Listing

A portion of Three Creek (part of K27R-02-BAC) was first listed as impaired on Virginia's *2002 303(d) Report on Impaired Waters* due to water quality violations of the fecal coliform bacteria standard. Flat Swamp (K13R-02-BAC) and Darden Mill Run (K30R-01-BAC) were first listed as impaired on Virginia's *Final 2004 305(b)/303(d) Water Quality Assessment Integrated Report* due to water quality violations of the fecal coliform bacteria standard. Mill Swamp (K28R-01-BAC) and two segments of Three Creek (K26R-02-BAC and the remainder of K27R-02-BAC) were first listed as impaired on Virginia's *Final 2006 305(b)/303(d) Water Quality Assessment Integrated Report* due to water quality violations of the fecal coliform and *E. coli* standards, respectively. Tarrara Creek (K13R-01-BAC) and one segment of Three Creek (K26R-03-BAC) were first listed as impaired on Virginia's *Final 2008 305(b)/303(d) Water Quality Assessment Integrated Report* due to water quality violations of the *E. coli* standard (VADEQ, 2010) (Figure 1.1). The Virginia Department of Environmental Quality (VADEQ) has described the impaired segments as presented in Table 1.1.

Table 1.1. Impaired Segments Addressed in this TMDL report.

Impaired Segment	Size	Target Date for TMDL Development	Description
Three Creek (K27R-02-BAC)	10.38 miles 8.85 miles	2012 2018	From the confluence of Chatman Branch (RM 20.95) downstream to the confluence with Nottoway River (RM 0.00).
Three Creek (K26R-02-BAC)	6.51 miles	2018	From Otterdam Swamp downstream to Browns Branch.
Three Creek (K26R-03-BAC)	4.34 miles	2020	Three Creek from Cattail Creek downstream to Slagles Dam.
Darden Mill Run (K30R-01-BAC)	10.37 miles	2016	From the headwaters near Newsoms downstream to Windbourne Millpond, near VA/NC state line.
Mill Swamp (K28R-01-BAC)	10.19 miles	2018	The main stem of Mill Swamp only, from the headwaters downstream to the confluence with the Nottoway River.
Flat Swamp (K13R-02-BAC)	8.14 miles	2016	Downstream of the confluence of Bellyache Swamp and Frank's Branch extending downstream to the confluence with Tarrara Creek.
Tarrara Creek (K13R-01-BAC)	13.94 miles	2020	The entirety of Tarrara Creek located northeast of Boykins.

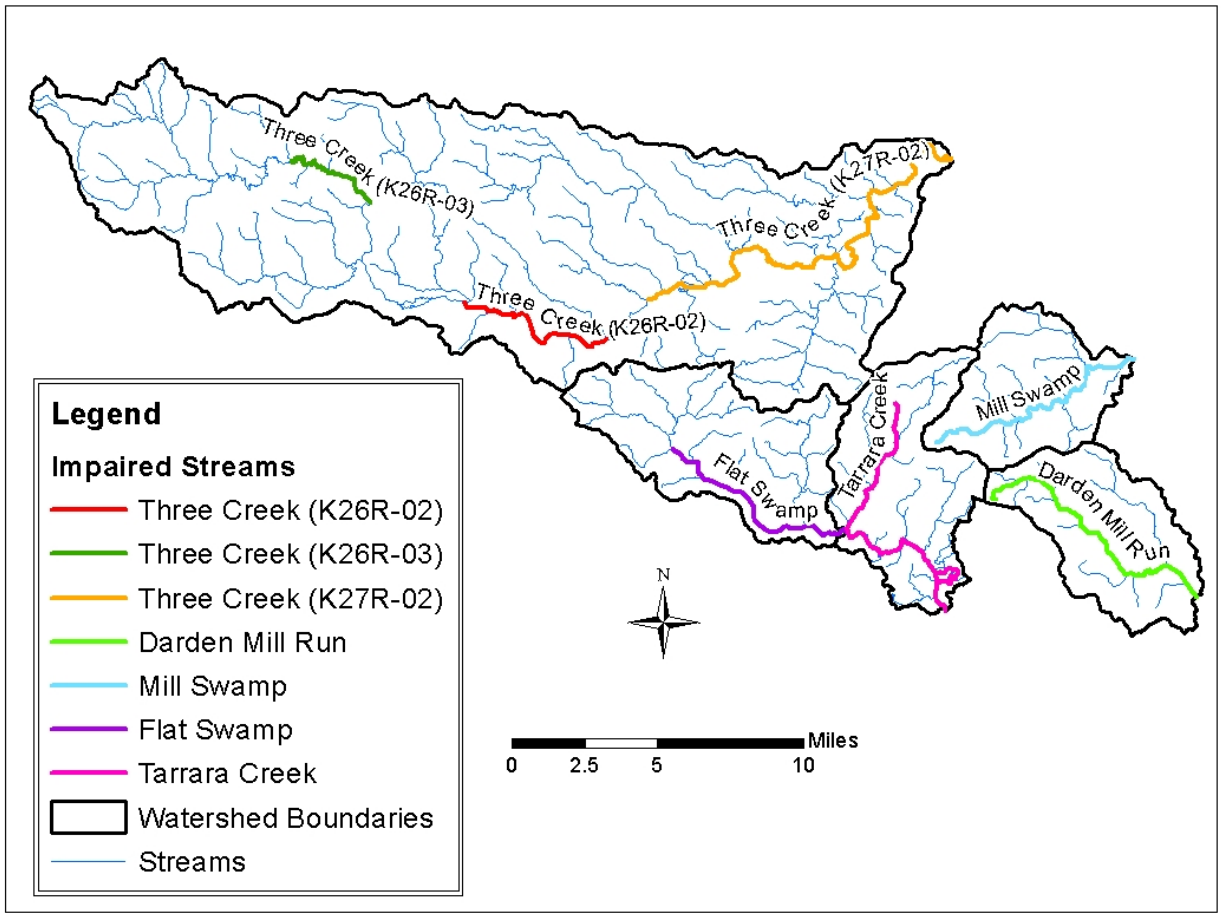

Figure 1.1. Impaired segments in the study area.

1.1.3 Watershed Location and Description

The Three Creek watershed is located in Southampton, Sussex, Greensville, and Brunswick Counties and the City of Emporia; the Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds are located in Southampton County (Figure 1.2). The watershed sizes are: Three Creek, 139,731 acres; Mill Swamp, 15,853 acres; Darden Mill Run, 17,781 acres; Flat Swamp, 23,682 acres; and Tarrara Creek (exclusive of Flat Swamp), 20,819 acres; all are part of the Chowan River Basin.

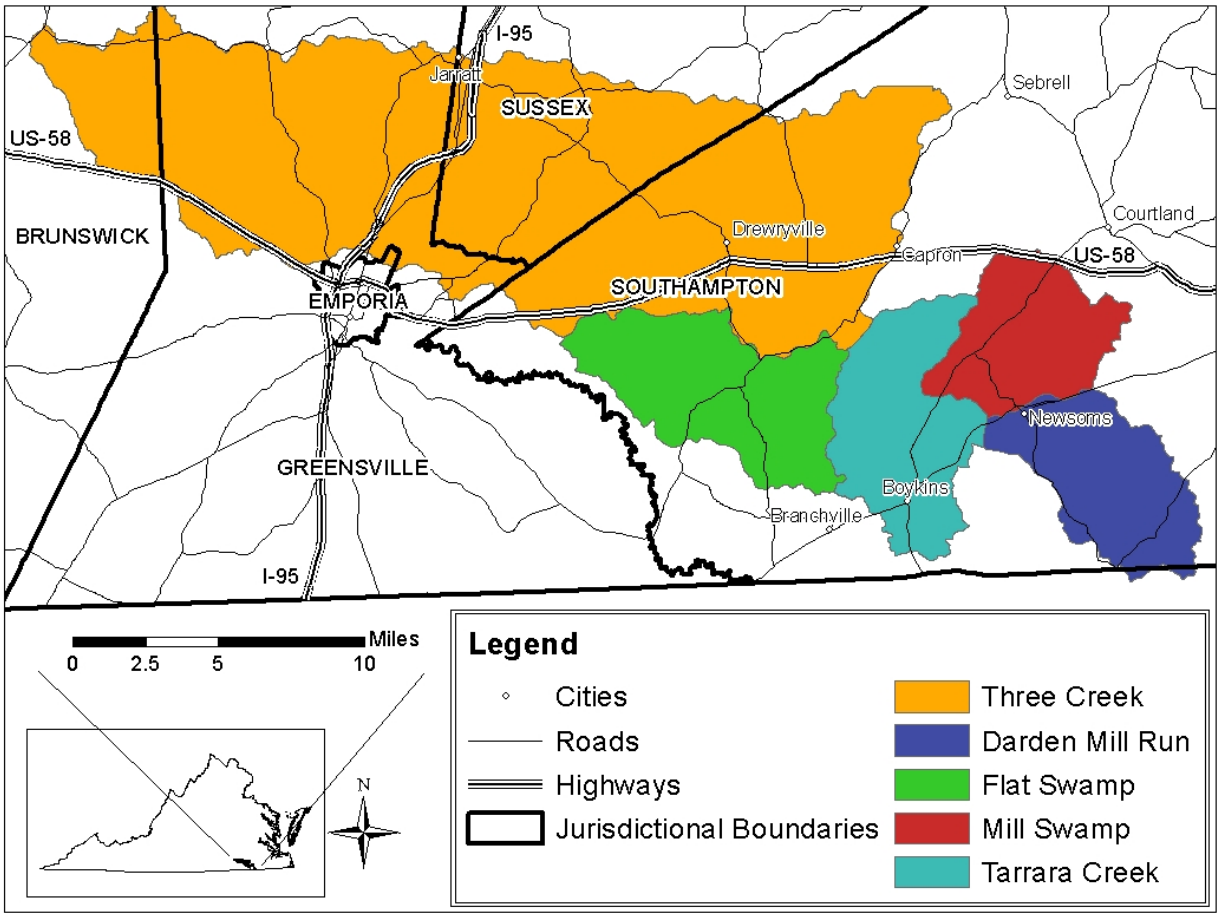

Figure 1.2. Impaired watershed locations.

The land use distribution in the Three Creek watershed consists mainly of forested area (64%) but with a significant portion of cropland (22%); less significant land uses include pasture (6%), residential (3%), and wetlands (6%). The land use distribution in the Darden Mill Run watershed consists mainly of forested area (51%) but with a significant portion of cropland (40%); less significant land uses include pasture (4%), residential (1%), and wetlands (5%). The land use distribution in the Mill Swamp watershed consists mainly of forested area (53%) but with a significant portion of cropland (37%); less significant land uses include pasture (5%), residential (1%), and wetlands (4%). The land use distribution in the Flat Swamp watershed consists mainly of forested area (53%) but with a significant portion of cropland (36%); less significant land uses include pasture (4%), residential (<1%), and wetlands (7%). The land use distribution in the Tarrara Creek watershed (exclusive of Flat Swamp) consists mainly of

forested area (48%) but with a significant portion of cropland (39%); less significant land uses include pasture (5%), residential (1%), and wetlands (7%). Darden Mill Run flows into Mill Creek; Mill Creek, Three Creek, and Mill Swamp flow into the Nottoway River (USGS Hydrologic Unit Code 03010201). Nottoway River discharges into the Chowan River near the North Carolina state line. Flat Swamp flows into Tarrara Creek, which flows into an unnamed swamp, which discharges to the Meherrin River (USGS Hydrologic Unit Code 03010204) near the North Carolina state line. The Meherrin River also flows into the Chowan River. The Chowan River flows into the Albemarle Sound in North Carolina.

1.1.4 Pollutants of Concern

Pollution from both point and nonpoint sources can lead to *Escherichia coli* (*E. coli*) contamination of water bodies. *E. coli*, a subset of the fecal coliform bacteria group, are found in the intestinal tract of warm-blooded animals; consequently, fecal waste of warm-blooded animals contains *E. coli*. Even though most *E. coli* are not pathogenic, their presence in water indicates contamination by fecal material. Because fecal material may contain pathogenic organisms, water bodies with *E. coli* bacteria are potential sources of pathogenic organisms. For contact recreational activities such as boating and swimming, health risks increase with increasing *E. coli* counts. If the *E. coli* concentration in a water body exceeds state water quality standards, the water body is listed for violation of the state bacteria standard for contact recreational uses. As will be discussed in Section 1.2.2, Virginia has adopted an *E. coli* water quality standard.

1.2 Designated Uses and Applicable Water Quality Standards

1.2.1 Designation of Uses (9 VAC 25-260-10)

"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." (VAC, 2010a).

Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek do not support the recreational (primary contact) designated use due to violations of the bacteria standard.

1.2.2 Bacteria Standard (9 VAC 25-260-170)

In accordance with EPA recommendations for protection of recreational uses, Virginia has adopted an *E. coli* standard for freshwater and an enterococci standard for marine waters. For a non-shellfish water body to be in compliance with Virginia's bacteria standards (as published in the Virginia Register Volume 25, Issue 12; effective January 6, 2011) the following criteria shall apply to protect primary contact recreational uses (VAC, 2010b) (note that as of November 7, 2011, there are no waters listed in 'subsection B'):

> A. The following bacteria criteria (colony forming units (CFU)/100 ml) shall apply to protect primary contact recreational uses in surface waters, except waters identified in subsection B of this section:
>
> *E. coli* bacteria shall not exceed a monthly geometric mean of 126 CFU/100 ml in freshwater.
>
> Enterococci bacteria shall not exceed a monthly geometric mean of 35 CFU/100 ml in transition and saltwater.
>
> 1. See 9VAC25-260-140 C for boundary delineations for freshwater, transition and saltwater.
> 2. Geometric means shall be calculated using all data collected during any calendar month with a minimum of four weekly samples.
> 3. If there are insufficient data to calculate monthly geometric means in freshwater, no more than 10% of the total samples in the assessment period shall exceed 235 *E. coli* CFU/100 ml.

Stations that were included in the impaired waters list prior to June 30, 2008 that had fewer than 12 samples of *E. coli* were evaluated with the interim fecal coliform standard listed below (as published in the Virginia Register Volume 18, Issue 20) (VRR, 2002):

> 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.

Section 1.1.2 describes the impaired stations and indicates whether they were first listed under an *E. coli* standard or the older fecal coliform standard.

Because there were not enough data at any of the stations in the study watersheds to calculate a monthly geometric mean, the so-called 'instantaneous' criteria (235 cfu/100 mL *E. coli* or 400 cfu/100 mL fecal coliform) were used for the impairment listing. During any assessment period, if more than 10.5% of a station's samples exceeded the applicable instantaneous criteria, the stream segment associated with that station was classified as impaired and now requires a TMDL to be developed and implemented to bring the station into compliance with the water quality standard. There are seven ambient monitoring stations on Three Creek, one of which ended sampling in 1979 and one of which only has one sample; the remaining five stations are in violation of the bacteria standard. Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek each have one station, all of which are in violation of the bacteria standard. These violations led to the impairment on the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek segments.

The bacteria TMDL for the impaired segments will be developed to meet the *E. coli* standard. As recommended by DEQ, the modeling will be conducted with fecal coliform inputs, and then a translator equation will be used to convert the output to *E. coli* concentrations.

2 Watershed Characterization

2.1 Selection of Sub-watersheds

To account for the spatial distribution of fecal coliform sources, the Three Creek watershed was subdivided into 37 sub-watersheds as shown in Figure 2.1. Darden Mill Run was subdivided into 11 sub-watersheds, Mill Swamp into 9 sub-watersheds, Flat Swamp into 12 sub-watersheds, and Tarrara Creek (exclusive of Flat Swamp) into 9 sub-watersheds, as shown in Figure 2.2. The sub-watersheds corresponding to each impaired stream are indicated by the sub-watershed prefixes in the two figures: Three Creek, TRE; Darden Mill Run, DMR; Mill Swamp, MSP; Flat Swamp, FTS; Tarrara Creek, TRR. The stream network used to help define the sub-watersheds was obtained from the National Hydrography Dataset. Sub-watersheds were delineated based on a number of factors: continuity of the stream network, similarity of land use distribution, and monitoring station locations. It is preferable to have a sub-watershed outlet at or near monitoring station locations in order to calibrate the model chosen for this study (to be discussed in Chapter 4); the monitoring stations used in modeling are shown in Figure 2.1 and Figure 2.2.

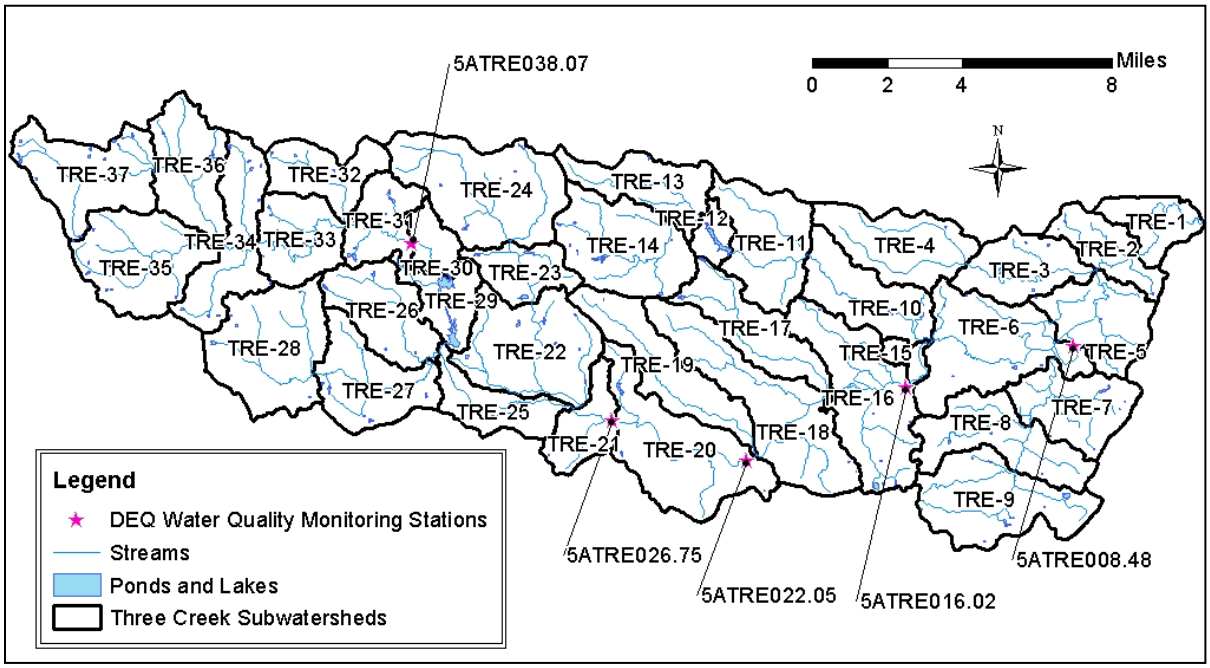

Figure 2.1. Sub-watersheds for the Three Creek watershed.

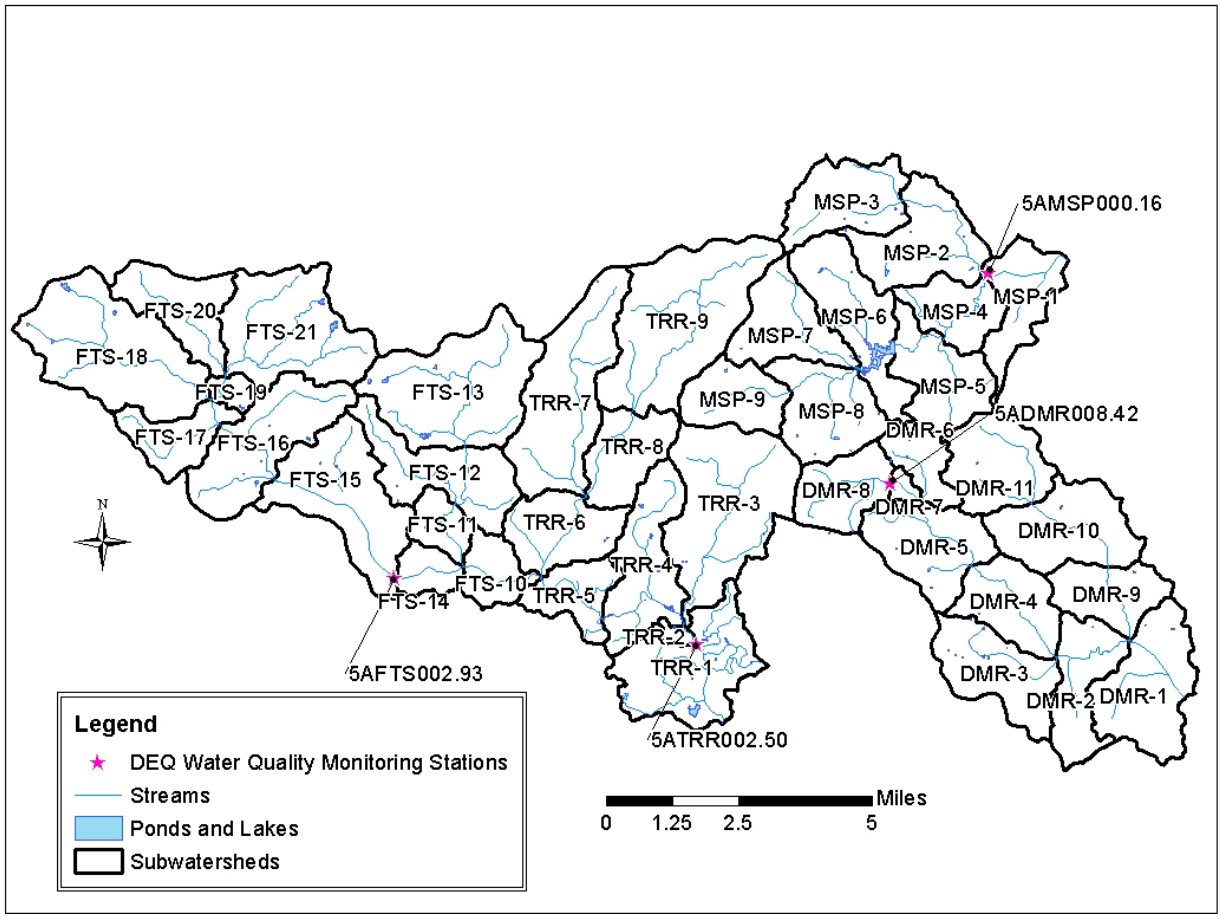

Figure 2.2. Sub-watersheds for Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek.

2.2 Ecoregion and Geology

Ecoregions in this section are classified at two levels: level III ecoregions and their subgroup level IV ecoregions. The study area lies in three level III/IV ecoregions. The western tip of the Three Creek watershed lies in the Piedmont level III ecoregion and Northern Outer Piedmont level IV ecoregion. The Northern Outer Piedmont ecoregion has the highest relief and elevation of the three ecoregions in the study area. Related to this, the eastern edge of the Northern Outer Piedmont ecoregion lies along the Fall Line; the resulting Fall Zone is characterized by “an area of rapids, cascades, waterfalls, and islands” (Woods *et al.*, 1999). The natural vegetation in this ecoregion would be Oak-Hickory-Pine Forest, and current primary land uses include forestry and agriculture. Agriculture in the region consists of both livestock operations as well as crops such as corn, oats, rye, tobacco, and hay. Soils in this region are derived from

gneissic rock and are commonly Ultisols (Woods *et al.*, 1999). The eastern portion of the Three Creek watershed, western sliver of the Mill Swamp watershed, and all of the Flat Swamp and Tarrara Creek watersheds fall within the Southeastern Plains level III ecoregion and the Rolling Coastal Plain level IV ecoregion. Drainage in the Rolling Coastal Plain ecoregion is improved over that of the Dismal Swamp ecoregion (see next) but streams can still be swampy and stained. Natural vegetation would be Oak-Hickory-Pine forest, but current land cover consists of woodland and farmland, including crops such as corn, soybeans, and peanuts. Soils in this region are commonly Ultisols (Woods *et al.*, 1999). Most of the Mill Swamp watershed and the entire Darden Mill Run watershed fall within the Middle Atlantic Coastal Plain level III ecoregion and the Dismal Swamp level IV ecoregion. The Dismal Swamp level IV ecoregion is nearly flat and poorly drained forested wetland with thick peat deposits. Surface water in this ecoregion tends to be acidic due to the acidic organically-derived soils (Histosols). Although the natural vegetation would be southern floodplain forest, fires, drainage, and logging activities have changed vegetation significantly and trees on organic soils are now primarily red maple and black gum (Woods *et al.*, 1999).

2.3 Soils

Although the finer resolution Soil Survey Geographic (SSURGO) soils were used for modeling purposes, the coarser resolution State Soil Geographic (STATSGO) soils are presented here to simplify the overall watershed soil characterization discussion. There are nine STATSGO soil groups represented in the study area (Table 2.1, Figure 2.3). Two soils groups, Suffolk-Rumford-Emporia and Craven-Mattaponi-Lenoir, are dominant, comprising 36.8% and 30.1% of the combined watershed areas, respectively. The remaining seven soil groups cover the remaining third of the combined watershed area.

Hydrologic soil groups describe soil texture in terms of potential for surface runoff and infiltration rates (Table 2.2). For example, soils in hydrologic group “A” pass a larger proportion of rainfall through to ground water than soils in hydrologic group “B.” Conversely, soils in hydrologic group “D” inhibit infiltration such that a large proportion of rainfall contributes to surface runoff and therefore a more direct path to stream

channels. These processes have consequences for bacteria residing on the land surface in terms of the potential bacteria loads transported to streams during storm events.

Table 2.1. Summary of STATSGO data for the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds.

Soil Name & Map Unit ID	% of Watershed Area[‡]	Component Name	Component Percent[¶]	Texture[†]	Hydrologic Group[§]	%Slope, Range
Suffolk-Rumford-Emporia (VA027, NC117)	TRE: 25% DMR: 47% MSP: 67% FTS: 56% TRR: 62%	Emporia	13	FSL	C	6 - 25
		Johnston	1	MK-L	D	0 – 2
		Kenansville	2	LS	A	0 – 2
		Remlik	6	LFS	A	6 – 25
		Rumford	15	LS	B	15 – 50
		Slagle	7	FSL	C	0 – 6
		Suffolk	54	FSL	B	0 – 6
		Tomotley	2	FSL	B/D	0 – 2
Appling-Wedowee-Louisburg (VA030)	TRE: 5% DMR: -- MSP: -- FTS: -- TRR: --	Appling	71	FSL	B	2 – 15
		Wedowee	8	SCL	B	2 – 15
		Ashlar	3	GR-SL	B	2 – 25
		Louisburg	8	SL	B	2 – 45
		Vance	4	FSL	C	2 – 25
		Worsham	6	SIL	D	0 – 7
Craven-Mattaponi-Lenoir (VA035)	TRE: 42% DMR: -- MSP: -- FTS: 29% TRR: --	Craven	76	FSL	C	0 – 4
		Mattaponi	14	L	C	0 – 10
		Lenoir	5	VFSL	D	0 – 1
		Coxville	5	L	D	0 – 1
Tetotum-Dragston-Nimmo (VA036)	TRE: -- DMR: 44% MSP: 30% FTS: 4% TRR: 27%	Tetotum	74	FSL	C	0 – 10
		Nansemond	1	FSL	C	10 – 15
		State	4	FSL	B	0 – 2
		Emporia	4	FSL	C	2 – 6
		Dragston	8	FSL	C	0 – 2
		Nimmo	7	SL	D	0 – 2
		Bladen	1	L	D	0 – 2
		Rumford	1	LS	B	0 – 2
Roanoke-Rains-Eunola (VA037)	TRE: 5% DMR: <1% MSP: 3% FTS: 11% TRR: 11%	Portsmouth	6	L	B/D	0 – 2
		Roanoke	58	FSL	D	0 – 2
		Rains	18	FSL	B/D	0 – 2
		Eunola	10	FSL	C	0 – 2
		Levy	5	SIL	D	0 – 2
		Kalmia	3	SL	B	0 – 2
Slagle-Kenansville-Lakeland (VA043)	TRE: 1% DMR: -- MSP: -- FTS: -- TRR: --	Slagle	62	FSL	C	0 – 10
		Kenansville	26	LS	A	0 – 6
		Lakeland	6	S	A	6 – 10
		Roanoke	6	L	D	0 – 2
Georgeville-Nason-Lignum (VA045)	TRE: 22% DMR: -- MSP: -- FTS: -- TRR: --	Georgeville (1)	68	L	B	2 – 15
		Nason	7	L	C	2 – 25
		Iredell	4	SIL	C/D	0 – 1
		Lignum	6	L	C	2 – 15
		Georgeville (2)	12	SICL	B	2 – 10
		Orange	1	SIL	D	7 – 15
		Goldston	2	CN-SIL	C	7 – 25

Soil Name & Map Unit ID	% of Watershed Area‡	Component Name	Component Percent¶	Texture†	Hydrologic Group§	%Slope, Range
Roanoke-Portsmoth-Tomotley (VA051)	TRE: --	Roanoke	53	FSL	D	0 – 2
	DMR: 9%	Portsmouth	20	FSL	B/D	0 – 2
	MSP: --	Tomotley	20	FSL	B/D	0 – 2
	FTS: --	Bojac	4	LS	B	0 – 3
	TRR: --	Munden	3	LS	B	0 – 3

¶ Component Percent is the percent each component comprises of the overall map unit

‡ TRE = Three Creek; DMR = Darden Mill Run; MSP = Mill Swamp; FTS = Flat Swamp; TRR = Tarrara Creek (exclusive of FTS); values indicate the percent of the indicated watershed area in each STATSGO soil type

† S = Sand; LS = Loamy Sand; SL = Sandy Loam; SIL = Silt Loam; L = Loam; SCL = Sandy Clay Loam; SICL = Silty Clay Loam; V = Very (as prefix); MK = Mucky (as prefix); GR = Gravelly (as prefix); CN = Channery* (as prefix)

* Channery: coarse, flat fragments

§ See Table 2.2 for a definition of Hydrologic Soil Groups

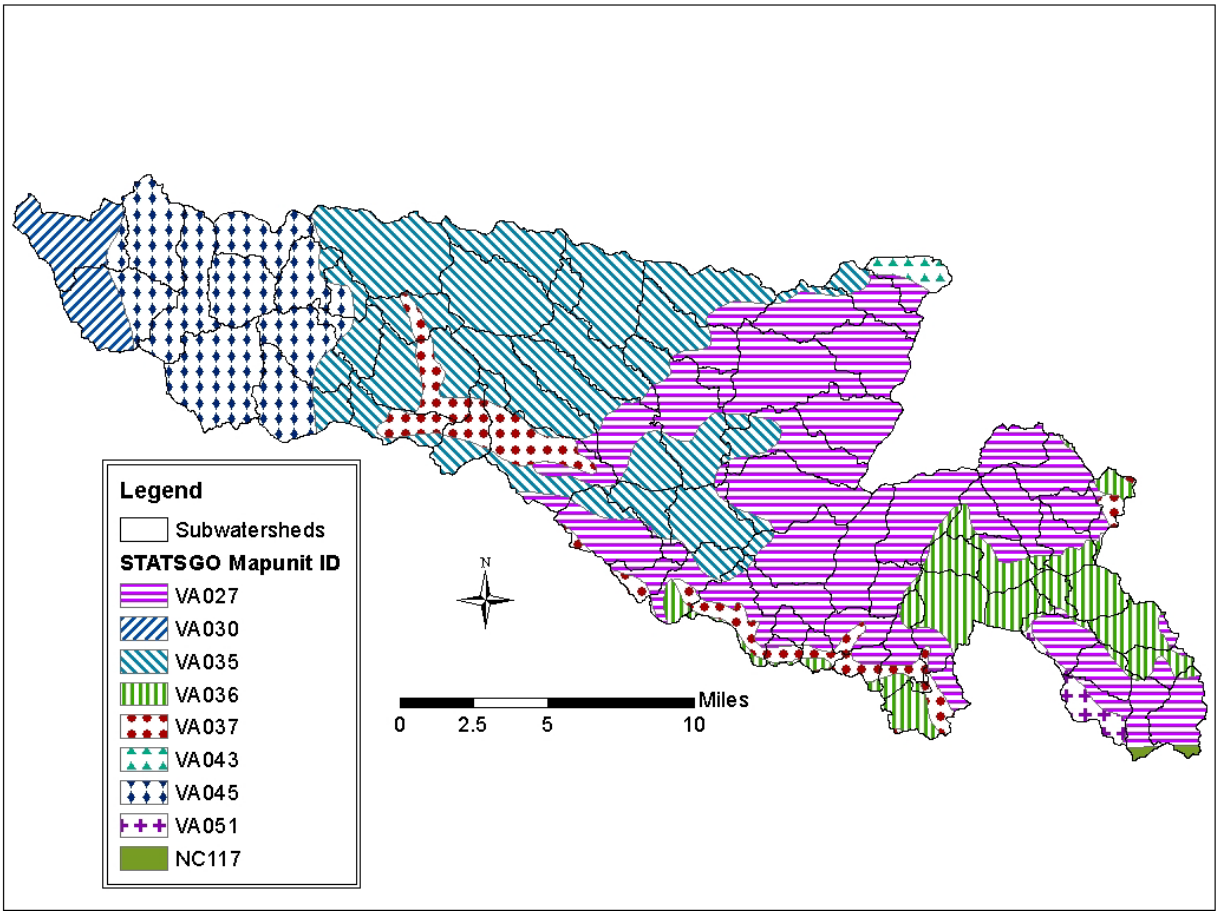

Figure 2.3. STATSGO soil groups in the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds.

Table 2.2. Soil Hydrologic Groups

Hydrologic Group	Description
A	Low runoff potential, high infiltration rates. Soils are deep, well drained to excessively drained sand, loamy sand or sandy loam, and gravels.
B	Moderate infiltration rates. Deep to moderately deep, moderately well and well-drained silt or silt loam soils (moderately coarse textures).
C	Moderate to Slow infiltration rates. Sandy clay loam soils (soils with moderately fine or fine textures) or soils with layers impeding downward movement of water.
D	High runoff potential, very slow infiltration rates. Soils are clayey (sandy clay to silty clay loam), have high water table, or are shallow over an impervious cover.

2.4 Climate

The climate of the watershed was characterized based on the meteorological observations acquired from the National Climatic Data Center (NCDC) for “nearby” weather stations. Precipitation data were obtained primarily from the National Weather Service COOP station at Wakefield (COOP ID 448800). The Wakefield 1NW station is located approximately 16 miles northeast of the northeastern-most tip of the Three Creek watershed and is the closest station to the watersheds that collects hourly precipitation data. Records from the Roanoke Rapids, NC (COOP ID 317319) and Murfreesboro, NC (COOP ID 315996) stations were used to patch missing precipitation data. Temperature data were collected from the Murfreesboro station, which is located approximately 6 miles south of the southern tip of the Darden Mill Run watershed. Other meteorological data, less commonly collected, were collected from the nearest available station, the Norfolk International Airport (COOP ID 446139), located approximately 50 miles east-northeast of the outlet of the Mill Swamp watershed.

The closest station to the watershed, centrally located about a mile from the nearest watershed boundary, was Emporia 1 WNW (COOP ID 442790). Because Emporia does not have an hourly record, it was inadequate for modeling purposes, but is informative for long-term trends analysis. The long-term record summary (covering 1/1/1971 – 12/31/2010) at Emporia shows an average annual precipitation of 43.98 inches, with 55% of the precipitation occurring during the cropping season (May-October). Mean annual snowfall at Emporia is 6.6 inches. Average annual daily

temperature is 58.5°F, with a highest average daily temperature of 78.6°F occurring in July, and a lowest average daily temperature of 38.3°F occurring in January (SERCC, 2011).

2.5 Land Use

The National Agricultural Statistics Service (NASS) 2009 cropland data layer (CDL) land use map for Virginia was used to obtain the land use estimates. This layer uses satellite imagery from sources such as the Indian Remote Sensing RESOURCESAT-1, Landsat 5 TM, and Landsat 7 ETM+, supplemented by the USGS National Elevation Dataset, USGS National Land Cover Dataset 2001 (NLCD 2001), and NASA Moderate Resolution Imaging Spetroradiometer data. The dataset was verified using the Farm Service Agency's Common Land Unit program and NLCD 2001 data (USDA-NASS, 2009). The land cover categories from the NASS data in the study watersheds were grouped into five major categories based on similarities in hydrologic features (Table 2.3). The five land use categories were assigned pervious and impervious percentages for use in the watershed model. Land uses for the study watersheds are presented graphically in Figure 2.4 and tabulated in Table 2.4 (Darden Mill Run, Mill Swamp, Flat Swamp, Tarrara Creek) and Table 2.5 (Three Creek).

Table 2.3. NASS land use aggregation.

TMDL Land Use Categories	Pervious/Impervious (Percentage)	NASS Land Use Categories (Class No.)
Cropland	Pervious (100%)	Corn (1) Cotton (2) Soybeans (5) Peanuts (10) Winter Wheat (24) Winter Wheat/Soybeans Double-Cropped (26) Oats (28) Millet (29) Seed/Sod Grass (59) Fallow/Idle Cropland (61) NLCD – Barren (131) Dbl. Crop Soybeans/Cotton (239) Dbl. Crop Soybeans/Oats (240) Dbl. Crop Barley/Soybeans (254)
Pasture	Pervious (100%)	Other Hays (37) Grass/Pasture (62) NLCD – Grassland Herbaceous (171) NLCD – Pasture/Hay (181)
Residential	Pervious (90%); Impervious (10%)[†] Pervious (65%); Impervious (35%) Pervious (35%); Impervious (65%) Pervious (10%); Impervious (90%)	NLCD – Developed/Open Space (121) NLCD – Developed/Low Intensity (122) NLCD – Developed/Medium Intensity (123) NLCD – Developed/High Intensity (124)
Forest	Pervious (100%)	NLCD – Open Water (111) NLCD – Deciduous Forest (141) NLCD – Evergreen Forest (142) NLCD – Mixed Forest (143)
Wetlands	Pervious (100%)	NLCD – Woody Wetlands (190) NLCD – Herbaceous Wetlands (195)

[†] These pervious/impervious fractions, estimated from the range in the documentation for the source data, correspond to the land use categories to the right. The pervious/impervious fractions were area-weighted for each impaired watershed to achieve an overall breakdown of urban impervious area for each watershed. The resulting overall breakdowns for the urban areas are: Three Creek, 16% impervious; Darden Mill Run, 13% impervious; Flat Swamp & Tarrara Creek, 20% impervious; Mill Swamp, 19% impervious.

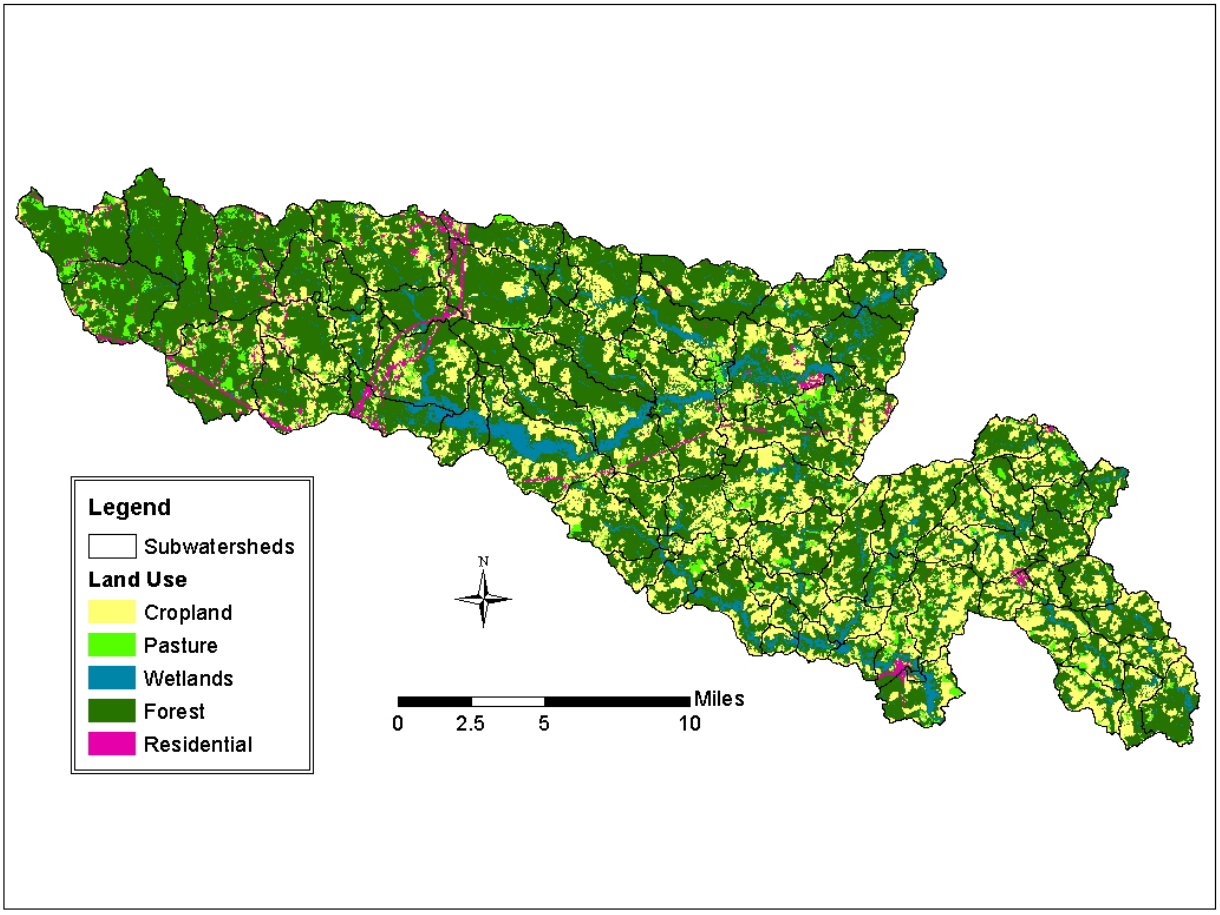

Figure 2.4. Land use in the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds.

Table 2.4. Land use areas in the Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds (acres).

Sub-watershed	Cropland	Forest	Pasture	Residential	Wetlands	Total
DMR-1	622.85	1587.11	76.51	1.51	153.88	2441.86
DMR-2	653.01	846.77	44.96	1.55	83.22	1629.51
DMR-3	994.02	805.24	114.69	4.64	64.49	1983.08
DMR-4	599.52	783.5	130.08	0.54	105.66	1619.3
DMR-5	1010.97	848.57	98.15		118.67	2076.36
DMR-6	397.19	444.66	11.72	13.26	17.18	884.01
DMR-7	88.86	60.43	24.82	1.55	7.3	182.96
DMR-8	651.53	574.37	61.84	92.28	27.54	1407.56
DMR-9	654.19	612.94	56.76	11.87	62.31	1398.07
DMR-10	782.07	1323.68	23	2.32	125.07	2256.14
DMR-11	628.96	1165.57	47.94	2.04	58.04	1902.55
Darden Mill Run Total:	**7083.18**	**9052.85**	**690.48**	**131.57**	**823.36**	**17781.44**
MSP-1	424.01	882.7	68.4		94.79	1469.9
MSP-2	716.95	1199.7	128.14	41.46	70.95	2157.2
MSP-3	614.22	1069.55	76.05	15.57	45.77	1821.16
MSP-4	360.24	759.78	75.7		31.53	1227.25
MSP-5	512.72	1195.94	27.38	1.06	57.68	1794.78
MSP-6	893.7	1127.11	114.46	11.75	117.76	2264.78
MSP-7	717.26	844.05	96.4	9.3	67.92	1734.93
MSP-8	1008.45	755.56	108.92	35.5	88.22	1996.65
MSP-9	671.75	581.46	71.6	10.07	51.11	1385.99
Mill Swamp Total:	**5919.3**	**8415.87**	**767.04**	**124.71**	**625.71**	**15852.63**
TRR-1	822.08	1333.86	173.21	59.7	353.74	2742.59
TRR-2	19.93	34.55	12.58	23.14	49.53	139.73
TRR-3	1839.01	1743.06	177.91	14.61	93.82	3868.41
TRR-4	809.39	797.77	238.7	161.99	195.98	2203.83
TRR-5	391.72	424.65	55.66	6.19	212.52	1090.74
TRR-6	925.09	495.96	44.99		202.89	1668.93
TRR-7	1114.78	2027.35	97.74	1.55	125.61	3367.03
TRR-8	456.55	812.42	126.63		101.43	1497.03
TRR-9	1689.6	2245.12	160.22	0.77	144.87	4240.58
Tarrara Creek Total:†	**8068.14**	**9914.74**	**1087.64**	**267.95**	**1480.4**	**20818.87**
FTS-10	312.68	338.11	19.25		199.54	869.58
FTS-11	288.79	334.18	16.18		68.47	707.62
FTS-12	940	1035.96	88.62		115.87	2180.45
FTS-13	1334.88	1985.83	208.64	1.87	151.95	3683.17
FTS-14	245.87	229.96	13.12		134.02	622.97
FTS-15	861.5	1625.64	62.94	0.77	383.96	2934.81
FTS-16	953.05	1303.83	201.95	1.35	174.41	2634.59
FTS-17	358.8	703.3	16.3		68.59	1146.99
FTS-18	1263.21	2258.3	172.05	6.99	170.4	3870.95
FTS-19	124.44	145.42	2.32	1.75	32.35	306.28
FTS-20	521.57	1005.12	74.11	2.92	30	1633.72
FTS-21	1209.47	1654.18	99.05	3.87	124.66	3091.23
Flat Swamp Total:	**8414.26**	**12619.84**	**974.55**	**19.53**	**1654.23**	**23682.41**

† Exclusive of Flat Swamp

Table 2.5. Land use areas in the Three Creek watershed (acres).

Sub-watershed	Cropland	Forest	Pasture	Residential	Wetlands	Total
TRE-1	469.84	1123.79	36.5		361.4	1991.53
TRE-2	527.52	1498.54	67.33		204.1	2297.49
TRE-3	853.92	1903.03	123.75	11.26	172.89	3064.85
TRE-4	670.68	3192.1	86.35	12.4	109.95	4071.48
TRE-5	624.41	2506.89	55.72	7.33	366.59	3560.94
TRE-6	1686.9	2937.74	210.41	228.48	816.86	5880.39
TRE-7	1164.82	1673.24	424.66	164.08	103.84	3530.64
TRE-8	1466.5	2357.12	218.05	72.47	129.1	4243.24
TRE-9	2260.03	2486.16	260.79	8.52	236.33	5251.83
TRE-10	995.46	2118.25	147.5	6.97	342.3	3610.48
TRE-11	1251.35	2793.9	66	1.55	180.97	4293.77
TRE-12	160.14	617.88	28.26	0.77	43.09	850.14
TRE-13	571.71	2063.63	164.91	178.06	118.86	3097.17
TRE-14	894.44	3666.98	173.03	327.41	108.78	5170.64
TRE-15	195.85	220.44	134.75	0.77	104.73	656.54
TRE-16	1785.48	3329.84	360.66	79.34	514.88	6070.2
TRE-17	662.74	2618.34	46.85	3.87	144.33	3476.13
TRE-18	1755.61	4013.02	215.72	70.41	622.85	6677.61
TRE-19	920.95	2953.41	64.32	8.48	163.62	4110.78
TRE-20	1910.3	2738.02	191.54	139.04	1298.04	6276.94
TRE-21	567.67	968.55	38.04	9.04	522.14	2105.44
TRE-22	1451.97	3030.9	334.31	374.56	522.64	5714.38
TRE-23	307.49	1590.59	18.06	130.23	131.96	2178.33
TRE-24	1253.69	4547.77	412.63	329.82	106.72	6650.63
TRE-25	207.76	1497.79	102.62	272.1	397.11	2477.38
TRE-26	1052.33	2208.17	160.45	116.56	30.18	3567.69
TRE-27	1036.58	2475.39	239.19	236.78	21.74	4009.68
TRE-28	881.04	3858.36	570.51	456.32	37.2	5803.43
TRE-29	520.13	1296.79	82.22	10.7	93.54	2003.38
TRE-30	217.27	996.96	57.87	3.53	17.02	1292.65
TRE-31	390.24	1754.17	188.85	64.89	30.34	2428.49
TRE-32	197.12	2141.61	259.38	133.03	17.05	2748.19
TRE-33	300.01	2337.91	300.86	109.8	25.31	3073.89
TRE-34	247.93	3311.9	365.84	107.9	14.98	4048.55
TRE-35	270	3864.86	663.03	225.62	23.08	5046.59
TRE-36	41.47	3427.05	206.77	13.48	32.29	3721.06
TRE-37	322.57	3437.21	715.16	194.77	8.95	4678.66
Three Creek Total:	**30093.93**	**89558.33**	**7792.86**	**4110.36**	**8175.76**	**139731.2**

2.6 Stream Flow Data

There are no continuous flow gages within any of the impaired watersheds. It was necessary to find a similar, gauged, ‘surrogate’ watershed on which to perform the hydrologic calibration (to be discussed in more detail in Chapter 4). Because the Three Creek watershed covers two very different ecoregions, two surrogate watersheds were

identified. Blackwater River in Surry County was chosen for Darden Mill Run, Mill Swamp, Flat Swamp, Tarrara Creek, and the portion of Three Creek east of the Fall Line (roughly equivalent to the area east of Slagles Lake). The USGS monitored flow on Blackwater River at station 02047500, near Dendron, VA. The drainage to the station is 290 mi^2; the period of record extends from October 1941 to present, with an average flow rate of 315 cfs between 1942 and 2010 (USGS, 2011a). North Meherrin River in Lunenburg County was chosen for the portion of Three Creek west of the Fall Line. The USGS monitored flow on North Meherrin River at station 02051000, near Lunenburg, VA. The drainage to the station is 56 mi^2; the period of record extends from October 1946 to present, with an average flow rate of 50 cfs between 1947 and 2010 (USGS, 2011b).

2.7 Water Quality Data

The Virginia Department of Environmental Quality (VADEQ) regularly and recently monitored Three Creek water quality at five stations and Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek water quality at one station each. Two additional stations on Three Creek collected only one sample or stopped collecting in 1979. The locations of the monitoring stations were shown previously (Figure 2.1, Figure 2.2); a summary of the bacteria data, including violation rates of the appropriate single-sample standards, is presented in Table 2.6.

The DEQ assessments for Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek list the source of bacteria as unknown. A portion of Three Creek (part of K27R-02-BAC) was first listed as impaired on Virginia's *2002 303(d) Report on Impaired Waters* due to water quality violations of the fecal coliform bacteria standard for the period 1996-2000. Flat Swamp (K13R-02-BAC) and Darden Mill Run (K30R-01-BAC) were first listed as impaired on Virginia's *Final 2004 305(b)/303(d) Water Quality Assessment Integrated Report* due to water quality violations of the fecal coliform bacteria standard for the period 1998-2002. Mill Swamp (K28R-01-BAC) and two segments of Three Creek (K26R-02-BAC and the remainder of K27R-02-BAC) were first listed as impaired on Virginia's *Final 2006 305(b)/303(d) Water Quality Assessment Integrated Report* due to water quality violations of the fecal coliform and *E. coli*

standards, respectively, over the period 2000-2004. Tarrara Creek (K13R-01-BAC) and one segment of Three Creek (K26R-03-BAC) were first listed as impaired on Virginia's *Final 2008 305(b)/303(d) Water Quality Assessment Integrated Report* due to water quality violations of the *E. coli* standard over the period 2002-2006 (VADEQ, 2010).

Table 2.6. VADEQ monitoring stations within the study watersheds.

Station ID	Stream Name	Station Description	Indicator Organism Measured	Number of Samples	Violation Rate[‡]	Period of Record
5ADMR008.42	Darden Mill Run	Route 673 Bridge	Fecal Coliform	114	18.4%	1995 – 2010
			E. coli	47	25.5%	2002 – 2010
5AMSP000.16	Mill Swamp	Route 731 Bridge	Fecal Coliform	12	16.7%	2001 – 2003
			E. coli	11	36.4%	2009 – 2010
5ATRR002.50	Tarrara Creek	Route 670 Bridge below Boykins STP	Fecal Coliform	161[†]	21.1%	1971 – 2010
			E. coli	49	20.4%	2002 – 2010
5AFTS002.93	Flat Swamp	Route 663 Bridge	Fecal Coliform	12	16.7%	2001 – 2003
			E. coli	11	0%	2009 – 2010
5ATRE008.48	Three Creek	Route 655 Bridge	Fecal Coliform	105	14.3%	1994 – 2010
			E. coli	51	19.6%	2002 – 2010
5ATRE016.02	Three Creek	Route 649 Bridge	Fecal Coliform	106	14.2%	1994 – 2010
			E. coli	51	17.6%	2002 – 2010
5ATRE022.05	Three Creek	Three Creek at Route 615	*E. coli*	23	13.0%	2003 – 2008
5ATRE026.75	Three Creek	Route 622 Bridge at County Line (Sussex/Greensville)	Fecal Coliform	51	15.7%	1990 – 2001
5ATRE038.07	Three Creek	Three Creek, Route 610 Bridge	*E. coli*	22	18.2%	2005 – 2008

[‡] Violation rate of current *E. coli* standard (235 cfu/100 mL) or interim fecal coliform standard (400 cfu/100 mL)
[†] Number of data points and violation rate listed only for 'recent' data collected from 1992-2010

Seasonality of fecal coliform concentrations in the streams was evaluated by plotting the mean monthly fecal coliform concentrations observed at stations 5ADMR008.42, 5ATRR002.50, 5ATRE008.48, and 5ATRE016.02 (Figure 2.5), the remaining stations having insufficient data to make a meaningful evaluation of seasonality. Mean monthly fecal coliform concentration was determined as the mean of all values in any given month for the period of record.

In general, seasonal trends are not clear. For 5ATRE008.48, the concentrations seem to increase through the spring and then drop off (the peak in June is a result of one outlying value out of six values available for that month). For 5ATRE016.02, the concentrations increase steadily through spring to June and then drop. For Tarrara Creek (TRR), concentrations are relatively constant year round. Darden Mill Run (DMR) shows the most seasonality, with a trend that generally peaks in the summer and

troughs in the winter. The pattern of Darden Mill Run suggests that sources of bacteria to the impaired watersheds are affected by seasonal trends (temperature, precipitation, management practices, and migration patterns), with higher fecal coliform concentrations occurring during the low-flow period of the year. This pattern also suggests that direct sources, such as direct deposit from livestock, play a large role in fecal coliform violations. For the remaining watersheds, high concentrations that may be due to direct deposit sources in the summer seem to be balanced by contributions during higher flow periods of the year, which are dominated by bacteria in storm runoff.

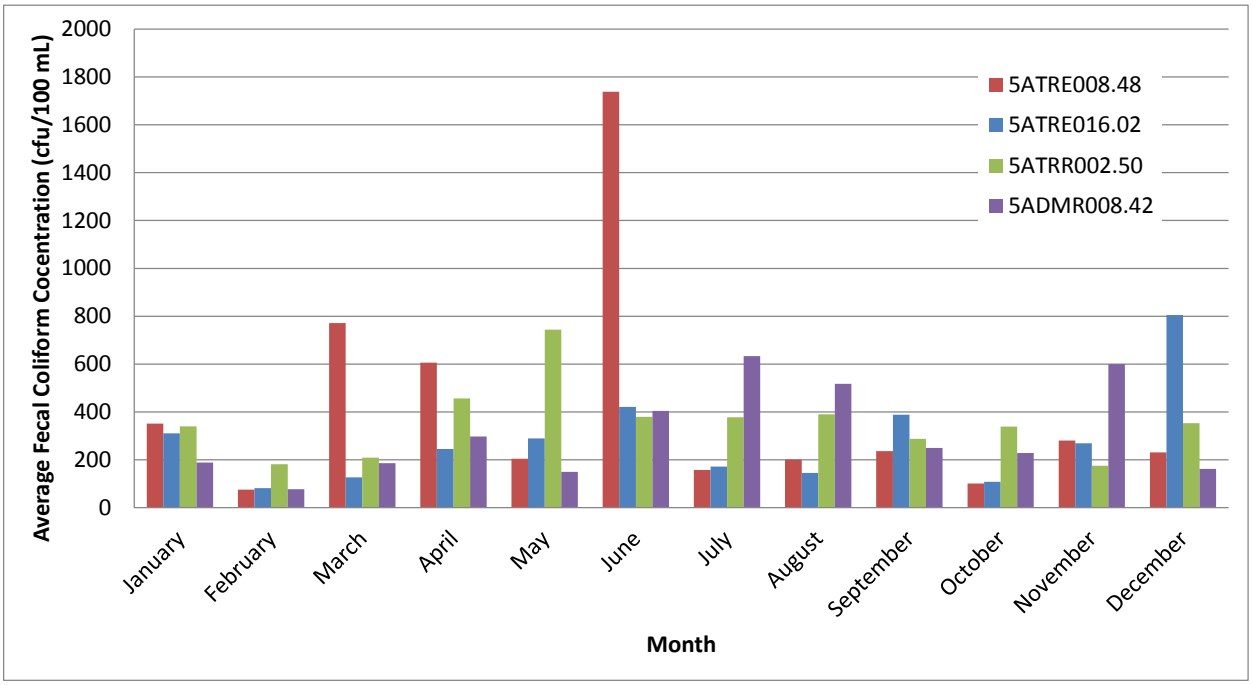

Figure 2.5. Average fecal coliform concentrations by month for stations 5ATRE008.48, 5ATRE016.02, 5ATRR002.50, and 5ADMR008.42.

3 Source Assessment of Fecal Coliform

Fecal coliform sources and production rates in the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds were assessed using information from the following sources: VADEQ, Virginia Department of Conservation and Recreation (VADCR), Virginia Department of Game and Inland Fisheries (VADGIF), United States Fish and Wildlife Service (USFWS), Soil and Water Conservation Districts (SWCD), public participation, watershed reconnaissance and monitoring, published information, and professional judgment. Potential nonpoint sources of fecal coliform in the study watersheds are summarized in Table 3.1; the population estimate methodology is described in the subsections of this chapter.

Virginia issues Virginia Pollutant Discharge Elimination System (VPDES) permits for point sources of pollution. In Virginia, point sources that treat human waste are required to maintain an *E. coli* concentration of 126 cfu/100 mL or less in their effluent. Point sources of fecal coliform bacteria in the Three Creek watershed include three sewage treatment plants and two small general permitted facilities (Table 3.2). In allocation scenarios for bacteria, the entire allowable point source discharge concentration of 126 cfu/100 mL was used for these five facilities. None of the other watersheds have point source discharges of bacteria.

Table 3.1. Potential fecal coliform sources and daily fecal coliform production by source for existing conditions in the study watersheds.

Potential Source	Population					Fecal coliform production rate (x 10^6 cfu/head/day)
	Three Creek	Darden Mill Run	Mill Swamp	Flat Swamp	Tarrara Creek[†]	
Humans	11016	817	756	540	1284	150[a]
Household Pets	2628	321	297	211	519	450[a]
Hunting Dogs	1151	158	146	228	181	450[a]
Beef Cows and Bulls	347	132	19	28	213	33,000[b]
Beef Calves, Steers, and Heifers	658	90	1	12	107	21,120[c]
Pullets	20000[d]	0	0	0	0	27[e]
Hogs	4514[d]	1250[d]	0	0	3000[d]	10,800[f]
Goats	27	33	0	250	17	28,000[f]
Sheep	0	83	0	0	43	12,000[f]
Horses	24	0	1	5	0	420[f]
Deer	4608	791	708	1035	896	350
Raccoons	4722	605	518	827	653	50
Muskrats	66178	6215	4759	12479	11227	25[g]
Beavers	396	97	145	229	185	0.2
Ducks[h]	973	126	115	166	143	2,400
Geese[h]	772	97	90	127	116	800
Wild Turkeys	826	117	111	162	128	93

[†] Exclusive of Flat Swamp
[a] Source: Weiskel *et al.* (1996)
[b] Source: within range of literature values (Geldreich, 1978; ASAE, 1998) for 1000-lb cow
[c] Source: based on bacteria production by beef cows[a] and relative weights of heifers and cows
[d] This is the actual population; the greater of the permitted or actual population is used for future conditions to support the conservative margin of safety
[e] Based on bacteria concentration in chicken manure[f] and manure production rate by pullets
[f] Source: ASAE(1998)
[g] Source: Yagow (2001)
[h] Residents and short-term migratory waterfowl

Table 3.2. Permitted facilities discharging into streams of the Three Creek watershed.

Permit Number	Facility Name	Sub-watershed	Design Flow (mgd[*])	Permitted *E. coli* Conc. (cfu/100 mL)	*E. coli* Load (cfu/year)
VA0062499	VDOC Southampton Correctional Center	TRE-6	0.45	126	7.84×10^{11}
VA0077259	Three Creek STP	TRE-25	0.75	126	1.31×10^{12}
VA0020761	Town of Jarratt STP	TRE-24	0.16	126	2.79×10^{11}
VAG404036	Residence	TRE-30	0.0005	126	8.71×10^{8}
VAG403043	Drewryville Fas-Shop	TRE-8	0.000621	126	1.08×10^{9}

[*] million gallons per day

3.1 Humans and Pets

The Three Creek watershed has an estimated population of 11,016 (2628 households with an average of 2.5 people per household plus 4446 incarcerated individuals; actual people per household varies by sub-watershed). The Darden Mill Run watershed has an estimated population of 817 (321 households with an average of 2.55 people per household; actual people per household varies by sub-watershed). The Mill Swamp watershed has an estimated population of 756 (297 households with an average of 2.55 people per household; actual people per household varies by sub-watershed). The Flat Swamp watershed has an estimated population of 540 (207 households with an average of 2.61 people per household; actual people per household varies by sub-watershed). The Tarrara Creek watershed (exclusive of Flat Swamp) has an estimated population of 1284 (519 households with an average of 2.47 people per household; actual people per household varies by sub-watershed).

The numbers of houses in the watersheds were estimated based on structure information provided by each county. Brunswick County provided address points, which could be homes, businesses, or public buildings. These were manually filtered to remove churches and schools visible on topographic maps. County and town officials confirmed that none of the watershed area in Brunswick County was served by the sewer network. Greensville County provided building footprints with a type classification – all houses that appeared to be residential (either type of residential, duplex, apartment, etc.) were chosen to represent houses. Greensville County additionally provided a map of the sewer network, which was used to classify houses in Greensville and Sussex Counties. Sussex County provided tax parcel information; parcels with a value of improvements (i.e., buildings) greater than zero and occupancy that was not non-residential were chosen to represent the locations of residences. County officials confirmed the only sewer in the watershed area of Sussex County was provided by the Greensville authority. Southampton County provided the locations of all building footprints in the watershed. These were filtered based on size to determine which structures were likely residences, as opposed to sheds or commercial or public facilities. With the knowledge that 1400 customers are served by a sewer network in Boykins, Newsoms, and Branchville, an appropriate number of house in those areas were

selected as served by the sewer network. Finally, Emporia provided locations of all structures, which were all assumed residential and served by the Greensville County sewer system. Total housing counts in Greensville, Sussex, and Southampton counties were compared against housing counts from the US Census to confirm selection methodology.

Human population estimates are based on the US Census Block Group information (Census Bureau, 2000). The occupancy rate per household from the US Census for each block group was multiplied by the number of houses in each block group to estimate total human population. Additionally, there are two correctional facilities in the watershed, whose populations were determined from the total population count in the US Census (this is a straightforward calculation, as the total houses according to the census multiplied by the population per house yields the normal residents, and the difference between that number and the total population count for a block group is the number of prisoners).

Fecal coliform from humans can be transported to streams from failing septic systems and via straight pipes discharging directly into streams. Although leaky sewer lines are not explicitly accounted for in modeling for this TMDL, they are considered to be part of the residential load, and should be addressed where found during implementation.

3.1.1 Failing Septic Systems

Septic system failure can result in the rise of effluent to the soil surface. Surface runoff can transport the effluent, containing fecal coliform, to receiving waters. Any houses not served by sewer or straight pipes are assumed to have septic systems or alternative treatment systems. Normally functioning septic systems and alternative treatment systems are assumed not to contribute bacteria to the land surface or to the stream. VDH reported that an intensive survey in a nearby area revealed that approximately 5% of houses had failing systems. A previous study by VADCR and VDH in a nearby area considered that 10% of houses in soil ‘danger zones’ had failing systems. However, the criterion to define the ‘danger zone’ was not clear.

The danger zone used in this study is based on the depth to water table from the Soil Survey Geographic Database (SSURGO) maps. Any house that fell into a soil unit with a depth to water table less than 30" was assumed to be in danger. Houses in Southampton County that fell into a soil unit with a depth to water table less than 36" were also considered to be in danger. The reason for the difference for Southampton County was that the soils in Southampton County had drastically deeper water table depths, even for the same soil unit (see Figure 3.1 as a zoomed-in example). A depth of 36" in Southampton County yielded approximately a 5% failure rate, while a depth of 30" in the remaining areas yielded approximately a 5% failure rate. These being consistent with the door-to-door estimates from VDH's study in a nearby area, the methodology was considered acceptable.

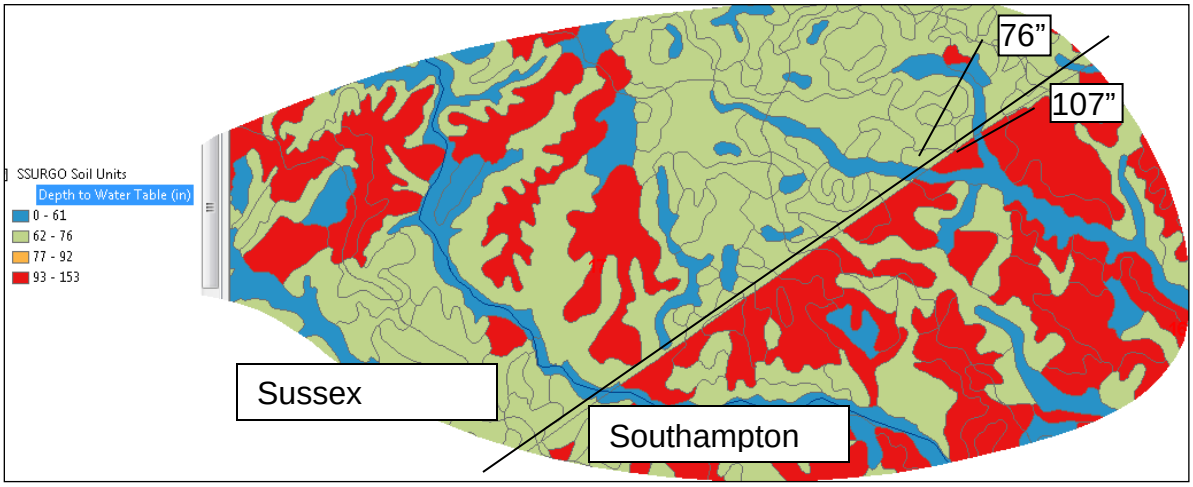

Figure 3.1. Example of SSURGO water table depth discrepancy across county line. Different colors represent different depth ranges.

Daily total fecal coliform load to the land from a failing septic system in each sub-watershed was determined by multiplying the average occupancy rate for that sub-watershed (occupancy rate of houses ranged from 2.36 to 2.60 persons per household (Census Bureau, 2000)) by the per capita fecal coliform production rate of 1.5×10^8 cfu/day (Geldreich, 1978). Hence, the total fecal coliform loading to the land from a single failing septic system in a sub-watershed with an occupancy rate of 1 person/household is 1.5×10^8 cfu/day. Transport of some portion of the fecal coliform to a stream by runoff may occur. The number of failing septic systems in the watershed is

given in Table 3.3. Note that the Southampton County structures data showed no houses present in sub-watershed TRE-15.

3.1.2 Straight Pipes

Bacteria discharged from straight pipes enter the stream directly, without treatment or die-off. Any houses not served by the sewer networks previously described and located within 150 ft of streams and swamps have the potential to discharge sewage directly into the stream via a straight pipe. It is assumed that 10% of older houses and 2% of middle-age houses within 150 ft of streams have straight pipes; old and middle-aged houses are determined by relative abundance of houses in each age category according to the US Census block groups (these report the fraction of houses in each block group built in each of nine age categories). Among all five watersheds, 10 old and 8 mid-age houses were within 150 ft of streams, and 49 old and 31 mid-age houses were within 150 ft of swamps. Based on these criteria, it was estimated that 3 houses with straight pipes exist in the study areas – one in the Tarrara Creek watershed, and the other two in the Mill Swamp watershed. The number of straight pipes in the watersheds is given in Table 3.3. This low number of estimated straight pipes is supported by VDH observations that most to all of the straight pipes they have seen and corrected in the area are gray-water straight pipes (that is, they do not discharge sewage). Even if no straight pipes were predicted for a particular sub-watershed in Three Creek, Flat Swamp, Tarrara Creek, Mill Swamp, or Darden Mill Run, they should be addressed if they are encountered during implementation.

Daily total fecal coliform load to the stream from a straight pipe in each sub-watershed was determined by multiplying the average occupancy rate for that sub-watershed by the per capita fecal coliform production rate of 1.5×10^8 cfu/day (Geldreich, 1978). Hence, the total fecal coliform loading to the stream from a single straight pipe in a sub-watershed with an occupancy rate of 1 person/household is 1.5×10^8 cfu/day. Straight pipes were assumed to discharge only between the hours of 6 AM and 9 PM (i.e., people are only defecating while they are awake).

Table 3.3. Estimated Household, Pet, and Hunting Dog Population Breakdown by sub-watershed for the Three Creek (TRE), Darden Mill Run (DMR), Mill Swamp (MSP), Flat Swamp (FTS), and Tarrara Creek (TRR) watersheds.

Sub-watershed	People per House	Sewered Houses	Straight Pipes	Total Septic Systems	Failing Septic Systems*	Household Pets	Hunt Club Dogs
DMR-1	2.54	0	0	24	2	24	28
DMR-2	2.53	0	0	15	1	15	15
DMR-3	2.52	0	0	33	2	33	14
DMR-4	2.55	0	0	11	1	11	14
DMR-5	2.55	0	0	66	6	66	15
DMR-6	2.55	4	0	18	2	22	7
DMR-7	2.60	0	0	5	0	5	1
DMR-8	2.55	76	0	2	0	78	10
DMR-9	2.57	0	0	23	1	23	11
DMR-10	2.53	0	0	17	1	17	23
DMR-11	2.56	0	0	27	3	27	20
Darden Mill Run Totals:	**2.55†**	**80**	**0**	**241**	**18**	**321**	**158**
MSP-1	2.53	0	0	17	1	17	16
MSP-2	2.54	0	0	59	3	59	20
MSP-3	2.53	0	1	46	2	47	18
MSP-4	2.55	0	0	20	1	20	13
MSP-5	2.55	0	1	28	0	29	20
MSP-6	2.56	0	0	25	2	25	20
MSP-7	2.54	0	0	13	1	13	15
MSP-8	2.55	52	0	26	1	78	14
MSP-9	2.56	0	0	9	0	9	10
Mill Swamp Totals:	**2.55†**	**52**	**2**	**243**	**10**	**297**	**146**
TRR-1	2.43	42	1	26	1	69	27
TRR -2	2.43	28	0	0	0	28	1
TRR -3	2.48	33	0	33	2	66	29
TRR -4	2.44	152	0	27	1	179	16
TRR -5	2.40	3	0	7	0	10	10
TRR -6	2.44	0	0	18	0	18	11
TRR -7	2.54	0	0	57	2	57	34
TRR -8	2.55	0	0	31	1	31	15
TRR -9	2.54	0	0	61	1	61	38

Sub-watershed	People per House	Sewered Houses	Straight Pipes	Total Septic Systems	Failing Septic Systems*	Household Pets	Hunt Club Dogs
Tarrara Creek Totals (Exclusive of Flat Swamp):	**2.47†**	**258**	**1**	**260**	**9**	**519**	**181**
FTS-10	2.50	0	0	6	0	6	9
FTS -11	2.50	0	0	4	0	4	6
FTS-12	2.55	0	0	22	1	22	18
FTS-13	2.55	0	0	38	2	38	34
FTS-14	2.50	0	0	4	0	4	6
FTS-15	2.48	0	0	23	1	23	32
FTS-16	2.58	0	0	24	1	24	24
FTS-17	2.50	0	0	2	0	2	12
FTS-18	2.60	0	0	35	2	35	39
FTS-19	2.50	0	0	4	0	4	3
FTS-20	2.59	0	0	32	2	32	17
FTS-21	2.59	0	0	17	1	17	28
Flat Swamp Totals:	**2.56†**	**0**	**0**	**211**	**10**	**211**	**228**
TRE-1	2.57	0	0	7	0	7	24
TRE-2	2.60	0	0	15	1	15	27
TRE-3	2.60	0	0	25	1	25	33
TRE-4	2.44	0	0	34	0	34	41
TRE-5	2.55	0	0	22	1	22	46
TRE-6	2.57	0	0	69	5	69	60
TRE-7	2.53	0	0	120	3	120	28
TRE-8	2.56	0	0	48	2	48	40
TRE-9	2.58	0	0	55	2	55	44
TRE-10	2.57	0	0	21	2	21	33
TRE-11	2.39	0	0	18	0	18	32
TRE-12	2.38	0	0	16	0	16	7
TRE-13	2.41	98	0	48	3	146	23
TRE-14	2.36	94	0	70	1	164	40
TRE-15		0	0	0	0	0	5
TRE-16	2.59	0	0	83	3	83	60
TRE-17	2.33	0	0	15	0	15	34
TRE-18	2.58	0	0	120	2	120	67
TRE-19	2.43	0	0	23	1	23	37
TRE-20	2.54	0	0	92	6	92	57

Sub-watershed	People per House	Sewered Houses	Straight Pipes	Total Septic Systems	Failing Septic Systems*	Household Pets	Hunt Club Dogs
TRE-21	2.51	8	0	33	1	41	13
TRE-22	2.47	100	0	29	2	129	34
TRE-23	2.37	7	0	12	1	19	15
TRE-24	2.49	275	0	97	7	372	39
TRE-25	2.52	131	0	33	2	164	15
TRE-26	2.51	0	0	61	3	61	19
TRE-27	2.49	153	0	43	2	196	21
TRE-28	2.47	0	0	163	11	163	33
TRE-29	2.51	11	0	38	2	49	12
TRE-30	2.50	0	0	48	4	48	9
TRE-31	2.50	0	0	16	1	16	15
TRE-32	2.52	0	0	31	2	31	18
TRE-33	2.50	0	0	40	2	40	20
TRE-34	2.50	0	0	42	2	42	28
TRE-35	2.60	0	0	75	1	75	46
TRE-36	2.50	0	0	6	0	6	32
TRE-37	2.58	0	0	83	2	83	44
Three Creek Totals:	**2.50**[†]	**877**	**0**	**1751**	**76**	**2628**	**1151**

* Failing septic systems are a subset of the total septic systems presented in the previous column; these were determined based on soil danger zones as described in Section 3.1.1.
[†] Average

3.1.3 Biosolids

There are numerous fields in the Three Creek, Flat Swamp, and Tarrara Creek watersheds that are permitted to receive biosolids applications. Some fields associated with the Virginia Department of Corrections Southampton Correctional Center (permit VA0062499) have been actively applied to for many years, while the remaining fields in Three Creek and all fields in Flat Swamp and Tarrara Creek are the result of a new permit obtained by Recyc Systems, Inc. (permit VPA01078) and have not yet received biosolids applications (as of 2011). The locations of the fields are shown in Figure 3.2 and the details of the fields are shown in Table 3.4. The VA0062499 fields and the CAS 20 and all FXF fields from VPA01078 are in the Three Creek watershed; the CAS 19

field from VPA01078 is in the Tarrara Creek watershed; and the remainder of the CAS fields and the AFE fields from VPA01078 are located in the Flat Swamp watershed.

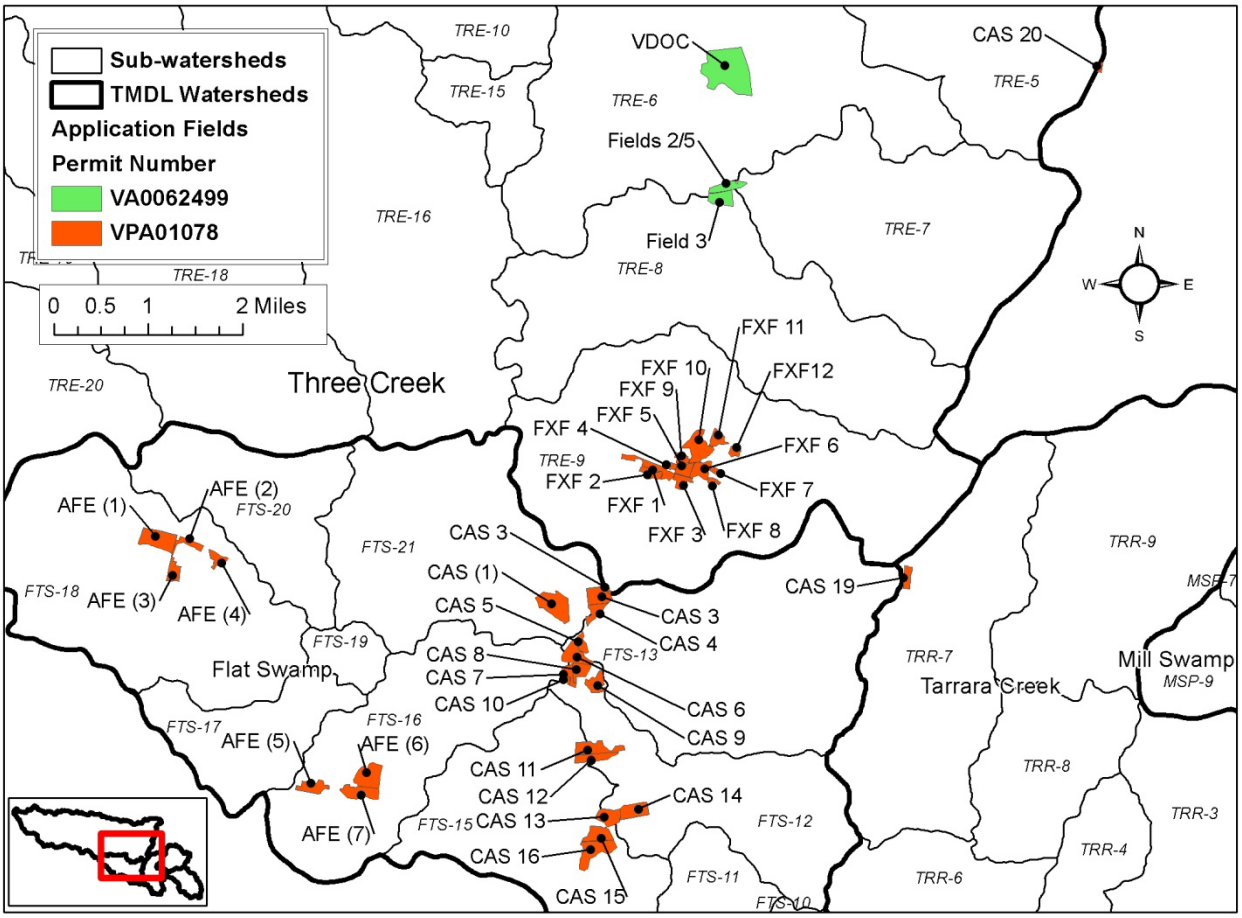

Figure 3.2. Permitted biosolids application fields in the study watersheds.

During calibration, the applications under permit VA0062499 were represented in the model according to timing, application rates, and bacteria concentrations extrapolated from recent data. All applications for the calibration and validation periods were made to the fields lumped under the "VDOC" label (Figure 3.2, Table 3.4). Where the existing data record overlapped the modeling period, actual data were used. Where there were not existing data, an application rate of 1.79 tons/acre, applied on May 1st to 18 acres with a concentration of 96,898 cfu/g was used. For VA0062499, biosolids were assumed to be incorporated within 6 hours of application according to recorded practices, reducing bacteria available to runoff by 90%. Applications under VPA01078 were not represented during the calibration and validation periods.

Table 3.4. Details of permitted biosolids application fields in the study watersheds.

Permit Number	Permit Holder	Field Name	Acres	Permit Number	Permit Holder	Field Name	Acres
VA0062499	VDOC Southampton	Fields 2/5	18.7	VPA01078	Recyc Systems Inc-Southampton	CAS (1)	48.1
		Field 3	21.1			CAS 4	15.2
		VDOC	123.8			CAS 3	28.8
VPA01078	Recyc Systems Inc-Southampton	FXF 1	23.3			CAS 5	10.8
		FXF 2	10.6			CAS 6	27.7
		FXF 3	12.9			CAS 7	10.9
		FXF 4	4.6			CAS 8	16.3
		FXF 5	13.2			CAS 9	19.8
		FXF 6	19.5			CAS 10	2.4
		FXF 7	4.9			CAS 11	30.4
		FXF 8	5.3			CAS 12	20.2
		FXF 9	8.7			CAS 13	23.2
		FXF 10	38.9			CAS 14	26.4
		FXF 11	13.5			CAS 15	22.9
		FXF12	7.1			CAS 16	40.7
		AFE (1)	42.6			CAS 19	11.0
		AFE (3)	16.3			CAS 20	18.2
		AFE (2)	12.3				
		AFE (4)	13.0				
		AFE (5)	20.1				
		AFE (6)	37.5				
		AFE (7)	28.4				

During the allocation period, applications to all fields at worst case scenario application rates and permitted bacteria concentrations (2,000,000 cfu/dry g) were represented in the model to ensure that applications at the 'worst case' permitted limits would be allowable in the watershed. The worst case scenario application rates were 3.55 dry tons/acre for VA0062499 – the maximum rate recorded in the available records – and 6 dry tons/acre for VPA01078 – based on the advice of the permit holder regarding an appropriate worst case application rate. Both permit holders commonly apply at 100% agronomic rate, which limits them to application on a given field once every three years. For the allocation scenarios, again 'worst case' conditions were assumed, such that all available fields would be applied to each year. For modeling purposes, this meant that application was simulated for one third of the permitted fields

in Table 3.4 every year (thus, in a three year cycle, each field would receive one application). Based on the advice of the permit holder, biosolids on VPA01078 fields were applied in spring to represent application before corn - May 1st was chosen as the application date. Based on the inspection records for VA0062499 and the advice of the inspector, half of VA0062499 fields (one-sixth of the total VA0062499 fields in Table 3.4) were applied to in spring and half in fall – May 1st and October 1st were chosen as the application dates based on application history. This methodology represents a conservative assumption in support of the implicit margin of safety for the TMDL because most fields are not applied to each year, application rates are typically lower than those assumed for allocation scenarios, and typical bacteria concentrations in treated biosolids are much lower than 2,000,000 cfu/g.

3.1.4 Pets

The American Pet Products Manufacturers Association conducts biannual pet owner surveys in the United States. The Humane Society of the United States reports a summary of these findings: for the 2009-2010 survey, 39% of American households owned an average of 1.7 dogs and 33% of American households owned an average of 2.45 cats (HSUS, 2011). Assuming that a unit pet is one dog or two cats, this yields (0.39*1.7 + (0.33*2.45)/2) = 1.067 unit pets per household. Therefore, the pet populations in the study watersheds were calculated at a rate of one unit pet per household. Given this assumption, there are 2628 pets in the Three Creek watershed, 321 pets in the Darden Mill Run watershed, 297 pets in the Mill Swamp watershed, 211 pets in the Flat Swamp watershed, and 519 pets in the Tarrara Creek watershed (exclusive of Flat Swamp). A dog produces fecal coliform at a rate of 4.5×10^8 cfu/day (Weiskel *et al.*, 1996); this was assumed to be representative of a 'unit pet' – one dog or several cats. The pet population distribution among the sub-watersheds is listed in Table 3.3. Pet waste is generated in residential areas; surface runoff can transport bacteria in pet waste from these areas to the stream.

3.1.5 Hunting Dogs

Hunting with dogs is very popular in this area of Virginia. Therefore, estimates of hunting dog populations associated with hunt clubs were made separately from the

household pet population estimates. To estimate hunting dog populations, the treasurer's offices for Brunswick, Greensville, Sussex, and Southampton Counties were contacted to obtain the total number of licensed kennels in the counties for 2010. The treasurers in each county who had an opinion felt that most, if not all, of the licensed kennels were hunt clubs. The animal control officers for each county were also contacted, and of the three counties that responded, all felt that unlicensed hunt clubs were very uncommon. Therefore, all kennels were assumed to be hunt clubs – any discrepancy being conservatively assumed to represent potential unlicensed kennels. All the treasurers who had an opinion also felt that the hunt clubs were fairly evenly distributed throughout the counties, so these hunt club dog populations were distributed for our estimates according to the forest and swamp area in the county (forest and swamp area being assumed to be the actual hunting locations). Finally, one treasurer advised that, as it was cheaper to buy 20-dog licenses in most cases than to license 5 dogs individually, and because the 50-dog license actually represents all kennels between 20 and 50 dogs, the average population per 20-dog kennel is closer to 15 dogs, and the average population per 50-dog kennel is closer to 30 dogs. Finally, because so many of these kennels are in the swamp and are cleaned by hosing down, 1% of the fecal material is assumed to enter the streams directly via hosed-down washoff from the kennels. A summary of the information provided by the treasurer's offices is presented in Table 3.5.

Table 3.5. County-wide kennel licenses in 2010 and hunting dog population assumed per county.

County	20-dog kennels		50-dog kennels	
	Licenses	Assumed Dogs†	Licenses	Assumed Dogs‡
Brunswick	173	2595	24	720
Greensville	51	765	11	330
Sussex	99	1485	29	870
Southampton	169	2535	40	1200

† Assumed 15 dogs per kennel based on guidance from treasurer
‡ Assumed 30 dogs per kennel based on guidance from treasurer

Using the numbers from the treasurers and distributing the hunting dog population according to forest and swamp area, it is estimated that there are 1151 hunting dogs in the Three Creek watershed, 158 hunting dogs in the Darden Mill Run

watershed, 146 hunting dogs in the Mill Swamp watershed, 228 hunting dogs in the Flat Swamp watershed, and 181 hunting dogs in the Tarrara Creek watershed (exclusive of Flat Swamp). The distribution of the hunt club dogs to each sub-watershed in the study area was given in Table 3.3. Dogs kenneled at the hunt clubs were assumed to produce fecal coliform at the same rate as household pets (4.5×10^8 cfu/animal/day). To represent the hosing down of dog pens carrying fecal matter directly to the stream, 1% of bacteria from hunting dogs was assumed to be directly deposited to the stream via washoff. This 1% allows for some die-off of bacteria prior to hosing down and for the possibility that not all hunt clubs will engage in this practice.

3.2 Cattle

Fecal coliform in cattle waste can be directly excreted to the stream, or it can be transported to the stream via surface runoff from animal waste deposited on pastures or applied to crops or pasture.

3.2.1 Distribution of Beef Cattle

There are numerous beef farms scattered throughout the study watersheds. Soil and Water Conservation District personnel from the Chowan District and the Lake Country District contacted farmers and/or drove the watersheds to estimate beef cattle populations. The total number of beef cows modeled throughout the year varied due to the presence or absences of calves and their weights relative to the adult cattle. The estimated number of beef cattle and the distribution of animals among the sub-watersheds are listed in Table 3.6 for the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds.

Cattle spend varying amounts of time in confinement, streams, and pastures depending on the time of year and type of cattle. Accordingly, the proportion of fecal coliform deposited in any given land area varies throughout the year. Information provided by District Conservationists and confirmed by the technical advisory committee indicated no cattle are currently confined in any of the study watersheds. However, personnel from the Southampton Correctional Center confirmed that approximately 450 steers were confined 100% of the time until approximately 2002, at which time they

were replaced with free-range heifers fenced away from the stream. Stream access for all cattle farms was estimated based on the observations of the Conservation District personnel: where the water source was an off-stream waterer, it was assumed there was no stream access; where the water source was the stream, 100% stream access was assumed; and where the water source was a pond, 30% stream access was assumed to represent the combined likelihood of access to a stream that drains the pond and/or the bacteria from defecation that occurs from cows standing in the pond that will be drained to the stream through an overflow pipe or draining stream.

The following assumptions and procedures were used to estimate the distribution of cattle (and thus, fecal coliform produced by cattle) among different land use types and in streams:

a) When cattle are not confined, they are on pasture.
b) Cows with stream access will spend varying amounts of time in the stream during different seasons (Table 3.7). Cows spend more time in the stream during the three summer months to protect their hooves from hornflies, among other reasons.
c) Thirty percent of cows in and around streams directly deposit fecal coliform into the stream. The remaining 70% of the feces is deposited on pastures.

A sample calculation for determining the distribution of cattle between the pasture and the stream in sub-watershed TRR-6 of the Tarrara Creek watershed is shown in Appendix B. The resulting numbers of cattle in pastures and streams for all sub-watersheds are given in Table 3.8.

Table 3.6. Estimated Beef Cattle Populations in the Three Creek (TRE), Darden Mill Run (DMR), Mill Swamp (MSP), Flat Swamp (FTS), and Tarrara Creek (TRR) watersheds.

Sub-watershed	Beef Cows and Bulls	Beef Calves, Steers, and Heifers
MSP-5	4	1
MSP-9	15	
Mill Swamp Totals:	**19**	**1**
DMR-3	56	37
DMR-4	36	15
DMR-5	20	17
DMR-6		4
DMR-9	20	17
Darden Mill Run Totals:	**132**	**90**
TRR-1	51	3
TRR-3	15	5
TRR-4	59	28
TRR-5	3	1
TRR-6	31	20
TRR-8	54	50
Tarrara Creek Totals (Exclusive of Flat Swamp):	**213**	**107**
FTS-13	28	12
Flat Swamp Totals:	**28**	**12**
TRE-2	20	
TRE-3	29	12
TRE-6	77	512[†]
TRE-13	10	5
TRE-14	30	
TRE-17	15	10
TRE-21	23	10
TRE-24	26	16
TRE-27	6	4
TRE-31	60	25
TRE-33	16	4
TRE-35	20	20
TRE-37	40	40
Three Creek Totals:	**347**	**658**

[†] During the calibration period and for future conditions, 450 beef heifers in sub-watershed TRE-6 grazed freely on pasture fenced from the stream; during the validation period, 450 beef steers in sub-watershed TRE-6 were confined 100% of the time.

Table 3.7. Time spent by beef cattle in the stream.

Month	Time spent in the stream (hours/day)
January	0.5
February	0.5
March	0.75
April	1
May	1.5
June	3.5
July	3.5
August	3.5
September	1.5
October	1
November	0.75
December	0.5

Table 3.8. Distribution of the cattle population.[†]

Month	Mill Swamp		Darden Mill Run		Tarrara Creek & Flat Swamp		Three Creek	
	Pasture	Streams[*]	Pasture	Streams[*]	Pasture	Streams[*]	Pasture[‡]	Streams[*]
January	21.1	0.01	158.0	0.25	276.0	0.40	429.3	0.32
February	21.9	0.01	176.2	0.28	305.0	0.44	477.3	0.36
March	21.7	0.01	178.3	0.43	306.6	0.65	481.3	0.54
April	21.4	0.02	180.4	0.57	308.3	0.87	485.3	0.72
May	21.1	0.03	182.3	0.87	309.7	1.31	489.2	1.09
June	20.7	0.06	175.3	1.95	309.7	3.06	491.1	2.56
July	20.5	0.06	177.2	1.96	311.6	3.06	495.2	2.57
August	20.2	0.06	179.2	1.98	313.4	3.06	499.4	2.59
September	19.9	0.03	182.3	0.86	317.0	1.31	505.0	1.12
October	19.0	0.01	137.8	0.44	240.3	0.69	374.1	0.56
November	19.7	0.01	144.6	0.35	252.3	0.55	392.5	0.44
December	20.4	0.01	151.3	0.24	264.2	0.38	411.0	0.31

[†]Reported as 1000-lb animal units; note that the total 1000-lb animal units will not add up to the animal number totals in Table 3.6 due to fluctuating cow and calf weights throughout the year

[*]Number of cow equivalent defecations in the stream

[‡]For the calibration period and for future conditions; during the validation period, 450 steers, at an average of 640 lb/head, were located in confinement rather than on pasture

3.2.2 Direct Manure Deposition in Streams

Direct manure loading to streams is due to beef cattle (Table 3.8) defecating in the stream. Manure loading increases during the warmer months, when cattle spend more time in water. The potential average annual manure loading directly deposited by cattle in the stream for the various watersheds, using the table above, is 577 lb in Mill Swamp; 18,692 lb in Darden Mill Run; 28,932 lb in Flat Swamp and Tarrara Creek; and 24,151 lb in Three Creek. The associated average daily fecal coliform loading to the stream for the various watersheds is 8.71 x 10^8 cfu for Mill Swamp; 2.82 x 10^{10} cfu for Darden Mill Run; 4.35 x 10^{10} cfu for Flat Swamp and Tarrara Creek; and 3.64 x 10^{10} cfu for Three Creek. Part of the fecal coliform deposited in the stream stays suspended, while the remainder adsorbs to the sediment in the streambed. Under base flow conditions, it is likely that suspended fecal coliform bacteria are the primary form transported with the flow. Sediment-bound fecal coliform bacteria are likely to be re-suspended and transported to the watershed outlet under high flow conditions. Die-off of fecal coliform in the stream depends on sunlight, predation, turbidity, and other environmental factors.

3.2.3 Direct Manure Deposition on Pastures

Beef cattle that graze on pastures (Table 3.8) but do not deposit in streams contribute the majority of fecal coliform loading on pastures. Fecal coliform loading on pasture was estimated by multiplying the total number of cattle on pasture by the daily generation of fecal coliform bacteria (3.3 x 10^{12} cfu/1000lb cow/day). Because the time spent in streams and the beef cow and calf weight varies by season, loading on pasture also changes with season.

Pasture has average annual cattle manure loadings of 4,564 lb/ac for the Mill Swamp sub-watersheds with cattle; 8,975 lb/ac for the Darden Mill Run sub-watersheds with cattle; 6,253 lb/ac for the Flat Swamp and Tarrara Creek sub-watersheds with cattle; and 5,020 lb/ac for the Three Creek sub-watersheds with cattle. The associated fecal coliform loading from cattle to pasture on a daily basis averaged over the year is 6.80 x 10^{11} cfu for the Mill Swamp watershed; 5.56 x 10^{12} cfu for the Darden Mill Run watershed; 9.66 x 10^{12} cfu for the Flat Swamp and Tarrara Creek watersheds; and 2.03

x 10^{13} cfu for the Three Creek watershed. Fecal coliform bacteria deposited on the pasture surface are subject to die-off due to desiccation and ultraviolet (UV) radiation. Runoff can transport part of the remaining fecal coliform to receiving waters.

3.2.4 Land Application of Solid Manure

All of the solid manure produced by beef steers during confinement in the validation period was collected for land application. It was assumed that solid cattle manure was applied at the rate of 12 tons/ac-year to cropland according to the schedule given in Table 3.9. Based on availability of land and solid manure, as well as the assumptions regarding application rates, it was estimated that solid cattle manure was applied to 279 acres (17%) of cropland in sub-watershed TRE-6 of the Three Creek watershed, only during the validation period.

Table 3.9. Schedule of solid cattle manure application.

Month	Solid manure applied (%)*
January	0
February	5
March	25
April	20
May	5
June	10
July	0
August	5
September	15
October	5
November	10
December	0

* As percent of annual production

3.3 Poultry

The poultry population (Table 3.1) was estimated based on the permitted confined poultry feeding operation located within the Three Creek watershed. Details of this facility can be found in Table 3.10. Poultry litter production was estimated from the poultry population after accounting for the time when the houses are not occupied. Pullets are assumed to grow for 20 weeks before being sold.

Table 3.10. Permitted Poultry Facility in the Three Creek watershed.

Permit Number	Type of Bird	Sub-watershed
VPG250037	Pullet	TRE-6

Because poultry is raised entirely in confinement, all litter produced is collected and stored prior to land application. The fecal coliform bacteria produced are subject to die-off in storage prior to being subject to transport via runoff. The estimated production rate of poultry litter in the Three Creek watershed is 2.06 x 10^6 lb/year; after die-off in storage, this quantity of litter corresponds to a fecal coliform load of 4.68 x 10^{13} cfu/year. CAFO inspection records indicate that poultry litter has historically been applied once a year at a rate between 1 and 1.5 tons/ac, primarily to cropland but occasionally to pasture. For modeling purposes, poultry litter was applied at the rate of 1.5 tons/ac-year to cropland. The application schedule of poultry litter is given in Table 3.11 and is extrapolated from CAFO inspection records from 2006-2010. Based on availability of land and poultry litter and the assumed poultry litter application rate, it was estimated for modeling purposes that poultry litter was applied to 68.5 acres (4%) of cropland each year. Note that the calculation of applied acres assumes that each application is made to a separate field; if multiple applications are made to a single field in one year, the actual applied acreage will be less than that listed above; however, the representation in the model is the same.

Table 3.11. Schedule of poultry waste application.

Month	Poultry litter applied (%)*
January	25
February	0
March	50
April	0
May	0
June	0
July	0
August	0
September	0
October	0
November	0
December	25

* As percent of annual production

3.4 Hogs

The hog population (Table 3.1) was estimated based on the permitted confined swine feeding operations located within the Three Creek, Darden Mill Run, and Tarrara Creek watersheds. Details of these facilities can be found in Table 3.12. During calibration, the actual population of hogs was used, but as a conservative assumption for future conditions the larger of the permitted or actual population was used.

Table 3.12. Permitted Hog Facilities in the Three Creek (TRE), Darden Mill Run (DMR), and Tarrara Creek (TRR) watersheds.

Permit Number	Sub-watershed	Permitted Hogs	Actual Hogs
VPG100157	TRE-6	1600	2114/1200[†]
VPG100166	TRE-9	2250	2400
VPG100163	TRR-9	3050	3000
VPG100162	DMR-4	1500	1250

[†] This facility was not contacted by SWCD personnel; our contact with the facility indicated that for 2010-2011 the actual hog population was around 1200-1250 due to budget issues and renovations, but that historically it was closer to the older permitted population of 2114; facility personnel expect that in the future the population will rise again, presumably to the population allowed in the new permit.

Because hogs are raised entirely in confinement, all manure produced is collected and stored prior to land application. The fecal coliform bacteria produced are subject to die-off in storage prior to being subject to transport via runoff. The estimated as-excreted production rate of swine manure in the Three Creek watershed is 1.4×10^6 gal/year; after die-off in storage, this volume of manure corresponds to a fecal coliform load of 1.4×10^{14} cfu/year. The estimated as-excreted production rate of swine manure in the Tarrara Creek watershed is 9.9×10^5 gal/year; after die-off in storage, this volume of manure corresponds to a fecal coliform load of 1.1×10^{14} cfu/year. The estimated as-excreted production rate of swine manure in the Darden Mill Run watershed is 4.1×10^5 gal/year; after die-off in storage, this volume of manure corresponds to a fecal coliform load of 4.2×10^{13} cfu/year.

In practical terms, hog manure is either stored where it is diluted by rainfall or where it is not, and the application rate will vary accordingly. To simplify this scenario, for modeling purposes the application rate was considered on an as-excreted basis, to eliminate the need to calculate dilution by rainfall. For modeling purposes all swine manure was applied at a rate of 3500 gal (as-excreted)/ac to cropland, the middle of the range suggested by nutrient management planners for undiluted manure. The

application schedule of swine manure is given in Table 3.13 and is extrapolated from CAFO inspection records from 2006-2010. The application schedule is an average annual schedule representing the likelihood that application will occur in a given month; the actual applications each year will occur only once or twice. However, the average schedule is used to be representative for modeling purposes. Based on availability of land and hog manure, as well as the assumptions regarding application rates, it was estimated that hog manure was applied to 410 acres (10%) of cropland in sub-watersheds TRE-6 and TRE-9 of the Three Creek watershed, 282 acres (17%) of cropland in sub-watershed TRR-9 of the Tarrara Creek watershed, and 117 acres (20%) of cropland in sub-watershed DMR-4 of the Darden Mill Run watershed. Note that the calculation of applied acres assumes that each application is made to a separate field; if multiple applications are made to a single field in one year, the actual applied acreage will be less than that listed above; however, the representation in the model is the same.

Table 3.13. Schedule of hog waste application.

Month	Hog waste applied (%)*		
	Three Creek	Tarrara Creek	Darden Mill Run
January	0	0	0
February	0	0	0
March	4	0	2
April	34	60	47
May	12	10	11
June	0	10	5
July	0	20	10
August	0	0	0
September	0	0	0
October	10	0	5
November	40	0	20
December	0	0	0

* As percent of annual production

3.5 Sheep and Goats

The sheep and goat populations (Table 3.1) were estimated from surveys conducted by Soil and Water Conservation District personnel. The sheep and goats were kept on pasture at all times. Sheep and goats are not usually confined and tend not to wade or defecate in the streams. Therefore, the fecal coliform produced by sheep

and goats was deposited directly on pasture. The distribution of sheep and goats among the sub-watersheds is given in Table 3.14.

The pastures in sub-watersheds where sheep and goats are present receive average annual sheep and goat manure loadings of 206 lb/ac-year for Three Creek; 2,081 lb/ac-year for Tarrara Creek and Flat Swamp; and 1,857 lb/ac-yr for Darden Mill Run. The associated fecal coliform loading to pasture on an annual basis is 2.76 x 10^{14} cfu for Three Creek; 311 x 10^{15} cfu for Tarrara Creek and Flat Swamp; and 1.07 x 10^{15} cfu for Darden Mill Run.

Table 3.14. Estimated distribution of sheep and goat populations in the Three Creek (TRE), Darden Mill Run (DMR), Mill Swamp (MSP), Flat Swamp (FTS), and Tarrara Creek (TRR) watersheds.

Sub-watershed	Sheep	Goats
Mill Swamp Totals:	**0**	**0**
DMR-3	83	33
Darden Mill Run Totals:	**83**	**33**
TRR-8	43	17
Tarrara Creek Totals (Exclusive of Flat Swamp):	**43**	**17**
FTS-18	0	250
Flat Swamp Totals:	**0**	**250**
TRE-12	0	3
TRE-14	0	15
TRE-27	0	9
Three Creek Totals:	**0**	**27**

3.6 Horses

Horse populations for the watershed were estimated from surveys conducted by Soil and Water Conservation District personnel. The estimated distribution of horses among the sub-watersheds is given in Table 3.15. The fecal coliform originating from horses contributes to the pasture load. Average annual fecal coliform loadings from horses to pasture are 3.68 x 10^{12} cfu for the Three Creek watershed; 7.67 x 10^{11} cfu for the Tarrara Creek and Flat Swamp watersheds; and 1.53 x 10^{11} cfu for the Mill Swamp watershed.

Table 3.15. Estimated Horse Population in the Three Creek (TRE), Darden Mill Run (DMR), Mill Swamp (MSP), Flat Swamp (FTS), and Tarrara Creek (TRR) watersheds.

Sub-watershed	Horses
MSP-9	1
Mill Swamp Total:	**1**
Darden Mill Run Total:	**0**
Tarrara Creek Total (Exclusive of Flat Swamp):	**0**
FTS-14	5
Flat Swamp Total:	**5**
TRE-14	2
TRE-19	2
TRE-20	6
TRE-23	3
TRE-28	1
TRE-29	1
TRE-32	3*
TRE-37	6
Three Creek Total:	**24**

* 4 donkeys, represented as 3 horses for modeling purposes

3.7 Wildlife

Wildlife fecal coliform contributions can come from excretion of waste on land and from excretion directly into streams. Information provided by VADGIF and watershed residents was used to estimate wildlife populations. Wildlife species that were found in quantifiable numbers in the watershed included deer, raccoon, muskrat, beaver, wild turkey, goose, and duck. Population numbers for each species and fecal coliform amounts were determined along with preferred habitat and habitat area.

Professional judgment was used in estimating the percent of each wildlife species depositing directly into streams, by considering each habitat area occupied (Table 3.16). Fecal loading from wildlife was estimated for each sub-watershed. The wildlife populations were distributed among the sub-watersheds based on the area of appropriate habitat in each sub-watershed. For example, the deer population was evenly distributed in forest and agricultural areas, whereas muskrats and raccoons had variable population densities based on proximity to a water source. Therefore, a sub-watershed with more stream length and impoundments and more area in crop land use would have more muskrats than a sub-watershed with shorter stream length, fewer impoundments, and less area in crop land use. Distribution of wildlife among sub-

watersheds is given in Table 3.17 for the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds.

Table 3.16. Wildlife habitat, population density, and direct fecal deposition in streams.

Wildlife type	Habitat	Population Density (animal/ac-habitat)
Deer‡	Forest, Cropland, and Pasture	30 (Southampton) 20 (Greensville, Sussex) 16 (Brunswick)
Raccoons†	low density on forests not in high density area; high density on forest within 600 ft of a permanent water source and wetlands	Low density: 10 High density: 30
Muskrats†	10/ac of wetlands;16/mile of ditch or medium sized stream intersecting cropland; 8/mile of ditch or medium sized stream intersecting pasture; 10/mile of pond or lake edge; 50/mile of slow-moving river edge	--see habitat column--
Beavers†	4.8/mile of permanent stream or swamp; 3.8/mile of pond or lake edge	--see habitat column--
Geese¶	All Land[β]	3.2 (summer) 3.85 (winter)
Wood Duck¶	All Land[β]	3.8 (summer) 4.45 (winter)
Wild Turkey§	Forest	8.3 (Southampton) 5.1 (Greensville, Sussex) 2.6 (Brunswick)

‡ Based on UVA model derived from kill rates, provided by VADGIF

† Based on habitat and population density recommendations from VADGIF; the final numbers calculated using this methodology were reduced by 25% during model calibration

¶ Based on the Atlantic Flyway Breeding Bird Survey, 2006-2011 and half of the ratio of migratory to breeding populations used in previous TMDLs

§ Extrapolated from kill rates provided by VADGIF

β Note that although the total population for each watershed was calculated based on total watershed area to match the source of population information, the distribution among sub-watersheds was done based on availability of permanent water sources

Table 3.17. Estimated wildlife populations in the Three Creek (TRE), Darden Mill Run (DMR), Mill Swamp (MSP), Flat Swamp (FTS), and Tarrara Creek (TRR) watersheds.

Sub-watershed	Deer	Raccoon	Muskrat & Mink	Beaver	Summer Geese	Winter Geese	Summer Duck	Winter Duck	Turkey
DMR-1	107	100	1154	10	8	9	10	12	21
DMR-2	73	56	630	9	7	8	9	11	11
DMR-3	90	60	492	11	11	13	14	17	10
DMR-4	71	57	795	13	11	13	13	16	10
DMR-5	92	63	894	11	10	12	12	15	11
DMR-6	40	25	131	4	4	5	5	6	6
DMR-7	8	5	54	3	3	3	3	4	1
DMR-8	61	34	219	2	2	2	3	3	7
DMR-9	62	42	468	8	7	8	8	10	8
DMR-10	100	89	940	12	9	10	11	14	17
DMR-11	87	74	438	14	12	14	14	18	15
Darden Mill Run Total:	**791**	**605**	**6215**	**97**	**84**	**97**	**102**	**126**	**117**
MSP-1	64	58	705	15	7	9	9	12	11
MSP-2	96	79	539	23	13	15	15	19	16
MSP-3	82	52	348	9	6	7	7	9	14
MSP-4	56	38	237	12	6	7	7	9	10
MSP-5	82	73	438	15	7	9	9	12	16
MSP-6	100	74	922	32	14	17	17	21	15
MSP-7	78	52	517	16	8	10	10	13	11
MSP-8	88	54	667	16	9	11	11	14	10
MSP-9	62	38	386	7	4	5	5	6	8
Mill Swamp Total:	**708**	**518**	**4759**	**145**	**74**	**90**	**90**	**115**	**111**
TRR-1	109	108	2715	34	19	22	22	27	17
TRR-2	3	6	373	3	1	1	2	2	0
TRR-3	177	95	716	25	13	16	16	20	23
TRR-4	87	66	1506	38	19	22	22	27	10
TRR-5	41	46	1596	16	8	9	10	12	6
TRR-6	69	49	1525	10	6	7	7	8	6
TRR-7	152	110	946	20	11	13	13	16	26
TRR-8	66	54	762	10	6	7	7	8	11
TRR-9	192	119	1088	29	16	19	18	23	29
Tarrara Creek Total (Exclusive of Flat Swamp):	**896**	**653**	**11227**	**185**	**99**	**116**	**117**	**143**	**128**
FTS-10	31	39	1495	9	4	5	5	6	4
FTS-11	30	30	514	8	4	4	4	5	4
FTS-12	97	71	871	22	11	13	14	17	13
FTS-13	166	111	1157	29	14	16	17	21	26
FTS-14	23	28	1005	7	3	3	4	5	3
FTS-15	120	119	2881	24	11	13	14	17	21
FTS-16	116	88	1319	32	15	18	19	24	17
FTS-17	51	46	518	15	7	8	9	11	9
FTS-18	174	130	1287	22	11	13	14	17	29
FTS-19	13	13	243	4	2	2	2	3	2

Sub-watershed	Deer	Raccoon	Muskrat & Mink	Beaver	Summer Geese	Winter Geese	Summer Duck	Winter Duck	Turkey
FTS-20	75	51	225	14	7	8	8	10	13
FTS-21	139	101	964	43	20	24	24	30	21
Flat Swamp Total:	**1035**	**827**	**12479**	**229**	**109**	**127**	**134**	**166**	**162**
TRE-1	77	102	2766	10	10	12	13	16	15
TRE-2	98	96	1724	8	8	9	9	11	19
TRE-3	135	122	1527	11	14	17	17	21	25
TRE-4	141	145	847	11	14	17	17	21	31
TRE-5	150	187	3022	21	19	23	23	28	33
TRE-6	227	249	6774	25	32	38	38	47	38
TRE-7	153	115	810	15	25	30	30	37	22
TRE-8	190	138	1016	13	19	22	23	28	31
TRE-9	235	150	1806	15	26	31	32	40	32
TRE-10	129	116	2872	8	15	18	19	23	22
TRE-11	127	141	1611	10	13	15	16	20	22
TRE-12	25	29	351	2	6	7	8	10	5
TRE-13	87	98	1020	7	12	14	14	18	17
TRE-14	147	145	903	10	22	26	27	33	29
TRE-15	26	23	840	3	5	5	5	6	3
TRE-16	251	223	4307	21	38	46	47	58	42
TRE-17	119	147	1280	13	19	23	23	29	25
TRE-18	248	246	4903	20	28	33	34	42	45
TRE-19	136	136	1413	10	12	14	15	19	27
TRE-20	205	251	10110	18	19	22	23	28	31
TRE-21	49	89	4041	5	5	6	6	8	8
TRE-22	149	174	4260	13	26	31	32	39	24
TRE-23	59	80	1039	6	11	13	13	16	13
TRE-24	193	199	893	16	30	36	36	45	36
TRE-25	56	118	3016	11	14	16	16	20	12
TRE-26	106	96	240	8	19	23	23	28	18
TRE-27	116	105	178	8	18	22	22	27	20
TRE-28	165	143	290	11	24	29	29	36	31
TRE-29	59	70	946	7	16	19	19	24	10
TRE-30	39	37	133	3	4	5	5	6	8
TRE-31	72	79	241	7	15	18	18	23	14
TRE-32	81	85	132	6	12	14	14	17	17
TRE-33	91	100	199	9	19	23	23	29	19
TRE-34	121	131	129	10	22	26	26	33	26
TRE-35	125	121	189	8	19	23	23	29	18
TRE-36	109	124	251	9	19	22	23	28	24
TRE-37	112	112	99	8	20	24	24	30	14
Three Creek Total:	**4608**	**4722**	**66178**	**396**	**649**	**772**	**785**	**973**	**826**

3.8 Summary: Contributions from All Sources

Based on the inventory of sources discussed in this chapter, an estimate of the contribution by the different direct nonpoint sources to the annual fecal coliform loading to the streams is given in Table 3.18 for Three Creek, Table 3.19 for Tarrara Creek & Flat Swamp, Table 3.20 for Mill Swamp, and Table 3.21 for Darden Mill Run. The estimated distribution of annual fecal coliform loading from nonpoint sources among the different land use categories is also given in these tables.

From Table 3.18 - Table 3.21, it is clear that nonpoint source loadings to the land surface are greater than direct nonpoint source loadings to the stream. However, factors such as precipitation amount and pattern, die-off rates, manure application activities, type of waste, and proximity to the streams impact the amount of fecal coliform from upland areas that reaches the streams. Due to their nature, direct nonpoint source loadings to streams are not modified before transmission to the stream. The HSPF model discussed in Chapter 4 considers these factors when estimating fecal coliform loadings in the receiving waters.

Table 3.18. Estimated annual fecal coliform loadings to the stream and the various land use categories for the Three Creek watershed.

Source	Fecal coliform loading ($x10^{12}$ cfu/yr)	Percent of total loading
Direct loading to streams		
Livestock in stream	13	<1%
Hunt Club washoff	2	<1%
Wildlife in stream	327	3%
Point Sources	<1	<1%
Loading to land surfaces		
Cropland†	627	6%
Pasture	7,810	71%
Residential	593	5%
Forest	1,454	13%
Wetlands	125	1%
Total	**10,954**	

† Includes an average 1.76 x 10^{10} cfu/year from biosolids

Table 3.19. Estimated annual fecal coliform loadings to the stream and the various land use categories for the Flat Swamp and Tarrara Creek watersheds.

Source	Fecal coliform loading ($x10^{12}$ cfu/yr)	Percent of total loading
Direct loading to streams		
Livestock in stream	24	<1%
Hunt Club washoff	1	<1%
Wildlife in stream	137	2%
Straight pipes	2	<1%
Loading to land surfaces		
Cropland	350	4%
Pasture	6,669	85%
Residential	154	2%
Forest	417	5%
Wetlands	47	1%
Total	**7,801**	

Table 3.20. Estimated annual fecal coliform loadings to the stream and the various land use categories for the Mill Swamp watershed.

Source	Fecal coliform loading ($x10^{12}$ cfu/yr)	Percent of total loading
Direct loading to streams		
Livestock in stream	<1	<1%
Hunt Club washoff	<1	<1%
Wildlife in stream	41	7%
Straight pipes	4	1%
Loading to land surfaces		
Cropland	79	13%
Pasture	259	43%
Residential	64	11%
Forest	146	24%
Wetlands	8	1%
Total	**601**	

Table 3.21. Estimated annual fecal coliform loadings to the stream and the various land use categories for the Darden Mill Run watershed.

Source	Fecal coliform loading ($x10^{12}$ cfu/yr)	Percent of total loading
Direct loading to streams		
Livestock in stream	10	<1%
Hunt Club washoff	<1	<1%
Wildlife in stream	48	1%
Loading to land surfaces		
Cropland	140	4%
Pasture	3,106	87%
Residential	88	2%
Forest	159	4%
Wetlands	10	<1%
Total	**3,561**	

4 Modeling Process for Bacteria TMDL Development

A key component in developing a TMDL is establishing the relationship between pollutant loadings (both point and nonpoint) and in-stream water quality conditions. Once this relationship is developed, management options for reducing pollutant loadings to streams can be assessed. In developing a TMDL, it is critical to understand the processes that affect the fate and transport of the pollutants and cause the impairment of the waterbody of concern. Pollutant transport to water bodies is evaluated using a variety of tools, including monitoring, geographic information systems (GIS), and computer simulation models. In this chapter, the modeling process, input data requirements, and model calibration procedure and results are discussed.

4.1 Model Description

The TMDL development process requires the use of a watershed-based model that integrates both point and nonpoint sources and simulates in-stream water quality processes. The Hydrologic Simulation Program – FORTRAN (HSPF) version 12 (Bicknell *et al.*, 2001; Duda *et al.*, 2001) was used to model fecal coliform transport and fate in the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds. The ArcGIS 9.1 Geographic Information System (GIS) software was used to display and analyze landscape information for the development of input for HSPF.

The HSPF model simulates nonpoint source runoff and pollutant loadings, performs flow routing through streams, and simulates in-stream water quality processes. HSPF estimates runoff from both pervious and impervious parts of the watershed and stream flow in the channel network. The sub-module PWATER within the module PERLND simulates runoff, and hence, estimates the water budget, on pervious areas (e.g., agricultural land). Runoff from impervious areas is modeled using the IWATER sub-module within the IMPLND module. The simulation of flow through the stream network is performed using the sub-modules HYDR and ADCALC within the module RCHRES. While HYDR routes the water through the stream network, ADCALC calculates variables used for simulating convective transport of the pollutant in the stream. Fate of fecal coliform on pervious and impervious land segments is simulated

using the PQUAL (PERLND module) and IQUAL (IMPLND module) sub-modules, respectively. Fate of fecal coliform in stream water is simulated using the general constituent pollutant (GQUAL) sub-module within the RCHRES module. Fecal coliform bacteria are simulated as dissolved pollutants in the GQUAL sub-module.

4.2 Input Data Requirements

The HSPF model requires a wide variety of input data to describe hydrology, water quality, and land use characteristics of the watershed. The different types and sources of input data used to develop the TMDLs for the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds are discussed below.

4.2.1 Climatological Data

Hourly precipitation data were obtained from NCDC's closest National Weather Service COOP station collecting hourly data, Wakefield 1NW in Sussex County, located 16 miles northeast of the watershed. Missing data were patched with data from the NCDC weather stations at Roanoke Rapids and Murfreesboro, both in North Carolina. Because data for some parameters needed by HSPF were not available at these stations, data from the Norfolk International Airport were also used to complete the meteorological data set required for running HSPF. Detailed descriptions of the weather data and the procedure for converting the raw data into the required data set are presented in Appendix C.

4.2.2 Model Parameters

The hydrology parameters required by HSPF were defined for every land use category. Required hydrology parameters are listed in the HSPF Version 12 User's Manual (Bicknell *et al.*, 2001). Because surrogate watersheds were used for hydrology calibration, initial estimates for required hydrology parameters were generated for the surrogate watersheds (Blackwater River and North Meherrin River) based on previous models and guidance in BASINS Technical Note 6 (USEPA, 2000); these parameters were refined during calibration, and the calibrated parameters were transferred to the corresponding land uses in the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds.

Each reach requires a function table (FTABLE) to describe the relationship between water depth, surface area, volume, and discharge (Bicknell *et al.*, 2001). The procedures described in Staley *et al.* (2006) were used to characterize the reaches in the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds using NRCS bankfull equations and digital elevation models. A visual inspection of stream characteristics was performed for Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek in March 2011; this inspection was used to inform decisions about roughness and floodplain characteristics in developing the FTABLEs. Stream lengths and slopes were determined using GIS data. Information on the calculated stream geometry for each sub-watershed is presented in Table 4.1 and Table 4.2 for the bankfull condition.

Table 4.1. Reach characteristics for Darden Mill Run (DMR), Mill Swamp (MSP), Tarrara Creek (TRR), and Flat Swamp (FTS).

Sub-watershed	Length (mi)	Slope (ft/ft)	Average Bankfull Width (ft)	Average Bankfull Depth (ft)
DMR-1	1.49	0.0004	35.20	2.84
DMR-2	1.88	0.0010	28.30	2.41
DMR-3	2.56	0.0031	15.79	1.56
DMR-4	2.59	0.0008	23.91	2.13
DMR-5	1.82	0.0011	21.39	1.96
DMR-6	1.37	0.0043	11.76	1.25
DMR-7	0.69	0.0027	14.57	1.47
DMR-8	2.05	0.0023	13.93	1.42
DMR-9	1.66	0.0013	23.01	2.07
DMR-10	2.23	0.0011	20.70	1.91
DMR-11	2.12	0.0032	15.55	1.54
MSP-1	1.89	0.0012	33.75	2.75
MSP-2	2.56	0.0022	20.37	1.89
MSP-3	2.34	0.0048	15.31	1.52
MSP-4	2.12	0.0011	28.94	2.46
MSP-5	1.39	0.0021	27.64	2.37
MSP-6[†]	1.25	n/a	n/a	n/a
MSP-7	2.81	0.0039	15.04	1.50
MSP-8	1.53	0.0012	19.20	1.81
MSP-9	1.96	0.0031	13.85	1.41
TRR-1	1.79	0.0006	49.22	3.65
TRR-2	0.46	0.0014	48.09	3.59
TRR-3	4.61	0.0027	20.16	1.87

TRR-4	2.18	0.0005	46.35	3.49
TRR-5	1.69	0.0004	45.34	3.44
TRR-6	1.98	0.0015	29.31	2.48
TRR-7	4.64	0.0024	19.16	1.80
TRR-8	2.01	0.0001	23.28	2.09
TRR-9	4.66	0.0026	20.85	1.92
FTS-10	1.83	0.0005	39.09	3.07
FTS-11	1.52	0.0011	24.47	2.17
FTS-12	1.33	0.0007	23.47	2.10
FTS-13	3.63	0.0023	19.80	1.85
FTS-14	1.4	0.0014	34.05	2.77
FTS-15	3.19	0.0005	33.57	2.74
FTS-16	1.72	0.0011	31.11	2.59
FTS-17	0.54	0.0004	28.58	2.43
FTS-18	4.14	0.0019	20.16	1.87
FTS-19	0.69	0.0003	22.19	2.01
FTS-20	2.94	0.0027	14.71	1.48
FTS-21	3.27	0.0026	18.57	1.76

† MSP-6 is Darden Pond and thus width and depth are highly variable and not listed here. The surface area for the pond according to USGS topographic maps is 76.3 acres.

Table 4.2. Reach characteristics for Three Creek (TRE).

Sub-watershed	Length (mi)	Slope (ft/ft)	Average Bankfull Width (ft)	Average Bankfull Depth (ft)
TRE-1	4.26	0.0003	74.77	4.99
TRE-2	1.44	0.0004	74.38	4.97
TRE-3	4.72	0.0011	25.22	2.21
TRE-4	4.24	0.0022	20.54	1.90
TRE-5	3.29	0.0005	72.48	4.88
TRE-6	5.9	0.0003	68.90	4.70
TRE-7	2.77	0.0008	31.42	2.61
TRE-8	1.39	0.0011	27.99	2.39
TRE-9	3.59	0.0029	22.54	2.04
TRE-10	5.02	0.0007	34.64	2.81
TRE-11	2.57	0.0013	31.75	2.63
TRE-12†	1.3	n/a	n/a	n/a
TRE-13	0.92	0.0006	26.61	2.31
TRE-14	4.94	0.0019	22.41	2.03
TRE-15	1.76	0.0001	63.36	4.41
TRE-16	2.59	0.0007	63.19	4.40
TRE-17	6.06	0.0022	19.39	1.82
TRE-18	3.12	0.0005	60.60	4.27
TRE-19	7.22	0.0019	20.61	1.90

TRE-20	5.33	0.0001	57.41	4.10
TRE-21	1.35	0.0006	55.41	3.99
TRE-22	4.38	0.0005	32.71	2.69
TRE-23	2.02	0.0010	27.25	2.35
TRE-24	4.89	0.0041	24.57	2.17
TRE-25	5.47	0.0015	49.38	3.66
TRE-26	4.86	0.0044	27.11	1.69
TRE-27	4.49	0.0018	41.87	2.46
TRE-28	3.66	0.0045	33.41	2.03
TRE-29[‡]	2.29	n/a	n/a	n/a
TRE-30	1.61	0.0007	64.69	3.59
TRE-31	2.7	0.0007	63.35	3.53
TRE-32	3.77	0.0057	24.24	1.53
TRE-33	5.21	0.0009	57.53	3.24
TRE-34	1.31	0.0009	53.66	3.06
TRE-35	5.63	0.0042	31.47	1.92
TRE-36	3.25	0.0018	39.16	2.33
TRE-37	4.58	0.0051	30.46	1.87

[†] TRE-12 is Harrells Pond and thus width and depth are highly variable and not listed here. The surface area for the pond according to USGS topographic maps is 59.4 acres.
[‡] TRE-29 is Slagles Lake and thus width and depth are highly variable and not listed here. The surface area for the pond according to USGS topographic maps is 150.5 acres.

Required water quality parameters are also given in the HSPF User's Manual (Bicknell *et al.*, 2001). Initial estimates for bacteria loading parameters in Darden Mill Run, Mill Swamp, Flat Swamp, Tarrara Creek, and Three Creek were based on estimates of bacteria production in the watersheds; initial estimates of die-off rates and subsurface bacteria concentrations were based on values commonly used in previous TMDLs.

4.3 Accounting for Pollutant Sources

4.3.1 Overview

There are three large and two small permitted facilities allowed to discharge bacteria into Three Creek (see Table 3.2). During future conditions, flow from these facilities was modeled at the facilities' design flows and bacteria concentrations were modeled at their permitted limits (126 cfu/100 mL). During calibration, flow from the large facilities was modeled according to their discharge monitoring reports and flow

from the small facilities, typically being much less than permitted and not required to be reported, was not represented.

The bacteria from biosolids are represented in the model as dry atmospheric deposition – this allows application of the correct amount of bacteria on a single day of the year as is appropriate for biosolids. For future conditions, the bacteria from biosolids were represented at permitted concentrations and for worst-case application rates and extents; for the calibration and validation periods, the applications were represented according to monitored data.

Bacteria loads that are directly deposited by cattle, wildlife, hunting dog kennel washoff, and straight pipes directly into streams were treated as direct nonpoint sources in the model. Direct nonpoint source loadings were applied to the stream reach in each sub-watershed as appropriate. The point sources permitted to discharge bacteria in the watershed were incorporated into the simulations at the stream locations designated in their permits.

Bacteria that were deposited on land were treated as nonpoint source loadings; all or part of that load may be transported to the stream as a result of surface runoff during rainfall events. The nonpoint source loading was applied in the model in the form of fecal coliform counts to individual land use categories by sub-watershed. Bacterial die-off on the land surface and in the stream was simulated within the model. Both direct nonpoint and nonpoint source loadings were varied by month to account for seasonal differences in bacteria production and deposition characteristics, such as migratory behavior, management practices, and cattle time in streams.

The Bacteria Source Load Calculator (BSLC) (Zeckoski *et al.*, 2005) was used to generate nonpoint source fecal coliform inputs to the HSPF model. This spreadsheet program takes inputs of animal numbers, land use, and management practices by sub-watershed and outputs hourly direct deposition to streams and monthly loads to each land use type. The BSLC allows direct deposition in the stream by cattle and waterfowl to occur only during daylight hours.

4.3.2 Modeling fecal coliform die-off

Fecal coliform die-off was modeled using first order die-off of the form:

$$C_t = C_o e^{-kt} \quad [4.1]$$

Where: C_t = concentration or load at time t;

C_o = starting concentration or load;

k = base e decay rate (day^{-1});

and t = time in days.

A review of literature provided estimates of decay rates that could be applied to waste storage and handling in the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds (Table 4.3).

Table 4.3. First order decay rates for different animal waste storage as affected by storage/application conditions and their sources.

Waste type	Storage/application	Decay rate (day^{-1}, base e)	Reference
Solid cattle manure (dairy)	Pile (not covered)	0.066	Crane and Moore (1986)
	Pile (covered)	0.028	
Swine manure	Anaerobic lagoon effluent	0.277	
Poultry litter	Soil surface	0.035	Giddens *et al*. (1973)
		0.342	Crane *et al*. (1980)

Based on the values cited in the literature, the following decay rates were used in simulating fecal coliform die-off in stored waste.

- Solid cattle manure: Based on the range of decay rates (0.028-0.066 day^{-1}) reported for solid dairy manure, a decay rate of 0.05 day^{-1} was used, assuming that a majority of manure piles are not covered.
- Swine manure: A decay rate of 0.227 day^{-1} was used based on the value found in the literature. This was incorporated into the model using a 'survival factor' of 0.011 in the BSLC.
- Poultry waste in pile/house: Because no decay rates were found for poultry waste in storage, a decay rate of 0.035 day^{-1} was used based on the lower decay rate reported for poultry litter applied to the soil surface. The lower value was used instead of the higher value of 0.342 day^{-1}

(Table 4.3) because fecal coliform die-off in storage was assumed to be lower, given the absence of UV radiation and predation by soil microbes. This was incorporated into the model using a 'survival factor' of 0.099 in the BSLC.

The procedure for calculating fecal coliform counts in waste at the time of land application is included in Appendix D. The fraction of fecal coliform surviving in the manure at the end of storage is calculated depending on the duration of storage and die-off factor. While calculating survival fraction at the end of the storage period, the daily addition of manure and coliform die-off of each fresh manure addition is considered to arrive at an effective survival fraction over the entire storage period. The amount of fecal coliform available for application to land per year is estimated by multiplying the survival fraction with total fecal coliform produced per year (in as-excreted manure). Monthly fecal coliform application to land is estimated by multiplying the amount of fecal coliform available for application to land per year by the fraction of manure applied to land during that month.

Whether applied to the land via stored manure or via direct deposition by the animal, bacteria on the land surface were assumed to die off at a base-10 decay rate of 0.05 day^{-1}. The decay rate of 0.05 day^{-1} is represented in HSPF by specifying a maximum surface buildup of nine times the daily loading rate. An in-stream base-10 decay rate of 1.632 day^{-1} (Khatiwada and Polprasert, 1999) was used for Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek; an in-stream base-10 decay rate of 2.3 day^{-1} was calibrated for the swamps of Three Creek. The lakes/ponds in Three Creek (Slagles Lake, Harrels Mill Pond) used an in-stream base-10 decay rate of 5.24 day^{-1} based on fitting a curve using HSPF's parameters to the temperature- and length of daylight-dependent decay rates for impoundments suggested by Gannon *et al.* (1983).

4.3.3 Modeling Nonpoint Sources

For modeling purposes, nonpoint fecal coliform loads were those that were deposited or applied to land, and hence, required surface runoff events for transport to

streams. Fecal coliform loading by land use for all sources in each sub-watershed was presented in Chapter 3. The existing condition fecal coliform loads are based on best estimates of existing wildlife, livestock, pet, and human populations and fecal coliform production rates. Fecal coliform loadings to each sub-watershed in the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds are presented in Appendix E for existing conditions. The sources of fecal coliform to different land use categories and how the model handled them are briefly discussed below.

1. Cropland: Solid cattle manure, liquid swine manure, and poultry litter are applied to cropland as described in Chapter 3. Fecal coliform loadings to cropland were adjusted to account for die-off during storage. Wildlife contributions were also added to the cropland areas. For modeling, the monthly fecal coliform loading assigned to cropland was distributed over the entire cropland acreage within a sub-watershed. Thus, loading rate varied by month and sub-watershed.
2. Pasture: Pastures receive direct deposition from livestock and wildlife. For modeling, the monthly fecal coliform loading assigned to pasture was distributed over the entire pasture acreage within a sub-watershed.
3. Residential: Fecal coliform loading on rural residential land uses came from failing septic systems and waste from pets. In the model simulations, fecal coliform loads produced by failing septic systems and pets in a sub-watershed were assumed to be uniformly applied to the residential pervious land use areas in each sub-watershed. Pet loads varied by sub-watershed but were constant throughout the year. Impervious areas (Table 2.3) received constant loads of 1.0×10^7 cfu/acre/day.
4. Forest and wetlands: Wildlife not defecating in streams, cropland, or pastures provided fecal coliform loading to the forested and wetland land uses. These loadings varied by month (to account for migration and hibernation) and by sub-watershed. Hunting dogs also provided loadings to these areas that varied by sub-watershed.

4.3.4 Modeling Direct Nonpoint Sources

Fecal coliform loads from direct nonpoint sources included cattle in streams, wildlife in streams, washoff from hunt clubs, and direct loading to streams from straight pipes from residences. Loads from direct nonpoint sources in each sub-watershed were described in detail in Chapter 3. Contributions of fecal coliform from interflow and groundwater were modeled with a constant concentration of 5 cfu/100mL for interflow and 3.75 cfu/100mL for groundwater.

4.4 Model Calibration and Validation

Model calibration is the process of selecting model parameters that provide an accurate representation of the watershed. In this section, the procedures followed for calibrating the hydrology and water quality components of the Hydrological Simulation Program-FORTRAN (HSPF) model are discussed.

4.4.1 Selection of Surrogate Watersheds

Because there are no continuous flow monitoring stations within any of the study watersheds, a detailed hydrology calibration needed to be performed for nearby 'surrogate' watersheds that have stream flow data available and characteristics similar to those of the study watersheds. This section describes the selection of those surrogate watersheds.

Two surrogate watersheds were needed for this TMDL study: one for the area of Three Creek in the Piedmont ecoregion, and one for the remainder of Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek in the Coastal Plain ecoregions. Several watersheds with stream flow data available and in close proximity to the study area were considered as possible surrogate watersheds for the hydrology calibration. For the Coastal Plain ecoregions, Blackwater River in Surry County, Ahoskie Creek in North Carolina, and Potecasi Creek in North Carolina were considered. For the Piedmont ecoregion, Stony Creek in Dinwiddie County, North Meherrin River in Lunenburg County, Allen Creek in Mecklenburg County, and Nottoway River near Burkeville in Nottoway County were considered. Blackwater River had a prior TMDL developed and therefore had a calibrated data set already available.

Several criteria were used to select the calibration watersheds. These include the relative location of the watersheds, watershed size, land use distribution, underlying geology, hydrologic soil group, and average land slope. The watershed size, land use distribution, hydrologic soil group, and average land slope are compared for the Coastal Plain ecoregions in Table 4.4 and for the Piedmont ecoregion in Table 4.5.

Table 4.4. Land use comparison and total watershed area of potential hydrologic surrogate watersheds in the Coastal Plain ecoregions.

Watershed	Area (ac)	% Forest	% Agriculture	% Residential	% Wetland	Primary STATSGO HYDGRP‡	Average Slope (%)¶
TMDL Watersheds							
Downstream Three Creek	97309	60	29	3	8	C	0
Darden Mill Run	17781	51	44	<1	5	B & C	0
Mill Swamp	15853	53	42	<1	4	B & C	0
Flat Swamp	23682	53	40	<1	7	B & C	0
Tarrara Creek†	20819	48	44	1	7	B & C	0
Potential Surrogate Watersheds							
Ahoskie Creek	40512	51	27	7	14	D	0
Potecasi Creek	144000	48	33	9	10	D	0.5
Blackwater River	185600	63	27	2	8	C	7

‡ Hydrologic soil group for the majority of the area; where two groups were dominant, both are listed
¶ From HYDRO1k dataset (USGS, 2011c)
† Exclusive of Flat Swamp

Table 4.5. Land use comparison and total watershed area of potential hydrologic surrogate watersheds in the Piedmont ecoregion.

Watershed	Area (ac)	% Forest	% Agriculture	% Residential	% Wetland	Primary STATSGO HYDGRP‡	Average Slope (%)¶
TMDL Watershed							
Upstream Three Creek	42422	73	22	4	1	B	0.2
Potential Surrogate Watersheds							
Stony Creek	72320	55	23	18	4	B	15
Allen Creek	34240	62	11	21	3	C	35
North Meherrin River	35840	60	16	21	2	B	37
Nottoway River	24768	62	15	20	2	B	31

‡ Hydrologic soil group for the majority of the area
¶ From HYDRO1k dataset (USGS, 2011c)

Considering first the Coastal Plain ecoregions, recall from section 0 that most of the study area is in the Southeastern Plain level III ecoregion, with a small eastern part

in the Atlantic Coastal Plain level III ecoregion. By comparison, Ahoskie and Potecasi Creek are located in the Atlantic Coastal Plain level III ecoregion and Blackwater River is located in the Southeastern Plain level III ecoregion with an eastern tip in the Atlantic Coastal Plain level III ecoregion. The Ahoskie Creek watershed is the farthest from the watershed (30 miles) while the other two watersheds are less than 25 miles away. The Ahoskie Creek watershed is the closest in size to the all of the watersheds, the other two being much larger in size than any of the impaired watersheds. The suitabilities of the land use breakdowns for each of the possible surrogates were roughly similar, with forest contributions basically within range of the impaired watersheds and agricultural contributions generally similar to Three Creek but much lower than the other four watersheds. However, Blackwater River provides the closest match on the residential and wetlands contributions to land use. Blackwater River matched the primary STATSGO hydrologic soil group the best of the three surrogate candidates. Average slopes in the Coastal Plain watersheds are comparable for all candidates and impaired watersheds except the Blackwater River watershed, which has a noticeably higher average slope.

Based on the selection criteria, hydrologic parameters from the nearby Blackwater River watershed were used in the model for the Coastal Plain ecoregions. The similarity in land use breakdown and hydrologic soil group outweighed the discrepancies in slope and watershed size. The hydrologic parameters were initially calibrated during the development of the fecal coliform TMDL for the non-tidal Chowan River basin (VADEQ, 2005), but were recalibrated for this effort to meet more stringent criteria and to take advantage of high water table routines currently available in HSPF that were not available at the time of the original Chowan River modeling effort. The hydrologic parameters that have a direct relation to physical characteristics of the watershed (e.g., land slope), were obtained from digital maps of the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds.

All four watersheds considered as surrogates for the Piedmont ecoregion portion of Three Creek are also in the Piedmont Level III Ecoregion. North Meherrin River and Allen Creek are the farthest away from the study area, at 70 and 64 miles, respectively. Stony Creek and Nottoway River are 40 miles or less away from Three Creek. North

Meherrin River and Allen Creek are closest in size to the Piedmont area of the Three Creek watershed, though Nottoway River is also relatively close in size. Stony Creek is considerably larger. All watersheds are dominated by forest land use, though all surrogates considered had noticeably more residential area than Three Creek. All potential surrogates matched the primary STATSGO hydrologic soil group for upstream Three Creek except Allen Creek. Average slopes in the surrogate watersheds for the Piedmont ecoregion were considerably larger than the slope for the Piedmont area of Three Creek.

Based on these criteria, the North Meherrin River watershed was chosen as the surrogate for the area of the Three Creek watershed in the Piedmont ecoregion. Although a TMDL was previously developed for North Meherrin River (VADEQ, 2009), a hydrologic model was not calibrated to the North Meherrin River flow data as a part of that effort, and so the hydrologic model for North Meherrin River was calibrated as a part of the current TMDL effort. After calibration, parameters from the North Meherrin River model were transferred to their land use counterparts in the Three Creek watershed. Hydrologic parameters for the Three Creek model that have a direct relation to physical characteristics of the watershed (e.g., land slope) were obtained from digital maps of the Three Creek watershed.

4.4.2 Hydrology

Hydrologic calibration could not be conducted for the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds due to the lack of observed flow data on these streams. However, hydrological parameters in HSPF had to be set to “reasonable” values because the output of the hydrological component of HSPF impacts fecal coliform predictions. Some of those parameters were estimated based on watershed characteristics, while others were based on the calibrated parameters for the nearby Blackwater River and North Meherrin River watersheds. Table 4.6 and Table 4.7 list the different hydrologic parameters and specify the source of each parameter. Parameters that vary by land use and month are listed in Appendix F.

Table 4.6. Hydrology parameters for Darden Mill Run, Mill Swamp, Flat Swamp, Tarrara Creek, and the Coastal Plain region of Three Creek.

Parameter	Definition	Units	FINAL CALIBRATION	FUNCTION OF…	Blackwater River or Estimated	Appendix F Table (if applicable)
PERLND						
PWAT-PARM2						
FOREST	Fraction forest cover	none	1.0 forest, 0.0 others	Forest cover	Blackwater River	
LZSN	Lower zone nominal soil moisture storage	inches	7.3 forest and crop, 7.2 pasture, 7.4 residential, 8 wetlands	Soil properties	Blackwater River	
INFILT	Index to infiltration capacity	in/hr	0.0534-0.0747[a]	Soil and cover conditions	Blackwater River	1
LSUR	Length of overland flow	feet	119.71-1257.6	Topography	Estimated	1
SLSUR	Slope of overland flowplane	none	0-0.05	Topography	Estimated	1
KVARY	Groundwater recession variable	1/in	0.0	Calibrate	Blackwater River	
AGWRC	Base groundwater recession	none	0.88	Calibrate	Blackwater River	
PWAT-PARM3						
PETMAX	Temp below which ET is reduced	deg. F	40.0	Climate, vegetation	Blackwater River	
PETMIN	Temp below which ET is set to zero	deg. F	35.0	Climate, vegetation	Blackwater River	
INFEXP	Exponent in infiltration equation	none	2.0	Soil properties	Blackwater River	
INFILD	Ratio of max/mean infiltration capacities	none	2.0	Soil properties	Blackwater River	
DEEPFR	Fraction of GW inflow to deep recharge	none	0.05	Geology	Blackwater River	
BASETP	Fraction of remaining ET from baseflow	none	0.13	Riparian vegetation	Blackwater River	
AGWETP	Fraction of remaining ET from active GW	none	0.7 wetlands, 0.0 others	Marsh/ wetlands ET	Blackwater River	
PWAT-PARM4						
CEPSC	Interception storage capacity	inches	monthly[b]	Vegetation	Blackwater River	2
UZSN	Upper zone nominal soil moisture storage	inches	1.026 forest, 1.008 pasture, 1.022 cropland, 1.041 residential, 1.120 wetlands	Soil properties	Blackwater River	
NSUR	Mannings' n (roughness)	none	0.45 forest, 0.25 pasture and crop, 0.15 residential, 0.1 wetlands	Land use, surface condition	Blackwater River	
INTFW	Interflow/surface runoff partition parameter	none	1.2	Soils, topography, land use	Blackwater River	
IRC	Interflow recession parameter	none	0.65	Soils, topography, land use	Blackwater River	
LZETP	Lower zone ET parameter	none	monthly[b]	Vegetation	Blackwater River	4

Table 4.6. Hydrology parameters for Darden Mill Run, Mill Swamp, Flat Swamp, Tarrara Creek, and the Coastal Plain region of Three Creek. (cont.)

Parameter	Definition	Units	FINAL CALIBRATION	FUNCTION OF…	Blackwater River or Estimated	Appendix F Table (if applicable)
PWAT-PARM6 (Wetlands Only)						
MELEV	Mean surface elevation	feet	21.6570-128.0072	Topography	Estimated	7
BELV	Base elevation for active groundwater	feet	9.7234-127.5072	Topography	Estimated	7
GWDATM	Datum for the groundwater elevation	feet	9.5937-116.877	Topography, Soils	Estimated	7
PCW	Cohesion water porosity	none	0.1054-0.1639	Soils	Estimated	7
PGW	Gravitational water porosity	none	0.1991-0.3073	Soils	Estimated	7
UPGW	Upper gravitational water porosity	none	0.2539-0.3078	Soils	Estimated	7
PWAT-PARM7 (Wetlands Only)						
SRRC	Surface runoff recession constant	1/hr	0.95	Calibrate	Blackwater River	
SREXP	Surface runoff exponent	none	1.5	Calibrate	Blackwater River	
IFWSC	maximum interflow storage capacity	inches	1.5	Soils, Calibrate	Blackwater River	
DELTA	Groundwater tolerance level	inches	0.001	Soils	Blackwater River	
UELFAC	multiplier on UZSN used to compute the upper zone capacity	none	4.0	Use default	Blackwater River	
LELFAC	multiplier on LZSN used to compute the lower zone capacity	none	2.5	Use default	Blackwater River	
IMPLND						
IWAT-PARM2						
LSUR	Length of overland flow	feet	100	Topography	Blackwater River	
SLSUR	Slope of overland flowplane	none	0.0186	Topography	Estimated	
NSUR	Mannings' n (roughness)	none	0.1	Land use, surface condition	Blackwater River	
RETSC	Retention/inter-ception storage capacity	inches	0.1	Land use, surface condition	Blackwater River	
IWAT-PARM3						
PETMAX	Temp below which ET is reduced	deg. F	40	Climate, vegetation	Blackwater River	
PETMIN	Temp below which ET is set to zero	deg. F	35	Climate, vegetation	Blackwater River	
RCHRES						
HYDR-PARM2						
KS	Weighting factor for hydraulic routing		0.5		Blackwater River	

[a] INFILT estimates were matched to Blackwater River data according to hydrologic soil group and land use
[b] Varies by month and with land use

Table 4.7. Hydrology parameters for the Piedmont region of Three Creek.

Parameter	Definition	Units	FINAL CALIBRATION	FUNCTION OF…	North Meherrin River or Estimated	Appendix F Table (if applicable)
PERLND						
PWAT-PARM2						
FOREST	Fraction forest cover	none	1.0 forest, 0.0 others	Forest cover	N. Meherrin River	
LZSN	Lower zone nominal soil moisture storage	inches	4.8	Soil properties	N. Meherrin River	
INFILT	Index to infiltration capacity	in/hr	0.0224 - 0.0918	Soil and cover conditions	N. Meherrin River	1
LSUR	Length of overland flow	feet	151.86 - 824.05	Topography	Estimated	1
SLSUR	Slope of overland flowplane	none	0.0151-0.0466	Topography	Estimated	1
KVARY	Groundwater recession variable	1/in	0	Calibrate	N. Meherrin River	
AGWRC	Base groundwater recession	none	0.971 forest, 0.951 other	Calibrate	N. Meherrin River	
PWAT-PARM3						
PETMAX	Temp below which ET is reduced	deg. F	40.0	Climate, vegetation	N. Meherrin River	
PETMIN	Temp below which ET is set to zero	deg. F	35.0	Climate, vegetation	N. Meherrin River	
INFEXP	Exponent in infiltration equation	none	2.0	Soil properties	N. Meherrin River	
INFILD	Ratio of max/mean infiltration capacities	none	2.0	Soil properties	N. Meherrin River	
DEEPFR	Fraction of GW inflow to deep recharge	none	0.4	Geology	N. Meherrin River	
BASETP	Fraction of remaining ET from baseflow	none	0.07	Riparian vegetation	N. Meherrin River	
AGWETP	Fraction of remaining ET from active GW	none	0.1 wetlands, 0.0 other	Marsh/wetlands ET	N. Meherrin River	
PWAT-PARM4						
CEPSC	Interception storage capacity	inches	monthly[a]	Vegetation	N. Meherrin River	3
UZSN	Upper zone nominal soil moisture storage	inches	monthly[a]	Soil properties	N. Meherrin River	6
NSUR	Mannings' n (roughness)	none	0.45 forest, 0.3 pasture & residential, 0.25 cropland, 0.4 wetlands	Land use, surface condition	Estimated	
INTFW	Interflow/surface runoff partition parameter	none	1.39	Soils, topography, land use	N. Meherrin River	
IRC	Interfiow recession parameter	none	0.7	Soils, topography, land use	N. Meherrin River	
LZETP	Lower zone ET parameter	none	monthly[a]	Vegetation	N. Meherrin River	5

Table 4.7. Hydrology parameters for the Piedmont region of Three Creek. (cont.)

Parameter	Definition	Units	FINAL CALIBRATION	FUNCTION OF…	N. Meherrin River or Estimated	Appendix F Table (if applicable)
IMPLND						
IWAT-PARM2						
LSUR	Length of overland flow	feet	150	Topography	N. Meherrin River	
SLSUR	Slope of overland flowplane	none	0.0571	Topography	Estimated	
NSUR	Mannings' n (roughness)	none	0.075	Land use, surface condition	N. Meherrin River	
RETSC	Retention/inter-ception storage capacity	inches	0.1	Land use, surface condition	N. Meherrin River	
IWAT-PARM3						
PETMAX	Temp below which ET is reduced	deg. F	40	Climate, vegetation	N. Meherrin River	
PETMIN	Temp below which ET is set to zero	deg. F	35	Climate, vegetation	N. Meherrin River	
RCHRES						
HYDR-PARM2						
KS	Weighting factor for hydraulic routing		0.5		N. Meherrin River	

[a]Varies by month and with land use

4.4.2.1 Hydrologic Calibration for Blackwater River

Blackwater River was used as the surrogate watershed for the low-lying portions of the study watersheds in the Coastal Plain ecoregions. Meteorological inputs and initial parameter estimates for Blackwater River were taken from previous work conducted by MapTech (VADEQ, 2005); recalibration was conducted to meet more stringent calibration criteria and to incorporate the high water table routines currently available in HSPF that were not available at the time of MapTech's initial calibration. Additionally, because most of the reaches in the watershed are surrounded by wetlands, and in fact the blue-line streams are at times indistinguishable from the wetlands (Figure 4.1), flow from all other land uses was routed through the wetlands before entering the reaches, with the exception of sub-watershed 11.

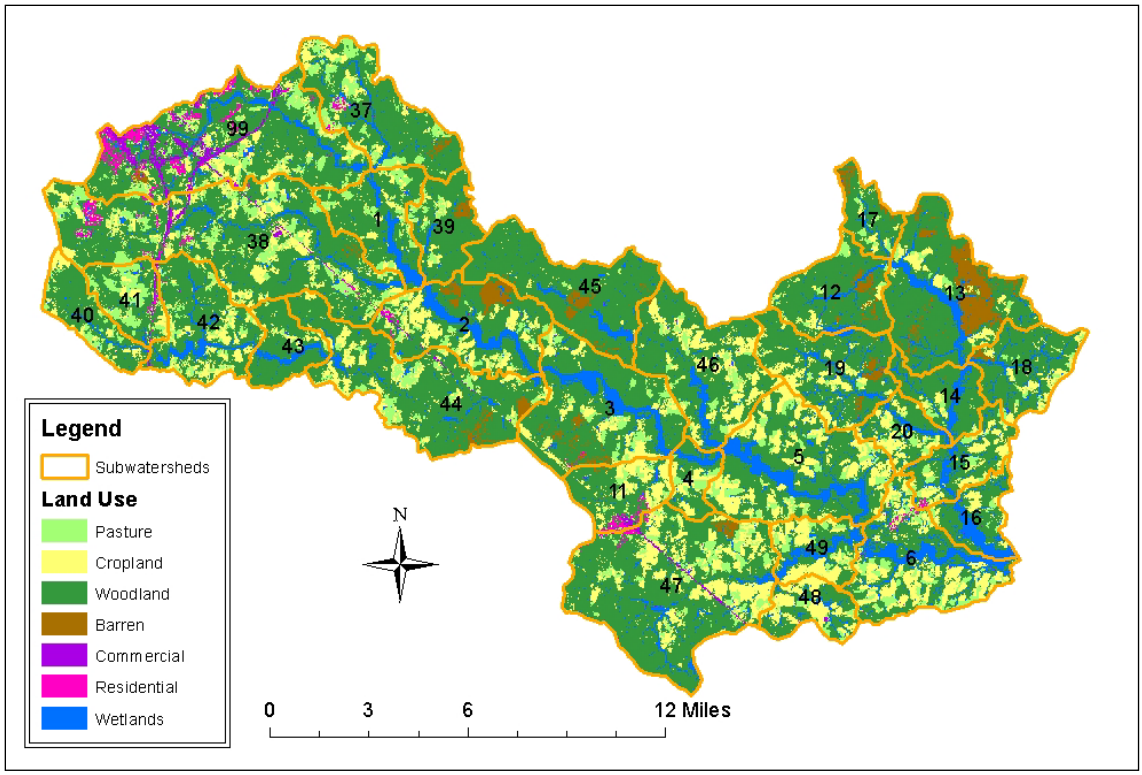

Figure 4.1. Land use map of the Blackwater River watershed.

The time-step used in the hydrologic simulations for Blackwater River was 1 hour. Observed daily flow data for Blackwater River were available from the USGS monitoring station 02047500, Blackwater River near Dendron, VA. Daily flow data were used in the hydrologic calibration/validation. MapTech obtained precipitation data from the National Weather Service COOP stations at Hopewell (444101) and Wakefield (448800). Hopewell is located 3.8 miles north of the Blackwater River watershed; Wakefield is located less than a half mile from the southern boundary of the watershed.

The calibration and validation periods chosen for Blackwater River matched the initial periods selected by MapTech. The hydrologic calibration period was October 1, 1991 to September 30, 1996. The hydrologic validation period was October 1, 1997 to September 30, 2002. The output from the HSPF model for both calibration and validation was daily average flow in cubic feet per second (cfs). Calibration parameters were adjusted within the recommended range.

The HSPEXP decision support system developed by USGS was used to support calibration of the hydrologic portion of HSPF for Blackwater River. The criteria used in

calibration and validation are listed in Table 4.8; these are the default HSPEXP criteria. After calibration, all criteria listed in Table 4.8 were met.

Table 4.8. Default criteria for HSPEXP.

Variable	Percent Error
Total Volume	±10%
50 % Lowest Flows	±10%
10 % Highest Flows	±15%
Storm Peaks	±15%
Seasonal Volume Error	±10%
Summer Storm Volume Error	±15%

The simulated flow for both the calibration and validation matched the observed flow well, as shown in Figure 4.2 and Figure 4.3. The agreement with observed flows is further illustrated in Figure 4.4 and Figure 4.5 for a representative year and Figure 4.6 and Figure 4.7 for a representative storm.

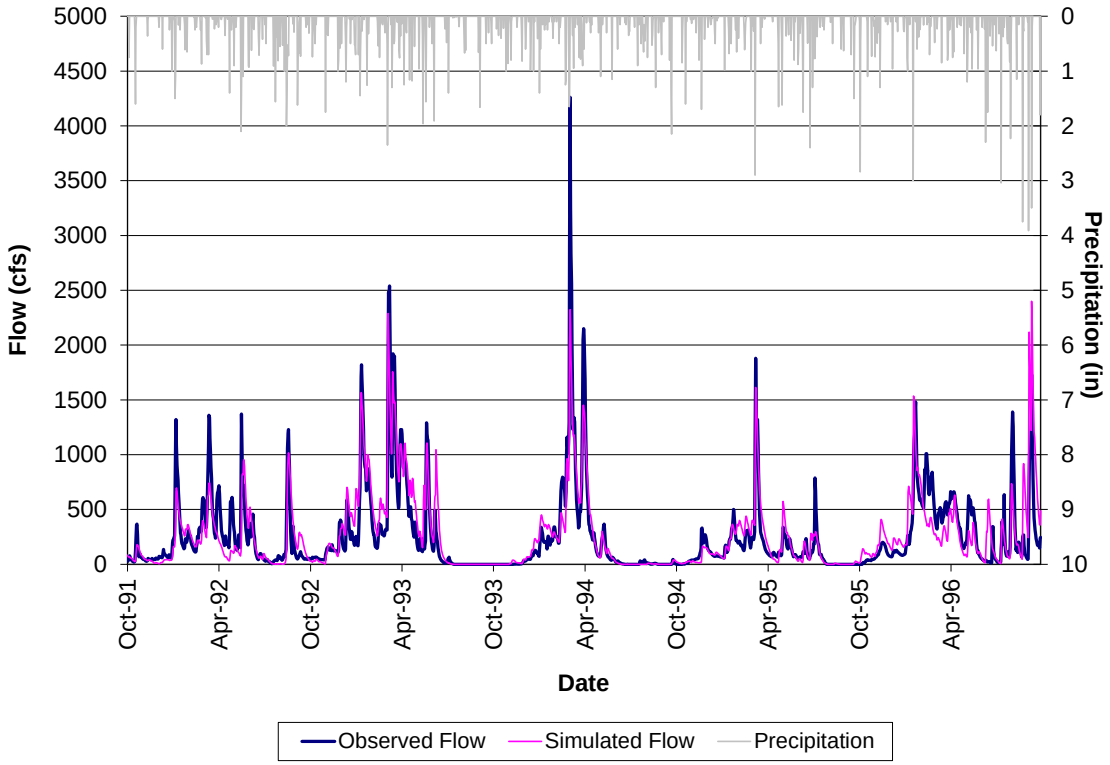

Figure 4.2. Observed and simulated flows during the calibration period for Blackwater River.

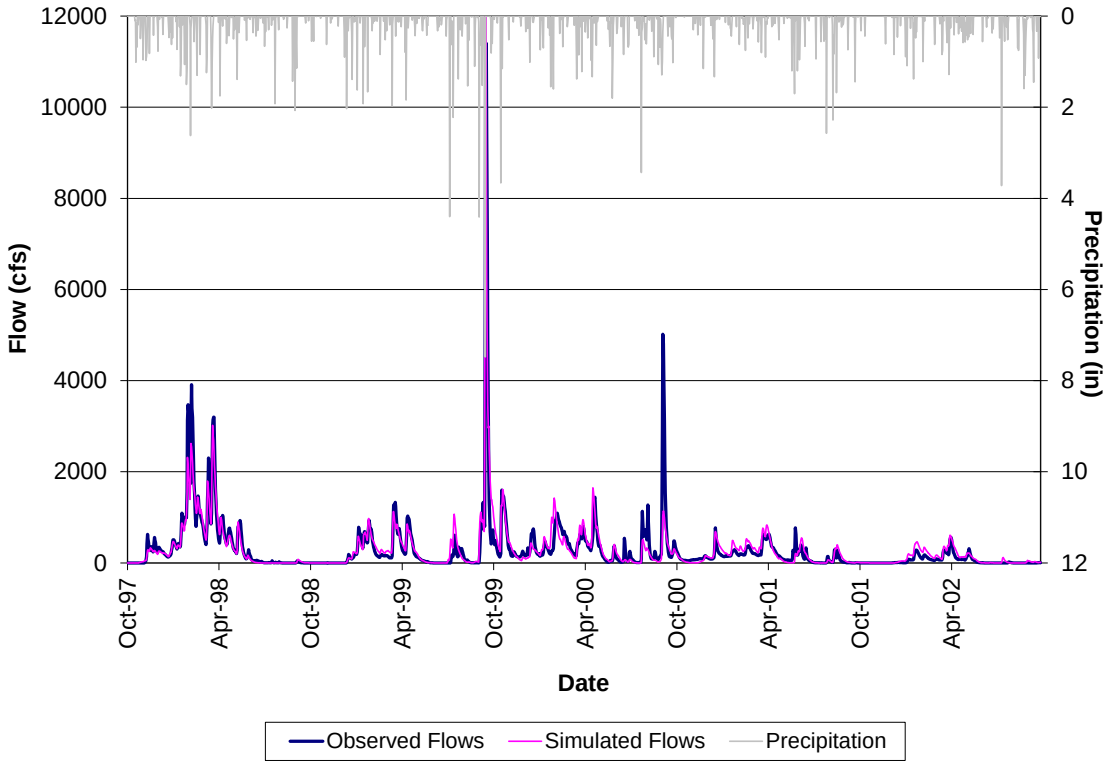

Figure 4.3. Observed and simulated flows during the validation period for Blackwater River.

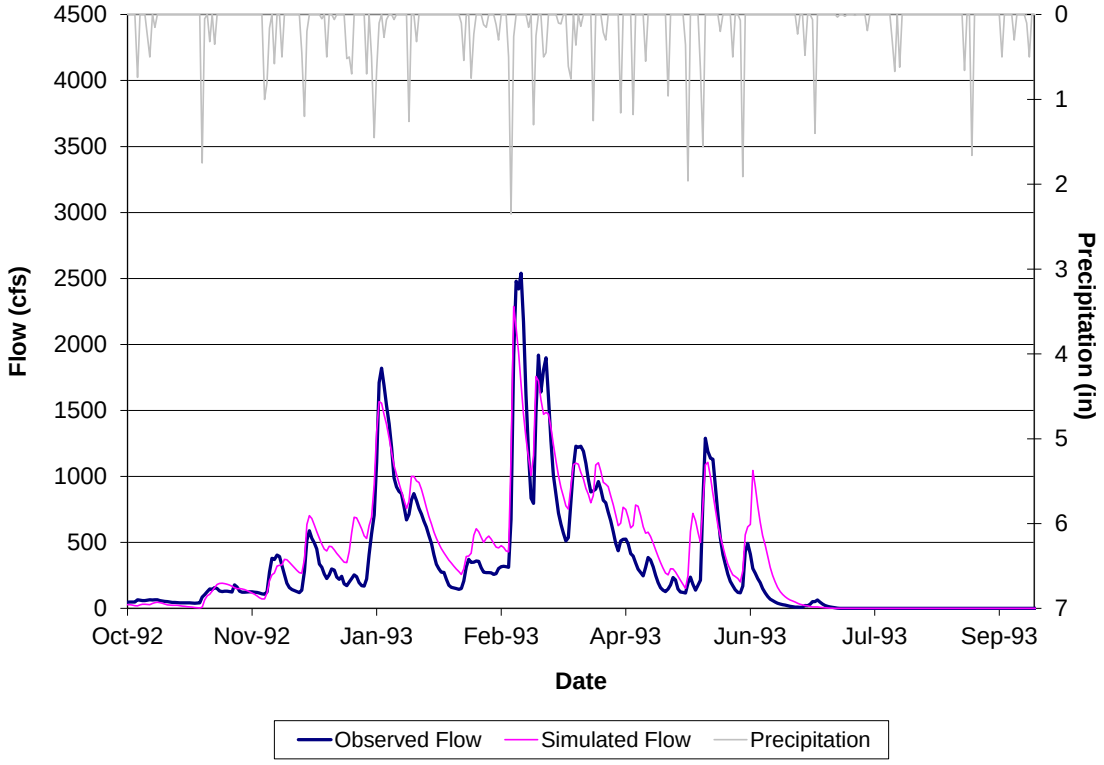

Figure 4.4. Observed and simulated flows for a representative hydrologic year in the calibration period for Blackwater River.

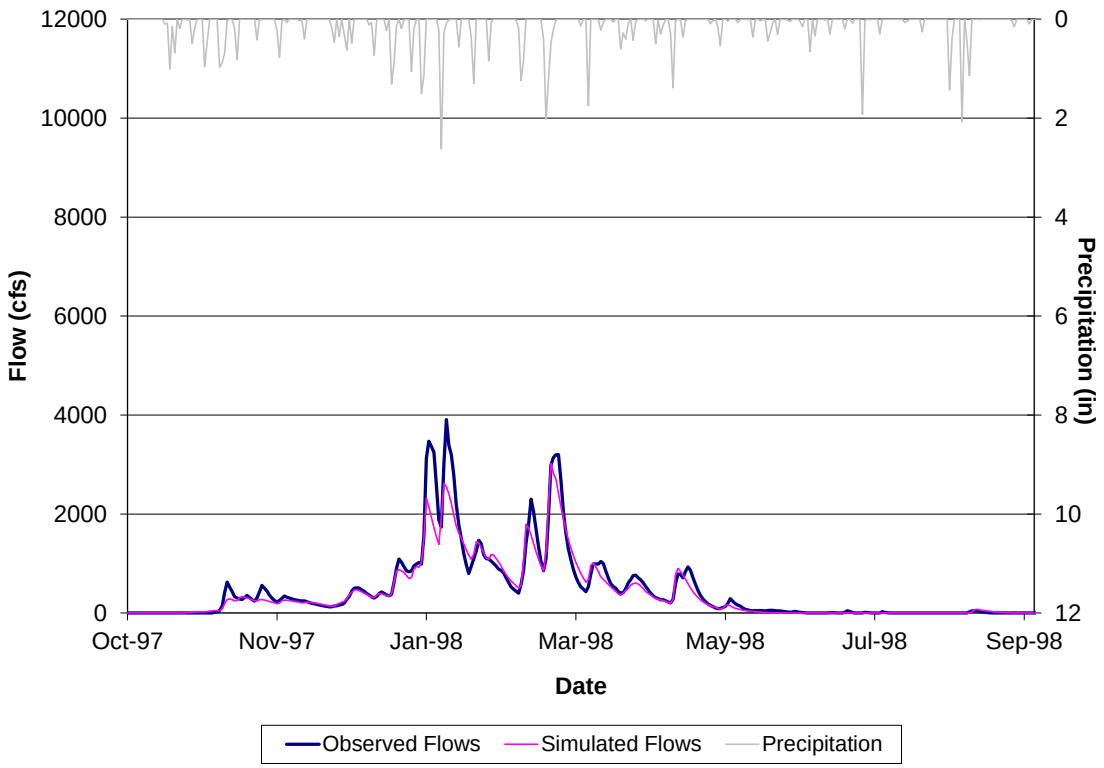

Figure 4.5. Observed and simulated flows for the representative hydrologic year in the validation period for Blackwater River.

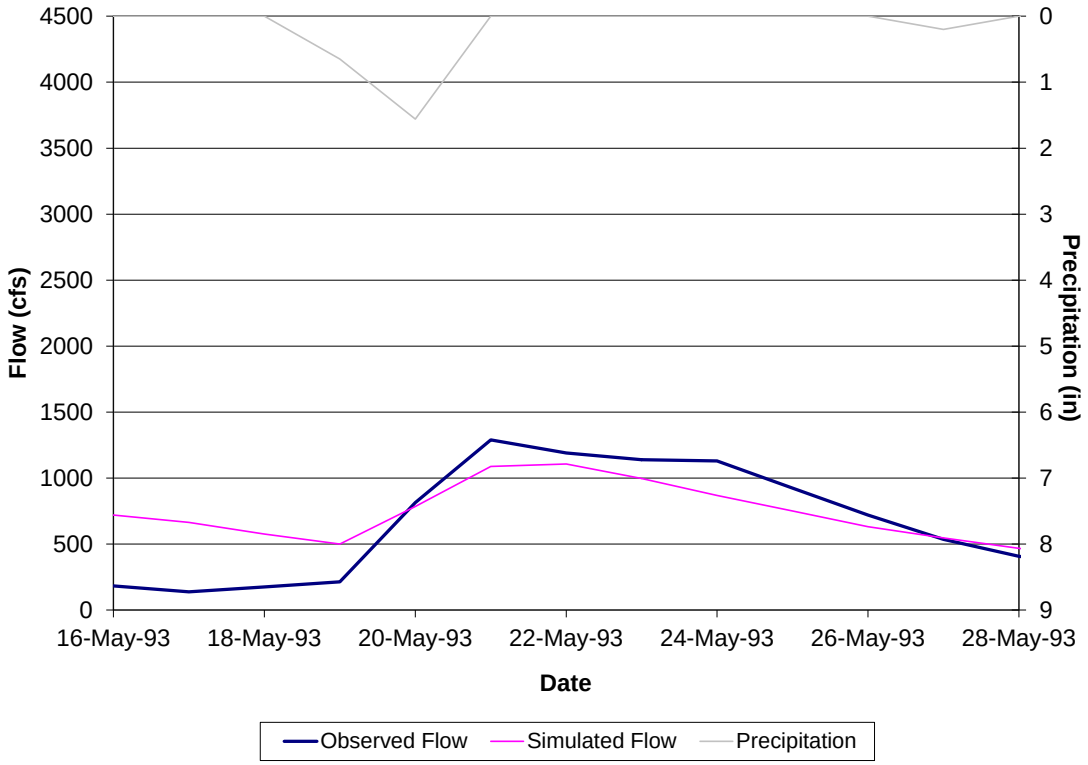

Figure 4.6. Observed and simulated flows for a representative storm in the calibration period for Blackwater River.

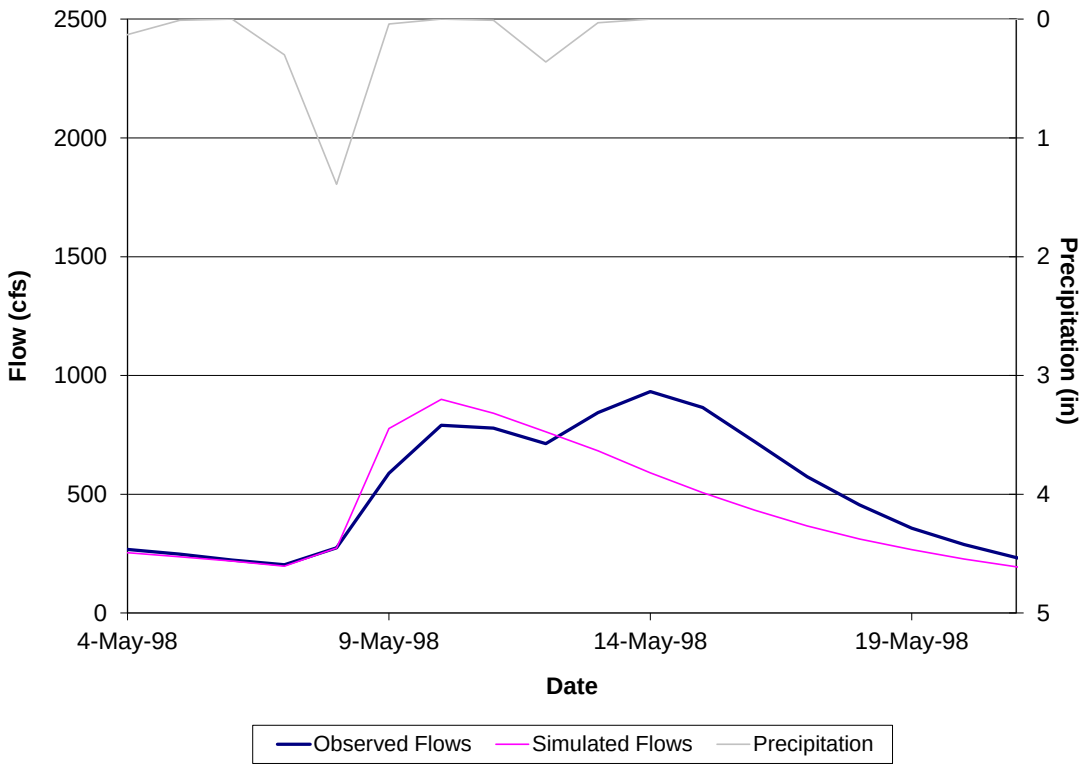

Figure 4.7. Observed and simulated flows for a representative storm in the validation period for Blackwater River.

The agreement between the simulated and observed time series can be further seen through the comparison of their flow exceedence curves (Figure 4.8 and Figure 4.9).

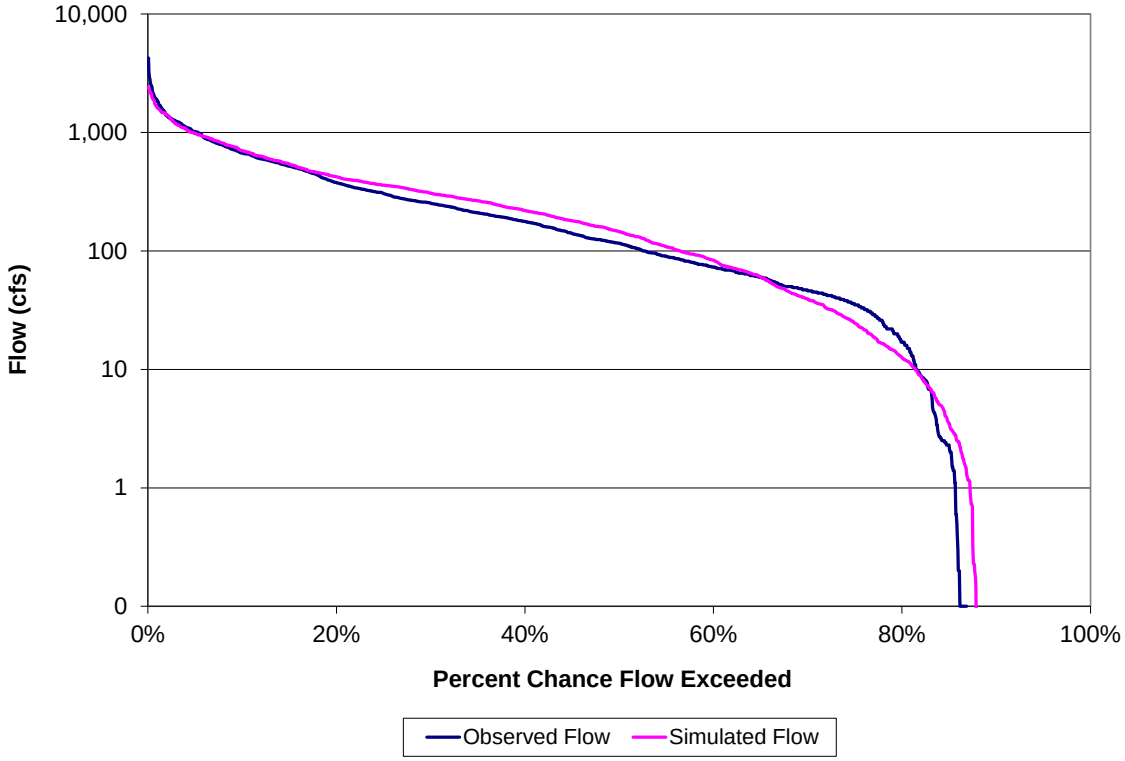

Figure 4.8. Flow exceedence curve for the calibration period for Blackwater River.

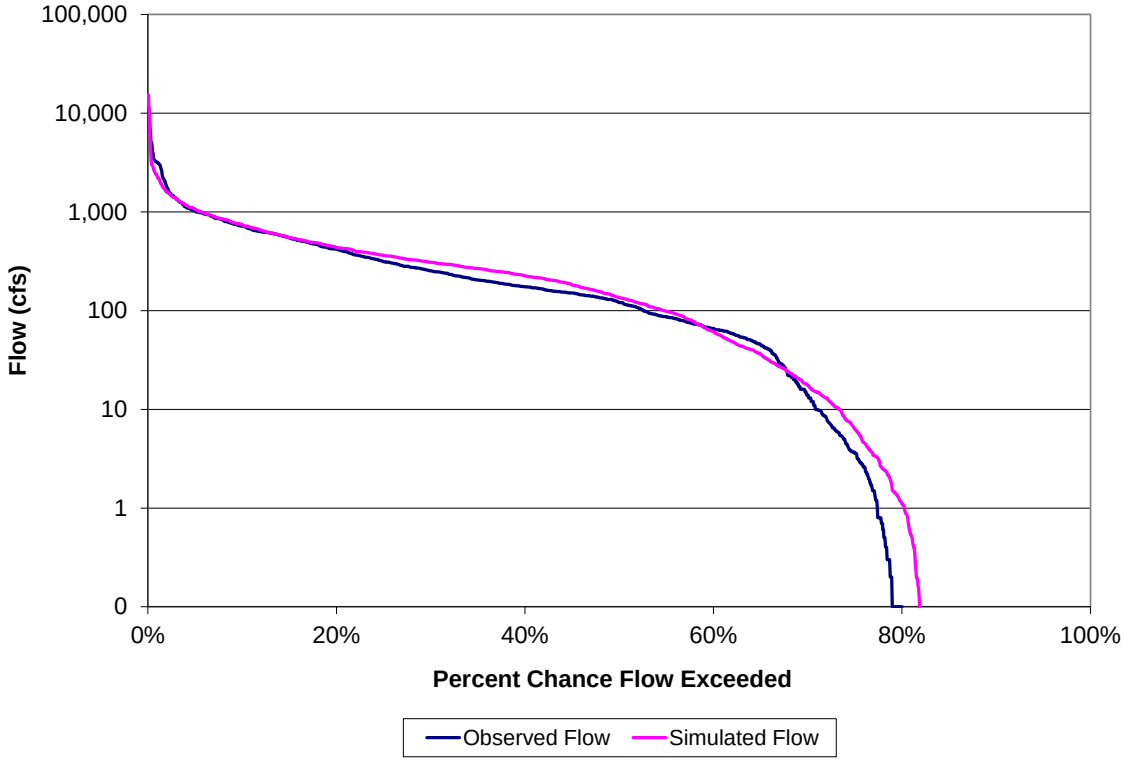

Figure 4.9. Flow exceedence curves for the validation period for Blackwater River.

Selected diagnostic output from the expert system HSPEXP is listed in Table 4.9 and Table 4.10. The total winter runoff and total summer runoff errors are considered in the HSPEXP term 'seasonal volume error' (see Table 4.8). The errors for seasonal volume were 9% for the calibration period and 3.9% for the validation period; both are within the required range of ± 10%.

Table 4.9. Summary statistics for the calibration period for Blackwater River.

	Simulated	Observed	Error (%)	Criterion
Total Runoff (in) †	63.07	60.06	5.0	±10%
Average Annual Total Runoff (in)	12.61	12.012	5.0	±10%
Total of Highest 10% of flows (in) †	26.22	27.488	-4.6	±15%
Total of Lowest 50% of flows (in) †	4.75	4.492	5.7	±10%
Total Winter Runoff (in) †	20.84	18.906	10.23	na
Total Summer Runoff (in) †	7.22	6.055	19.24	na
Coefficient of Determination, r^2	0.75			

†total for the 5-year calibration period
na = not applicable; these are not criteria directly considered by HSPEXP

Table 4.10. Summary statistics for the validation period for Blackwater River.

	Simulated	Observed	Error (%)	Criterion
Total Runoff (in) †	70.91	69.903	1.4	±10%
Average Annual Total Runoff (in)	14.18	13.981	1.4	±10%
Total of Highest 10% of flows (in) †	34.69	37.435	-7.3	±15%
Total of Lowest 50% of flows (in) †	3.38	3.208	5.4	±10%
Total Winter Runoff (in) †	23.88	22.963	3.99	na
Total Summer Runoff (in) †	4.78	4.776	0.08	na
Coefficient of Determination, r^2	0.79			

†total for the 5-year validation period
na = not applicable; these were not criteria directly considered by HSPEXP

Flow partitioning for the Blackwater River hydrologic model calibration and validation is shown in Table 4.11. When the observed flow data were evaluated using

the hydrograph separation program HYSEP (Sloto and Crouse, 1996), the average baseflow indices for the calibration and validation periods were 0.50 and 0.46, respectively. The annual baseflow indices ranged from 0.44 to 0.54 for the calibration period and 0.30 to 0.61 for the validation period. The baseflow indices for the simulated data are presented in Table 4.11. The simulated baseflow index falls within the observed range of baseflow indices for both periods.

Table 4.11. Flow partitioning for the calibration and validation periods for Blackwater River.

Average Annual Flow	Calibration	Validation
Total Annual Runoff (in)	12.61	14.18
Surface Runoff (in)	1.10 (8.7%)	2.50 (17.6%)
Interflow (in)	4.70 (37.3%)	4.80 (33.9%)
Baseflow (in)	6.81 (54.0%)	6.88 (48.5%)
Baseflow Index	0.54	0.49

4.4.2.2 Hydrologic Calibration for North Meherrin River

North Meherrin River was used as the surrogate for the western portion of the Three Creek watershed in the Piedmont ecoregion. The time-step used in the hydrologic calibration was 1 hour. Observed daily flow data for North Meherrin River were available from the USGS monitoring station 02051000, North Meherrin River near Lunenburg, VA. Daily flow data were used in the hydrologic calibration/validation. Precipitation data were obtained primarily from the National Weather Service COOP station Keysville 2 S (444568). Keysville is located 1.5 miles from the North Meherrin River watershed, and is the closest active COOP station to the watershed. Where holes or inconsistencies were present in the Keysville record, data from (in preferential order) Greenbay (443565) (4 miles northwest), Charlotte Court House (441585) (10 miles west), and Chase City (441606) (14 miles west) were used. Other meteorological data, which are less variable and/or to which the model is less sensitive, were obtained from the same stations used to develop the meteorological record for the TMDL watersheds: Murfreesboro (315996) (air temperature), Emporia (442790) (air temperature

(secondary)), and Norfolk International Airport (446139) (wind speed, percent sun, dew point temperature).

The hydrologic record at North Meherrin River is long and complete. The precipitation record at Keysville is also long and fairly complete. Therefore, a 15.5-year calibration and validation period was chosen to allow ample evaluation of high and low flow conditions in the North Meherrin River watershed. The hydrologic calibration period was January 1, 1991 to December 31, 2000. The hydrologic validation period was January 1, 2001 to June 30, 2005. This period stops just short of an extreme and unusually active hurricane season for Virginia. The output from the HSPF model for both calibration and validation was daily average flow in cubic feet per second (cfs). Calibration parameters were adjusted within the recommended range.

The HSPEXP decision support system developed by USGS was used to support calibration of the hydrologic portion of HSPF for North Meherrin River. Most of the default HSPEXP criteria for evaluating the accuracy of the flow simulation were used in the calibration for North Meherrin River. The one exception was the seasonal volume error during the validation period. After 383 model runs, the seasonal volume error was minimized to 12.7%, just over the default HSPEXP criteria of 10%. It is believed that due diligence was performed in reducing the seasonal volume error and relaxing the criteria to 15% is acceptable.

The criteria used in calibration and validation were previously listed in Table 4.8. After calibration, all criteria listed in Table 4.8 were met with the exception of the seasonal volume error, the criterion for which as previously described was relaxed to 15% for this calibration.

The simulated flow for both the calibration and validation matched the observed flow well, as shown in Figure 4.10 and Figure 4.11. The agreement with observed flows is further illustrated in Figure 4.12 and Figure 4.13 for a representative year and Figure 4.14 and Figure 4.15 for a representative storm.

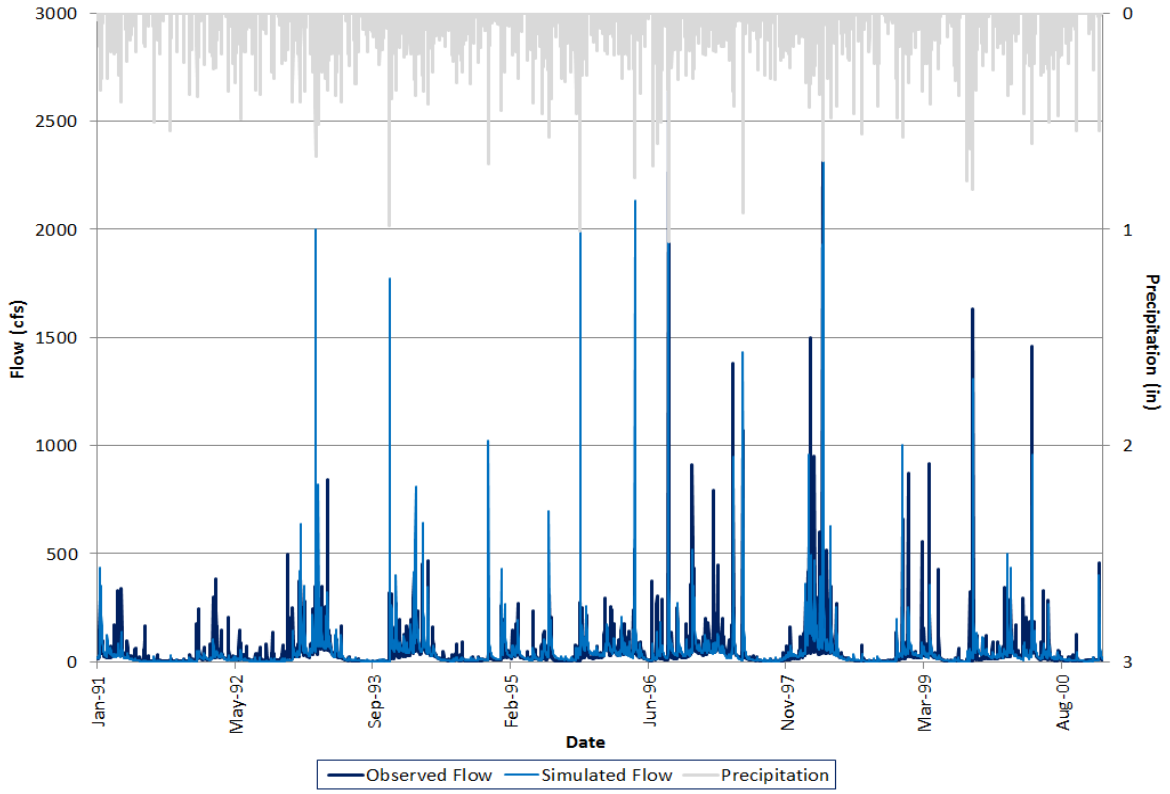

Figure 4.10. Observed and simulated flows during the calibration period for North Meherrin River.

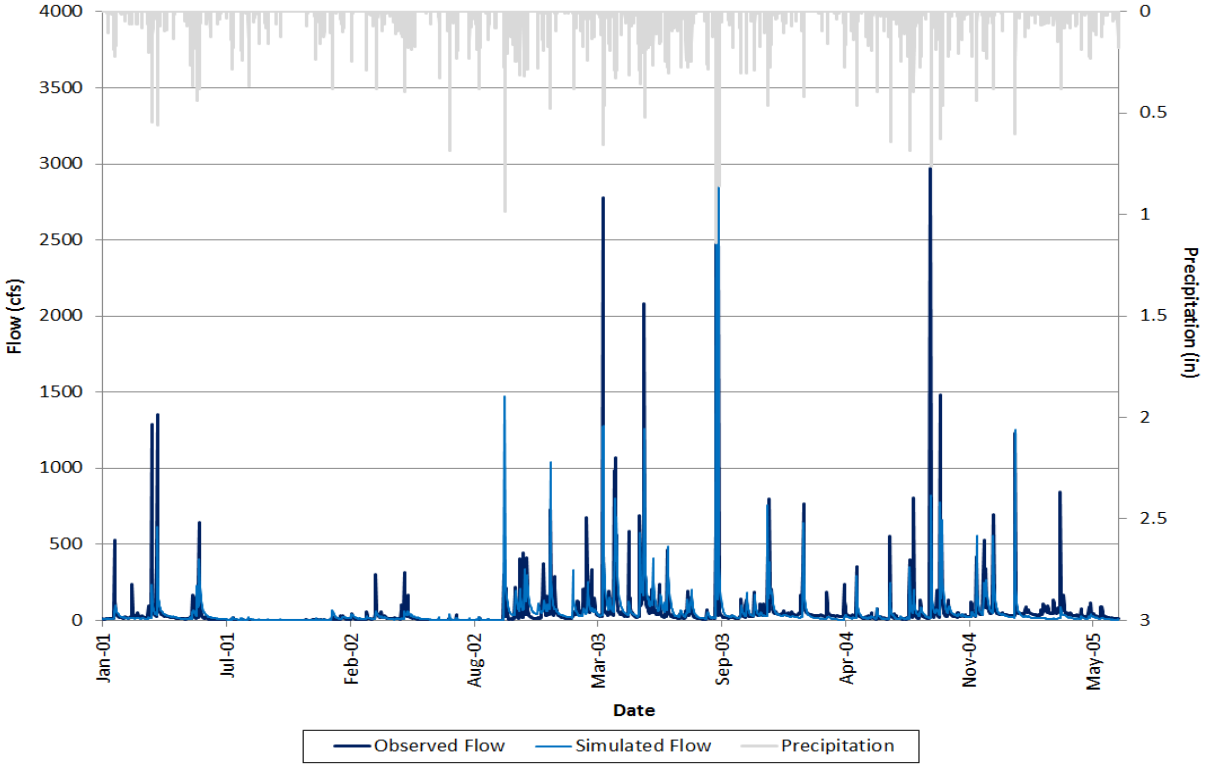

Figure 4.11. Observed and simulated flows during the validation period for North Meherrin River.

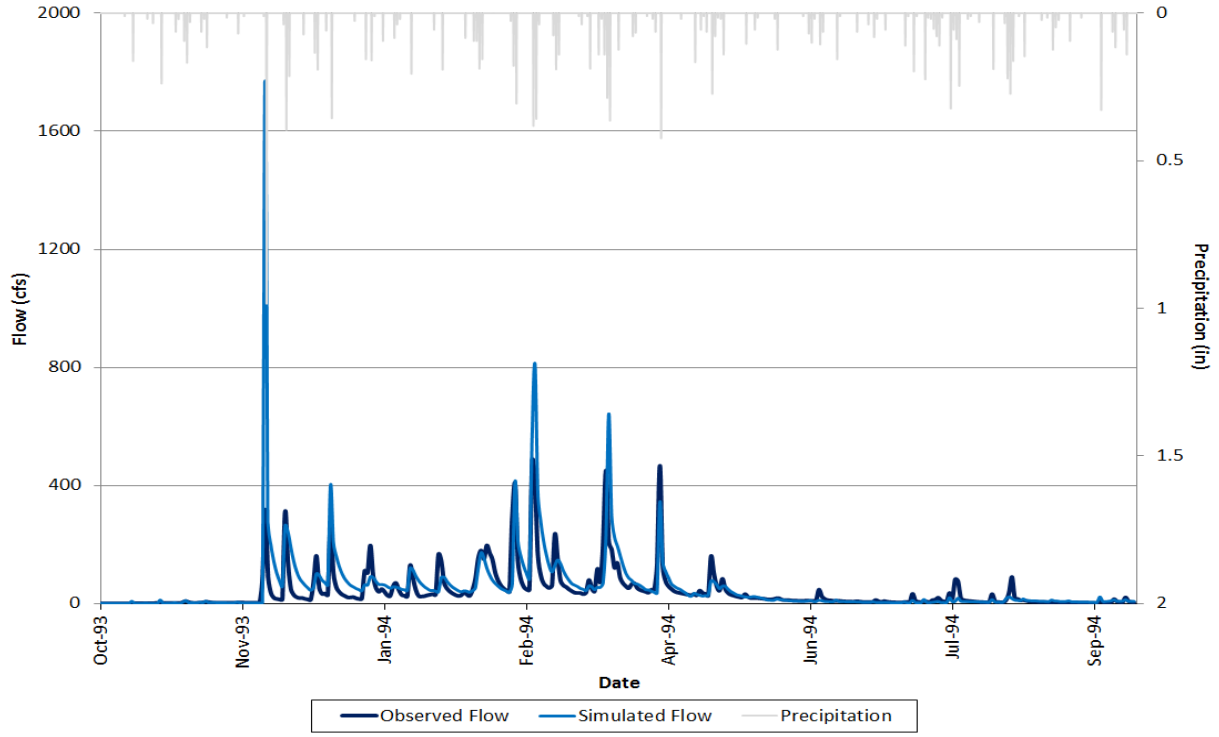

Figure 4.12. Observed and simulated flows for a representative hydrologic year in the calibration period for North Meherrin River.

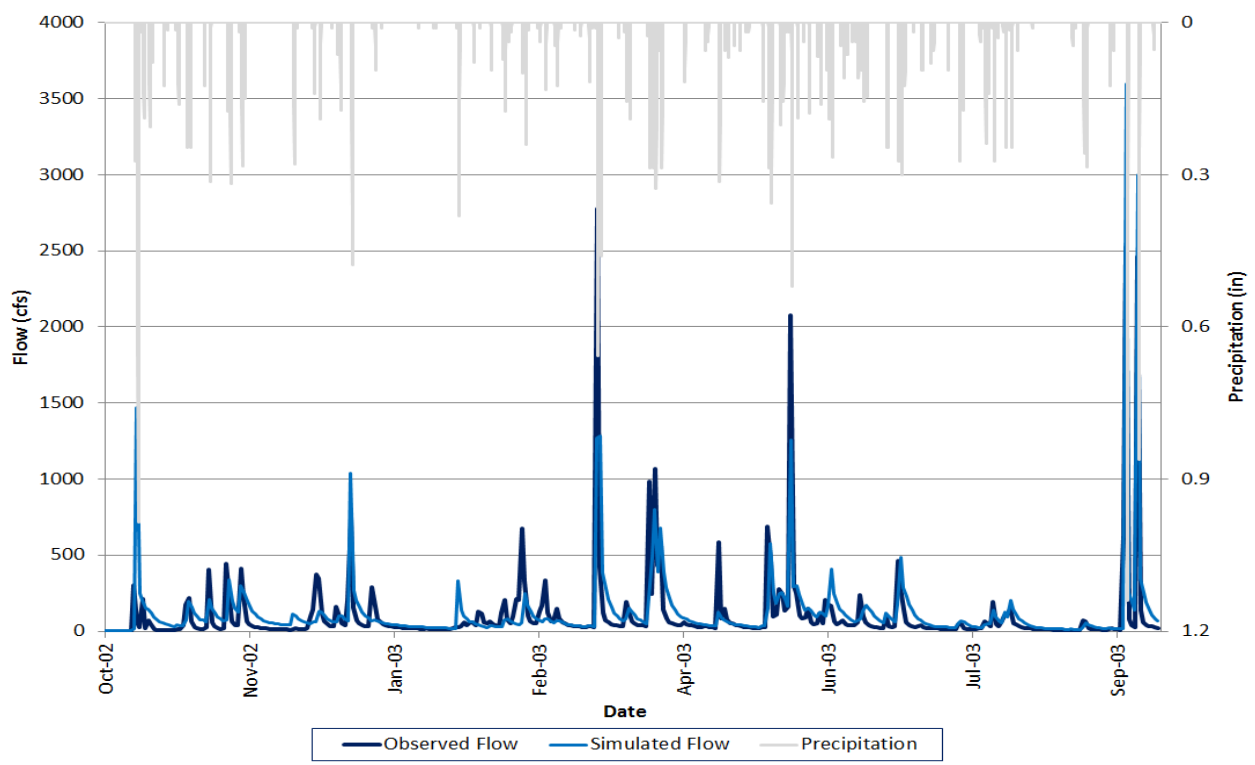

Figure 4.13. Observed and simulated flows for the representative hydrologic year in the validation period for Meherrin River.

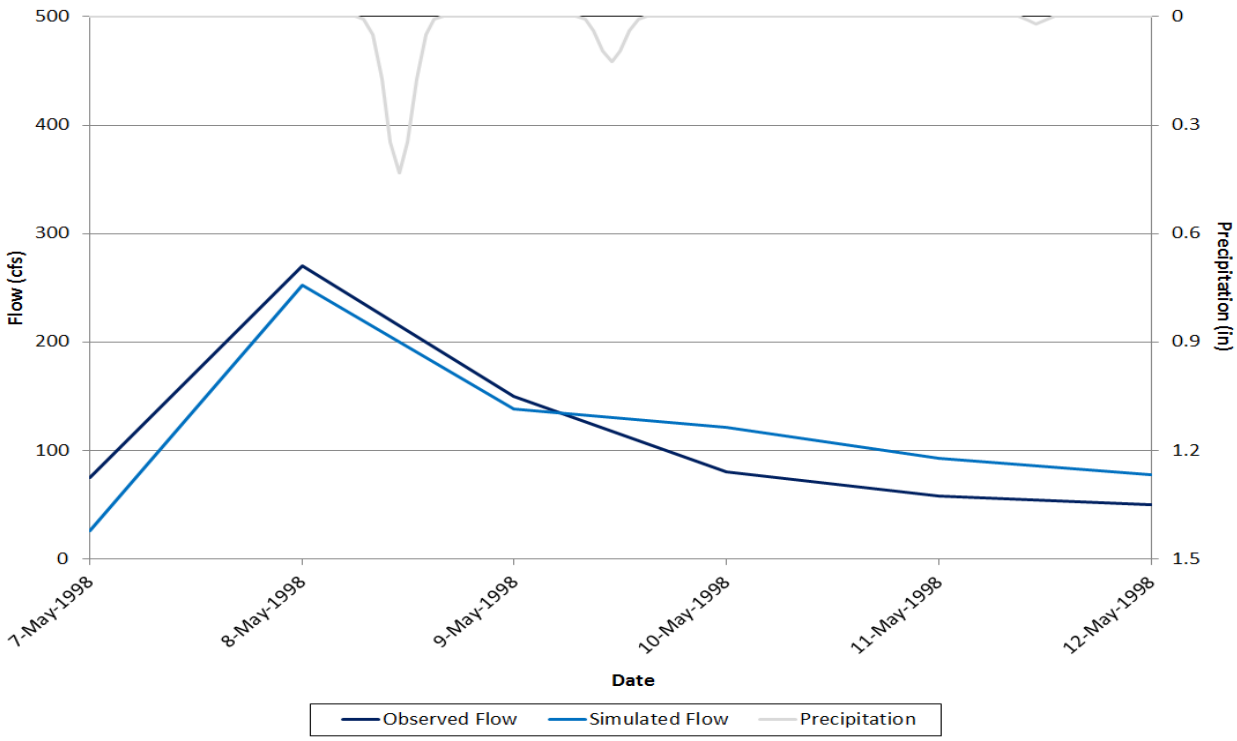

Figure 4.14. Observed and simulated flows for a representative storm in the calibration period for North Meherrin River.

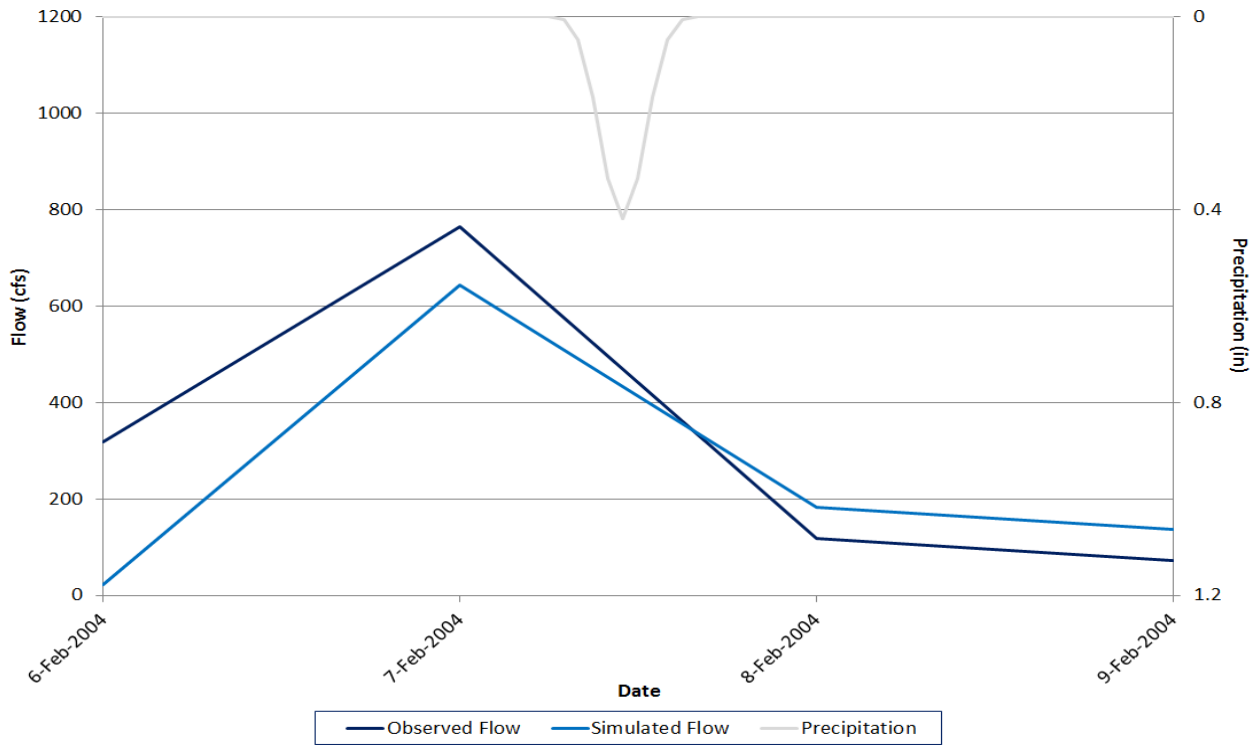

Figure 4.15. Observed and simulated flows for a representative storm in the validation period for North Meherrin River.

The agreement between the simulated and observed time series can be further seen through the comparison of their cumulative frequency curves (Figure 4.16 and Figure 4.17).

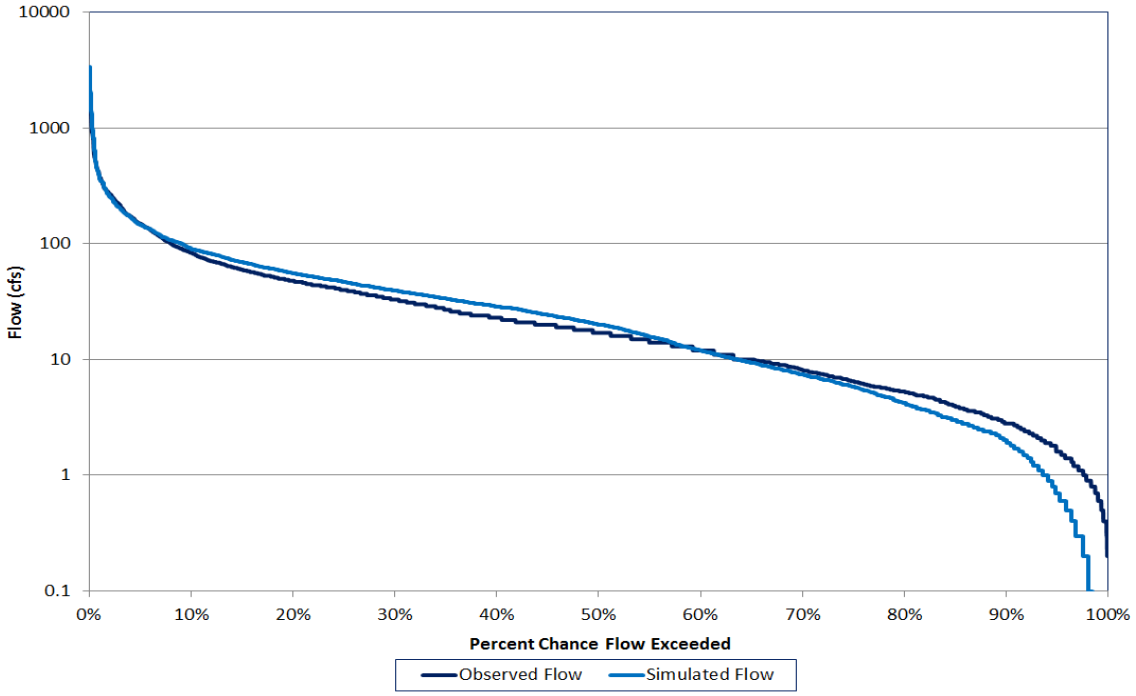

Figure 4.16. Flow exceedence curves for the calibration period for North Meherrin River.

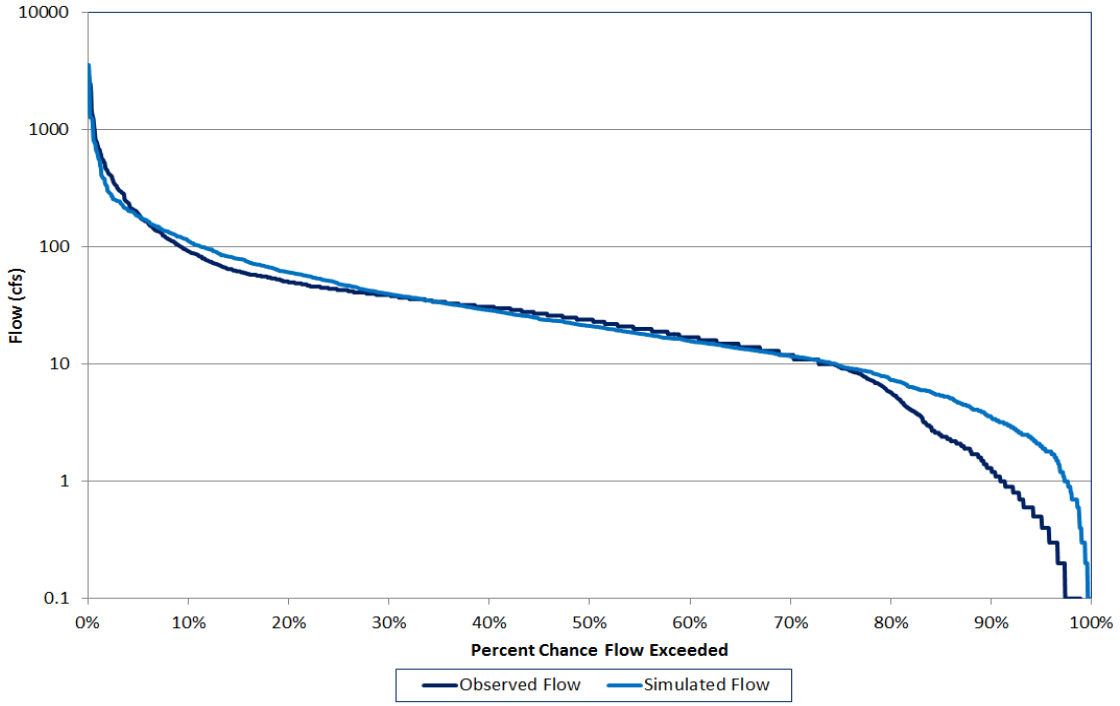

Figure 4.17. Flow exceedence curves for the validation period for North Meherrin River.

Selected diagnostic output from the HSPEXP program is listed in Table 4.12 and Table 4.13. The total winter runoff and total summer runoff errors are considered in the HSPEXP term 'seasonal volume error' (see Table 4.8). The errors for seasonal volume were 2.8% for the calibration period and 12.7% for the validation period; both are within the adjusted range of ± 15%.

Table 4.12. Summary statistics for the calibration period for North Meherrin River.

	Simulated	Observed	Error (%)	Criterion
Total Runoff (in) †	110.7	100.612	10.0	±10%
Average Annual Total Runoff (in)	11.07	10.06	10.0	±10%
Total of Highest 10% of flows (in) †	59.6	55.526	7.3	±15%
Total of Lowest 50% of flows (in) †	8.49	8.939	-5.0	±10%
Total Winter Runoff (in) †	39.96	35.623	12.2	na
Total Summer Runoff (in) †	11.5	10.001	15	na
Coefficient of Determination, r^2	0.20			

†total for the 10-year calibration period
na = not applicable; these are not criteria directly considered by HSPEXP

Table 4.13. Summary statistics for the validation period for North Meherrin River.

	Simulated	Observed	Error (%)	Criterion
Total Runoff (in) †	58.87	62.373	-5.6	±10%
Average Annual Total Runoff (in)	10.70	11.34	-5.6	±10%
Total of Highest 10% of flows (in) †	32.94	38.671	-14.8	±15%
Total of Lowest 50% of flows (in) †	5.33	5.13	3.9	±10%
Total Winter Runoff (in) †	14.04	15.739	-10.8	na
Total Summer Runoff (in) †	10.44	10.247	1.9	na
Coefficient of Determination, r^2	0.50			

†total for the 5.5-year validation period
na = not applicable; these were not criteria directly considered by HSPEXP

Flow partitioning for the North Meherrin River hydrologic model calibration and validation is shown in Table 4.14. When the observed flow data were evaluated using HYSEP, the average baseflow indices for the calibration and validation periods were 0.36 and 0.35, respectively. The observed annual baseflow indices ranged from 0.20 to 0.49 for the calibration period and 0.20 to 0.46 for the validation period. The baseflow indices for the simulated data are presented in Table 4.14. The simulated baseflow

index is close to the observed index for both periods, and the simulated baseflow index falls within the observed range of baseflow indices for both periods.

Table 4.14. Flow partitioning for the calibration and validation periods for North Meherrin River.

Average Annual Flow	Calibration	Validation
Total Annual Runoff (in)	11.07	10.7
Surface Runoff (in)	2.42 (21.9%)	2.71 (25.4%)
Interflow (in)	3.84 (34.7%)	3.85 (35.9%)
Baseflow (in)	4.81 (43.4%)	4.14 (38.7%)
Baseflow Index	0.43	0.39

4.4.3 Water Quality

The water quality calibrations for the Three Creek, Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek watersheds were performed at an hourly time step using the HSPF model. Observations of bacterial water quality were available for several stations in Three Creek and one station each in the remaining watersheds, as shown in Table 2.6 and discussed in Section 2.7. Because it is preferred to calibrate to fecal coliform data (and not *E. coli* data), use of the most current data is limited. There is an inherent amount of uncertainty in the *E. coli* translator regression equation. As would be expected, the equation does not perfectly describe the relationship between *E. coli* and fecal coliform. Thus, although all stations with available data were used in calibration, the results for the comparisons with fecal coliform data were weighted more heavily than the results from comparisons with *E. coli*. This particularly affected consideration of stations 5ATRE022.05 and 5ATRE038.07, for which only *E. coli* data have been collected. The calibration period varied by station according to the length of the sampling record but generally covered the more recently collected data so that all stations could be considered during calibration. The multiple stations in Tarrara Creek/Flat Swamp and in Three Creek were calibrated simultaneously so that the upstream and downstream stations properly reflected potentially spatially variable changes. An effort was made, where possible, to keep calibrated parameters consistent between the five major watersheds, in part to compensate for limited spatial

representation (e.g., 5ADMR008.42) and limited data collection (e.g., 5ADMR008.42 and 5AFTS002.93) at some stations – keeping parameters relatively consistent allows the stations in Tarrara Creek and Three Creek, with extensive spatial and temporal representation, to more strongly affect the calibrated parameter values. Where the data record was sufficient, a validation on historic data was also conducted. The calibration and validation periods for each station are shown in Table 4.15.

Table 4.15. Water quality calibration and validation periods by observation station.

Station ID	Indicator Organism Considered	Calibration Period†	Number of Samples in Calibration Period	Validation Period†	Number of Samples in Validation Period
5ADMR008.42	Fecal Coliform	12/1/2000-2/15/2008	48	4/15/1995-11/15/2000	55
	E. coli	7/15/2002-2/15/2008	31	--[a]	--[a]
5AMSP000.16	Fecal Coliform	8/15/2001-6/30/2003	12	--[a]	--[a]
	E. coli	--[b]	--[b]	--[a]	--[a]
5ATRR002.50	Fecal Coliform	1/1/1999-2/15/2008	70	7/15/1992-12/15/1998	76
	E. coli	7/15/2002-2/15/2008	33	--[a]	--[a]
5AFTS002.93	Fecal Coliform	8/1/2001-6/15/2003	12	--[a]	--[a]
	E. coli	--[b]	--[b]	--[a]	--[a]
5ATRE008.48	Fecal Coliform	2/15/2002-11/15/2009	48	5/1/1994-12/15/2001	51
	E. coli	8/1/2002-11/15/2009	45	--[a]	--[a]
5ATRE016.02	Fecal Coliform	2/15/2002-11/15/2009	48	5/1/1994-12/15/2001	52
	E. coli	8/1/2002-11/15/2009	45	--[a]	--[a]
5ATRE022.05	*E. coli*	7/1/2003-11/30/2008	23	--[a]	--[a]
5ATRE026.75	Fecal Coliform	1/1/1996-3/15/2001	29	7/1/1990-10/15/1995	22
5ATRE038.07	*E. coli*	6/1/2005-11/30/2008	22	--[a]	--[a]

[a] insufficient data to conduct a validation
[b] insufficient data to conduct a calibration
† note that because the period of record does not often perfectly correspond to the calibration and/or validation periods, the observed violation rates given in the tables in the rest of this chapter may not match the violation rates initially listed in Table 2.6.

Output from the HSPF model was generated as an hourly time series and daily average time series of fecal coliform concentration at sub-watersheds DMR-8, MSP-2 & MSP-4 (sub-watershed output combined before exporting), TRR-2, FTS-15, TRE-6 & TRE-7 (sub-watershed output combined before exporting), TRE-16, TRE-20, TRE-21, and TRE-31, which correspond to the locations of the sequentially listed stations in Table 4.15. The DEQ *E. coli* translator (Eqn. 4.2) was implemented using the GENER block in HSPF to calculate instream *E. coli* concentration for the relevant stations (see Table 4.15). During allocation, this equation will also be used to calculate the geometric mean of *E. coli* concentrations on a monthly basis.

$$\log_2 EC(cfu/100mL) = -0.0172 + 0.91905 * \log_2 FC(cfu/100mL) \qquad [4.2]$$

Observed data in the Darden Mill Run, Mill Swamp, Tarrara Creek, Flat Swamp, and Three Creek watersheds were typically collected through grab samples collected on a monthly basis (at best). Because it is not practical to expect such data to exactly match an average simulated value on a specific day, other methods of comparison are needed. The strongest method of comparison is the use of a visual comparison of the minimum and maximum simulated daily values – the observed data should fall roughly within the range of values simulated near the date of observed data collection. Other parameters to consider include violation rates, averages, medians, and geometric means. However, these statistics must be used with care, as the artificial detection limits imposed on the observed data (typically 100 cfu/100 mL at the lower end and 2000 cfu/100 mL at the higher end, though the minimum detection limit sometimes falls to 25 cfu/100 mL while the maximum detection limit is sometimes as high as 8000 cfu/100 mL) will bias the calculation of statistics for the observed data. Many of the observed values in this watershed were at the detection limits – meaning the actual values were lower or higher than those reported. For this additional reason the visual comparison of the daily minima and maxima is most useful, as a human can readily evaluate whether the detection limits are exceeded as appropriate.

4.4.3.1 Darden Mill Run

4.4.3.1.1 Calibration

The calibration period for Darden Mill Run was December 2000 – February 2008 for fecal coliform and July 2002-February 2008 for *E. coli*. This station has the unique characteristic that it represents only one small, forested/swamped upland sub-watershed with limited agricultural and residential impacts. Initial model predictions were high. The major adjustments and reasoning behind each adjustment are given in Table 4.16. Once these adjustments were made, the fecal coliform and *E. coli* predictions from HSPF acceptably matched the simulated data. The final goodness-of-fit measures for the calibration for the fecal coliform and *E. coli* data are listed in Table 4.17. Figure 4.18

and Figure 4.19 show the daily maxima, minima, and averages of simulated values for the final calibration runs for the fecal coliform and *E. coli* data at station 5ADMR008.42, respectively. Based on the goodness-of-fit parameter values and the visual comparisons, the water quality calibration was considered acceptable.

Table 4.16. Adjustments made during the Darden Mill Run bacteria model calibration.

Symptom	Adjustment	Rationale
Wildlife direct deposit concentrations were too high, particularly in dry summer months	Reduce muskrat population estimate by 25%	Stakeholders felt that muskrat population estimates were too high
	Reduce migratory waterfowl population by 50%	Stakeholders felt geese did not migrate; estimates of total migratory population were not available from VADGIF, so migratory waterfowl population was inherently uncertain (NOTE: resident bird populations were not changed from initial estimates)
	Implement 'stage cutoff' at 0.5 inches for wildlife	Procedure used in previous TMDLs (e.g., Beaver Creek (Benham *et al.*, 2005)) to represent behavioral changes in wildlife at low flows in summer months
Small area upstream of station did not sufficiently represent the watershed	Decrease WSQOP from 2.0 in/hr to 1.5 in/hr	Neighboring Mill Swamp, of similar size to Darden Mill Run, required a reduction of WSQOP, the rate of surface runoff which will remove 90 percent of stored bacteria from the surface, so it was decreased as much as possible for Darden Mill Run while still keeping simulated violation rates & maxima within an appropriate range of observed values
	Increase FSTDEC from 1.15 day^{-1} to 1.632 day^{-1} and THFST from 1.05 to 1.07	Neighboring Tarrara Creek required an increase of FSTDEC (the in-stream decay rate) and THFST (the temperature correction to the decay rate), so these values were increased in Darden Mill Run to match. This is particularly relevant because the effects of FSTDEC are less apparent in smaller, upstream waters, and thus a long stream such as Tarrara Creek is more suited to properly evaluate the parameter.
	Implement 'stage cutoff' at 1 inch for cattle	No cattle were present above the Darden Mill Run station to evaluate cattle behavior; however, neighboring Tarrara Creek and Three Creek, with large comprehensive contributing areas and long records, required a stage cutoff for cattle at 1 inch, so this was applied to Darden Mill Run as well

Table 4.17. Water quality calibration statistics for Darden Mill Run.

	Geometric Mean cfu/100ml	Average* cfu/100ml	Median* cfu/100ml	Single Sample Criterion Violation Rate (%)
Darden Mill Run (5ADMR008.42) – Fecal Coliform				
Observed	110	241	100	16
Simulated	125	287	144	22
Darden Mill Run (5ADMR008.42) – *E. coli*				
Observed	85	197	75	29
Simulated	84	172	86	23

* simulated values for these parameters were calculated from the average daily predictions in the 5 days surrounding each observed data collection day; this provides a more detailed comparison with the actual observations, as it targets the specific meteorological and hydrologic conditions at the time of data collection

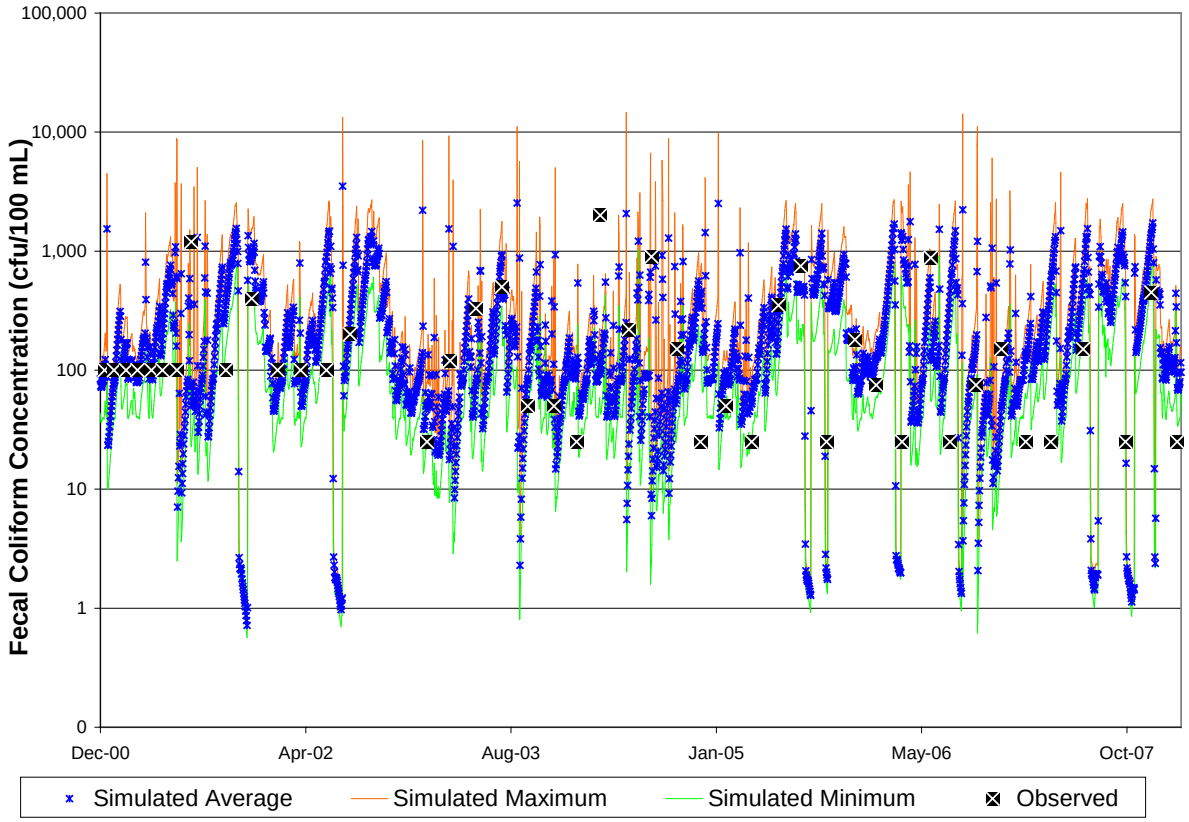

Figure 4.18. Observed fecal coliform data plotted with the daily maximum, minimum, and average simulated fecal coliform values for Darden Mill Run (5ADMR008.42) for the calibration period (Dec. 1, 2000 to Feb. 15, 2008).

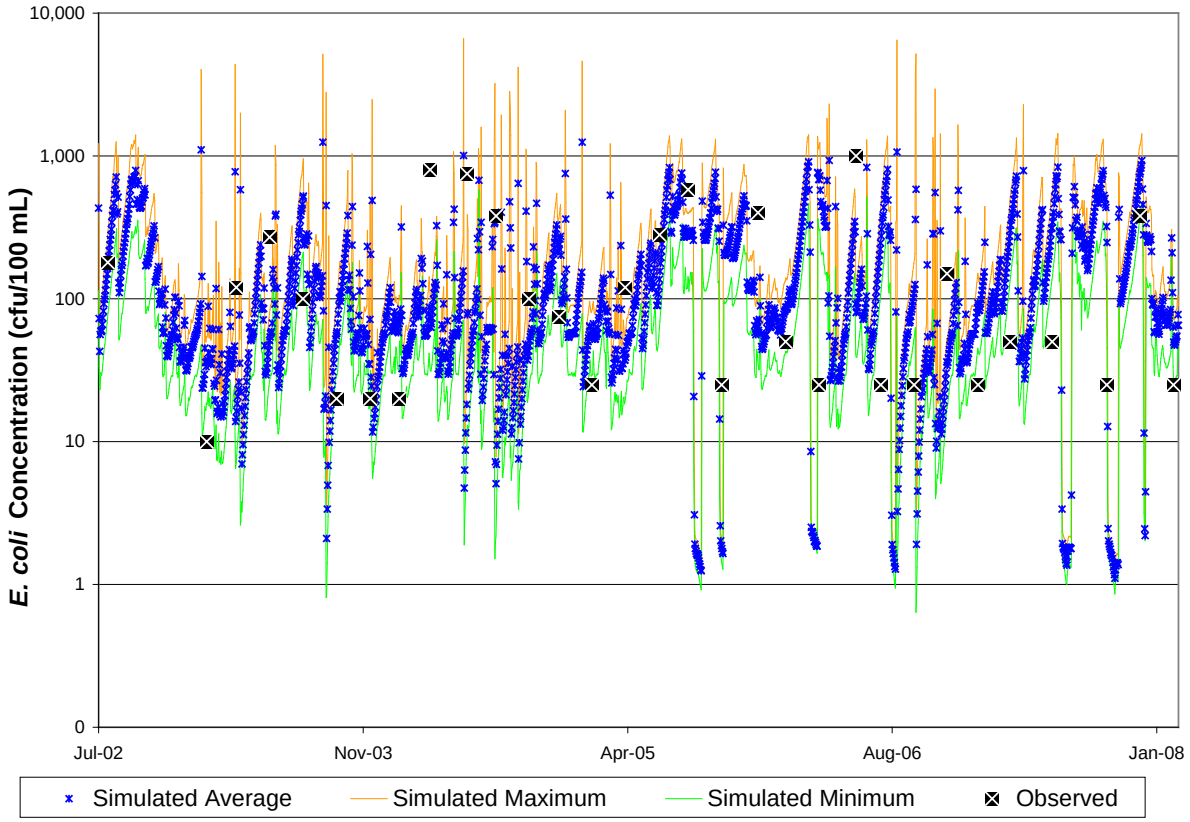

Figure 4.19. Observed *E. coli* data plotted with the daily maximum, minimum, and average simulated *E. coli* values for Darden Mill Run (5ADMR008.42) for the calibration period (Jul. 15, 2002 to Feb. 15, 2008).

4.4.3.1.2 Validation

After the calibration of Darden Mill Run at VADEQ monitoring station 5ADMR008.42, the model was run for a different period (April 15, 1995 - November 15, 2000) as a validation to ensure the calibrated input parameters were appropriate. A comparison was done only for the fecal coliform data, as there were insufficient *E. coli* data to conduct a second comparison. The goodness-of-fit statistics for the validation run are listed in Table 4.18. Figure 4.20 shows the daily maxima, minima, and averages of the simulated values for the validation. The simulated concentrations varied with the seasonal trend. Based on the goodness-of-fit parameter values and the visual comparisons both the water quality calibration and validation for Darden Mill Run were considered acceptable. The final calibrated water quality parameters are given in Table 4.19.

Table 4.18. Summarized goodness-of-fit measures for simulated and observed fecal coliform concentrations for the validation period for Darden Mill Run at station 5ADMR008.42.

	Geometric Mean cfu/100ml	Average* cfu/100ml	Median* cfu/100ml	Single Sample Criterion Violation Rate (%)
Observed	186	285	100	20
Simulated	135	266	146	21

* simulated values for these parameters were calculated from the average daily predictions in the 5 days surrounding each observed data collection day; this provides a more detailed comparison with the actual observations, as it targets the specific meteorological and hydrologic conditions at the time of data collection

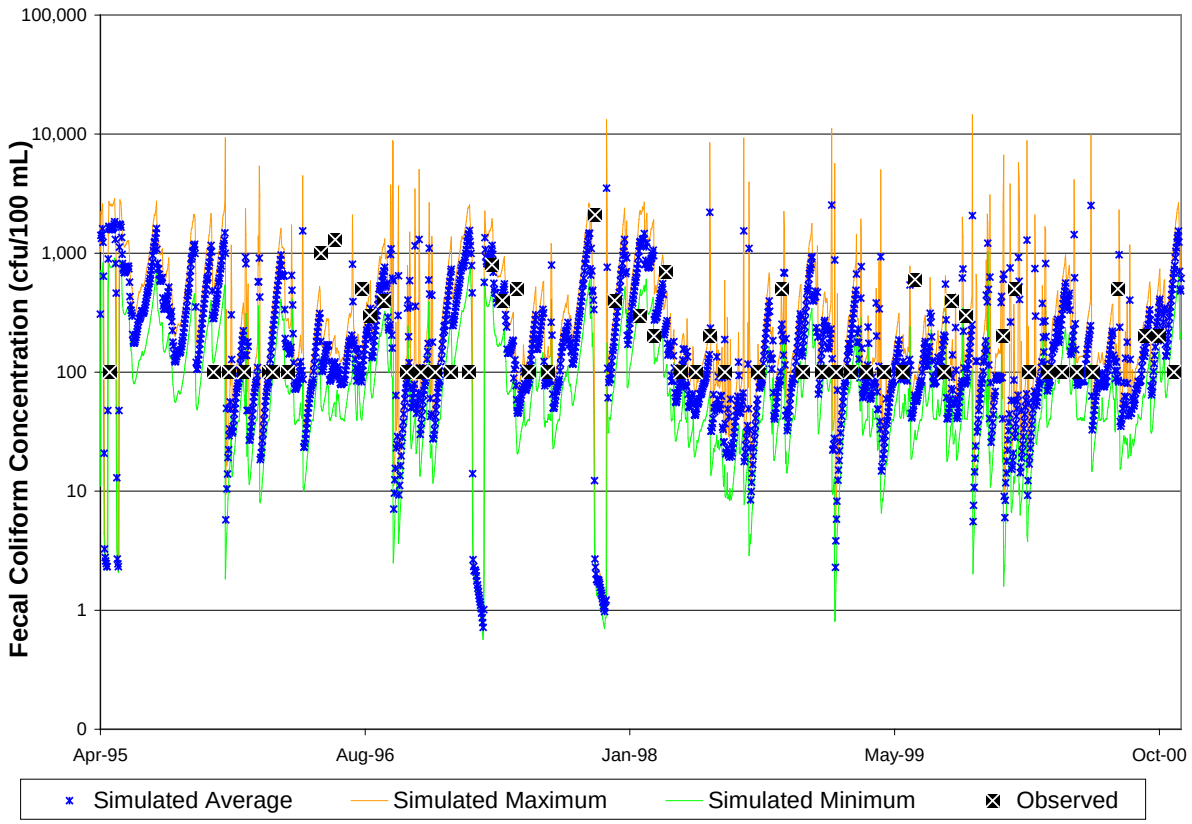

Figure 4.20. Observed fecal coliform data plotted with the daily maximum, minimum, and average simulated fecal coliform values for Darden Mill Run (5ADMR008.42) for the validation period (Apr. 15, 1995 to Nov. 15, 2000).

Table 4.19. Calibrated water quality parameters for the Darden Mill Run watershed.

Parameter	Definition	Units	FINAL CALIBRATION	FUNCTION OF…	Appendix F Table (if applicable)
PQUAL					
SQO	Initial storage of constituent	#/ac	0	Land use	
POTFW	Washoff potency factor	#/ton	0		
POTFS	Scour potency factor	#/ton	0		
ACQOP	Rate of accumulation of constituent	#/day	Monthly[a]	Land use	8
SQOLIM	Maximum accumulation of constituent	#	9 x ACQOP[a]	Land use	9
WSQOP	Wash-off rate	in/hr	1.5	Land use	
IOQC	Constituent conc. in interflow	#/ft3	1416		
AOQC	Constituent conc. in active groundwater	#/ft3	1062		
IQUAL					
SQO	Initial storage of constituent	#/ac	$1x10^7$		
POTFW	Washoff potency factor	#/ton	0		
ACQOP	Rate of accumulation of constituent	#/day	$1x10^7$	Land use	
SQOLIM	Maximum accumulation of constituent	#	$3x10^7$	Land use	
WSQOP	Wash-off rate	in/hr	1.5	Land use	
GQUAL					
FSTDEC	First order decay rate of the constituent	1/day	1.632		
THFST	Temperature correction coeff. for FSTDEC		1.07		

[a]Values varied by month and with land use

4.4.3.2 Mill Swamp

4.4.3.2.1 Calibration

The calibration period for Mill Swamp was August 2001 – June 2003 for fecal coliform; insufficient data existed to conduct a validation. The observed period of record for Mill Swamp was limited, so some parameter adjustments were made to match those made for neighboring watersheds with longer periods of record. Initial model predictions were low. The major adjustments and reasoning behind each adjustment are given in Table 4.20. Once these adjustments were made, the fecal coliform predictions from HSPF acceptably matched the simulated data. The final goodness-of-fit measures for the calibration for the fecal coliform data are listed in Table 4.21. Figure 4.21 shows the daily maxima, minima, and averages of simulated values for the final calibration runs for the fecal coliform data at station 5AMSP000.16, respectively. Based on the goodness-of-fit parameter values and the visual comparisons, the water quality calibration was considered acceptable; however, as this may not be readily apparent, it

bears some discussion. The most notable discrepancy between the observed and simulated data for Mill Swamp is the instantaneous violation rate – 17% observed vs. 1% simulated (Table 4.21). However, visual inspection (Figure 4.21) demonstrates the cause of the discrepancy. Due to the short period of record, the isolated peaks of concentration drive the observed violation rates up. It is readily apparent from Figure 4.21 that the vast majority of the samples collected had bacteria concentrations below the minimum detection limit of 100 cfu/100 mL. Appropriately, the model predicts the majority of bacteria concentrations below that minimum detection limit, driving the simulated violation rate lower than observed. The model does in fact simulate numerous peaks similar to the three observed peaks, and on two of the three observed peak occasions the modeled peaks are close to those observed. The large number of observed points at the minimum detection limit also drive the geometric mean, average, and median observed concentrations to be higher than they should be, which is why it is appropriate that the modeled geometric mean, average, and median values are lower than observed. Considering all these factors, the model predicts fecal coliform concentrations in Mill Swamp adequately. The final calibrated water quality parameters are given in Table 4.22.

Table 4.20. Adjustments made during the Mill Swamp bacteria model calibration.

Symptom	Adjustment	Rationale
Observed period of record was short and did not encompass low flows	Implement 'stage cutoff' at 0.5 inches for wildlife	This cutoff was needed in all the watersheds in this study – and in particular for the wildlife-dominated area represented by neighboring Darden Mill Run - and was therefore implemented here. This cutoff should ensure that the model will continue to perform adequately under low flow conditions.
	Implement 'stage cutoff' at 1 inch for cattle	Neighboring Tarrara Creek and Three Creek, with large comprehensive contributing areas and long records, required a stage cutoff for cattle at 1 inch, so this was applied to Mill Swamp as well. This cutoff should ensure that the model will continue to perform adequately under low flow conditions.
Watershed size was small compared to Tarrara Creek & Three Creek	Increase FSTDEC from 1.15 day^{-1} to 1.632 day^{-1} and THFST from 1.05 to 1.07	Neighboring Tarrara Creek required an increase of FSTDEC (the in-stream decay rate) and THFST (the temperature correction to the decay rate), so these values were increased in Mill Swamp to match. This is particularly relevant because the effects of FSTDEC are less apparent in smaller watersheds like Mill Swamp, and thus a long stream such as Tarrara Creek is more suited to properly evaluate the parameter.
Maintain consistency with other watersheds	Reduce muskrat population estimate by 25%	Stakeholders felt that muskrat population estimates were too high, and all other watersheds in the study required a decrease in estimated muskrat populations
	Reduce migratory waterfowl population by 50%	Stakeholders felt geese did not migrate; estimates of total migratory population were not available from VADGIF, so migratory waterfowl population was inherently uncertain, and all other watersheds in the study required a decrease in estimated migratory waterfowl populations (NOTE: resident bird populations were not changed from initial estimates)
Simulated bacteria concentrations, particularly after storms, were low during all seasons	Decrease WSQOP from 2.0 in/hr to 0.6 in/hr for pervious areas and from 2.0 in/hr to 0.25 in/hr for impervious areas	WSQOP, the rate of surface runoff which will remove 90 percent of stored bacteria from the surface, is a commonly used calibration parameter for HSPF. Reducing it increases the 'peakiness' of storm flows, thus increasing instantaneous violation rate.

Table 4.21. Water quality calibration statistics for Mill Swamp.

	Geometric Mean cfu/100ml	Average* cfu/100ml	Median* cfu/100ml	Single Sample Criterion Violation Rate (%)
Mill Swamp (5AMSP000.16) – Fecal Coliform				
Observed	164	233	100	17
Simulated	60	55	52	1

* simulated values for these parameters were calculated from the average daily predictions in the 5 days surrounding each observed data collection day; this provides a more detailed comparison with the actual observations, as it targets the specific meteorological and hydrologic conditions at the time of data collection

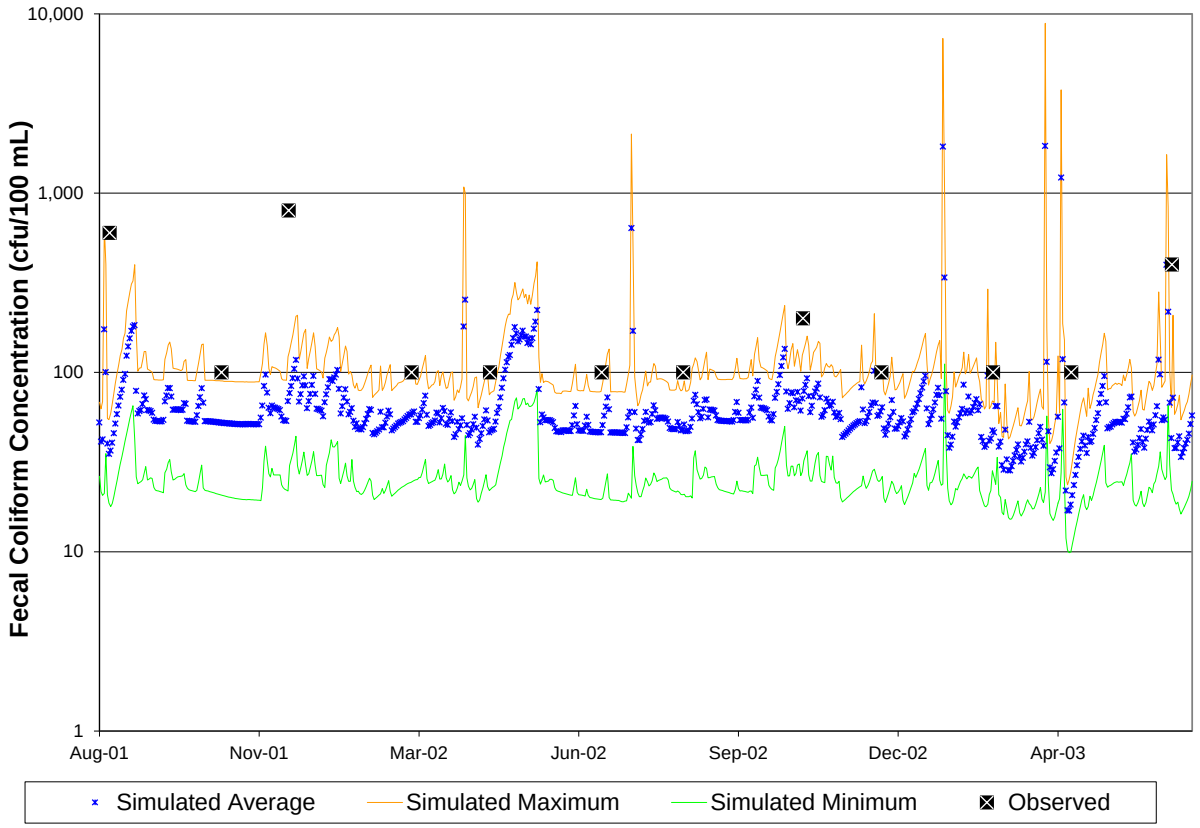

Figure 4.21. Observed fecal coliform data plotted with the daily maximum, minimum, and average simulated fecal coliform values for Mill Swamp (5AMSP000.16) for the calibration period (Aug. 15, 2001 to Jun. 30, 2003).

Table 4.22. Calibrated water quality parameters for the Mill Swamp watershed.

Parameter	Definition	Units	FINAL CALIBRATION	FUNCTION OF…	Appendix F Table (if applicable)
PQUAL					
SQO	Initial storage of constituent	#/ac	0	Land use	
POTFW	Washoff potency factor	#/ton	0		
POTFS	Scour potency factor	#/ton	0		
ACQOP	Rate of accumulation of constituent	#/day	Monthly[a]	Land use	10
SQOLIM	Maximum accumulation of constituent	#	9 x ACQOP[a]	Land use	11
WSQOP	Wash-off rate	in/hr	0.6	Land use	
IOQC	Constituent conc. in interflow	#/ft3	1416		
AOQC	Constituent conc. in active groundwater	#/ft3	1062		
IQUAL					
SQO	Initial storage of constituent	#/ac	$1x10^7$		
POTFW	Washoff potency factor	#/ton	0		
ACQOP	Rate of accumulation of constituent	#/day	$1x10^7$	Land use	
SQOLIM	Maximum accumulation of constituent	#	$3x10^7$	Land use	
WSQOP	Wash-off rate	in/hr	0.25	Land use	
GQUAL					
FSTDEC	First order decay rate of the constituent	1/day	1.632		
THFST	Temperature correction coeff. for FSTDEC		1.07		

[a]Values varied by month and with land use

4.4.3.3 Flat Swamp and Tarrara Creek

4.4.3.3.1 Calibration

Flat Swamp and Tarrara Creek were calibrated simultaneously, so that calibrated changes made that affected Flat Swamp were appropriately represented in the downstream Tarrara Creek. The calibration period evaluated for Flat Swamp was August 2001 – June 2003 for fecal coliform only. The calibration period evaluated for Tarrara Creek was January 1999 – February 2008 for fecal coliform and July 2002-February 2008 for *E. coli*. The Flat Swamp station represents a small area with a short period of record; therefore, more consideration was given to the downstream Tarrara Creek station, which represents a large area with an extensive period of record. Initial model predictions were high at both stations. The major adjustments and reasoning behind each adjustment are given in Table 4.23. Once these adjustments were made, the fecal coliform and *E. coli* predictions from HSPF acceptably matched the simulated data. Although the goodness-of-fit measures are still mostly high, the visual assessment

demonstrates that overall the model is doing an adequate job of predicting values near those observed. The final goodness-of-fit measures for the calibration for the fecal coliform and *E. coli* data are listed in Table 4.24. Figure 4.22, Figure 4.23, and Figure 4.24 show the daily maxima, minima, and averages of simulated values for the final calibration runs for the fecal coliform data at station 5AFTS002.93, the fecal coliform data at station 5ATRR002.50, and the *E. coli* data at station 5ATRR002.50, respectively. Based on the goodness-of-fit parameter values and the visual comparisons, the water quality calibration was considered acceptable.

Table 4.23. Adjustments made during the Flat Swamp/Tarrara Creek bacteria model calibration.

Symptom	Adjustment	Rationale
Wildlife direct deposit concentrations were too high, particularly in dry summer months	Reduce muskrat population estimate by 25%	Stakeholders felt that muskrat population estimates were too high
	Reduce migratory waterfowl population by 50%	Stakeholders felt geese did not migrate; estimates of total migratory population were not available from VADGIF, so migratory waterfowl population was inherently uncertain (NOTE: resident bird populations were not changed from initial estimates)
	Implement 'stage cutoff' at 0.5 inches for wildlife	Procedure used in previous TMDLs (e.g., Beaver Creek (Benham *et al.*, 2005)) to represent behavioral changes in wildlife at low flows in summer months
Bacteria concentrations continued to be elevated	Increase FSTDEC from 1.15 day^{-1} to 1.632 day^{-1} and THFST from 1.05 to 1.07	FSTDEC (the in-stream decay rate) and THFST (the temperature correction to the decay rate) are commonly used calibration parameters for HSPF. Increasing these values increases bacterial die-off in-stream, thus decreasing bacteria concentrations in-stream. The original estimates were based on previous TMDLs completed in the west of the Commonwealth; these were increased to the values reported by Khatiwada and Polprasert (1999) to more appropriately represent the swamp areas in this region
	Implement 'stage cutoff' at 1 inch for cattle	Procedure used in previous TMDLs (e.g., Beaver Creek (Benham *et al.*, 2005)) to represent behavioral/management changes for livestock at low flows in summer months
Consistency with other watersheds	Decrease WSQOP for impervious areas from 2.0 in/hr to 1.5 in/hr	Because lower WSQOP (the rate of surface runoff which will remove 90 percent of stored bacteria from the surface) values were needed for Mill Swamp and Darden Mill Run, WSQOP was changed to be as low as practical for Flat Swamp and Tarrara Creek to attempt to be consistent. However, it was only possible to adjust the impervious WSQOP without severely impacting the calibration statistics.

Table 4.24. Water quality calibration statistics for Flat Swamp and Tarrara Creek.

	Geometric Mean cfu/100ml	Average* cfu/100ml	Median* cfu/100ml	Single Sample Criterion Violation Rate (%)
Flat Swamp (5AFTS002.93) – Fecal Coliform				
Observed	155	267	100	17
Simulated	208	703	299	39
Tarrara Creek (5ATRR002.50) – Fecal Coliform				
Observed	209	397	200	23
Simulated	269	572	335	39
Tarrara Creek (5ATRR002.50) – *E. coli*				
Observed	115	196	120	18
Simulated	158	320	178	38

* simulated values for these parameters were calculated from the average daily predictions in the 5 days surrounding each observed data collection day; this provides a more detailed comparison with the actual observations, as it targets the specific meteorological and hydrologic conditions at the time of data collection

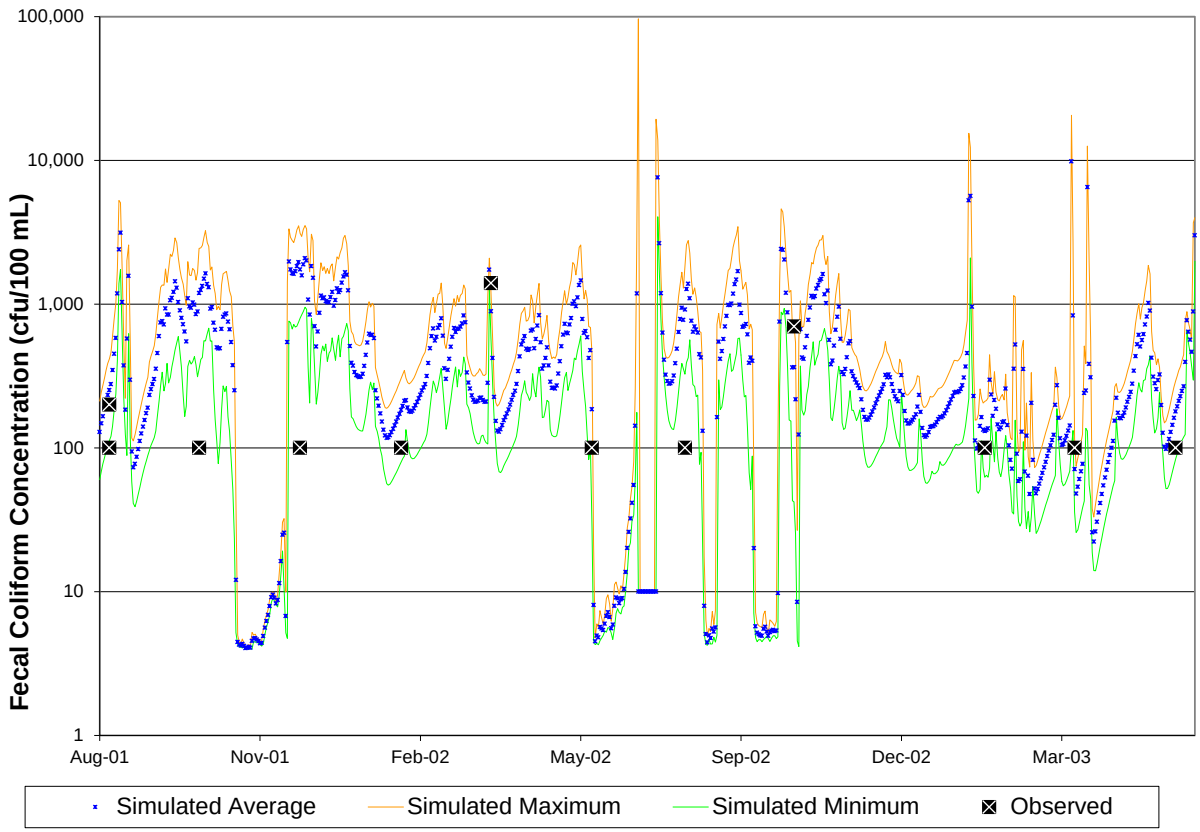

Figure 4.22. Observed fecal coliform data plotted with the daily maximum, minimum, and average simulated fecal coliform values for Flat Swamp (5AFTS002.93) for the calibration period (Aug. 1, 2001 to Jun. 15, 2003).

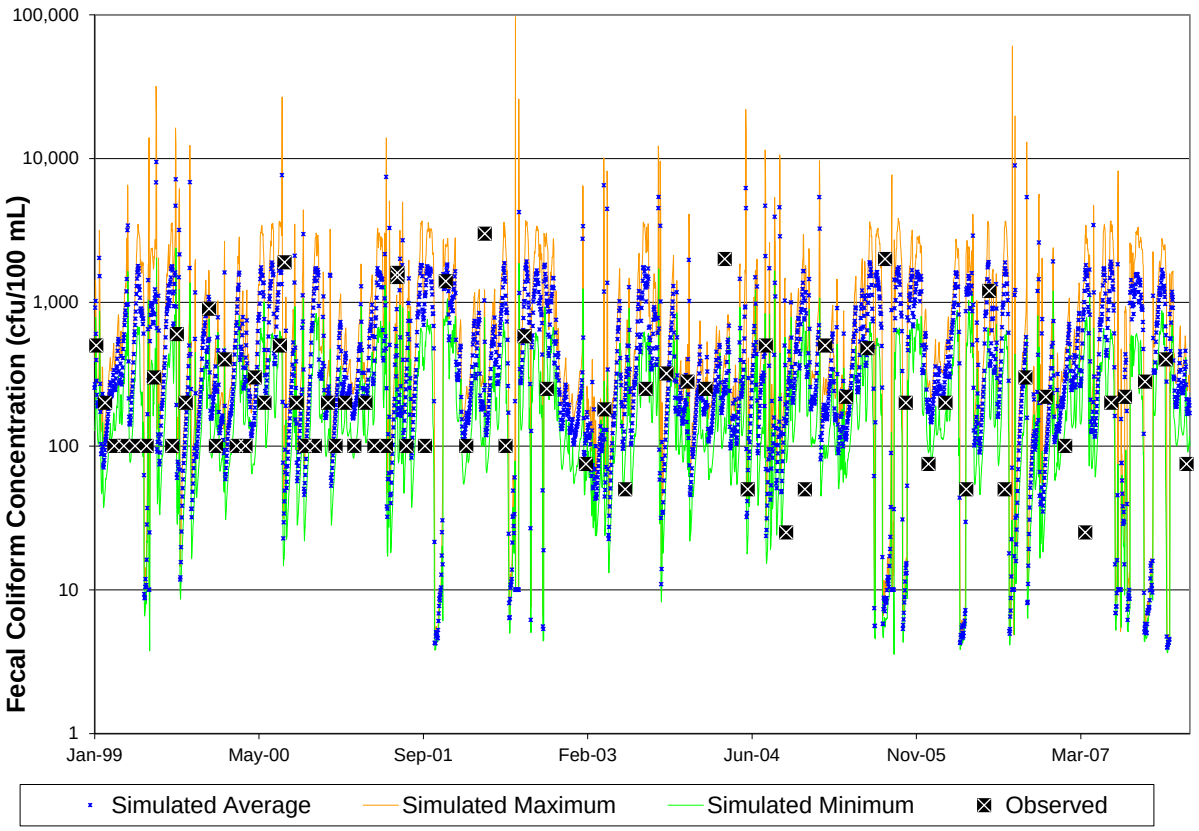

Figure 4.23. Observed fecal coliform data plotted with the daily maximum, minimum, and average simulated fecal coliform values for Tarrara Creek (5ATRR002.50) for the calibration period (Jan. 1, 1999 to Feb. 15, 2008).

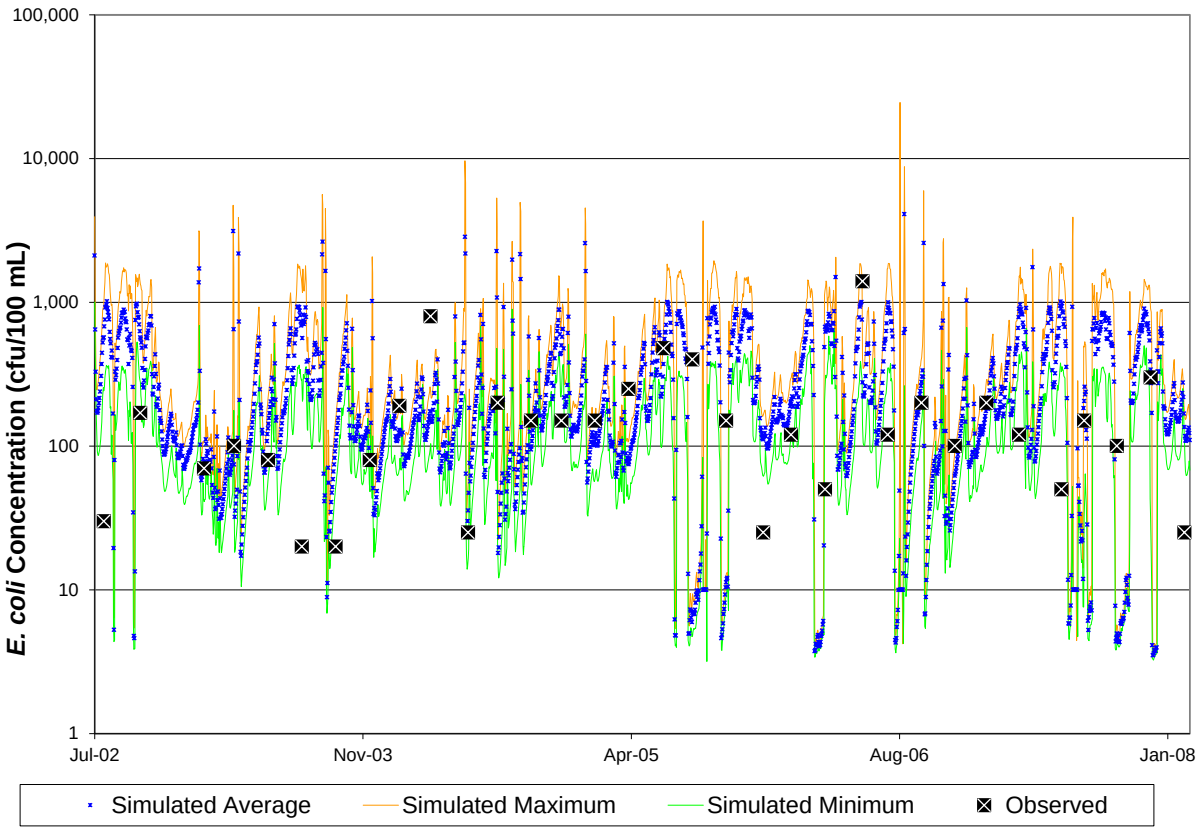

Figure 4.24. Observed *E. coli* data plotted with the daily maximum, minimum, and average simulated *E. coli* values for Tarrara Creek (5ATRR002.50) for the calibration period (Jul. 1, 2002 to Feb. 15, 2008).

4.4.3.3.2 Validation

After the calibration of Tarrara Creek at VADEQ monitoring station 5ATRR002.50, the model was run for a different period (July 15, 1992 - December 15, 1998) as a validation to ensure the calibrated input parameters were appropriate. A comparison was done only for the fecal coliform data, as there were insufficient *E. coli* data to conduct a second comparison. There were insufficient data from the Flat Swamp station to conduct a validation for Flat Swamp. The goodness-of-fit statistics for the validation run are listed in Table 4.25. Figure 4.25 shows the daily maxima, minima, and averages of the simulated values for the validation. Based on the goodness-of-fit parameter values and the visual comparisons both the water quality calibration and validation for Flat Swamp and Tarrara Creek were considered acceptable. The final calibrated water quality parameters are given in Table 4.26.

Table 4.25. Summarized goodness-of-fit measures for simulated and observed fecal coliform concentrations for the validation period for Tarrara Creek at station 5ATRR002.50.

	Geometric Mean cfu/100ml	Average* cfu/100ml	Median* cfu/100ml	Single Sample Criterion Violation Rate (%)
Observed	192	325	100	20
Simulated	149	432	243	33

* simulated values for these parameters were calculated from the average daily predictions in the 5 days surrounding each observed data collection day; this provides a more detailed comparison with the actual observations, as it targets the specific meteorological and hydrologic conditions at the time of data collection

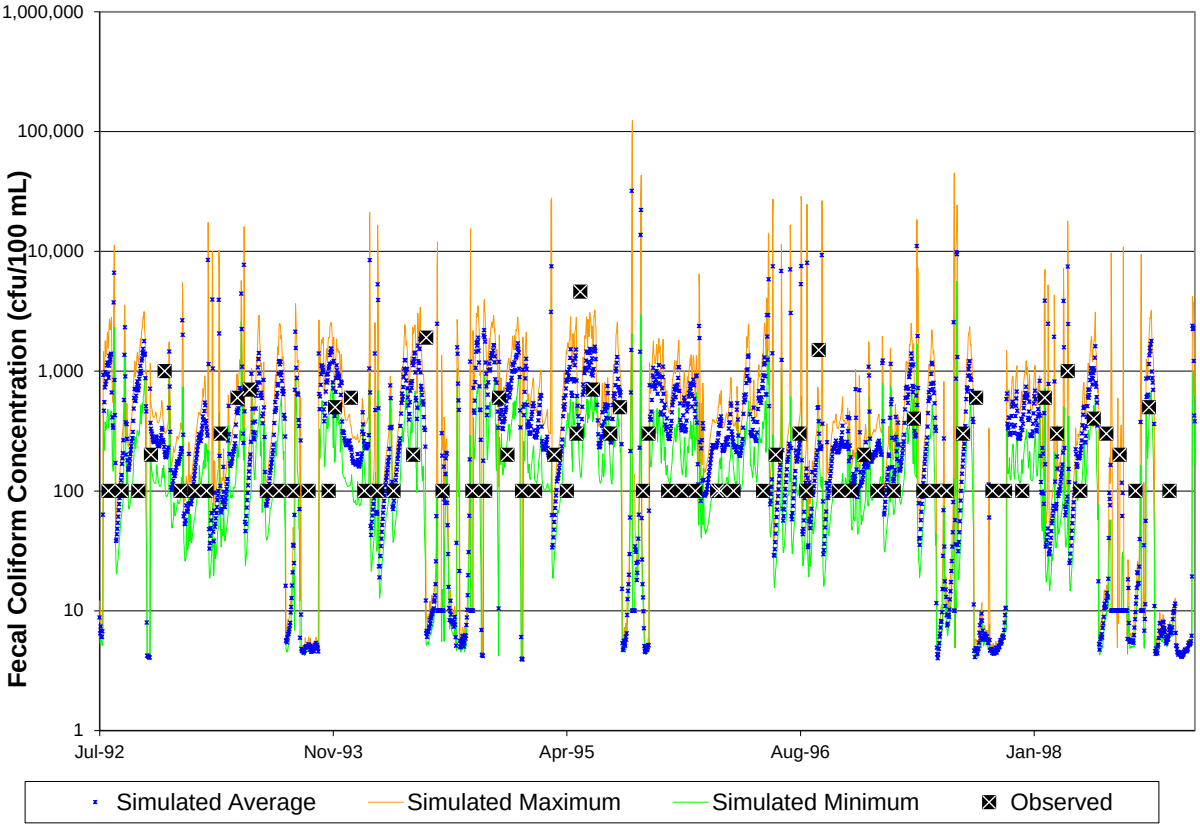

Figure 4.25. Observed fecal coliform data plotted with the daily maximum, minimum, and average simulated fecal coliform values for Tarrara Creek (5ATRR002.50) for the validation period (Jul. 15, 1992 to Dec. 15, 1998).

Table 4.26. Calibrated water quality parameters for the Tarrara Creek and Flat Swamp watersheds.

Parameter	Definition	Units	FINAL CALIBRATION	FUNCTION OF…	Appendix F Table (if applicable)
PQUAL					
SQO	Initial storage of constituent	#/ac	0	Land use	
POTFW	Washoff potency factor	#/ton	0		
POTFS	Scour potency factor	#/ton	0		
ACQOP	Rate of accumulation of constituent	#/day	Monthly[a]	Land use	12
SQOLIM	Maximum accumulation of constituent	#	9 x ACQOP[a]	Land use	13
WSQOP	Wash-off rate	in/hr	2.0	Land use	
IOQC	Constituent conc. in interflow	#/ft3	1416		
AOQC	Constituent conc. in active groundwater	#/ft3	1062		
IQUAL					
SQO	Initial storage of constituent	#/ac	$1x10^7$		
POTFW	Washoff potency factor	#/ton	0		
ACQOP	Rate of accumulation of constituent	#/day	$1x10^7$	Land use	
SQOLIM	Maximum accumulation of constituent	#	$3x10^7$	Land use	
WSQOP	Wash-off rate	in/hr	1.5	Land use	
GQUAL					
FSTDEC	First order decay rate of the constituent	1/day	1.632		
THFST	Temperature correction coeff. for FSTDEC		1.07		

[a]Values varied by month and with land use

4.4.3.4 Three Creek

4.4.3.4.1 Calibration

The five stations on Three Creek were calibrated simultaneously, so that calibrated changes made that affected the upstream stations were appropriately represented at the downstream stations. The calibration periods for fecal coliform were February 2002 – November 2009, February 2002 – November 2009, and January 1996-- March 2001 for stations 5ATRE008.48, 5ATRE016.02, and 5ATRE026.75, respectively. The calibration periods for *E. coli* were August 2002 – November 2009, August 2002 – November 2009, July 2003 – November 2008, and June 2005 – November 2008 for stations 5ATRE008.48, 5ATRE016.02, 5ATRE022.05, and 5ATRE038.07, respectively. Initial model predictions were high at all stations. The major adjustments and reasoning behind each adjustment are given in Table 4.27. Once these adjustments were made, the fecal coliform and *E. coli* predictions from HSPF acceptably matched the simulated data. The final goodness-of-fit measures for

the calibration for the fecal coliform and *E. coli* data are listed in Table 4.28. Figure 4.26 - Figure 4.32 show the daily maxima, minima, and averages of simulated values for the final calibration runs for all stations. Based on the goodness-of-fit parameter values and the visual comparisons, the water quality calibration was considered acceptable.

Table 4.27. Adjustments made during the Three Creek bacteria model calibration.

Symptom	Adjustment	Rationale
Wildlife direct deposit concentrations were too high, particularly in dry summer months	Reduce muskrat population estimate by 25%	Stakeholders felt that muskrat population estimates were too high
	Reduce migratory waterfowl population by 50%	Stakeholders felt geese did not migrate; estimates of total migratory population were not available from VADGIF, so migratory waterfowl population was inherently uncertain (NOTE: resident bird populations were not changed from initial estimates)
	Implement 'stage cutoff' at 0.5 inches for wildlife	Procedure used in previous TMDLs (e.g., Beaver Creek (Benham *et al.*, 2005)) to represent behavioral changes in wildlife at low flows in summer months
Bacteria concentrations continued to be elevated	Increase FSTDEC from 1.15 day^{-1} to 2.30 day^{-1}	FSTDEC (the in-stream decay rate) is a commonly used calibration parameter for HSPF. Increasing this value increases bacterial die-off in-stream, thus decreasing bacteria concentrations in-stream. The original estimates were based on previous TMDLs completed in the west of the Commonwealth; the value for FSTDEC used by the other watersheds in this study was not quite high enough to make a sufficient difference in the Three Creek calibration, and thus the parameter was increased to double the original estimate.
	Implement 'stage cutoff' at 1 inch for cattle	Procedure used in previous TMDLs (e.g., Beaver Creek (Benham *et al.*, 2005)) to represent behavioral/management changes for livestock at low flows in summer months
Consistency with other watersheds	Decrease WSQOP from 2.0 in/hr to 1.5 in/hr	Because lower WSQOP (the rate of surface runoff which will remove 90 percent of stored bacteria from the surface) values were needed for Mill Swamp and Darden Mill Run, WSQOP was changed to be as low as practical for Three Creek to attempt to be consistent.

Table 4.28. Water quality calibration statistics for Three Creek.

	Geometric Mean cfu/100ml	Average* cfu/100ml	Median* cfu/100ml	Single Sample Criterion Violation Rate (%)
Three Creek (5ATRE008.48) – Fecal Coliform				
Observed	102	202	100	8
Simulated	103	116	109	2
Three Creek (5ATRE008.48) – *E. coli*				
Observed	94	189	80	20
Simulated	69	76	72	2
Three Creek (5ATRE016.02) – Fecal Coliform				
Observed	101	219	100	13
Simulated	176	314	153	28
Three Creek (5ATRE016.02) – *E. coli*				
Observed	77	171	75	16
Simulated	112	179	100	28
Three Creek (5ATRE022.05) – *E. coli*				
Observed	83	212	100	13
Simulated	104	142	92	24
Three Creek (5ATRE026.75) – Fecal Coliform				
Observed	168	516	120	17
Simulated	144	302	146	21
Three Creek (5ATRE038.07) – *E. coli*				
Observed	100	178	100	18
Simulated	142	166	161	14

* simulated values for these parameters were calculated from the average daily predictions in the 5 days surrounding each observed data collection day; this provides a more detailed comparison with the actual observations, as it targets the specific meteorological and hydrologic conditions at the time of data collection

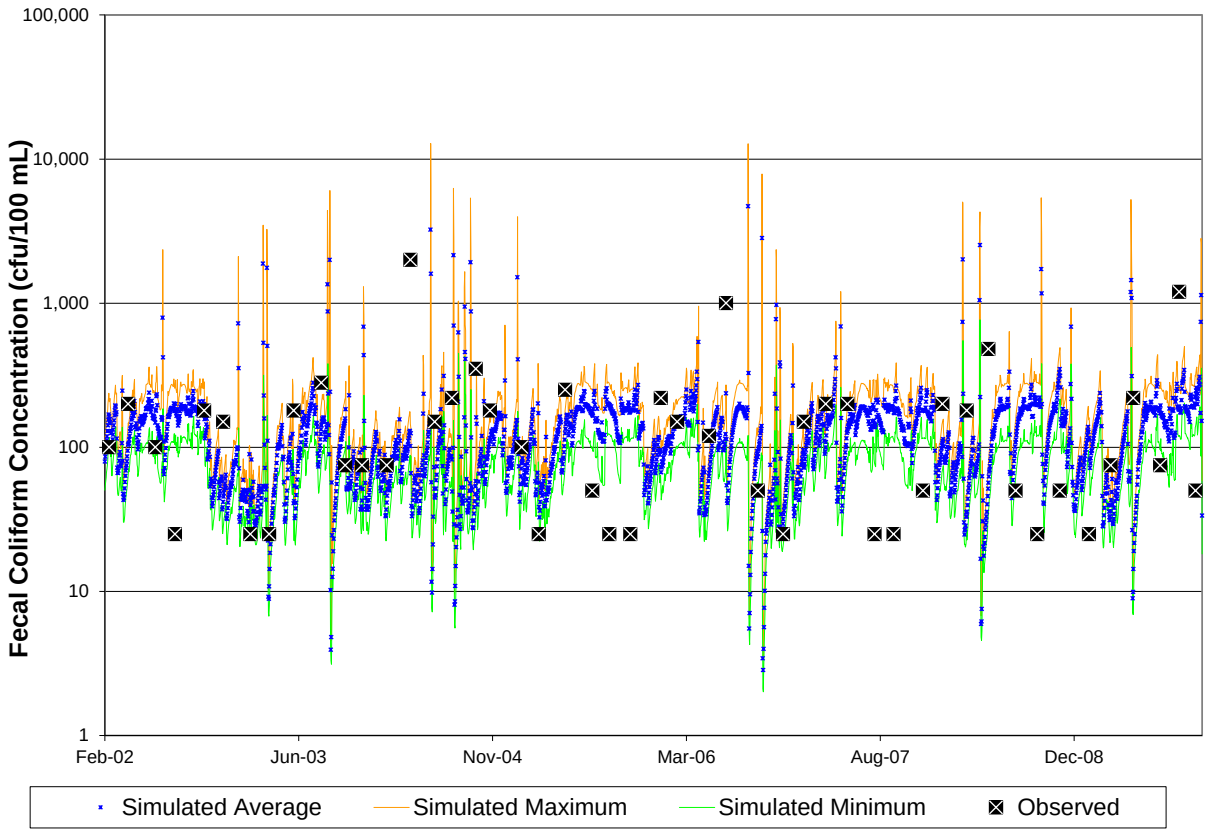

Figure 4.26. Observed fecal coliform data plotted with the daily maximum, minimum, and average simulated fecal coliform values for Three Creek (5ATRE008.48) for the calibration period (Feb. 15, 2002 to Nov. 15, 2009).

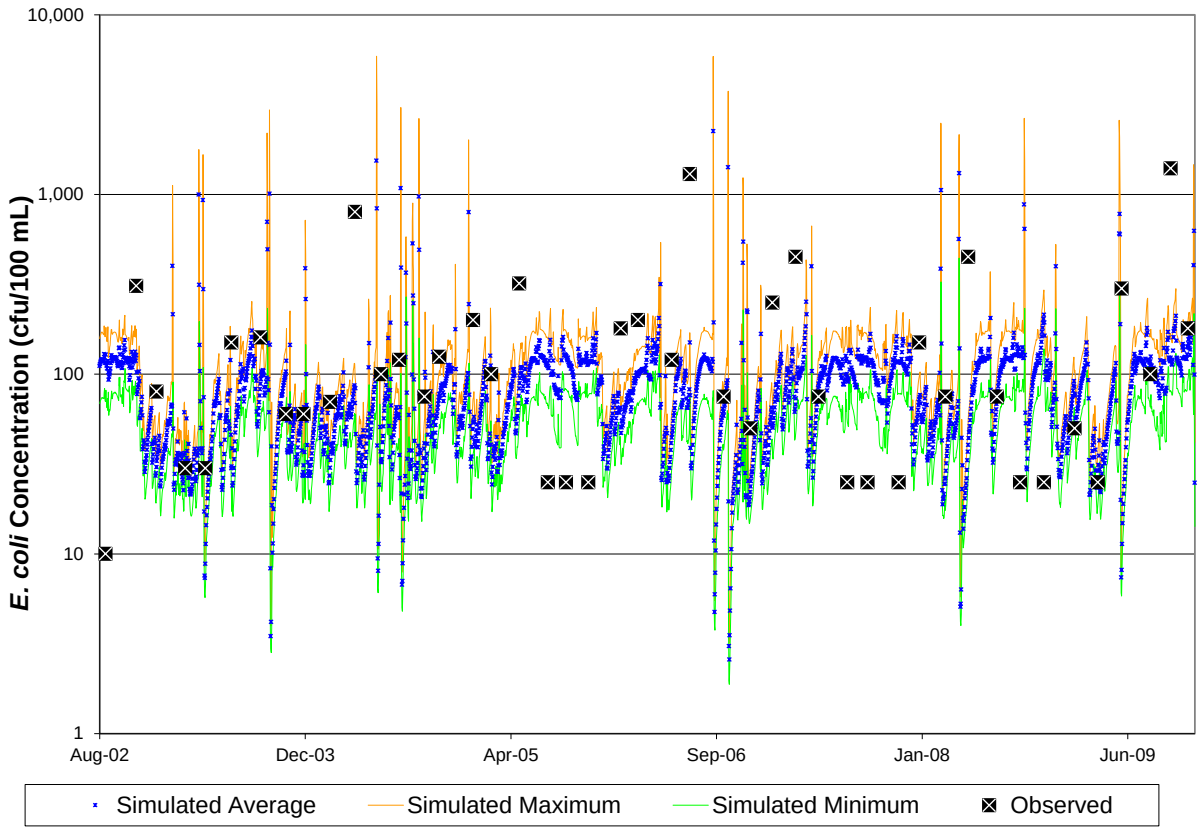

Figure 4.27. Observed *E. coli* data plotted with the daily maximum, minimum, and average simulated *E. coli* values for Three Creek (5ATRE008.48) for the calibration period (Aug. 1, 2002 to Nov. 15, 2000).

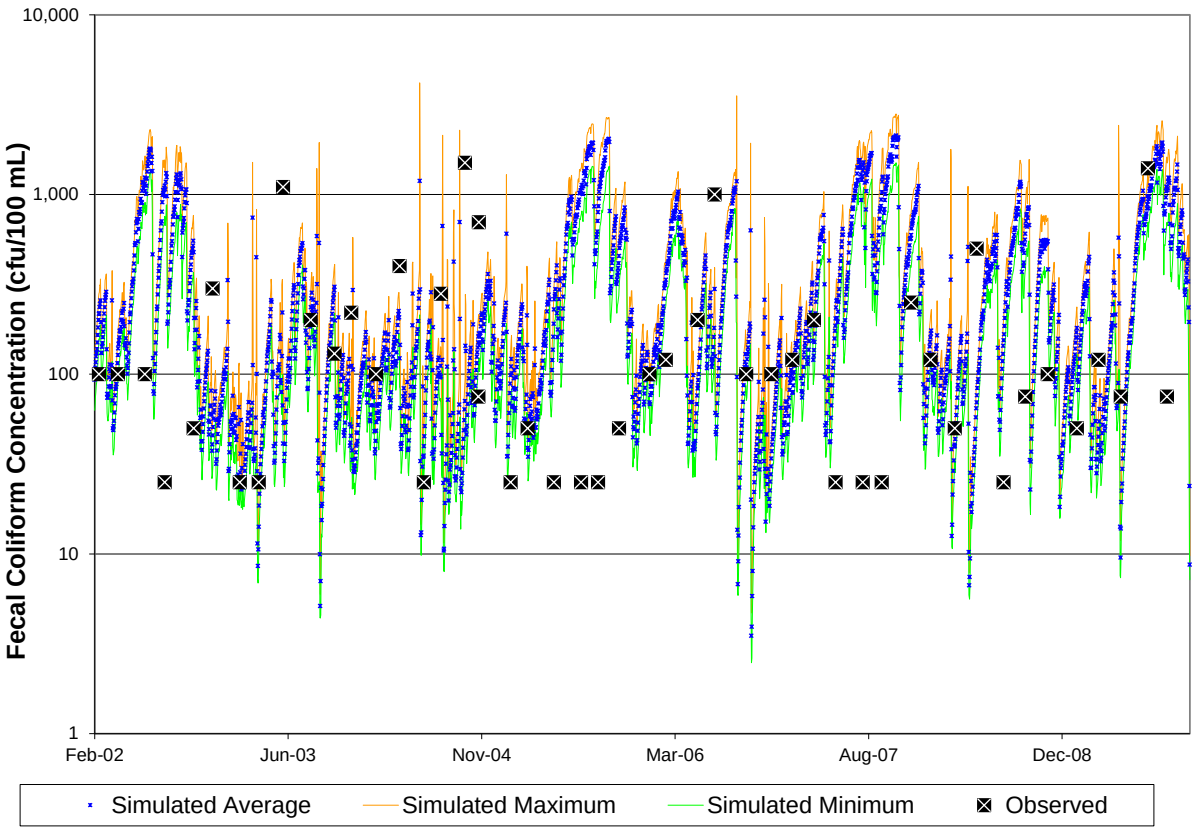

Figure 4.28. Observed fecal coliform data plotted with the daily maximum, minimum, and average simulated fecal coliform values for Three Creek (5ATRE016.02) for the calibration period (Feb. 15, 2002 to Nov. 15, 2009).

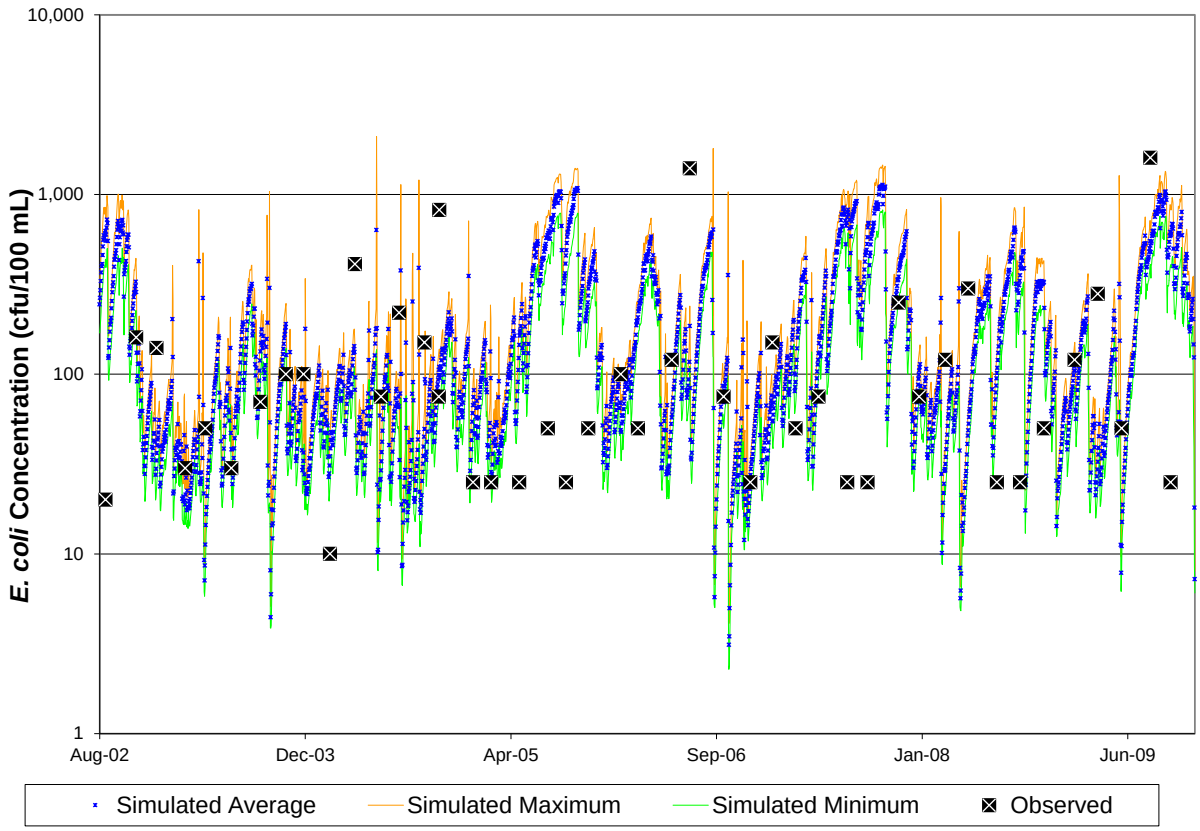

Figure 4.29. Observed *E. coli* data plotted with the daily maximum, minimum, and average simulated *E. coli* values for Three Creek (5ATRE016.02) for the calibration period (Aug. 1, 2002 to Nov. 15, 2009).

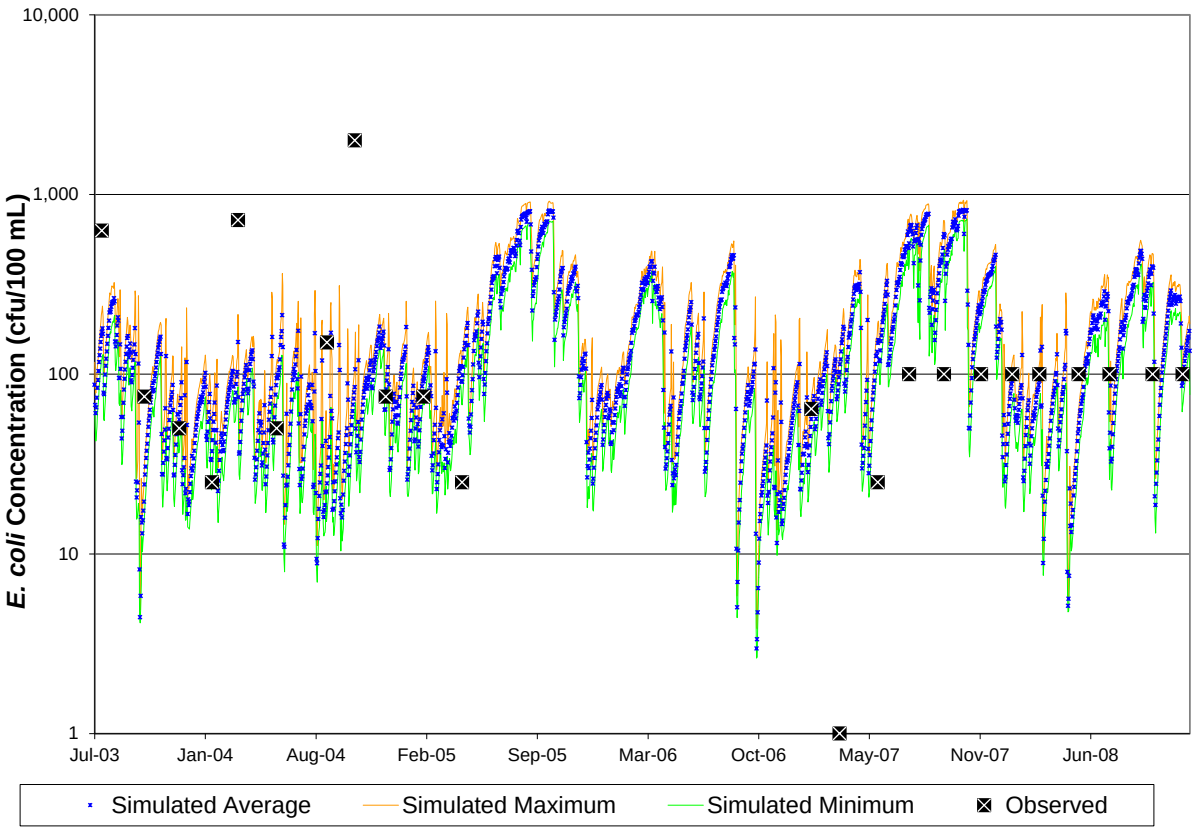

Figure 4.30. Observed *E. coli* data plotted with the daily maximum, minimum, and average simulated *E. coli* values for Three Creek (5ATRE022.05) for the calibration period (Jul. 1, 2003 to Nov. 30, 2008).

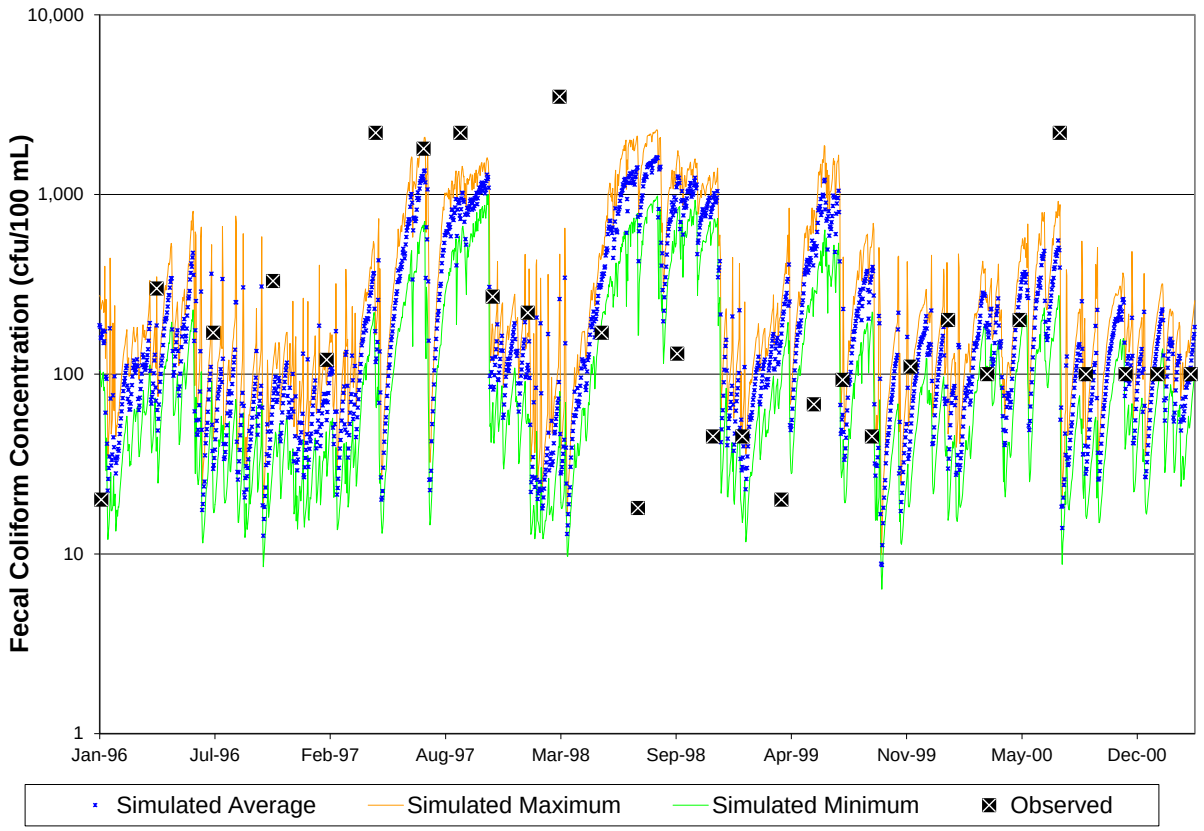

Figure 4.31. Observed fecal coliform data plotted with the daily maximum, minimum, and average simulated fecal coliform values for Three Creek (5ATRE026.75) for the calibration period (Jan. 1, 1996 to Mar. 15, 2001).

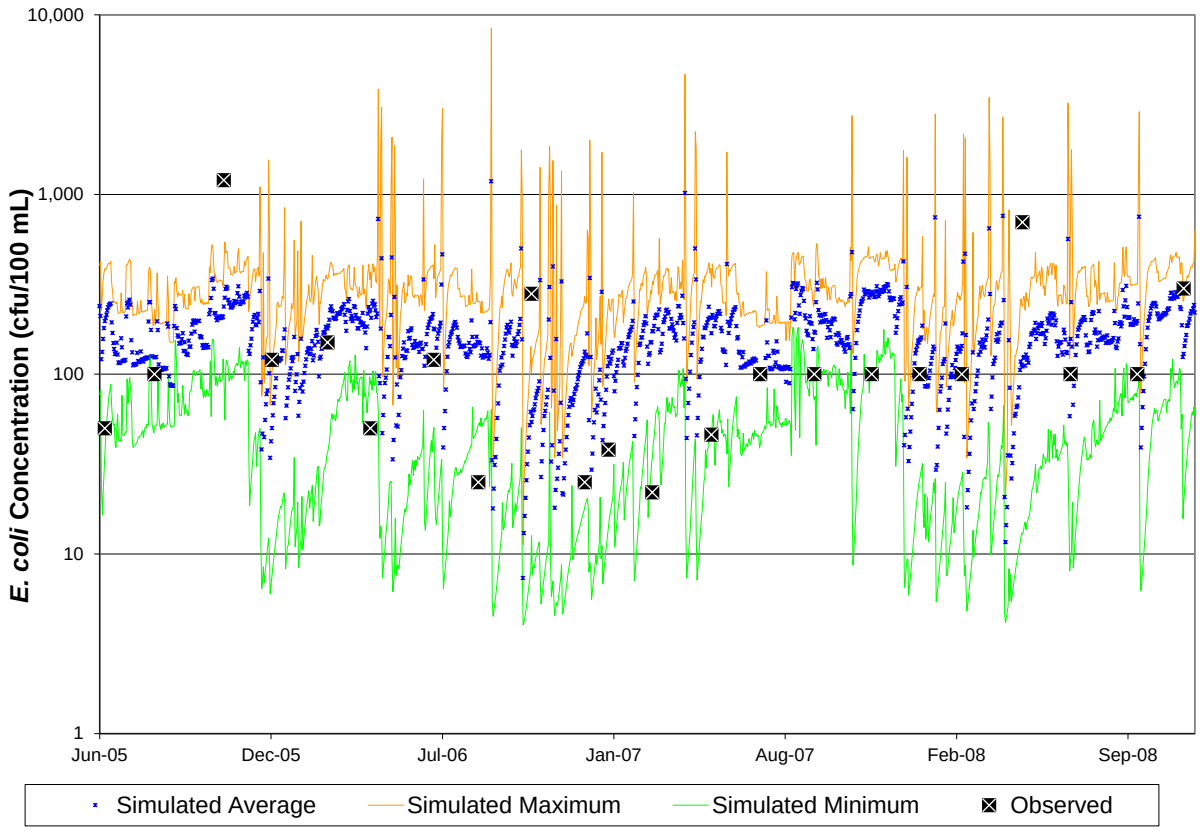

Figure 4.32. Observed *E. coli* data plotted with the daily maximum, minimum, and average simulated *E. coli* values for Three Creek (5ATRE038.07) for the calibration period (Jun. 1, 2005 to Nov. 30, 2008).

4.4.3.4.2 Validation

After the calibration of Three Creek at its various VADEQ monitoring stations, the model was run for different time periods as a validation to ensure the calibrated input parameters were appropriate. Only three of the stations had sufficient data – and only fecal coliform data – to conduct the validation. The validation periods for these stations were: May 1994 – December 2001, May 1994 – December 2001, and July 1990 – October 1995 for 5ATRE008.48, 5ATRE016.02, and 5ATRE026.75, respectively. The goodness-of-fit statistics for the validation run are listed in Table 4.29. Figure 4.33 – Figure 4.35 show the daily maxima, minima, and averages of the simulated values for the validation. Based on the goodness-of-fit parameter values and the visual comparisons both the water quality calibration and validation for Three Creek were considered acceptable. The final calibrated water quality parameters are given in Table 4.30.

Table 4.29. Summarized goodness-of-fit measures for simulated and observed fecal coliform concentrations for the validation period for Three Creek.

	Geometric Mean cfu/100ml	Average* cfu/100ml	Median* cfu/100ml	Single Sample Criterion Violation Rate (%)
Three Creek (5ATRE008.48)				
Observed	207	597	100	22
Simulated	106	136	136	2
Three Creek (5ATRE016.02)				
Observed	174	288	100	13
Simulated	192	333	174	29
Three Creek (5ATRE026.75)				
Observed	149	620	100	14
Simulated	195	392	165	25

* simulated values for these parameters were calculated from the average daily predictions in the 5 days surrounding each observed data collection day; this provides a more detailed comparison with the actual observations, as it targets the specific meteorological and hydrologic conditions at the time of data collection

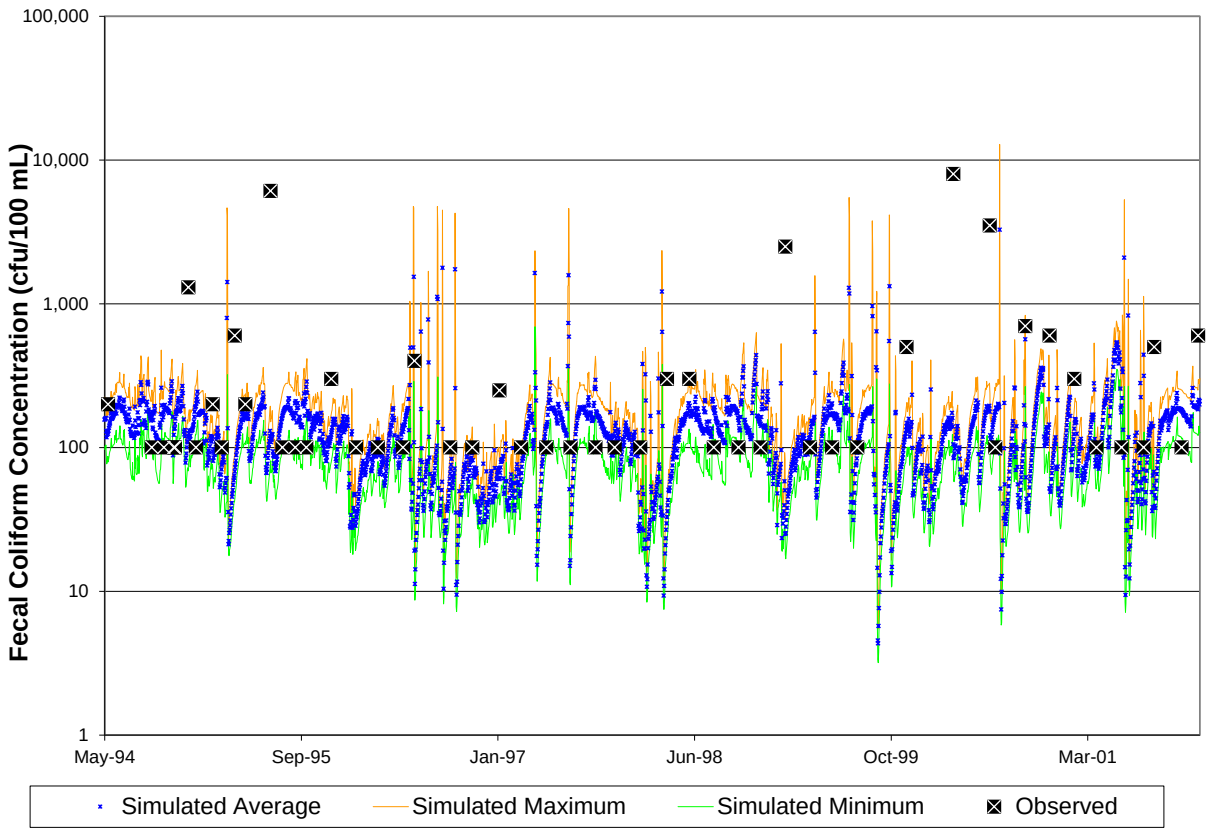

Figure 4.33. Observed fecal coliform data plotted with the daily maximum, minimum, and average simulated fecal coliform values for Three Creek (5ATRE008.48) for the validation period (May 1, 1994 to Dec. 15, 2001).

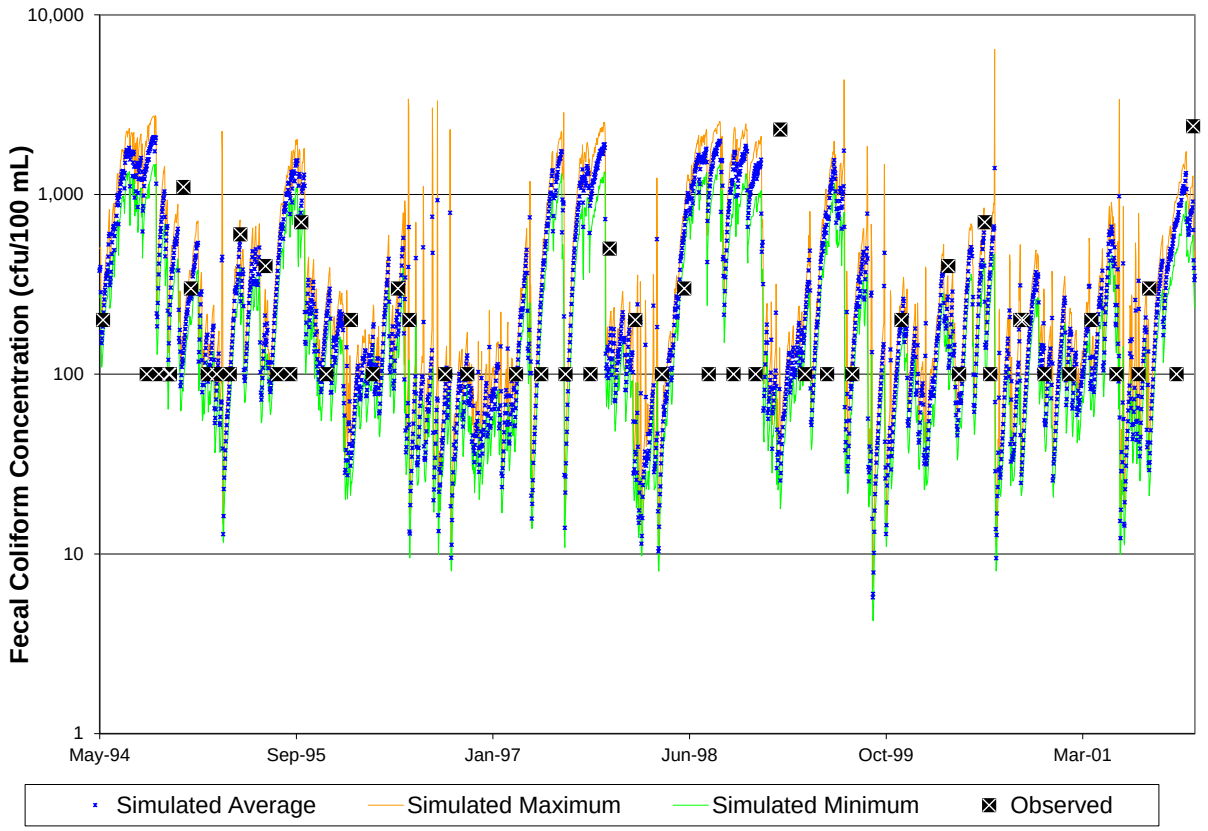

Figure 4.34. Observed fecal coliform data plotted with the daily maximum, minimum, and average simulated fecal coliform values for Three Creek (5ATRE016.02) for the validation period (May 1, 1994 to Dec. 15, 2001).

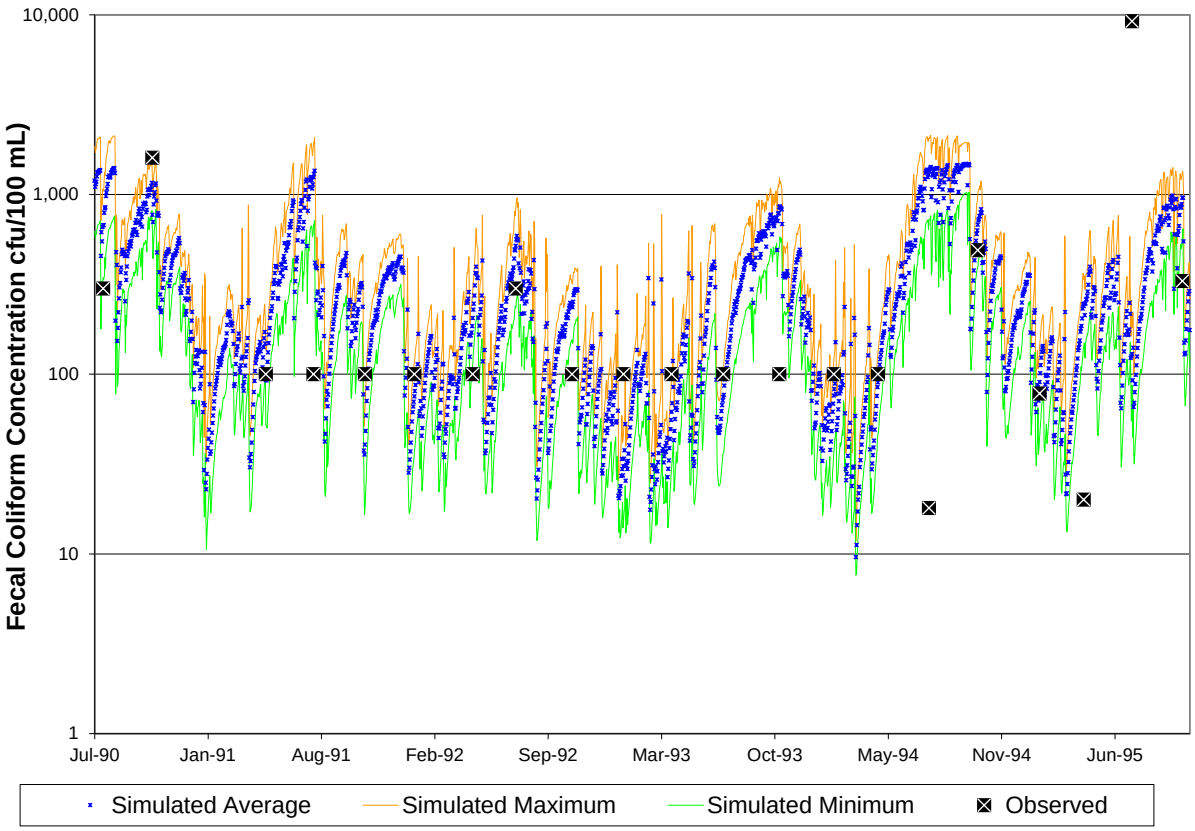

Figure 4.35. Observed fecal coliform data plotted with the daily maximum, minimum, and average simulated fecal coliform values for Three Creek (5ATRE026.75) for the validation period (Jul. 1, 1990 to Oct. 15, 1995).

Table 4.30. Calibrated water quality parameters for the Three Creek watershed.

Parameter	Definition	Units	FINAL CALIBRATION	FUNCTION OF…	Appendix F Table (if applicable)
PQUAL					
SQO	Initial storage of constituent	#/ac	0	Land use	
POTFW	Washoff potency factor	#/ton	0		
POTFS	Scour potency factor	#/ton	0		
ACQOP	Rate of accumulation of constituent	#/day	Monthly[a]	Land use	14
SQOLIM	Maximum accumulation of constituent	#	9 x ACQOP[a]	Land use	15
WSQOP	Wash-off rate	in/hr	1.5	Land use	
IOQC	Constituent conc. in interflow	#/ft3	1416		
AOQC	Constituent conc. in active groundwater	#/ft3	1062		
IQUAL					
SQO	Initial storage of constituent	#/ac	$1x10^7$		
POTFW	Washoff potency factor	#/ton	0		
ACQOP	Rate of accumulation of constituent	#/day	$1x10^7$	Land use	
SQOLIM	Maximum accumulation of constituent	#	$3x10^7$	Land use	
WSQOP	Wash-off rate	in/hr	1.5	Land use	
GQUAL					
FSTDEC	First order decay rate of the constituent	1/day	2.3 (swamps); 5.24 (lakes)		
THFST	Temperature correction coeff. for FSTDEC		1.05 (swamps); 1.02 (lakes)		

[a]Values varied by month and with land use

5 TMDL Allocations

The objective of a TMDL is to allocate allowable loads among different pollutant sources so that the appropriate control actions can be taken to achieve water quality standards (USEPA, 1991).

5.1 Background

The objective of the bacteria TMDLs for the Three Creek, Mill Swamp, Darden Mill Run, Flat Swamp, and Tarrara Creek watersheds was to determine what reductions in bacteria loadings from point and nonpoint sources are required to meet state water quality standards. The state water quality standard for *E. coli* used in the development of the TMDL (see section 1.2.2 in this report) specifies a maximum calendar-month geometric mean concentration of 126 cfu/100 mL (calendar-month geometric mean). The 'instantaneous' portion of the standard, with a criteria of 235 cfu/100 mL, was not used for development of the TMDL but was considered during allocation and was used later in the development of implementation scenarios (Chapter 6). The TMDL considers all significant sources contributing *E. coli* to the impaired streams. The sources can be separated into nonpoint and point sources. The different sources in the TMDL are defined in the following equation:

$$TMDL = WLA + LA + MOS \qquad [5.1]$$

Where: WLA = waste load allocation (point source contributions)
LA = load allocation (nonpoint source contributions); and
MOS = margin of safety.

A TMDL accounts for critical conditions, seasonal variations and must include a margin of safety (MOS).

5.1.1 Margin of Safety

A MOS is factored into a TMDL to account for model uncertainty. The MOS can be either explicit, as an additional load reduction requirement, or implicit, which incorporates conservative assumptions within the application of the TMDL model. An implicit MOS was used in these bacteria TMDLs by using conservative estimations of all

factors that would affect bacteria loadings in the watershed (e.g., animal numbers, production rates, contributions to the stream). These factors were estimated in such a way as to represent the worst-case scenario; i.e., they describe the worst stream conditions that could exist in the watersheds. Creating TMDLs with conservative estimates ensures that the worst-case scenario has been considered and that no water quality standard violations will occur if the TMDL plan is followed.

5.1.2 Translating Fecal Coliform to *E. coli*

A translator equation developed by VADEQ (equation 5.2) was used to convert the fecal coliform model output to *E. coli* for comparison with the water quality standards. The *E. coli* translator equation was implemented in the HSPF simulation using the GENER block. In order to develop the actual TMDL equation, it was necessary to generate *loads* (rather than concentrations) of *E. coli*. Daily *E. coli* loads were obtained by using the *E. coli* concentrations calculated from the translator equation and multiplying them by the average daily flow. Annual loads were obtained by summing the daily loads and dividing by the number of years in the allocation period.

$$\log_2 EC(cfu/100mL) = -0.0172 + 0.91905 * \log_2 FC(cfu/100mL) \qquad [5.2]$$

5.1.3 Accounting for Critical Conditions and Seasonal Variations

Current EPA regulations [40 CFR 130.7(c)(1)] require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Such an approach ensures that TMDLs, when implemented, will not result in violations of the water quality criteria under a wide variety of flow regimes that affect E. coli concentrations.

A period of five years was used for allocation modeling. Observed meteorological data from the weather file used during calibration (see Appendix C:) were extracted for 1991, 1993, 1998, 2002, and 2004 and used in the allocation simulations. These particular rainfall years were selected because they incorporate average rainfall, low rainfall, and high rainfall; and the climate during these years caused a wide range of

hydrologic events including both low and high flow conditions (for stream flow charts for the allocation period, see Appendix G). The bacteria loading in the model for allocation scenarios was representative of anticipated future conditions.

The continuous simulation model developed for these TMDLs explicitly incorporates the seasonal variations of rainfall and other meteorological parameters, in addition to monthly estimates of fecal coliform loads. By using an hourly time-step in the model, these measures account for the seasonal effects in fecal coliform loading within the watershed.

When developing a bacteria TMDL, the required bacteria load reductions are modeled by decreasing the amount of bacteria running off the land surface that reach the stream or decreasing the amount of bacteria directly deposited in the stream; these reductions are presented in the tables in the following sections. The reductions called for in the following sections indicate the need to decrease the amount of bacteria reaching the stream in order to meet the applicable water quality standard. The reductions shown in these sections are not intended to infer that agricultural producers should reduce their herd size, or limit the use of manures as fertilizer or soil conditioner. Rather, it is assumed that the required reductions from affected agricultural source categories (cattle direct deposit, cropland, etc.) will be accomplished by implementing BMPs like filter strips, stream fencing, and off-stream watering; and that required reductions from residential source categories will be accomplished by repairing aging septic systems, eliminating straight pipe discharges, and other appropriate measures included in the TMDL Implementation Plan.

The calendar-month geometric mean values used in this report are geometric means of the simulated daily concentrations. Because HSPF was operated with a one-hour time step in this study, 24 hourly concentrations were generated each day. To estimate the calendar-month geometric mean from the hourly HSPF output, the arithmetic mean of the hourly values was computed on a daily basis, and then the geometric mean was calculated from these average daily values.

5.2 Existing Conditions

Analysis of the simulation results for the existing conditions in the watershed (Table 5.1 - Table 5.7) shows that contributions from wildlife direct deposits are the primary source of *E. coli* to the stream. Contributions from pervious land surfaces, straight pipes, and livestock direct deposits are also contributors to the mean daily *E. coli* concentration, the significance of each varying by watershed. The results in these tables were taken as the average daily contributions for the allocation simulation period, irrespective of the magnitude of the concentration or the flow rate (this does cause an oddity in Tarrara Creek, Table 5.3, as is explained in the table's footnote). Table 5.1 - Table 5.7 give an idea of which sources will be the dominant contributors to the instantaneous *E. coli* concentrations, and thus what sources will control the violations of the single sample criterion: loadings from wildlife direct deposit and straight pipes will violate the single sample criterion by themselves in one or more watersheds. Although the overall contribution from pervious land sources is not as high as loading from wildlife direct deposits, it dominates the concentration during high flow events and is typically equally as important as the wildlife direct deposits in violating the single sample criterion.

The contribution of each of the sources listed in Table 5.1 - Table 5.7 to the calendar-month geometric mean *E. coli* concentration is shown in Figure 5.1 - Figure 5.7. These figures illustrate which contributors will be of greatest concern for the geometric mean criterion. The pervious land surface (PLS_IntGr) category in the figures includes both the 'nonpoint source loadings from pervious land segments' and the 'interflow and groundwater contribution' categories from the tables.

Table 5.1. Relative contributions of different *E. coli* sources to the overall *E. coli* concentration for existing conditions in Darden Mill Run.

Source	Mean Daily *E. coli* Concentration by Source, cfu/100 mL	Relative Contribution by Source
Direct nonpoint source loadings to the stream from wildlife	157	70%
Nonpoint source loadings from pervious land segments	41	18%
Direct nonpoint source loadings to the stream from livestock	22	10%
Interflow and groundwater contribution	3	1%
Direct nonpoint source loadings to the stream from hunt clubs	1	<1%
Straight-pipe discharges to stream	<1	<1%
Nonpoint source loadings from impervious land segments	<1	<1%
All Sources	224	

Table 5.2. Relative contributions of different *E. coli* sources to the overall *E. coli* concentration for existing conditions in Mill Swamp.

Source	Mean Daily *E. coli* Concentration by Source, cfu/100 mL	Relative Contribution by Source
Direct nonpoint source loadings to the stream from wildlife	37	67%
Nonpoint source loadings from pervious land segments	9	15%
Straight-pipe discharges to stream	7	12%
Interflow and groundwater contribution	2	3%
Direct nonpoint source loadings to the stream from livestock	1	1%
Direct nonpoint source loadings to the stream from hunt clubs	<1	<1%
Nonpoint source loadings from impervious land segments	<1	<1%
All Sources	55	

Table 5.3. Relative contributions of different *E. coli* sources to the overall *E. coli* concentration for existing conditions in Tarrara Creek.

Source	Mean Daily *E. coli* Concentration by Source, cfu/100 mL	Relative Contribution by Source
Direct nonpoint source loadings to the stream from wildlife	253	12%
Straight-pipe discharges to stream	1865‡	85%
Nonpoint source loadings from pervious land segments	34	2%
Direct nonpoint source loadings to the stream from livestock	31	1%
Interflow and groundwater contribution	7	<1%
Direct nonpoint source loadings to the stream from hunt clubs	2	<1%
Nonpoint source loadings from impervious land segments	<1	<1%
All Sources	2192‡	

‡These numbers appear high because the straight pipe contributions that come in near the outlet become extremely concentrated during times of low flow in dry months. A flow-weighted average (that gives more weight to higher flow events and little weight to low flow conditions) gives a straight pipe contribution of 3 cfu/100 mL, 1.4% of the overall flow-weighted average of 212 cfu/100 mL. These high numbers tell us that during low flow conditions the straight pipe contributions will dominate the total bacteria concentration in the stream and cause violations of the water quality criteria.

Table 5.4. Relative contributions of different *E. coli* sources to the overall *E. coli* concentration for existing conditions in Flat Swamp.

Source	Mean Daily *E. coli* Concentration by Source, cfu/100 mL	Relative Contribution by Source
Direct nonpoint source loadings to the stream from wildlife	203	75%
Nonpoint source loadings from pervious land segments	42	16%
Interflow and groundwater contribution	13	5%
Direct nonpoint source loadings to the stream from livestock	9	3%
Direct nonpoint source loadings to the stream from hunt clubs	2	<1%
Straight-pipe discharges to stream	<1	<1%
Nonpoint source loadings from impervious land segments	<1	<1%
All Sources	269	

Table 5.5. Relative contributions of different *E. coli* sources to the overall *E. coli* concentration for existing conditions in Three Creek (K27R-02, sub-watershed 1).

Source	Mean Daily *E. coli* Concentration by Source, cfu/100 mL	Relative Contribution by Source
Direct nonpoint source loadings to the stream from wildlife	56	81%
Nonpoint source loadings from pervious land segments	8	11%
Direct nonpoint source loadings to the stream from livestock	4	6%
Interflow and groundwater contribution	1	1%
Straight-pipe discharges to stream	<1	<1%
Nonpoint source loadings from impervious land segments	<1	<1%
Direct nonpoint source loadings to the stream from hunt clubs	<1	<1%
Biosolids	<1	<1%
All Sources	69	

Table 5.6. Relative contributions of different *E. coli* sources to the overall *E. coli* concentration for existing conditions in Three Creek (K26R-02, sub-watershed 20).

Source	Mean Daily *E. coli* Concentration by Source, cfu/100 mL	Relative Contribution by Source
Direct nonpoint source loadings to the stream from wildlife	172	91%
Direct nonpoint source loadings to the stream from livestock	11	6%
Nonpoint source loadings from pervious land segments	5	3%
Interflow and groundwater contribution	1	<1%
Straight-pipe discharges to stream	<1	<1%
Nonpoint source loadings from impervious land segments	<1	<1%
Direct nonpoint source loadings to the stream from hunt clubs	1	<1%
All Sources	190	

Table 5.7. Relative contributions of different *E. coli* sources to the overall *E. coli* concentration for existing conditions in Three Creek (K26R-03, sub-watershed 30).

Source	Mean Daily *E. coli* Concentration by Source, cfu/100 mL	Relative Contribution by Source
Direct nonpoint source loadings to the stream from wildlife	110	83%
Nonpoint source loadings from pervious land segments	17	12%
Direct nonpoint source loadings to the stream from livestock	3	2%
Interflow and groundwater contribution	2	1%
Direct nonpoint source loadings to the stream from hunt clubs	1	<1%
Straight-pipe discharges to stream	<1	<1%
Nonpoint source loadings from impervious land segments	<1	<1%
All Sources	133	

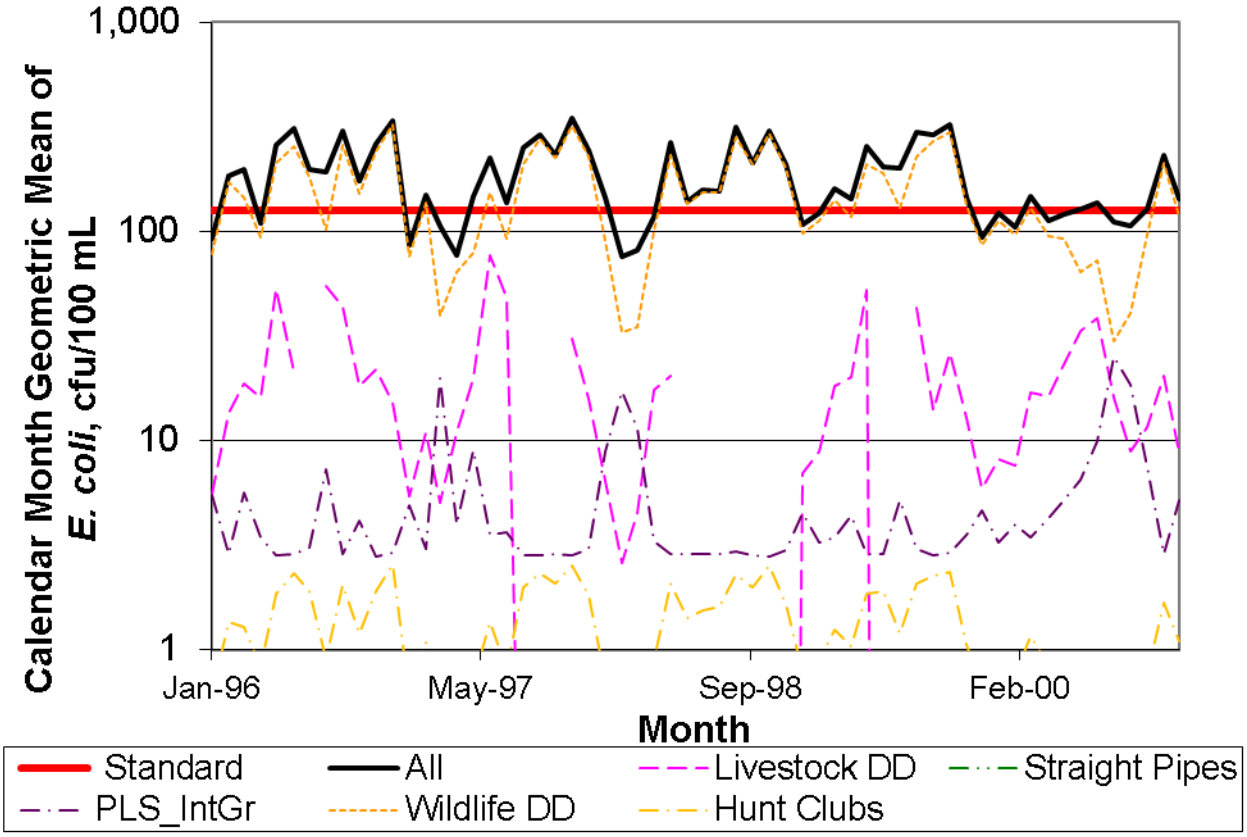

Figure 5.1. Contributions of different sources to the calendar-month geometric mean *E. coli* concentration at the outlet of Darden Mill Run for existing conditions. (PLS_IntGr = pervious land runoff, interflow, and groundwater concentrations; DD = direct deposit)

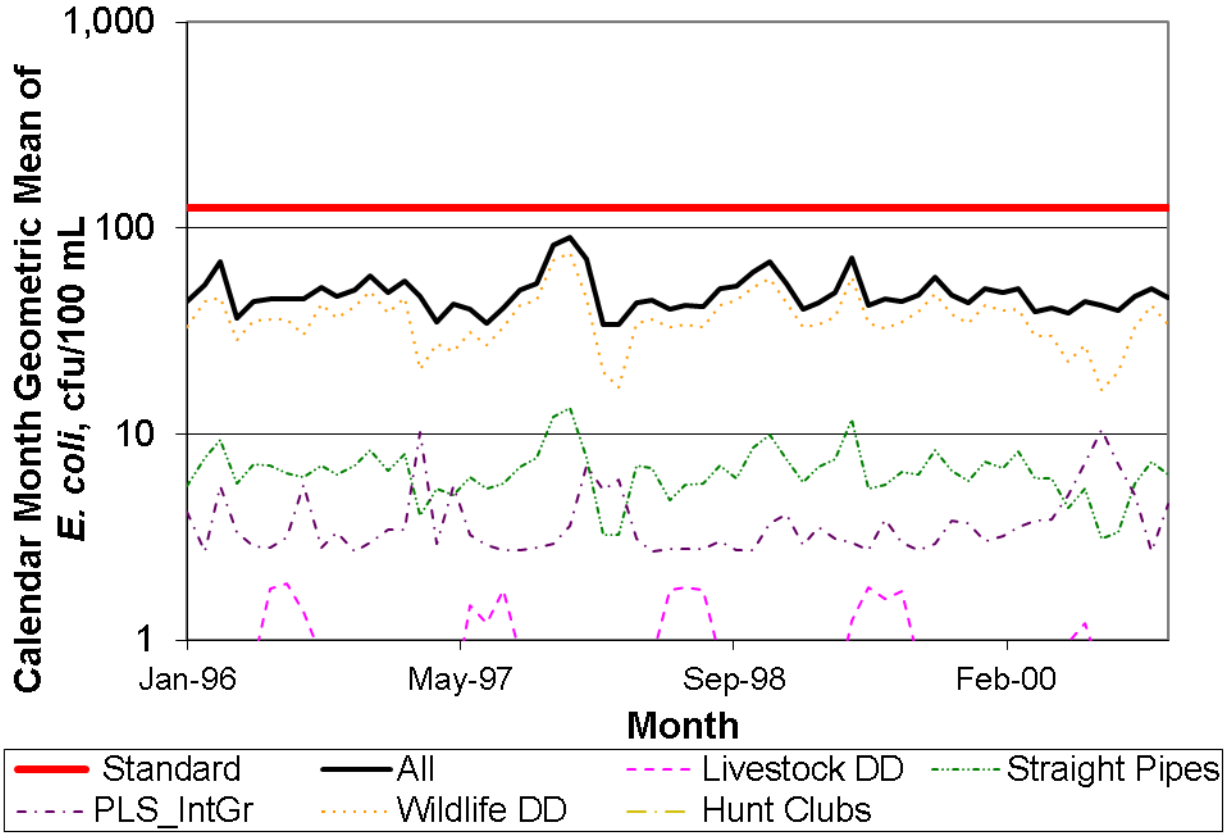

Figure 5.2. Contributions of different sources to the calendar-month geometric mean *E. coli* concentration at the outlet of Mill Swamp for existing conditions. (PLS_IntGr = pervious land runoff, interflow, and groundwater concentrations; DD = direct deposit)

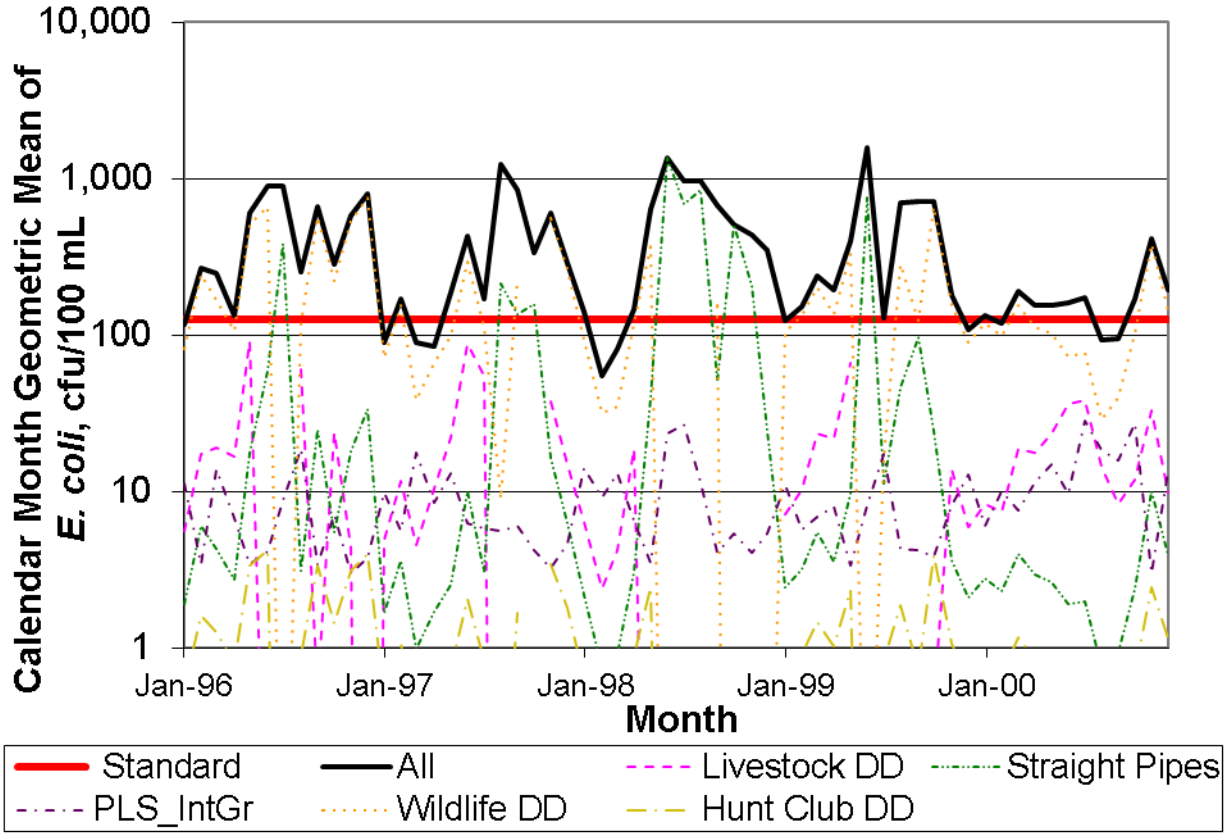

Figure 5.3. Contributions of different sources to the calendar-month geometric mean *E. coli* concentration at the outlet of Tarrara Creek for existing conditions. (PLS_IntGr = pervious land runoff, interflow, and groundwater concentrations; DD = direct deposit)

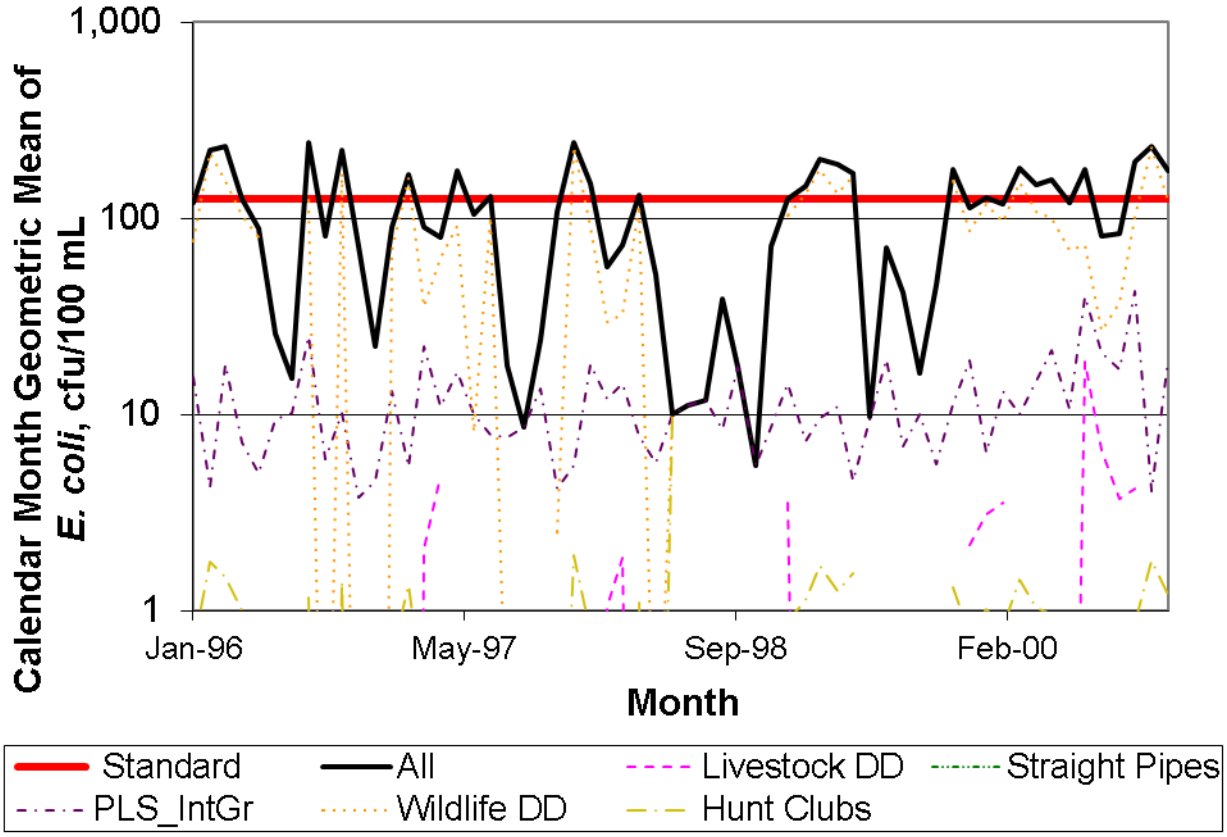

Figure 5.4. Contributions of different sources to the calendar-month geometric mean *E. coli* concentration at the outlet of Flat Swamp for existing conditions. (PLS_IntGr = pervious land runoff, interflow, and groundwater concentrations; DD = direct deposit)

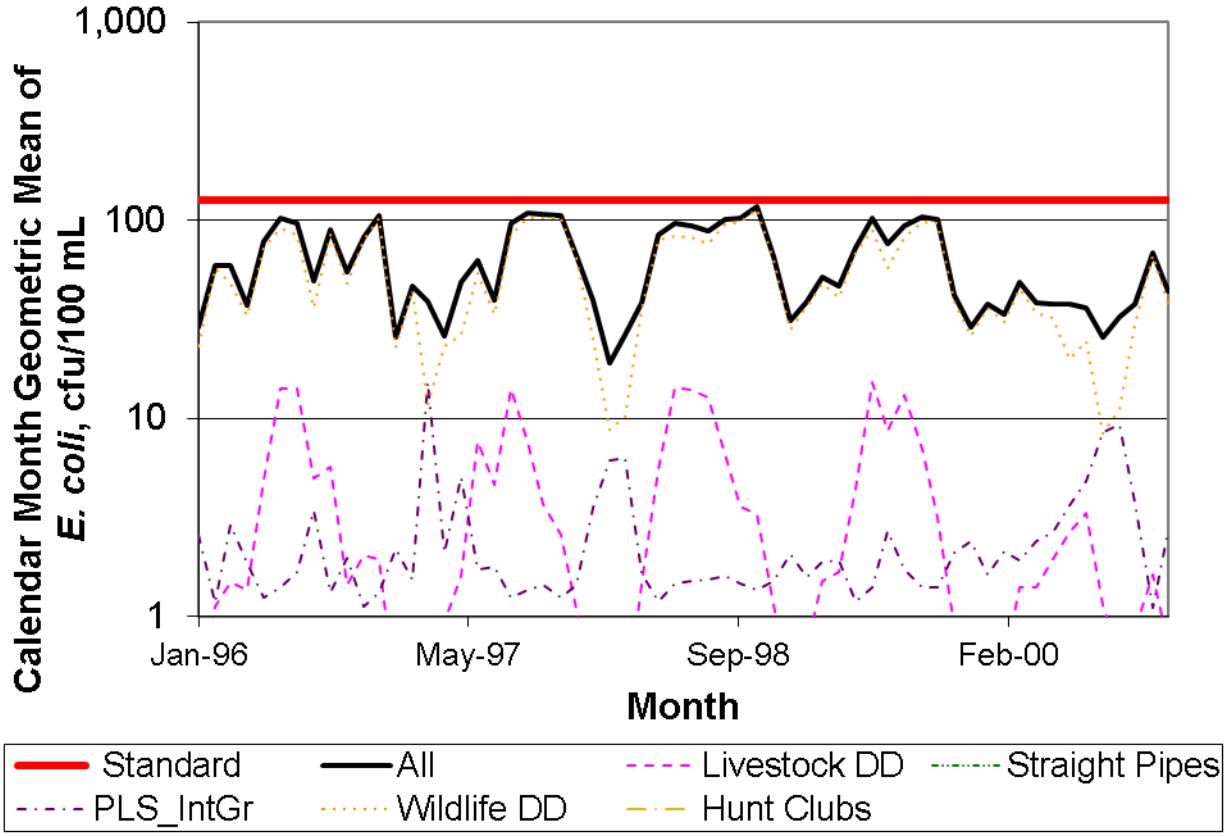

Figure 5.5. Contributions of different sources to the calendar-month geometric mean *E. coli* concentration at the outlet of Three Creek (K27R-02, sub-watershed 1) for existing conditions. (PLS_IntGr = pervious land runoff, interflow, and groundwater concentrations; DD = direct deposit)

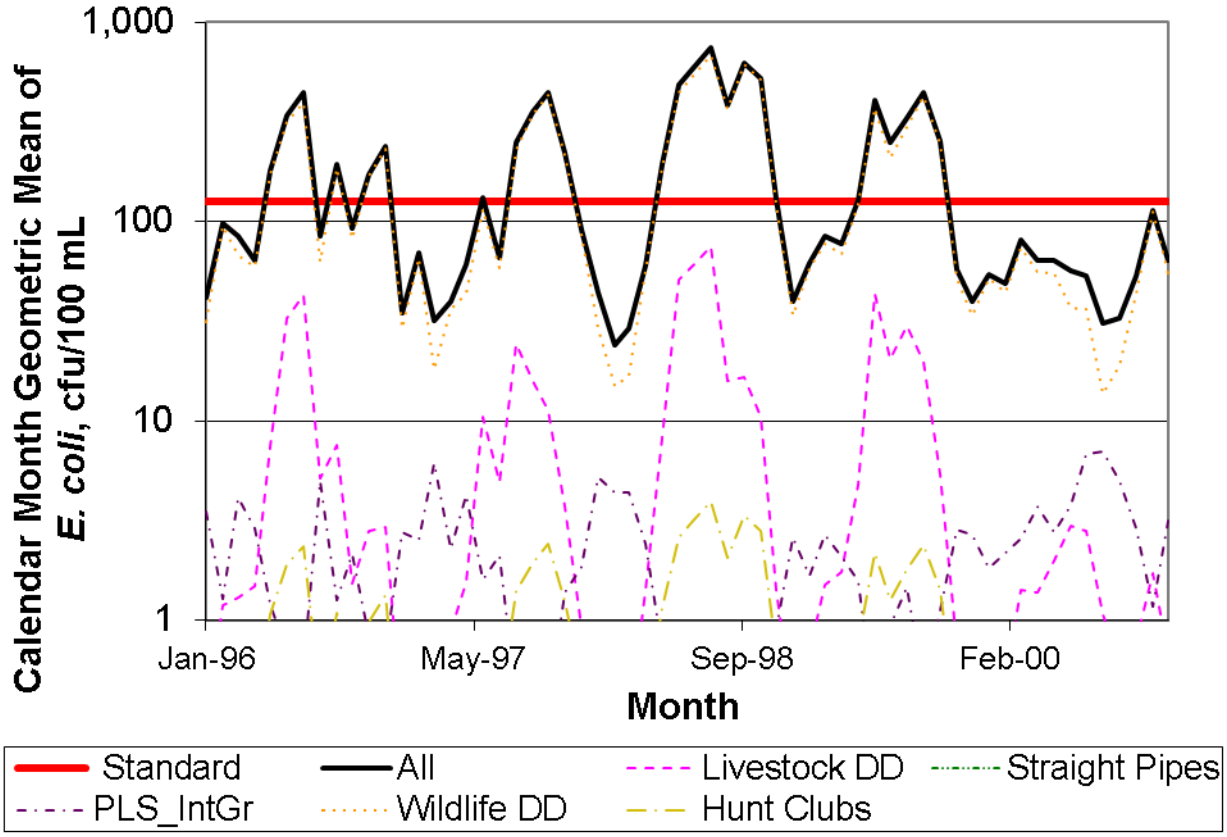

Figure 5.6. Contributions of different sources to the calendar-month geometric mean *E. coli* concentration at the outlet of Three Creek (K26R-02, sub-watershed 20) for existing conditions. (PLS_IntGr = pervious land runoff, interflow, and groundwater concentrations; DD = direct deposit)

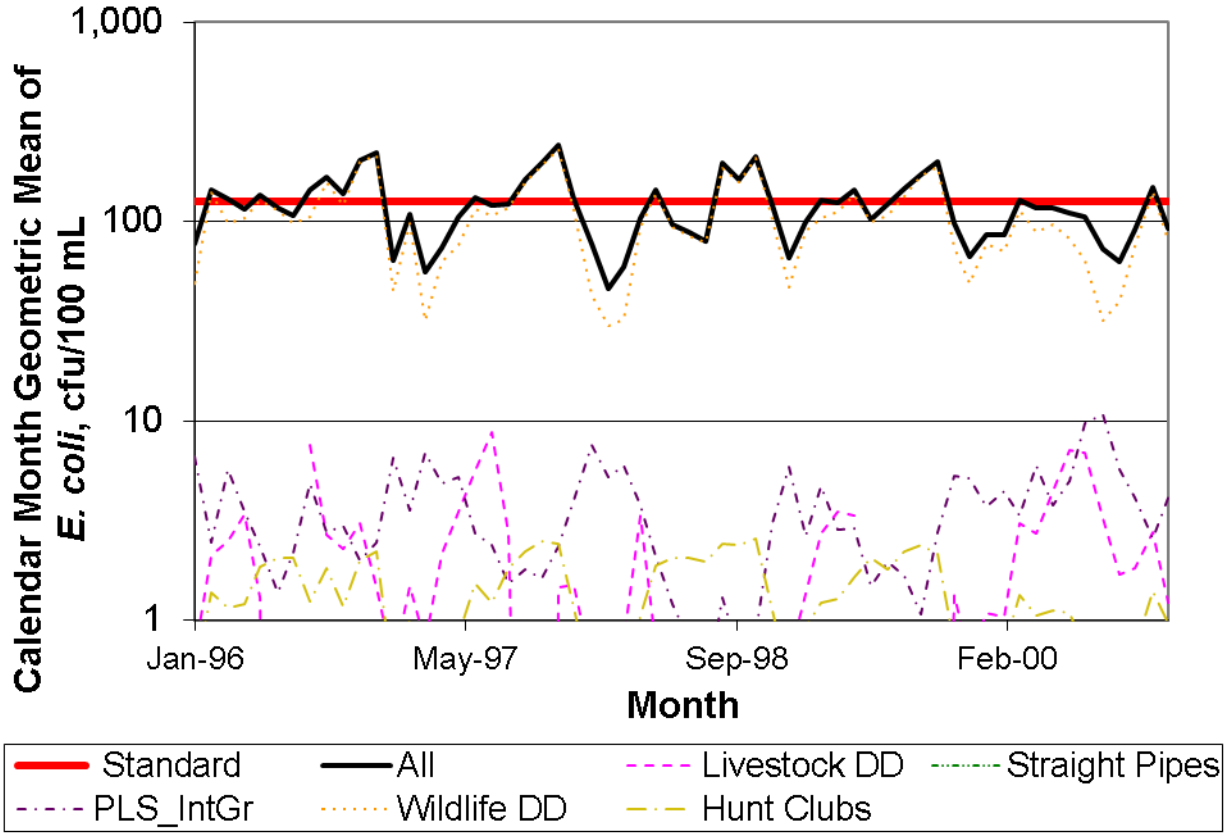

Figure 5.7. Contributions of different sources to the calendar-month geometric mean *E. coli* concentration at the outlet of Three Creek (K26R-03, sub-watershed 30) for existing conditions. (PLS_IntGr = pervious land runoff, interflow, and groundwater concentrations; DD = direct deposit)

The contributions from wildlife direct deposit dominate the calendar-month geometric mean concentration in all watersheds. In Tarrara Creek, the concentration is occasionally dominated by straight pipe contributions during lower flows. The cyclic nature of livestock direct deposit contributions is due to increased time spent in streams by livestock during summer months, combined with lower flow volumes; these two factors combine to increase bacteria concentrations during the summer months. The lower flow volumes in the summer months also increase bacteria concentrations originating from wildlife direct deposit and straight pipes. Contributions from pervious land surfaces contribute a less significant amount to the geometric mean concentration because they contribute zero bacteria whenever it is not raining; they are combined with the ever-present low level of interflow and groundwater contributions for display. From these graphs, it is evident that violations of the calendar-month geometric mean

criterion will be most controlled by contributions from direct in-stream sources (wildlife direct deposit and straight pipes), and further, that it will be impossible to meet the calendar-month geometric mean criterion in many watersheds without reducing contributions from wildlife direct deposits and straight pipes, as each of those sources alone violates the criterion during the allocation period.

5.3 Future Conditions

Although the comprehensive plans for all of the jurisdictions in the study area outlined potential growth areas in the study watersheds, projected growth described by the plans was minimal. Additionally, the Virginia Employment Commission (VEC) community profiles for Southampton, Sussex, and Greensville Counties show a projected decline in populations (VEC, 2011). The VEC projected populations for 2020 for Brunswick County do show a minor increase over current populations (4.73%); however, this is likely to be centered around existing towns in the county that are not located in the Three Creek watershed. Therefore, allocation scenarios were developed using existing residential, commercial, and industrial conditions in the watersheds.

As mentioned in Chapter 3, many of the current confined animal populations are different from those permitted. As a conservative assumption and to ensure the full permitted livestock populations can exist in the watershed, the greater of the actual livestock population and the permitted livestock population was used in the relevant watersheds. This amounted to increases in the poultry population and in the hog population in sub-watersheds TRE-9 and DMR-4 when compared to existing conditions.

Section 3.1.3 presented the manner in which biosolids would be represented for the future (allocation) scenarios. They are represented as permitted, which provides a considerable conservative estimate compared to actual practices, which occur less frequently on less land at a lower bacteria concentration than permitted.

5.3.1 Allocation Scenarios

A variety of allocation scenarios were evaluated to meet the *E. coli* TMDL goal of a calendar-month geometric mean concentration less than 126 cfu/100 mL. The scenarios and results are summarized in Table 5.8 - Table 5.14 for Darden Mill Run, Mill

Swamp, Flat Swamp, Tarrara Creek, and the three segments of Three Creek; recall that these reductions are those used for modeling, and implementation of these reductions will require implementation of BMPs as discussed at the beginning of this chapter. The recommended scenarios are highlighted in yellow in Table 5.8 - Table 5.14. The Mill Swamp and Three Creek (K27R-02) watersheds did not exceed the calendar month geometric mean criterion at existing conditions; therefore, their TMDLs only call for the elimination of illegal straight pipes. Recall that the criterion under which these were listed (>10% violation of the instantaneous criterion of 235 cfu/100 mL) is not the same as that for which the TMDL is developed. Existing conditions for these two watersheds do violate the instantaneous criterion, though at a low level not expected to violate the 10% criterion under intensive sampling.

Table 5.8. Bacteria allocation scenarios for the Darden Mill Run watershed.

Scenario Number	Required Fecal Coliform Loading Reductions to Meet the *E. coli* Standards, %								% Violation of *E. coli* Geo. Mean Criterion
	Livestock Direct Deposit	Loads from Pasture	Loads from Cropland	Straight Pipes	Loads from Residential Areas	Land Loads from Hunt Clubs	Hunt Club 'Direct Deposit'	Wildlife Direct Deposit	
Unsuccessful Scenarios									
Baseline Future Conditions	0	0	0	0	0	0	0	0	33
1	100	100	100	100	100	100	100	0	24
Successful Scenario									
2	95	0	0	100	0	0	75	65	0

Table 5.9. Bacteria allocation scenarios for the Mill Swamp watershed.

Scenario Number	Required Fecal Coliform Loading Reductions to Meet the *E. coli* Standards, %								% Violation of *E. coli* Geo. Mean Criterion
	Livestock Direct Deposit	Loads from Pasture	Loads from Cropland	Straight Pipes	Loads from Residential Areas	Land Loads from Hunt Clubs	Hunt Club 'Direct Deposit'	Wildlife Direct Deposit	
Baseline Future Conditions	0	0	0	0	0	0	0	0	0
1	0	0	0	100	0	0	0	0	0

Table 5.10. Bacteria allocation scenarios for the Flat Swamp watershed.

Scenario Number	Required Fecal Coliform Loading Reductions to Meet the *E. coli* Standards, %								% Violation of *E. coli* Geo. Mean Criterion
	Livestock Direct Deposit	Loads from Pasture	Loads from Cropland	Straight Pipes	Loads from Residential Areas	Land Loads from Hunt Clubs	Hunt Club 'Direct Deposit'	Wildlife Direct Deposit	
Unsuccessful Scenarios									
Baseline Future Conditions	0	0	0	0	0	0	0	0	65
1	100	100	100	100	100	100	100	0	45
Successful Scenario									
2	0	35	35	100	35	0	0	85	0

Table 5.11. Bacteria allocation scenarios for the Tarrara Creek watershed.

Scenario Number	Required Fecal Coliform Loading Reductions to Meet the *E. coli* Standards, %*								% Violation of *E. coli* Geo. Mean Criterion
	Livestock Direct Deposit	Loads from Pasture	Loads from Cropland	Straight Pipes	Loads from Residential Areas	Land Loads from Hunt Clubs	Hunt Club 'Direct Deposit'	Wildlife Direct Deposit	
Unsuccessful Scenarios									
Baseline Future Conditions	0	0	0	0	0	0	0	0	82
1	100	100	100	100	100	100	100	0	45
Successful Scenarios									
2	75	0	0	100	0	0	0	90	0

* Scenario 2 includes the reductions from Flat Swamp's scenario 2 (Table 5.10) applied to the Flat Swamp contributing area.

Table 5.12. Bacteria allocation scenarios for the Three Creek watershed (K26R-03, sub-watershed 30).

Scenario Number	Required Fecal Coliform Loading Reductions to Meet the *E. coli* Standards, %								% Violation of *E. coli* Geo. Mean Criterion
	Livestock Direct Deposit	Loads from Pasture	Loads from Cropland	Straight Pipes	Loads from Residential Areas	Land Loads from Hunt Clubs	Hunt Club 'Direct Deposit'	Wildlife Direct Deposit	
Unsuccessful Scenarios									
Baseline Future Conditions	0	0	0	0	0	0	0	0	40
1	100	100	100	100	100	100	100	0	30
Successful Scenario									
2	75	75	75	100	75	0	55	50	0

Table 5.13. Bacteria allocation scenarios for the Three Creek watershed (K26R-02, sub-watershed 20).

Scenario Number	Required Fecal Coliform Loading Reductions to Meet the *E. coli* Standards, %*								% Violation of *E. coli* Geo. Mean Criterion
	Livestock Direct Deposit	Loads from Pasture	Loads from Cropland	Straight Pipes	Loads from Residential Areas	Land Loads from Hunt Clubs	Hunt Club 'Direct Deposit'	Wildlife Direct Deposit	
Unsuccessful Scenarios									
Baseline Future Conditions	0	0	0	0	0	0	0	0	42
1	100	100	100	100	100	100	100	0	37
Successful Scenario									
2	90	0	0	100	0	0	45	85	0

* All scenarios other than baseline include the reductions from Three Creek (K26R-03)'s scenario 2 (Table 5.12) applied to the K26R-03 contributing area.

Table 5.14. Bacteria allocation scenarios for the Three Creek watershed (K27R-02, sub-watershed 1).

Scenario Number	Required Fecal Coliform Loading Reductions to Meet the *E. coli* Standards, %*								% Violation of *E. coli* Geo. Mean Criterion
	Livestock Direct Deposit	Loads from Pasture	Loads from Cropland	Straight Pipes	Loads from Residential Areas	Land Loads from Hunt Clubs	Hunt Club 'Direct Deposit'	Wildlife Direct Deposit	
Baseline Future Conditions	0	0	0	0	0	0	0	0	0
1	0	0	0	100	0	0	0	0	0

* All scenarios other than baseline include the reductions from Three Creek (K26R-03)'s scenario 2 (Table 5.12) applied to the K26R-03 contributing area and reductions from Three Creek (K26R-02)'s scenario 2 (Table 5.13) applied to the K26R-02 contributing area.

Unsuccessful scenarios labeled "1" are shown in Table 5.8 - Table 5.14 to illustrate the need for reductions in wildlife loads in nearly all the watersheds. In these cases, Scenario 1 demonstrates that compliance with the standard cannot be achieved through anthropogenic reductions alone. The wildlife reductions required in successful scenarios labeled "2" in these tables; these are the minimum reductions required assuming all anthropogenic sources are 100% reduced. The final anthropogenic reductions called for in the tables are less than 100% for two reasons: first, overall the anthropogenic sources were much lower contributors to the geometric mean

concentration; additionally, non-straight pipe anthropogenic sources are not significant contributors during the critical low flow conditions causing wildlife direct deposit to violate the criteria. Successful scenarios show the minimum modeled reductions needed to attain compliance with the *E. coli* standard. However, the true measure of water quality improvement in these watersheds will not be based on modeled results, but rather on the results of in-stream monitoring.

As a general rule, direct deposit sources (livestock, where present; wildlife; and straight pipes) control the constant inputs to the water body, and thus control the geometric mean of the daily average predictions over the entire month. Because of the immense wildlife populations in these watersheds, coupled with very few livestock sources and fewer sewage straight pipes, most of the watersheds require reductions in wildlife sources to achieve the geometric mean criterion. Figure 5.8 - Figure 5.14 display the simulated daily average and calendar month geometric mean concentrations at the outlets of Darden Mill Run, Mill Swamp, Flat Swamp, Tarrara Creek, and the three segments of Three Creek for the successful allocation scenarios.

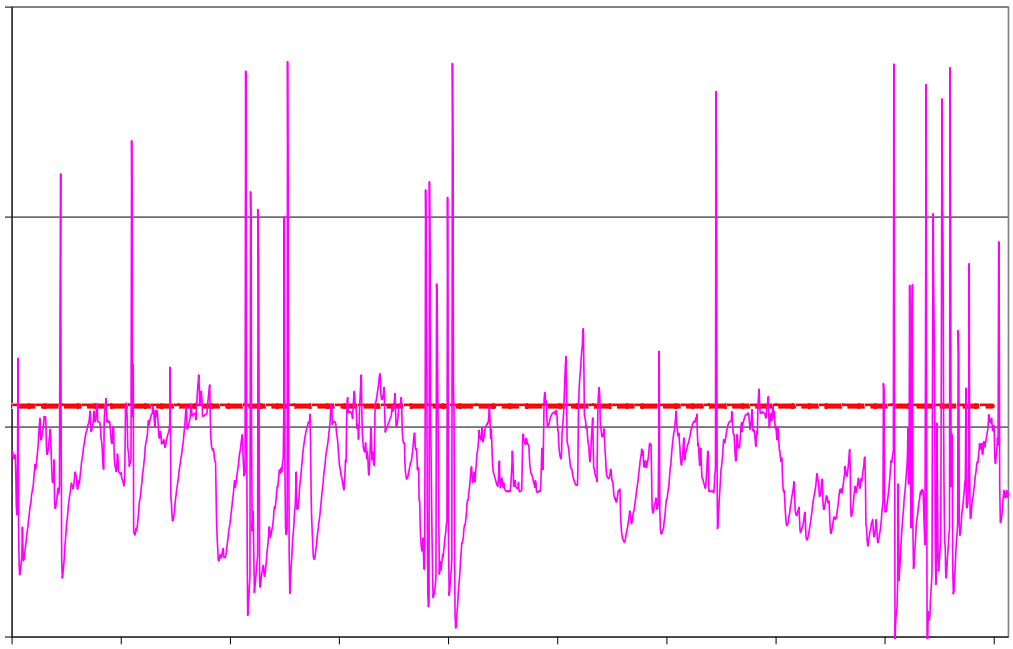

Figure 5.8. Bacteria concentrations for successful allocation scenario 2 for Darden Mill Run.

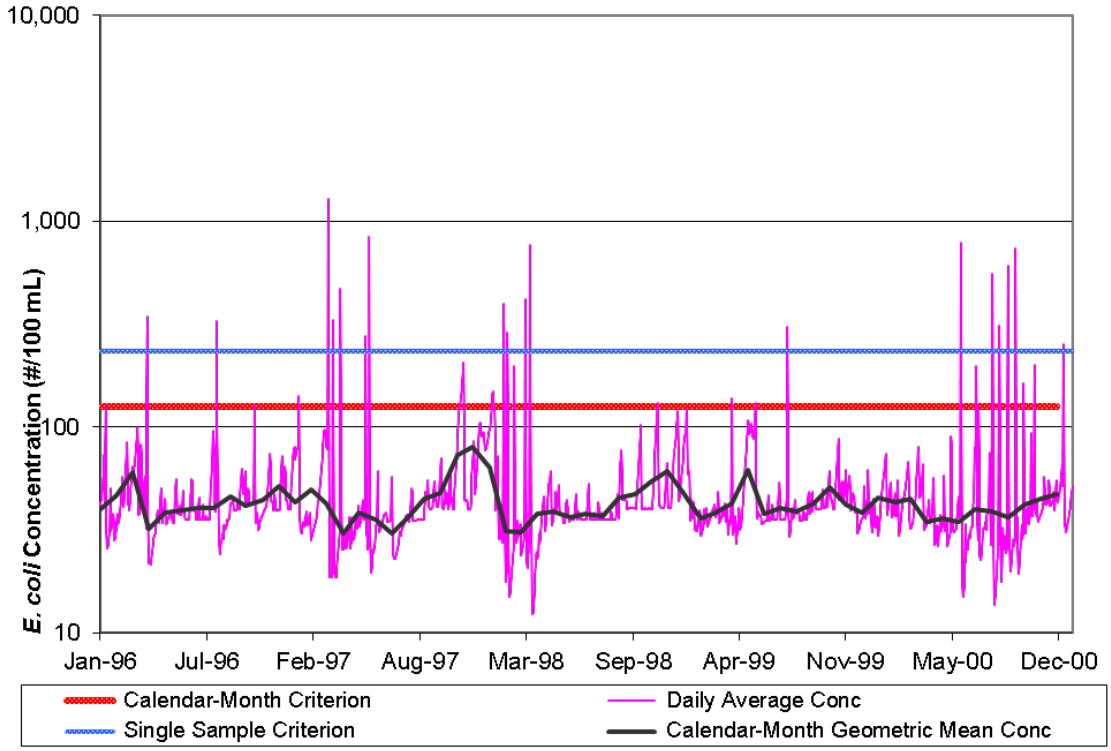

Figure 5.9. Bacteria concentrations for successful allocation scenario 1 for Mill Swamp.

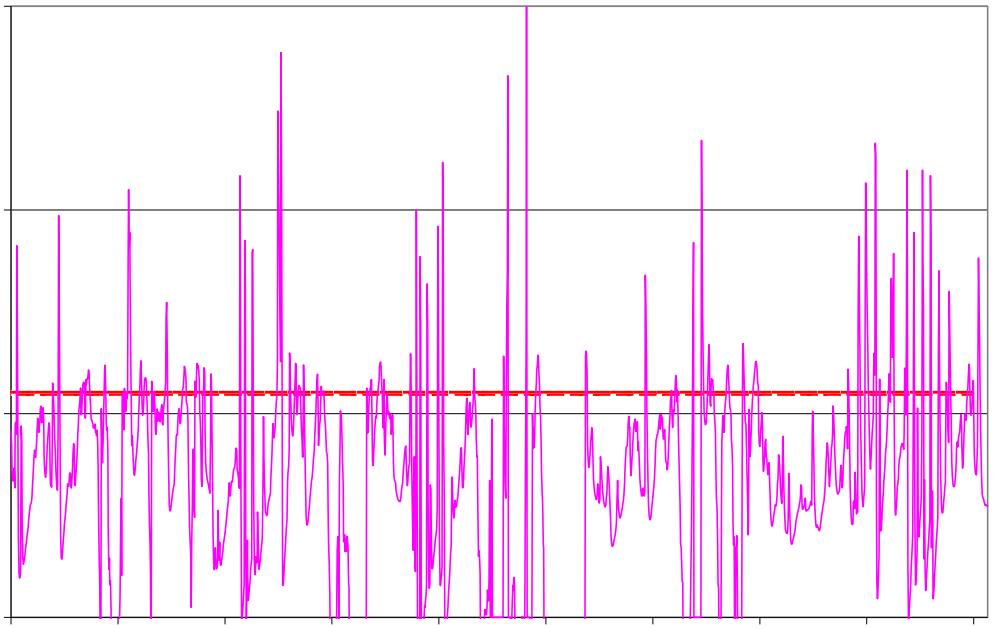

Figure 5.10. Bacteria concentrations for successful allocation scenario 2 for Flat Swamp.

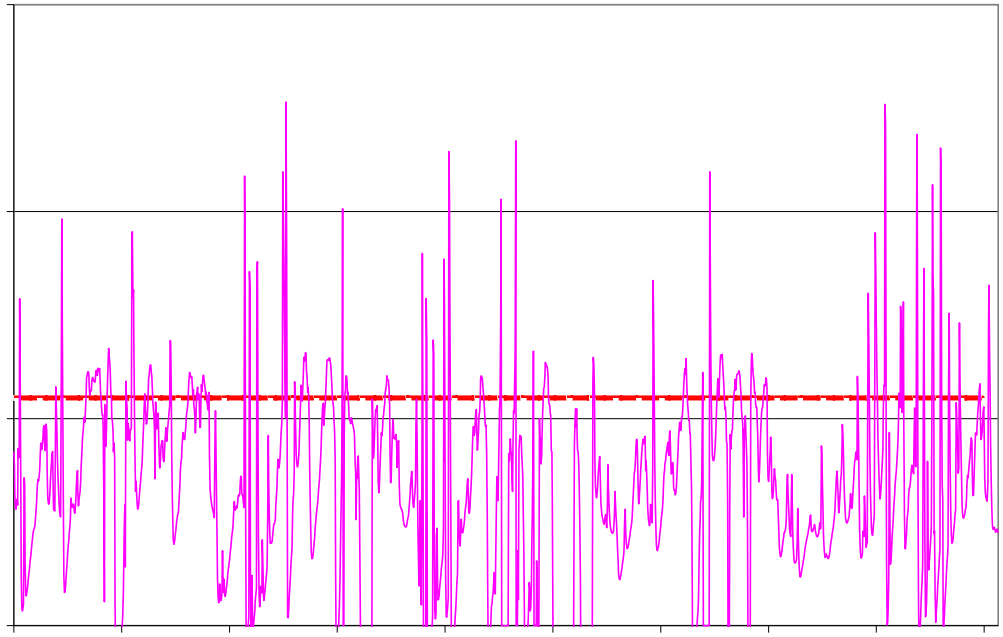

Figure 5.11. Bacteria concentrations for successful allocation scenario 2 for Tarrara Creek.

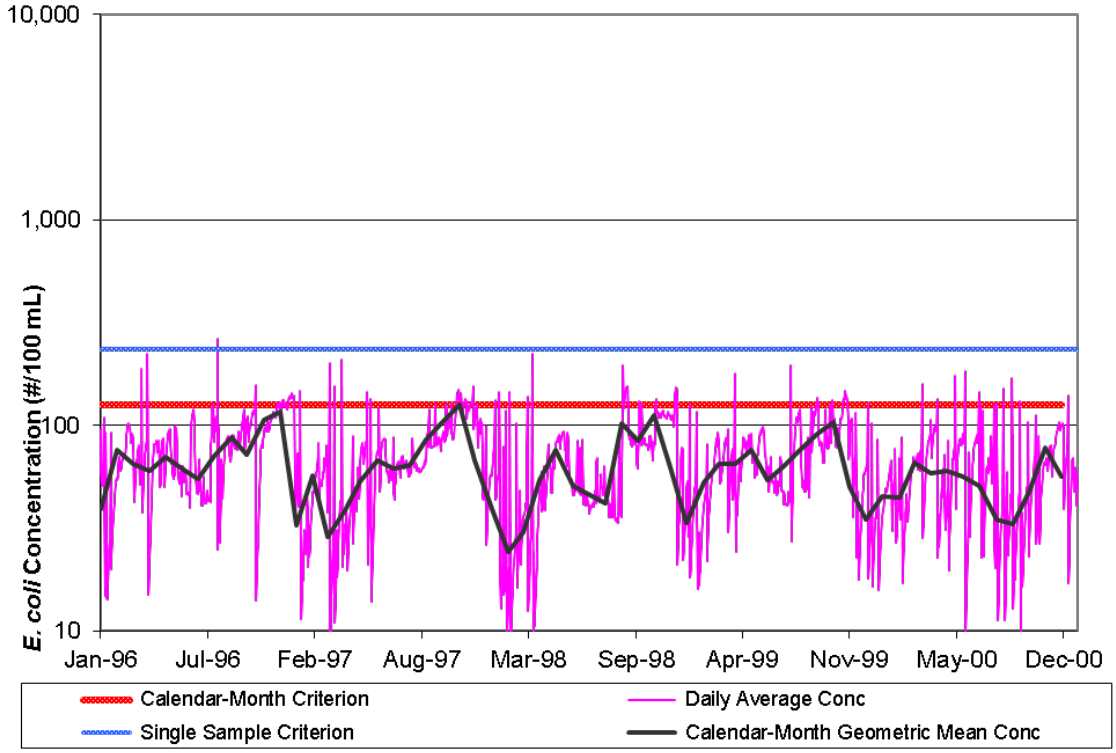

Figure 5.12. Bacteria concentrations for successful allocation scenario 2 for Three Creek (K26R-03, sub-watershed 30).

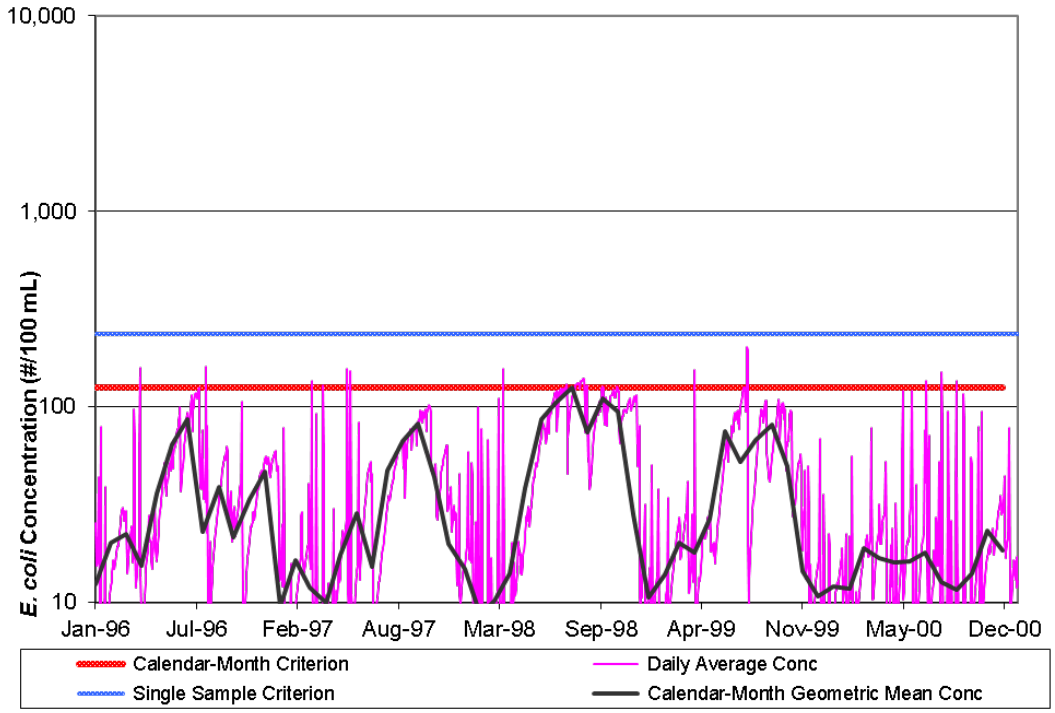

Figure 5.13. Bacteria concentrations for successful allocation scenario 2 for Three Creek (K26R-02, sub-watershed 20).

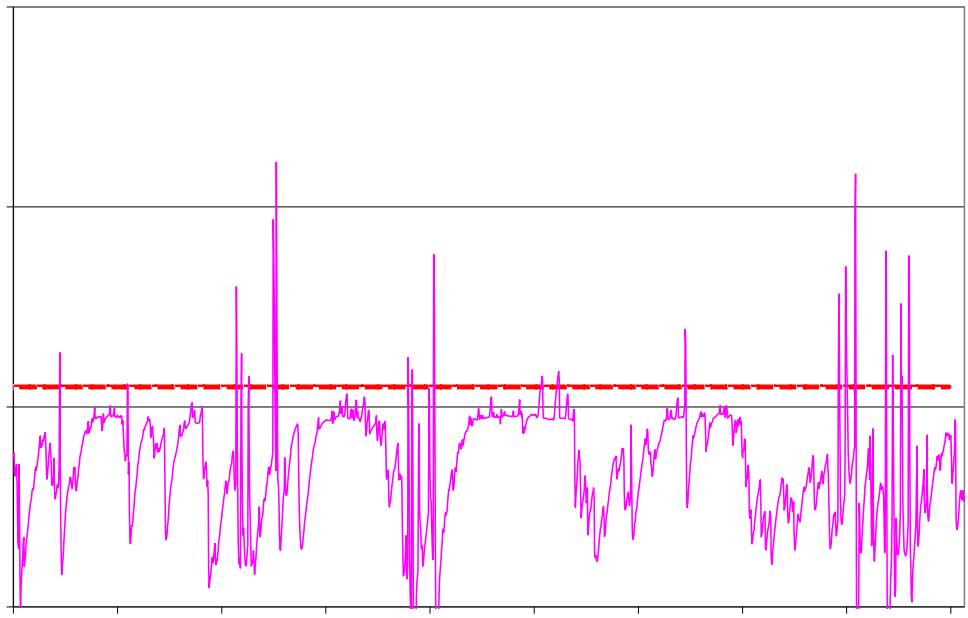

Figure 5.14. Bacteria concentrations for successful allocation scenario 1 for Three Creek (K27R-02, sub-watershed 1).

Loadings for the baseline future conditions and the chosen successful TMDL allocation scenarios are presented for nonpoint sources by land use in Table 5.15 - Table 5.21 and for direct nonpoint sources in Table 5.22 - Table 5.28. For sub-watershed specific loadings and reductions, see Appendix H.

Table 5.15. Estimated annual nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for TMDL allocation scenario 2 for Darden Mill Run.

Land use category	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)	Percent of total land deposited load from nonpoint sources	TMDL nonpoint source allocation load ($x10^{12}$ cfu/yr)	Percent Reduction from Baseline Load
Cropland	148	4	148	0
Pasture	3,106	88	3,106	0
Residential – septics	35	1	0	100
Residential – other	53	2	53	0
Forest – wildlife	135	4	135	0
Forest – hunt clubs	24	1	24	0
Wetlands – wildlife	7	<1	7	0
Wetlands – hunt clubs	2	<1	2	0
Total	3,510		3,475	1

Table 5.16. Estimated annual nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for TMDL allocation scenario 1 for Mill Swamp.

Land use category	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)	Percent of total land deposited load from nonpoint sources	TMDL nonpoint source allocation load ($x10^{12}$ cfu/yr)	Percent Reduction from Baseline Load
Cropland	79	14	79	0
Pasture	259	47	259	0
Residential – septics	15	3	0	100
Residential – other	49	9	49	0
Forest – wildlife	124	22	124	0
Forest – hunt clubs	22	4	22	0
Wetlands – wildlife	5	1	5	0
Wetlands – hunt clubs	2	<1	2	0
Total	555		540	3

Table 5.17. Estimated annual nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for TMDL allocation scenario 2 for Flat Swamp.

Land use category	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)	Percent of total land deposited load from nonpoint sources	TMDL nonpoint source allocation load ($x10^{12}$ cfu/yr)	Percent Reduction from Baseline Load
Cropland - biosolids	2,084	38	1,355	35
Cropland - other	125	2	81	35
Pasture	2,969	54	1,930	35
Residential - septics	17	<1	0	100
Residential - other	35	<1	23	35
Forest – wildlife	201	4	201	0
Forest – hunt clubs	33	1	33	0
Wetlands – wildlife	19	<1	19	0
Wetlands – hunt clubs	4	<1	4	0
Total	5,483		3,646	34

Table 5.18. Estimated annual nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for TMDL allocation scenario 2 for Tarrara Creek.

Land use category	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)†	Percent of total land deposited load from nonpoint sources	TMDL nonpoint source allocation load ($x10^{12}$ cfu/yr)†	Percent Reduction from Baseline Load
Cropland - biosolids	45	1	45	0
Cropland - other	226	5	226	0
Pasture	3,691	86	3,691	0
Residential - septics	15	<1	0	100
Residential - other	87	2	87	0
Forest – wildlife	157	4	157	0
Forest – hunt clubs	26	1	26	0
Wetlands – wildlife	20	<1	20	0
Wetlands – hunt clubs	4	<1	4	0
Total	4,271		4,256	<1

† Exclusive of Flat Swamp loads

Table 5.19. Estimated annual nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for TMDL allocation scenario 2 for Three Creek (K26R-03, sub-watershed 30).

Land use category	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)	Percent of total land deposited load from nonpoint sources	TMDL nonpoint source allocation load ($x10^{12}$ cfu/yr)	Percent Reduction from Baseline Load
Cropland	20	1	5	75
Pasture	2,093	85	523	75
Residential – septics	26	2	0	100
Residential – other	61	2	15	75
Forest – wildlife	227	9	227	0
Forest – hunt clubs	34	1	34	0
Wetlands – wildlife	1	<1	1	0
Wetlands – hunt clubs	0.3	<1	0.3	0
Total	2,462		805	67

Table 5.20. Estimated annual nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for TMDL allocation scenario 2 for Three Creek (K26R-02, sub-watershed 20).

Land use category	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)†	Percent of total land deposited load from nonpoint sources	TMDL nonpoint source allocation load ($x10^{12}$ cfu/yr)†	Percent Reduction from Baseline Load
Cropland	134	7	134	0
Pasture	957	52	957	0
Residential - septics	64	4	0	100
Residential - other	222	12	222	0
Forest – wildlife	356	20	356	0
Forest – hunt clubs	36	2	36	0
Wetlands – wildlife	49	3	49	0
Wetlands – hunt clubs	6	<1	6	0
Total	1,824		1,760	4

†Exclusive of K26R-03 loads

Table 5.21. Estimated annual nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for TMDL allocation scenario 2 for Three Creek (K27R-02, sub-watershed 1).

Land use category	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)†	Percent of total land deposited load from nonpoint sources	TMDL nonpoint source allocation load ($x10^{12}$ cfu/yr)†	Percent Reduction from Baseline Load
Cropland - biosolids	706	10	706	0
Cropland - other	465	7	465	0
Pasture	4,760	68	4,760	0
Residential – septics	48	1	0	100
Residential – other	172	2	172	0
Forest – wildlife	701	10	701	0
Forest – hunt clubs	99	1	99	0
Wetlands – wildlife	60	1	60	0
Wetlands – hunt clubs	12	<1	12	0
Total	7,023		6,975	1

†Exclusive of K26R-03 and K26R-02 loads

Table 5.22. Estimated annual direct nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for TMDL allocation scenario 2 for Darden Mill Run.

Source	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)	Percent of total direct deposited load from direct nonpoint source	TMDL direct nonpoint source allocation load ($x10^{12}$ cfu/yr)	Percent Reduction from Baseline Load
Livestock in Streams	10	17	0.5	95
Straight Pipes	0	0	0	100
Wildlife in Streams	48	83	17	65
Washoff from Hunt Clubs	0.3	<1	0.08	75
Total	58.3		17.6	70

Table 5.23. Estimated annual direct nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for TMDL allocation scenario 1 for Mill Swamp.

Source	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)	Percent of total direct deposited load from direct nonpoint source	TMDL direct nonpoint source allocation load ($x10^{12}$ cfu/yr)	Percent Reduction from Baseline Load
Livestock in Streams	0.3	1	0.3	0
Straight Pipes	4	9	0	100
Wildlife in Streams	41	90	41	0
Washoff from Hunt Clubs	0.2	<1	0.2	0
Total	45.5		41.5	9

Table 5.24. Estimated annual direct nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for TMDL allocation scenario 2 for Flat Swamp.

Source	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)	Percent of total direct deposited load from direct nonpoint source	TMDL direct nonpoint source allocation load ($x10^{12}$ cfu/yr)	Percent Reduction from Baseline Load
Livestock in Streams	8	10	8	0
Straight Pipes	<1	<1	0	100
Wildlife in Streams	73	90	11	85
Washoff from Hunt Clubs	0.4	<1	0.4	0
Total	81.4		19.4	76

Table 5.25. Estimated annual direct nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for TMDL allocation scenario 4 for Tarrara Creek.

Source	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)†	Percent of total direct deposited load from direct nonpoint source	TMDL direct nonpoint source allocation load ($x10^{12}$ cfu/yr)†	Percent Reduction from Baseline Load
Livestock in Streams	16	19	4	75
Straight Pipes	2	2	0	100
Wildlife in Streams	64	78	6.4	90
Washoff from Hunt Clubs	0.3	<1	0.3	0
Total	82.3		10.7	87

† Excludes loads from Flat Swamp

Table 5.26. Estimated annual direct nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for TMDL allocation scenario 2 for Three Creek (K26R-03, sub-watershed 30).

Source	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)	Percent of total direct deposited load from direct nonpoint source	TMDL direct nonpoint source allocation load ($x10^{12}$ cfu/yr)	Percent Reduction from Baseline Load
Livestock in Streams	1	2	0.3	75
Straight Pipes	0	0	0	100
Wildlife in Streams	43	97	21.5	50
Washoff from Hunt Clubs	0.3	1	0.14	55
Total	44.3		21.9	51

Table 5.27. Estimated annual direct nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for TMDL allocation scenario 2 for Three Creek (K26R-02, sub-watershed 20).

Source	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)†	Percent of total direct deposited load from direct nonpoint source	TMDL direct nonpoint source allocation load ($x10^{12}$ cfu/yr)†	Percent Reduction from Baseline Load
Livestock in Streams	2	2	0.2	90
Straight Pipes	0	0	0	100
Wildlife in Streams	103	98	15.5	85
Washoff from Hunt Clubs	0.4	<1	0.2	45
Total	105.4		15.9	85

† Exclusive of K26R-03 loads

Table 5.28. Estimated annual direct nonpoint source fecal coliform loads under baseline future conditions and corresponding reductions for TMDL allocation scenario 2 for Three Creek (K27R-02, sub-watershed 1).

Source	Baseline Future Conditions		Allocation Scenario	
	Baseline Conditions Load ($x10^{12}$ cfu/yr)†	Percent of total direct deposited load from direct nonpoint source	TMDL direct nonpoint source allocation load ($x10^{12}$ cfu/yr)†	Percent Reduction from Baseline Load
Livestock in Streams	10	5	10	0
Straight Pipes	0	0	0	100
Wildlife in Streams	181	94	181	0
Washoff from Hunt Clubs	1	1	1	0
Total	192		192	0

† Exclusive of K26R-03 and K26R-02 loads

The fecal coliform loads presented in Table 5.15 - Table 5.28 are the fecal coliform loads that result in in-stream *E. coli* concentrations that meet the applicable *E. coli* water quality standards after application of the VADEQ fecal coliform to *E. coli* translator to the HSPF-predicted mean daily fecal coliform concentrations.

5.3.2 Waste Load Allocation

There are currently no facilities permitted to discharge bacteria directly to the stream in the Darden Mill Run, Mill Swamp, Flat Swamp, and Tarrara Creek

watersheds. However, a waste load allocation (WLA) of approximately 1% of the TMDL was modeled for Darden Mill Run and Mill Swamp to allow for future growth in those watersheds. No modeled future growth will be included in this bacterial TMDL for Flat Swamp and Tarrara Creek due to the hydrologic nature of the swamp water (with significant evaporative losses during low flows) and the significant wildlife bacterial loading component in those watersheds. New permitted bacteria sources will be evaluated on an individual basis for Flat Swamp and Tarrara Creek. It may be considered appropriate to permit new facilities in the Flat Swamp and Tarrara Creek watersheds at the *E. coli* bacteria water quality standard criteria, 126 cfu/L. In consideration of factors presented in this bacteria TMDL for Flat Swamp and Tarrara Creek, EPA Region 3 TMDL staff are in agreement with this approach.

A WLA was assigned to the permitted point source facilities in the Three Creek watersheds (Table 5.29). The point sources were represented in the allocation scenario by their current permit conditions; no reductions were required from the point sources in the TMDL. Current permit requirements are expected to result in attainment of the *E. coli* WLA as required by the TMDL. Point source contributions to bacteria concentrations, even in terms of maximum flow, are minimal. In addition, the point source facilities are required to discharge at or below the bacteria water quality criteria and therefore typically cannot cause a violation of those criteria without also violating their discharge permits. Because the permits for these facilities already protect against violating the bacteria water quality standard, there is no need to modify the existing permits.

Table 5.29. Point sources discharging into the Three Creek watershed.

Permit Number	Facility Name	Design Flow (gpd)	Permitted *E. coli* Conc. (cfu/100 mL)	Permitted *E. coli* Load (cfu/yr)
VA0062499	VDOC Southampton Correctional Center	4.5×10^5	126	7.84×10^{11}
VA0077259	Three Creek STP	7.5×10^5	126	1.31×10^{12}
VA0020761	Town of Jarratt STP	1.6×10^5	126	2.79×10^{11}
VAG404036	Residence	500	126	8.71×10^8
VAG403043	Drewryville Fas-Shop	621	126	1.08×10^9

A scenario has also been developed to account for future growth in permitted operations in the three segments of the Three Creek watershed. The point source flows permitted by VADEQ were increased by a factor of 5, while retaining the 126 cfu/100mL limit on *E. coli* bacteria concentration. This effectively increased the WLA for the three sections of Three Creek by a factor of 5. The WLA for each section of Three Creek is increased with the addition of the WLAs for the upstream segment(s).

5.3.3 Summary of the TMDL Allocation Scenarios for Bacteria

TMDLs for *E. coli* have been developed for Mill Swamp, Darden Mill Run, Flat Swamp, Tarrara Creek, and three segments of Three Creek. The TMDLs address the following issues:

1. The TMDLs meet the calendar-month geometric mean component of the water quality standard.
2. Because *E. coli* loading data were not available to quantify nonpoint source bacterial loads, available fecal coliform loading data were used as input to HSPF. HSPF was then used to simulate in-stream fecal coliform concentrations. The VADEQ fecal coliform to *E. coli* concentration translator equation was then used to convert the simulated fecal coliform concentrations to *E. coli* concentrations.
3. The TMDLs were developed taking into account all fecal bacteria sources (anthropogenic and natural) from both point and nonpoint sources, as well as bacterial die-off occurring in storage or on the land surface and decay occurring in stream.
4. An implicit margin of safety (MOS) was incorporated by utilizing professional judgment and conservative estimates of model parameters.
5. Both high- and low-flow stream conditions were considered while developing the TMDLs. In the study watersheds, violations of the water quality standard were caused during low stream flow and high stream flow; because the TMDL was developed using a continuous simulation model, it applies to both high- and low-flow conditions.

6. Both the flow regime and bacteria loading to the streams are seasonal. The TMDLs account for these seasonal effects.

Using equation 5.1, the summary of the bacteria TMDLs for Darden Mill Run, Mill Swamp, Flat Swamp, Tarrara Creek, and three segments of Three Creek for the selected allocation scenarios are given in Table 5.30 - Table 5.36, respectively.

Table 5.30. Estimated annual *E. coli* loadings (cfu/yr) at the watershed outlet used for the Darden Mill Run bacteria TMDL.

Parameter	ΣWLA	ΣLA	MOS*	TMDL
E. coli	4.10×10^{11}	410.17×10^{11}	--	414.27×10^{11}
Future Growth	*4.10×10^{11}*			

*Implicit MOS

Table 5.31. Estimated annual *E. coli* loadings (cfu/yr) at the watershed outlet used for the Mill Swamp bacteria TMDL.

Parameter	ΣWLA	ΣLA	MOS*	TMDL
E. coli	1.93×10^{11}	192.60×10^{11}	--	194.53×10^{11}
Future Growth	*1.93×10^{11}*			

*Implicit MOS

Table 5.32. Estimated annual *E. coli* loadings (cfu/yr) at the watershed outlet used for the Flat Swamp bacteria TMDL.

Parameter	ΣWLA‡	ΣLA	MOS*	TMDL
E. coli	--	378.2×10^{11}	--	378.2×10^{11}

*Implicit MOS
‡New permitted bacteria sources will be evaluated on an individual basis for Flat Swamp

Table 5.33. Estimated annual *E. coli* loadings (cfu/yr) at the watershed outlet used for the Tarrara Creek bacteria TMDL.

Parameter	ΣWLA‡	ΣLA	MOS*	TMDL
E. coli	--	657.7×10^{11}	--	657.7×10^{11}

*Implicit MOS
‡New permitted bacteria sources will be evaluated on an individual basis for Tarrara Creek

Table 5.34. Estimated annual *E. coli* loadings (cfu/yr) at the watershed outlet used for the Three Creek (K26R-03, sub-watershed 30) bacteria TMDL.

Parameter	ΣWLA	ΣLA	MOS*	TMDL
E. coli	0.05×10^{11}	445.06×10^{11}	--	445.11×10^{11}
VAG404036	*8.71×10^{8}*			
Future Growth- K26R-03	*4.36×10^{9}*			

*Implicit MOS

Table 5.35. Estimated annual *E. coli* loadings (cfu/yr) at the watershed outlet used for the Three Creek (K26R-02, sub-watershed 20) bacteria TMDL.

Parameter	ΣWLA	ΣLA	MOS*	TMDL
E. coli	95.39×10^{11}	156.91×10^{11}	--	252.30×10^{11}
VAG404036	*8.71×10^{8}*			
VA0077259	*1.31×10^{12}*			
VA0020761	*2.79×10^{11}*			
Future Growth – K26R-03	*4.36×10^{9}*			
Future Growth – K26R-02†	*7.95×10^{12}*			

*Implicit MOS
†excluding K26R-03

Table 5.36. Estimated annual *E. coli* loadings (cfu/yr) at the watershed outlet used for the Three Creek (K27R-02, sub-watershed 1) bacteria TMDL.

Parameter	ΣWLA	ΣLA	MOS*	TMDL
E. coli	142.5×10^{11}	755.49×10^{11}	--	897.99×10^{11}
VAG404036	*8.71×10^{8}*			
VA0077259	*1.31×10^{12}*			
VA0020761	*2.79×10^{11}*			
VA0062499	*7.84×10^{11}*			
VAG403043	*1.08×10^{9}*			
Future Growth – K26R-03	*4.36×10^{9}*			
Future Growth – K26R-02†	*7.95×10^{12}*			
Future Growth – K27R-02‡	*3.93×10^{12}*			

*Implicit MOS
†excluding K26R-03
‡excluding K26R-03 and K26R-02

5.3.4 Daily *E. coli* TMDL

The USEPA has mandated that TMDL studies completed in 2007 and later include a daily maximum load as well as the average annual load shown in the previous section. The daily load was determined as the product of a representative flow rate from the watershed and the appropriate concentration criterion from the water quality standard. This section summarizes the daily maximum loads for Darden Mill Run, Mill Swamp, Flat Swamp, Tarrara Creek, and the three segments of Three Creek.

5.3.4.1 Hydrologic Considerations

According to guidance from EPA (USEPA, 2006) it was necessary to assess the flow duration curve to determine an appropriate flow rate to use in the load calculation. EPA guidance suggests that the flow duration curve should be plotted using observed continuous flow data; because continuous flow data were not available for the study

watersheds, flows from the surrogate watershed used in calibration (North Meherrin River for Three Creek segment K26R-03 and Blackwater River for the remaining segments) were used instead. As is specified in the EPA guidance, the observed flows from Blackwater River (or North Meherrin River) were multiplied by the ratio of each study watershed's area to the drainage area above the Blackwater River (or North Meherrin River) gage. The flow rate corresponding to the 99th percentile flow (that is, the flow rate exceeded by only 1% of the observed flows) was used in calculation in order to determine the *maximum* daily load. The flow rate corresponding to the 99th percentile flow for Blackwater River is 1902 cfs; for North Meherrin River, 483 cfs. For Darden Mill Run, the corresponding flow rate was 182 cfs; for Mill Swamp, 162 cfs; for Flat Swamp, 243 cfs; for Tarrara Creek, 456 cfs; for Three Creek segment K26R-03, 364 cfs; for Three Creek segment K26R-02, 695 cfs; and for Three Creek segment K27R-02, 1432 cfs.

5.3.4.2 Daily Load

Setting a *maximum daily* load will help ensure that the annual loads given in Table 5.30 – Table 5.36 are appropriately distributed such that on any given day the single sample component of the bacteria water quality standard will be met. The maximum daily load was computed as the product of the critical flow condition and the geometric mean criterion (126 cfu/100 mL) used as a target for allocation scenarios. Since the annual WLA is already based on a maximum daily permitted flow and a maximum daily permitted concentration, the daily WLA is calculated as the annual WLA divided by 365; the daily LA is then the TMDL less the WLA. The resulting daily maximum loadings are shown in Table 5.37. The actual maximum daily load is dependent upon flow conditions, and progress toward water quality improvement will be assessed against the numeric water quality criteria (126 cfu *E. coli*/100 mL for a calendar month geometric mean, and 235 cfu *E. coli*/100 mL for a single sample).

Table 5.37. Maximum daily *E. coli* loadings (cfu/day) at the watershed outlets.

Watershed	ΣWLA[†]	ΣLA	MOS[*]	TMDL
Darden Mill Run	1.12×10^{9}	5.61×10^{11}	--	5.62×10^{11}
Future Growth	*1.12×10^{9}*			
Mill Swamp	5.28×10^{8}	5.00×10^{11}	--	5.01×10^{11}
Future Growth	*5.28×10^{8}*			
Flat Swamp	--	7.48×10^{11}	--	7.48×10^{11}
Tarrara Creek[‡]	--	1.41×10^{12}	--	1.41×10^{12}
Three Creek K26R-03	1.43×10^{7}	1.12×10^{12}	--	1.12×10^{12}
VAG404036	*2.39×10^{6}*			
Future Growth- K26R-03	*1.19×10^{7}*			
Three Creek K26R-02[‡]	2.61×10^{10}	2.12×10^{12}	--	2.14×10^{12}
VAG404036	*2.39×10^{6}*			
VA0077259	*3.59×10^{9}*			
VA0020761	*7.64×10^{8}*			
Future Growth - K26R-03	*1.19×10^{7}*			
Future Growth - K26R-02	*2.18×10^{10}*			
Three Creek K27R-02[‡]	3.90×10^{10}	4.38×10^{12}	--	4.41×10^{12}
VAG404036	*2.39×10^{6}*			
VA0077259	*3.59×10^{9}*			
VA0020761	*7.64×10^{8}*			
VA0062499	*2.15×10^{9}*			
VAG403043	*2.96×10^{6}*			
Future Growth - K26R-03	*1.19×10^{7}*			
Future Growth - K26R-02	*2.18×10^{10}*			
Future Growth - K27R-02	*1.08×10^{10}*			

[†]all issued permits within the WLA will be implemented in accordance with permitting regulations; new permitted bacteria sources will be evaluated on an individual basis for Flat Swamp and Tarrara Creek.
[*]Implicit MOS
[‡]inclusive of upstream impaired segments

6 TMDL Implementation and Reasonable Assurance

Once a TMDL has been approved by EPA, measures must be taken to reduce pollution levels from both point and nonpoint sources in the stream (see Section 6.4.2). For point sources, all new or revised VPDES/NPDES permits must be consistent with the TMDL WLA pursuant to 40 CFR §122.44 (d)(1)(vii)(B) and must be submitted to EPA for approval. The measures for nonpoint source reductions, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in an iterative process that is described along with specific BMPs in the implementation plan. The process for developing an implementation plan has been described in the "TMDL Implementation Plan Guidance Manual", published in July 2003 and available upon request from the VADEQ and VADCR TMDL project staff or at http://www.deq.virginia.gov/tmdl/implans/ipguide.pdf (VADCR and VADEQ, 2003). With successful completion of implementation plans, local stakeholders will have a blueprint to restore impaired waters and enhance the value of their land and water resources. Additionally, development of an approved implementation plan may enhance opportunities for obtaining financial and technical assistance during implementation.

6.1 Staged Implementation

In general, Virginia intends for the required bacteria reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. For example, in agricultural areas of the watershed, the most promising best 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 straight pipe discharges and failing septic systems should be a primary implementation focus because of their health implications. These components could be implemented through education on septic tank pump-outs, a septic system

installation/repair/replacement program, and the use of alternative waste treatment systems.

In urban areas, reducing the human bacteria loading from leaking sewer lines could be accomplished through a sanitary sewer inspection and management program. Other BMPs that might be appropriate for controlling urban wash-off from parking lots and roads and that could be readily implemented may include more restrictive ordinances to reduce fecal loads from pets, improved garbage collection and control, and improved street cleaning.

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

1. It enables tracking of water quality improvements following BMP implementation through follow-up stream monitoring;
2. It provides a measure of quality control, given the uncertainties inherent in computer simulation modeling;
3. It provides a mechanism for developing public support through periodic updates on BMP implementation and water quality improvements;
4. It helps ensure that the most cost effective practices are implemented first; and
5. It allows for the evaluation of the adequacy of the TMDL in achieving water quality standards.

Watershed stakeholders will have opportunity to participate in the development of the TMDL implementation plan. While specific goals for BMP implementation will be established as part of the implementation plan development, the following Stage 1 scenarios are targeted at controllable, anthropogenic bacteria sources and can serve as starting points for targeting BMP implementation activities.

6.2 Stage 1 Scenarios

The goal of the Stage 1 scenarios is to reduce the bacteria loadings from controllable sources (excluding wildlife) such that violations of the instantaneous criterion (235 cfu/100mL) are less than 10.5 percent while requiring no reductions from wildlife sources. However, because wildlife direct deposit contributions cause extreme violations of the instantaneous criterion by themselves in most watersheds, that goal was not achievable for most of the impaired watersheds. Therefore, the ‘successful’

Stage 1 scenarios in most of the watersheds simply remove the required wildlife reductions from the successful TMDL scenarios. The Stage 1 scenarios were generated with the same model setup as was used for the TMDL allocation scenarios.

Continued monitoring on the Mill Swamp watershed is expected to demonstrate that the instantaneous criterion is violated less than 10% of the time. However, should this not be the case, it is suggested that, during the latter stages of adaptive implementation where multiple years of data are available, reductions similar to those in neighboring Darden Mill Run be implemented. Achievement of the stage 1 scenarios in segments K26R-03 and K26R-02 of Three Creek are expected to achieve the stage 1 goals in the lowest Three Creek segment (K27R-02).

One successful scenario was selected for each of the impaired watersheds (Table 6.1). *E. coli* concentrations resulting from application of the fecal coliform to *E. coli* translator equation to the fecal coliform concentrations predicted by the model for each stage 1 scenario are presented graphically in Figure 6.1 through Figure 6.7.

Table 6.1. Allocation scenario for Stage 1 TMDL implementation for Darden Mill Run, Mill Swamp, Flat Swamp, Tarrara Creek, and three segments of Three Creek.

Impaired Segment	Required Fecal Coliform Loading Reductions to Meet the Stage 1 Goal, %							% Violation of *E. coli* Single Sample Standard
	Livestock Direct Deposit	Loads from Cropland	Loads from Pasture	Household Straight Pipes & Failing Septics	Non-Human Loads from Residential Areas	Hunt Club 'Direct Deposit'	Wildlife Direct Deposit	
Darden Mill Run	95	0	0	100	0	75	0	27
Mill Swamp	0	0	0	100	0	0	0	1
Flat Swamp	0	35	35	100	35	0	0	37
Tarrara Creek	75	0	0	100	0	0	0	39
Three Creek (K26R-03)	0	0	0	100	0	0	0	8
Three Creek (K26R-02)	90	0	0	100	0	45	0	27
Three Creek (K7R-02)	0	0	0	100	0	0	0	1

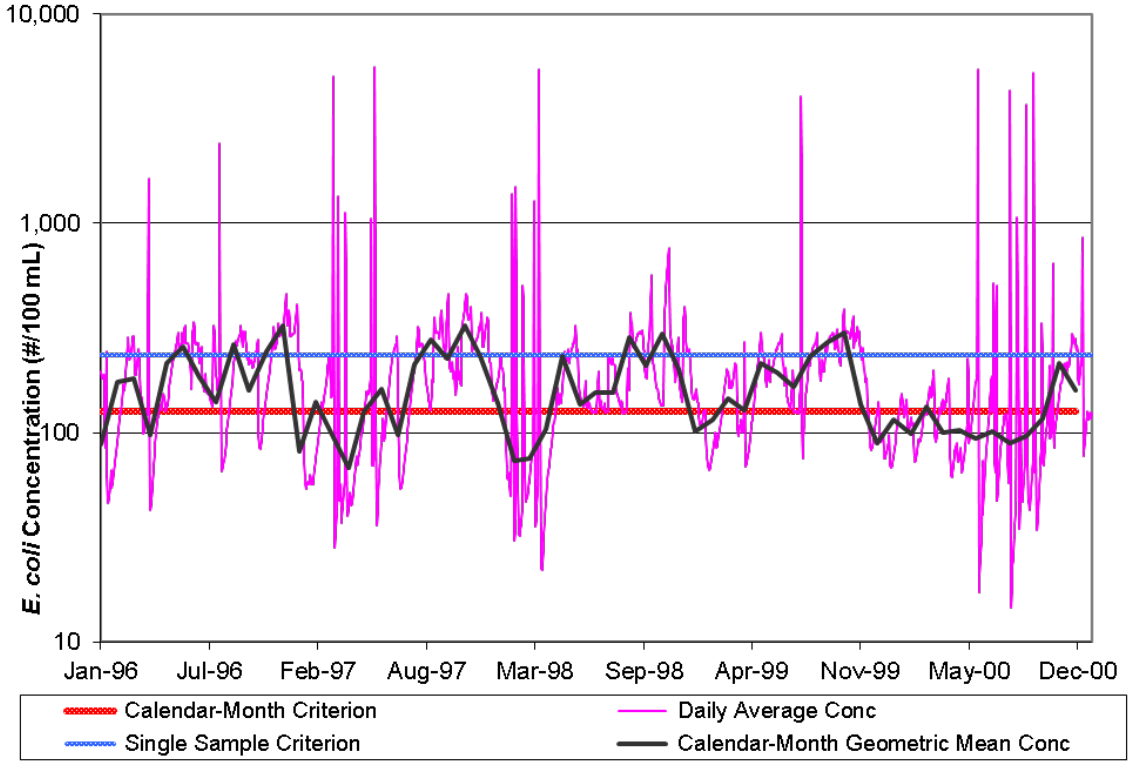

Figure 6.1. Simulated *E. coli* concentrations with the two components of the bacteria standard for the Stage 1 implementation scenario for Darden Mill Run.

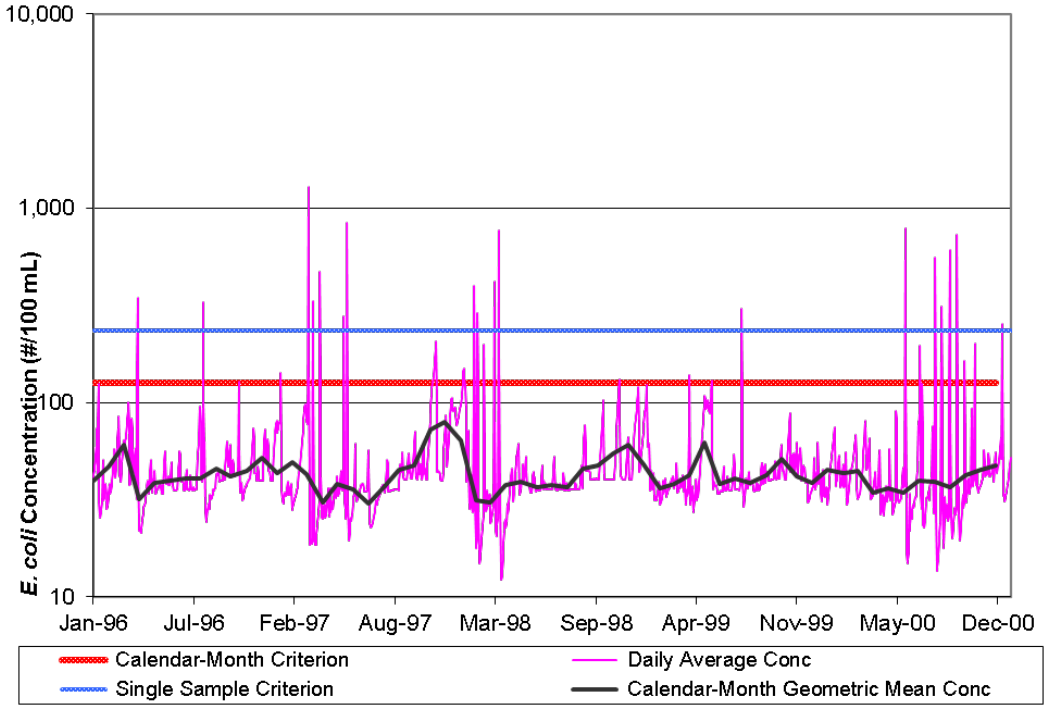

Figure 6.2. Simulated *E. coli* concentrations with the two components of the bacteria standard for the Stage 1 implementation scenario for Mill Swamp.

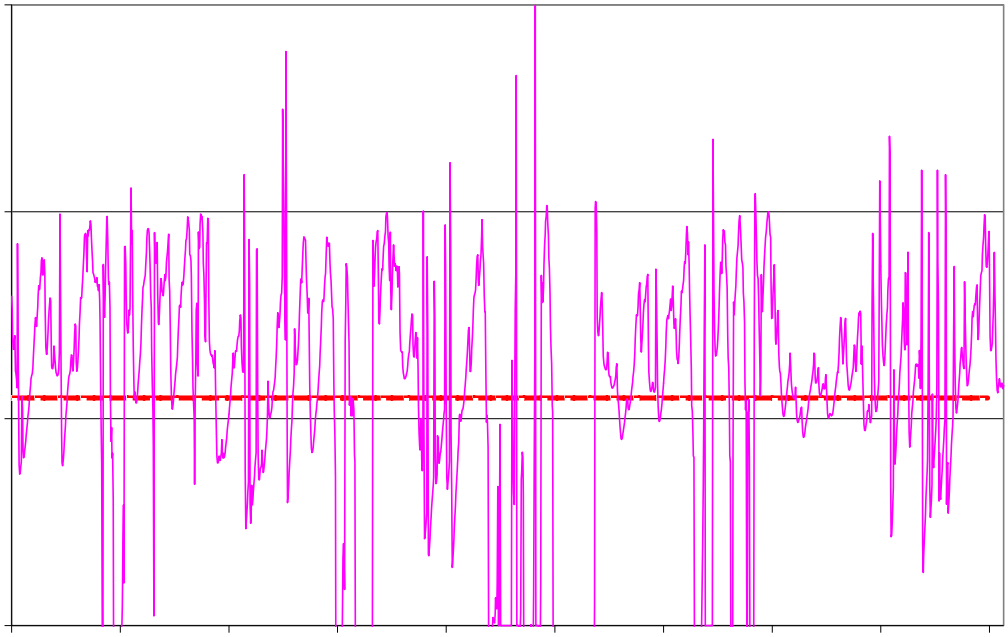

Figure 6.3. Simulated *E. coli* concentrations with the two components of the bacteria standard for the Stage 1 implementation scenario for Flat Swamp.

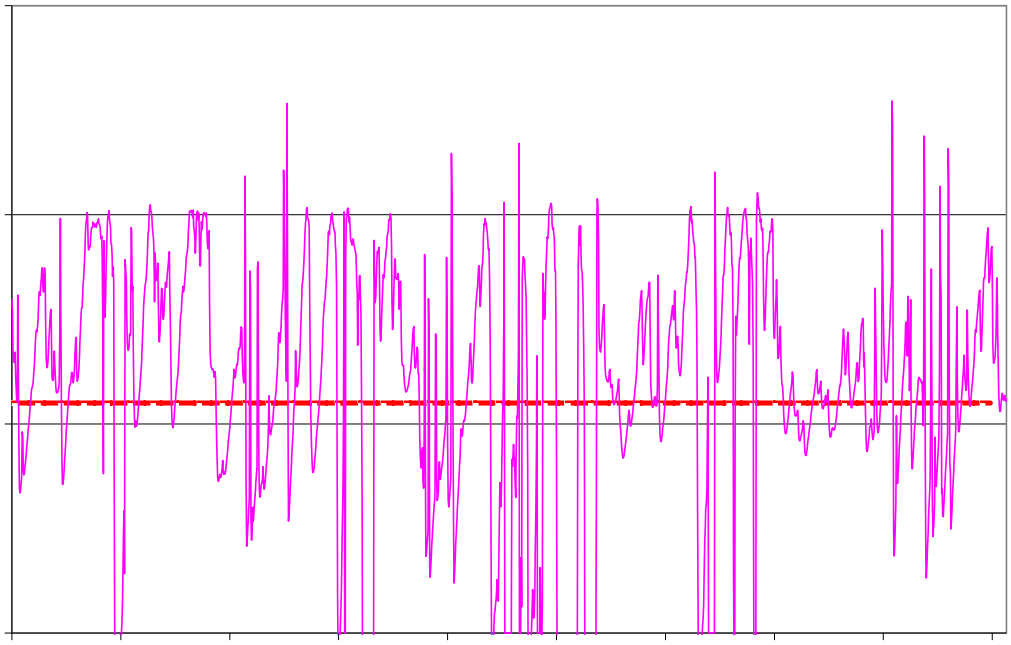

Figure 6.4. Simulated *E. coli* concentrations with the two components of the bacteria standard for the Stage 1 implementation scenario for Tarrara Creek.

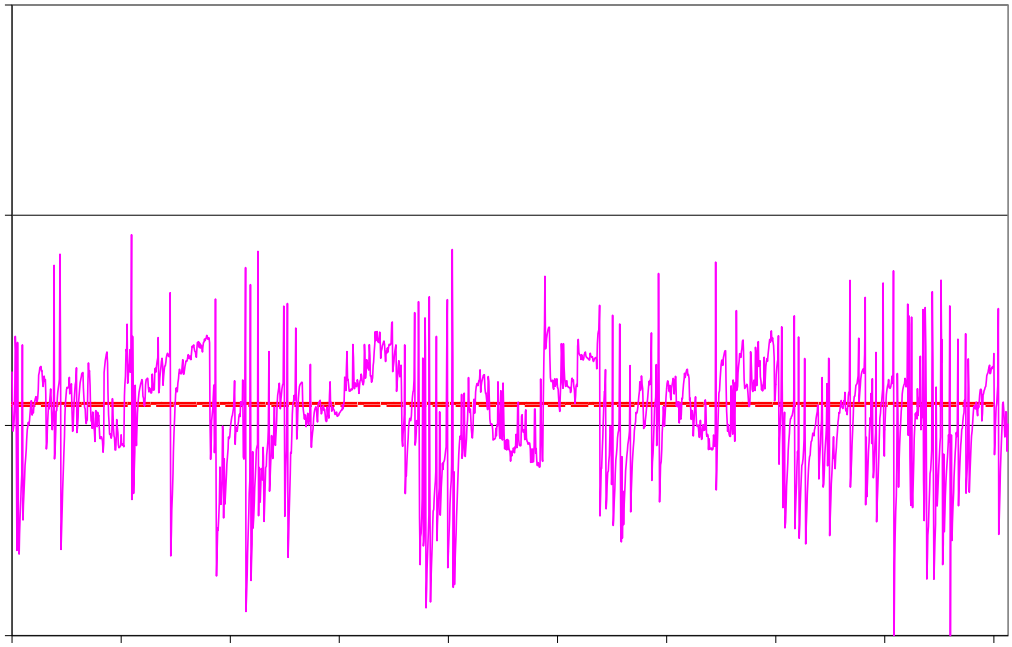

Figure 6.5. Simulated *E. coli* concentrations with the two components of the bacteria standard for the Stage 1 implementation scenario for Three Creek (K26R-03, sub-watershed 30).

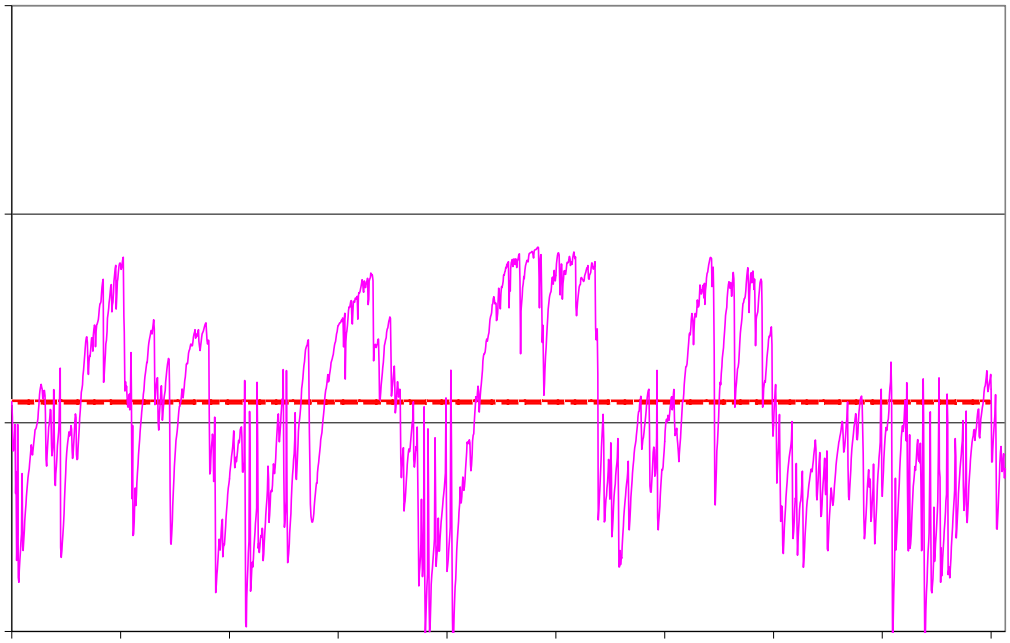

Figure 6.6. Simulated *E. coli* concentrations with the two components of the bacteria standard for the Stage 1 implementation scenario for Three Creek (K26R-02, sub-watershed 20).

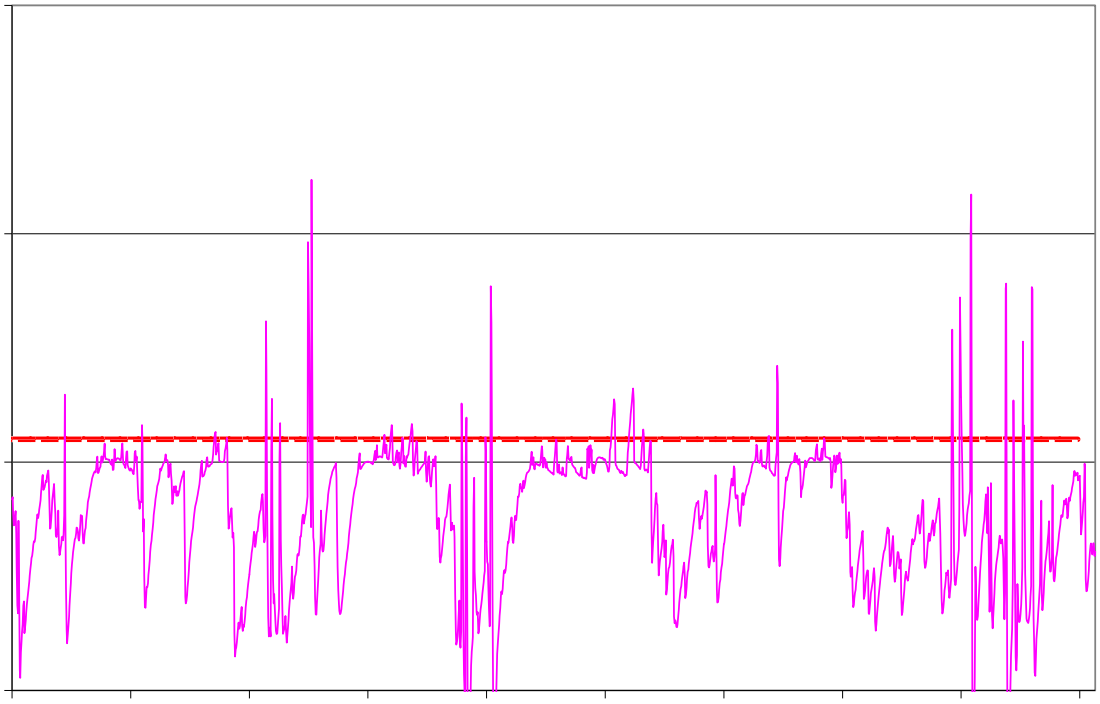

Figure 6.7. Simulated *E. coli* concentrations with the two components of the bacteria standard for the Stage 1 implementation scenario for Three Creek (K27R-02, sub-watershed 1).

6.3 Link to Ongoing Restoration Efforts

Implementation of this TMDL will contribute to on-going water quality improvement efforts aimed at restoring water quality in the Nottoway River, the Meherrin River and the Chowan River.

6.4 Reasonable Assurance for Implementation

6.4.1 Follow-up Monitoring

Following the development of the TMDL, the Department of Environmental Quality (DEQ) will make every effort to continue to monitor the impaired streams in accordance with its ambient monitoring program. VADEQ's Ambient Watershed Monitoring Plan for conventional pollutants calls for watershed monitoring to take place on a rotating basis, bi-monthly for two consecutive years of a six-year cycle. In accordance with VADEQ Guidance Memo No. 03-2004, during periods of reduced

resources, monitoring can temporarily discontinue until the TMDL staff determines that implementation measures to address the source(s) of impairments are being installed. Monitoring can resume at the start of the following fiscal year, next scheduled monitoring station rotation, or where deemed necessary by the regional office or TMDL staff, as a new special study.

The purpose, location, parameters, frequency, and duration of the monitoring will be determined by the VADEQ staff, in cooperation with DCR staff, the Implementation Plan Steering Committee, and local stakeholders. Whenever possible, the location of the follow-up monitoring station(s) will be the same as the listing station(s). At a minimum, the monitoring station must be representative of the original impaired segment. The details of the follow-up monitoring will be outlined in the Annual Water Monitoring Plan prepared by each VADEQ Regional Office. Other agency personnel, watershed stakeholders, etc. may provide input on the Annual Water Monitoring Plan. These recommendations must be made to the VADEQ regional TMDL coordinator by September 30 of each year.

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

In some cases, watersheds will require monitoring above and beyond what is included in VADEQ's standard monitoring plan. Ancillary monitoring by citizens, watershed groups, local government, or universities is an option that may be used in such cases. An effort should be made to ensure that ancillary monitoring follows established QA/QC guidelines in order to maximize compatibility with VADEQ monitoring data. In instances where citizens' monitoring data are not available and additional monitoring is needed to assess the effectiveness of targeting efforts, TMDL staff may request of the monitoring managers in each regional office an increase in the number of stations or monitor existing stations at a higher frequency in the watershed.

The additional monitoring beyond the original bimonthly single station monitoring will be contingent on staff resources and available laboratory budget. More information on citizen monitoring in Virginia and QA/QC guidelines is available at http://www.deq.virginia.gov/cmonitor/.

To demonstrate that the watershed is meeting water quality standards in watersheds where corrective actions have taken place (whether or not a TMDL or TMDL Implementation Plan has been completed), VADEQ must meet the minimum data requirements from the original listing station or a station representative of the originally listed segment. The minimum data requirement for conventional pollutants (bacteria, dissolved oxygen, etc) is bimonthly monitoring for two consecutive years. For biological monitoring, the minimum requirement is two consecutive samples (one in the spring and one in the fall) in a one year period.

6.4.2 Regulatory Framework

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

Additionally, Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (WQMIRA) 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). WQMIRA also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management

measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans and milestones for attaining water quality standards.

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

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

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

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

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

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

6.4.3 Stormwater Permits

DEQ and DCR coordinate separate State programs that regulate the management of pollutants carried by storm water runoff. VADEQ regulates storm water discharges associated with "industrial activities", while VADCR regulates storm water discharges from construction sites, and from municipal separate storm sewer systems (MS4s).

It is the intent of the Commonwealth that TMDLs implement existing regulations and programs where they apply. There are three industrial stormwater permits in the Three Creek watershed, but none are permitted to discharge bacteria and thus are not represented in the TMDL. There are no MS4s permitted in the Darden Mill Run, Mill Swamp, Flat Swamp, Tarrara Creek, or Three Creek watersheds at the time of this TMDL and thus MS4 areas are not included in this study. More information is available on VADCR's web site through the following link: http://www.dcr.virginia.gov/soil_&_water/vsmp.shtml. Additional information on Virginia's Stormwater Management program and a downloadable menu of Best Management Practices and Measurable Goals Guidance can be found at http://www.dcr.virginia.gov/soil_&_water/stormwat.shtml.

6.4.4 Implementation Funding Sources

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

6.4.5 Attainability of Primary Contact Recreation Use

In some streams for which TMDLs have been developed, including Darden Mill Run, Flat Swamp, Tarrara Creek, and Three Creek segments K26R-02 and K26R-03, water quality modeling indicates that even after removal of all anthropogenic bacteria sources (other than wildlife), the stream will not attain standards under all flow regimes at all times. These streams may not be able to attain standards without some reduction in wildlife load.

With respect to these potential reductions in bacteria loads attributed to wildlife, Virginia and EPA are not proposing the elimination of wildlife to allow for the attainment of water quality standards. However, if bacteria levels remain high and localized overabundant populations of wildlife are identified as the source, then measures to reduce such populations may be an option if undertaken in consultation with the VADGIF or the United States Fish and Wildlife Service (USFWS). Additional information on VADGIF's wildlife programs can be found at http://www.dgif.virginia.gov/wildlife/game/. While managing such overpopulations of wildlife remains as an option to local stakeholders, the reduction of wildlife or changing a natural background condition is not the intended goal of a TMDL.

To address the overall issue of attainability of the primary contact criteria, Virginia has a secondary contact recreation designated use option. Secondary contact recreation is defined as "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)."

In order for the secondary contact criteria to apply to a specific stream segment, the segment must be listed in section 9 VAC 25-260-170 B. 6. To remove or alter a designated use, the state must demonstrate 1) that the use is not an existing use, 2) that downstream uses are protected, and 3) that the source of contamination is natural and uncontrollable by effluent limitations and by implementing cost-effective and reasonable best management practices for nonpoint source control (9 VAC 25-260-10). This and other information is collected through a special study called a Use Attainability Analysis (UAA). All site-specific criteria or designated use changes must be adopted as amendments to the water quality standards regulations. Watershed stakeholders and

EPA will be able to provide comment during this process. Additional information can be obtained at http://www.deq.virginia.gov/wqs/designated.html.

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

The hydrologic nature of the swamp waters in this TMDL and the significant wildlife bacterial loading component impacted the modeling results for these TMDLs. The model shows that wildlife are major contributors to the bacteria concentrations, nearly to the exclusion of all other sources (Section 5.2), and furthermore that the evaporative losses over the swamp surface during critical low flow periods may cause noticeable increased concentrations of bacteria. New permitted bacteria sources will be evaluated on an individual basis. No use change will be pursued at this time; however, it may be appropriate to do so in the future, and efforts to develop this bacteria TMDL and an associated Natural Conditions report for dissolved oxygen provide the basis for such evaluation. In consideration of factors presented in this bacteria TMDL for Darden Mill Run, Mill Swamp, Flat Swamp, Tarrara Creek, and Three Creek, EPA Region 3 TMDL staff are in agreement with this approach.

7 Public Participation

The first public meeting was held on May 19, 2011 at the Capron Elementary School in Capron, Virginia, located near the mouth of the Three Creek watershed. The purpose of this meeting was to inform the general public about the TMDL process and to gain general information about the watershed. Approximately 8 people attended this meeting.

Two Technical Advisory Committee (TAC) meetings were held. The first TAC meeting was held on June 28, 2011 at the Southampton County Board Room in Courtland, VA. The purpose of the meeting was to present preliminary watershed and bacteria source characterization for the watersheds and gain feedback on these estimates, including animal populations. During this meeting, stakeholders provided and/or confirmed information on human and animal populations. Three stakeholders and four DEQ/VT representatives attended this meeting.

The second TAC meeting was held on January 23, 2012 at the Southampton County Board Room. The purpose of this meeting was to present the water quality calibration and the proposed allocation scenarios, and to solicit feedback from the interested stakeholders and agency personnel on the allocations. Three stakeholders and five DEQ/VT representatives attended this meeting.

The final public meeting was held on February 15, 2012 at the Southampton County Board Room. Final allocation and stage 1 scenarios were presented at this meeting. The report was available online prior to the meeting and copies of the executive summary were available at the meeting itself.

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Appendix A: Glossary of Terms

Allocation
That portion of a receiving water's loading capacity that is attributed to one of its existing or future pollution sources (nonpoint or point) or to natural background sources.

Allocation Scenario
A proposed series of point and nonpoint source allocations (loadings from different sources), which are being considered to meet a water quality planning goal.

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

BASINS (Better Assessment Science Integrating Point and Nonpoint Sources)
A computer-run tool that contains an assessment and planning component that allows users to organize and display geographic information for selected watersheds. It also contains a modeling component to examine impacts of pollutant loadings from point and nonpoint sources and to characterize the overall condition of specific watersheds.

Best Management Practices (BMP)
Methods, measures, or practices that are determined to be reasonable and cost-effective means for a land owner to meet certain, generally nonpoint source, pollution control needs. BMPs include structural and nonstructural controls and operation and maintenance procedures.

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

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

Direct nonpoint sources
Sources of pollution that are defined statutorily (by law) as nonpoint sources that are represented in the model as point source loadings due to limitations of the model. Examples include: direct deposits of fecal material to streams from livestock and wildlife.

Failing septic system
Septic systems in which drain fields have failed such that effluent (wastewater) that is supposed to percolate into the soil, now rises to the surface and ponds on the surface where it can flow over the soil surface to streams or contribute pollutants to the surface where they can be lost during storm runoff events.

Fecal coliform
A type of bacteria found in the feces of various warm-blooded animals that is used as indicator of the possible presence of pathogenic (disease causing) organisms. *E. coli* bacteria are a subset of this group found to more closely correlate with human health problems.

Geometric mean
The geometric mean is simply the nth root of the product of n values. Using the geometric mean lessens the significance of a few extreme values (extremely high or low values). In practical terms, this means that if you have just a few bad samples, their weight is lessened.

Mathematically the geometric mean, $\overline{x}_g$, is expressed as:

$$\overline{x}_g = \sqrt[n]{x_1 \cdot x_2 \cdot x_3 \ldots \cdot x_n}$$

where n is the number of samples, and x_i is the value of sample i.

HSPF (Hydrological Simulation Program-Fortran)
A computer-based model that calculates runoff, sediment yield, and fate and transport of various pollutants to the stream. The model was developed under the direction of the U.S. Environmental Protection Agency (EPA).

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.

Instantaneous or Single Sample criterion
The instantaneous criterion or instantaneous water quality standard is the value of the water quality standard that should not be exceeded at any time. For example, the Virginia instantaneous water quality standard for *E. coli* is 235 cfu/100 mL. If this value is exceeded at any time, the water body is in violation of the state water quality standard.

Load allocation (LA)
The portion of a receiving water's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background.

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. The MOS is normally incorporated into the conservative assumptions used to develop TMDLs (generally within the calculations or models).

Model
Mathematical representation of hydrologic and water quality processes. Effects of land use, slope, soil characteristics, and management practices are included.

Nonpoint source
Pollution that is not released through pipes but rather 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.

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

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.

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.

Reach
Segment of a stream or river.

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

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

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.

Straight pipe
Delivers wastewater directly from a building, e.g., house, milking parlor, to a stream, pond, lake, or river.

Total Maximum Daily Load (TMDL)
The sum of the individual wasteload allocations (WLA's) for point sources, load allocations (LA's) 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.

Urban Runoff
Surface runoff originating from an urban drainage area including streets, parking lots, and rooftops.

Validation (of a model)
Process of determining how well the mathematical model's computer representation describes the actual behavior of the physical process under investigation. This follows the calibration of the model and ensures that the calibrated values adequately represent the watershed.

Wasteload allocation (WLA)
The portion of a receiving water's 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.

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

For more definitions, see the Virginia Cooperative Extension publications available online:

Glossary of Water-Related Terms. Publication 442-758.
http://www.ext.vt.edu/pubs/bse/442-758/442-758.html

and

TMDLs (Total Maximum Daily Loads) - Terms and Definitions. Publication 442-550.
http://www.ext.vt.edu/pubs/bse/442-550/442-550.html

Appendix B: Sample Calculation of Cattle (Sub-watershed 3)

Sample Calculation: Distribution of Cattle

(Sub-watershed TRR-6 during June for Existing Conditions)

(Note: Due to rounding, the numbers may not add up.)

There are 30 representative beef cattle in sub-watershed TRR-6 (the representative number for 31 adults and 20 young).

1. During June, each representative cattle represents 1400 lbs of weight, or 1.4 animal units.

   Beef cattle on pasture and in the stream = 1.4 * 30 = 42

2. Thirty percent of beef cattle in sub-watershed TRR-6 have stream access. Hence beef cattle animal units with stream access are calculated as:

   Beef cattle on pastures with stream access = 42 * 30% = 12.6

3. Beef cattle animal units in and around the stream are calculated using the numbers in Step 2 and the number of hours cattle spend in the stream in June (Table 3.7) as:

   Beef cattle in and around streams = 12.6 * 3.5/24 =1.8375

4. Number of cattle animal units defecating in the stream is calculated by multiplying the number of cattle in and around the stream by 30% (Section 3.2.1):

   Beef cattle defecating in streams = 1.8375 * 30% =0.55125

5. After calculating the number of cattle animal units defecating in the stream, the number of cattle animal units defecating on the pasture is calculated by subtracting the number of cattle defecating in the stream (Step 4) from the number of cattle in pasture and stream (Step 1):

   Beef cattle defecating on pasture = 42 – 0.55125 =41.44875

Now, obviously there are not fractions of cows standing and defecating in the stream. This number (0.55125) represents the fraction of fecal coliform produced in one day by one cattle animal unit that will be deposited in the stream in sub-watershed TRR-6.

Appendix C: Weather Data Preparation

Introduction

A meteorological file for providing the weather data inputs into the HSPF Model was created for the period January 1990 through December 2009 using the Watershed Data Management Utility (WDMUtil). Raw data required for creating the weather data file included daily precipitation (in), average daily temperatures (maximum, minimum, and dew point) (°F), average daily wind speed (mi/hr), total daily solar radiation (Langleys), and percent sun. The primary data source was the National Climatic Data Center's (NCDC) Cooperative Weather Station 448800 located in Wakefield Virginia, located about 16 miles northeast of the outlet of the Three Creek watershed. Data from other NCDC stations were also used where Wakefield data were missing. The raw data required varying amounts of preprocessing within WDMUtil to obtain the following hourly values: precipitation (PREC) (in), air temperature (ATEM) (°F), dew point temperature (DEWP) (°F), solar radiation (SOLR) (Langleys), wind speed (WIND) (mi/hr), potential evapotranspiration (PEVT) (in), potential evaporation (EVAP) (in), and cloud cover (CLOU) (tenths, range 0-10). The final WDM file contains these hourly datasets.

Raw data collection and processing

Weather data were obtained from the NCDC's weather stations in Wakefield, VA (448800, Lat./Long. 36°59'N / 77°00'W, elevation 113 ft); Roanoke Rapids, NC (317319, Lat./Long. 36°29'N / 77°40'W, elevation 210 ft); Murfreesboro, NC (315996, Lat./Long. 36°27'N / 77°05'W, elevation 100 ft); Emporia, VA (442790, Lat./Long. 36°42'N / 77°34'W, elevation 100 ft); and Norfolk International Airport, VA (446139, Lat./Long. 36°54'N / 76°12'W, elevation 30 ft). While deciding on the period of record for the weather WDM file, availability of flow and water quality data was considered in addition to the availability and quality of weather data. Percent sun (PSUN) data were available only from Norfolk International Airport and then only through July 1996. The majority of the water quality data were collected between 1990 through 2010. In order to make the best use of the available water quality data, the timespan of the meteorological file was chosen to be January 1990 – December 2009. There are 7,304 days within this period. Substitutions for missing data are described below. The procedures used to process

the raw data to obtain finished data required for input to HSPF are also described in the following sections.

1. Hourly Precipitation

   Hourly precipitation (HPCP) data were downloaded from NCDC's web site for Wakefield 1NW for the entire January 1990 – December 2009 period. Of the 175,319 possible hourly values in this period, 41560 values were missing. The Roanoke Rapids and Murfreesboro stations were used to patch the hourly recorded precipitation. The resulting file was imported into WDMUtil and given the constituent label "PREC."

2. Temperature

   Separate daily maximum temperature (TMAX) and daily minimum temperature (TMIN) files were downloaded from the NCDC website for Murfreesboro for the entire period. The TMAX dataset was missing 430 of 7,304 possible days of data; the TMIN dataset was missing 436 days of data. Data from the Emporia station were used to fill in the missing days. Daily dew point temperature (DPTP) was taken from the Norfolk International Airport station, the closest station that recorded dew point temperature. These data had units of tenths of degrees Fahrenheit and were divided by a factor of 10 prior to use in the WDM file. The DPTP dataset was missing 52 of the possible 7,304 days of data. TMIN values were used to patch the missing dew point temperatures. The *disaggregate temperature* function in WDMUtil was used to create an hourly average temperature file (ATEM). The *disaggregate dew point temperature* function in WDMUtil was used to create an hourly dew point temperature file (DEWP).

3. Average Daily Wind Speed

   Average daily wind speed (AWND) was not recorded at Wakefield 1NW; therefore, average daily wind speed was obtained from the Norfolk International Airport station. The units of the data were tenths of miles per hour; therefore, the time series was divided by a factor of 10 prior to use in the WDM file. The

compute wind travel function in WDMUtil was used to calculate the total wind travel in miles/day. Then the *disaggregate wind travel* function in WDMUtil was used to calculate the hourly wind speed throughout the day (WIND) using the distribution coefficients shown in Table C. 1.

Table C. 1. Hourly Distribution Coefficients for Wind Speed.

Hour	12	1	2	3	4	5	6	7	8	9	10	11
AM	0.035	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.035	0.037	0.041	0.046
PM	0.05	0.053	0.054	0.058	0.057	0.056	0.05	0.043	0.04	0.038	0.036	0.036

4. <u>Cloud cover and solar radiation</u>

In the absence of daily cloud cover, percent sun (PSUN) can be used to estimate DCLO. DCLO is used by WDMUtil to estimate hourly cloud cover in tenths (CLOU) as well as solar radiation (SOLR) in Langleys. The closest weather station that recorded PSUN was the Norfolk International Airport station, and data from that station were used to develop this portion of the weather file. PSUN was only available at this station for the period through February 1996. It is the experience of the authors that the model is rather insensitive to the parameters derived from PSUN; therefore, to bridge the gap of missing data, values from March 1996-December 2009 were filled in by copying the values from the measured period.

The *compute percent cloud cover* function in WDMUtil was used to calculate the daily percent cloud cover in tenths (DCLO) from PSUN. Because there is no *disaggregate percent cloud cover* function available, the *disaggregate wind travel* function was used with hourly distribution coefficients all set to 1 to calculate the hourly percent cloud cover in tenths (CLOU).

The *compute solar radiation* function in WDMUtil was used to calculate the daily solar radiation in Langleys (DSOL) from DCLO and the Murfreesboro station latitude (36°27’N). The *disaggregate solar radiation* function was then used to calculate the hourly solar radiation (SOLR).

5. Evaporation/Evapotranspiration

   Two types of evaporation/evapotranspiration are required for input to HSPF: potential evaporation from a reach or reservoir surface (EVAP), represented as Penman pan evaporation; and potential evapotranspiration (PEVT), represented as Hamon potential evapotranspiration.

   The *compute Penman pan evaporation* function in WDMUtil was used to calculate daily Penman pan evaporation (DEVP) from TMIN, TMAX, DPTP, TWND, and DSOL. Then the *disaggregate evapotranspiration* function was used to calculate EVAP from DEVP.

   The *compute Hamon PET* function in WDMUtil was used to calculate daily potential evapotranspiration (DEVT) from TMIN, TMAX, the Murfreesboro station latitude (36°27'N), and monthly coefficients all equal to 0.005. Then the *disaggregate evapotranspiration* function was used to calculate PEVT from DEVT.

Summary of weather data preparation

The weather data were prepared for input to HSPF as described in the previous section. A summary of the NCDC input parameters, WDMUtil functions used, and final HSPF parameters is presented in Table C. 2.

Table C. 2. Weather parameters and processing in WDMUtil required for HSPF modeling.

NCDC Input Parameters	Intermediate Input	WDMUtil Functions	Intermediate Output	Final HSPF Parameter
HPCP	--	None	--	PREC
TMAX, TMIN	--	Disaggregate temperature	--	ATEM
DPTP	--	Disaggregate dewpoint temperature	--	DEWP
PSUN	--	Compute percent cloud cover	DCLO	--
	DCLO	Disaggregate wind travel[1]	--	CLOU
	DCLO	Compute solar radiation	DSOL	--
	DSOL	Disaggregate solar radiation	--	SOLR
AWND	--	Compute wind travel	TWND	--
	TWND	Disaggregate wind travel	--	WIND
TMAX, TMIN, DPTP	TWND, DSOL	Compute Penman pan evaporation	DEVP	--
	DEVP	Disaggregate evapotranspiration	--	EVAP
TMAX, TMIN	--	Compute Hamon PET	DEVT	--
	DEVT	Disaggregate evapotranspiration	--	PEVT

[1]all hourly coefficients set to 1

.

Appendix D: Die-off of Fecal Coliform During Storage

Die-off of Fecal Coliform During Storage

The following procedure was used to calculate amount of fecal coliform produced in confinement in hog manure applied to cropland. All calculations were performed in a spreadsheet for each sub-watershed with swine operations.

1. The annual production of fecal coliform (L cfu/d * 365.25 d/yr) based on 'as-excreted' values was calculated for swine manure using Eq. [C.1].

$$L_{annual} = L * 365.25 \qquad \text{[C.1]}$$

Where: L_{annual} = annual fecal coliform production, cfu/yr

L = daily fecal coliform production, cfu/d

365.25 = conversion from days to years, d/yr

2. Using a base-e decay rate of 0.277 day^{-1} for swine manure, the steady state accumulation of fecal coliform was calculated using Eq. [C.2]. Eq. [C.2] is the mathematical formula for a sum of a geometric progression, applicable in this case to calculate the remaining bacteria after a long period of time when a constant loading L is added to the total bacteria count daily and the bacteria die off at a rate of k per day.

$$L_{surv} = \frac{L}{1-e^{-k}} \qquad \text{[C.2]}$$

Where: L_{surv} = amount of bacteria surviving after extended storage (cfu)

k = base-e die-off rate for fecal coliform bacteria, day^{-1}

3. The surviving fraction of fecal coliform is then determined according to Eq. [C.3] – that is, the steady state bacteria concentration from [C.2] divided by the annual total from [C.1]. This survival fraction ends up being independent of the daily loading, and is 0.011 for swine manure with a base-e die-off rate of 0.277 day^{-1}.

$$surfac = L_{surv} \div L_{annual} = \frac{1}{365.25*(1-e^{-k})} \qquad \text{[C.3]}$$

Where: surfac = surviving fraction of fecal coliform after storage (ø)

The annual fecal coliform production from swine manure was multiplied by the fraction of surviving fecal coliform to obtain the amount of fecal coliform that was available for land application on annual basis. For monthly application, the annual figure was multiplied by the fraction of swine manure applied during that month based on the application schedule given in Table 3.13.

Appendix E: Fecal Coliform Loading in Sub-watersheds

Table E. 1. Monthly nonpoint fecal coliform loadings in sub-watershed DMR-1.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	71	9	65	14	230
Feb.	65	8	59	13	210
Mar.	68	8	65	13	221
Apr.	66	8	63	13	214
May.	68	8	65	13	221
Jun.	66	8	63	13	214
Jul.	68	8	65	13	221
Aug.	68	8	65	13	221
Sep.	69	8	63	14	223
Oct.	71	9	65	14	230
Nov.	69	8	63	14	223
Dec.	71	9	65	14	230
Total	822	101	768	162	2,659

Table E. 2. Monthly nonpoint fecal coliform loadings in sub-watershed DMR-2.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	80	5	37	8	129
Feb.	73	5	34	8	118
Mar.	75	5	37	8	123
Apr.	72	5	36	7	119
May.	75	5	37	8	123
Jun.	72	5	36	7	119
Jul.	75	5	37	8	123
Aug.	75	5	37	8	123
Sep.	77	5	36	8	125
Oct.	80	5	37	8	129
Nov.	77	5	36	8	125
Dec.	80	5	37	8	129
Total	908	63	434	94	1,484

Table E. 3. Monthly nonpoint fecal coliform loadings in sub-watershed DMR-3.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	126	16,299	77	7	128
Feb.	115	15,487	70	6	116
Mar.	115	17,055	77	6	119
Apr.	112	16,565	75	6	115
May.	115	17,171	77	6	119
Jun.	112	15,818	75	6	115
Jul.	115	16,389	77	6	119
Aug.	115	16,432	77	6	119
Sep.	122	16,000	75	7	123
Oct.	126	15,398	77	7	128
Nov.	122	15,194	75	7	123
Dec.	126	16,003	77	7	128
Total	1,420	193,811	911	77	1,453

Table E. 4. Monthly nonpoint fecal coliform loadings in sub-watershed DMR-4.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	90	4,232	31	14	142
Feb.	82	4,221	28	12	130
Mar.	188	4,637	31	12	132
Apr.	2,540	4,493	30	12	128
May.	658	4,644	31	12	132
Jun.	80	4,470	30	12	128
Jul.	83	4,629	31	12	132
Aug.	83	4,639	31	12	132
Sep.	88	4,535	30	13	138
Oct.	295	3,689	31	14	142
Nov.	904	3,746	30	13	138
Dec.	90	4,053	31	14	142
Total	5,181	51,987	367	153	1,618

Table E. 5. Monthly nonpoint fecal coliform loadings in sub-watershed DMR-5.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)			
	Cropland	Pasture	Wetlands	Forest
Jan.	130	2,361	13	135
Feb.	118	2,474	12	123
Mar.	120	2,773	11	126
Apr.	116	2,741	11	122
May.	120	2,888	11	126
Jun.	116	2,833	11	122
Jul.	120	2,989	11	126
Aug.	120	3,050	11	126
Sep.	125	3,034	12	130
Oct.	130	2,051	13	135
Nov.	125	2,085	12	130
Dec.	130	2,259	13	135
Total	1,468	31,539	142	1,537

Table E. 6. Monthly nonpoint fecal coliform loadings in sub-watershed DMR-6.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	43	1	63	1	61
Feb.	40	55	57	1	56
Mar.	40	87	63	1	58
Apr.	39	110	61	1	56
May.	40	140	63	1	58
Jun.	39	159	61	1	56
Jul.	40	191	63	1	58
Aug.	40	217	63	1	58
Sep.	42	238	61	1	59
Oct.	43	1	63	1	61
Nov.	42	1	61	1	59
Dec.	43	1	63	1	61
Total	493	1,201	741	16	701

Table E. 7. Monthly nonpoint fecal coliform loadings in sub-watershed DMR-7.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	20	5	7	1	15
Feb.	18	5	7	1	14
Mar.	17	5	7	1	13
Apr.	16	5	7	1	13
May.	17	5	7	1	13
Jun.	16	5	7	1	13
Jul.	17	5	7	1	13
Aug.	17	5	7	1	13
Sep.	19	5	7	1	15
Oct.	20	5	7	1	15
Nov.	19	5	7	1	15
Dec.	20	5	7	1	15
Total	215	60	85	16	168

Table E. 8. Monthly nonpoint fecal coliform loadings in sub-watershed DMR-8.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	50	5	110	2	62
Feb.	46	4	100	1	56
Mar.	50	5	110	2	62
Apr.	48	5	107	1	60
May.	50	5	110	2	62
Jun.	48	5	107	1	60
Jul.	50	5	110	2	62
Aug.	50	5	110	2	62
Sep.	48	5	107	1	60
Oct.	50	5	110	2	62
Nov.	48	5	107	1	60
Dec.	50	5	110	2	62
Total	588	56	1,298	18	727

Table E. 9. Monthly nonpoint fecal coliform loadings in sub-watershed DMR-9.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	80	2,360	48	6	94
Feb.	73	2,474	44	6	86
Mar.	74	2,776	48	6	88
Apr.	71	2,746	47	6	85
May.	74	2,899	48	6	88
Jun.	71	2,866	47	6	85
Jul.	74	3,023	48	6	88
Aug.	74	3,085	48	6	88
Sep.	77	3,046	47	6	91
Oct.	80	2,053	48	6	94
Nov.	77	2,086	47	6	91
Dec.	80	2,258	48	6	94
Total	906	31,671	571	71	1,074

Table E. 10. Monthly nonpoint fecal coliform loadings in sub-watershed DMR-10.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	94	3	40	12	199
Feb.	85	3	36	11	181
Mar.	87	3	40	11	188
Apr.	84	2	38	11	182
May.	87	3	40	11	188
Jun.	84	2	38	11	182
Jul.	87	3	40	11	188
Aug.	87	3	40	11	188
Sep.	91	3	38	12	193
Oct.	94	3	40	12	199
Nov.	91	3	38	12	193
Dec.	94	3	40	12	199
Total	1,066	31	467	138	2,280

Table E. 11. Monthly nonpoint fecal coliform loadings in sub-watershed DMR-11.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	84	6	85	6	191
Feb.	76	6	78	6	174
Mar.	75	6	85	6	175
Apr.	73	6	82	5	169
May.	75	6	85	6	175
Jun.	73	6	82	5	169
Jul.	75	6	85	6	175
Aug.	75	6	85	6	175
Sep.	81	6	82	6	185
Oct.	84	6	85	6	191
Nov.	81	6	82	6	185
Dec.	84	6	85	6	191
Total	934	71	1,004	71	2,157

Table E. 12. Monthly nonpoint fecal coliform loadings in sub-watershed MSP-1.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)			
	Cropland	Pasture	Wetlands	Forest
Jan.	57	9	11	149
Feb.	52	8	10	136
Mar.	51	8	10	137
Apr.	50	8	9	133
May.	51	8	10	137
Jun.	50	8	9	133
Jul.	51	8	10	137
Aug.	51	8	10	137
Sep.	55	9	11	145
Oct.	57	9	11	149
Nov.	55	9	11	145
Dec.	57	9	11	149
Total	638	103	121	1,687

Table E. 13. Monthly nonpoint fecal coliform loadings in sub-watershed MSP-2.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	91	16	132	8	194
Feb.	83	15	121	7	177
Mar.	83	15	132	7	179
Apr.	80	14	128	7	174
May.	83	15	132	7	179
Jun.	80	14	128	7	174
Jul.	83	15	132	7	179
Aug.	83	15	132	7	179
Sep.	88	16	128	7	188
Oct.	91	16	132	8	194
Nov.	88	16	128	7	188
Dec.	91	16	132	8	194
Total	1,024	183	1,556	85	2,197

Table E. 14. Monthly nonpoint fecal coliform loadings in sub-watershed MSP-3.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	59	7	98	3	137
Feb.	54	7	89	3	125
Mar.	55	7	97	3	130
Apr.	53	7	94	3	126
May.	55	7	97	3	130
Jun.	53	7	94	3	126
Jul.	55	7	97	3	130
Aug.	55	7	97	3	130
Sep.	57	7	94	3	133
Oct.	59	7	98	3	137
Nov.	57	7	94	3	133
Dec.	59	7	98	3	137
Total	669	83	1,148	38	1,574

Table E. 15. Monthly nonpoint fecal coliform loadings in sub-watershed MSP-4.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)			
	Cropland	Pasture	Wetlands	Forest
Jan.	41	9	3	111
Feb.	37	8	3	101
Mar.	37	8	3	103
Apr.	36	8	2	100
May.	37	8	3	103
Jun.	36	8	2	100
Jul.	37	8	3	103
Aug.	37	8	3	103
Sep.	39	8	3	108
Oct.	41	9	3	111
Nov.	39	8	3	108
Dec.	41	9	3	111
Total	457	96	32	1,261

Table E. 16. Monthly nonpoint fecal coliform loadings in sub-watershed MSP-5.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	57	442	41	5	174
Feb.	52	426	37	5	159
Mar.	51	468	40	5	160
Apr.	50	454	39	4	155
May.	51	470	40	5	160
Jun.	50	453	39	4	155
Jul.	51	469	40	5	160
Aug.	51	471	40	5	160
Sep.	55	461	39	5	168
Oct.	57	411	41	5	174
Nov.	55	408	39	5	168
Dec.	57	432	41	5	174
Total	639	5,363	477	58	1,970

Table E. 17. Monthly nonpoint fecal coliform loadings in sub-watershed MSP-6.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	125	16	67	14	196
Feb.	114	15	61	13	179
Mar.	114	15	67	13	182
Apr.	110	14	65	12	176
May.	114	15	67	13	182
Jun.	110	14	65	12	176
Jul.	114	15	67	13	182
Aug.	114	15	67	13	182
Sep.	121	15	65	14	190
Oct.	125	16	67	14	196
Nov.	121	15	65	14	190
Dec.	125	16	67	14	196
Total	1,407	180	790	158	2,229

Table E. 18. Monthly nonpoint fecal coliform loadings in sub-watershed MSP-7.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	86	12	19	7	131
Feb.	79	11	17	6	119
Mar.	78	10	19	6	121
Apr.	75	10	18	6	117
May.	78	10	19	6	121
Jun.	75	10	18	6	117
Jul.	78	10	19	6	121
Aug.	78	10	19	6	121
Sep.	84	11	18	7	127
Oct.	86	12	19	7	131
Nov.	84	11	18	7	127
Dec.	86	12	19	7	131
Total	968	130	219	76	1,481

Table E. 19. Monthly nonpoint fecal coliform loadings in sub-watershed MSP-8.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	121	13	126	9	117
Feb.	110	12	115	8	107
Mar.	110	12	126	8	110
Apr.	107	12	122	8	106
May.	110	12	126	8	110
Jun.	107	12	122	8	106
Jul.	110	12	126	8	110
Aug.	110	12	126	8	110
Sep.	117	13	122	9	114
Oct.	121	13	126	9	117
Nov.	117	13	122	9	114
Dec.	121	13	126	9	117
Total	1,360	147	1,487	100	1,336

Table E. 20. Monthly nonpoint fecal coliform loadings in sub-watershed MSP-9.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	65	1,727	13	4	77
Feb.	60	1,630	12	4	70
Mar.	62	1,757	13	4	73
Apr.	60	1,671	12	4	71
May.	62	1,696	13	4	73
Jun.	60	1,611	12	4	71
Jul.	62	1,634	13	4	73
Aug.	62	1,604	13	4	73
Sep.	63	1,523	12	4	74
Oct.	65	1,543	13	4	77
Nov.	63	1,552	12	4	74
Dec.	65	1,666	13	4	77
Total	750	19,614	151	45	883

Table E. 21. Monthly nonpoint fecal coliform loadings in sub-watershed TRR-1.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	147	6,004	116	56	285
Feb.	134	5,745	105	51	260
Mar.	137	6,188	115	52	269
Apr.	133	5,879	111	50	260
May.	137	5,956	115	52	269
Jun.	133	5,618	111	50	260
Jul.	137	5,699	115	52	269
Aug.	137	5,592	115	52	269
Sep.	142	5,351	112	55	276
Oct.	147	5,229	116	56	285
Nov.	142	5,312	112	55	276
Dec.	147	5,749	116	56	285
Total	1,674	68,322	1,357	640	3,260

Table E. 22. Monthly nonpoint fecal coliform loadings in sub-watershed TRR-2.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	7	4	41	15	12
Feb.	6	4	38	14	11
Mar.	7	4	41	15	12
Apr.	6	4	40	15	12
May.	7	4	41	15	12
Jun.	6	4	40	15	12
Jul.	7	4	41	15	12
Aug.	7	4	41	15	12
Sep.	6	4	40	15	12
Oct.	7	4	41	15	12
Nov.	6	4	40	15	12
Dec.	7	4	41	15	12
Total	77	49	486	179	144

Table E. 23. Monthly nonpoint fecal coliform loadings in sub-watershed TRR-3.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	180	1,779	124	7	228
Feb.	164	1,758	113	7	208
Mar.	167	1,921	124	6	215
Apr.	161	1,853	120	6	208
May.	167	1,906	124	6	215
Jun.	161	1,826	120	6	208
Jul.	167	1,881	124	6	215
Aug.	167	1,876	124	6	215
Sep.	174	1,826	120	7	220
Oct.	180	1,546	124	7	228
Nov.	174	1,572	120	7	220
Dec.	180	1,702	124	7	228
Total	2,043	21,445	1,457	80	2,609

Table E. 24. Monthly nonpoint fecal coliform loadings in sub-watershed TRR-4.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	146	6,935	279	32	172
Feb.	133	6,962	254	29	157
Mar.	134	7,666	276	29	160
Apr.	129	7,448	268	28	155
May.	134	7,716	276	29	160
Jun.	129	7,425	268	28	155
Jul.	134	7,712	276	29	160
Aug.	134	7,751	276	29	160
Sep.	141	7,625	270	31	166
Oct.	146	6,046	279	32	172
Nov.	141	6,140	270	31	166
Dec.	146	6,644	279	32	172
Total	1,648	86,070	3,272	355	1,954

Table E. 25. Monthly nonpoint fecal coliform loadings in sub-watershed TRR-5.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	83	349	14	41	106
Feb.	76	341	13	38	96
Mar.	79	374	14	39	101
Apr.	76	363	14	37	97
May.	79	376	14	39	101
Jun.	76	363	14	37	97
Jul.	79	377	14	39	101
Aug.	79	378	14	39	101
Sep.	81	371	14	40	102
Oct.	83	318	14	41	106
Nov.	81	318	14	40	102
Dec.	83	339	14	41	106
Total	955	4,266	170	471	1,214

Table E. 26. Monthly nonpoint fecal coliform loadings in sub-watershed TRR-6.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)			
	Cropland	Pasture	Wetlands	Forest
Jan.	128	3,631	24	86
Feb.	117	3,718	22	78
Mar.	124	4,132	23	84
Apr.	120	4,050	23	81
May.	124	4,233	23	84
Jun.	120	4,119	23	81
Jul.	124	4,312	23	84
Aug.	124	4,367	23	84
Sep.	124	4,313	23	83
Oct.	128	3,166	24	86
Nov.	124	3,214	23	83
Dec.	128	3,478	24	86
Total	1,482	46,733	280	999

Table E. 27. Monthly nonpoint fecal coliform loadings in sub-watershed TRR-7.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	112	10	111	10	270
Feb.	102	9	101	9	246
Mar.	105	9	111	9	257
Apr.	102	9	107	9	249
May.	105	9	111	9	257
Jun.	102	9	107	9	249
Jul.	105	9	111	9	257
Aug.	105	9	111	9	257
Sep.	108	10	107	10	261
Oct.	112	10	111	10	270
Nov.	108	10	107	10	261
Dec.	112	10	111	10	270
Total	1,279	112	1,308	112	3,105

Table E. 28. Monthly nonpoint fecal coliform loadings in sub-watershed TRR-8.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)			
	Cropland	Pasture	Wetlands	Forest
Jan.	54	11,055	10	125
Feb.	49	11,002	9	114
Mar.	52	12,267	10	121
Apr.	50	12,059	9	117
May.	52	12,655	10	121
Jun.	50	12,435	9	117
Jul.	52	13,044	10	121
Aug.	52	13,239	10	121
Sep.	53	13,000	10	121
Oct.	54	10,226	10	125
Nov.	53	10,164	10	121
Dec.	54	10,779	10	125
Total	626	141,926	115	1,447

Table E. 29. Monthly nonpoint fecal coliform loadings in sub-watershed TRR-9.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	176	17	101	12	306
Feb.	160	15	92	11	279
Mar.	162	15	101	11	289
Apr.	9,306	15	98	10	279
May.	1,687	15	101	11	289
Jun.	157	15	98	10	279
Jul.	162	15	101	11	289
Aug.	162	15	101	11	289
Sep.	170	16	98	12	297
Oct.	176	17	101	12	306
Nov.	170	16	98	12	297
Dec.	176	17	101	12	306
Total	12,663	189	1,188	134	3,505

Table E. 30. Monthly nonpoint fecal coliform loadings in sub-watershed FTS-10.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)			
	Cropland	Pasture	Wetlands	Forest
Jan.	62	4	36	80
Feb.	57	3	33	73
Mar.	60	4	35	77
Apr.	58	4	34	74
May.	60	4	35	77
Jun.	58	4	34	74
Jul.	60	4	35	77
Aug.	60	4	35	77
Sep.	60	4	35	77
Oct.	62	4	36	80
Nov.	60	4	35	77
Dec.	62	4	36	80
Total	717	44	419	921

Table E. 31. Monthly nonpoint fecal coliform loadings in sub-watershed FTS-11.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)			
	Cropland	Pasture	Wetlands	Forest
Jan.	41	2	8	59
Feb.	38	2	8	54
Mar.	39	2	8	57
Apr.	38	2	8	55
May.	39	2	8	57
Jun.	38	2	8	55
Jul.	39	2	8	57
Aug.	39	2	8	57
Sep.	40	2	8	57
Oct.	41	2	8	59
Nov.	40	2	8	57
Dec.	41	2	8	59
Total	472	26	96	682

Table E. 32. Monthly nonpoint fecal coliform loadings in sub-watershed FTS-12.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)			
	Cropland	Pasture	Wetlands	Forest
Jan.	121	11	13	168
Feb.	110	10	11	153
Mar.	112	11	11	158
Apr.	108	10	11	153
May.	112	11	11	158
Jun.	108	10	11	153
Jul.	112	11	11	158
Aug.	112	11	11	158
Sep.	117	11	12	162
Oct.	121	11	13	168
Nov.	117	11	12	162
Dec.	121	11	13	168
Total	1,369	129	141	1,921

Table E. 33. Monthly nonpoint fecal coliform loadings in sub-watershed FTS-13.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	145	3,296	85	13	281
Feb.	132	3,295	77	12	256
Mar.	136	3,611	85	12	267
Apr.	131	3,491	82	12	259
May.	136	3,593	85	12	267
Jun.	131	3,396	82	12	259
Jul.	136	3,517	85	12	267
Aug.	136	3,525	85	12	267
Sep.	140	3,509	82	13	272
Oct.	145	2,851	85	13	281
Nov.	140	2,905	82	13	272
Dec.	145	3,154	85	13	281
Total	1,653	40,144	997	150	3,231

Table E. 34. Monthly nonpoint fecal coliform loadings in sub-watershed FTS-14.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)			
	Cropland	Pasture	Wetlands	Forest
Jan.	49	9	24	54
Feb.	44	8	22	49
Mar.	47	9	23	52
Apr.	45	9	22	50
May.	47	9	23	52
Jun.	45	9	22	50
Jul.	47	9	23	52
Aug.	47	9	23	52
Sep.	47	9	23	52
Oct.	49	9	24	54
Nov.	47	9	23	52
Dec.	49	9	24	54
Total	561	107	279	625

Table E. 35. Monthly nonpoint fecal coliform loadings in sub-watershed FTS-15.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	128	9	48	49	296
Feb.	116	9	43	45	270
Mar.	122	9	48	46	285
Apr.	118	9	46	45	276
May.	122	9	48	46	285
Jun.	118	9	46	45	276
Jul.	122	9	48	46	285
Aug.	122	9	48	46	285
Sep.	124	9	46	48	287
Oct.	128	9	48	49	296
Nov.	124	9	46	48	287
Dec.	128	9	48	49	296
Total	1,469	107	560	563	3,421

Table E. 36. Monthly nonpoint fecal coliform loadings in sub-watershed FTS-16.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	137	29	49	22	232
Feb.	124	26	45	20	211
Mar.	124	26	49	19	215
Apr.	120	26	48	19	208
May.	124	26	49	19	215
Jun.	120	26	48	19	208
Jul.	124	26	49	19	215
Aug.	124	26	49	19	215
Sep.	132	28	48	21	224
Oct.	137	29	49	22	232
Nov.	132	28	48	21	224
Dec.	137	29	49	22	232
Total	1,538	326	583	240	2,633

Table E. 37. Monthly nonpoint fecal coliform loadings in sub-watershed FTS-17.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)			
	Cropland	Pasture	Wetlands	Forest
Jan.	52	2	8	124
Feb.	47	2	8	113
Mar.	47	2	8	116
Apr.	46	2	7	113
May.	47	2	8	116
Jun.	46	2	7	113
Jul.	47	2	8	116
Aug.	47	2	8	116
Sep.	50	2	8	120
Oct.	52	2	8	124
Nov.	50	2	8	120
Dec.	52	2	8	124
Total	583	26	94	1,419

Table E. 38. Monthly nonpoint fecal coliform loadings in sub-watershed FTS-18.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	127	21,705	81	14	303
Feb.	116	19,779	74	12	276
Mar.	121	21,704	81	13	291
Apr.	117	21,004	79	12	281
May.	121	21,704	81	13	291
Jun.	117	21,004	79	12	281
Jul.	121	21,704	81	13	291
Aug.	121	21,704	81	13	291
Sep.	123	21,005	79	13	293
Oct.	127	21,705	81	14	303
Nov.	123	21,005	79	13	293
Dec.	127	21,705	81	14	303
Total	1,460	255,728	956	155	3,496

Table E. 39. Monthly nonpoint fecal coliform loadings in sub-watershed FTS-19.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	20	0	6	5	29
Feb.	19	0	5	4	27
Mar.	18	0	6	4	27
Apr.	18	0	5	4	26
May.	18	0	6	4	27
Jun.	18	0	5	4	26
Jul.	18	0	6	4	27
Aug.	18	0	6	4	27
Sep.	20	0	6	5	28
Oct.	20	0	6	5	29
Nov.	20	0	6	5	28
Dec.	20	0	6	5	29
Total	228	4	67	52	331

Table E. 40. Monthly nonpoint fecal coliform loadings in sub-watershed FTS-20.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	53	8	77	2	136
Feb.	48	7	70	2	124
Mar.	49	7	77	2	128
Apr.	47	7	74	2	123
May.	49	7	77	2	128
Jun.	47	7	74	2	123
Jul.	49	7	77	2	128
Aug.	49	7	77	2	128
Sep.	51	7	74	2	131
Oct.	53	8	77	2	136
Nov.	51	7	74	2	131
Dec.	53	8	77	2	136
Total	600	85	906	27	1,550

Table E. 41. Monthly nonpoint fecal coliform loadings in sub-watershed FTS-21.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	166	14	24	15	282
Feb.	151	12	22	13	257
Mar.	150	12	24	13	260
Apr.	145	12	23	12	252
May.	150	12	24	13	260
Jun.	145	12	23	12	252
Jul.	150	12	24	13	260
Aug.	150	12	24	13	260
Sep.	161	13	23	14	273
Oct.	166	14	24	15	282
Nov.	161	13	23	14	273
Dec.	166	14	24	15	282
Total	1,860	152	282	161	3,192

Table E. 42. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-1.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)			
	Cropland	Pasture	Wetlands	Forest
Jan.	92	7	64	262
Feb.	84	7	59	238
Mar.	87	7	60	249
Apr.	84	7	59	241
May.	87	7	60	249
Jun.	84	7	59	241
Jul.	87	7	60	249
Aug.	87	7	60	249
Sep.	89	7	62	253
Oct.	92	7	64	262
Nov.	89	7	62	253
Dec.	92	7	64	262
Total	1,058	82	736	3,010

Table E. 43. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-2.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)			
	Cropland	Pasture	Wetlands	Forest
Jan.	70	2,361	23	250
Feb.	64	2,245	21	228
Mar.	67	2,411	22	241
Apr.	65	2,284	21	233
May.	67	2,308	22	241
Jun.	65	2,182	21	233
Jul.	67	2,203	22	241
Aug.	67	2,152	22	241
Sep.	68	2,036	22	242
Oct.	70	2,054	23	250
Nov.	68	2,087	22	242
Dec.	70	2,259	23	250
Total	808	26,582	264	2,893

Table E. 44. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-3.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	114	3,413	51	20	319
Feb.	104	3,403	47	18	290
Mar.	105	3,741	51	18	300
Apr.	102	3,628	50	17	291
May.	105	3,757	51	18	300
Jun.	102	3,644	50	17	291
Jul.	105	3,774	51	18	300
Aug.	105	3,782	51	18	300
Sep.	110	3,669	50	19	308
Oct.	114	2,983	51	20	319
Nov.	110	3,026	50	19	308
Dec.	114	3,270	51	20	319
Total	1,290	42,090	606	221	3,646

Table E. 45. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-4.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	61	8	48	8	372
Feb.	55	7	44	8	339
Mar.	56	7	48	8	349
Apr.	54	7	46	7	338
May.	56	7	48	8	349
Jun.	54	7	46	7	338
Jul.	56	7	48	8	349
Aug.	56	7	48	8	349
Sep.	59	8	46	8	360
Oct.	61	8	48	8	372
Nov.	59	8	46	8	360
Dec.	61	8	48	8	372
Total	684	88	564	93	4,249

Table E. 46. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-5.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	102	9	31	53	497
Feb.	93	8	28	48	453
Mar.	95	8	31	49	471
Apr.	92	8	30	47	456
May.	95	8	31	49	471
Jun.	92	8	30	47	456
Jul.	95	8	31	49	471
Aug.	95	8	31	49	471
Sep.	98	9	30	51	481
Oct.	102	9	31	53	497
Nov.	98	9	30	51	481
Dec.	102	9	31	53	497
Total	1,159	103	366	599	5,701

Table E. 47. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-6.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	1,597	24,993	190	136	648
Feb.	285	23,961	173	124	591
Mar.	2,701	26,502	187	127	616
Apr.	2,841	25,850	181	123	596
May.	1,196	26,910	187	127	616
Jun.	284	26,173	181	123	596
Jul.	294	27,263	187	127	616
Aug.	294	27,481	187	127	616
Sep.	302	26,893	184	132	627
Oct.	899	23,829	190	136	648
Nov.	2,651	23,438	184	132	627
Dec.	1,597	24,610	190	136	648
Total	14,941	307,902	2,220	1,549	7,444

Table E. 48. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-7.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	168	61	227	13	300
Feb.	153	56	207	12	274
Mar.	151	55	225	12	276
Apr.	146	53	218	11	267
May.	151	55	225	12	276
Jun.	146	53	218	11	267
Jul.	151	55	225	12	276
Aug.	151	55	225	12	276
Sep.	163	59	220	13	291
Oct.	168	61	227	13	300
Nov.	163	59	220	13	291
Dec.	168	61	227	13	300
Total	1,882	686	2,665	144	3,395

Table E. 49. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-8.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	169	25	102	12	352
Feb.	154	23	93	11	321
Mar.	157	23	102	11	332
Apr.	151	23	98	11	321
May.	157	23	102	11	332
Jun.	151	23	98	11	321
Jul.	157	23	102	11	332
Aug.	157	23	102	11	332
Sep.	163	24	99	12	341
Oct.	169	25	102	12	352
Nov.	163	24	99	12	341
Dec.	169	25	102	12	352
Total	1,917	285	1,201	138	4,029

Table E. 50. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-9.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	291	34	109	26	405
Feb.	265	31	99	23	369
Mar.	587	31	109	23	378
Apr.	2,980	30	106	22	366
May.	1,227	31	109	23	378
Jun.	258	30	106	22	366
Jul.	266	31	109	23	378
Aug.	266	31	109	23	378
Sep.	282	33	106	25	392
Oct.	916	34	109	26	405
Nov.	2,781	33	106	25	392
Dec.	291	34	109	26	405
Total	10,410	379	1,286	288	4,611

Table E. 51. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-10.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	139	21	62	42	356
Feb.	127	19	56	38	325
Mar.	131	19	62	39	339
Apr.	127	19	60	38	328
May.	131	19	62	39	339
Jun.	127	19	60	38	328
Jul.	131	19	62	39	339
Aug.	131	19	62	39	339
Sep.	135	20	60	41	345
Oct.	139	21	62	42	356
Nov.	135	20	60	41	345
Dec.	139	21	62	42	356
Total	1,590	236	726	478	4,093

Table E. 52. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-11.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	114	6	25	14	322
Feb.	104	5	23	13	293
Mar.	106	6	25	13	304
Apr.	102	5	24	13	294
May.	106	6	25	13	304
Jun.	102	5	24	13	294
Jul.	106	6	25	13	304
Aug.	106	6	25	13	304
Sep.	110	6	24	14	311
Oct.	114	6	25	14	322
Nov.	110	6	24	14	311
Dec.	114	6	25	14	322
Total	1,295	68	296	163	3,685

Table E. 53. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-12.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	23	265	22	6	104
Feb.	21	241	20	5	95
Mar.	21	264	22	5	94
Apr.	20	256	22	5	91
May.	21	264	22	5	94
Jun.	20	256	22	5	91
Jul.	21	264	22	5	94
Aug.	21	264	22	5	94
Sep.	23	256	22	6	101
Oct.	23	265	22	6	104
Nov.	23	256	22	6	101
Dec.	23	265	22	6	104
Total	259	3,114	264	63	1,168

Table E. 54. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-13.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	56	1,193	255	10	252
Feb.	51	1,201	233	9	230
Mar.	51	1,324	254	9	233
Apr.	50	1,289	246	9	226
May.	51	1,340	254	9	233
Jun.	50	1,304	246	9	226
Jul.	51	1,355	254	9	233
Aug.	51	1,363	254	9	233
Sep.	55	1,327	247	10	244
Oct.	56	1,039	255	10	252
Nov.	55	1,055	247	10	244
Dec.	56	1,142	255	10	252
Total	634	14,931	2,999	115	2,859

Table E. 55. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-14.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	83	4,843	259	9	423
Feb.	76	4,553	236	8	386
Mar.	76	4,915	256	8	392
Apr.	73	4,679	248	8	380
May.	76	4,752	256	8	392
Jun.	73	4,501	248	8	380
Jul.	76	4,575	256	8	392
Aug.	76	4,499	256	8	392
Sep.	80	4,305	251	8	410
Oct.	83	4,378	259	9	423
Nov.	80	4,388	251	8	410
Dec.	83	4,690	259	9	423
Total	934	55,080	3,037	97	4,803

Table E. 56. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-15.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	39	27	0	19	52
Feb.	36	25	0	17	47
Mar.	37	26	0	18	50
Apr.	36	25	0	17	48
May.	37	26	0	18	50
Jun.	36	25	0	17	48
Jul.	37	26	0	18	50
Aug.	37	26	0	18	50
Sep.	38	26	0	18	50
Oct.	39	27	0	19	52
Nov.	38	26	0	18	50
Dec.	39	27	0	19	52
Total	450	310	1	217	599

Table E. 57. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-16.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	296	60	170	75	664
Feb.	270	54	155	69	605
Mar.	272	55	169	69	619
Apr.	263	53	163	66	599
May.	272	55	169	69	619
Jun.	263	53	163	66	599
Jul.	272	55	169	69	619
Aug.	272	55	169	69	619
Sep.	286	58	164	73	643
Oct.	296	60	170	75	664
Nov.	286	58	164	73	643
Dec.	296	60	170	75	664
Total	3,344	676	1,993	848	7,559

Table E. 58. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-17.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	82	1,770	21	16	397
Feb.	75	1,819	19	15	362
Mar.	74	2,023	21	14	364
Apr.	72	1,985	20	14	352
May.	74	2,079	21	14	364
Jun.	72	2,040	20	14	352
Jul.	74	2,136	21	14	364
Aug.	74	2,164	21	14	364
Sep.	80	2,122	20	15	384
Oct.	82	1,540	21	16	397
Nov.	80	1,565	20	15	384
Dec.	82	1,694	21	16	397
Total	919	22,936	249	177	4,482

Table E. 59. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-18.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	242	30	203	75	677
Feb.	220	27	185	69	617
Mar.	227	28	202	70	643
Apr.	219	27	196	68	622
May.	227	28	202	70	643
Jun.	219	27	196	68	622
Jul.	227	28	202	70	643
Aug.	227	28	202	70	643
Sep.	234	29	196	73	655
Oct.	242	30	203	75	677
Nov.	234	29	196	73	655
Dec.	242	30	203	75	677
Total	2,760	339	2,385	856	7,773

Table E. 60. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-19.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	85	9	47	13	349
Feb.	78	8	43	12	318
Mar.	79	8	47	12	329
Apr.	77	8	46	11	318
May.	79	8	47	12	329
Jun.	77	8	46	11	318
Jul.	79	8	47	12	329
Aug.	79	8	47	12	329
Sep.	83	8	46	12	338
Oct.	85	9	47	13	349
Nov.	83	8	46	12	338
Dec.	85	9	47	13	349
Total	969	98	559	145	3,993

Table E. 61. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-20.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	346	43	228	213	583
Feb.	315	39	207	194	532
Mar.	335	41	227	206	568
Apr.	324	40	219	199	549
May.	335	41	227	206	568
Jun.	324	40	219	199	549
Jul.	335	41	227	206	568
Aug.	335	41	227	206	568
Sep.	335	41	220	206	564
Oct.	346	43	228	213	583
Nov.	335	41	220	206	564
Dec.	346	43	228	213	583
Total	4,012	494	2,676	2,469	6,780

Table E. 62. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-21.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	103	2,708	73	88	198
Feb.	94	2,709	67	80	180
Mar.	99	2,978	73	85	192
Apr.	96	2,886	71	82	185
May.	99	2,985	73	85	192
Jun.	96	2,874	71	82	185
Jul.	99	2,977	73	85	192
Aug.	99	2,985	73	85	192
Sep.	100	2,918	71	85	192
Oct.	103	2,351	73	88	198
Nov.	100	2,391	71	85	192
Dec.	103	2,590	73	88	198
Total	1,190	33,352	860	1,017	2,295

Table E. 63. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-22.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	195	45	229	63	475
Feb.	177	41	209	58	433
Mar.	182	42	226	59	448
Apr.	176	40	218	57	433
May.	182	42	226	59	448
Jun.	176	40	218	57	433
Jul.	182	42	226	59	448
Aug.	182	42	226	59	448
Sep.	188	43	222	61	460
Oct.	195	45	229	63	475
Nov.	188	43	222	61	460
Dec.	195	45	229	63	475
Total	2,216	510	2,677	719	5,436

Table E. 64. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-23.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	37	6	48	14	225
Feb.	34	6	44	13	205
Mar.	34	6	47	13	209
Apr.	33	6	46	12	202
May.	34	6	47	13	209
Jun.	33	6	46	12	202
Jul.	34	6	47	13	209
Aug.	34	6	47	13	209
Sep.	36	6	47	14	217
Oct.	37	6	48	14	225
Nov.	36	6	47	14	217
Dec.	37	6	48	14	225
Total	417	70	562	157	2,553

Table E. 65. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-24.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	117	3,358	629	8	515
Feb.	106	3,355	573	8	469
Mar.	104	3,702	626	7	470
Apr.	101	3,607	605	7	455
May.	104	3,752	626	7	470
Jun.	101	3,574	605	7	455
Jul.	104	3,716	626	7	470
Aug.	104	3,738	626	7	470
Sep.	113	3,643	608	8	498
Oct.	117	2,967	629	8	515
Nov.	113	2,997	608	8	498
Dec.	117	3,228	629	8	515
Total	1,302	41,638	7,389	91	5,803

Table E. 66. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-25.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	37	18	276	66	302
Feb.	34	17	252	60	275
Mar.	35	17	273	61	285
Apr.	34	17	265	59	276
May.	35	17	273	61	285
Jun.	34	17	265	59	276
Jul.	35	17	273	61	285
Aug.	35	17	273	61	285
Sep.	36	18	267	64	292
Oct.	37	18	276	66	302
Nov.	36	18	267	64	292
Dec.	37	18	276	66	302
Total	424	210	3,239	749	3,453

Table E. 67. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-26.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	102	16	139	2	259
Feb.	93	14	126	2	236
Mar.	91	14	137	2	236
Apr.	88	13	133	2	228
May.	91	14	137	2	236
Jun.	88	13	133	2	228
Jul.	91	14	137	2	236
Aug.	91	14	137	2	236
Sep.	99	15	134	2	251
Oct.	102	16	139	2	259
Nov.	99	15	134	2	251
Dec.	102	16	139	2	259
Total	1,138	174	1,625	27	2,918

Table E. 68. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-27.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	90	1,508	316	2	265
Feb.	82	1,456	288	1	242
Mar.	81	1,607	314	1	242
Apr.	78	1,566	304	1	234
May.	81	1,629	314	1	242
Jun.	78	1,588	304	1	234
Jul.	81	1,652	314	1	242
Aug.	81	1,663	314	1	242
Sep.	87	1,623	306	2	257
Oct.	90	1,416	316	2	265
Nov.	87	1,400	306	2	257
Dec.	90	1,477	316	2	265
Total	1,006	18,585	3,715	17	2,989

Table E. 69. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-28.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	74	49	402	3	397
Feb.	67	45	366	2	362
Mar.	66	44	398	2	363
Apr.	64	42	385	2	351
May.	66	44	398	2	363
Jun.	64	42	385	2	351
Jul.	66	44	398	2	363
Aug.	66	44	398	2	363
Sep.	71	47	389	2	384
Oct.	74	49	402	3	397
Nov.	71	47	389	2	384
Dec.	74	49	402	3	397
Total	821	547	4,709	28	4,478

Table E. 70. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-29.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	80	14	100	13	226
Feb.	72	13	91	12	206
Mar.	70	12	100	11	203
Apr.	68	12	97	11	197
May.	70	12	100	11	203
Jun.	68	12	97	11	197
Jul.	70	12	100	11	203
Aug.	70	12	100	11	203
Sep.	77	13	97	13	219
Oct.	80	14	100	13	226
Nov.	77	13	97	13	219
Dec.	80	14	100	13	226
Total	882	155	1,181	143	2,528

Table E. 71. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-30.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	16	4	129	1	94
Feb.	15	4	118	1	86
Mar.	15	4	129	1	88
Apr.	14	4	125	1	85
May.	15	4	129	1	88
Jun.	14	4	125	1	85
Jul.	15	4	129	1	88
Aug.	15	4	129	1	88
Sep.	16	4	125	1	91
Oct.	16	4	129	1	94
Nov.	16	4	125	1	91
Dec.	16	4	129	1	94
Total	183	49	1,521	11	1,074

Table E. 72. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-31.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	43	7,049	42	3	230
Feb.	39	7,032	39	3	209
Mar.	37	7,732	41	2	204
Apr.	36	7,499	40	2	197
May.	37	7,767	41	2	204
Jun.	36	7,534	40	2	197
Jul.	37	7,803	41	2	204
Aug.	37	7,821	41	2	204
Sep.	42	7,589	41	3	222
Oct.	43	6,159	42	3	230
Nov.	42	6,247	41	3	222
Dec.	43	6,752	42	3	230
Total	474	86,984	494	32	2,553

Table E. 73. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-32.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	16	26	80	1	221
Feb.	15	23	73	1	201
Mar.	15	24	79	1	204
Apr.	14	23	77	1	197
May.	15	24	79	1	204
Jun.	14	23	77	1	197
Jul.	15	24	79	1	204
Aug.	15	24	79	1	204
Sep.	16	25	78	1	214
Oct.	16	26	80	1	221
Nov.	16	25	78	1	214
Dec.	16	26	80	1	221
Total	185	289	942	13	2,501

Table E. 74. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-33.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	33	1,911	95	2	301
Feb.	30	1,870	86	2	274
Mar.	28	2,032	93	2	268
Apr.	27	1,951	90	2	259
May.	28	1,998	93	2	268
Jun.	27	1,905	90	2	259
Jul.	28	1,955	93	2	268
Aug.	28	1,940	93	2	268
Sep.	31	1,882	92	2	291
Oct.	33	1,663	95	2	301
Nov.	31	1,690	92	2	291
Dec.	33	1,830	95	2	301
Total	358	22,628	1,105	26	3,347

Table E. 75. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-34.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	24	35	96	1	384
Feb.	22	32	88	1	350
Mar.	21	31	95	1	344
Apr.	20	30	92	1	333
May.	21	31	95	1	344
Jun.	20	30	92	1	333
Jul.	21	31	95	1	344
Aug.	21	31	95	1	344
Sep.	23	34	93	1	372
Oct.	24	35	96	1	384
Nov.	23	34	93	1	372
Dec.	24	35	96	1	384
Total	264	389	1,126	13	4,288

Table E. 76. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-35.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	20	2,402	131	2	371
Feb.	18	2,552	119	1	338
Mar.	18	2,877	129	1	337
Apr.	17	2,863	124	1	326
May.	18	3,040	129	1	337
Jun.	17	3,022	124	1	326
Jul.	18	3,204	129	1	337
Aug.	18	3,286	129	1	337
Sep.	19	3,265	126	1	359
Oct.	20	2,095	131	2	371
Nov.	19	2,126	126	1	359
Dec.	20	2,299	131	2	371
Total	220	33,032	1,526	17	4,169

Table E. 77. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-36.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	4	19	9	3	386
Feb.	3	17	8	2	352
Mar.	3	17	9	2	353
Apr.	3	17	9	2	342
May.	3	17	9	2	353
Jun.	3	17	9	2	342
Jul.	3	17	9	2	353
Aug.	3	17	9	2	353
Sep.	4	19	9	2	374
Oct.	4	19	9	3	386
Nov.	4	19	9	2	374
Dec.	4	19	9	3	386
Total	43	214	107	28	4,352

Table E. 78. Monthly nonpoint fecal coliform loadings in sub-watershed TRE-37.

Month	Fecal Coliform loadings ($x10^{10}$ cfu/month)				
	Cropland	Pasture	Residential	Wetlands	Forest
Jan.	25	4,768	157	1	344
Feb.	23	5,073	143	1	314
Mar.	22	5,723	155	1	312
Apr.	21	5,697	150	1	302
May.	22	6,051	155	1	312
Jun.	21	6,014	150	1	302
Jul.	22	6,378	155	1	312
Aug.	22	6,542	155	1	312
Sep.	24	6,496	152	1	333
Oct.	25	4,155	157	1	344
Nov.	24	4,219	152	1	333
Dec.	25	4,564	157	1	344
Total	273	65,678	1,841	7	3,867

Appendix F: HSPF Parameters that Vary by Month or Land Use

Table F. 1. INFILT (index to infiltration capacity), LSUR (length of overland flow plane, ft), and SLSUR (slope) for Darden Mill Run (DMR), Mill Swamp (MSP), Tarrara Creek (TRR), Flat Swamp (FTS), and Three Creek (TRE).

Land Use	Sub	INFILT	LSUR	SLSUR	Land Use	Sub	INFILT	LSUR	SLSUR
Forest	DMR-1	0.0641	453.82	0.0205	Forest	TRE-1	0.0649	383.77	0.0319
Forest	DMR-2	0.0633	441.9	0.016	Forest	TRE-2	0.0641	442.33	0.025
Forest	DMR-3	0.0623	321.02	0.0182	Forest	TRE-3	0.0641	343.12	0.0294
Forest	DMR-4	0.062	331.71	0.0241	Forest	TRE-4	0.0638	374.29	0.0315
Forest	DMR-5	0.0625	381.94	0.0206	Forest	TRE-5	0.0638	397.73	0.0297
Forest	DMR-6	0.0588	396.66	0.0129	Forest	TRE-6	0.0619	414.54	0.0254
Forest	DMR-7	0.059	285.52	0.0352	Forest	TRE-7	0.0619	300.14	0.0366
Forest	DMR-8	0.0592	365.22	0.0144	Forest	TRE-8	0.061	320.04	0.0348
Forest	DMR-9	0.0629	287.34	0.0266	Forest	TRE-9	0.0624	292.71	0.0381
Forest	DMR-10	0.0631	373.7	0.0182	Forest	TRE-10	0.0646	356.29	0.0341
Forest	DMR-11	0.0604	398.65	0.0132	Forest	TRE-11	0.0628	331.68	0.0333
Pasture	DMR-1	0.0695	422.9	0.0163	Forest	TRE-12	0.0654	377.8	0.0321
Pasture	DMR-2	0.0657	488.19	0.0159	Forest	TRE-13	0.0633	330.1	0.0373
Pasture	DMR-3	0.0626	428.62	0.0148	Forest	TRE-14	0.0612	336.39	0.0357
Pasture	DMR-4	0.0643	623.41	0.0137	Forest	TRE-15	0.0599	361.56	0.0187
Pasture	DMR-5	0.0649	471.58	0.0142	Forest	TRE-16	0.0615	339.62	0.0317
Pasture	DMR-6	0.0635	397.32	0.0165	Forest	TRE-17	0.0637	369.23	0.0345
Pasture	DMR-7	0.0654	407.77	0.0406	Forest	TRE-18	0.0615	355.97	0.0295
Pasture	DMR-8	0.0639	373.45	0.0188	Forest	TRE-19	0.0618	400.53	0.025
Pasture	DMR-9	0.0651	461.31	0.0294	Forest	TRE-20	0.0613	382.06	0.0252
Pasture	DMR-10	0.0656	616.96	0.0175	Forest	TRE-21	0.0591	379.56	0.0311
Pasture	DMR-11	0.0651	448.37	0.0152	Forest	TRE-22	0.0602	376.6	0.0257
Cropland	DMR-1	0.0685	647.56	0.0222	Forest	TRE-23	0.0617	403.84	0.0303
Cropland	DMR-2	0.0656	624.44	0.016	Forest	TRE-24	0.0624	375.36	0.028
Cropland	DMR-3	0.0656	572.11	0.014	Forest	TRE-25	0.0572	381.15	0.0301
Cropland	DMR-4	0.0656	563.06	0.0195	Forest	TRE-26	0.0614	352.1	0.0304
Cropland	DMR-5	0.0654	524.66	0.0157	Forest	TRE-27	0.0557	315.05	0.0405
Cropland	DMR-6	0.0649	481.3	0.0116	Forest	TRE-28	0.0586	362.12	0.0342
Cropland	DMR-7	0.0657	613.9	0.0186	Forest	TRE-29	0.0606	453.57	0.0187
Cropland	DMR-8	0.0645	458.4	0.0092	Forest	TRE-30	0.0566	405.35	0.026
Cropland	DMR-9	0.0658	537.88	0.0205	Forest	TRE-31	0.0555	347.23	0.0466
Cropland	DMR-10	0.0669	585.1	0.0147	Forest	TRE-32	0.0501	370.52	0.0346
Cropland	DMR-11	0.0655	463.19	0.0123	Forest	TRE-33	0.0682	344.08	0.0446
Residential	DMR-1	0.0691	1257.6	0.0016	Forest	TRE-34	0.0638	358.62	0.0419
Residential	DMR-2	0.0657	608.11	0.0172	Forest	TRE-35	0.0742	321.77	0.0407
Residential	DMR-3	0.0639	672.87	0.0114	Forest	TRE-36	0.0637	397.62	0.0395
Residential	DMR-4	0.0586	362.33	0.0025	Forest	TRE-37	0.0774	353.99	0.0362
Residential	DMR-6	0.0655	475.48	0.0048	Pasture	TRE-1	0.0624	564.06	0.0219
Residential	DMR-7	0.0657	332.84	0.0514	Pasture	TRE-2	0.0592	402.48	0.0254

Land Use	Sub	INFILT	LSUR	SLSUR	Land Use	Sub	INFILT	LSUR	SLSUR
Residential	DMR-8	0.0649	387.75	0.0112	Pasture	TRE-3	0.0617	405.43	0.0281
Residential	DMR-9	0.066	491.48	0.0118	Pasture	TRE-4	0.0592	415.75	0.0287
Residential	DMR-10	0.0623	393.23	0.0322	Pasture	TRE-5	0.0613	587.45	0.03
Residential	DMR-11	0.0633	283.65	0.0037	Pasture	TRE-6	0.0595	447.73	0.0293
Wetlands	DMR-1	0.0607	664.67	0.0117	Pasture	TRE-7	0.059	435.48	0.035
Wetlands	DMR-2	0.058	315.41	0.0163	Pasture	TRE-8	0.0582	457.66	0.0254
Wetlands	DMR-3	0.061	277.01	0.0205	Pasture	TRE-9	0.0594	443.58	0.0292
Wetlands	DMR-4	0.0551	196.01	0.0176	Pasture	TRE-10	0.0577	492.76	0.0237
Wetlands	DMR-5	0.0577	229.85	0.0167	Pasture	TRE-11	0.0596	499.57	0.027
Wetlands	DMR-6	0.0595	291.64	0.0132	Pasture	TRE-12	0.0604	394.9	0.0287
Wetlands	DMR-7	0.0535	139.18	0.0206	Pasture	TRE-13	0.0558	442.58	0.0188
Wetlands	DMR-8	0.0611	254.95	0.0228	Pasture	TRE-14	0.0578	504.24	0.0189
Wetlands	DMR-9	0.0581	195.27	0.021	Pasture	TRE-15	0.0593	511.94	0.0141
Wetlands	DMR-10	0.059	270.14	0.0199	Pasture	TRE-16	0.0597	428	0.022
Wetlands	DMR-11	0.0595	311.46	0.0153	Pasture	TRE-17	0.0569	535.58	0.0226
					Pasture	TRE-18	0.0579	484.23	0.0223
Forest	MSP-1	0.0663	352.04	0.0247	Pasture	TRE-19	0.0592	529.14	0.023
Forest	MSP-2	0.0646	299.63	0.0377	Pasture	TRE-20	0.0595	500.94	0.0261
Forest	MSP-3	0.0637	313.53	0.0308	Pasture	TRE-21	0.0599	458.46	0.0322
Forest	MSP-4	0.0655	303.41	0.03	Pasture	TRE-22	0.0576	440.9	0.02
Forest	MSP-5	0.0667	355.86	0.0271	Pasture	TRE-23	0.0547	493.03	0.022
Forest	MSP-6	0.0639	339.44	0.0248	Pasture	TRE-24	0.0588	480.65	0.023
Forest	MSP-7	0.0624	346.98	0.0301	Pasture	TRE-25	0.0581	509.1	0.0286
Forest	MSP-8	0.0597	289.71	0.026	Pasture	TRE-26	0.0775	470.2	0.0284
Forest	MSP-9	0.0616	325.49	0.0254	Pasture	TRE-27	0.0629	441.2	0.031
Pasture	MSP-1	0.0696	542.84	0.0205	Pasture	TRE-28	0.0614	433.75	0.036
Pasture	MSP-2	0.0669	494.49	0.0401	Pasture	TRE-29	0.0586	524.02	0.0155
Pasture	MSP-3	0.065	417.8	0.0228	Pasture	TRE-30	0.0544	634.8	0.0297
Pasture	MSP-4	0.0686	548.22	0.0231	Pasture	TRE-31	0.0568	415.54	0.037
Pasture	MSP-5	0.066	357.6	0.0358	Pasture	TRE-32	0.0541	491.73	0.038
Pasture	MSP-6	0.0661	445.83	0.0227	Pasture	TRE-33	0.0782	486.31	0.0397
Pasture	MSP-7	0.0652	440.68	0.0269	Pasture	TRE-34	0.0802	457.38	0.0383
Pasture	MSP-8	0.064	346.61	0.0238	Pasture	TRE-35	0.0865	441.07	0.0371
Pasture	MSP-9	0.064	400.32	0.0252	Pasture	TRE-36	0.0763	461.09	0.0406
Cropland	MSP-1	0.0717	536.09	0.0122	Pasture	TRE-37	0.0773	403.52	0.0329
Cropland	MSP-2	0.0673	487.78	0.0218	Cropland	TRE-1	0.0717	514.39	0.0159
Cropland	MSP-3	0.0661	521.6	0.0195	Cropland	TRE-2	0.0685	681.72	0.0219
Cropland	MSP-4	0.0684	551.85	0.0186	Cropland	TRE-3	0.0703	530.82	0.0262
Cropland	MSP-5	0.0677	503	0.0193	Cropland	TRE-4	0.069	473.35	0.03
Cropland	MSP-6	0.0671	527.68	0.0184	Cropland	TRE-5	0.0697	629.73	0.0241
Cropland	MSP-7	0.0659	563.68	0.0202	Cropland	TRE-6	0.0692	519.39	0.0199
Cropland	MSP-8	0.0654	495.91	0.0174	Cropland	TRE-7	0.0676	532.61	0.0295

Land Use	Sub	INFILT	LSUR	SLSUR	Land Use	Sub	INFILT	LSUR	SLSUR
Cropland	MSP-9	0.0648	529.38	0.0181	Cropland	TRE-8	0.067	475.25	0.0241
Residential	MSP-2	0.0672	470.86	0.0215	Cropland	TRE-9	0.068	485.25	0.0253
Residential	MSP-3	0.0649	424.34	0.0194	Cropland	TRE-10	0.0679	445.89	0.0253
Residential	MSP-5	0.0534	119.71	0.0015	Cropland	TRE-11	0.0686	462.64	0.0292
Residential	MSP-6	0.0623	284.05	0.0188	Cropland	TRE-12	0.071	363.59	0.0282
Residential	MSP-7	0.0656	735.58	0.0211	Cropland	TRE-13	0.0688	481.92	0.0286
Residential	MSP-8	0.0624	600.27	0.0025	Cropland	TRE-14	0.0664	523.58	0.0241
Residential	MSP-9	0.0628	335.05	0.016	Cropland	TRE-15	0.0665	463.55	0.0228
Wetlands	MSP-1	0.0602	325.82	0.0341	Cropland	TRE-16	0.0677	487.73	0.0247
Wetlands	MSP-2	0.0628	219.72	0.0438	Cropland	TRE-17	0.068	517.69	0.0249
Wetlands	MSP-3	0.0599	163.93	0.0485	Cropland	TRE-18	0.0663	472.04	0.0263
Wetlands	MSP-4	0.0615	211.56	0.0357	Cropland	TRE-19	0.0669	497.47	0.0225
Wetlands	MSP-5	0.0654	315.67	0.0271	Cropland	TRE-20	0.0681	541.58	0.0191
Wetlands	MSP-6	0.0588	263.83	0.021	Cropland	TRE-21	0.0658	560.96	0.0216
Wetlands	MSP-7	0.0574	155.68	0.0266	Cropland	TRE-22	0.0671	485.44	0.0207
Wetlands	MSP-8	0.0558	152.49	0.0258	Cropland	TRE-23	0.0641	502.75	0.0183
Wetlands	MSP-9	0.0594	198.96	0.0311	Cropland	TRE-24	0.0669	514.28	0.0209
					Cropland	TRE-25	0.0656	576.17	0.0252
Forest	TRR-1	0.0619	391.99	0.0127	Cropland	TRE-26	0.0753	519.75	0.0208
Forest	TRR-2	0.0666	286.61	0.0203	Cropland	TRE-27	0.0749	476.19	0.024
Forest	TRR-3	0.0611	315.31	0.0338	Cropland	TRE-28	0.0643	540	0.0263
Forest	TRR-4	0.0619	282.18	0.0296	Cropland	TRE-29	0.0585	596.34	0.0159
Forest	TRR-5	0.0633	265.21	0.0328	Cropland	TRE-30	0.0563	563.7	0.0216
Forest	TRR-6	0.0621	288.42	0.0325	Cropland	TRE-31	0.0642	550.73	0.0262
Forest	TRR-7	0.0661	330.57	0.0369	Cropland	TRE-32	0.0602	656.23	0.0277
Forest	TRR-8	0.0638	351.87	0.0375	Cropland	TRE-33	0.0778	524.35	0.0321
Forest	TRR-9	0.0633	286.64	0.0379	Cropland	TRE-34	0.0631	499.92	0.0292
Forest	FTS-10	0.0686	303.5	0.0384	Cropland	TRE-35	0.0917	573.99	0.0305
Forest	FTS-11	0.0675	299.78	0.0336	Cropland	TRE-36	0.0563	472.43	0.0291
Forest	FTS-12	0.064	267.67	0.0289	Cropland	TRE-37	0.087	561.85	0.0275
Forest	FTS-13	0.0663	292.21	0.045	Residential	TRE-3	0.0614	374.53	0.0279
Forest	FTS-14	0.0632	318.65	0.0372	Residential	TRE-4	0.0615	529.91	0.0111
Forest	FTS-15	0.066	346.85	0.0316	Residential	TRE-5	0.063	467.27	0.0179
Forest	FTS-16	0.0647	333.63	0.0314	Residential	TRE-6	0.0644	525.05	0.0235
Forest	FTS-17	0.0656	348.97	0.0331	Residential	TRE-7	0.0618	392.4	0.0283
Forest	FTS-18	0.0661	338.04	0.0366	Residential	TRE-8	0.0608	358.65	0.0372
Forest	FTS-19	0.0635	384.02	0.0321	Residential	TRE-9	0.0536	134.05	0.0236
Forest	FTS-20	0.0643	297.12	0.0346	Residential	TRE-10	0.0661	360.77	0.0292
Forest	FTS-21	0.0631	306.21	0.041	Residential	TRE-11	0.0619	467.82	0.0308
Pasture	TRR-1	0.066	398.33	0.0138	Residential	TRE-12	0.0687	185.01	0.0228
Pasture	TRR-2	0.0738	472.44	0.0209	Residential	TRE-13	0.0587	453.24	0.0133
Pasture	TRR-3	0.0664	382.54	0.0325	Residential	TRE-14	0.0602	423.34	0.013

Land Use	Sub	INFILT	LSUR	SLSUR	Land Use	Sub	INFILT	LSUR	SLSUR
Pasture	TRR-4	0.0675	350.76	0.0395	Residential	TRE-15	0.0619	675.74	0.0129
Pasture	TRR-5	0.0672	394.96	0.0361	Residential	TRE-16	0.0613	444.01	0.0403
Pasture	TRR-6	0.0644	343.38	0.035	Residential	TRE-17	0.0624	796.71	0.0261
Pasture	TRR-7	0.0673	395.75	0.0299	Residential	TRE-18	0.0608	508.9	0.0275
Pasture	TRR-8	0.066	466.98	0.0363	Residential	TRE-19	0.0655	680.93	0.0116
Pasture	TRR-9	0.0652	428.88	0.0324	Residential	TRE-20	0.0623	386.47	0.0219
Pasture	FTS-10	0.0665	309.64	0.0302	Residential	TRE-21	0.059	486.07	0.0229
Pasture	FTS-11	0.0665	348.69	0.0331	Residential	TRE-22	0.0601	432.66	0.0257
Pasture	FTS-12	0.066	593.52	0.0272	Residential	TRE-23	0.0618	435.8	0.0281
Pasture	FTS-13	0.0666	441.2	0.0378	Residential	TRE-24	0.0604	467.22	0.0151
Pasture	FTS-14	0.0682	419.85	0.04	Residential	TRE-25	0.0614	413.5	0.0276
Pasture	FTS-15	0.0668	399.63	0.0197	Residential	TRE-26	0.0685	459.8	0.0252
Pasture	FTS-16	0.0659	420.1	0.0264	Residential	TRE-27	0.0749	468.34	0.025
Pasture	FTS-17	0.0649	653.93	0.0251	Residential	TRE-28	0.0616	431.1	0.0313
Pasture	FTS-18	0.0662	485.01	0.0243	Residential	TRE-29	0.0662	824.05	0.0151
Pasture	FTS-19	0.0657	235	0.0252	Residential	TRE-30	0.061	654.71	0.0178
Pasture	FTS-20	0.066	380.89	0.0282	Residential	TRE-31	0.0566	521.38	0.0314
Pasture	FTS-21	0.0661	510.67	0.0341	Residential	TRE-32	0.0589	537.72	0.0295
Cropland	TRR-1	0.0707	470.28	0.016	Residential	TRE-33	0.0786	506.27	0.0369
Cropland	TRR-2	0.0747	352.27	0.0167	Residential	TRE-34	0.0601	536.88	0.0324
Cropland	TRR-3	0.0666	503.23	0.0227	Residential	TRE-35	0.0918	507.58	0.0285
Cropland	TRR-4	0.0674	531.12	0.0237	Residential	TRE-36	0.074	498.71	0.0281
Cropland	TRR-5	0.0674	527.7	0.0242	Residential	TRE-37	0.0866	503.4	0.0291
Cropland	TRR-6	0.0666	514.16	0.024	Wetlands	TRE-1	0.0627	372.1	0.0166
Cropland	TRR-7	0.0675	549.19	0.0227	Wetlands	TRE-2	0.0604	740.51	0.011
Cropland	TRR-8	0.0677	557.78	0.0262	Wetlands	TRE-3	0.0648	254.37	0.0223
Cropland	TRR-9	0.0661	545.64	0.0243	Wetlands	TRE-4	0.066	201.54	0.0411
Cropland	FTS-10	0.068	517.78	0.0242	Wetlands	TRE-5	0.0626	475.92	0.0135
Cropland	FTS-11	0.0681	548.81	0.0255	Wetlands	TRE-6	0.0588	518.28	0.0085
Cropland	FTS-12	0.0677	542.89	0.021	Wetlands	TRE-7	0.0645	277.69	0.0255
Cropland	FTS-13	0.0681	518.32	0.0268	Wetlands	TRE-8	0.0624	264.73	0.03
Cropland	FTS-14	0.0673	521.57	0.0269	Wetlands	TRE-9	0.0658	192.54	0.0377
Cropland	FTS-15	0.0676	587.45	0.0227	Wetlands	TRE-10	0.0584	244.72	0.0156
Cropland	FTS-16	0.0667	485.13	0.0239	Wetlands	TRE-11	0.0621	182.74	0.0343
Cropland	FTS-17	0.0676	493.86	0.0271	Wetlands	TRE-12	0.065	186.13	0.0237
Cropland	FTS-18	0.0669	501.05	0.0245	Wetlands	TRE-13	0.0605	208.36	0.0274
Cropland	FTS-19	0.0661	447.31	0.0311	Wetlands	TRE-14	0.0601	185.92	0.0258
Cropland	FTS-20	0.066	510.03	0.0209	Wetlands	TRE-15	0.0602	258.12	0.012
Cropland	FTS-21	0.0648	462.69	0.0327	Wetlands	TRE-16	0.0596	362.11	0.0131
Residential	TRR-1	0.069	558.33	0.008	Wetlands	TRE-17	0.0631	229.26	0.0302
Residential	TRR-2	0.0732	542.89	0.026	Wetlands	TRE-18	0.0583	254.86	0.0093
Residential	TRR-3	0.0651	579.46	0.0169	Wetlands	TRE-19	0.0597	255.15	0.0204

Land Use	Sub	INFILT	LSUR	SLSUR	Land Use	Sub	INFILT	LSUR	SLSUR
Residential	TRR-4	0.0709	473.09	0.0113	Wetlands	TRE-20	0.0563	488.57	0.0058
Residential	TRR-5	0.0634	596.38	0.0171	Wetlands	TRE-21	0.0547	393.85	0.0082
Residential	TRR-7	0.0632	434.64	0.0082	Wetlands	TRE-22	0.0561	284.38	0.0103
Residential	TRR-9	0.0656	314.24	0.0409	Wetlands	TRE-23	0.0598	378.36	0.0143
Residential	FTS-13	0.0656	358.24	0.0276	Wetlands	TRE-24	0.0611	252.56	0.0268
Residential	FTS-15	0.0708	414.92	0.0506	Wetlands	TRE-25	0.0552	426.04	0.0107
Residential	FTS-16	0.0656	892.5	0.0286	Wetlands	TRE-26	0.0457	195.91	0.0384
Residential	FTS-18	0.0657	519.29	0.0098	Wetlands	TRE-27	0.051	226.96	0.0261
Residential	FTS-19	0.0656	495.78	0.0367	Wetlands	TRE-28	0.0397	218.59	0.0411
Residential	FTS-20	0.0656	525.66	0.005	Wetlands	TRE-29	0.0513	222.17	0.0171
Residential	FTS-21	0.0654	181.66	0.0401	Wetlands	TRE-30	0.0521	262.61	0.0203
Wetlands	TRR-1	0.057	231.44	0.015	Wetlands	TRE-31	0.0312	185.68	0.0274
Wetlands	TRR-2	0.0573	182.69	0.0166	Wetlands	TRE-32	0.0349	170.87	0.0336
Wetlands	TRR-3	0.0606	200.69	0.0395	Wetlands	TRE-33	0.0393	180.7	0.0357
Wetlands	TRR-4	0.0564	203.14	0.0201	Wetlands	TRE-34	0.0363	162.82	0.0456
Wetlands	TRR-5	0.0571	238.01	0.0193	Wetlands	TRE-35	0.0224	151.86	0.0191
Wetlands	TRR-6	0.0578	224.83	0.0288	Wetlands	TRE-36	0.0331	198.92	0.021
Wetlands	TRR-7	0.0617	241.23	0.0377	Wetlands	TRE-37	0.062	182.15	0.0339
Wetlands	TRR-8	0.0581	222.31	0.035					
Wetlands	TRR-9	0.0601	167.92	0.0435					
Wetlands	FTS-10	0.0625	225.05	0.031					
Wetlands	FTS-11	0.064	251.94	0.0273					
Wetlands	FTS-12	0.0609	238.14	0.0327					
Wetlands	FTS-13	0.0619	159.31	0.0438					
Wetlands	FTS-14	0.0591	242.98	0.0239					
Wetlands	FTS-15	0.0578	258.11	0.0195					
Wetlands	FTS-16	0.0575	210.1	0.0226					
Wetlands	FTS-17	0.0569	286.24	0.0214					
Wetlands	FTS-18	0.0585	190.12	0.0301					
Wetlands	FTS-19	0.0581	352.01	0.0242					
Wetlands	FTS-20	0.0572	141.64	0.0313					
Wetlands	FTS-21	0.0595	242.3	0.0339					

Table F. 2. MON-INTERCEP (monthly CEPSC) - Monthly interception storage (in) for Darden Mill Run, Mill Swamp, Flat Swamp, Tarrara Creek, and the portion of Three Creek in the Coastal Plain ecoregion.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Forest	0.1	0.1	0.18	0.25	0.34	0.4	0.4	0.4	0.34	0.25	0.18	0.1
Pasture	0.05	0.05	0.09	0.13	0.17	0.2	0.2	0.2	0.17	0.13	0.09	0.05
Cropland	0.05	0.05	0.11	0.18	0.25	0.3	0.3	0.3	0.25	0.18	0.11	0.05
Residential	0.1	0.1	0.11	0.13	0.14	0.15	0.15	0.15	0.14	0.13	0.11	0.1
Wetlands	0.15	0.15	0.21	0.28	0.35	0.4	0.4	0.4	0.35	0.28	0.21	0.15

Table F. 3. MON-INTERCEP (monthly CEPSC) - Monthly interception storage (in) for the portion of Three Creek in the Piedmont ecoregion.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Forest	0.03	0.03	0.04	0.15	0.2	0.22	0.22	0.22	0.19	0.1	0.05	0.05
Pasture	0.04	0.04	0.08	0.12	0.15	0.18	0.18	0.18	0.12	0.1	0.05	0.04
Cropland	0.03	0.04	0.09	0.15	0.17	0.19	0.19	0.19	0.16	0.09	0.05	0.03
Residential	0.04	0.04	0.07	0.1	0.15	0.15	0.15	0.15	0.15	0.12	0.05	0.05
Wetlands	0.03	0.04	0.06	0.2	0.2	0.2	0.2	0.2	0.15	0.1	0.05	0.04

Table F. 4. MON-LZETP - Monthly lower zone evapotranspiration parameter for Darden Mill Run, Mill Swamp, Flat Swamp, Tarrara Creek, and the portion of Three Creek in the Coastal Plain ecoregion.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Forest	0.3	0.3	0.45	0.6	0.78	0.9	0.9	0.9	0.78	0.6	0.45	0.3
Pasture	0.4	0.4	0.45	0.5	0.56	0.6	0.6	0.6	0.56	0.5	0.45	0.4
Cropland	0.2	0.2	0.33	0.45	0.6	0.7	0.7	0.7	0.6	0.45	0.33	0.2
Residential	0.3	0.3	0.33	0.35	0.38	0.4	0.4	0.4	0.38	0.35	0.33	0.3
Wetlands	0.5	0.5	0.6	0.7	0.82	0.9	0.9	0.9	0.82	0.7	0.6	0.5

Table F. 5. MON-LZETP - Monthly lower zone evapotranspiration parameter for the portion of Three Creek in the Piedmont ecoregion.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Forest	0.1	0.1	0.35	0.5	0.55	0.75	0.75	0.75	0.65	0.4	0.1	0.1
Pasture	0.1	0.15	0.45	0.5	0.65	0.7	0.7	0.7	0.45	0.45	0.15	0.1
Cropland	0.1	0.15	0.45	0.5	0.65	0.7	0.7	0.7	0.55	0.45	0.15	0.1
Residential	0.1	0.15	0.4	0.45	0.45	0.5	0.5	0.5	0.45	0.45	0.15	0.1
Wetlands	0.1	0.15	0.45	0.5	0.55	0.7	0.7	0.7	0.6	0.5	0.15	0.1

Table F. 6. MON-UZSN - Monthly upper zone nominal soil moisture storage (in) for the portion of Three Creek in the Piedmont ecoregion.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Forest	0.3	0.3	0.35	0.95	0.95	1.1	1.1	1.1	0.9	0.7	0.4	0.4
Pasture	0.4	0.4	0.65	0.75	0.95	0.95	0.95	0.95	0.65	0.65	0.4	0.4
Cropland	0.5	0.5	0.5	0.7	0.8	0.9	0.9	0.9	0.7	0.7	0.5	0.5
Residential	0.5	0.5	0.5	0.65	0.75	0.8	0.8	0.8	0.65	0.65	0.5	0.5
Wetlands	0.4	0.4	0.6	0.85	0.95	1	1	1	0.75	0.75	0.5	0.5

Table F. 7. PWAT-PARM6 (high water table) parameters for Darden Mill Run (DMR), Mill Swamp (MSP), Tarrara Creek (TRR), Flat Swamp (FTS), and the Coastal Plain portion of Three Creek.

Sub	MELEV	BELV	GWDATM	PCW	PGW	UPGW
MSP-1	21.657	9.7234	9.5937	0.1379	0.264	0.2787
MSP-2	53.974	30.5846	40.5588	0.124	0.3018	0.3061
MSP-3	66.6567	66.1567	53.3772	0.1252	0.2867	0.2885
MSP-4	30.7463	21.8551	16.9409	0.1205	0.285	0.288
MSP-5	60.6361	35.9152	46.0707	0.1142	0.3073	0.3078
MSP-6	55.8549	44.2934	43.1411	0.1308	0.2777	0.2952
MSP-7	63.8811	63.3811	52.0226	0.1403	0.261	0.2765
MSP-8	61.4521	49.7248	49.3013	0.1369	0.2629	0.2717
MSP-9	76.8317	70.6245	64.8265	0.1385	0.2826	0.2895
TRE-1	28.7307	21.8154	16.5435	0.1368	0.2637	0.291
TRE-2	32.8139	26.7041	20.6253	0.1367	0.2587	0.2944
TRE-3	54.3353	42.3548	40.8846	0.1239	0.2847	0.2978
TRE-4	81.814	81.314	68.6817	0.1269	0.2669	0.2853
TRE-5	44.1445	32.9446	31.7061	0.134	0.2706	0.3002
TRE-6	44.4848	42.9072	32.8254	0.1429	0.2613	0.2942
TRE-7	61.5007	43.3585	48.87	0.132	0.2797	0.3073
TRE-8	70.4388	52.8857	58.1311	0.1354	0.2771	0.3001
TRE-9	75.2258	74.7258	61.5911	0.1222	0.2927	0.2983
TRE-10	67.8412	57.6384	55.955	0.1402	0.2436	0.2754
TRE-11	83.9851	75.5391	72.2299	0.1418	0.2435	0.2959
TRE-12	88.2546	84.431	75.2962	0.1286	0.2655	0.3
TRE-13	95.4787	86.1852	83.6277	0.1406	0.2496	0.2903
TRE-14	103.6176	103.1176	91.94	0.1427	0.2564	0.2948
TRE-15	51.1426	48.5091	38.7745	0.1348	0.2728	0.3043
TRE-16	60.916	53.3038	49.3472	0.1441	0.2623	0.2937

Sub	MELEV	BELV	GWDATM	PCW	PGW	UPGW
DMR-1	33.7845	25.8561	21.6029	0.1365	0.2666	0.2861
DMR-2	46.7588	32.1951	33.8427	0.1288	0.2777	0.2785
DMR-3	65.6358	58.0704	52.3854	0.1255	0.305	0.3046
DMR-4	48.5742	42.2543	35.7779	0.13	0.2645	0.2652
DMR-5	61.9367	52.6072	49.1635	0.1302	0.2834	0.2845
DMR-6	84.1137	73.2715	72.8028	0.147	0.2965	0.2893
DMR-7	60.812	60.312	48.2104	0.132	0.251	0.2539
DMR-8	83.7447	80.1341	71.4226	0.135	0.3023	0.304
DMR-9	47.4991	32.9703	35.1571	0.1348	0.2784	0.2786
DMR-10	53.5039	45.2175	40.7035	0.1299	0.286	0.2865
DMR-11	73.354	69.7433	61.1846	0.1367	0.2902	0.2847
TRR-1	23.0051	16.8379	11.2091	0.141	0.2586	0.2925
TRR-2	23.7522	21.4053	11.4367	0.135	0.2632	0.2616
TRR-3	57.1114	56.2675	43.4372	0.1216	0.289	0.29
TRR-4	34.122	26.128	20.7081	0.124	0.2613	0.2615
TRR-5	37.9654	30.7712	24.212	0.1209	0.2613	0.2666
TRR-6	46.8973	40.2163	33.1934	0.1214	0.2762	0.278
TRR-7	63.728	63.228	49.9724	0.1209	0.2908	0.305
TRR-8	53.5207	45.1315	41.2238	0.1353	0.2754	0.2896
TRR-9	74.4508	73.9508	62.2766	0.1366	0.2848	0.2983
FTS-10	44.4243	35.0291	29.4541	0.1111	0.2726	0.2763
FTS-11	54.5224	42.2675	38.7372	0.1054	0.2858	0.2875
FTS-12	61.2417	49.2229	48.057	0.1261	0.2931	0.293
FTS-13	76.3899	73.9246	62.304	0.1181	0.2916	0.2939
FTS-14	50.5286	43.0221	37.4466	0.1271	0.274	0.2781

Sub	MELEV	BELV	GWDATM	PCW	PGW	UPGW	Sub	MELEV	BELV	GWDATM	PCW	PGW	UPGW
TRE-17	84.2633	83.7633	71.0409	0.126	0.2727	0.296	FTS-15	59.4426	52.9334	45.6666	0.1207	0.2637	0.2657
TRE-18	64.3312	61.6606	53.3122	0.1513	0.2546	0.2871	FTS-16	69.8237	62.4507	56.8583	0.1283	0.272	0.2731
TRE-19	85.0727	84.5727	73.1874	0.1402	0.2585	0.2845	FTS-17	76.537	66.6771	63.3326	0.126	0.2702	0.2717
TRE-20	70.5116	67.1241	59.7841	0.1554	0.2397	0.2893	FTS-18	79.6535	79.1535	66.5626	0.127	0.2748	0.2748
TRE-21	76.2301	71.0715	65.9165	0.1616	0.2081	0.2952	FTS-19	74.8615	65.8445	61.8886	0.1282	0.2807	0.2833
TRE-22	83.9378	79.5239	73.0128	0.1526	0.2374	0.2926	FTS-20	80.118	79.618	67.1325	0.1281	0.2736	0.2748
TRE-23	98.807	90.9174	87.9498	0.1535	0.221	0.2874	FTS-21	84.3498	83.8498	71.7806	0.1323	0.2885	0.292
TRE-24	128.0072	127.5072	116.877	0.1497	0.2335	0.2899							
TRE-25	82.3879	81.8879	72.2215	0.1639	0.1991	0.2962							

Table F. 8. MON-ACCUM (monthly accumulation (ACQOP)) table for Darden Mill Run - values in cfu/acre/day for fecal coliform.

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Cropland	DMR-1	3.70E+07	3.70E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07
Pasture	DMR-1	3.70E+07	3.70E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07
Residential	DMR-1	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10
Wetlands	DMR-1	3.00E+07	3.00E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07
Forest	DMR-1	4.70E+07	4.70E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07
Cropland	DMR-2	3.90E+07	3.90E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07
Pasture	DMR-2	3.90E+07	3.90E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07
Residential	DMR-2	8.80E+09	8.80E+09	8.80E+09	8.80E+09	8.80E+09	8.80E+09	8.80E+09	8.80E+09	8.80E+09	8.80E+09	8.80E+09	8.80E+09
Wetlands	DMR-2	3.20E+07	3.20E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07
Forest	DMR-2	4.90E+07	4.90E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07
Cropland	DMR-3	4.10E+07	4.10E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07
Pasture	DMR-3	4.60E+10	4.80E+10	4.80E+10	4.80E+10	4.80E+10	4.60E+10	4.60E+10	4.60E+10	4.70E+10	4.30E+10	4.40E+10	4.50E+10
Residential	DMR-3	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09
Wetlands	DMR-3	3.40E+07	3.40E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.40E+07	3.40E+07	3.40E+07	3.40E+07
Forest	DMR-3	5.10E+07	5.10E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	5.10E+07	5.10E+07	5.10E+07	5.10E+07
Cropland	DMR-4	4.90E+07	4.90E+07	1.00E+08	1.40E+09	3.50E+08	4.50E+07	4.50E+07	4.50E+07	4.90E+07	1.60E+08	5.00E+08	4.90E+07
Pasture	DMR-4	1.00E+10	1.10E+10	1.10E+10	1.20E+10	1.20E+10	1.10E+10	1.10E+10	1.20E+10	1.20E+10	9.10E+09	9.60E+09	1.00E+10
Residential	DMR-4	2.10E+10	2.10E+10	2.10E+10	2.10E+10	2.10E+10	2.10E+10	2.10E+10	2.10E+10	2.10E+10	2.10E+10	2.10E+10	2.10E+10
Wetlands	DMR-4	4.20E+07	4.20E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07
Forest	DMR-4	5.90E+07	5.90E+07	5.50E+07	5.50E+07	5.50E+07	5.50E+07	5.50E+07	5.50E+07	5.90E+07	5.90E+07	5.90E+07	5.90E+07
Cropland	DMR-5	4.10E+07	4.10E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07
Pasture	DMR-5	7.80E+09	8.90E+09	9.10E+09	9.30E+09	9.50E+09	9.60E+09	9.80E+09	1.00E+10	1.00E+10	6.70E+09	7.10E+09	7.40E+09
Wetlands	DMR-5	3.40E+07	3.40E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.40E+07	3.40E+07	3.40E+07	3.40E+07
Forest	DMR-5	5.10E+07	5.10E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	5.10E+07	5.10E+07	5.10E+07	5.10E+07
Cropland	DMR-6	3.50E+07	3.50E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Pasture	DMR-6	3.50E+07	1.70E+09	2.40E+09	3.10E+09	3.80E+09	4.50E+09	5.30E+09	6.00E+09	6.80E+09	3.50E+07	3.50E+07	3.50E+07
Residential	DMR-6	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09
Wetlands	DMR-6	2.80E+07	2.80E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07
Forest	DMR-6	4.50E+07	4.50E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07
Cropland	DMR-7	7.10E+07	7.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	7.10E+07	7.10E+07	7.10E+07	7.10E+07
Pasture	DMR-7	7.10E+07	7.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	7.10E+07	7.10E+07	7.10E+07	7.10E+07
Residential	DMR-7	1.70E+09	1.70E+09	1.70E+09	1.70E+09	1.70E+09	1.70E+09	1.70E+09	1.70E+09	1.70E+09	1.70E+09	1.70E+09	1.70E+09
Wetlands	DMR-7	6.50E+07	6.50E+07	5.50E+07	5.50E+07	5.50E+07	5.50E+07	5.50E+07	5.50E+07	6.50E+07	6.50E+07	6.50E+07	6.50E+07
Forest	DMR-7	8.10E+07	8.10E+07	7.10E+07	7.10E+07	7.10E+07	7.10E+07	7.10E+07	7.10E+07	8.10E+07	8.10E+07	8.10E+07	8.10E+07
Cropland	DMR-8	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07
Pasture	DMR-8	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07
Residential	DMR-8	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08
Wetlands	DMR-8	1.80E+07	1.80E+07	1.80E+07	1.80E+07	1.80E+07	1.80E+07	1.80E+07	1.80E+07	1.80E+07	1.80E+07	1.80E+07	1.80E+07
Forest	DMR-8	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07
Cropland	DMR-9	3.90E+07	3.90E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07
Pasture	DMR-9	1.30E+10	1.50E+10	1.60E+10	1.60E+10	1.60E+10	1.70E+10	1.70E+10	1.80E+10	1.80E+10	1.20E+10	1.20E+10	1.30E+10
Residential	DMR-9	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09
Wetlands	DMR-9	3.30E+07	3.30E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07
Forest	DMR-9	4.90E+07	4.90E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07
Cropland	DMR-10	3.90E+07	3.90E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07
Pasture	DMR-10	3.90E+07	3.90E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07
Residential	DMR-10	6.30E+09	6.30E+09	6.30E+09	6.30E+09	6.30E+09	6.30E+09	6.30E+09	6.30E+09	6.30E+09	6.30E+09	6.30E+09	6.30E+09
Wetlands	DMR-10	3.10E+07	3.10E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07
Forest	DMR-10	4.80E+07	4.80E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07
Cropland	DMR-11	4.30E+07	4.30E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07
Pasture	DMR-11	4.30E+07	4.30E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07
Residential	DMR-11	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10
Wetlands	DMR-11	3.60E+07	3.60E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Forest	DMR-11	5.30E+07	5.30E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07

Table F. 9. MON-SQOLIM (monthly limit on surface accumulation) table for Darden Mill Run - values in cfu/day for fecal coliform.

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Cropland	DMR-1	3.30E+08	3.30E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08
Pasture	DMR-1	3.30E+08	3.30E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08
Residential	DMR-1	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11
Wetlands	DMR-1	2.70E+08	2.70E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08
Forest	DMR-1	4.20E+08	4.20E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08
Cropland	DMR-2	3.50E+08	3.50E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
Pasture	DMR-2	3.50E+08	3.50E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
Residential	DMR-2	7.90E+10	7.90E+10	7.90E+10	7.90E+10	7.90E+10	7.90E+10	7.90E+10	7.90E+10	7.90E+10	7.90E+10	7.90E+10	7.90E+10
Wetlands	DMR-2	2.90E+08	2.90E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08
Forest	DMR-2	4.40E+08	4.40E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08
Cropland	DMR-3	3.70E+08	3.70E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08
Pasture	DMR-3	4.10E+11	4.30E+11	4.30E+11	4.30E+11	4.30E+11	4.10E+11	4.10E+11	4.20E+11	4.20E+11	3.90E+11	4.00E+11	4.10E+11
Residential	DMR-3	5.60E+10	5.60E+10	5.60E+10	5.60E+10	5.60E+10	5.60E+10	5.60E+10	5.60E+10	5.60E+10	5.60E+10	5.60E+10	5.60E+10
Wetlands	DMR-3	3.10E+08	3.10E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08
Forest	DMR-3	4.60E+08	4.60E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08
Cropland	DMR-4	4.40E+08	4.40E+08	9.10E+08	1.30E+10	3.20E+09	4.00E+08	4.00E+08	4.00E+08	4.40E+08	1.40E+09	4.50E+09	4.40E+08
Pasture	DMR-4	9.40E+10	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	8.20E+10	8.60E+10	9.00E+10
Residential	DMR-4	1.90E+11	1.90E+11	1.90E+11	1.90E+11	1.90E+11	1.90E+11	1.90E+11	1.90E+11	1.90E+11	1.90E+11	1.90E+11	1.90E+11
Wetlands	DMR-4	3.80E+08	3.80E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08
Forest	DMR-4	5.30E+08	5.30E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08
Cropland	DMR-5	3.70E+08	3.70E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08
Pasture	DMR-5	7.00E+10	8.00E+10	8.20E+10	8.40E+10	8.50E+10	8.70E+10	8.80E+10	9.00E+10	9.30E+10	6.10E+10	6.40E+10	6.70E+10
Wetlands	DMR-5	3.10E+08	3.10E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08
Forest	DMR-5	4.60E+08	4.60E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08
Cropland	DMR-6	3.20E+08	3.20E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08
Pasture	DMR-6	3.20E+08	1.50E+10	2.20E+10	2.80E+10	3.50E+10	4.10E+10	4.70E+10	5.40E+10	6.10E+10	3.20E+08	3.20E+08	3.20E+08
Residential	DMR-6	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10
Wetlands	DMR-6	2.50E+08	2.50E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Forest	DMR-6	4.00E+08	4.00E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08
Cropland	DMR-7	6.40E+08	6.40E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	6.40E+08	6.40E+08	6.40E+08	6.40E+08
Pasture	DMR-7	6.40E+08	6.40E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	6.40E+08	6.40E+08	6.40E+08	6.40E+08
Residential	DMR-7	1.60E+10	1.60E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10
Wetlands	DMR-7	5.80E+08	5.80E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08
Forest	DMR-7	7.30E+08	7.30E+08	6.40E+08	6.40E+08	6.40E+08	6.40E+08	6.40E+08	6.40E+08	7.30E+08	7.30E+08	7.30E+08	7.30E+08
Cropland	DMR-8	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08
Pasture	DMR-8	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08
Residential	DMR-8	4.00E+09	4.00E+09	4.00E+09	4.00E+09	4.00E+09	4.00E+09	4.00E+09	4.00E+09	4.00E+09	4.00E+09	4.00E+09	4.00E+09
Wetlands	DMR-8	1.60E+08	1.60E+08	1.60E+08	1.60E+08	1.60E+08	1.60E+08	1.60E+08	1.60E+08	1.60E+08	1.60E+08	1.60E+08	1.60E+08
Forest	DMR-8	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08
Cropland	DMR-9	3.50E+08	3.50E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
Pasture	DMR-9	1.20E+11	1.40E+11	1.40E+11	1.50E+11	1.50E+11	1.50E+11	1.50E+11	1.60E+11	1.60E+11	1.10E+11	1.10E+11	1.20E+11
Residential	DMR-9	1.40E+10	1.40E+10	1.40E+10	1.40E+10	1.40E+10	1.40E+10	1.40E+10	1.40E+10	1.40E+10	1.40E+10	1.40E+10	1.40E+10
Wetlands	DMR-9	2.90E+08	2.90E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08
Forest	DMR-9	4.50E+08	4.50E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08
Cropland	DMR-10	3.50E+08	3.50E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
Pasture	DMR-10	3.50E+08	3.50E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
Residential	DMR-10	5.70E+10	5.70E+10	5.70E+10	5.70E+10	5.70E+10	5.70E+10	5.70E+10	5.70E+10	5.70E+10	5.70E+10	5.70E+10	5.70E+10
Wetlands	DMR-10	2.80E+08	2.80E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08
Forest	DMR-10	4.40E+08	4.40E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08
Cropland	DMR-11	3.90E+08	3.90E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08
Pasture	DMR-11	3.90E+08	3.90E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08
Residential	DMR-11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11
Wetlands	DMR-11	3.20E+08	3.20E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08
Forest	DMR-11	4.80E+08	4.80E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08

Table F. 10. MON-ACCUM (monthly accumulation (ACQOP)) table for Mill Swamp - values in cfu/acre/day for fecal coliform.

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Cropland	MSP-1	4.30E+07	4.30E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07
Pasture	MSP-1	4.30E+07	4.30E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07
Wetlands	MSP-1	3.70E+07	3.70E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07
Forest	MSP-1	5.50E+07	5.50E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.50E+07	5.50E+07	5.50E+07	5.50E+07
Cropland	MSP-2	4.10E+07	4.10E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07
Pasture	MSP-2	4.10E+07	4.10E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07
Residential	MSP-2	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09
Wetlands	MSP-2	3.50E+07	3.50E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07
Forest	MSP-2	5.20E+07	5.20E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07
Cropland	MSP-3	3.10E+07	3.10E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07
Pasture	MSP-3	3.10E+07	3.10E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07
Residential	MSP-3	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09
Wetlands	MSP-3	2.40E+07	2.40E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07
Forest	MSP-3	4.10E+07	4.10E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07
Cropland	MSP-4	3.60E+07	3.60E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07
Pasture	MSP-4	3.60E+07	3.60E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07
Wetlands	MSP-4	3.00E+07	3.00E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07
Forest	MSP-4	4.70E+07	4.70E+07	4.40E+07	4.40E+07	4.40E+07	4.40E+07	4.40E+07	4.40E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07
Cropland	MSP-5	3.60E+07	3.60E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07
Pasture	MSP-5	5.20E+09	5.50E+09	5.50E+09	5.50E+09	5.50E+09	5.50E+09	5.50E+09	5.50E+09	5.60E+09	4.80E+09	5.00E+09	5.10E+09
Residential	MSP-5	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10
Wetlands	MSP-5	2.90E+07	2.90E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07
Forest	MSP-5	4.70E+07	4.70E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07
Cropland	MSP-6	4.50E+07	4.50E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07
Pasture	MSP-6	4.50E+07	4.50E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07
Residential	MSP-6	2.30E+09	2.30E+09	2.30E+09	2.30E+09	2.30E+09	2.30E+09	2.30E+09	2.30E+09	2.30E+09	2.30E+09	2.30E+09	2.30E+09
Wetlands	MSP-6	3.90E+07	3.90E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07
Forest	MSP-6	5.60E+07	5.60E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07	5.60E+07	5.60E+07	5.60E+07	5.60E+07
Cropland	MSP-7	3.90E+07	3.90E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Pasture	MSP-7	3.90E+07	3.90E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07
Residential	MSP-7	8.00E+08	8.00E+08	7.90E+08	7.90E+08	7.90E+08	7.90E+08	7.90E+08	7.90E+08	8.00E+08	8.00E+08	8.00E+08	8.00E+08
Wetlands	MSP-7	3.20E+07	3.20E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07
Forest	MSP-7	5.00E+07	5.00E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07
Cropland	MSP-8	3.90E+07	3.90E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07
Pasture	MSP-8	3.90E+07	3.90E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07
Residential	MSP-8	1.40E+09	1.40E+09	1.40E+09	1.40E+09	1.40E+09	1.40E+09	1.40E+09	1.40E+09	1.40E+09	1.40E+09	1.40E+09	1.40E+09
Wetlands	MSP-8	3.30E+07	3.30E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07
Forest	MSP-8	5.00E+07	5.00E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07
Cropland	MSP-9	3.10E+07	3.10E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07
Pasture	MSP-9	7.80E+09	8.10E+09	7.90E+09	7.80E+09	7.60E+09	7.50E+09	7.40E+09	7.20E+09	7.10E+09	7.00E+09	7.20E+09	7.50E+09
Residential	MSP-9	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08
Wetlands	MSP-9	2.50E+07	2.50E+07	2.30E+07	2.30E+07	2.30E+07	2.30E+07	2.30E+07	2.30E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07
Forest	MSP-9	4.20E+07	4.20E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07

Table F. 11. MON-SQOLIM (monthly limit on surface accumulation) table for Mill Swamp - values in cfu/day for fecal coliform.

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Cropland	MSP-1	3.90E+08	3.90E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08
Pasture	MSP-1	3.90E+08	3.90E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08
Wetlands	MSP-1	3.40E+08	3.40E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08
Forest	MSP-1	4.90E+08	4.90E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08
Cropland	MSP-2	3.70E+08	3.70E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08
Pasture	MSP-2	3.70E+08	3.70E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08
Residential	MSP-2	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10
Wetlands	MSP-2	3.10E+08	3.10E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08
Forest	MSP-2	4.70E+08	4.70E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.70E+08	4.70E+08	4.70E+08	4.70E+08
Cropland	MSP-3	2.80E+08	2.80E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08
Pasture	MSP-3	2.80E+08	2.80E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Residential	MSP-3	2.20E+10	2.20E+10	2.20E+10	2.20E+10	2.20E+10	2.20E+10	2.20E+10	2.20E+10	2.20E+10	2.20E+10	2.20E+10	2.20E+10
Wetlands	MSP-3	2.20E+08	2.20E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08
Forest	MSP-3	3.70E+08	3.70E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08
Cropland	MSP-4	3.30E+08	3.30E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08
Pasture	MSP-4	3.30E+08	3.30E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08
Wetlands	MSP-4	2.70E+08	2.70E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08
Forest	MSP-4	4.20E+08	4.20E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08
Cropland	MSP-5	3.20E+08	3.20E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08
Pasture	MSP-5	4.70E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	4.40E+10	4.50E+10	4.60E+10
Residential	MSP-5	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11	1.40E+11
Wetlands	MSP-5	2.60E+08	2.60E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08
Forest	MSP-5	4.20E+08	4.20E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08
Cropland	MSP-6	4.10E+08	4.10E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08
Pasture	MSP-6	4.10E+08	4.10E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08
Residential	MSP-6	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10
Wetlands	MSP-6	3.50E+08	3.50E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
Forest	MSP-6	5.10E+08	5.10E+08	4.70E+08	4.70E+08	4.70E+08	4.70E+08	4.70E+08	4.70E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08
Cropland	MSP-7	3.50E+08	3.50E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
Pasture	MSP-7	3.50E+08	3.50E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
Residential	MSP-7	7.20E+09	7.20E+09	7.10E+09	7.10E+09	7.10E+09	7.10E+09	7.10E+09	7.10E+09	7.20E+09	7.20E+09	7.20E+09	7.20E+09
Wetlands	MSP-7	2.90E+08	2.90E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08
Forest	MSP-7	4.50E+08	4.50E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08
Cropland	MSP-8	3.50E+08	3.50E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
Pasture	MSP-8	3.50E+08	3.50E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
Residential	MSP-8	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10
Wetlands	MSP-8	2.90E+08	2.90E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08
Forest	MSP-8	4.50E+08	4.50E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08
Cropland	MSP-9	2.80E+08	2.80E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08
Pasture	MSP-9	7.00E+10	7.30E+10	7.10E+10	7.00E+10	6.90E+10	6.80E+10	6.60E+10	6.50E+10	6.40E+10	6.30E+10	6.50E+10	6.80E+10

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Residential	MSP-9	4.60E+09	4.60E+09	4.60E+09	4.60E+09	4.60E+09	4.60E+09	4.60E+09	4.60E+09	4.60E+09	4.60E+09	4.60E+09	4.60E+09
Wetlands	MSP-9	2.20E+08	2.20E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08
Forest	MSP-9	3.80E+08	3.80E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08

Table F. 12. MON-ACCUM (monthly accumulation (ACQOP)) table for Tarrara Creek and Flat Swamp - values in cfu/acre/day for fecal coliform.

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Cropland	TRR-1	5.80E+07	5.80E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07	5.80E+07	5.80E+07	5.80E+07	5.80E+07
Pasture	TRR-1	1.10E+10	1.20E+10	1.20E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.00E+10	1.00E+10	9.70E+09	1.00E+10	1.10E+10
Residential	TRR-1	7.80E+08	7.80E+08	7.80E+08	7.80E+08	7.80E+08	7.80E+08	7.80E+08	7.80E+08	7.80E+08	7.80E+08	7.80E+08	7.80E+08
Wetlands	TRR-1	5.20E+07	5.20E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07
Forest	TRR-1	6.90E+07	6.90E+07	6.50E+07	6.50E+07	6.50E+07	6.50E+07	6.50E+07	6.50E+07	6.90E+07	6.90E+07	6.90E+07	6.90E+07
Cropland	TRR-2	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08
Pasture	TRR-2	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08
Residential	TRR-2	7.20E+08	7.20E+08	7.20E+08	7.20E+08	7.20E+08	7.20E+08	7.20E+08	7.20E+08	7.20E+08	7.20E+08	7.20E+08	7.20E+08
Wetlands	TRR-2	9.90E+07	9.90E+07	9.90E+07	9.90E+07	9.90E+07	9.90E+07	9.90E+07	9.90E+07	9.90E+07	9.90E+07	9.90E+07	9.90E+07
Forest	TRR-2	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08
Cropland	TRR-3	3.20E+07	3.20E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07
Pasture	TRR-3	3.20E+09	3.50E+09	3.50E+09	3.50E+09	3.50E+09	3.40E+09	3.40E+09	3.40E+09	3.40E+09	2.80E+09	2.90E+09	3.10E+09
Residential	TRR-3	3.40E+09	3.40E+09	3.40E+09	3.40E+09	3.40E+09	3.40E+09	3.40E+09	3.40E+09	3.40E+09	3.40E+09	3.40E+09	3.40E+09
Wetlands	TRR-3	2.50E+07	2.50E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07
Forest	TRR-3	4.20E+07	4.20E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07
Cropland	TRR-4	5.80E+07	5.80E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07	5.80E+07	5.80E+07	5.80E+07	5.80E+07
Pasture	TRR-4	9.40E+09	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.10E+10	8.20E+09	8.60E+09	9.00E+09
Residential	TRR-4	6.90E+08	6.90E+08	6.90E+08	6.90E+08	6.90E+08	6.90E+08	6.90E+08	6.90E+08	6.90E+08	6.90E+08	6.90E+08	6.90E+08
Wetlands	TRR-4	5.20E+07	5.20E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07
Forest	TRR-4	7.00E+07	7.00E+07	6.50E+07	6.50E+07	6.50E+07	6.50E+07	6.50E+07	6.50E+07	7.00E+07	7.00E+07	7.00E+07	7.00E+07
Cropland	TRR-5	6.90E+07	6.90E+07	6.50E+07	6.50E+07	6.50E+07	6.50E+07	6.50E+07	6.50E+07	6.90E+07	6.90E+07	6.90E+07	6.90E+07
Pasture	TRR-5	2.00E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	1.80E+09	1.90E+09	2.00E+09

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Residential	TRR-5	9.40E+08	9.40E+08	9.30E+08	9.30E+08	9.30E+08	9.30E+08	9.30E+08	9.30E+08	9.40E+08	9.40E+08	9.40E+08	9.40E+08
Wetlands	TRR-5	6.30E+07	6.30E+07	5.90E+07	5.90E+07	5.90E+07	5.90E+07	5.90E+07	5.90E+07	6.30E+07	6.30E+07	6.30E+07	6.30E+07
Forest	TRR-5	8.00E+07	8.00E+07	7.60E+07	7.60E+07	7.60E+07	7.60E+07	7.60E+07	7.60E+07	8.00E+07	8.00E+07	8.00E+07	8.00E+07
Cropland	TRR-6	4.50E+07	4.50E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07
Pasture	TRR-6	2.60E+10	2.90E+10	3.00E+10	3.00E+10	3.00E+10	3.10E+10	3.10E+10	3.10E+10	3.20E+10	2.30E+10	2.40E+10	2.50E+10
Wetlands	TRR-6	3.80E+07	3.80E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07
Forest	TRR-6	5.60E+07	5.60E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07	5.60E+07	5.60E+07	5.60E+07	5.60E+07
Cropland	TRR-7	3.20E+07	3.20E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07
Pasture	TRR-7	3.20E+07	3.20E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07
Residential	TRR-7	2.90E+10	2.90E+10	2.90E+10	2.90E+10	2.90E+10	2.90E+10	2.90E+10	2.90E+10	2.90E+10	2.90E+10	2.90E+10	2.90E+10
Wetlands	TRR-7	2.50E+07	2.50E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07
Forest	TRR-7	4.30E+07	4.30E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07
Cropland	TRR-8	3.80E+07	3.80E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07
Pasture	TRR-8	2.80E+10	3.10E+10	3.10E+10	3.20E+10	3.20E+10	3.30E+10	3.30E+10	3.40E+10	3.40E+10	2.60E+10	2.70E+10	2.70E+10
Wetlands	TRR-8	3.20E+07	3.20E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07
Forest	TRR-8	5.00E+07	5.00E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07
Cropland	TRR-9	3.40E+07	3.40E+07	3.10E+07	1.80E+09	3.20E+08	3.10E+07	3.10E+07	3.10E+07	3.40E+07	3.40E+07	3.40E+07	3.40E+07
Pasture	TRR-9	3.40E+07	3.40E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.40E+07	3.40E+07	3.40E+07	3.40E+07
Residential	TRR-9	5.20E+10	5.20E+10	5.20E+10	5.20E+10	5.20E+10	5.20E+10	5.20E+10	5.20E+10	5.20E+10	5.20E+10	5.20E+10	5.20E+10
Wetlands	TRR-9	2.70E+07	2.70E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07
Forest	TRR-9	4.40E+07	4.40E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.40E+07	4.40E+07	4.40E+07	4.40E+07
Cropland	FTS-10	6.40E+07	6.40E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.40E+07	6.40E+07	6.40E+07	6.40E+07
Pasture	FTS-10	6.40E+07	6.40E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.40E+07	6.40E+07	6.40E+07	6.40E+07
Wetlands	FTS-10	5.90E+07	5.90E+07	5.60E+07	5.60E+07	5.60E+07	5.60E+07	5.60E+07	5.60E+07	5.90E+07	5.90E+07	5.90E+07	5.90E+07
Forest	FTS-10	7.60E+07	7.60E+07	7.30E+07	7.30E+07	7.30E+07	7.30E+07	7.30E+07	7.30E+07	7.60E+07	7.60E+07	7.60E+07	7.60E+07
Cropland	FTS-11	4.60E+07	4.60E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07
Pasture	FTS-11	4.60E+07	4.60E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07
Wetlands	FTS-11	4.00E+07	4.00E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07
Forest	FTS-11	5.70E+07	5.70E+07	5.50E+07	5.50E+07	5.50E+07	5.50E+07	5.50E+07	5.50E+07	5.70E+07	5.70E+07	5.70E+07	5.70E+07

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Cropland	FTS-12	4.10E+07	4.10E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07
Pasture	FTS-12	4.10E+07	4.10E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07
Wetlands	FTS-12	3.50E+07	3.50E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07
Forest	FTS-12	5.20E+07	5.20E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07
Cropland	FTS-13	3.50E+07	3.50E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07
Pasture	FTS-13	5.10E+09	5.60E+09	5.60E+09	5.60E+09	5.60E+09	5.40E+09	5.40E+09	5.50E+09	5.60E+09	4.40E+09	4.60E+09	4.90E+09
Residential	FTS-13	1.80E+10	1.80E+10	1.80E+10	1.80E+10	1.80E+10	1.80E+10	1.80E+10	1.80E+10	1.80E+10	1.80E+10	1.80E+10	1.80E+10
Wetlands	FTS-13	2.80E+07	2.80E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07
Forest	FTS-13	4.60E+07	4.60E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07
Cropland	FTS-14	6.40E+07	6.40E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.40E+07	6.40E+07	6.40E+07	6.40E+07
Pasture	FTS-14	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08
Wetlands	FTS-14	5.80E+07	5.80E+07	5.60E+07	5.60E+07	5.60E+07	5.60E+07	5.60E+07	5.60E+07	5.80E+07	5.80E+07	5.80E+07	5.80E+07
Forest	FTS-14	7.60E+07	7.60E+07	7.30E+07	7.30E+07	7.30E+07	7.30E+07	7.30E+07	7.30E+07	7.60E+07	7.60E+07	7.60E+07	7.60E+07
Cropland	FTS-15	4.80E+07	4.80E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07
Pasture	FTS-15	4.80E+07	4.80E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07
Residential	FTS-15	2.50E+10	2.50E+10	2.50E+10	2.50E+10	2.50E+10	2.50E+10	2.50E+10	2.50E+10	2.50E+10	2.50E+10	2.50E+10	2.50E+10
Wetlands	FTS-15	4.10E+07	4.10E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07
Forest	FTS-15	5.90E+07	5.90E+07	5.70E+07	5.70E+07	5.70E+07	5.70E+07	5.70E+07	5.70E+07	5.90E+07	5.90E+07	5.90E+07	5.90E+07
Cropland	FTS-16	4.60E+07	4.60E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07
Pasture	FTS-16	4.60E+07	4.60E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07
Residential	FTS-16	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10
Wetlands	FTS-16	4.00E+07	4.00E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07
Forest	FTS-16	5.70E+07	5.70E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07	5.70E+07	5.70E+07	5.70E+07	5.70E+07
Cropland	FTS-17	4.60E+07	4.60E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07
Pasture	FTS-17	4.60E+07	4.60E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07
Wetlands	FTS-17	4.00E+07	4.00E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07
Forest	FTS-17	5.70E+07	5.70E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07	5.70E+07	5.70E+07	5.70E+07	5.70E+07
Cropland	FTS-18	3.20E+07	3.20E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07
Pasture	FTS-18	4.10E+10	4.10E+10	4.10E+10	4.10E+10	4.10E+10	4.10E+10	4.10E+10	4.10E+10	4.10E+10	4.10E+10	4.10E+10	4.10E+10

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Residential	FTS-18	4.70E+09	4.70E+09	4.70E+09	4.70E+09	4.70E+09	4.70E+09	4.70E+09	4.70E+09	4.70E+09	4.70E+09	4.70E+09	4.70E+09
Wetlands	FTS-18	2.60E+07	2.60E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07
Forest	FTS-18	4.30E+07	4.30E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07
Cropland	FTS-19	5.30E+07	5.30E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07
Pasture	FTS-19	5.30E+07	5.30E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07
Residential	FTS-19	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09
Wetlands	FTS-19	4.70E+07	4.70E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07
Forest	FTS-19	6.50E+07	6.50E+07	5.90E+07	5.90E+07	5.90E+07	5.90E+07	5.90E+07	5.90E+07	6.50E+07	6.50E+07	6.50E+07	6.50E+07
Cropland	FTS-20	3.30E+07	3.30E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07
Pasture	FTS-20	3.30E+07	3.30E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07
Residential	FTS-20	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10
Wetlands	FTS-20	2.60E+07	2.60E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07
Forest	FTS-20	4.40E+07	4.40E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.40E+07	4.40E+07	4.40E+07	4.40E+07
Cropland	FTS-21	4.40E+07	4.40E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.40E+07	4.40E+07	4.40E+07	4.40E+07
Pasture	FTS-21	4.40E+07	4.40E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.40E+07	4.40E+07	4.40E+07	4.40E+07
Residential	FTS-21	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09
Wetlands	FTS-21	3.80E+07	3.80E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07
Forest	FTS-21	5.50E+07	5.50E+07	5.10E+07	5.10E+07	5.10E+07	5.10E+07	5.10E+07	5.10E+07	5.50E+07	5.50E+07	5.50E+07	5.50E+07

Table F. 13. MON-SQOLIM (monthly limit on surface accumulation) table for Tarrara Creek and Flat Swamp - values in cfu/day for fecal coliform.

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Cropland	TRR-1	5.20E+08	5.20E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08	5.20E+08	5.20E+08	5.20E+08	5.20E+08
Pasture	TRR-1	1.00E+11	1.10E+11	1.00E+11	1.00E+11	1.00E+11	9.70E+10	9.60E+10	9.40E+10	9.30E+10	8.80E+10	9.20E+10	9.60E+10
Residential	TRR-1	7.00E+09	7.00E+09	7.00E+09	7.00E+09	7.00E+09	7.00E+09	7.00E+09	7.00E+09	7.00E+09	7.00E+09	7.00E+09	7.00E+09
Wetlands	TRR-1	4.60E+08	4.60E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08
Forest	TRR-1	6.20E+08	6.20E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08	6.20E+08	6.20E+08	6.20E+08	6.20E+08
Cropland	TRR-2	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08
Pasture	TRR-2	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Residential	TRR-2	6.50E+09	6.50E+09	6.50E+09	6.50E+09	6.50E+09	6.50E+09	6.50E+09	6.50E+09	6.50E+09	6.50E+09	6.50E+09	6.50E+09
Wetlands	TRR-2	8.90E+08	8.90E+08	8.90E+08	8.90E+08	8.90E+08	8.90E+08	8.90E+08	8.90E+08	8.90E+08	8.90E+08	8.90E+08	8.90E+08
Forest	TRR-2	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09
Cropland	TRR-3	2.80E+08	2.80E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08
Pasture	TRR-3	2.90E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	2.50E+10	2.70E+10	2.80E+10
Residential	TRR-3	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10
Wetlands	TRR-3	2.20E+08	2.20E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08
Forest	TRR-3	3.80E+08	3.80E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08
Cropland	TRR-4	5.20E+08	5.20E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08	5.20E+08	5.20E+08	5.20E+08	5.20E+08
Pasture	TRR-4	8.40E+10	9.30E+10	9.30E+10	9.40E+10	9.40E+10	9.30E+10	9.40E+10	9.40E+10	9.60E+10	7.40E+10	7.70E+10	8.10E+10
Residential	TRR-4	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09
Wetlands	TRR-4	4.70E+08	4.70E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08	4.70E+08	4.70E+08	4.70E+08	4.70E+08
Forest	TRR-4	6.30E+08	6.30E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08	6.30E+08	6.30E+08	6.30E+08	6.30E+08
Cropland	TRR-5	6.20E+08	6.20E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08	6.20E+08	6.20E+08	6.20E+08	6.20E+08
Pasture	TRR-5	1.80E+10	1.90E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	1.70E+10	1.70E+10	1.80E+10
Residential	TRR-5	8.50E+09	8.50E+09	8.40E+09	8.40E+09	8.40E+09	8.40E+09	8.40E+09	8.40E+09	8.50E+09	8.50E+09	8.50E+09	8.50E+09
Wetlands	TRR-5	5.60E+08	5.60E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08	5.60E+08	5.60E+08	5.60E+08	5.60E+08
Forest	TRR-5	7.20E+08	7.20E+08	6.90E+08	6.90E+08	6.90E+08	6.90E+08	6.90E+08	6.90E+08	7.20E+08	7.20E+08	7.20E+08	7.20E+08
Cropland	TRR-6	4.00E+08	4.00E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08
Pasture	TRR-6	2.30E+11	2.60E+11	2.70E+11	2.70E+11	2.70E+11	2.70E+11	2.80E+11	2.80E+11	2.90E+11	2.00E+11	2.10E+11	2.20E+11
Wetlands	TRR-6	3.50E+08	3.50E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
Forest	TRR-6	5.00E+08	5.00E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	5.00E+08	5.00E+08	5.00E+08	5.00E+08
Cropland	TRR-7	2.90E+08	2.90E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08
Pasture	TRR-7	2.90E+08	2.90E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08
Residential	TRR-7	2.60E+11	2.60E+11	2.60E+11	2.60E+11	2.60E+11	2.60E+11	2.60E+11	2.60E+11	2.60E+11	2.60E+11	2.60E+11	2.60E+11
Wetlands	TRR-7	2.30E+08	2.30E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08
Forest	TRR-7	3.90E+08	3.90E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08
Cropland	TRR-8	3.50E+08	3.50E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
Pasture	TRR-8	2.50E+11	2.80E+11	2.80E+11	2.90E+11	2.90E+11	2.90E+11	3.00E+11	3.00E+11	3.10E+11	2.30E+11	2.40E+11	2.50E+11

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Wetlands	TRR-8	2.90E+08	2.90E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08
Forest	TRR-8	4.50E+08	4.50E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08
Cropland	TRR-9	3.00E+08	3.00E+08	2.80E+08	1.70E+10	2.90E+09	2.80E+08	2.80E+08	2.80E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08
Pasture	TRR-9	3.00E+08	3.00E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08
Residential	TRR-9	4.70E+11	4.70E+11	4.70E+11	4.70E+11	4.70E+11	4.70E+11	4.70E+11	4.70E+11	4.70E+11	4.70E+11	4.70E+11	4.70E+11
Wetlands	TRR-9	2.40E+08	2.40E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08
Forest	TRR-9	4.00E+08	4.00E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08
Cropland	FTS-10	5.80E+08	5.80E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08
Pasture	FTS-10	5.80E+08	5.80E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08
Wetlands	FTS-10	5.30E+08	5.30E+08	5.00E+08	5.00E+08	5.00E+08	5.00E+08	5.00E+08	5.00E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08
Forest	FTS-10	6.80E+08	6.80E+08	6.60E+08	6.60E+08	6.60E+08	6.60E+08	6.60E+08	6.60E+08	6.80E+08	6.80E+08	6.80E+08	6.80E+08
Cropland	FTS-11	4.10E+08	4.10E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08
Pasture	FTS-11	4.10E+08	4.10E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08
Wetlands	FTS-11	3.60E+08	3.60E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08
Forest	FTS-11	5.10E+08	5.10E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08
Cropland	FTS-12	3.70E+08	3.70E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08
Pasture	FTS-12	3.70E+08	3.70E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08
Wetlands	FTS-12	3.10E+08	3.10E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08
Forest	FTS-12	4.70E+08	4.70E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.70E+08	4.70E+08	4.70E+08	4.70E+08
Cropland	FTS-13	3.20E+08	3.20E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08
Pasture	FTS-13	4.60E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	4.90E+10	4.90E+10	4.90E+10	5.00E+10	4.00E+10	4.20E+10	4.40E+10
Residential	FTS-13	1.60E+11	1.60E+11	1.60E+11	1.60E+11	1.60E+11	1.60E+11	1.60E+11	1.60E+11	1.60E+11	1.60E+11	1.60E+11	1.60E+11
Wetlands	FTS-13	2.50E+08	2.50E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08
Forest	FTS-13	4.10E+08	4.10E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08
Cropland	FTS-14	5.80E+08	5.80E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08
Pasture	FTS-14	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09
Wetlands	FTS-14	5.30E+08	5.30E+08	5.00E+08	5.00E+08	5.00E+08	5.00E+08	5.00E+08	5.00E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08
Forest	FTS-14	6.80E+08	6.80E+08	6.60E+08	6.60E+08	6.60E+08	6.60E+08	6.60E+08	6.60E+08	6.80E+08	6.80E+08	6.80E+08	6.80E+08
Cropland	FTS-15	4.30E+08	4.30E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Pasture	FTS-15	4.30E+08	4.30E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08
Residential	FTS-15	2.20E+11	2.20E+11	2.20E+11	2.20E+11	2.20E+11	2.20E+11	2.20E+11	2.20E+11	2.20E+11	2.20E+11	2.20E+11	2.20E+11
Wetlands	FTS-15	3.70E+08	3.70E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08
Forest	FTS-15	5.30E+08	5.30E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08
Cropland	FTS-16	4.20E+08	4.20E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08
Pasture	FTS-16	4.20E+08	4.20E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08
Residential	FTS-16	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11
Wetlands	FTS-16	3.60E+08	3.60E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08
Forest	FTS-16	5.20E+08	5.20E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08	5.20E+08	5.20E+08	5.20E+08	5.20E+08
Cropland	FTS-17	4.20E+08	4.20E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08
Pasture	FTS-17	4.20E+08	4.20E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08
Wetlands	FTS-17	3.60E+08	3.60E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08
Forest	FTS-17	5.10E+08	5.10E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08
Cropland	FTS-18	2.90E+08	2.90E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08
Pasture	FTS-18	3.70E+11	3.70E+11	3.70E+11	3.70E+11	3.70E+11	3.70E+11	3.70E+11	3.70E+11	3.70E+11	3.70E+11	3.70E+11	3.70E+11
Residential	FTS-18	4.20E+10	4.20E+10	4.20E+10	4.20E+10	4.20E+10	4.20E+10	4.20E+10	4.20E+10	4.20E+10	4.20E+10	4.20E+10	4.20E+10
Wetlands	FTS-18	2.30E+08	2.30E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08
Forest	FTS-18	3.90E+08	3.90E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08
Cropland	FTS-19	4.80E+08	4.80E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08
Pasture	FTS-19	4.80E+08	4.80E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08
Residential	FTS-19	1.20E+10	1.20E+10	1.20E+10	1.20E+10	1.20E+10	1.20E+10	1.20E+10	1.20E+10	1.20E+10	1.20E+10	1.20E+10	1.20E+10
Wetlands	FTS-19	4.30E+08	4.30E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08
Forest	FTS-19	5.90E+08	5.90E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08	5.90E+08	5.90E+08	5.90E+08	5.90E+08
Cropland	FTS-20	3.00E+08	3.00E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08
Pasture	FTS-20	3.00E+08	3.00E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08
Residential	FTS-20	9.60E+10	9.60E+10	9.60E+10	9.60E+10	9.60E+10	9.60E+10	9.60E+10	9.60E+10	9.60E+10	9.60E+10	9.60E+10	9.60E+10
Wetlands	FTS-20	2.30E+08	2.30E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08
Forest	FTS-20	3.90E+08	3.90E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08
Cropland	FTS-21	4.00E+08	4.00E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Pasture	FTS-21	4.00E+08	4.00E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08
Residential	FTS-21	2.20E+10	2.20E+10	2.20E+10	2.20E+10	2.20E+10	2.20E+10	2.20E+10	2.20E+10	2.20E+10	2.20E+10	2.20E+10	2.20E+10
Wetlands	FTS-21	3.40E+08	3.40E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08
Forest	FTS-21	4.90E+08	4.90E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08

Table F. 14. MON-ACCUM (monthly accumulation (ACQOP)) table for Three Creek - values in cfu/acre/day for fecal coliform.

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Cropland	TRE-1	6.30E+07	6.30E+07	6.00E+07	6.00E+07	6.00E+07	6.00E+07	6.00E+07	6.00E+07	6.30E+07	6.30E+07	6.30E+07	6.30E+07
Pasture	TRE-1	6.30E+07	6.30E+07	6.00E+07	6.00E+07	6.00E+07	6.00E+07	6.00E+07	6.00E+07	6.30E+07	6.30E+07	6.30E+07	6.30E+07
Wetlands	TRE-1	5.80E+07	5.80E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07	5.80E+07	5.80E+07	5.80E+07	5.80E+07
Forest	TRE-1	7.50E+07	7.50E+07	7.20E+07	7.20E+07	7.20E+07	7.20E+07	7.20E+07	7.20E+07	7.50E+07	7.50E+07	7.50E+07	7.50E+07
Cropland	TRE-2	4.30E+07	4.30E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07
Pasture	TRE-2	1.10E+10	1.20E+10	1.20E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.00E+10	1.00E+10	9.80E+09	1.00E+10	1.10E+10
Wetlands	TRE-2	3.60E+07	3.60E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07
Forest	TRE-2	5.40E+07	5.40E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07
Cropland	TRE-3	4.30E+07	4.30E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07
Pasture	TRE-3	8.90E+09	9.70E+09	9.80E+09	9.80E+09	9.80E+09	9.80E+09	9.80E+09	9.90E+09	9.90E+09	7.80E+09	8.10E+09	8.50E+09
Residential	TRE-3	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09	1.80E+09
Wetlands	TRE-3	3.70E+07	3.70E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07
Forest	TRE-3	5.40E+07	5.40E+07	5.10E+07	5.10E+07	5.10E+07	5.10E+07	5.10E+07	5.10E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07
Cropland	TRE-4	2.90E+07	2.90E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07
Pasture	TRE-4	2.90E+07	2.90E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07
Residential	TRE-4	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09
Wetlands	TRE-4	2.40E+07	2.40E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07
Forest	TRE-4	3.80E+07	3.80E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07
Cropland	TRE-5	5.30E+07	5.30E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07
Pasture	TRE-5	5.30E+07	5.30E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07
Residential	TRE-5	1.60E+09	1.60E+09	1.60E+09	1.60E+09	1.60E+09	1.60E+09	1.60E+09	1.60E+09	1.60E+09	1.60E+09	1.60E+09	1.60E+09

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Wetlands	TRE-5	4.60E+07	4.60E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07
Forest	TRE-5	6.40E+07	6.40E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.40E+07	6.40E+07	6.40E+07	6.40E+07
Cropland	TRE-6	3.10E+08	6.00E+07	5.20E+08	5.60E+08	2.30E+08	5.60E+07	5.60E+07	5.60E+07	6.00E+07	1.70E+08	5.20E+08	3.10E+08
Pasture	TRE-6	3.80E+10	4.00E+10	4.10E+10	4.10E+10	4.10E+10	4.10E+10	4.20E+10	4.20E+10	4.30E+10	3.70E+10	3.70E+10	3.80E+10
Residential	TRE-6	3.20E+08	3.20E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08
Wetlands	TRE-6	5.40E+07	5.40E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07
Forest	TRE-6	7.10E+07	7.10E+07	6.80E+07	6.80E+07	6.80E+07	6.80E+07	6.80E+07	6.80E+07	7.10E+07	7.10E+07	7.10E+07	7.10E+07
Cropland	TRE-7	4.70E+07	4.70E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07
Pasture	TRE-7	4.70E+07	4.70E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07
Residential	TRE-7	5.30E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08
Wetlands	TRE-7	4.00E+07	4.00E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07
Forest	TRE-7	5.80E+07	5.80E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07	5.80E+07	5.80E+07	5.80E+07	5.80E+07
Cropland	TRE-8	3.70E+07	3.70E+07	3.40E+07	3.40E+07	3.40E+07	3.40E+07	3.40E+07	3.40E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07
Pasture	TRE-8	3.70E+07	3.70E+07	3.40E+07	3.40E+07	3.40E+07	3.40E+07	3.40E+07	3.40E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07
Residential	TRE-8	5.40E+08	5.40E+08	5.40E+08	5.40E+08	5.40E+08	5.40E+08	5.40E+08	5.40E+08	5.40E+08	5.40E+08	5.40E+08	5.40E+08
Wetlands	TRE-8	3.10E+07	3.10E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07
Forest	TRE-8	4.80E+07	4.80E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07
Cropland	TRE-9	4.20E+07	4.20E+07	8.40E+07	4.40E+08	1.80E+08	3.80E+07	3.80E+07	3.80E+07	4.20E+07	1.30E+08	4.10E+08	4.20E+07
Pasture	TRE-9	4.20E+07	4.20E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07
Residential	TRE-9	4.90E+09	4.90E+09	4.90E+09	4.90E+09	4.90E+09	4.90E+09	4.90E+09	4.90E+09	4.90E+09	4.90E+09	4.90E+09	4.90E+09
Wetlands	TRE-9	3.50E+07	3.50E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07
Forest	TRE-9	5.30E+07	5.30E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07
Cropland	TRE-10	4.50E+07	4.50E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07
Pasture	TRE-10	4.50E+07	4.50E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07
Residential	TRE-10	3.40E+09	3.40E+09	3.40E+09	3.40E+09	3.40E+09	3.40E+09	3.40E+09	3.40E+09	3.40E+09	3.40E+09	3.40E+09	3.40E+09
Wetlands	TRE-10	4.00E+07	4.00E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07
Forest	TRE-10	5.40E+07	5.40E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07
Cropland	TRE-11	2.90E+07	2.90E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07
Pasture	TRE-11	2.90E+07	2.90E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Residential	TRE-11	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09
Wetlands	TRE-11	2.60E+07	2.60E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07
Forest	TRE-11	3.70E+07	3.70E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07
Cropland	TRE-12	4.70E+07	4.70E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07
Pasture	TRE-12	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09
Residential	TRE-12	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10	1.10E+10
Wetlands	TRE-12	4.30E+07	4.30E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07
Forest	TRE-12	5.40E+07	5.40E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07
Cropland	TRE-13	3.20E+07	3.20E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07
Pasture	TRE-13	2.30E+09	2.60E+09	2.60E+09	2.60E+09	2.60E+09	2.60E+09	2.70E+09	2.70E+09	2.70E+09	2.00E+09	2.10E+09	2.20E+09
Residential	TRE-13	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08
Wetlands	TRE-13	2.80E+07	2.80E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07
Forest	TRE-13	3.90E+07	3.90E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07
Cropland	TRE-14	3.00E+07	3.00E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07
Pasture	TRE-14	9.00E+09	9.30E+09	9.20E+09	9.00E+09	8.90E+09	8.70E+09	8.50E+09	8.40E+09	8.30E+09	8.20E+09	8.50E+09	8.70E+09
Residential	TRE-14	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08
Wetlands	TRE-14	2.60E+07	2.60E+07	2.30E+07	2.30E+07	2.30E+07	2.30E+07	2.30E+07	2.30E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07
Forest	TRE-14	3.70E+07	3.70E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07
Cropland	TRE-15	6.40E+07	6.40E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.40E+07	6.40E+07	6.40E+07	6.40E+07
Pasture	TRE-15	6.40E+07	6.40E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.40E+07	6.40E+07	6.40E+07	6.40E+07
Residential	TRE-15	2.70E+07	2.70E+07	2.30E+07	2.30E+07	2.30E+07	2.30E+07	2.30E+07	2.30E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07
Wetlands	TRE-15	5.80E+07	5.80E+07	5.50E+07	5.50E+07	5.50E+07	5.50E+07	5.50E+07	5.50E+07	5.80E+07	5.80E+07	5.80E+07	5.80E+07
Forest	TRE-15	7.60E+07	7.60E+07	7.30E+07	7.30E+07	7.30E+07	7.30E+07	7.30E+07	7.30E+07	7.60E+07	7.60E+07	7.60E+07	7.60E+07
Cropland	TRE-16	5.30E+07	5.30E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07
Pasture	TRE-16	5.30E+07	5.30E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07
Residential	TRE-16	8.20E+08	8.20E+08	8.20E+08	8.20E+08	8.20E+08	8.20E+08	8.20E+08	8.20E+08	8.20E+08	8.20E+08	8.20E+08	8.20E+08
Wetlands	TRE-16	4.70E+07	4.70E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07	4.70E+07	4.70E+07	4.70E+07	4.70E+07
Forest	TRE-16	6.40E+07	6.40E+07	6.00E+07	6.00E+07	6.00E+07	6.00E+07	6.00E+07	6.00E+07	6.40E+07	6.40E+07	6.40E+07	6.40E+07
Cropland	TRE-17	4.00E+07	4.00E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Pasture	TRE-17	1.20E+10	1.40E+10	1.40E+10	1.40E+10	1.40E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.10E+10	1.10E+10	1.20E+10
Residential	TRE-17	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09
Wetlands	TRE-17	3.60E+07	3.60E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07
Forest	TRE-17	4.90E+07	4.90E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07
Cropland	TRE-18	4.40E+07	4.40E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.40E+07	4.40E+07	4.40E+07	4.40E+07
Pasture	TRE-18	4.40E+07	4.40E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.40E+07	4.40E+07	4.40E+07	4.40E+07
Residential	TRE-18	1.10E+09	1.10E+09	1.10E+09	1.10E+09	1.10E+09	1.10E+09	1.10E+09	1.10E+09	1.10E+09	1.10E+09	1.10E+09	1.10E+09
Wetlands	TRE-18	3.90E+07	3.90E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07
Forest	TRE-18	5.40E+07	5.40E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07
Cropland	TRE-19	3.00E+07	3.00E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07
Pasture	TRE-19	4.30E+07	4.30E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.10E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07
Residential	TRE-19	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09
Wetlands	TRE-19	2.50E+07	2.50E+07	2.30E+07	2.30E+07	2.30E+07	2.30E+07	2.30E+07	2.30E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07
Forest	TRE-19	3.80E+07	3.80E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07
Cropland	TRE-20	5.80E+07	5.80E+07	5.70E+07	5.70E+07	5.70E+07	5.70E+07	5.70E+07	5.70E+07	5.80E+07	5.80E+07	5.80E+07	5.80E+07
Pasture	TRE-20	7.20E+07	7.20E+07	7.00E+07	7.00E+07	7.00E+07	7.00E+07	7.00E+07	7.00E+07	7.20E+07	7.20E+07	7.20E+07	7.20E+07
Residential	TRE-20	6.30E+08	6.30E+08	6.30E+08	6.30E+08	6.30E+08	6.30E+08	6.30E+08	6.30E+08	6.30E+08	6.30E+08	6.30E+08	6.30E+08
Wetlands	TRE-20	5.30E+07	5.30E+07	5.10E+07	5.10E+07	5.10E+07	5.10E+07	5.10E+07	5.10E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07
Forest	TRE-20	6.90E+07	6.90E+07	6.70E+07	6.70E+07	6.70E+07	6.70E+07	6.70E+07	6.70E+07	6.90E+07	6.90E+07	6.90E+07	6.90E+07
Cropland	TRE-21	5.80E+07	5.80E+07	5.60E+07	5.60E+07	5.60E+07	5.60E+07	5.60E+07	5.60E+07	5.80E+07	5.80E+07	5.80E+07	5.80E+07
Pasture	TRE-21	2.30E+10	2.50E+10	2.50E+10	2.50E+10	2.50E+10	2.50E+10	2.50E+10	2.50E+10	2.60E+10	2.00E+10	2.10E+10	2.20E+10
Residential	TRE-21	3.10E+09	3.10E+09	3.10E+09	3.10E+09	3.10E+09	3.10E+09	3.10E+09	3.10E+09	3.10E+09	3.10E+09	3.10E+09	3.10E+09
Wetlands	TRE-21	5.40E+07	5.40E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07
Forest	TRE-21	6.60E+07	6.60E+07	6.40E+07	6.40E+07	6.40E+07	6.40E+07	6.40E+07	6.40E+07	6.60E+07	6.60E+07	6.60E+07	6.60E+07
Cropland	TRE-22	4.30E+07	4.30E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07
Pasture	TRE-22	4.30E+07	4.30E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.30E+07	4.30E+07	4.30E+07	4.30E+07
Residential	TRE-22	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08
Wetlands	TRE-22	3.90E+07	3.90E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07
Forest	TRE-22	5.10E+07	5.10E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	4.80E+07	5.10E+07	5.10E+07	5.10E+07	5.10E+07

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Cropland	TRE-23	3.90E+07	3.90E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07
Pasture	TRE-23	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08	1.10E+08
Residential	TRE-23	1.40E+08	1.40E+08	1.40E+08	1.40E+08	1.40E+08	1.40E+08	1.40E+08	1.40E+08	1.40E+08	1.40E+08	1.40E+08	1.40E+08
Wetlands	TRE-23	3.40E+07	3.40E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.40E+07	3.40E+07	3.40E+07	3.40E+07
Forest	TRE-23	4.60E+07	4.60E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07	4.60E+07	4.60E+07	4.60E+07	4.60E+07
Cropland	TRE-24	3.00E+07	3.00E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07
Pasture	TRE-24	2.60E+09	2.90E+09	2.90E+09	2.90E+09	2.90E+09	2.90E+09	2.90E+09	2.90E+09	2.90E+09	2.30E+09	2.40E+09	2.50E+09
Residential	TRE-24	7.30E+08	7.30E+08	7.30E+08	7.30E+08	7.30E+08	7.30E+08	7.30E+08	7.30E+08	7.30E+08	7.30E+08	7.30E+08	7.30E+08
Wetlands	TRE-24	2.50E+07	2.50E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07
Forest	TRE-24	3.70E+07	3.70E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07
Cropland	TRE-25	5.80E+07	5.80E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07	5.80E+07	5.80E+07	5.80E+07	5.80E+07
Pasture	TRE-25	5.80E+07	5.80E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07	5.80E+07	5.80E+07	5.80E+07	5.80E+07
Residential	TRE-25	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08
Wetlands	TRE-25	5.30E+07	5.30E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.30E+07	5.30E+07	5.30E+07	5.30E+07
Forest	TRE-25	6.50E+07	6.50E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.10E+07	6.50E+07	6.50E+07	6.50E+07	6.50E+07
Cropland	TRE-26	3.10E+07	3.10E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07
Pasture	TRE-26	3.10E+07	3.10E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07
Residential	TRE-26	4.60E+08	4.60E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08
Wetlands	TRE-26	2.60E+07	2.60E+07	2.30E+07	2.30E+07	2.30E+07	2.30E+07	2.30E+07	2.30E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07
Forest	TRE-26	3.80E+07	3.80E+07	3.40E+07	3.40E+07	3.40E+07	3.40E+07	3.40E+07	3.40E+07	3.80E+07	3.80E+07	3.80E+07	3.80E+07
Cropland	TRE-27	2.80E+07	2.80E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07
Pasture	TRE-27	2.00E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.30E+09	1.90E+09	2.00E+09	2.00E+09
Residential	TRE-27	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08
Wetlands	TRE-27	2.30E+07	2.30E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.30E+07	2.30E+07	2.30E+07	2.30E+07
Forest	TRE-27	3.50E+07	3.50E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07
Cropland	TRE-28	2.70E+07	2.70E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07
Pasture	TRE-28	2.80E+07	2.80E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07
Residential	TRE-28	3.40E+08	3.40E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08
Wetlands	TRE-28	2.20E+07	2.20E+07	1.90E+07	1.90E+07	1.90E+07	1.90E+07	1.90E+07	1.90E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Forest	TRE-28	3.30E+07	3.30E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07
Cropland	TRE-29	4.90E+07	4.90E+07	4.40E+07	4.40E+07	4.40E+07	4.40E+07	4.40E+07	4.40E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07
Pasture	TRE-29	5.40E+07	5.40E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	4.90E+07	5.40E+07	5.40E+07	5.40E+07	5.40E+07
Residential	TRE-29	3.60E+09	3.60E+09	3.60E+09	3.60E+09	3.60E+09	3.60E+09	3.60E+09	3.60E+09	3.60E+09	3.60E+09	3.60E+09	3.60E+09
Wetlands	TRE-29	4.50E+07	4.50E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07	3.90E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07
Forest	TRE-29	5.60E+07	5.60E+07	5.10E+07	5.10E+07	5.10E+07	5.10E+07	5.10E+07	5.10E+07	5.60E+07	5.60E+07	5.60E+07	5.60E+07
Cropland	TRE-30	2.40E+07	2.40E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07
Pasture	TRE-30	2.40E+07	2.40E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07
Residential	TRE-30	1.40E+10	1.40E+10	1.40E+10	1.40E+10	1.40E+10	1.40E+10	1.40E+10	1.40E+10	1.40E+10	1.40E+10	1.40E+10	1.40E+10
Wetlands	TRE-30	1.90E+07	1.90E+07	1.70E+07	1.70E+07	1.70E+07	1.70E+07	1.70E+07	1.70E+07	1.90E+07	1.90E+07	1.90E+07	1.90E+07
Forest	TRE-30	3.10E+07	3.10E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07
Cropland	TRE-31	3.60E+07	3.60E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07
Pasture	TRE-31	1.20E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.10E+10	1.10E+10	1.20E+10
Residential	TRE-31	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08
Wetlands	TRE-31	3.10E+07	3.10E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07
Forest	TRE-31	4.20E+07	4.20E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07
Cropland	TRE-32	2.70E+07	2.70E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07
Pasture	TRE-32	3.20E+07	3.20E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07
Residential	TRE-32	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08
Wetlands	TRE-32	2.20E+07	2.20E+07	1.90E+07	1.90E+07	1.90E+07	1.90E+07	1.90E+07	1.90E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07
Forest	TRE-32	3.30E+07	3.30E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07
Cropland	TRE-33	3.50E+07	3.50E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.50E+07	3.50E+07	3.50E+07	3.50E+07
Pasture	TRE-33	2.00E+09	2.20E+09	2.20E+09	2.20E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	1.80E+09	1.90E+09	2.00E+09
Residential	TRE-33	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08
Wetlands	TRE-33	3.00E+07	3.00E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07
Forest	TRE-33	4.20E+07	4.20E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07	4.20E+07	4.20E+07	4.20E+07	4.20E+07
Cropland	TRE-34	3.10E+07	3.10E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07
Pasture	TRE-34	3.10E+07	3.10E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07
Residential	TRE-34	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Wetlands	TRE-34	2.60E+07	2.60E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.60E+07	2.60E+07	2.60E+07	2.60E+07
Forest	TRE-34	3.70E+07	3.70E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.70E+07	3.70E+07	3.70E+07	3.70E+07
Cropland	TRE-35	2.40E+07	2.40E+07	2.10E+07	2.10E+07	2.10E+07	2.10E+07	2.10E+07	2.10E+07	2.40E+07	2.40E+07	2.40E+07	2.40E+07
Pasture	TRE-35	1.20E+09	1.40E+09	1.40E+09	1.40E+09	1.50E+09	1.50E+09	1.60E+09	1.60E+09	1.60E+09	1.00E+09	1.10E+09	1.10E+09
Residential	TRE-35	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08
Wetlands	TRE-35	2.10E+07	2.10E+07	1.90E+07	1.90E+07	1.90E+07	1.90E+07	1.90E+07	1.90E+07	2.10E+07	2.10E+07	2.10E+07	2.10E+07
Forest	TRE-35	3.10E+07	3.10E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	2.80E+07	3.10E+07	3.10E+07	3.10E+07	3.10E+07
Cropland	TRE-36	3.00E+07	3.00E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07
Pasture	TRE-36	3.00E+07	3.00E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07
Residential	TRE-36	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08
Wetlands	TRE-36	2.50E+07	2.50E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07
Forest	TRE-36	3.60E+07	3.60E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.30E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07
Cropland	TRE-37	2.50E+07	2.50E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.20E+07	2.50E+07	2.50E+07	2.50E+07	2.50E+07
Pasture	TRE-37	2.20E+09	2.50E+09	2.60E+09	2.70E+09	2.70E+09	2.80E+09	2.90E+09	3.00E+09	3.00E+09	1.90E+09	2.00E+09	2.10E+09
Residential	TRE-37	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08
Wetlands	TRE-37	2.30E+07	2.30E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.30E+07	2.30E+07	2.30E+07	2.30E+07
Forest	TRE-37	3.20E+07	3.20E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	2.90E+07	3.20E+07	3.20E+07	3.20E+07	3.20E+07

Table F. 15. MON-SQOLIM (monthly limit on surface accumulation) table for Three Creek - values in cfu/day for fecal coliform.

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Cropland	TRE-1	5.70E+08	5.70E+08	5.40E+08	5.40E+08	5.40E+08	5.40E+08	5.40E+08	5.40E+08	5.70E+08	5.70E+08	5.70E+08	5.70E+08
Pasture	TRE-1	5.70E+08	5.70E+08	5.40E+08	5.40E+08	5.40E+08	5.40E+08	5.40E+08	5.40E+08	5.70E+08	5.70E+08	5.70E+08	5.70E+08
Wetlands	TRE-1	5.20E+08	5.20E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	5.20E+08	5.20E+08	5.20E+08	5.20E+08
Forest	TRE-1	6.80E+08	6.80E+08	6.40E+08	6.40E+08	6.40E+08	6.40E+08	6.40E+08	6.40E+08	6.80E+08	6.80E+08	6.80E+08	6.80E+08
Cropland	TRE-2	3.90E+08	3.90E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08
Pasture	TRE-2	1.00E+11	1.10E+11	1.00E+11	1.00E+11	1.00E+11	9.70E+10	9.50E+10	9.30E+10	9.10E+10	8.90E+10	9.30E+10	9.70E+10
Wetlands	TRE-2	3.30E+08	3.30E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08
Forest	TRE-2	4.80E+08	4.80E+08	4.70E+08	4.70E+08	4.70E+08	4.70E+08	4.70E+08	4.70E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Cropland	TRE-3	3.90E+08	3.90E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08
Pasture	TRE-3	8.00E+10	8.80E+10	8.80E+10	8.80E+10	8.80E+10	8.80E+10	8.90E+10	8.90E+10	8.90E+10	7.00E+10	7.30E+10	7.70E+10
Residential	TRE-3	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10	1.60E+10
Wetlands	TRE-3	3.30E+08	3.30E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08
Forest	TRE-3	4.90E+08	4.90E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08
Cropland	TRE-4	2.60E+08	2.60E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08
Pasture	TRE-4	2.60E+08	2.60E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08
Residential	TRE-4	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10	1.30E+10
Wetlands	TRE-4	2.20E+08	2.20E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08
Forest	TRE-4	3.40E+08	3.40E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08
Cropland	TRE-5	4.70E+08	4.70E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.70E+08	4.70E+08	4.70E+08	4.70E+08
Pasture	TRE-5	4.70E+08	4.70E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.70E+08	4.70E+08	4.70E+08	4.70E+08
Residential	TRE-5	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10	1.50E+10
Wetlands	TRE-5	4.20E+08	4.20E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08
Forest	TRE-5	5.80E+08	5.80E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08
Cropland	TRE-6	2.70E+09	5.40E+08	4.60E+09	5.10E+09	2.10E+09	5.10E+08	5.10E+08	5.10E+08	5.40E+08	1.50E+09	4.70E+09	2.70E+09
Pasture	TRE-6	3.40E+11	3.60E+11	3.70E+11	3.70E+11	3.70E+11	3.70E+11	3.80E+11	3.80E+11	3.80E+11	3.30E+11	3.30E+11	3.40E+11
Residential	TRE-6	2.90E+09	2.90E+09	2.80E+09	2.80E+09	2.80E+09	2.80E+09	2.80E+09	2.80E+09	2.90E+09	2.90E+09	2.90E+09	2.90E+09
Wetlands	TRE-6	4.80E+08	4.80E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08
Forest	TRE-6	6.40E+08	6.40E+08	6.10E+08	6.10E+08	6.10E+08	6.10E+08	6.10E+08	6.10E+08	6.40E+08	6.40E+08	6.40E+08	6.40E+08
Cropland	TRE-7	4.20E+08	4.20E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08
Pasture	TRE-7	4.20E+08	4.20E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08
Residential	TRE-7	4.80E+09	4.80E+09	4.70E+09	4.70E+09	4.70E+09	4.70E+09	4.70E+09	4.70E+09	4.80E+09	4.80E+09	4.80E+09	4.80E+09
Wetlands	TRE-7	3.60E+08	3.60E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08
Forest	TRE-7	5.20E+08	5.20E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08	5.20E+08	5.20E+08	5.20E+08	5.20E+08
Cropland	TRE-8	3.30E+08	3.30E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08
Pasture	TRE-8	3.30E+08	3.30E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08
Residential	TRE-8	4.90E+09	4.90E+09	4.80E+09	4.80E+09	4.80E+09	4.80E+09	4.80E+09	4.80E+09	4.90E+09	4.90E+09	4.90E+09	4.90E+09
Wetlands	TRE-8	2.80E+08	2.80E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Forest	TRE-8	4.30E+08	4.30E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08
Cropland	TRE-9	3.70E+08	3.70E+08	7.50E+08	4.00E+09	1.60E+09	3.40E+08	3.40E+08	3.40E+08	3.70E+08	1.20E+09	3.70E+09	3.70E+08
Pasture	TRE-9	3.70E+08	3.70E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08
Residential	TRE-9	4.40E+10	4.40E+10	4.40E+10	4.40E+10	4.40E+10	4.40E+10	4.40E+10	4.40E+10	4.40E+10	4.40E+10	4.40E+10	4.40E+10
Wetlands	TRE-9	3.20E+08	3.20E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08
Forest	TRE-9	4.70E+08	4.70E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.70E+08	4.70E+08	4.70E+08	4.70E+08
Cropland	TRE-10	4.10E+08	4.10E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08
Pasture	TRE-10	4.10E+08	4.10E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08
Residential	TRE-10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10
Wetlands	TRE-10	3.60E+08	3.60E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08
Forest	TRE-10	4.90E+08	4.90E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08
Cropland	TRE-11	2.60E+08	2.60E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08
Pasture	TRE-11	2.60E+08	2.60E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08
Residential	TRE-11	5.60E+10	5.60E+10	5.60E+10	5.60E+10	5.60E+10	5.60E+10	5.60E+10	5.60E+10	5.60E+10	5.60E+10	5.60E+10	5.60E+10
Wetlands	TRE-11	2.30E+08	2.30E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08
Forest	TRE-11	3.30E+08	3.30E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08
Cropland	TRE-12	4.20E+08	4.20E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	4.20E+08	4.20E+08	4.20E+08	4.20E+08
Pasture	TRE-12	2.70E+10	2.70E+10	2.70E+10	2.70E+10	2.70E+10	2.70E+10	2.70E+10	2.70E+10	2.70E+10	2.70E+10	2.70E+10	2.70E+10
Residential	TRE-12	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11
Wetlands	TRE-12	3.90E+08	3.90E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08
Forest	TRE-12	4.90E+08	4.90E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08
Cropland	TRE-13	2.90E+08	2.90E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08
Pasture	TRE-13	2.10E+10	2.30E+10	2.30E+10	2.30E+10	2.40E+10	2.40E+10	2.40E+10	2.40E+10	2.40E+10	1.80E+10	1.90E+10	2.00E+10
Residential	TRE-13	5.00E+09	5.00E+09	4.90E+09	4.90E+09	4.90E+09	4.90E+09	4.90E+09	4.90E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09
Wetlands	TRE-13	2.50E+08	2.50E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08
Forest	TRE-13	3.50E+08	3.50E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
Cropland	TRE-14	2.70E+08	2.70E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08
Pasture	TRE-14	8.10E+10	8.40E+10	8.20E+10	8.10E+10	8.00E+10	7.80E+10	7.70E+10	7.50E+10	7.50E+10	7.30E+10	7.60E+10	7.90E+10
Residential	TRE-14	2.70E+09	2.70E+09	2.70E+09	2.70E+09	2.70E+09	2.70E+09	2.70E+09	2.70E+09	2.70E+09	2.70E+09	2.70E+09	2.70E+09

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Wetlands	TRE-14	2.30E+08	2.30E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08
Forest	TRE-14	3.40E+08	3.40E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08
Cropland	TRE-15	5.80E+08	5.80E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08
Pasture	TRE-15	5.80E+08	5.80E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08
Residential	TRE-15	2.40E+08	2.40E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08
Wetlands	TRE-15	5.20E+08	5.20E+08	5.00E+08	5.00E+08	5.00E+08	5.00E+08	5.00E+08	5.00E+08	5.20E+08	5.20E+08	5.20E+08	5.20E+08
Forest	TRE-15	6.80E+08	6.80E+08	6.60E+08	6.60E+08	6.60E+08	6.60E+08	6.60E+08	6.60E+08	6.80E+08	6.80E+08	6.80E+08	6.80E+08
Cropland	TRE-16	4.80E+08	4.80E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08
Pasture	TRE-16	4.80E+08	4.80E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08
Residential	TRE-16	7.40E+09	7.40E+09	7.30E+09	7.30E+09	7.30E+09	7.30E+09	7.30E+09	7.30E+09	7.40E+09	7.40E+09	7.40E+09	7.40E+09
Wetlands	TRE-16	4.30E+08	4.30E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08
Forest	TRE-16	5.80E+08	5.80E+08	5.40E+08	5.40E+08	5.40E+08	5.40E+08	5.40E+08	5.40E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08
Cropland	TRE-17	3.60E+08	3.60E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08
Pasture	TRE-17	1.10E+11	1.20E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.40E+11	9.50E+10	1.00E+11	1.00E+11
Residential	TRE-17	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10
Wetlands	TRE-17	3.20E+08	3.20E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08
Forest	TRE-17	4.40E+08	4.40E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08
Cropland	TRE-18	4.00E+08	4.00E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08
Pasture	TRE-18	4.00E+08	4.00E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08
Residential	TRE-18	9.90E+09	9.90E+09	9.90E+09	9.90E+09	9.90E+09	9.90E+09	9.90E+09	9.90E+09	9.90E+09	9.90E+09	9.90E+09	9.90E+09
Wetlands	TRE-18	3.50E+08	3.50E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
Forest	TRE-18	4.90E+08	4.90E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08
Cropland	TRE-19	2.70E+08	2.70E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08
Pasture	TRE-19	3.90E+08	3.90E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08
Residential	TRE-19	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10
Wetlands	TRE-19	2.30E+08	2.30E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08
Forest	TRE-19	3.40E+08	3.40E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08
Cropland	TRE-20	5.30E+08	5.30E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08
Pasture	TRE-20	6.40E+08	6.40E+08	6.30E+08	6.30E+08	6.30E+08	6.30E+08	6.30E+08	6.30E+08	6.40E+08	6.40E+08	6.40E+08	6.40E+08

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Residential	TRE-20	5.70E+09	5.70E+09	5.60E+09	5.60E+09	5.60E+09	5.60E+09	5.60E+09	5.60E+09	5.70E+09	5.70E+09	5.70E+09	5.70E+09
Wetlands	TRE-20	4.80E+08	4.80E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08
Forest	TRE-20	6.20E+08	6.20E+08	6.00E+08	6.00E+08	6.00E+08	6.00E+08	6.00E+08	6.00E+08	6.20E+08	6.20E+08	6.20E+08	6.20E+08
Cropland	TRE-21	5.30E+08	5.30E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08	5.30E+08	5.30E+08	5.30E+08	5.30E+08
Pasture	TRE-21	2.10E+11	2.30E+11	2.30E+11	2.30E+11	2.30E+11	2.30E+11	2.30E+11	2.30E+11	2.30E+11	1.80E+11	1.90E+11	2.00E+11
Residential	TRE-21	2.80E+10	2.80E+10	2.80E+10	2.80E+10	2.80E+10	2.80E+10	2.80E+10	2.80E+10	2.80E+10	2.80E+10	2.80E+10	2.80E+10
Wetlands	TRE-21	4.90E+08	4.90E+08	4.70E+08	4.70E+08	4.70E+08	4.70E+08	4.70E+08	4.70E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08
Forest	TRE-21	5.90E+08	5.90E+08	5.70E+08	5.70E+08	5.70E+08	5.70E+08	5.70E+08	5.70E+08	5.90E+08	5.90E+08	5.90E+08	5.90E+08
Cropland	TRE-22	3.90E+08	3.90E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08
Pasture	TRE-22	3.90E+08	3.90E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08
Residential	TRE-22	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09
Wetlands	TRE-22	3.50E+08	3.50E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
Forest	TRE-22	4.60E+08	4.60E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.30E+08	4.60E+08	4.60E+08	4.60E+08	4.60E+08
Cropland	TRE-23	3.50E+08	3.50E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
Pasture	TRE-23	9.80E+08	9.80E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.50E+08	9.80E+08	9.80E+08	9.80E+08	9.80E+08
Residential	TRE-23	1.30E+09	1.30E+09	1.20E+09	1.20E+09	1.20E+09	1.20E+09	1.20E+09	1.20E+09	1.30E+09	1.30E+09	1.30E+09	1.30E+09
Wetlands	TRE-23	3.10E+08	3.10E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08
Forest	TRE-23	4.10E+08	4.10E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08	4.10E+08	4.10E+08	4.10E+08	4.10E+08
Cropland	TRE-24	2.70E+08	2.70E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08
Pasture	TRE-24	2.40E+10	2.60E+10	2.60E+10	2.60E+10	2.60E+10	2.60E+10	2.60E+10	2.60E+10	2.60E+10	2.10E+10	2.20E+10	2.30E+10
Residential	TRE-24	6.60E+09	6.60E+09	6.60E+09	6.60E+09	6.60E+09	6.60E+09	6.60E+09	6.60E+09	6.60E+09	6.60E+09	6.60E+09	6.60E+09
Wetlands	TRE-24	2.30E+08	2.30E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08
Forest	TRE-24	3.30E+08	3.30E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08
Cropland	TRE-25	5.20E+08	5.20E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	5.20E+08	5.20E+08	5.20E+08	5.20E+08
Pasture	TRE-25	5.20E+08	5.20E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08	5.20E+08	5.20E+08	5.20E+08	5.20E+08
Residential	TRE-25	3.50E+09	3.50E+09	3.50E+09	3.50E+09	3.50E+09	3.50E+09	3.50E+09	3.50E+09	3.50E+09	3.50E+09	3.50E+09	3.50E+09
Wetlands	TRE-25	4.80E+08	4.80E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08	4.80E+08	4.80E+08	4.80E+08	4.80E+08
Forest	TRE-25	5.80E+08	5.80E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.50E+08	5.80E+08	5.80E+08	5.80E+08	5.80E+08
Cropland	TRE-26	2.80E+08	2.80E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Pasture	TRE-26	2.80E+08	2.80E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08
Residential	TRE-26	4.10E+09	4.10E+09	4.10E+09	4.10E+09	4.10E+09	4.10E+09	4.10E+09	4.10E+09	4.10E+09	4.10E+09	4.10E+09	4.10E+09
Wetlands	TRE-26	2.40E+08	2.40E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08
Forest	TRE-26	3.40E+08	3.40E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08
Cropland	TRE-27	2.50E+08	2.50E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08
Pasture	TRE-27	1.80E+10	1.90E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	1.70E+10	1.80E+10	1.80E+10
Residential	TRE-27	4.60E+09	4.60E+09	4.60E+09	4.60E+09	4.60E+09	4.60E+09	4.60E+09	4.60E+09	4.60E+09	4.60E+09	4.60E+09	4.60E+09
Wetlands	TRE-27	2.10E+08	2.10E+08	1.80E+08	1.80E+08	1.80E+08	1.80E+08	1.80E+08	1.80E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08
Forest	TRE-27	3.10E+08	3.10E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08
Cropland	TRE-28	2.40E+08	2.40E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08
Pasture	TRE-28	2.50E+08	2.50E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08
Residential	TRE-28	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09
Wetlands	TRE-28	2.00E+08	2.00E+08	1.70E+08	1.70E+08	1.70E+08	1.70E+08	1.70E+08	1.70E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08
Forest	TRE-28	3.00E+08	3.00E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08
Cropland	TRE-29	4.40E+08	4.40E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	3.90E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08
Pasture	TRE-29	4.90E+08	4.90E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.40E+08	4.90E+08	4.90E+08	4.90E+08	4.90E+08
Residential	TRE-29	3.20E+10	3.20E+10	3.20E+10	3.20E+10	3.20E+10	3.20E+10	3.20E+10	3.20E+10	3.20E+10	3.20E+10	3.20E+10	3.20E+10
Wetlands	TRE-29	4.00E+08	4.00E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08
Forest	TRE-29	5.10E+08	5.10E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08	4.50E+08	5.10E+08	5.10E+08	5.10E+08	5.10E+08
Cropland	TRE-30	2.20E+08	2.20E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08
Pasture	TRE-30	2.20E+08	2.20E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08
Residential	TRE-30	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11	1.30E+11
Wetlands	TRE-30	1.70E+08	1.70E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.70E+08	1.70E+08	1.70E+08	1.70E+08
Forest	TRE-30	2.70E+08	2.70E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08
Cropland	TRE-31	3.20E+08	3.20E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	3.20E+08	3.20E+08	3.20E+08	3.20E+08
Pasture	TRE-31	1.10E+11	1.20E+11	1.20E+11	1.20E+11	1.20E+11	1.20E+11	1.20E+11	1.20E+11	1.20E+11	9.50E+10	9.90E+10	1.00E+11
Residential	TRE-31	2.30E+09	2.30E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.20E+09	2.30E+09	2.30E+09	2.30E+09	2.30E+09
Wetlands	TRE-31	2.80E+08	2.80E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08
Forest	TRE-31	3.80E+08	3.80E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08	3.80E+08	3.80E+08	3.80E+08	3.80E+08

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Cropland	TRE-32	2.40E+08	2.40E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08
Pasture	TRE-32	2.90E+08	2.90E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08
Residential	TRE-32	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09	2.10E+09
Wetlands	TRE-32	2.00E+08	2.00E+08	1.70E+08	1.70E+08	1.70E+08	1.70E+08	1.70E+08	1.70E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08
Forest	TRE-32	3.00E+08	3.00E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08
Cropland	TRE-33	3.10E+08	3.10E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08	3.10E+08	3.10E+08	3.10E+08	3.10E+08
Pasture	TRE-33	1.80E+10	2.00E+10	2.00E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.90E+10	1.60E+10	1.70E+10	1.80E+10
Residential	TRE-33	3.00E+09	3.00E+09	2.90E+09	2.90E+09	2.90E+09	2.90E+09	2.90E+09	2.90E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09
Wetlands	TRE-33	2.70E+08	2.70E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08
Forest	TRE-33	3.70E+08	3.70E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08	3.70E+08	3.70E+08	3.70E+08	3.70E+08
Cropland	TRE-34	2.80E+08	2.80E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08
Pasture	TRE-34	2.80E+08	2.80E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08
Residential	TRE-34	3.10E+09	3.10E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.10E+09	3.10E+09	3.10E+09	3.10E+09
Wetlands	TRE-34	2.30E+08	2.30E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08
Forest	TRE-34	3.40E+08	3.40E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.40E+08	3.40E+08	3.40E+08	3.40E+08
Cropland	TRE-35	2.10E+08	2.10E+08	1.90E+08	1.90E+08	1.90E+08	1.90E+08	1.90E+08	1.90E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08
Pasture	TRE-35	1.10E+10	1.20E+10	1.30E+10	1.30E+10	1.30E+10	1.40E+10	1.40E+10	1.40E+10	1.50E+10	9.20E+09	9.60E+09	1.00E+10
Residential	TRE-35	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09
Wetlands	TRE-35	1.90E+08	1.90E+08	1.70E+08	1.70E+08	1.70E+08	1.70E+08	1.70E+08	1.70E+08	1.90E+08	1.90E+08	1.90E+08	1.90E+08
Forest	TRE-35	2.80E+08	2.80E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.80E+08	2.80E+08	2.80E+08	2.80E+08
Cropland	TRE-36	2.70E+08	2.70E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08
Pasture	TRE-36	2.70E+08	2.70E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.40E+08	2.70E+08	2.70E+08	2.70E+08	2.70E+08
Residential	TRE-36	2.30E+09	2.30E+09	2.30E+09	2.30E+09	2.30E+09	2.30E+09	2.30E+09	2.30E+09	2.30E+09	2.30E+09	2.30E+09	2.30E+09
Wetlands	TRE-36	2.30E+08	2.30E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.30E+08	2.30E+08	2.30E+08	2.30E+08
Forest	TRE-36	3.30E+08	3.30E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.30E+08	3.30E+08	3.30E+08	3.30E+08
Cropland	TRE-37	2.20E+08	2.20E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.20E+08	2.20E+08	2.20E+08	2.20E+08
Pasture	TRE-37	1.90E+10	2.30E+10	2.30E+10	2.40E+10	2.50E+10	2.50E+10	2.60E+10	2.70E+10	2.70E+10	1.70E+10	1.80E+10	1.90E+10
Residential	TRE-37	2.80E+09	2.80E+09	2.80E+09	2.80E+09	2.80E+09	2.80E+09	2.80E+09	2.80E+09	2.80E+09	2.80E+09	2.80E+09	2.80E+09
Wetlands	TRE-37	2.10E+08	2.10E+08	1.80E+08	1.80E+08	1.80E+08	1.80E+08	1.80E+08	1.80E+08	2.10E+08	2.10E+08	2.10E+08	2.10E+08

Land Use	Sub	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Forest	TRE-37	2.90E+08	2.90E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.60E+08	2.90E+08	2.90E+08	2.90E+08	2.90E+08

Appendix G: Simulated Stream Flow Charts for TMDL Allocation Period

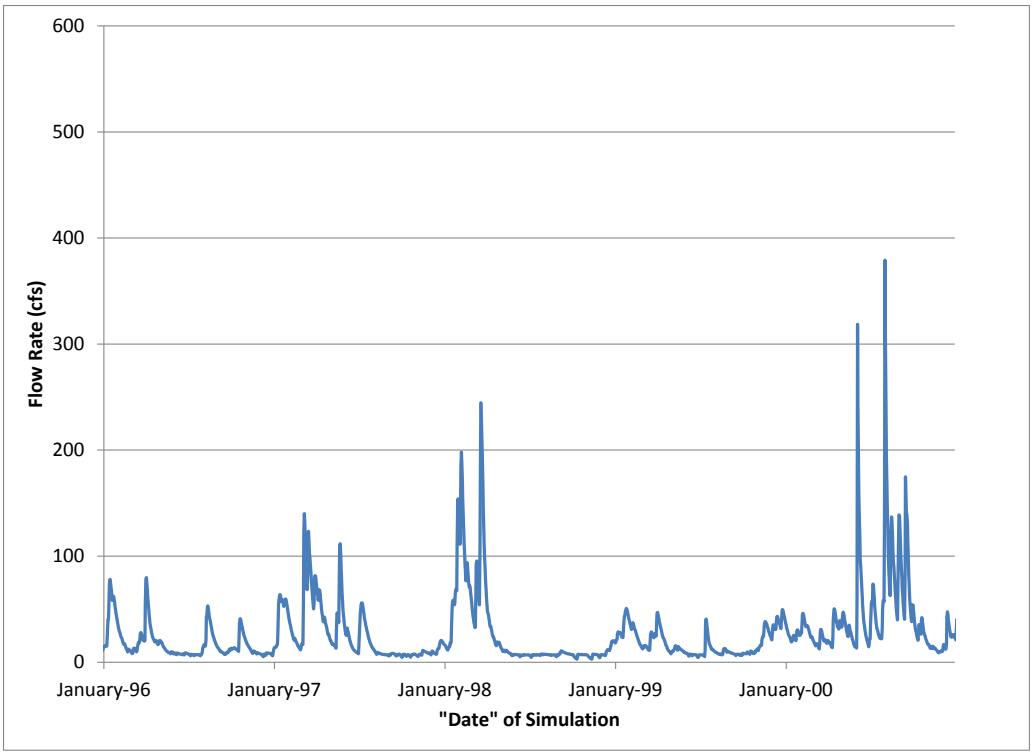

Figure G. 1. Simulated stream flow for the allocation period at the outlet of Darden Mill Run.

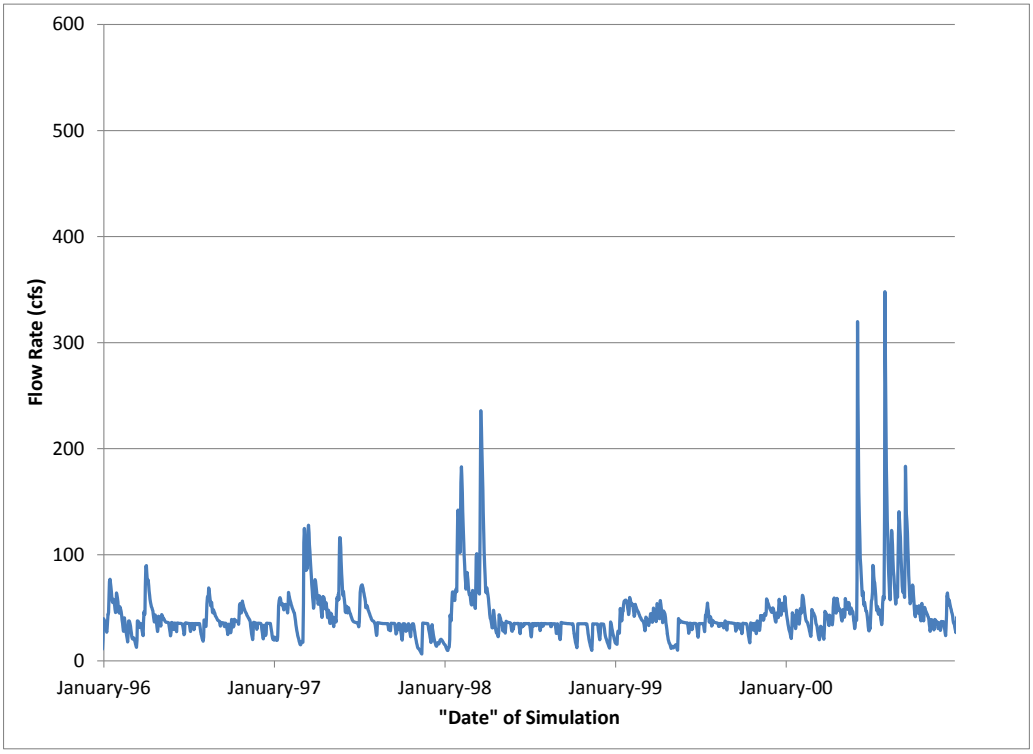

Figure G. 2. Simulated stream flow for the allocation period at the outlet of Mill Swamp.

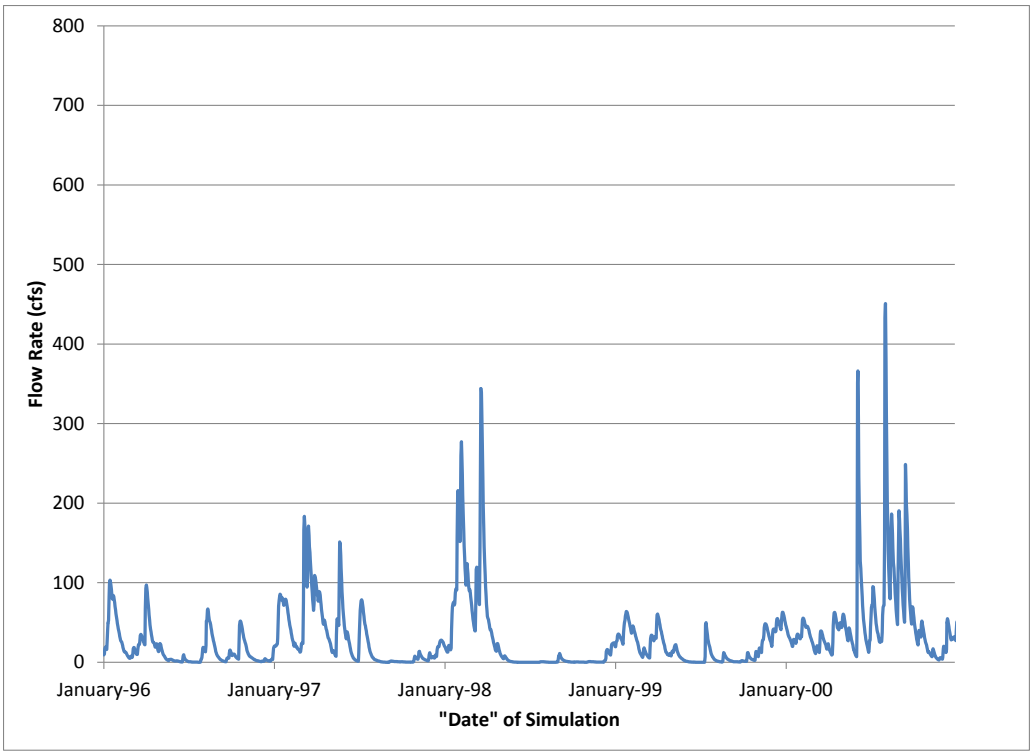

Figure G. 3. Simulated stream flow for the allocation period at the outlet of Flat Swamp.

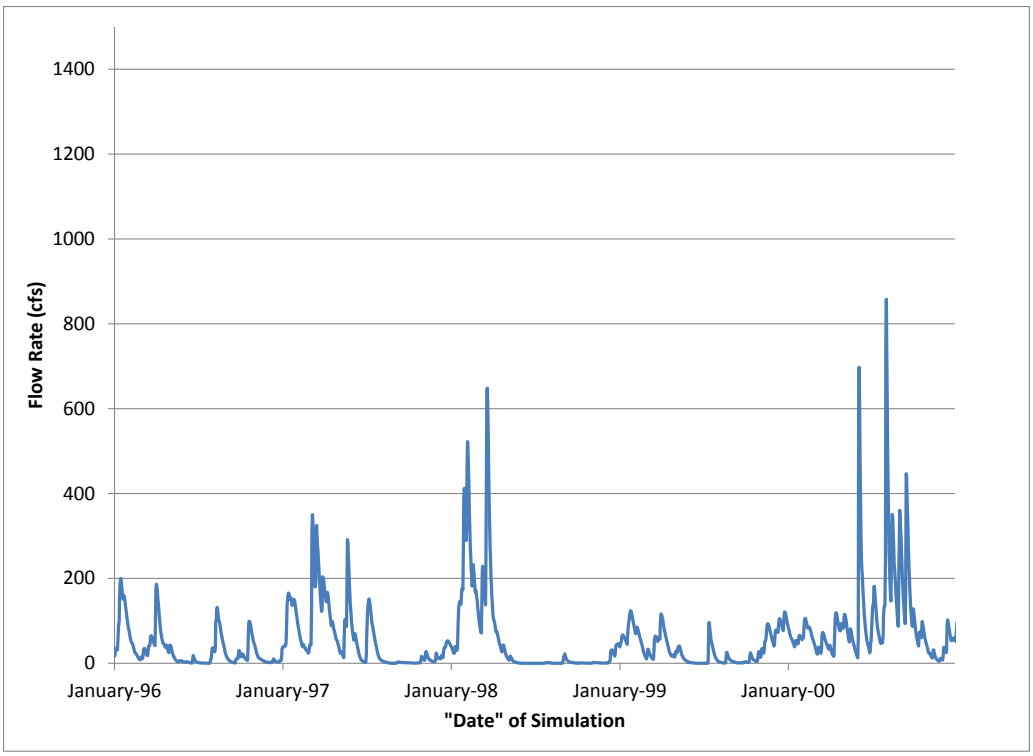

Figure G. 4. Simulated stream flow for the allocation period at the outlet of Tarrara Creek.

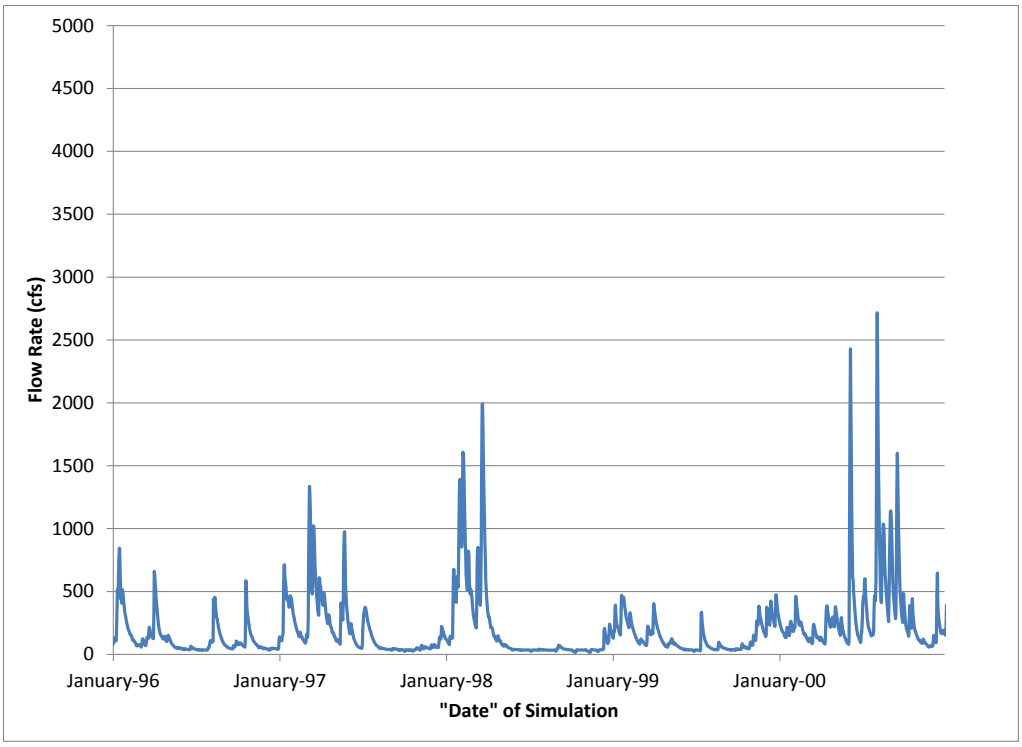

Figure G. 5. Simulated stream flow for the allocation period at the outlet of Three Creek (segment K27R-02).

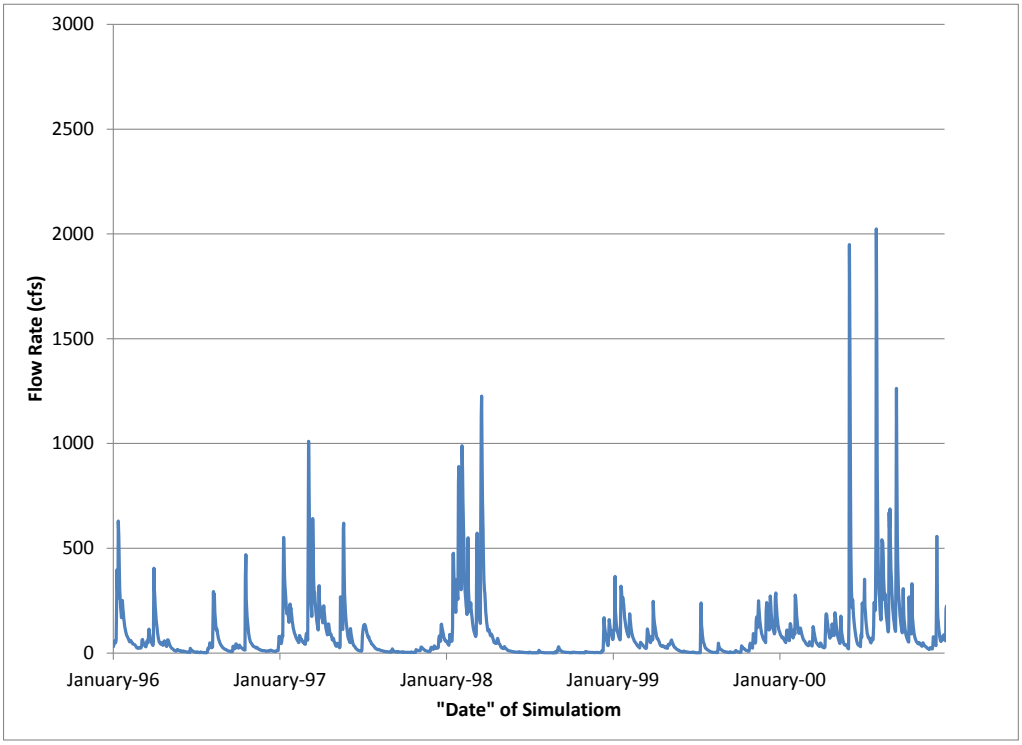

Figure G. 6. Simulated stream flow for the allocation period at the outlet of Three Creek (segment K26R-02).

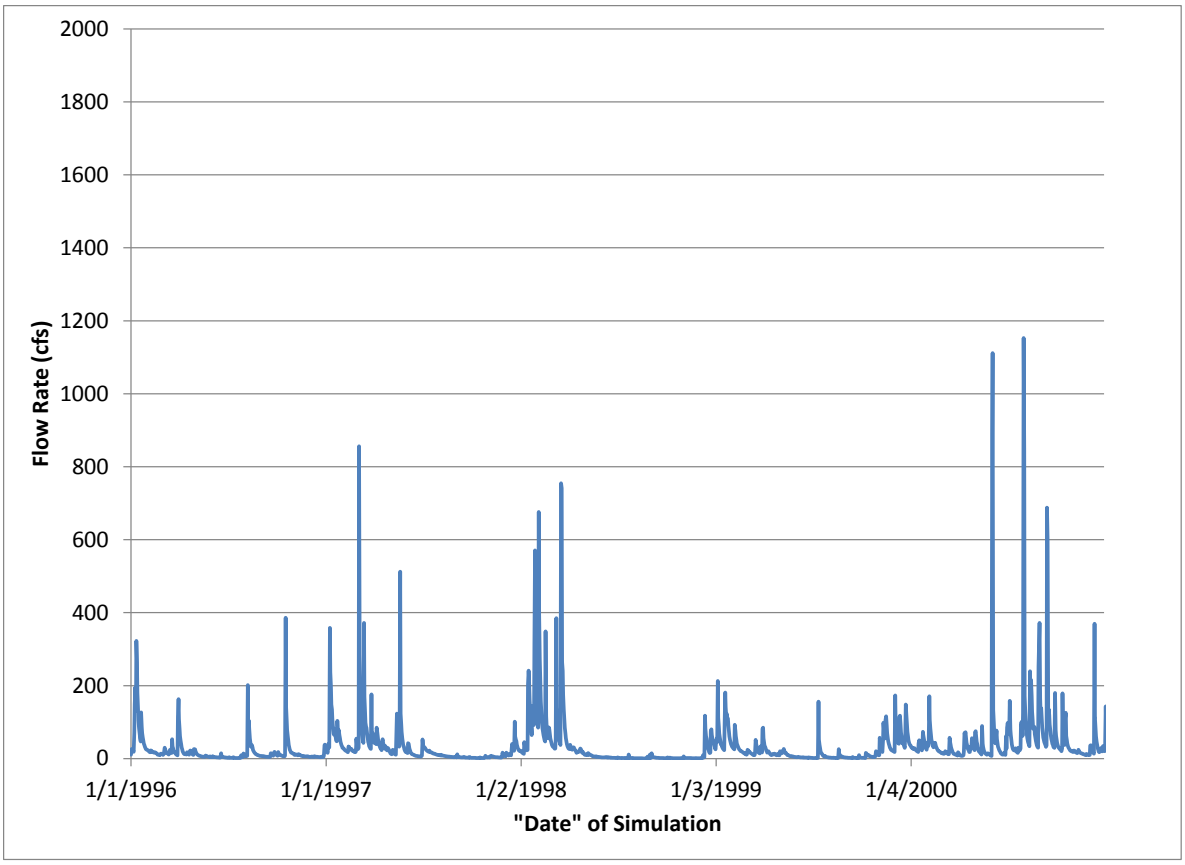

Figure G. 7. Simulated stream flow for the allocation period at the outlet of Three Creek (segment K26R-03).

Appendix H: Required Reductions in Fecal Coliform Loads by Sub-watershed – Allocation Scenario

Table H. 1. Required annual reductions in nonpoint sources in sub-watershed DMR-1.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	82,167	18%	82,167	0%
Pasture	10,094	2%	10,094	0%
Residential	76,759	17%	39,503	49%
Wetlands	16,191	4%	16,191	0%
Forest	265,894	59%	265,894	0%
Total	451,104	100%	413,849	8%

Table H. 2. Required annual reductions in direct nonpoint sources in sub-watershed DMR-1.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	460	1%	115	75%
Wildlife in Streams	59,909	99%	20,968	65%
Total	60,369	100%	21,083	65%

Table H. 3. Required annual reductions in nonpoint sources in sub-watershed DMR-2.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	90,836	30%	90,836	0%
Pasture	6,254	2%	6,254	0%
Residential	43,360	15%	24,732	43%
Wetlands	9,407	3%	9,407	0%
Forest	148,396	50%	148,396	0%
Total	298,254	100%	279,625	6%

Table H. 4. Required annual reductions in direct nonpoint sources in sub-watershed DMR-2.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	247	1%	62	75%
Wildlife in Streams	43,752	99%	15,313	65%
Total	43,999	100%	15,375	65%

Table H. 5. Required annual reductions in nonpoint sources in sub-watershed DMR-3.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	142,048	1%	142,048	0%
Pasture	19,381,134	98%	19,381,134	0%
Residential	91,064	0%	54,539	40%
Wetlands	7,685	0%	7,685	0%
Forest	145,296	1%	145,296	0%
Total	19,767,228	100%	19,730,702	<1%

Table H. 6. Required annual reductions in direct nonpoint sources in sub-watershed DMR-3.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cattle in Streams	51,066	47%	2,553	95%
Hunt Club Washoff	230	1%	58	75%
Wildlife in Streams	56,220	52%	19,677	65%
Total	107,516	100%	22,288	79%

Table H. 7. Required annual reductions in nonpoint sources in sub-watershed DMR-4.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	601,357	10%	601,357	0%
Pasture	5,198,717	86%	5,198,717	0%
Residential	36,675	1%	18,120	51%
Wetlands	15,304	<1%	15,304	0%
Forest	161,761	3%	161,761	0%
Total	6,013,814	100%	5,995,261	<1%

Table H. 8. Required annual reductions in direct nonpoint sources in sub-watershed DMR-4.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cattle in Streams	31,130	34%	1,557	95%
Hunt Club Washoff	230	<1%	58	75%
Wildlife in Streams	60,648	66%	21,227	65%
Total	92,008	100%	22,842	75%

Table H. 9. Required annual reductions in nonpoint sources in sub-watershed DMR-5.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	146,757	4%	146,757	0%
Pasture	3,153,903	91%	3,153,903	0%
Wetlands	14,210	0%	14,210	0%
Forest	153,682	4%	153,682	0%
Total	3,468,551	100%	3,468,551	0%

Table H. 10. Required annual reductions in direct nonpoint sources in sub-watershed DMR-5.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cattle in Streams	19,575	24%	979	95%
Hunt Club Washoff	247	1%	62	75%
Wildlife in Streams	60,366	75%	21,128	65%
Total	80,188	100%	22,169	72%

Table H. 11. Required annual reductions in nonpoint sources in sub-watershed DMR-6.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	49,250	16%	49,250	0%
Pasture	120,142	38%	120,142	0%
Residential	74,105	24%	36,849	50%
Wetlands	1,648	1%	1,648	0%
Forest	70,061	22%	70,061	0%
Total	315,206	100%	277,950	12%

Table H. 12. Required annual reductions in direct nonpoint sources in sub-watershed DMR-6.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cattle in Streams	1,037	5%	52	95%
Hunt Club Washoff	115	1%	29	75%
Wildlife in Streams	19,310	94%	6,759	65%
Total	20,462	100%	6,840	67%

Table H. 13. Required annual reductions in nonpoint sources in sub-watershed DMR-7.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	21,507	40%	21,507	0%
Pasture	6,008	11%	6,008	0%
Residential	8,469	16%	8,469	0%
Wetlands	1,592	3%	1,592	0%
Forest	16,812	31%	16,812	0%
Total	54,388	100%	54,388	0%

Table H. 14. Required annual reductions in direct nonpoint sources in sub-watershed DMR-7.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	16	<1%	4	75%
Wildlife in Streams	11,285	100%	3,950	65%
Total	11,301	100%	3,954	65%

Table H. 15. Required annual reductions in nonpoint sources in sub-watershed DMR-8.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	58,838	22%	58,838	0%
Pasture	5,585	2%	5,585	0%
Residential	129,783	48%	129,783	0%
Wetlands	1,786	1%	1,786	0%
Forest	72,731	27%	72,731	0%
Total	268,723	100%	268,723	0%

Table H. 16. Required annual reductions in direct nonpoint sources in sub-watershed DMR-8.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	164	1%	41	75%
Wildlife in Streams	14,460	99%	5,061	65%
Total	14,624	100%	5,102	65%

Table H. 17. Required annual reductions in nonpoint sources in sub-watershed DMR-9.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	90,580	3%	90,580	0%
Pasture	3,167,088	92%	3,167,088	0%
Residential	57,073	2%	38,445	33%
Wetlands	7,097	0%	7,097	0%
Forest	107,384	3%	107,384	0%
Total	3,429,222	100%	3,410,594	1%

Table H. 18. Required annual reductions in direct nonpoint sources in sub-watershed DMR-9.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	181	<1%	45	75%
Wildlife in Streams	37,456	100%	13,110	65%
Total	37,637	100%	13,155	65%

Table H. 19. Required annual reductions in nonpoint sources in sub-watershed DMR-10.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	106,609	27%	106,609	0%
Pasture	3,136	1%	3,136	0%
Residential	46,675	12%	28,048	40%
Wetlands	13,772	3%	13,772	0%
Forest	228,004	57%	228,004	0%
Total	398,197	100%	379,569	5%

Table H. 20. Required annual reductions in direct nonpoint sources in sub-watershed DMR-10.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	378	1%	95	75%
Wildlife in Streams	58,730	99%	20,556	65%
Total	59,108	100%	20,651	65%

Table H. 21. Required annual reductions in nonpoint sources in sub-watershed DMR-11.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	93,391	22%	93,391	0%
Pasture	7,118	2%	7,118	0%
Residential	100,404	24%	44,521	56%
Wetlands	7,111	2%	7,111	0%
Forest	215,661	51%	215,661	0%
Total	423,686	100%	367,802	13%

Table H. 22. Required annual reductions in direct nonpoint sources in sub-watershed DMR-11.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	329	1%	82	75%
Wildlife in Streams	57,040	99%	19,964	65%
Total	57,369	100%	20,046	65%

Table H. 23. Required annual reductions in nonpoint sources in sub-watershed MSP-1.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	63,847	25%	63,847	0%
Pasture	10,300	4%	10,300	0%
Wetlands	12,139	5%	12,139	0%
Forest	168,740	66%	168,740	0%
Total	255,025	100%	255,025	0%

Table H. 24. Required annual reductions in direct nonpoint sources in sub-watershed MSP-1.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	263	1%	263	0%
Wildlife in Streams	46,839	99%	46,839	0%
Total	47,102	100%	47,102	0%

Table H. 25. Required annual reductions in nonpoint sources in sub-watershed MSP-2.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	102,413	20%	102,413	0%
Pasture	18,305	4%	18,305	0%
Residential	155,571	31%	99,710	36%
Wetlands	8,461	2%	8,461	0%
Forest	219,744	44%	219,744	0%
Total	504,494	100%	448,633	11%

Table H. 26. Required annual reductions in direct nonpoint sources in sub-watershed MSP-2.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	329	1%	329	0%
Wildlife in Streams	62,481	99%	62,481	0%
Total	62,810	100%	62,810	0%

Table H. 27. Required annual reductions in nonpoint sources in sub-watershed MSP-3.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	66,853	19%	66,853	0%
Pasture	8,278	2%	8,278	0%
Residential	114,828	33%	77,821	32%
Wetlands	3,835	1%	3,835	0%
Forest	157,405	45%	157,405	0%
Total	351,199	100%	314,192	11%

Table H. 28. Required annual reductions in direct nonpoint sources in sub-watershed MSP-3.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	296	1%	296	0%
Wildlife in Streams	32,254	63%	32,254	0%
Straight Pipes	18,503	36%	0	100%
Total	51,053	100%	32,550	36%

Table H. 29. Required annual reductions in nonpoint sources in sub-watershed MSP-4.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	45,720	25%	45,720	0%
Pasture	9,608	5%	9,608	0%
Wetlands	3,224	2%	3,224	0%
Forest	126,102	68%	126,102	0%
Total	184,653	100%	184,653	0%

Table H. 30. Required annual reductions in direct nonpoint sources in sub-watershed MSP-4.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	214	1%	214	0%
Wildlife in Streams	29,119	99%	29,119	0%
Total	29,333	100%	29,333	0%

Table H. 31. Required annual reductions in nonpoint sources in sub-watershed MSP-5.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	63,927	8%	63,927	0%
Pasture	536,275	63%	536,275	0%
Residential	47,716	6%	47,716	0%
Wetlands	5,793	1%	5,793	0%
Forest	196,991	23%	196,991	0%
Total	850,702	100%	850,702	0%

Table H. 32. Required annual reductions in direct nonpoint sources in sub-watershed MSP-5.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cattle in Streams	3,175	5%	3,175	0%
Hunt Club Washoff	329	1%	329	0%
Wildlife in Streams	41,264	65%	41,593	0%
Straight Pipes	18,628	29%	0	100%
Total	63,396	100%	44,768	29%

Table H. 33. Required annual reductions in nonpoint sources in sub-watershed MSP-6.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	140,665	30%	140,665	0%
Pasture	18,016	4%	18,016	0%
Residential	79,030	17%	41,914	47%
Wetlands	15,785	3%	15,785	0%
Forest	222,934	47%	222,934	0%
Total	476,430	100%	439,315	8%

Table H. 34. Required annual reductions in direct nonpoint sources in sub-watershed MSP-6.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	329	<1%	329	0%
Wildlife in Streams	76,660	100%	76,989	0%
Total	76,989	100%	76,989	0%

Table H. 35. Required annual reductions in nonpoint sources in sub-watershed MSP-7.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	96,804	34%	96,804	0%
Pasture	13,011	5%	13,011	0%
Residential	21,878	8%	21,878	0%
Wetlands	7,577	3%	7,577	0%
Forest	148,120	52%	148,120	0%
Total	287,389	100%	287,389	0%

Table H. 36. Required annual reductions in direct nonpoint sources in sub-watershed MSP-7.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	247	1%	247	0%
Wildlife in Streams	45,538	99%	45,538	0%
Total	45,785	100%	45,785	0%

Table H. 37. Required annual reductions in nonpoint sources in sub-watershed MSP-8.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	135,986	31%	135,986	0%
Pasture	14,688	3%	14,688	0%
Residential	148,679	34%	130,052	13%
Wetlands	9,960	2%	9,960	0%
Forest	133,599	30%	133,599	0%
Total	442,912	100%	424,284	4%

Table H. 38. Required annual reductions in direct nonpoint sources in sub-watershed MSP-8.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	230	<1%	230	0%
Wildlife in Streams	52,046	100%	52,046	0%
Total	52,276	100%	52,276	0%

Table H. 39. Required annual reductions in nonpoint sources in sub-watershed MSP-9.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	74,983	3%	74,983	0%
Pasture	1,961,361	91%	1,961,361	0%
Residential	15,127	1%	15,127	0%
Wetlands	4,497	0%	4,497	0%
Forest	88,295	4%	88,295	0%
Total	2,144,262	100%	2,144,262	0%

Table H. 40. Required annual reductions in direct nonpoint sources in sub-watershed MSP-9.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	164	1%	164	0%
Wildlife in Streams	25,658	99%	25,658	0%
Total	25,822	100%	25,822	0%

Table H. 41. Required annual reductions in nonpoint sources in sub-watershed TRR-1.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	167,367	2%	167,367	0%
Pasture	6,832,186	91%	6,832,186	0%
Residential	135,715	2%	117,891	13%
Wetlands	63,999	1%	63,999	0%
Forest	326,041	4%	326,041	0%
Total	7,525,307	100%	7,507,483	<1%

Table H. 42. Required annual reductions in direct nonpoint sources in sub-watershed TRR-1.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cattle in Streams	39,393	21%	9,848	75%
Hunt Club Washoff	444	<1%	444	0%
Wildlife in Streams	134,032	70%	13,403	90%
Straight Pipes	17,824	9%	0	100%
Total	191,692	100%	23,695	88%

Table H. 43. Required annual reductions in nonpoint sources in sub-watershed TRR-2.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	7,695	8%	7,695	0%
Pasture	4,858	5%	4,858	0%
Residential	48,562	52%	48,562	0%
Wetlands	17,858	19%	17,858	0%
Forest	14,413	15%	14,413	0%
Total	93,386	100%	93,386	0%

Table H. 44. Required annual reductions in direct nonpoint sources in sub-watershed TRR-2.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	16	<1%	16	0%
Wildlife in Streams	13,811	100%	1,381	90%
Total	13,817	100%	1,397	90%

Table H. 45. Required annual reductions in nonpoint sources in sub-watershed TRR-3.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	204,269	7%	204,269	0%
Pasture	2,144,544	78%	2,144,544	0%
Residential	145,717	5%	109,046	25%
Wetlands	8,040	0%	8,040	0%
Forest	260,948	9%	260,948	0%
Total	2,763,518	100%	2,726,846	1%

Table H. 46. Required annual reductions in direct nonpoint sources in sub-watershed TRR-3.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cattle in Streams	12,671	15%	3,168	75%
Hunt Club Washoff	477	1%	477	0%
Wildlife in Streams	70,428	84%	7,043	90%
Total	83,576	100%	10,688	87%

Table H. 47. Required annual reductions in nonpoint sources in sub-watershed TRR-4.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	164,767	2%	164,767	0%
Pasture	8,606,999	92%	8,606,999	0%
Residential	327,164	4%	309,339	5%
Wetlands	35,481	0%	35,481	0%
Forest	195,382	2%	195,382	0%
Total	9,329,793	100%	9,311,969	<1%

Table H. 48. Required annual reductions in direct nonpoint sources in sub-watershed TRR-4.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cattle in Streams	74,367	41%	18,592	75%
Hunt Club Washoff	263	<1%	263	0%
Wildlife in Streams	105,362	59%	10,536	90%
Total	179,992	100%	29,391	84%

Table H. 49. Required annual reductions in nonpoint sources in sub-watershed TRR-5.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	95,452	13%	95,452	0%
Pasture	426,591	60%	426,591	0%
Residential	16,952	2%	16,952	0%
Wetlands	47,091	7%	47,091	0%
Forest	121,381	17%	121,381	0%
Total	707,468	100%	707,468	0%

Table H. 50. Required annual reductions in direct nonpoint sources in sub-watershed TRR-5.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cattle in Streams	2,476	3%	619	75%
Hunt Club Washoff	164	1%	164	0%
Wildlife in Streams	68,144	96%	6,814	90%
Total	70,783	100%	7,597	89%

Table H. 51. Required annual reductions in nonpoint sources in sub-watershed TRR-6.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	148,241	3%	148,241	0%
Pasture	4,673,328	94%	4,673,328	0%
Wetlands	27,963	1%	27,963	0%
Forest	99,914	2%	99,914	0%
Total	4,949,446	100%	4,949,446	0%

Table H. 52. Required annual reductions in direct nonpoint sources in sub-watershed TRR-6.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cattle in Streams	28,635	33%	7,159	75%
Hunt Club Washoff	181	<1%	181	0%
Wildlife in Streams	57,810	67%	5,781	90%
Total	86,626	100%	13,121	85%

Table H. 53. Required annual reductions in nonpoint sources in sub-watershed TRR-7.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	127,913	22%	127,913	0%
Pasture	11,216	2%	11,216	0%
Residential	130,821	22%	93,743	28%
Wetlands	11,238	2%	11,238	0%
Forest	310,495	52%	310,495	0%
Total	591,682	100%	554,604	6%

Table H. 54. Required annual reductions in direct nonpoint sources in sub-watershed TRR-7.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	559	1%	559	0%
Wildlife in Streams	66,178	99%	6,618	90%
Total	66,737	100%	7,177	89%

Table H. 55. Required annual reductions in nonpoint sources in sub-watershed TRR-8.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	62,611	0%	62,611	0%
Pasture	14,192,584	98%	14,192,584	0%
Wetlands	11,534	0%	11,534	0%
Forest	144,708	1%	144,708	0%
Total	14,411,438	100%	14,411,438	0%

Table H. 56. Required annual reductions in direct nonpoint sources in sub-watershed TRR-8.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	247	1%	247	0%
Wildlife in Streams	40,439	99%	4,044	90%
Total	40,686	100%	4,291	89%

Table H. 57. Required annual reductions in nonpoint sources in sub-watershed TRR-9.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	1,284,102	72%	1,284,102	0%
Pasture	18,859	1%	18,859	0%
Residential	118,839	7%	100,293	16%
Wetlands	13,390	1%	13,390	0%
Forest	350,484	20%	350,484	0%
Total	1,785,674	100%	1,767,127	1%

Table H. 58. Required annual reductions in direct nonpoint sources in sub-watershed TRR-9.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	625	1%	625	0%
Wildlife in Streams	87,233	99%	8,723	90%
Total	87,858	100%	9,348	89%

Table H. 59. Required annual reductions in nonpoint sources in sub-watershed FTS-10.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	71,685	34%	46,595	35%
Pasture	4,413	2%	2,869	35%
Wetlands	41,877	20%	41,877	0%
Forest	92,103	44%	92,103	0%
Total	210,078	100%	183,443	13%

Table H. 60. Required annual reductions in direct nonpoint sources in sub-watershed FTS-10.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	148	<1%	148	0%
Wildlife in Streams	50,606	100%	7,591	85%
Total	50,754	100%	7,739	85%

Table H. 61. Required annual reductions in nonpoint sources in sub-watershed FTS-11.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	47,191	37%	30,674	35%
Pasture	2,644	2%	1,719	35%
Wetlands	9,620	8%	9,620	0%
Forest	68,150	53%	68,150	0%
Total	127,606	100%	110,164	14%

Table H. 62. Required annual reductions in direct nonpoint sources in sub-watershed FTS-11.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	99	<1%	99	0%
Wildlife in Streams	25,479	100%	3,822	85%
Total	25,578	100%	3,837	85%

Table H. 63. Required annual reductions in nonpoint sources in sub-watershed FTS-12.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	136,868	38%	88,964	35%
Pasture	12,903	4%	8,387	35%
Wetlands	14,103	4%	14,103	0%
Forest	192,057	54%	192,057	0%
Total	355,932	100%	303,512	15%

Table H. 64. Required annual reductions in direct nonpoint sources in sub-watershed FTS-12.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	296	<1%	296	0%
Wildlife in Streams	65,199	100%	9,780	85%
Total	65,495	100%	10,076	85%

Table H. 65. Required annual reductions in nonpoint sources in sub-watershed FTS-13.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	165,336	4%	107,469	35%
Pasture	4,014,425	87%	2,609,377	35%
Residential	99,663	2%	40,650	59%
Wetlands	15,005	0%	15,005	0%
Forest	323,055	7%	323,055	0%
Total	4,617,484	100%	3,095,555	33%

Table H. 66. Required annual reductions in direct nonpoint sources in sub-watershed FTS-13.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cattle in Streams	81,148	49%	81,148	0%
Hunt Club Washoff	559	1%	559	0%
Wildlife in Streams	83,218	50%	12,483	85%
Total	164,925	100%	94,190	43%

Table H. 67. Required annual reductions in nonpoint sources in sub-watershed FTS-14.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	56,089	36%	36,458	35%
Pasture	10,663	7%	6,931	35%
Wetlands	27,886	18%	27,886	0%
Forest	62,547	40%	62,547	0%
Total	157,186	100%	133,823	15%

Table H. 68. Required annual reductions in direct nonpoint sources in sub-watershed FTS-14.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	99	<1%	99	0%
Wildlife in Streams	35,828	100%	5,374	85%
Total	35,927	100%	5,473	85%

Table H. 69. Required annual reductions in nonpoint sources in sub-watershed FTS-15.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	146,866	24%	95,463	35%
Pasture	10,731	2%	6,975	35%
Residential	56,004	9%	24,594	56%
Wetlands	56,277	9%	56,277	0%
Forest	342,147	56%	342,147	0%
Total	612,025	100%	525,456	14%

Table H. 70. Required annual reductions in direct nonpoint sources in sub-watershed FTS-15.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	526	<1%	526	0%
Wildlife in Streams	112,282	100%	16,842	85%
Total	112,808	100%	17,368	85%

Table H. 71. Required annual reductions in nonpoint sources in sub-watershed FTS-16.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	153,757	29%	99,942	35%
Pasture	32,583	6%	21,179	35%
Residential	58,303	11%	25,700	56%
Wetlands	24,040	5%	24,040	0%
Forest	263,276	49%	263,276	0%
Total	531,959	100%	434,137	18%

Table H. 72. Required annual reductions in direct nonpoint sources in sub-watershed FTS-16.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	394	<1%	394	0%
Wildlife in Streams	92,391	100%	13,859	85%
Total	92,785	100%	14,253	85%

Table H. 73. Required annual reductions in nonpoint sources in sub-watershed FTS-17.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	58,261	27%	37,870	35%
Pasture	2,647	1%	1,721	35%
Wetlands	9,440	4%	9,440	0%
Forest	141,913	67%	141,913	0%
Total	212,263	100%	190,944	10%

Table H. 74. Required annual reductions in direct nonpoint sources in sub-watershed FTS-17.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	197	<1%	197	0%
Wildlife in Streams	40,728	100%	6,109	85%
Total	40,925	100%	6,306	85%

Table H. 75. Required annual reductions in nonpoint sources in sub-watershed FTS-18.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	145,957	1%	94,872	35%
Pasture	25,572,770	98%	16,622,301	35%
Residential	95,598	0%	37,543	61%
Wetlands	15,482	0%	15,482	0%
Forest	349,570	1%	349,570	0%
Total	26,179,377	100%	17,119,768	35%

Table H. 76. Required annual reductions in direct nonpoint sources in sub-watershed FTS-18.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	641	1%	641	0%
Wildlife in Streams	76,812	99%	11,522	85%
Total	77,453	100%	12,163	84%

Table H. 77. Required annual reductions in nonpoint sources in sub-watershed FTS-19.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	22,799	33%	14,819	35%
Pasture	426	1%	277	35%
Residential	6,693	10%	4,350	35%
Wetlands	5,248	8%	5,248	0%
Forest	33,058	48%	33,058	0%
Total	68,224	100%	57,753	15%

Table H. 78. Required annual reductions in direct nonpoint sources in sub-watershed FTS-19.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	49	<1%	49	0%
Wildlife in Streams	12,914	100%	1,937	85%
Total	12,963	100%	1,986	85%

Table H. 79. Required annual reductions in nonpoint sources in sub-watershed FTS-20.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	59,996	19%	38,997	35%
Pasture	8,525	3%	5,541	35%
Residential	90,571	29%	34,275	62%
Wetlands	2,717	1%	2,717	0%
Forest	154,995	49%	154,995	0%
Total	316,803	100%	236,525	25%

Table H. 80. Required annual reductions in direct nonpoint sources in sub-watershed FTS-20.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	279	1%	279	0%
Wildlife in Streams	32,282	99%	4,842	85%
Total	32,561	100%	5,121	84%

Table H. 81. Required annual reductions in nonpoint sources in sub-watershed FTS-21.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	185,950	33%	120,868	35%
Pasture	15,230	3%	9,899	35%
Residential	28,224	5%	18,346	35%
Wetlands	16,122	3%	16,122	0%
Forest	319,203	57%	319,203	0%
Total	564,729	100%	484,437	14%

Table H. 82. Required annual reductions in direct nonpoint sources in sub-watershed FTS-21.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	460	<1%	460	0%
Wildlife in Streams	100,919	100%	15,138	85%
Total	101,379	100%	15,598	85%

Table H. 83. Required annual reductions in nonpoint sources in sub-watershed TRE-1.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	105,790	22%	105,790	0%
Pasture	8,218	2%	8,218	0%
Wetlands	73,578	15%	73,578	0%
Forest	301,021	62%	301,021	0%
Total	488,606	100%	488,606	0%

Table H. 84. Required annual reductions in direct nonpoint sources in sub-watershed TRE-1.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	394	<1%	394	0%
Wildlife in Streams	84,310	100%	84,310	0%
Total	84,704	100%	84,704	0%

Table H. 85. Required annual reductions in nonpoint sources in sub-watershed TRE-2.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	80,820	3%	80,820	0%
Pasture	2,658,183	87%	2,658,183	0%
Wetlands	26,441	1%	26,441	0%
Forest	289,308	9%	289,308	0%
Total	3,054,752	100%	3,054,752	0%

Table H. 86. Required annual reductions in direct nonpoint sources in sub-watershed TRE-2.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cattle in Streams	2,528	4%	2,528	0%
Hunt Club Washoff	444	1%	44	0%
Wildlife in Streams	56,165	95%	56,165	0%
Total	59,137	100%	59,137	0%

Table H. 87. Required annual reductions in nonpoint sources in sub-watershed TRE-3.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	129,022	3%	129,022	0%
Pasture	4,208,961	88%	4,208,961	0%
Residential	60,607	1%	41,713	31%
Wetlands	22,104	0%	22,104	0%
Forest	364,575	8%	364,575	0%
Total	4,785,268	100%	4,766,374	<1%

Table H. 88. Required annual reductions in direct nonpoint sources in sub-watershed TRE-3.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	542	1%	542	0%
Wildlife in Streams	73,152	99%	73,152	0%
Total	73,694	100%	73,694	0%

Table H. 89. Required annual reductions in nonpoint sources in sub-watershed TRE-4.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	68,425	12%	68,425	0%
Pasture	8,810	2%	8,810	0%
Residential	56,399	10%	56,399	0%
Wetlands	9,309	2%	9,309	0%
Forest	424,907	75%	424,907	0%
Total	567,850	100%	567,850	0%

Table H. 90. Required annual reductions in direct nonpoint sources in sub-watershed TRE-4.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	674	1%	674	0%
Wildlife in Streams	61,040	99%	61,040	0%
Total	61,714	100%	61,714	0%

Table H. 91. Required annual reductions in nonpoint sources in sub-watershed TRE-5.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	115,919	15%	115,919	0%
Pasture	10,345	1%	10,345	0%
Residential	36,629	5%	36,629	0%
Wetlands	59,909	8%	59,909	0%
Forest	570,102	72%	570,102	0%
Total	792,904	100%	792,904	0%

Table H. 92. Required annual reductions in direct nonpoint sources in sub-watershed TRE-5.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	756	1%	756	0%
Wildlife in Streams	115,871	99%	115,871	0%
Total	116,627	100%	116,627	0%

Table H. 93. Required annual reductions in nonpoint sources in sub-watershed TRE-6.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	1,505,783	5%	1,505,783	0%
Pasture	30,790,235	92%	30,790,235	0%
Residential	221,964	1%	128,158	42%
Wetlands	154,887	0%	154,887	0%
Forest	744,368	2%	744,368	0%
Total	33,417,237	100%	33,323,431	<1%

Table H. 94. Required annual reductions in direct nonpoint sources in sub-watershed TRE-6.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cattle in Streams	74,350	25%	74,350	0%
Hunt Club Washoff	986	<1%	986	0%
Wildlife in Streams	223,916	75%	223,916	0%
Total	299,252	100%	299,252	0%

Table H. 95. Required annual reductions in nonpoint sources in sub-watershed TRE-7.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	188,242	21%	188,242	0%
Pasture	68,628	8%	68,628	0%
Residential	266,542	30%	211,130	21%
Wetlands	14,447	2%	14,447	0%
Forest	339,495	39%	339,495	0%
Total	877,354	100%	821,942	6%

Table H. 96. Required annual reductions in direct nonpoint sources in sub-watershed TRE-7.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	460	<1%	460	0%
Wildlife in Streams	92,625	100%	92,625	0%
Total	93,085	100%	93,085	0%

Table H. 97. Required annual reductions in nonpoint sources in sub-watershed TRE-8.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	191,658	25%	191,658	0%
Pasture	28,497	4%	28,497	0%
Residential	120,147	16%	82,764	31%
Wetlands	13,815	2%	13,815	0%
Forest	402,890	53%	402,890	0%
Total	757,007	100%	719,624	5%

Table H. 98. Required annual reductions in direct nonpoint sources in sub-watershed TRE-8.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	657	1%	657	0%
Wildlife in Streams	79,001	99%	79,001	0%
Total	79,658	100%	79,658	0%

Table H. 99. Required annual reductions in nonpoint sources in sub-watershed TRE-9.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	1,041,021	61%	1,041,021	0%
Pasture	37,885	2%	37,885	0%
Residential	128,581	8%	90,917	29%
Wetlands	28,768	2%	28,768	0%
Forest	461,074	27%	461,074	0%
Total	1,697,330	100%	1,659,665	2%

Table H. 100. Required annual reductions in direct nonpoint sources in sub-watershed TRE-9.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	723	1%	723	0%
Wildlife in Streams	117,177	99%	117,177	0%
Total	117,900	100%	117,900	0%

Table H. 101. Required annual reductions in nonpoint sources in sub-watershed TRE-10.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	158,993	22%	158,993	0%
Pasture	23,558	3%	23,558	0%
Residential	72,555	10%	34,875	52%
Wetlands	47,806	7%	47,806	0%
Forest	409,277	57%	409,277	0%
Total	712,188	100%	674,508	5%

Table H. 102. Required annual reductions in direct nonpoint sources in sub-watershed TRE-10.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	542	1%	542	0%
Wildlife in Streams	101,663	99%	101,663	0%
Total	102,205	100%	102,205	0%

Table H. 103. Required annual reductions in nonpoint sources in sub-watershed TRE-11.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	129,520	24%	129,520	0%
Pasture	6,832	1%	6,832	0%
Residential	29,643	5%	29,643	0%
Wetlands	16,312	3%	16,312	0%
Forest	368,461	67%	368,461	0%
Total	550,767	100%	550,767	0%

Table H. 104. Required annual reductions in direct nonpoint sources in sub-watershed TRE-11.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	526	1%	526	0%
Wildlife in Streams	72,118	99%	72,118	0%
Total	72,644	100%	72,644	0%

Table H. 105. Required annual reductions in nonpoint sources in sub-watershed TRE-12.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	25,859	5%	25,859	0%
Pasture	311,372	64%	311,372	0%
Residential	26,369	5%	26,369	0%
Wetlands	6,338	1%	6,338	0%
Forest	116,802	24%	116,802	0%
Total	486,740	100%	486,740	0%

Table H. 106. Required annual reductions in direct nonpoint sources in sub-watershed TRE-12.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	115	<1%	115	0%
Wildlife in Streams	26,574	100%	26,574	0%
Total	26,689	100%	26,689	0%

Table H. 107. Required annual reductions in nonpoint sources in sub-watershed TRE-13.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	63,372	3%	63,372	0%
Pasture	1,493,134	69%	1,493,134	0%
Residential	299,880	14%	248,160	17%
Wetlands	11,465	1%	11,465	0%
Forest	285,928	13%	285,928	0%
Total	2,153,778	100%	2,102,059	2%

Table H. 108. Required annual reductions in direct nonpoint sources in sub-watershed TRE-13.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	378	1%	378	0%
Wildlife in Streams	56,312	99%	56,312	0%
Total	56,690	100%	56,690	0%

Table H. 109. Required annual reductions in nonpoint sources in sub-watershed TRE-14.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	93,394	1%	93,394	0%
Pasture	5,508,029	86%	5,508,029	0%
Residential	303,656	5%	286,416	6%
Wetlands	9,684	0%	9,684	0%
Forest	480,292	8%	480,292	0%
Total	6,395,055	100%	6,377,815	<1%

Table H. 110. Required annual reductions in direct nonpoint sources in sub-watershed TRE-14.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cattle in Streams	22,749	21%	22,749	0%
Hunt Club Washoff	657	<1%	657	0%
Wildlife in Streams	86,370	79%	86,370	0%
Total	109,776	100%	109,776	0%

Table H. 111. Required annual reductions in nonpoint sources in sub-watershed TRE-15.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	45,005	29%	45,005	0%
Pasture	30,966	20%	30,966	0%
Residential	59	0%	59	0%
Wetlands	21,718	14%	21,718	0%
Forest	59,888	38%	59,888	0%
Total	157,636	100%	157,636	0%

Table H. 112. Required annual reductions in direct nonpoint sources in sub-watershed TRE-15.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	82	<1%	82	0%
Wildlife in Streams	28,452	100%	28,452	0%
Total	28,534	100%	28,534	0%

Table H. 113. Required annual reductions in nonpoint sources in sub-watershed TRE-16.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	334,412	23%	334,412	0%
Pasture	67,551	5%	67,551	0%
Residential	199,271	14%	142,511	28%
Wetlands	84,822	6%	84,822	0%
Forest	755,857	52%	755,857	0%
Total	1,441,914	100%	1,385,154	4%

Table H. 114. Required annual reductions in direct nonpoint sources in sub-watershed TRE-16.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	986	<1%	986	0%
Wildlife in Streams	200,549	100%	200,549	0%
Total	201,535	100%	201,535	0%

Table H. 115. Required annual reductions in nonpoint sources in sub-watershed TRE-17.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	91,924	3%	91,924	0%
Pasture	2,293,609	80%	2,293,609	0%
Residential	24,912	1%	24,912	0%
Wetlands	17,711	1%	17,711	0%
Forest	448,188	16%	448,188	0%
Total	2,876,343	100%	2,876,343	0%

Table H. 116. Required annual reductions in direct nonpoint sources in sub-watershed TRE-17.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	559	1%	559	0%
Wildlife in Streams	84,136	99%	84,136	0%
Total	84,695	100%	84,695	0%

Table H. 117. Required annual reductions in nonpoint sources in sub-watershed TRE-18.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	275,987	20%	275,987	0%
Pasture	33,911	2%	33,911	0%
Residential	238,466	17%	200,794	16%
Wetlands	85,630	6%	85,630	0%
Forest	777,314	55%	777,314	0%
Total	1,411,308	100%	1,373,636	3%

Table H. 118. Required annual reductions in direct nonpoint sources in sub-watershed TRE-18.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	1,101	1%	1,101	0%
Wildlife in Streams	179,499	99%	179,499	0%
Total	180,600	100%	180,600	0%

Table H. 119. Required annual reductions in nonpoint sources in sub-watershed TRE-19.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	96,907	17%	96,907	0%
Pasture	9,836	2%	9,836	0%
Residential	55,863	10%	38,112	32%
Wetlands	14,466	3%	14,466	0%
Forest	399,259	69%	399,259	0%
Total	576,331	100%	558,580	3%

Table H. 120. Required annual reductions in direct nonpoint sources in sub-watershed TRE-19.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	608	1%	608	0%
Wildlife in Streams	66,251	99%	66,251	0%
Total	66,859	100%	66,859	0%

Table H. 121. Required annual reductions in nonpoint sources in sub-watershed TRE-20.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	401,219	24%	401,219	0%
Pasture	49,433	3%	49,433	0%
Residential	267,637	16%	156,233	42%
Wetlands	246,879	15%	246,879	0%
Forest	677,954	41%	677,954	0%
Total	1,643,122	100%	1,531,717	7%

Table H. 122. Required annual reductions in direct nonpoint sources in sub-watershed TRE-20.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	937	<1%	515	45%
Wildlife in Streams	246,305	100%	36,946	85%
Total	247,242	100%	37,461	85%

Table H. 123. Required annual reductions in nonpoint sources in sub-watershed TRE-21.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	118,980	3%	118,980	0%
Pasture	3,335,207	86%	3,335,207	0%
Residential	85,957	2%	67,654	21%
Wetlands	101,689	3%	101,689	0%
Forest	229,473	6%	229,473	0%
Total	3,871,306	100%	3,853,003	<1%

Table H. 124. Required annual reductions in direct nonpoint sources in sub-watershed TRE-21.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cattle in Streams	20,034	18%	2,003	90%
Hunt Club Washoff	214	<1%	118	45%
Wildlife in Streams	90,738	82%	13,611	85%
Total	110,986	100%	15,732	86%

Table H. 125. Required annual reductions in nonpoint sources in sub-watershed TRE-22.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	221,584	19%	221,584	0%
Pasture	51,018	4%	51,018	0%
Residential	267,741	23%	232,697	13%
Wetlands	71,878	6%	71,878	0%
Forest	543,552	47%	543,552	0%
Total	1,155,773	100%	1,120,729	3%

Table H. 126. Required annual reductions in direct nonpoint sources in sub-watershed TRE-22.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	559	<1%	307	45%
Wildlife in Streams	160,214	100%	24,032	85%
Total	160,773	100%	24,339	85%

Table H. 127. Required annual reductions in nonpoint sources in sub-watershed TRE-23.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	41,678	11%	41,678	0%
Pasture	7,050	2%	7,050	0%
Residential	56,219	15%	38,979	31%
Wetlands	15,676	4%	15,676	0%
Forest	255,318	68%	255,318	0%
Total	375,941	100%	358,701	5%

Table H. 128. Required annual reductions in direct nonpoint sources in sub-watershed TRE-23.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	247	<1%	136	45%
Wildlife in Streams	52,915	100%	7,937	85%
Total	53,162	100%	8,073	85%

Table H. 129. Required annual reductions in nonpoint sources in sub-watershed TRE-24.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	130,244	2%	130,244	0%
Pasture	4,163,751	74%	4,163,751	0%
Residential	738,900	13%	629,325	15%
Wetlands	9,139	0%	9,139	0%
Forest	580,312	10%	580,312	0%
Total	5,622,346	100%	5,512,771	2%

Table H. 130. Required annual reductions in direct nonpoint sources in sub-watershed TRE-24.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	641	1%	353	45%
Wildlife in Streams	110,938	99%	16,641	85%
Total	111,579	100%	16,994	85%

Table H. 131. Required annual reductions in nonpoint sources in sub-watershed TRE-25.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	42,416	5%	42,416	0%
Pasture	20,951	3%	20,951	0%
Residential	323,861	40%	287,257	11%
Wetlands	74,914	9%	74,914	0%
Forest	345,300	43%	345,300	0%
Total	807,442	100%	770,838	5%

Table H. 132. Required annual reductions in direct nonpoint sources in sub-watershed TRE-25.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	247	<1%	136	45%
Wildlife in Streams	97,210	100%	14,582	85%
Total	97,457	100%	14,718	85%

Table H. 133. Required annual reductions in nonpoint sources in sub-watershed TRE-26.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	113,790	19%	113,790	0%
Pasture	17,350	3%	17,350	0%
Residential	162,490	28%	107,702	34%
Wetlands	2,721	0%	2,721	0%
Forest	291,760	50%	291,760	0%
Total	588,110	100%	533,323	9%

Table H. 134. Required annual reductions in direct nonpoint sources in sub-watershed TRE-26.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	312	<1%	172	45%
Wildlife in Streams	63,616	100%	9,542	85%
Total	63,928	100%	9,714	85%

Table H. 135. Required annual reductions in nonpoint sources in sub-watershed TRE-27.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	100,601	4%	100,601	0%
Pasture	1,858,488	71%	1,858,488	0%
Residential	371,538	14%	335,047	10%
Wetlands	1,715	0%	1,715	0%
Forest	298,900	11%	298,900	0%
Total	2,631,242	100%	2,594,751	1%

Table H. 136. Required annual reductions in direct nonpoint sources in sub-watershed TRE-27.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	345	1%	190	45%
Wildlife in Streams	60,363	99%	9,054	85%
Total	60,708	100%	9,244	85%

Table H. 137. Required annual reductions in nonpoint sources in sub-watershed TRE-28.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	82,110	8%	82,110	0%
Pasture	54,704	5%	54,704	0%
Residential	470,934	45%	290,685	38%
Wetlands	2,753	0%	2,753	0%
Forest	447,770	42%	447,770	0%
Total	1,058,271	100%	878,022	17%

Table H. 138. Required annual reductions in direct nonpoint sources in sub-watershed TRE-28.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	542	1%	298	45%
Wildlife in Streams	81,229	99%	12,184	85%
Total	81,771	100%	12,482	85%

Table H. 139. Required annual reductions in nonpoint sources in sub-watershed TRE-29.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	88,213	18%	88,213	0%
Pasture	15,479	3%	15,479	0%
Residential	118,085	24%	81,560	31%
Wetlands	14,318	3%	14,318	0%
Forest	252,838	52%	252,838	0%
Total	488,933	100%	452,408	7%

Table H. 140. Required annual reductions in direct nonpoint sources in sub-watershed TRE-29.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	197	<1%	108	45%
Wildlife in Streams	66,587	100%	9,988	85%
Total	66,784	100%	10,096	85%

Table H. 141. Required annual reductions in nonpoint sources in sub-watershed TRE-30.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	18,313	6%	4,578	75%
Pasture	4,877	2%	1,219	75%
Residential	152,078	54%	19,757	87%
Wetlands	1,128	0%	1,128	0%
Forest	107,432	38%	107,432	0%
Total	283,828	100%	134,114	53%

Table H. 142. Required annual reductions in direct nonpoint sources in sub-watershed TRE-30.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	148	1%	67	55%
Wildlife in Streams	15,557	99%	7,779	50%
Total	15,705	100%	7,846	50%

Table H. 143. Required annual reductions in nonpoint sources in sub-watershed TRE-31.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	47,421	1%	11,855	75%
Pasture	8,698,445	96%	2,174,611	75%
Residential	49,429	1%	7,792	84%
Wetlands	3,150	0%	3,150	0%
Forest	255,339	3%	255,339	0%
Total	9,053,783	100%	2,452,747	73%

Table H. 144. Required annual reductions in direct nonpoint sources in sub-watershed TRE-31.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	247	<1%	111	55%
Wildlife in Streams	51,636	100%	25,818	50%
Total	51,883	100%	25,929	50%

Table H. 145. Required annual reductions in nonpoint sources in sub-watershed TRE-32.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	18,474	5%	4,618	75%
Pasture	28,912	7%	7,228	75%
Residential	94,206	24%	14,420	85%
Wetlands	1,273	0%	1,273	0%
Forest	250,117	64%	250,117	0%
Total	392,981	100%	277,656	29%

Table H. 146. Required annual reductions in direct nonpoint sources in sub-watershed TRE-32.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	296	1%	133	55%
Wildlife in Streams	39,029	99%	19,515	50%
Total	39,325	100%	19,648	50%

Table H. 147. Required annual reductions in nonpoint sources in sub-watershed TRE-33.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	35,796	1%	8,949	75%
Pasture	2,262,770	82%	565,693	75%
Residential	110,530	4%	18,501	83%
Wetlands	2,563	0%	2,563	0%
Forest	334,704	12%	334,704	0%
Total	2,746,362	100%	930,409	66%

Table H. 148. Required annual reductions in direct nonpoint sources in sub-watershed TRE-33.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cattle in Streams	13,170	17%	3,293	75%
Hunt Club Washoff	329	1%	148	55%
Wildlife in Streams	63,585	82%	31,793	50%
Total	77,084	100%	35,234	54%

Table H. 149. Required annual reductions in nonpoint sources in sub-watershed TRE-34.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	26,356	4%	6,589	75%
Pasture	38,890	6%	9,722	75%
Residential	112,591	19%	19,009	83%
Wetlands	1,316	0%	1,316	0%
Forest	428,792	71%	428,792	0%
Total	607,945	100%	465,428	23%

Table H. 150. Required annual reductions in direct nonpoint sources in sub-watershed TRE-34.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	460	1%	207	55%
Wildlife in Streams	70,881	99%	35,441	50%
Total	71,341	100%	35,648	50%

Table H. 151. Required annual reductions in nonpoint sources in sub-watershed TRE-35.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	22,047	1%	5,512	75%
Pasture	3,303,163	85%	825,791	75%
Residential	152,611	4%	33,402	78%
Wetlands	1,693	0%	1,693	0%
Forest	416,917	11%	416,917	0%
Total	3,896,431	100%	1,283,314	67%

Table H. 152. Required annual reductions in direct nonpoint sources in sub-watershed TRE-35.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	756	1%	340	55%
Wildlife in Streams	64,026	99%	32,013	50%
Total	64,782	100%	32,353	50%

Table H. 153. Required annual reductions in nonpoint sources in sub-watershed TRE-36.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	4,287	1%	1,072	75%
Pasture	21,375	5%	5,344	75%
Residential	10,683	2%	2,671	75%
Wetlands	2,813	1%	2,813	0%
Forest	435,236	92%	435,236	0%
Total	474,393	100%	447,135	6%

Table H. 154. Required annual reductions in direct nonpoint sources in sub-watershed TRE-36.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	526	1%	237	55%
Wildlife in Streams	63,841	99%	31,921	50%
Total	64,367	100%	32,158	50%

Table H. 155. Required annual reductions in nonpoint sources in sub-watershed TRE-37.

Land Use	Baseline future conditions load (x 10^8 cfu/year)	Percent of total load from nonpoint sources	TMDL nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Cropland	27,325	0%	6,831	75%
Pasture	6,567,832	92%	1,641,958	75%
Residential	184,063	3%	36,609	80%
Wetlands	711	0%	711	0%
Forest	386,664	5%	386,664	0%
Total	7,166,595	100%	2,072,773	71%

Table H. 156. Required annual reductions in direct nonpoint sources in sub-watershed TRE-37.

Source	Baseline future Conditions load (x 10^8 cfu/year)	Percent of total load to stream from direct nonpoint sources	TMDL direct nonpoint source allocation load (x 10^8 cfu/year)	Percent Reduction
Hunt Club Washoff	723	1%	325	55%
Wildlife in Streams	64,458	99%	32,229	50%
Total	65,181	100%	32,554	50%