TOTAL MAXIMUM DAILY LOAD (TMDL)

for

Pathogens

in the

South Fork Holston River Watershed (HUC 06010102)

Sullivan County, Tennessee

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TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

¾ ¾

LIST OF TABLES

LIST OF ABBREVIATIONS

ADB	Assessment Database
AFO	Animal Feeding Operation
BMP	Best Management Practices
BST	Bacteria Source Tracking
CAFO	Concentrated Animal Feeding Operation
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
DEM	Digital Elevation Model
DMR	Discharge Monitoring Report
DWPC	Division of Water Pollution Control
EPA	Environmental Protection Agency
FCLES	Fecal Coliform Load Estimation Spreadsheet
GIS	Geographic Information System
HSPF	Hydrological Simulation Program - Fortran
HUC	Hydrologic Unit Code
IPSI	Integrated Pollutant Source Identification
LA	Load Allocation
LSPC	Loading Simulation Program in C^{++}
MGD	Million Gallons per Day
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
NMP	Nutrient Management Plan
NOV	Notice of Violation
NPS	Nonpoint Source
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PDFE	Percent of Days Flow Exceeded
Rf3	Reach File v.3
RILR	Required In-stream Load Reduction
RM	River Mile
SWMP	Storm Water Management Plan
TDA	Tennessee Department of Agriculture
TDEC	Tennessee Department of Environment & Conservation
TDOT	Tennessee Department of Transportation
TMDL	Total Maximum Daily Load
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
USGS	United States Geological Survey
VDOT	Virginia Department of Transportation
WCS	Watershed Characterization System
WLA	Waste Load Allocation
WWTF	Wastewater Treatment Facility

SUMMARY SHEET

Total Maximum Daily Load for Pathogens in South Fork Holston River Watershed (HUC 06010102)

Impaired Waterbody Information

State: Tennessee
County: Sullivan
Watershed: South Fork Holston River (HUC 06010102)
Constituents of Concern: Pathogens

Impaired Waterbodies:

	Waterbody ID	Waterbody	RM
2002 303(d) List	TN06010102042 – 1000 & 2000	BEAVER CREEK	21.6

Designated Uses:

The designated use classifications for the South Fork Holston River and its tributaries include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. Some waterbodies in the watershed are also classified for industrial water supply and domestic water supply.

Water Quality Goal:

Derived from *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, January, 2004* for recreation use classification (most stringent):

> The concentration of the E. coli group shall not exceed 126 colony forming units per 100 mL, as a geometric mean based on a minimum of 5 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. In addition, the concentration of the E. coli group in any individual sample taken from a lake, reservoir, State Scenic River, or Tier II or III stream (1200-4-3-.06) shall not exceed 487 colony forming units per 100 mL. The concentration of the E. coli group in any individual sample taken from any other waterbody shall not exceed 941 colony forming units per 100 mL.

Additionally, consistent with current TMDL methodology, standards from *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, October 1999* for recreation use classification:

> The concentration of a fecal coliform group shall not exceed 200 per 100 mL as a geometric mean based on a minimum of 10 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. In addition, the concentration of the fecal coliform group in any individual sample shall not exceed 1,000 per 100 mL.

TMDL Scope:

Waterbodies identified on the EPA-approved 2002 303(d) list as impaired due to pathogens. TMDLs are generally developed for impaired waterbodies on a HUC-12 basis.

Analysis/Methodology:

The TMDL for Beaver Creek in the South Fork Holston River watershed was developed using two different methodologies to assure compliance with the E. Coli 941 counts/100 mL maximum standard and the fecal coliform 200 counts/100 mL geometric mean and 1,000 counts/100 mL maximum standards.

<u>Dynamic Loading Model Method</u>
In order to demonstrate compliance with the 200 counts/100 mL geometric mean standard, the Loading Simulation Program C++ (LSPC) was used to simulate the buildup and washoff of fecal coliform bacteria from land surfaces, loading from point sources, and compute the resulting water quality response. From model output, instream 30-day geometric mean concentrations were computed, critical conditions identified, existing loads determined, and reductions required to meet the target concentrations (standard - MOS) calculated for impaired subwatersheds.

<u>Load Duration Curve Method</u>
A duration curve is a cumulative frequency graph that represents the percentage of time during which the value of a given parameter is equaled or exceeded. Load duration curves are developed from flow duration curves and can illustrate existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired targets, and the portion of the waterbody flow regime represented by these existing loads. Load duration curves were used to determine the load reductions required to meet the target maximum concentrations for fecal coliform and E. coli (standard - MOS).

The required load reductions that were determined using each method were compared and the largest load reduction specified as the TMDL for impaired subwatersheds.

Critical Conditions:

An LSPC model simulation period of 10 years and water quality data collected quarterly over a period of 10 years for load duration curve analysis were used to assess the water quality standards representing a range of hydrologic and meteorological conditions.

Seasonal Variation:

The 10-year period used for LSPC model simulation period and for load duration curve analysis included all seasons and a full range of flow and meteorological conditions.

Margin of Safety (MOS):

Implicit – Conservative modeling assumptions.
Explicit – 10% of the water quality standard for each impaired subwatershed.

TMDLs, WLAs, & LAs

Summary of TMDLs, WLAs, & LAs for Impaired Waterbodies

Impaired Waterbody	HUC-12 Subwatershed (06010102____)	TMDL	WLAs						LAs	
			WWTFs[a] (Monthly Avg.)		Leaking Collection Systems[b]	CAFOs	MS4s[c]		Precipitation Induced Nonpoint Sources	Other Direct Sources[d]
			Fecal Coliform	E. Coli						
		[% Red.]	[cts./day]	[cts./day]	[cts./day]	[cts./day]	[% Red.]		[% Red.]	[cts./day]
Lower Beaver Creek (at the Mouth)	0502	66.5	1.136×10^{8}	7.157×10^{7}	0	NA	66.5		66.5	0

Note: NA = Not applicable.

a. WLAs for WWTFs expressed as fecal coliform and E. coli loads (counts/day).

b. The objective for leaking collection systems is a waste load allocation of zero. It is recognized, however, that a WLA of 0 counts/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in coliform loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for pathogens.

c. Applies to any MS4 discharge loading in the HUC-12 subwatershed.

d. The objective for all "other direct sources" is a load allocation of zero. It is recognized, however, that for leaking septic systems a LA of 0 counts/day may not be practical. For these sources, the LA is interpreted to mean a reduction in coliform loading by the application of best management practices, consistent with the requirement that these sources not contribute to a violation of the water quality standard for pathogens.

PATHOGEN TOTAL MAXIMUM DAILY LOAD (TMDL)
SOUTH FORK HOLSTON RIVER WATERSHED (HUC 06010102)

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those waterbodies that are not attaining water quality standards. State water quality standards consist of designated uses for individual waterbodies, appropriate numeric and narrative water quality criteria protective of the designated uses, and an antidegradation statement. The TMDL process establishes the maximum allowable loadings of pollutants for a waterbody that will allow the waterbody to maintain water quality standards. The TMDL may then be used to develop controls for reducing pollution from both point and nonpoint sources in order to restore and maintain the quality of water resources (USEPA, 1991).

2.0 SCOPE OF DOCUMENT

This document presents details of TMDL development for the Tennessee portion of Beaver Creek, located in the South Fork Holston River Watershed and identified on the 2002 303(d) list as not supporting designated uses due to pathogens.

3.0 WATERSHED DESCRIPTION

The South Fork Holston River watershed (HUC 06010102) is located in Northeast Tennessee and Southwest Virginia (Figure 1). The watershed lies within the Level III Ridge and Valley (67) and Blue Ridge Mountains (66) ecoregions. The Beaver Creek watershed lies in the Level IV Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f) and Southern Dissected Ridges and Knobs (67i) ecoregions as shown in Figure 2 (USEPA, 1997):

- The Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f) is a heterogeneous ecoregion composed predominately of limestone and dolomite as well as other rock formations and strata with varying characteristics. Landforms include undulating valleys and low rolling hills and ridges. The soils are variable in productivity, and landcover ranges from areas of intensive agriculture to other areas of thick forest. Most of the Ridge and Valley's urban areas are located in 67f.

- The Southern Dissected Ridges and Knobs (67i). The ridges of this ecoregion are primarily those with abundant shale that have a predominant topographic expression. They are lower and more dissected than the ridges of the Southern Sandstone Ridges (67h) ecoregion to the north and west. In states to the north of Tennessee, streams of this ecoregion tend to be less acidic than on the sandstone ridges (67h), and have storm hydrographs with higher peaks.

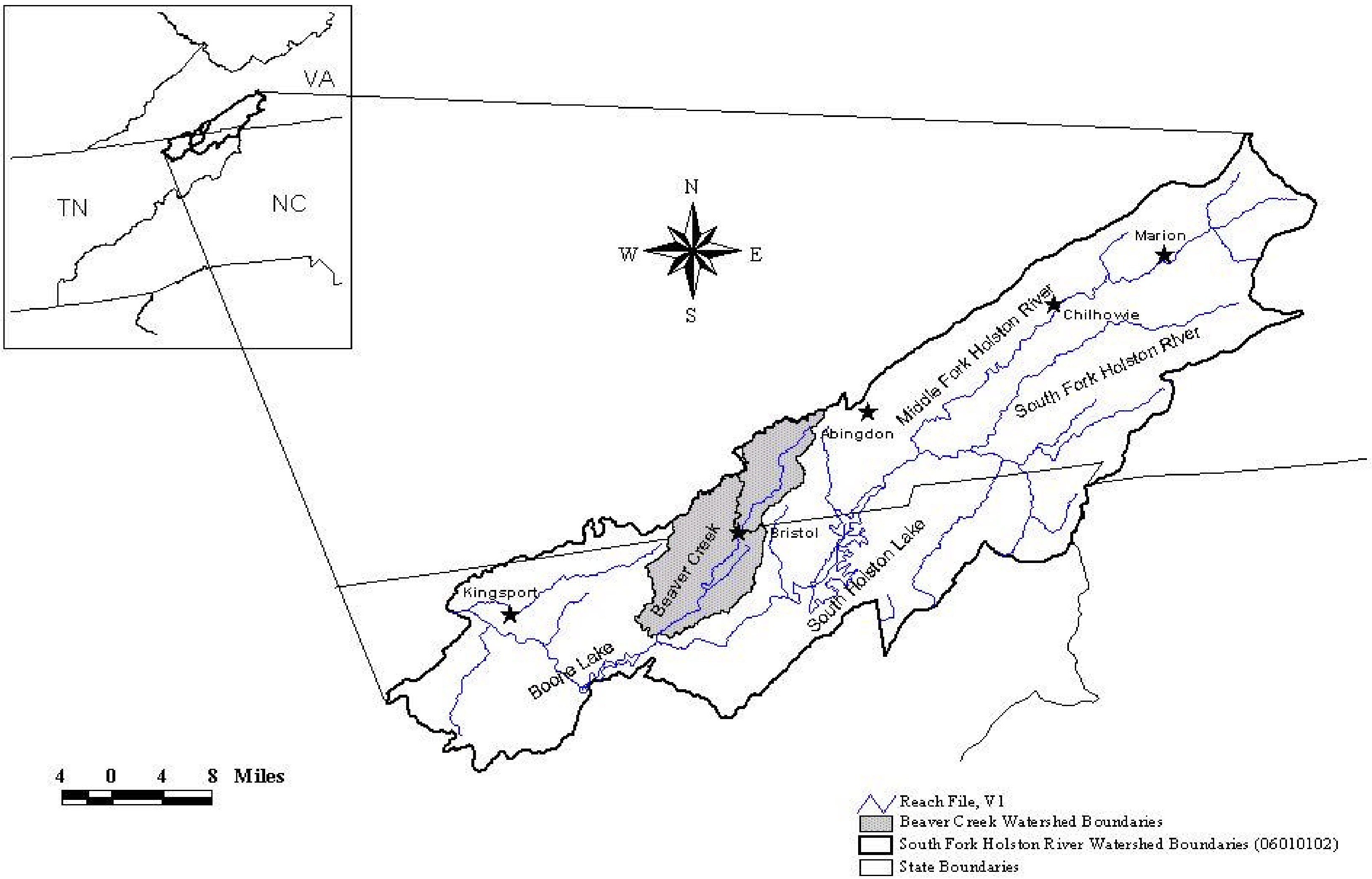

Figure 1. Location of the South Fork Holston and Beaver Creek watersheds.

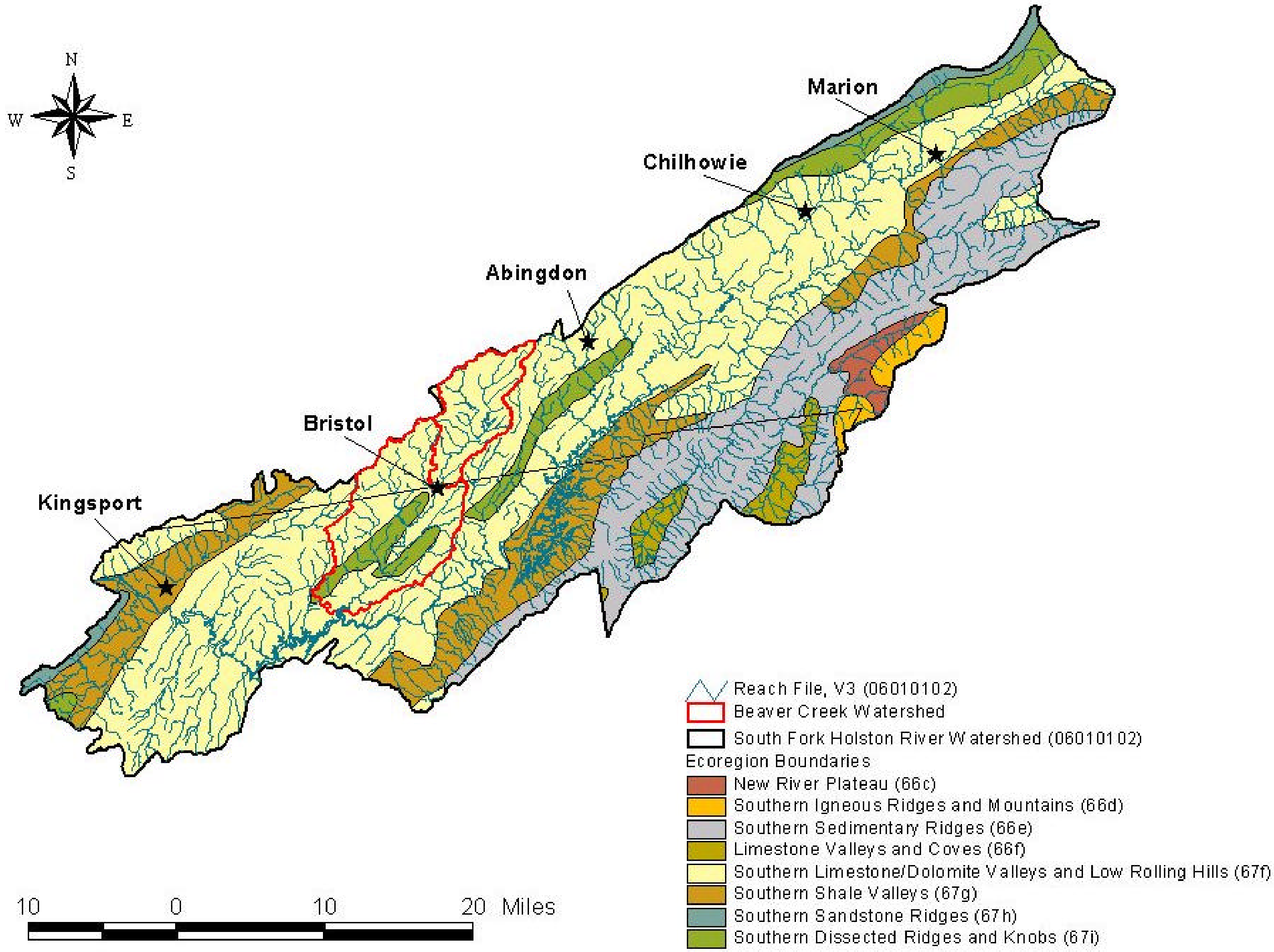

Figure 2. Level IV Ecoregions in the South Fork Holston River and Beaver Creek Watersheds.

The Beaver Creek watershed, located in Sullivan County, Tennessee and Washington County, Virginia, has a drainage area of approximately 109.3 square miles (mi^2) and enters the South Fork Holston River at approximately mile 29.5 (Figure 1). Approximately 52.4% (57.3 mi^2) of the Beaver Creek watershed lies in Tennessee, with the remainder (47.6% or 52.0 mi^2) in Virginia. Watershed land use distribution is based on the Tennessee Valley Authority (TVA) Integrated Pollutant Source Identification (IPSI) data collected in April 1994. Land use is summarized in Table 1 and shown in Figure 3. Predominate land use in the Beaver Creek watershed, according to TVA IPSI data, is agriculture (37.6%) followed by forest (35.5%). Urban areas represent approximately 27.0% of the total drainage area of the watershed.

Table 1. IPSI Land Use Distribution – Beaver Creek Watershed

Land Use	Upper Beaver Creek Subwatershed[1]		Lower Beaver Creek Subwatershed[2]		Total Beaver Creek Watershed	
	Area (ac)	[%]	Area (ac)	[%]	Area (ac)	[%]
Urban Pervious	3,517	14. 9	8,515	18.4	12,033	17.2
Urban Impervious	2,108	8.9	4,728	10.2	6,836	9.8
Forest	6,340	26.9	18,481	39.9	24,821	35.5
Pasture	11,452	48.5	13,637	29.4	25,089	35.9
Cropland	200	0.9	983	2.1	1,182	1.7
Total (mi^2)	**23,617 (36.9)**	**100**	**46,344 (72.4)**	**100**	**69,961 (109.3)**	**100**

[1] Beaver Creek at the State Line (mile 15.3).
[2] Beaver Creek at the Mouth (mile 0.1). Note: the Lower Beaver Creek subwatershed includes area north of the state line, in Virginia (see Figures 1 and 2).

4.0 PROBLEM DEFINITION

The State of Tennessee's final 2002 303(d) list (TDEC, 2004) was approved by the U.S. Environmental Protection Agency (EPA), Region IV in January of 2004. The list identified Beaver Creek in the South Fork Holston River watershed as not fully supporting designated use classifications due, in part, to pathogens (see Table 2). The designated use classifications for Beaver Creek and its tributaries include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. Beaver Creek is also classified for industrial water supply from mile 9.1 to the state line.

When used in the context of waterbody assessments, the term pathogens is defined as disease-causing organisms such as bacteria or viruses that can pose an immediate and serious health threat if ingested or introduced into the body. The primary sources for pathogens are untreated or inadequately treated human or animal fecal matter. The fecal coliform and E. coli groups are indicators of the presence of pathogens in a stream.

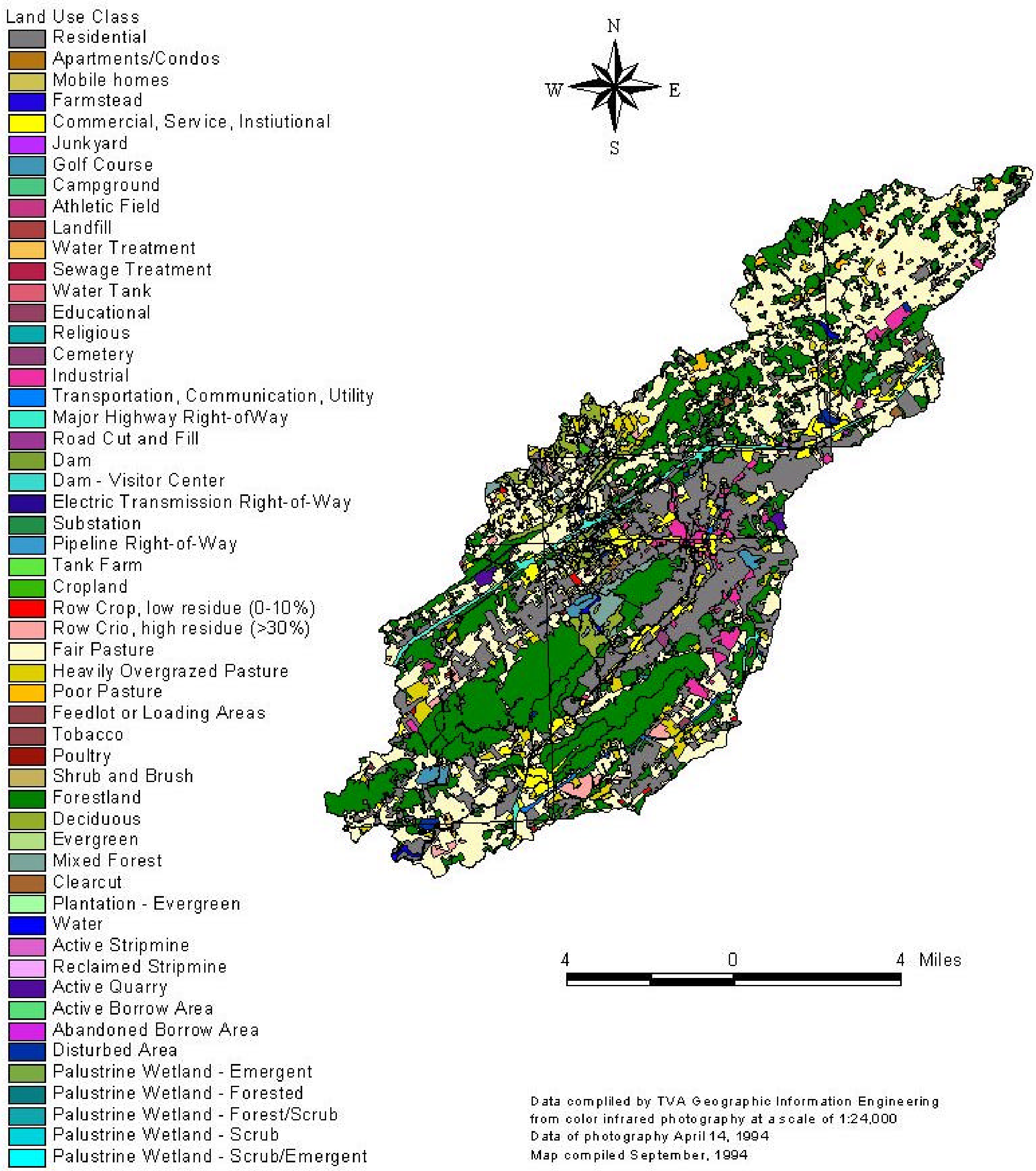

Figure 3. IPSI Land Use Characteristics of the Beaver Creek Watershed.

A description of the stream assessment process in Tennessee can be found in *2002 305(b) Report, The Status of Water Quality in Tennessee* (TDEC, 2002a). The waterbody segment listed in Table 2 was assessed as impaired based on sampling data and/or biological surveys. The results of these assessment surveys are summarized in Table 3 and shown in Figure 4. The assessment information presented is excerpted from the EPA/TDEC Assessment Database (ADB) and is referenced to the waterbody ID in Table 2. ADB information may be accessed at:

http://gwidc.memphis.edu/website/wpc_arcmap

5.0 WATER QUALITY GOAL

As previously stated, the designated use classifications for Beaver Creek and its tributaries include fish & aquatic life, recreation, irrigation, livestock watering & wildlife, and industrial water supply. Of the use classifications with numeric criteria for pathogens, the recreation use classification is the most stringent and will be used to establish target levels for TMDL development. The coliform water quality criteria, for protection of the recreation use classification, is established by *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, January 2004* (TDEC, 2004b). Section 1200-4-3-.03 (4) (f) states:

> The concentration of the E. coli group shall not exceed 126 colony forming units per 100 mL, as a geometric mean based on a minimum of 5 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purposes of determining the geometric mean, individual samples having an E. coli concentration of less than 1 per 100 mL shall be considered as having a concentration of 1 per 100 mL.
>
> Additionally, the concentration of the E. coli group in any individual sample taken from a lake, reservoir, State Scenic River, or Tier II or III stream (1200-4-3-.06) shall not exceed 487 colony forming units per 100 mL. The concentration of the E. coli group in any individual sample taken from any other waterbody shall not exceed 941 colony forming units per 100 mL.

Prior to January 2004, the coliform water quality criteria, for protection of the recreation use classification, established by *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, October 1999* (TDEC, 1999), Section 1200-4-3-.03 (4) (f) stated:

> The concentration of a fecal coliform group shall not exceed 200 per 100 mL, nor shall the concentration of the *E. coli* group exceed 126 per 100 mL, as a geometric mean based on a minimum of 10 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purposes of determining the geometric mean, individual samples having a fecal coliform group or *E. coli* concentration of less than 1 per 100 mL shall be considered as having a concentration of 1 per 100 mL. In addition, the concentration of the fecal coliform group in any individual sample shall not exceed 1,000 per 100 mL.

Table 2. 2002 303(d) List entries for Waterbodies Impaired due to Pathogens - South Fork Holston River Watershed

Waterbody ID	Impacted Waterbody	RM Partially Supporting	RM Not Supporting	CAUSE (Pollutant)	Pollutant Source
TN06010102042 – 1000 & 2000	BEAVER CREEK		21.6	Pathogens Nutrients	Pasture Grazing Urban runoff/storm sewers Source in Other State

Table 3. Water Quality Assessment of Waterbodies Impaired due to Pathogens - South Fork Holston River Watershed

Waterbody ID	Segment Name	Cause	Sources	Comments
TN06010102042 – 1000 & 2000	BEAVER CREEK	Pathogens Nutrients	Agriculture Grazing related Sources Pasture grazing Urban Runoff/Storm Sewers Sources outside State Jurisdiction	Beaver Creek from South Fork Holston to Virginia Stateline

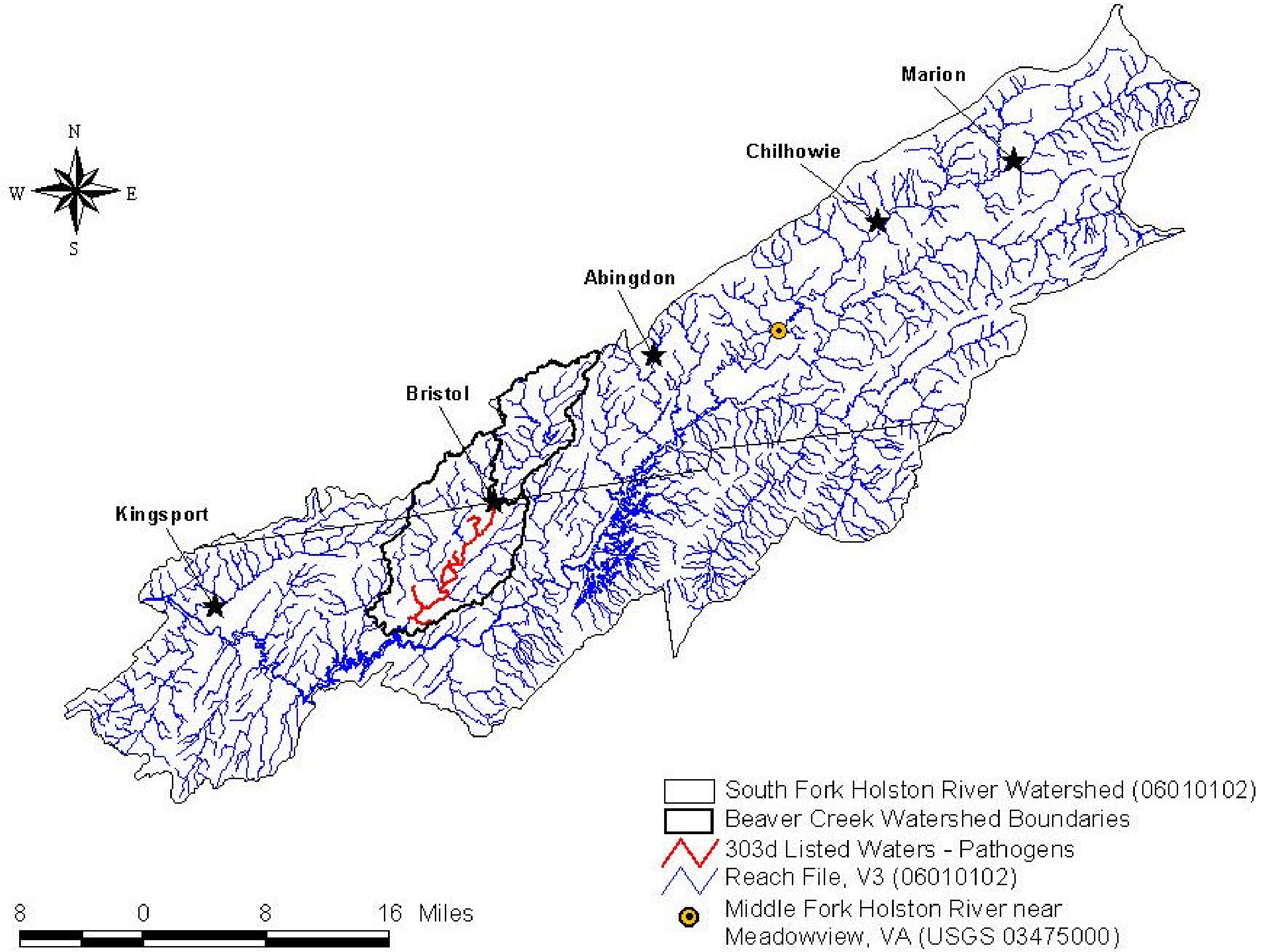

Figure 4. Waterbodies on the 2002 303(d) List - Pathogens.

For consistency with current TMDL methodology, since the dynamic loading model method is only applicable to fecal coliform, and to comply with current water quality standards for pathogens, the primary instream goals selected for TMDL development are threefold: 1) the geometric mean standard for fecal coliform of 200 counts/100 mL, 2) the fecal coliform sample maximum of 1,000 counts/100 mL, and 3) the E. coli sample maximum of 941 counts/100 mL. The most protective (or highest percent of load reduction) of the three methodologies will determine the percent reduction(s) required for impaired waterbodies.

Note: In this document, the water quality standards are the instream goals. The term "target concentration" reflects the application of an explicit Margin of Safety (MOS) to the water quality standard. See Section 8.4 for an explanation of MOS.

6.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM GOAL

There are two primary water quality monitoring stations that provide data for the Beaver Creek watershed:

- BEAVE001.0SU – Beaver Creek, 0.1 mile upstream from South Fork Holston River/Boone Lake.
- BEAVE015.3SU – Beaver Creek near the state line (mile 15.3).

The location of these monitoring stations is shown in Figure 5. Water quality monitoring results for these stations are tabulated in Appendix A and summarized in Table 4. Examination of these data shows multiple violations of the 1,000 counts/100 mL maximum fecal coliform standard and the 941 counts/100 mL maximum E. coli standard at both monitoring stations. There was not enough data to determine compliance with the geometric mean standard for fecal coliform.

Table 4. Summary of Water Quality Monitoring Data

Monitoring Station	Fecal Coliform					E. Coli				
	Data Pts.	[Counts/100 mL]			No. Viol. WQ Std.	Data Pts.	[Counts/100 mL]			No. Viol. WQ Std.
		Min.	Avg.	Max.			Min.	Avg.	Max.	
BEAVE015.3SU	57	154	4813	65,000	47	26	200	3742	30,760	19
BEAVE001.0SU	54	20	2097	26,000	16	26	5	640	2430	8

7.0 SOURCE ASSESSMENT

An important part of TMDL analysis is the identification of individual sources, or source categories of pollutants in the watershed that affect pathogen loading and the amount of loading contributed by each of these sources.

Under the Clean Water Act, sources are classified as either point or nonpoint sources. Under 40 CFR §122.2, a point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. The National Pollutant Discharge Elimination System (NPDES) program regulates point source discharges. Point sources can be described by three broad categories: 1) NPDES regulated municipal and industrial wastewater treatment facilities

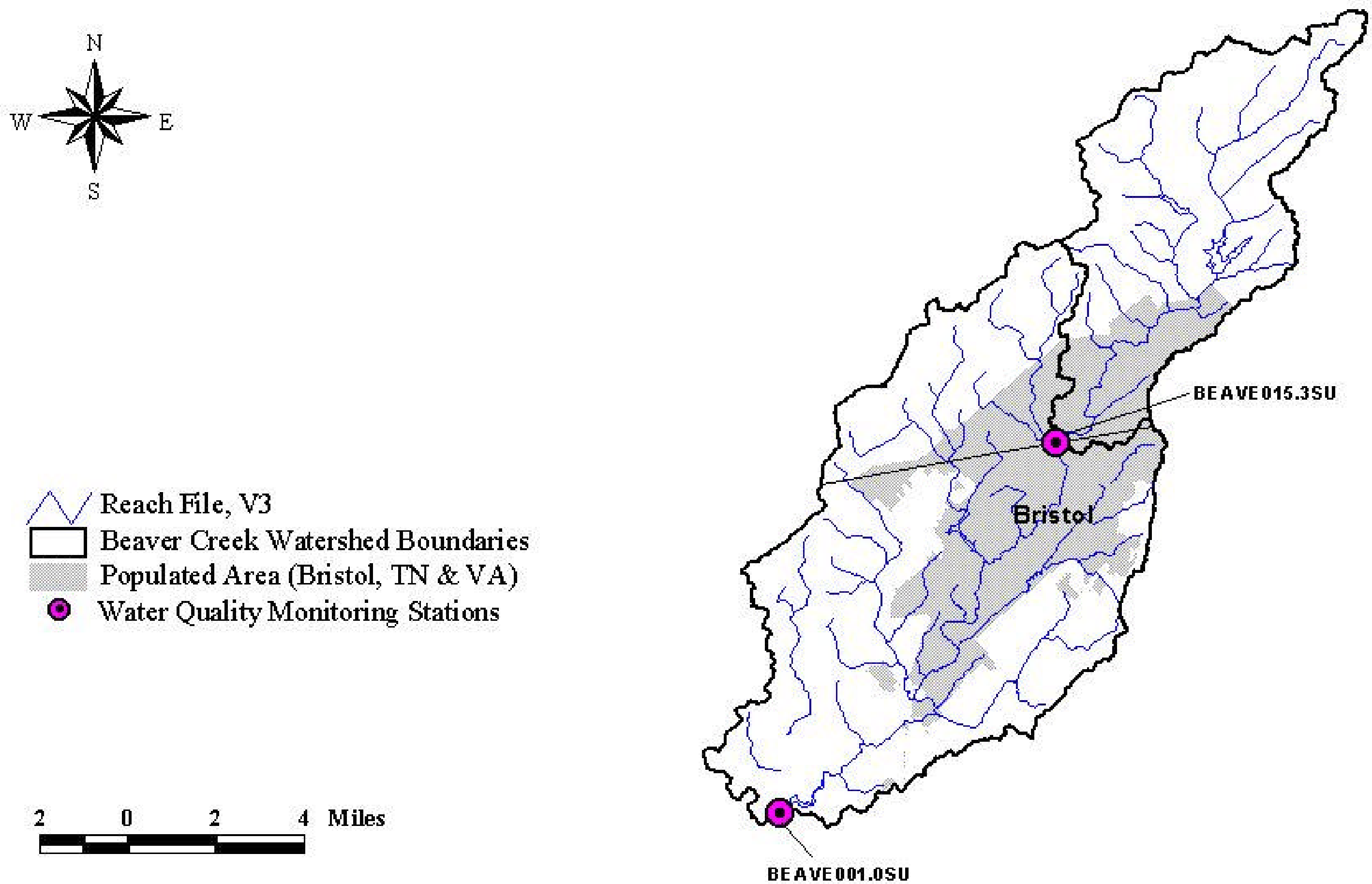

Figure 5. Selected Water Quality Monitoring Stations in the Beaver Creek Watershed.

(WWTFs); 2) NPDES regulated industrial and municipal storm water discharges; and 3) NPDES regulated Concentrated Animal Feeding Operations (CAFOs). A TMDL must provide Waste Load Allocations (WLAs) for all NPDES regulated point sources. Nonpoint sources are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. For the purposes of this TMDL, all sources of pollutant loading not regulated by NPDES permits are considered nonpoint sources. The TMDL must provide a Load Allocation (LA) for these sources.

7.1 Point Sources

7.1.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

Both treated and untreated sanitary wastewater contain coliform bacteria. There are eight (8) NPDES permitted WWTFs that are authorized to discharge treated sanitary wastewater in the Beaver Creek watershed. These facilities are tabulated in Table 5 and their locations are shown in Figure 6. The fecal coliform and E. coli permit limits for discharges from these WWTFs are in accordance with the criteria specified in the 1999 and 2004 State of Tennessee water quality standards (TDEC, 1999 and TDEC, 2004b, respectively) (ref.: Section 5.0) and/or equivalent water quality standards for the State of Virginia.

The Bristol Sewage Treatment Plant (STP) #2 (TN0023531) is located in the Tennessee portion of the Beaver Creek watershed and serves both Bristol, Virginia and Bristol, Tennessee municipalities. The STP outfall discharges to Boone reservoir, downstream from the mouth of Beaver Creek, and hence is not depicted in Figure 6. However, the sanitary sewage collection system, with documented long-term wet-weather overflow problems, has historically been a significant source of coliform loading to the Beaver Creek watershed during these overflow events.

7.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

Municipal Separate Storm Sewer Systems (MS4s) are considered to be point sources of pathogens. Discharges from MS4s occur in response to storm events through road drainage systems, curb and gutter systems, ditches, and storm drains. Large and medium MS4s serving populations greater than 100,000 people are required to obtain NPDES storm water permits. At present, there are no MS4s of this size in the South Fork Holston River watershed. As of March 2003, small MS4s serving urbanized areas, or having the potential to exceed instream water quality standards, are required to obtain a permit under the *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2002b). An urbanized area is defined as an entity with a residential population of at least 50,000 people and an overall population density of at least 1,000 people per square mile. Bristol, TN; Sullivan County, TN; and Bristol, VA are covered under Phase II of the NPDES Storm Water Program. The Tennessee Department of Transportation (TDOT) and Virginia Department of Transportation (VDOT) are also being issued MS4 permits for State roads in urban areas. Information regarding storm water permitting in Tennessee may be obtained from the TDEC website at http://www.state.tn.us/environment/wpc/stormh2o/.

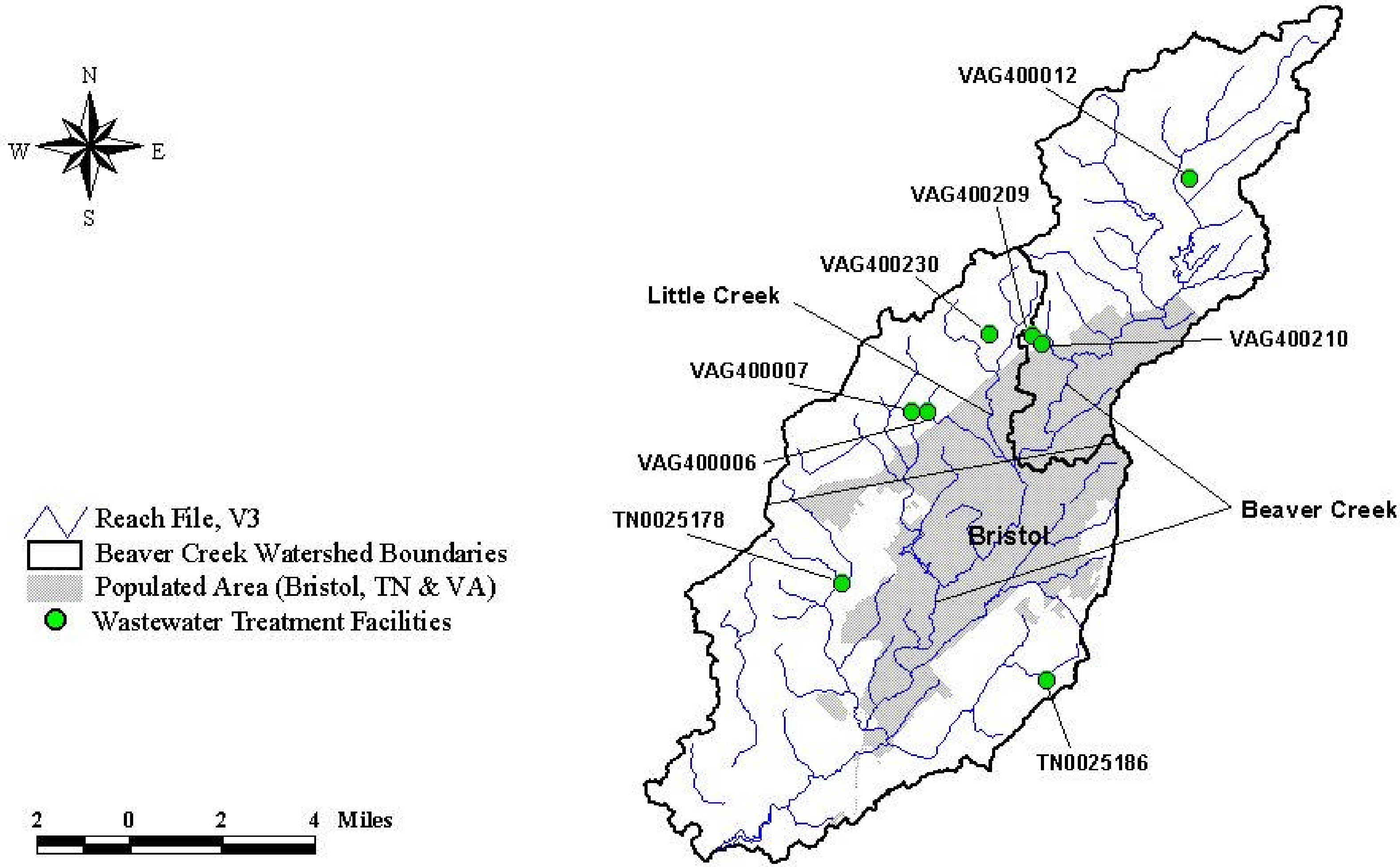

Figure 6. NPDES Permitted Wastewater Treatment Facilities.

Table 5. WWTFs Permitted to Discharge Treated Sanitary Wastewater in the Beaver Creek Watershed

NPDES Permit No.	Facility	Design Flow [MGD]	Receiving Stream
TN0025178	Akard Elementary School	0.006	Unnamed tributary to Back Creek
TN0025186	Weaver Elementary School	0.003	Unnamed tributary to Whitetop Creek
VAG400006	Harrell Duplex II STP	0.001	Susong Branch
VAG400007	Harrell Duplex I STP	0.001	Susong Branch
VAG400012	Rollins Residence	0.001	Unnamed Tributary to Beaver Creek
VAG400209	Long Residence STP	0.001	Unnamed Tributary to Beaver Creek
VAG400210	Willow Creek Residence STP	0.001	Unnamed Tributary to Beaver Creek
VAG400230	Siloh Free Will Baptist Church	0.001	Mumpower Creek

7.1.3 NPDES Concentrated Animal Feeding Operations (CAFOs)

Animal feeding operations (AFOs) are agricultural enterprises where animals are kept and raised in confined situations. AFOs congregate animals, feed, manure and urine, dead animals, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures, fields, or on rangeland (USEPA, 2002). Concentrated Animal Feeding Operations (CAFOs) are AFOs that meet certain criteria with respect to animal type, number of animals, and type of manure management system. CAFOs are considered to be potential point sources of pathogen loading and are required to obtain an NPDES permit. Most CAFOs in Tennessee obtain coverage under TNA000000, *Class II Concentrated Animal Feeding Operation General Permit*, while larger, Class I CAFOs are required to obtain an individual NPDES permit. Requirements of both the general and individual CAFO permits include:

- Development of a Nutrient Management Plan (NMP), and approval of the NMP by the Tennessee Department of Agriculture (TDA).

- Liquid waste handling systems, if utilized, shall be designed, constructed, and operated to contain all process generated waste waters plus the runoff from a 25-year, 24-hour rainfall event. A discharge from a liquid waste handling facility to waters of the state during a chronic or catastrophic rainfall event, or as a result of an unpermitted discharge, upset, or bypass of the system, shall not cause or contribute to an exceedance of Tennessee water quality standards.

- Other Best Management Practices (BMPs).

As of January 14, 2004, there were no Class I or Class II CAFOs in the Tennessee portion of the South Fork Holston River watershed with coverage under the general NPDES permit.

7.2 Nonpoint Sources

Nonpoint sources of coliform bacteria are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. These sources generally, but not always, involve accumulation of coliform bacteria on land surfaces and wash off as a result of storm events. Nonpoint sources of pathogen loading are primarily associated with agricultural and urban land uses. The vast majority of waterbodies identified on the approved 2002 303(d) list as impaired due to pathogens are attributed to nonpoint agricultural or urban sources.

7.2.1 Wildlife

Wildlife deposit coliform bacteria, with their feces, onto land surfaces where it can be transported during storm events to nearby streams. The overall deer density for Tennessee was estimated by the Tennessee Wildlife Resources Agency (TWRA) to be 23 animals per square mile. In order to account for higher density areas and loading due to other species, a conservative density of 45 animals per square mile was used for modeling purposes. Fecal coliform loads due to deer are estimated by EPA to be 5.0×10^8 counts/animal/day.

7.2.2 Agricultural Animals

Agricultural activities can be a significant source of coliform bacteria loading to surface waters. The activities of greatest concern are typically those associated with livestock operations:

- Agricultural livestock grazing in pastures deposit manure containing coliform bacteria onto land surfaces. This material accumulates during periods of dry weather and is available for washoff and transport to surface waters during storm events. The number of animals in pasture and the time spent grazing are important factors in determining the loading contribution.

- Processed agricultural manure from confined feeding operations is often applied to land surfaces and can provide a significant source of coliform bacteria loading. Guidance for issues relating to manure application is available through the University of Tennessee Agricultural Extension Service and the Natural Resources Conservation Service (NRCS).

- Agricultural livestock and other unconfined animals (i.e., deer and other wildlife) often have direct access to waterbodies and can provide a concentrated source of coliform bacteria loading directly to a stream.

Livestock data for the Beaver Creek watershed was compiled from the TVA IPSI and summarized in Table 6.

It can be seen from Table 6 that the Beaver Creek watershed contains a significant number of agricultural animals. The percentage of subwatershed land use area classified as agricultural is 49.3% and 31.5% for Upper Beaver Creek (VA) and Lower Beaver Creek (TN), respectively (see Table B-1 and Figures 7 & 8).

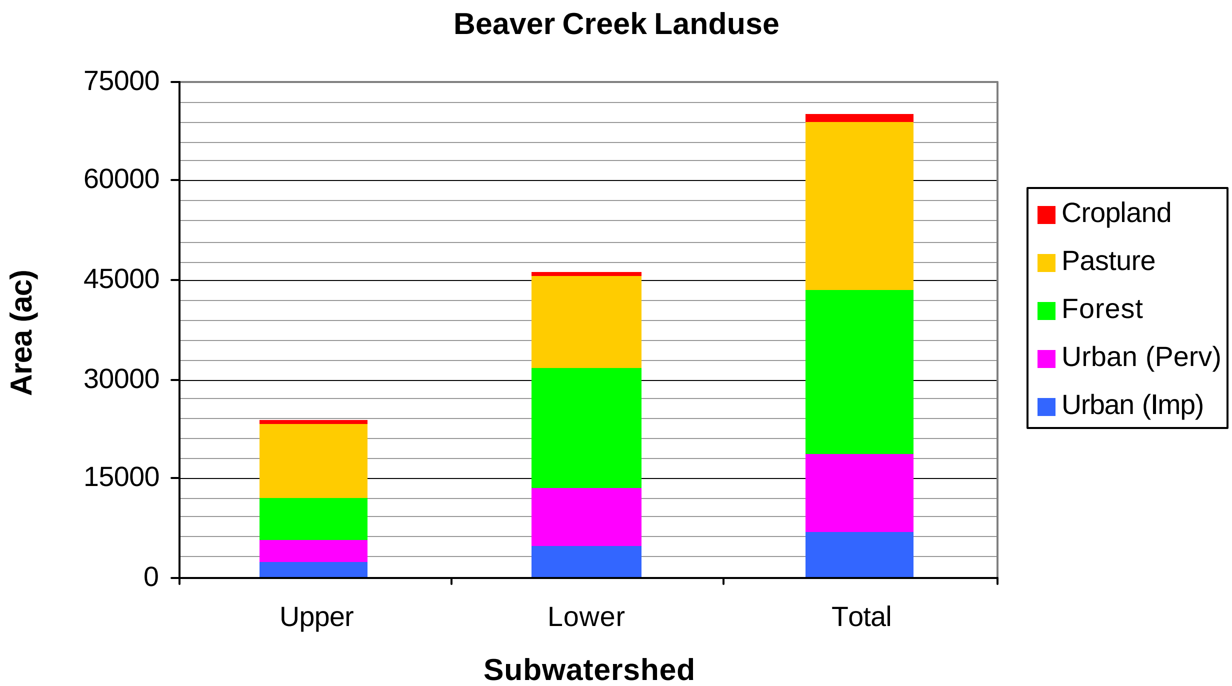

Figure 7. Land Use Area of Beaver Creek.

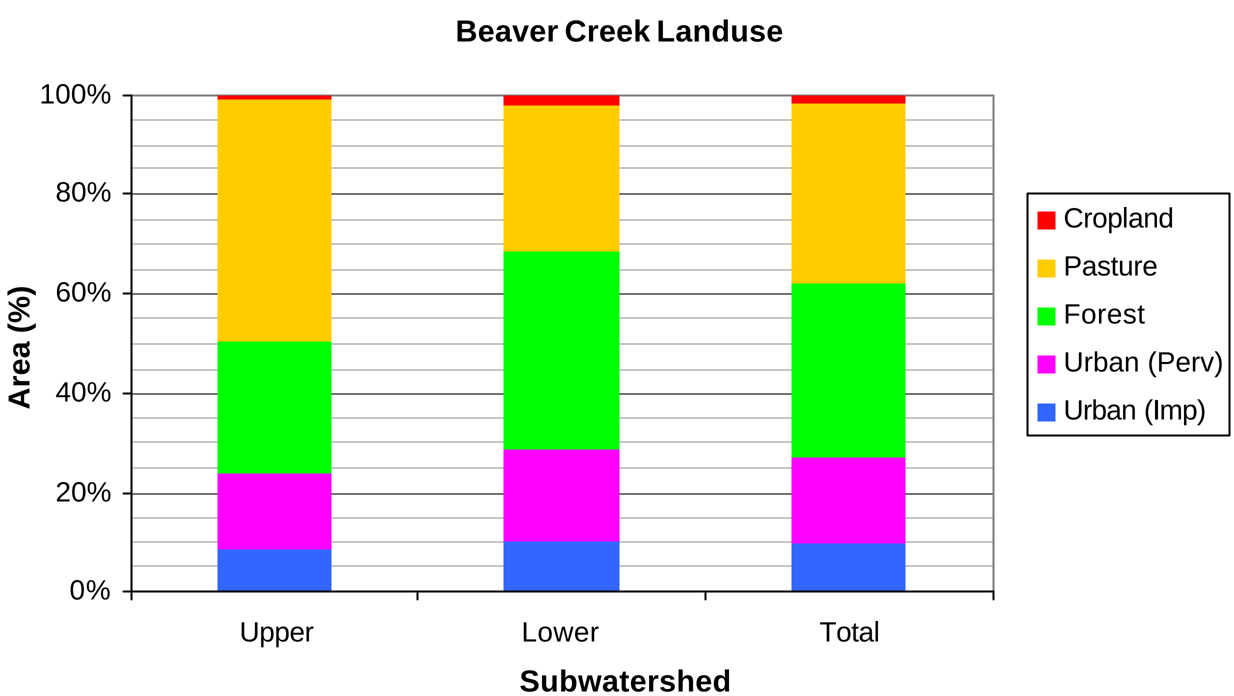

Figure 8. Land Use Percent of Beaver Creek.

Table 6. Livestock Distribution in the Beaver Creek Watershed

Subwatershed	Livestock Population (IPSI)				
	Beef Cow	Milk Cow	Horses	Poultry	Hogs
Beaver Creek Watershed	11615	2200	370	64,000	240

7.2.3 Failing Septic Systems

Some coliform loading in the Beaver Creek watershed can be attributed to failure of septic systems and illicit discharges of raw sewage. Estimates from 1997 county census data of people in the Beaver Creek watershed utilizing septic systems were compiled using the Watershed Characterization System (WCS) and are summarized in Table 7. WCS is an Arcview geographic information system (GIS) based program developed by USEPA Region IV to facilitate watershed characterization and TMDL development. In east Tennessee, it is estimated that there are approximately 2.37 people per household on septic systems, some of which can be reasonably assumed to be failing. As with livestock in streams, discharges of raw sewage provide a concentrated source of coliform bacteria directly to waterbodies.

Table 7. Population on Septic Systems in the Beaver Creek Watershed

Subwatershed	Population on Septic Systems
Beaver Creek Watershed	3816

7.2.4 Urban Development

Nonpoint source loading of coliform bacteria from urban land use areas is attributable to multiple sources. These include: stormwater runoff, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, leaking septic systems, and domestic animals. Impervious surfaces in urban areas allow runoff to be conveyed to streams quickly, without interaction with soils and groundwater. The Beaver Creek watershed has a high percentage of urban land area (see Table B-1 and Figures 7 & 8).

8.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOAD

The Total Maximum Daily Load (TMDL) process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), non-point source loads (Load Allocations), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$\text{TMDL} = \Sigma\ \text{WLAs} + \Sigma\ \text{LAs} + \text{MOS}$$

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time, toxicity, or <u>other appropriate measure</u>.

8.1 Scope of TMDL Development

This document describes pathogen TMDL, Waste Load Allocation (WLA), and Load Allocation (LA) development for waterbodies identified as impaired due to pathogens on the 2002 303(d) list. The drainage area of the Beaver Creek waterbody corresponds to two HUC-12 subwatershed drainage areas, Upper Beaver Creek in Virginia and Lower Beaver Creek, predominantly in Tennessee, at the desired location for water quality analysis. The Beaver Creek subwatersheds are shown in Figures 1, 2, 4, 5, and 6.

8.2 Critical Conditions

The critical condition for non-point source fecal coliform loading is an extended dry period followed by a rainfall runoff event. During the dry weather period, fecal coliform bacteria builds up on the land surface, and is washed off by rainfall. The critical condition for point source loading occurs during periods of low streamflow when dilution is minimized. Both conditions are represented in each TMDL analysis method.

8.2.1 Dynamic Loading Model Method

The ten-year period from October 1, 1991 to September 30, 2001 was used to simulate continuous 30-day geometric mean concentrations to compare to the target. This 10-year period contained a range of hydrologic conditions that included both low and high streamflows from which critical conditions were identified and used to derive the TMDL value.

The 30-day critical period is the period preceding the highest simulated violation of the geometric mean standard (USEPA, 1991). Meeting water quality standards during the critical period ensures that water quality standards can be achieved throughout the ten-year period. For Beaver Creek at the mouth, the highest violation of the 30-day geometric mean occurred during the 30-day period 8/13/92 – 9/11/92.

8.2.2 Load Duration Curve Method

Critical conditions are accounted for in the load duration curve analysis by using the entire period of simulated flow and water quality data available for Beaver Creek. Water quality data have been collected during all flow ranges. Based on the location of the majority of water quality exceedances on the load duration curves (between the 0% and 40% duration intervals), runoff during wet weather events is the probable dominant delivery mode for pathogens (see Section 9.3).

8.3 TMDL Analysis Methodology

Establishing the relationship between in-stream water quality and source loading is an important component of TMDL development. It allows the determination of the relative contribution of sources to total pollutant loading and the evaluation of potential changes to water quality resulting from implementation of various management options. This relationship can be developed using a variety of techniques ranging from qualitative assumptions based on scientific principles to numerical computer modeling. The TMDL for the Beaver Creek watershed was developed using two different methodologies to assure compliance with both the 200 counts/100 mL geometric mean standard and the dual maximum standards (ref.: Section 5.0) of 1,000 counts/100 mL for fecal coliform and 941 counts/100 mL for E. coli.

8.3.1 Dynamic Loading Model Method

In order to demonstrate compliance with the 200 counts/100 mL geometric mean standard, a dynamic loading model was chosen to: a) continuously simulate fecal coliform bacteria deposition on land surfaces and pollutant transport to receiving waters in response to storm events; b) incorporate seasonal effects on the production and fate of fecal coliform bacteria; and c) simulate continuous fecal coliform concentration in surface waters.

The Loading Simulation Program C++ (LSPC) is a dynamic watershed model based on the Hydrologic Simulation Program - Fortran (HSPF) and was selected for TMDL analysis of pathogen impaired waters in the Beaver Creek watershed. LSPC was used to simulate the deposition and transport of fecal coliform bacteria from land surfaces, incorporate point source loading, and compute the resulting water quality response. From model output, instream 30-day geometric mean concentrations were computed, critical conditions identified, existing loads determined, and reductions required to meet the target concentrations (standard - MOS) calculated. Details of model development, calibration and TMDL analysis are presented in Appendix C.

8.3.2 Load Duration Curve Method

A load duration curve is a cumulative frequency graph that illustrates existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired targets, and the portion of the waterbody flow regime represented by these existing loads. Load duration curves were considered to be well suited for analysis of periodic monitoring data collected by grab sample and determination of the load reductions required to meet the target maximum concentration (standard - MOS). Details of load duration curve development for Lower Beaver Creek are presented in Appendix D.

8.4 Margin of Safety

There are two methods for incorporating an MOS in the analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. In these TMDLs, both explicit and implicit MOS were utilized.

Dynamic Loading Model Analysis
An explicit MOS, equal to 10% of the geometric mean fecal coliform standard (200 counts/100 mL), was utilized for TMDL modeling analysis. Application of this explicit MOS of 20 counts/100 mL results in an effective 30-day geometric mean target concentration of 180 counts/100 mL.

Implicit MOS includes the use of conservative modeling assumptions and a 10-year continuous simulation that incorporates a range of meteorological events. Conservative modeling assumptions used include: septic systems discharging directly into the streams; development of the TMDL using loads based on the design flow and fecal coliform permit limits of NPDES facilities; and all land uses connected directly to streams.

Load Duration Curve Analysis
An explicit MOS, equal to 10% of the maximum coliform standard, was utilized for TMDL analysis. Application of the explicit MOS of 100 counts/100 mL to the fecal coliform maximum standard of 1000 counts/100 mL results in an effective maximum target concentration of 900 counts/100 mL. Application of the explicit MOS of 94 counts/100 mL to the E. coli maximum standard of 941 counts/100 mL results in an effective maximum target concentration of 847 counts/100 mL.

8.5 Expression of TMDL, WLAs, & LAs

In this document, the pathogen TMDL is expressed as the percent reduction in instream loading required to decrease: a) the existing 30-day geometric mean concentration of fecal coliform to the target of 180 counts/100 mL, b) the existing maximum concentration of fecal coliform to the target of 900 counts/100 mL, and c) the existing maximum concentration of E. coli to the target of 847 counts/100 mL. WLAs & LAs for precipitation-induced loading sources are also expressed as required percent reductions in pathogen loading. Allocations for loading that is independent of precipitation (WLAs for WWTFs, WLAs for CAFOs, and LAs for “other direct sources”) are expressed as counts per day.

8.5.1 Determination of TMDL

A load reduction for Lower Beaver Creek was developed using the Dynamic Loading Model to achieve compliance with the 30-day geometric mean target concentration (Appendix C). Load reductions were also developed using Load Duration Curves to achieve compliance with the dual maximum target concentrations (Appendix D). The instream load reductions determined by these two methodologies were compared and the largest required load reduction was selected as the TMDL. TMDL load reductions for Lower Beaver Creek are shown in Table 8.

8.5.2 Determination of WLAs & LAs

WLAs & LAs are developed in Appendix E for point sources and nonpoint sources respectively. TMDLs, WLAs, & LAs for Lower Beaver Creek are summarized in Table 9.

Table 8. Determination of TMDLs for Beaver Creek, Tennessee

Impaired Waterbody	HUC-12 Subwatershed (06010102____)	Required Load Reduction			
		Dynamic Loading Model [%] (Fecal Coliform)	Load Duration Curve [%]		TMDL [%]
			Fecal Coliform	E. Coli	
Lower Beaver Creek (at the Mouth)	**0502**	**66.5**	**64.8**	**39.1**	**66.5**

8.6 Seasonal Variation

Seasonal variation was incorporated in the continuous simulation water quality model by using varying monthly loading rates and daily meteorological data over a ten-year period. Seasonal variation was incorporated in the load duration curves by using the entire simulation period and all water quality data collected at the monitoring stations. The water quality data were collected during all seasons.

Table 9. WLAs & LAs for Beaver Creek, Tennessee

Impaired Waterbody	HUC-12 Subwatershed (06010102____)	WLAs					LAs	
		WWTFs [a] (Monthly Avg.)		Leaking Collection Systems[b]	CAFOs	MS4s[c]	Precipitation Induced Nonpoint Sources	Other Direct Sources[d]
		Fecal Coliform	E. Coli					
		[cts./day]	[cts./day]	[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
Beaver Creek at the Mouth (mile 0.1)	**0502**	**1.136×10^8**	**7.157×10^7**	**0**	**NA**	**66.5**	**66.5**	**0**

Note: NA = Not Applicable.

a. WLAs for WWTFs expressed as fecal coliform and E. coli loads (counts/day).

b. The objective for leaking collection systems is a waste load allocation of zero. It is recognized, however, that a WLA of 0 counts/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in coliform loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for pathogens.

c. Applies to any MS4 discharge loading in the subwatershed.

d. The objective for all "other direct sources" is a load allocation of zero. It is recognized, however, that for leaking septic systems a LA of 0 counts/day may not be practical. For these sources, the LA is interpreted to mean a reduction in coliform loading by the application of best management practices, consistent with the requirement that these sources not contribute to a violation of the water quality standard for pathogens.

9.0 IMPLEMENTATION PLAN

The TMDLs, WLAs, and LAs developed in Section 8 are intended to be the first phase of a long-term effort to restore the water quality of Lower Beaver Creek through reduction of excessive pathogen loading. Adaptive management methods, within the context of the State's rotating watershed management approach, will be used to modify TMDLs, WLAs, and LAs as required to meet water quality goals.

TMDLs, WLAs, & LAs for the Beaver Creek watershed are implemented only for the drainage area of the watershed located in the state of Tennessee. The state of Virginia is responsible for implementation in the impaired portion of the watershed located north of the state line. The state of Virginia has developed a bacteria TMDL for upper Beaver Creek and received approval from EPA Region III on 7/6/04. In addition, the state of Virginia has an approved fecal coliform TMDL for Little Creek, a tributary to Beaver Creek at mile 15.1, downstream from the state line (Figure 6). Through the implementation of these TMDLs, the State of Virginia will meet water quality standards at the state line. Watershed implementation plans are developed by the state of Virginia subsequent to TMDL development and approval by EPA. The Virginia Beaver Creek and Little Creek TMDLs will be implemented by BMPs through an iterative process, occurring in stages.

9.1 Point Sources

9.1.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

All present and future discharges from industrial and municipal wastewater treatment facilities are required to be in compliance with the conditions of their NPDES permits at all times. In Tennessee, permit limits for treated sanitary wastewater require compliance with coliform water quality standards (ref: Section 5.0) prior to discharge. No additional reduction is required. WLAs for WWTFs are expressed as average loads in counts per day. WLAs are derived from facility design flows and permitted fecal coliform and E. coli limits.

Eleven (11) Notices of Violation (NOVs) were issued against the Bristol STP #2 (TN0023531) by the State of Tennessee for 46 bypass/overflow events during the period December 1999 through September 2003. A total of 125 bypass/overflow events were reported by the Bristol STP #2 from May 1995 through September 2003. The collection system continues to be a source of wet weather overflows, presumably caused by excessive inflow and infiltration (I/I). In order to meet water quality criteria for Beaver Creek, the Bristol STP #2 must meet the provisions of its NPDES permit, including elimination of bypasses and overflows.

9.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

For regulated discharges from municipal separate storm sewer systems, WLAs will be implemented through Phase I & II MS4 permits. These permits will require the development and implementation of a Storm Water Management Program (SWMP) that will reduce the discharge of pollutants to the "maximum extent practicable" and not cause or contribute to violations of State water quality standards. The *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2002b) was issued on February 27, 2003 and requires SWMPs to include six minimum control measures:

- Public education and outreach on storm water impacts
- Public involvement/participation
- Illicit discharge detection and elimination

- Construction site storm water runoff control
- Post-construction storm water management in new development and re-development
- Pollution prevention/good housekeeping for municipal operations

For discharges into impaired waters, the proposed Small MS4 General Permit (ref: http://www.state.tn.us/environment/wpc/stormh2o/MS4II.php) requires that SWMPs include a section describing how discharges of pollutants of concern will be controlled to ensure that they do not cause or contribute to instream exceedances of water quality standards. Specific measures and BMPs to control pollutants of concern must also be identified. In addition, MS4s must implement the WLA provisions of an applicable TMDL and describe methods to evaluate whether storm water controls are adequate to meet the WLA.

Implementation of the coliform WLAs for MS4s in this TMDL document will require effluent or instream monitoring to evaluate SWMP effectiveness with respect to reduction of pathogen loading.

9.1.3 NPDES Regulated Concentrated Animal Feeding Operations (CAFOs)

Existing or future CAFOs that are located in impaired subwatersheds will be required to comply with WLAs consistent with their permits. These WLAs will be implemented through the Nutrient Management Plan (NMP), liquid waste handling system, and Best Management Practices (BMP) provisions of NPDES Permit No. TNA000000, *Class II Concentrated Animal Feeding Operation General Permit* or the individual NPDES permit for Class I CAFOs. All discharges, except during a catastrophic or chronic rainfall event, are not authorized by this permit. Any discharge shall not cause an exceedance of Tennessee water quality standards.

9.2 Nonpoint Sources

The Tennessee Department of Environment & Conservation (TDEC) has no direct regulatory authority over most nonpoint source discharges. Reductions of pathogen loading from nonpoint sources (NPS) will be achieved using a phased approach. Voluntary, incentive-based mechanisms will be used to implement NPS management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the targeted impaired waters. Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs. Local citizen-led and implemented management measures offer the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. For example, the Boone Watershed Partnership (BWP) was established in August 1995 by TVA. It includes agencies, citizens, local governments and others interested in working together to identify pollution problems and solutions within the Boone Reservoir watershed. There are links to a number of publications and information resources on EPA's Nonpoint Source Pollution web page (http://www.epa.gov/owow/nps/pubs.html) relating to the implementation and evaluation of nonpoint source pollution control measures.

TMDL implementation activities will be accomplished within the framework of Tennessee's Watershed Approach (ref: http://www.state.tn.us/environment/wpc/watershed/). The Watershed Approach is based on a five-year cycle and encompasses planning, monitoring, assessment, TMDLs, WLAs/LAs, and permit issuance. It relies on participation at the federal, state, local and nongovernmental levels to be successful.

BMPs have been utilized in the Beaver Creek watershed to reduce the amount of coliform bacteria transported to surface waters from agricultural sources. These BMPs (e.g., streambank protection, fencing, critical area treatment, livestock exclusion, etc.) may have contributed to reductions in in-stream concentrations of coliform bacteria in the Beaver Creek watershed during the TMDL evaluation period. The TDA keeps a database of BMPs implemented in Tennessee. Those listed in Beaver Creek are shown in Figure 9. It is recommended that additional information (e.g., livestock access to streams, manure application practices, etc.) be provided and evaluated to better identify and quantify agricultural sources of coliform bacteria loading in order to minimize uncertainty in future modeling efforts.

It is further recommended that BMPs be utilized to reduce the amount of coliform bacteria transported to surface waters from agricultural sources. Demonstration sites for various types of BMPs should be established, maintained, and evaluated (performance in source reduction) over a period of at least two years prior to recommendations for utilization for Stage 2 implementation. Coliform bacteria sampling and monitoring are recommended during low-flow (baseflow) and storm periods at sites with and without BMPs and/or before and after implementation of BMPs.

9.3 Example Application of Load Duration Curves for Implementation Planning

The Load Duration Curve methodology (Appendix D) is a form of water quality analysis and presentation of data that aids in guiding implementation by targeting strategies to appropriate flow conditions. One of the strengths of this method is that it can be used to interpret possible delivery mechanisms of pathogens by differentiating between point and non-point problems. The fecal coliform load duration analysis was utilized for implementation planning because the data are more abundant than E. coli and cover a much longer period of record. The fecal coliform load duration curve for Beaver Creek at the mouth (Figure 10) was analyzed to determine the frequency with which water quality monitoring data exceed the fecal coliform target maximum concentration of 900 counts/100 mL (standard – MOS) under five flow conditions (low, dry, mid-range, moist, and high). Observation of the plot suggests the lower Beaver Creek, Tennessee watershed is impacted primarily by non-point sources.

Table 10 presents Load Duration analysis statistics for fecal coliform in Beaver Creek Tennessee and targeted implementation strategies for each source category covering the entire range of flow (Stiles, 2003). Each implementation strategy addresses a range of flow conditions and targets point sources, non-point sources, or a combination of each. Results indicate the Beaver Creek, Tennessee implementation strategy will require BMPs targeting primarily non-point sources (dominant under high flow/runoff conditions). The implementation strategies listed in Table 10 are a subset of the categories of BMPs and implementation strategies available for application to the Beaver Creek watershed for reduction of pathogen loading and mitigation of water quality impairment.

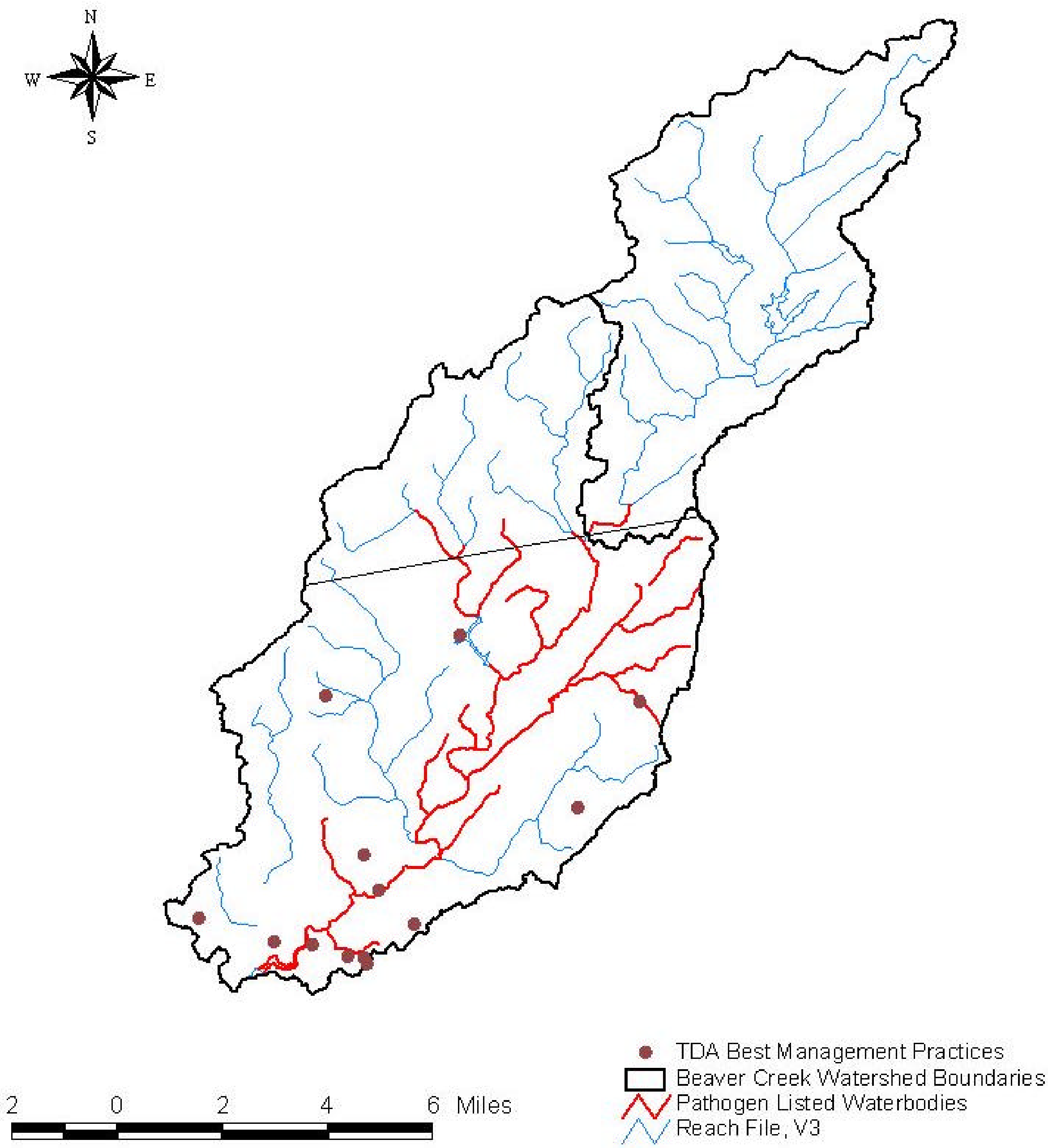

Figure 9. Tennessee Department of Agriculture Best Management Practices located in the Beaver Creek watershed.

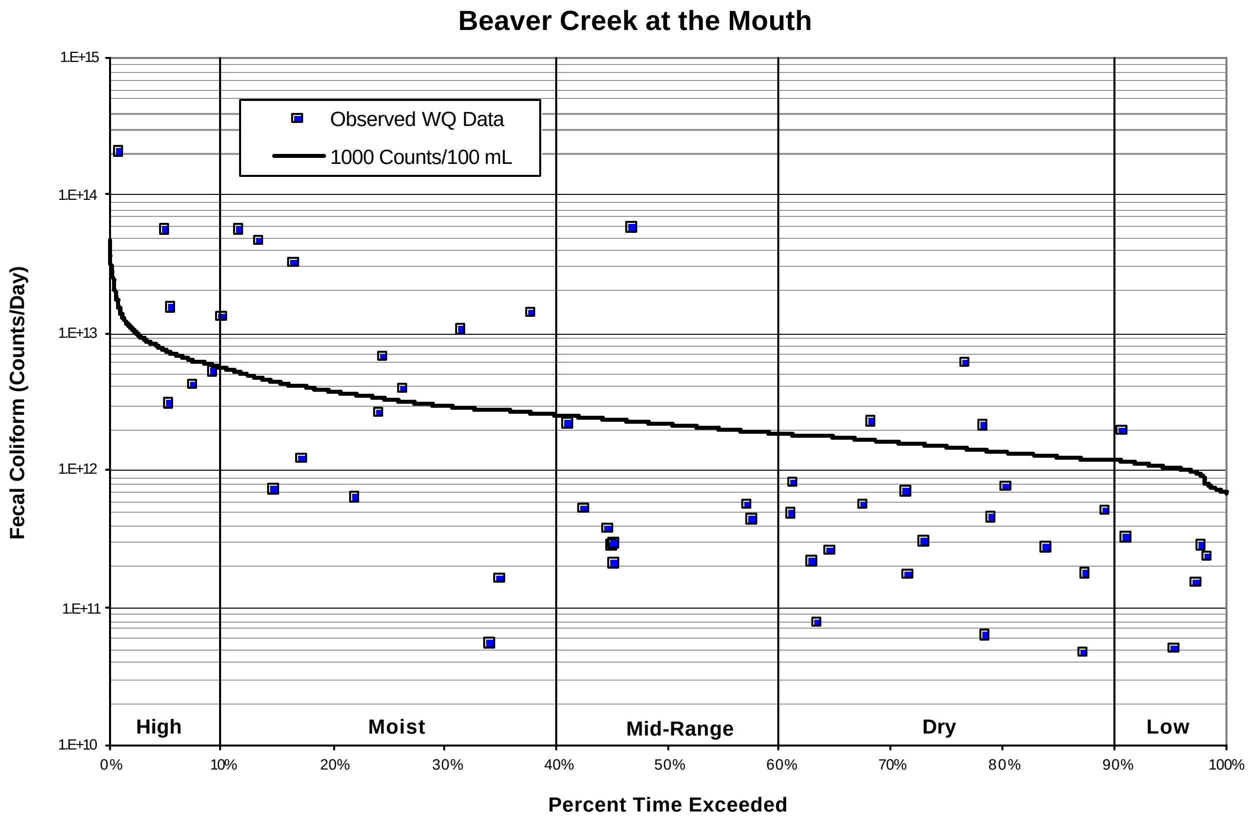

Figure 10. Load Duration Curve for Beaver Creek Implementation.

Table 10. Load Duration Curve Summary for Implementation Strategies

Flow Condition		High	Moist	Mid-range	Dry	Low
% Time Flow Exceeded		0-10	10-40	40-60	60-90	90-100
Beaver Creek at the Mouth (Tennessee)	% Samples > 900 Counts/100 mL[1]	50	57.1	11.1	15.8	16.7
	Reduction[2]	77.9%	67.3%	96.5%	47.4%	47.1%
Example Implementation Strategies						
Municipal NPDES			L	M	H	H
Stormwater Management			H	H	H	
SSO Mitigation		H	H	M	L	
Collection System Repair			L	M	H	H
Septic System Repair			L	M	H	M
Livestock Exclusion[3]				M	H	H
Pasture Management/Land Application of Manure[3]		H	H	M	L	
Riparian Buffers[3]			H	H	H	
		Potential for source area contribution under given hydrologic condition (H: High; M: Medium; L: Low)				

[1] Tennessee maximum daily water quality standard for fecal coliform (1000 Counts/100 mL) minus 10% MOS (100 Counts/100 mL).
[2] Reductions based on analyses of observed values in each range (see Appendix D).
[3] Example Best Management Practices (BMPs) for Agricultural Source reduction. Actual BMPs applied to Beaver Creek may vary.

See Appendix D for a detailed discussion of the Load Duration Curve Methodology applied to Beaver Creek.

9.4 Additional Monitoring

Documenting progress in reducing the quantity of pathogens entering Beaver Creek is an essential element of the TMDL Implementation Plan. Additional monitoring and assessment activities are recommended for Beaver Creek to determine whether implementation of TMDLs, WLAs, & LAs in tributaries and upstream reaches will result in achievement of instream water quality standards for pathogens.

Tennessee's watershed management approach specifies a five-year cycle for planning and assessment. Each watershed will be examined (or re-examined) on a rotating basis. Generally, in years two and three of the five-year cycle, water quality data are collected in support of water quality assessment (including TMDL development) and planning activities. Therefore, a watershed TMDL is developed one to two years prior to commencement of the next cycle's monitoring period.

Continued monitoring at multiple water quality sampling points in the watershed is critical in characterizing sources of pathogen contamination and documenting future reduction of loading. In the next watershed cycle, monitoring should be expanded to provide water quality information to characterize seasonal trends and refined source identification and delineation. Recommended monitoring for the Beaver Creek watershed includes monthly grab samples and intensive sampling for one month during both the wet season (January-March) and the dry season (July-September). In addition, monitoring efforts may be refined and enhanced in order to characterize dry and wet season base flow conditions (concentrations). Lastly, stream flow should be measured or estimated with the collection of each coliform bacteria sample to characterize the dynamics of coliform bacteria transport within the surface-water system.

9.5 Source Identification

An important aspect of pathogen load reduction activities is the accurate identification of the actual sources of pollution. In cases where the sources of pathogen impairment are not readily apparent, utilization of Bacteria Source Tracking (BST) technologies are recommended.

9.6 Evaluation of TMDL Effectiveness

The effectiveness of the TMDL will be assessed within the context of the State's rotating watershed management approach. Watershed monitoring and assessment activities will provide information by which the effectiveness of pathogen loading reduction measures can be evaluated. Additional monitoring data, ground-truthing activities, and bacterial source identification actions are recommended to enable implementation of particular types of BMPs to be directed to specific areas in impaired subwatersheds. This will optimize utilization of resources to achieve maximum reductions in pathogen loading. These TMDLs will be re-evaluated during subsequent watershed cycles and revised as required to assure attainment of applicable water quality standards.

10.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed pathogen TMDL for Beaver Creek was placed on Public Notice for a 35-day period and comments solicited. Steps that were taken in this regard included:

1) Notice of the proposed TMDL was posted on the Tennessee Department of Environment and Conservation website. The announcement invited public and stakeholder comment and provided a link to a downloadable version of the TMDL document.

2) Notice of the availability of the proposed TMDL (similar to the website announcement) was sent to approximately 90 interested persons or groups who have requested this information.

3) A draft copy of the proposed TMDL was sent to the City of Bristol, Tennessee and the Tennessee Department of Transportation. These MS4s are wholly or partially located in pathogen-impaired subwatersheds.

Written comments were received from one stakeholder during the public comment period. These comments are included in Appendix G and the TDEC Division of Water Pollution Control responses are contained in Appendix H. No requests to hold public meetings were received regarding the proposed TMDL as of close of business on August 23, 2004.

11.0 FURTHER INFORMATION

Further information concerning Tennessee's TMDL program can be found on the Internet at the Tennessee Department of Environment and Conservation website:

http://www.state.tn.us/environment/wpc/tmdl/

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Pollution Control staff:

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APPENDIX A

Water Quality Monitoring Data

There are a number of water quality monitoring stations that provide data for waterbodies identified as impaired for pathogens in the Beaver Creek watershed. The location of these monitoring stations is shown in Figure 5. Monitoring data recorded at these stations for Fecal Coliform, Fecal Streptococci and Escherichia Coli (E. Coli) are tabulated in Table A-1.

Table A-1. Water Quality Monitoring Data – Beaver Creek Watershed

Monitoring Station	Date	Fecal Coliform	Fecal Streptococcus[a]	E. Coli
		[cts./100 mL]	[cts./100 mL]	[cts./100 mL]
BEAVE015.3SU	7/26/88	2300	1390	NA
	1/4/89	9200	4000	NA
	7/24/89	8300	1510	NA
	11/13/89	11000	850	NA
	2/12/90	920	480	NA
	8/14/90	6000	3500	NA
	5/13/91	8000	2700	NA
	8/12/91	6400	4300	NA
	11/5/91	2600	1400	NA
	2/10/92	65000	12000	NA
	5/13/92	3600	950	NA
	8/10/92	5700	3100	NA
	11/16/92	4300	1000	NA
	2/2/93	1200	64	NA
	5/18/93	3800	650	NA
	8/11/93	3400	3100	NA
	12/1/93	2300	NA	NA
	2/23/94	6300	70000	NA
	6/1/94	2300	1200	NA
	8/13/94	6000	2000	NA
	11/22/94	4800	1700	NA
	2/13/95	1800	2700	NA
	5/17/95	3000	3200	NA
	8/29/95	11000	6300	NA
	11/27/95	8200	1800	NA
	2/27/96	200	3200	NA
	5/22/96	2500	3200	NA
	12/2/97	5100	1553	NA
	3/3/98	1510	2419	548
	6/25/98	2400	NA	1553
	9/17/98	6200	NA	NA

Table A-1. Water Quality Monitoring Data – Beaver Creek Watershed (Cont.)

Monitoring Station	Date	Fecal Coliform [cts./100 mL]	Fecal Streptococcus [cts./100 mL]	E. Coli [cts./100 mL]
BEAVE015.3SU	12/15/98	1600	126	1046
	3/2/99	250	NA	326
	6/15/99	1100	NA	1046
	9/7/99	3200	NA	1414
	12/2/99	630	NA	461
	2/17/00	560	NA	1046
	5/11/00	1300	NA	1553
	8/10/00	6600	10000	1986
	11/28/00	250	280	308
	3/7/01	790	60	1553
	6/26/01	2000	NA	1300
	7/17/01	1000	NA	613
	4/16/02	3800	NA	NA
	7/17/02	5100	560	6890
	8/20/02	7800	400	30760
	9/11/02	3700	710	5210
	10/23/02	6900	700	18600
	11/13/02	2900	600	3320
	12/3/02	3100	200	1350
	1/15/03	154	22	200
	2/18/03	260	160	410
	3/12/03	1600	40	2160
	4/15/03	1400	540	4640
	5/12/03	3100	600	4870
	6/25/03	4400	1100	4130
	8/12/03	5500	NA	NA
BEAVE001.0SU	7/26/88	60	10	NA
	10/25/88	330	430	NA
	1/4/89	430	480	NA
	7/24/89	110	200	NA
	11/13/89	264	172	NA
	2/12/90	660	880	NA
	8/15/90	150	200	NA
	5/13/91	26000	33000	NA
	8/12/91	120	80	NA

Table A-1. Water Quality Monitoring Data – Beaver Creek Watershed (Cont.)

Monitoring Station	Date	Fecal Coliform [cts./100 mL]	Fecal Streptococcus [cts./100 mL]	E. Coli [cts./100 mL]
BEAVE001.0SU	2/10/92	290	420	NA
	5/13/92	11000	10000	NA
	8/10/92	44	30	NA
	11/16/92	200	120	NA
	2/2/93	890	120	NA
	3/11/93	20	80	NA
	5/18/93	160	100	NA
	12/1/93	440	NA	NA
	2/23/94	14700	13400	NA
	6/1/94	1220	530	NA
	11/22/94	1360	970	NA
	2/13/95	126	128	NA
	5/17/95	2100	1700	NA
	8/29/95	160	790	NA
	11/27/95	440	480	NA
	2/27/96	5500	2300	NA
	5/22/96	7800	13000	NA
	12/2/97	4200	2419	NA
	3/3/98	224	10	299
	6/25/98	3700	NA	>2419
	9/17/98	48	NA	24
	12/15/98	1500	64	1120
	3/2/99	160	NA	179
	6/15/99	146	NA	249
	9/7/99	38	NA	11
	12/2/99	210	NA	166
	2/17/00	120	NA	89
	5/11/00	340	NA	152
	8/10/00	10000	12000	2419
	11/28/00	280	240	517
	3/7/01	220	250	249
	6/26/01	180	NA	144
	7/17/01	44	NA	5
	7/17/02	570	410	1090
	8/20/02	1700	700	2110

Table A-1. Water Quality Monitoring Data – Beaver Creek Watershed (Cont.)

Monitoring Station	Date	Fecal Coliform [cts./100 mL]	Fecal Streptococcus [cts./100 mL]	E. Coli [cts./100 mL]
BEAVE001.0SU	9/11/02	300	280	200
	10/23/02	310	400	520
	11/13/02	2400	700	2430
	12/3/02	ND	80	630
	1/15/03	90	310	200
	2/18/03	420	270	200
	3/12/03	300	18	200
	4/15/03	900	230	1080
	5/12/03	2000	1400	1610
	6/25/03	780	510	740
	8/12/03	7500	NA	NA

[a] NA = Not Applicable (no data collected).

APPENDIX B

Land Use Distribution in Beaver Creek

Table B-1. IPSI Land Use Distribution of the Beaver Creek Subwatersheds

Land Use	Beaver Creek Watersheds (06010102__)					
	0501 (at the State Line)		0502 (at the Mouth)		Total	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Residential	3916	16.6	9569	20.6	13485	19.3
Apartments/Condo	0	0	24.2	0.05	24.2	0.03
Mobile Homes	23.3	0.10	34.0	0.07	57.3	0.08
Farmstead	0	0	16.3	0.04	16.3	0.02
Commercial, Service, Institutional	847	3.59	1674	3.61	2521	3.60
Junkyard	2.90	0.01	2.46	0.01	5.36	0.01
Golf Course	0	0	408	0.88	408	0.58
Campground	38.6	0.16	0	0	38.6	0.06
Athletic Field	36.2	0.15	30.8	0.07	67.0	0.10
Landfill	2.73	0.01	10.1	0.02	12.8	0.02
Water Treatment	0	0	34.8	0.08	34.8	0.05
Sewage Treatment	0.77	0.00	0	0	0.77	0.00
Water Tank	0.44	0.00	1.27	0.00	1.72	0.00
Educational	0	0	11.1	0.02	11.1	0.02
Religious	0	0	18.2	0.04	18.2	0.03
Cemetery	0	0	71.1	0.15	71.1	0.10
Industrial	545	2.31	796	1.72	1341	1.92
Transportation, Communication, Utility	56.7	0.24	198	0.43	255	0.36
Major Highway Right-of-Way	236	1.00	840	1.81	1077	1.54
Road Cut and Fill	0	0	5.39	0.01	5.39	0.01

Table B-1. IPSI Land Use Distribution of the Beaver Creek Subwatersheds (Cont.)

Land Use	Beaver Creek Watersheds (06010102__)					
	0501 (at the State Line)		0502 (at the Mouth)		Total	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Dam	0	0	1.19	0.00	1.19	0.00
Dam - Visitor Center	0	0	16.2	0.03	16.2	0.02
Electric Transmission Right-of-Way	4.00	0.02	180	0.39	184	0.26
Substation	0	0	1.86	0.00	1.86	0.00
Pipeline Right-of-Way	0	0	4.93	0.01	4.93	0.01
Tank Farm	0	0	1.29	0.00	1.29	0.00
Cropland	0	0	127	0.27	127	0.18
Row Crop, low residue (0-10%)	78.5	0.33	119	0.26	197	0.28
Row Crop, high residue (>30%)	0	0	584	1.26	584	0.83
Fair Pasture	10891	46.1	11635	25.1	22526	32.2
Heavily Overgrazed Pasture	362	1.53	1848	3.99	2210	3.16
Poor Pasture	190	0.80	103	0.22	293	0.42
Feedlot or Loading Areas	4.50	0.02	49.9	0.11	54.4	0.08
Tobacco	121	0.51	153	0.33	275	0.39
Poultry	5.48	0.02	0	0	5.48	0.01
Shrub and Brush	0	0	54.8	0.12	54.8	0.08
Forestland	5814	24.6	14448	31.2	20262	29.0
Deciduous	0	0	1699	3.67	1699	2.43
Evergreen	0	0	17.4	0.04	17.4	0.02
Mixed Forest	0	0	933	2.01	933	1.33

Table B-1. IPSI Land Use Distribution of the Beaver Creek Subwatersheds (Cont.)

Land Use	Beaver Creek Watersheds (06010102__)					
	0501 (at the State Line)		0502 (at the Mouth)		Total	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Clearcut	96.8	0.41	77.8	0.17	175	0.25
Plantation - Evergreen	0	0	7.39	0.02	7.39	0.01
Water	79.0	0.33	218	0.47	297	0.42
Active Stripmine	17.0	0.07	0	0	17.0	0.02
Reclaimed Stripmine	9.06	0.04	0	0	9.06	0.01
Active Quarry	69.0	0.29	96.6	0.21	166	0.24
Active Borrow Area	26.5	0.11	0.70	0.00	27.2	0.04
Abandoned Borrow Area	9.36	0.04	0	0	9.36	0.01
Disturbed Area	127	0.54	196	0.42	323	0.46
Palustrine Wetland - Emergent	0	0	2.08	0.00	2.08	0.00
Palustrine Wetland - Forested	6.19	0.03	5.85	0.01	12.0	0.02
Palustrine Wetland - Forest/Scrub	0	0	15.0	0.03	15.0	0.02
Palustrine Wetland - Scrub	0	0	0.63	0.00	0.63	0.00
Palustrine Wetland - Scrub/Emergent	2.22	0.01	0	0	2.22	0.00
Subtotal - Urban Impervious	2108	8.92	4728	10.20	6836	9.77
Subtotal - Urban Pervious	3517	14.89	8515	18.37	12033	17.20
Subtotal - Forest	6340	26.85	18481	39.88	24821	35.48
Subtotal - Pasture	11452	48.49	13637	29.42	25089	35.86
Subtotal - Cropland	200	0.85	983	2.12	1182	1.69
Total	**23617**	100	**46344**	100	**69961**	100

APPENDIX C

Dynamic Loading Model Methodology

DYNAMIC LOADING MODEL METHOD

C.1 Model Selection

The Loading Simulation Program C++ (LSPC) was selected for TMDL analysis of pathogen-impaired waters in the South Fork Holston River watershed. LSPC is a dynamic watershed model based on the Hydrologic Simulation Program - Fortran (HSPF) and is well suited to demonstrate compliance with the 200 counts/100 mL geometric mean standard. LSPC was used to simulate the buildup and washoff of fecal coliform bacteria from land surfaces in response to storm events, loading from point sources, and compute the resulting water quality response. From model output, instream 30-day geometric mean concentrations were computed, critical conditions identified, existing loads determined, and reductions required to meet target concentrations (standard - MOS) were calculated.

C.2 Model Set Up

The Beaver Creek watershed was delineated into subwatersheds in order to facilitate model hydrologic and water quality calibration; and to characterize relative fecal coliform contributions from significant contributing drainage areas. Boundaries were constructed so that subwatershed “pour points” coincided with water quality monitoring stations located approximately at the mouth of Beaver Creek and the state line. Watershed delineation was based on the Rf3 stream coverage and Digital Elevation Model (DEM) data. This discretization allows management and load reduction alternatives to be varied by subwatershed.

Several computer-based tools were utilized to generate input data for the LSPC model. The Watershed Characterization System (WCS), a geographic information system (GIS) tool, was used to display, analyze, and compile available information to support water quality model simulations for selected subwatersheds. This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics. In addition, the TVA IPSI, a GIS-based nonpoint source inventory, provided updated (1994) subwatershed-level livestock data for enhancement of source characterization. Results of the WCS and TVA IPSI characterizations were input into the Fecal Coliform Loading Estimation Spreadsheet (FCLES), developed by Tetra Tech, Inc., to estimate LSPC input parameters associated with fecal coliform buildup (loading rates) and subsequent washoff from land surfaces. In addition, FCLES was used to estimate direct sources of fecal coliform loading to water bodies from leaking septic systems and animals having access to streams. Information from the WCS, TVA IPSI, and FCLES utilities were used as initial input for variables in the LSPC model.

An important factor influencing model results is the precipitation data contained in the meteorological data files used in these simulations. The pattern and intensity of rainfall affects the buildup and washoff of fecal coliform bacteria from the land into the streams, as well as the dilution potential of the stream. Weather data from the multiple meteorological stations were available for the time period from January 1970 through December 2001. Meteorological data for a selected 11-year period were used for all simulations. The first year of this period was used for model stabilization with simulation data from the subsequent 10-year period (10/1/91 – 9/30/01) used for TMDL analysis.

C.3 Model Calibration

The calibration of the LSPC watershed model involves both hydrology and water quality components. The model must first be calibrated to appropriately represent hydrologic response to meteorological conditions before water quality calibration and subsequent simulations can be performed. Due to the lack of continuous flow data at the mouths of the listed waterbodies, data collected at the nearest appropriate location was used to calibrate the subwatershed models.

C.3.1 Hydrologic Calibration

Hydrologic calibration of the watershed model involves comparison of simulated streamflow to historic streamflow data from USGS stream gaging stations for the same period of time. A USGS continuous record station located in the South Fork Holston River watershed with a sufficiently long and recent historical record was selected as the basis of the hydrology calibration. The USGS station was selected based on similarity of drainage area, Level IV ecoregion, land use, and topography. The calibration involved comparison of simulated and observed hydrographs until statistical stream volumes and flows were within acceptable ranges as reported in the literature (Lumb, et al., 1994).

Initial values for hydrologic variables were taken from an EPA developed default data set. During the calibration process, model parameters were adjusted within reasonable constraints until acceptable agreement was achieved between simulated and observed streamflow. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge.

The results of the hydrologic calibration for Middle Fork Holston River at USGS Station 03475000 (ref.: Figure 4) are shown in Table C-1 and Figures C-1 through C-5.

C.3.2 Water Quality Calibration

After hydrologic calibration, the watershed model was calibrated for water quality through comparison of simulated fecal coliform concentrations to instream monitoring data at a specified location. Watershed data, produced with WCS, were processed through the FCLES spreadsheet to generate fecal coliform loading data for use as initial input to the LSPC model. In the model, in-stream decay of fecal coliform bacteria was estimated using the values reported in Lombardo (1972). For freshwater streams, decay ranges from 0.008 hr^{-1} to 0.13 hr^{-1}, with a median value of 0.048 hr^{-1}. The value of 0.083 hr^{-1} was used as initial input to model simulations.

C.3.2.1 Point Sources

For existing conditions, NPDES facilities located in modeled watersheds are represented as point sources of average (constant) flow and concentration based on the facility's flow and effluent fecal coliform concentration as reported on Discharge Monitoring Reports (DMRs).

C.3.2.2 Nonpoint Sources

A number of nonpoint source categories are not associated with land loading processes and are represented as direct, instream source contributions in the model. These may include, but are not limited to, failing septic systems, leaking sewer lines, animals in streams, illicit connections, direct discharge of raw sewage, and undefined sources. All other nonpoint sources involve land loading of fecal coliform bacteria and washoff as a result of storm events. Only a portion of the load from these sources is actually delivered to streams due to the mechanisms of washoff (efficiency), decay, and incorporation into soil (adsorption, absorption, filtering) before being transported to the stream. Therefore, land loading nonpoint sources are represented as indirect contributions to the stream. Buildup, washoff, and die-off rates are dependent on seasonal and hydrologic processes.

C.3.2.2.1 Wildlife

Wildlife deposit fecal coliform bacteria, with their feces, onto land surfaces where it can be transported during storm events to nearby streams. The overall deer density for Tennessee was estimated by the Tennessee Wildlife Resources Agency (TWRA) to be 23 animals per square mile. In order to account for higher density areas and loading due to other species, a conservative density of 45 animals per square mile was used for modeling purposes. Fecal coliform loads due to deer are estimated by EPA to be 5.0×10^8 counts/animal/day. The resulting fecal coliform loading on a unit area basis is 3.52×10^7 counts/acre/day and is considered background.

C.3.2.2.2 Land Application of Agricultural Manure

In the water quality model, livestock populations are distributed to subwatersheds based on information derived from WCS and IPSI. Fecal coliform loading rates were calculated from livestock populations based on manure application rates, literature values for bacteria concentrations in livestock manure, and the following assumptions:

- Fecal content in manure was adjusted to account for die-off due to known treatment/storage methods.
- Manure application rates from the various animal sources are applied according to application practices throughout the year.
- The fraction of manure available for runoff is dependent on the method of manure application. In the water quality model, the fraction available is estimated based on incorporation into the soil.

Fecal coliform production rates used in the model for beef cattle, dairy cattle, hogs, horses, and chicken are 1.06×10^{11} counts/day/beef cow, 1.04×10^{11} counts/day/dairy cow, 1.24×10^{10} counts/day/hog, 4.18×10^8 counts/day/horse, and 1.38×10^8 counts/day/chicken (NCSU, 1994)**.**

C.3.2.2.3 Grazing Animals

Cattle spend time grazing on pastureland and deposit feces onto the land. During storm events, a portion of this material containing fecal coliform bacteria is transported to streams. Beef cattle are assumed to spend all their time in pasture. The percentage of feces deposited during grazing time is used to estimate fecal coliform loading rates from pastureland. Because there is no assumed monthly variation in animal access to pastures in east Tennessee, the fecal loading rate does not vary significantly throughout the year. Therefore, the loading rate to pastureland is assumed to be relatively constant within each subwatershed. However, this rate varies across subwatersheds depending on livestock population. The approximate loads from grazing cattle vary from 3.495×10^{10} to 1.165×10^{11} counts/acre-day. Contributions of fecal coliform from wildlife (as noted in Section C.3.2.2.1) are also included in these rates.

C.3.2.2.4 Urban Development

Urban land use represented in the IPSI database includes areas classified as: commercial, service, institutional; transportation, communication, utility; industrial; and residential. Associated with each of these classifications is a percent of the land area that is impervious. A single, area-weighted loading rate from urban areas is used for each subwatershed in the model and is based on the percentage of each urban land use type in the watershed and buildup and accumulation rates referenced in Horner (Horner, 1992). In the water quality calibrated model, this rate varies from 7.5×10^8 to 2.0×10^9 counts/acre-day and is assumed constant within each subwatershed throughout the year.

C.3.2.2.5 Other Direct Sources

As previously stated, there are a number of nonpoint sources of fecal coliform bacteria that are not associated with land loading and washoff processes. These include animal access to streams, failing septic systems, illicit discharges, and other undefined sources. In each subwatershed, these miscellaneous sources have been modeled as point sources of constant flow and fecal coliform concentration and are referred to as "other direct sources" in this document. The initial baseline values of flow and concentration were estimated using the FCLES spreadsheets and the following assumptions:

- The load attributed to animals having access to streams is initially based on the beef cow population in the watershed. The percentage of animals having access to streams is derived from assumptions on animals in operations that are adjacent to streams and seasonal and behavioral assumptions. Literature values were used to estimate the fecal coliform bacteria concentration in beef cow manure.

- The initial baseline loads attributable to leaking septic systems is based on an assumed failure rate of 20 percent.

Flow and concentration variables were adjusted during water quality calibration to best-fit simulated in-stream fecal coliform concentrations during dry weather conditions.

C.3.2.3 Water Quality Calibration Results

During water quality calibration, model parameters were adjusted within reasonable limits until acceptable agreement between simulation output and instream observed data was achieved. Model variables adjusted include:

- Rate of fecal coliform bacteria accumulation
- Maximum storage of fecal coliform bacteria
- Rate of surface runoff that will remove 90% of stored fecal coliform bacteria
- Concentration of fecal coliform bacteria in interflow
- Concentration of fecal coliform bacteria in groundwater
- Concentration of fecal coliform bacteria and rate of flow of "other direct sources".
- In-stream fecal coliform decay (die-off) rate

At times, a high observed value may not have been simulated in the model due to the absence of rainfall at the meteorological station as compared to localized rainfall occurring in the watershed, or as the result of an unknown source that is not included in the model.

Water quality calibration for the Beaver Creek watershed was performed at mile 0.1 (at the mouth). The results of the water quality calibration are shown in Figure C-6. Results show that the model adequately simulates peaks in fecal coliform bacteria in response to rainfall events and pollutant loading dynamics.

C.4 Margin of Safety

There are two methods for incorporating an MOS in the analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. For TMDL analyses using LSPC, both an explicit and implicit MOS were used. The explicit MOS is 20 counts/100 mL, equal to 10% of the 200 counts/100 mL geometric standard. This results in a target fecal coliform concentration of 180 counts/100 mL. The implicit MOS includes the use of conservative modeling assumptions and a 10-year continuous simulation that incorporates a wide range of meteorological events. Conservative modeling assumptions used include: septic systems discharging directly into the streams; development of the TMDL using loads based on the design flow and fecal coliform permit limits of NPDES facilities; and all land uses connected directly to streams.

Note: In this document, the water quality standard is the instream goal. The term "target concentration" reflects the application of an explicit Margin of Safety (MOS) to the water quality standard. See Section 5.0.

C.5 Determination of Existing Loading

The critical condition for nonpoint source fecal coliform loading is typically an extended dry period followed by a rainfall runoff event. During the dry weather period, fecal coliform bacteria builds up on the land surface, and is washed off by rainfall. The critical condition for point source loading occurs during periods of low streamflow when dilution is minimized. Both conditions are simulated in the water quality model.

For each modeled subwatershed, the 10-year simulation period was used to generate daily mean instream concentrations. These were used to calculate continuous 30-day geometric mean concentrations that were then compared to the target concentration. The 10-year simulation period contained a range of hydrologic conditions that included both low and high streamflows. The 30-day critical period for each subwatershed is the period preceding the highest simulated violation of the geometric mean standard. The magnitude of the highest peak, together with the corresponding simulated flow, represents the existing fecal coliform loading to the waterbody.

The drainage areas of the waterbody segments (Beaver Creek), in Tennessee and Virginia, coincided with HUC-12 subwatersheds and the waterbody segments were at the "pour points" of the HUC-12 subwatersheds. In addition, these pour points coincided with water quality monitoring stations with sufficient fecal coliform data for water quality calibration. Existing loads and required load reductions were determined on a HUC-12 subwatershed basis for the lower Beaver Creek waterbody (in Tennessee).

The results of the 10-year simulation used to determine existing conditions for Lower Beaver Creek are shown in Figure C-7.

C.6 Determination of TMDL

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), nonpoint source loads (Load Allocations), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time, toxicity, or <u>other appropriate measure</u>.

For the purposes of these analyses, fecal coliform TMDLs are expressed as the percent reduction in instream loading required to decrease the existing instream 30-day geometric mean concentration (as defined in Section C.5) to the target of 180 counts/100 mL. The required reduction can be determined directly using the following equation:

$$\text{TMDL} = \text{RILR} = \frac{[(C)\ (Q)\ (\text{Const})]_{\text{Existing}} - [(C)\ (Q)\ (\text{Const})]_{\text{Target}}}{[(C)\ (Q)\ (\text{Const})]_{\text{Existing}}} \times 100$$

where: RILR = Required Instream Load Reduction [%]
C = Instream Concentration [counts/100 mL]
Q = Daily Mean Flow [cfs]
Const = Unit Conversion Constant

Since the streamflow for the existing condition is equal to the streamflow for the target condition:

$$\text{TMDL} = \text{RILR} = \cancel{\frac{(Q)\ (\text{Const})}{(Q)\ (\text{Const})}} \times \frac{[C]_{\text{Existing}} - [C]_{\text{Target}}}{[C]_{\text{Existing}}} \times 100$$

therefore:

$$\text{TMDL} = \text{RILR} = \frac{[C]_{\text{Existing}} - [C]_{\text{Target}}}{[C]_{\text{Existing}}} \times 100$$

As an example, for subwatershed 0502 (Beaver Creek, Tennessee), the simulated 30-day geometric mean concentration for the existing loading condition (ref.: Section C.5) is 537 counts/100 mL. The required instream load reduction is calculated by:

$$\text{TMDL} = \text{RILR} = \frac{(537\ \text{cts/100 mL}) - (180\ \text{cts/100 mL})}{(537\ \text{cts/100 mL})} \times 100$$

$$\text{TMDL} = \text{RILR} = 66.5\%$$

Required load reductions are summarized in Table C-2.

Table C-1. Hydrologic Calibration Summary: Middle Fork Holston River (USGS Station 03475000)

Simulation Name:	Middle Fork Holston	**Simulation Period:**	
	USGS 03475000	**Watershed Area (ac):**	151485.60
Period for Flow Analysis			
Begin Date:	**10/01/91**		
End Date:	**09/30/01**		
Total Simulated In-stream Flow:	**148.67**	Total Observed In-stream Flow:	**156.51**
Total of highest 10% flows:	**57.21**	Total of Observed highest 10% flows:	**59.50**
Total of lowest 50% flows:	**29.72**	Total of Observed Lowest 50% flows:	**29.09**
Simulated Summer Flow Volume (months 7-9):	**22.57**	Observed Summer Flow Volume (7-9):	**21.51**
Simulated Fall Flow Volume (months 10-12):	**24.06**	Observed Fall Flow Volume (10-12):	**20.63**
Simulated Winter Flow Volume (months 1-3):	**55.29**	Observed Winter Flow Volume (1-3):	**68.07**
Simulated Spring Flow Volume (months 4-6):	**46.75**	Observed Spring Flow Volume (4-6):	**46.30**
Total Simulated Storm Volume:	**121.39**	Total Observed Storm Volume:	**118.53**
Simulated Summer Storm Volume (7-9):	**15.69**	Observed Summer Storm Volume (7-9):	**11.96**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**-5.01**	10	
Error in 50% lowest flows:	**2.17**	10	
Error in 10% highest flows:	**-3.84**	15	
Seasonal volume error - Summer:	**4.90**	30	
Seasonal volume error - Fall:	**16.65**	30	
Seasonal volume error - Winter:	**-18.77**	30	
Seasonal volume error - Spring:	**0.97**	30	
Error in storm volumes:	**2.41**	20	
Error in summer storm volumes:	**31.19**	50	

Table C-2. TMDL for Beaver Creek Tennessee – 30-Day Geometric Mean Target

Impaired Waterbody	HUC-12 Subwatershed (06010102____)	Existing Conditions		TMDL - Required Load Reduction
		Date(s) of Max. 30-Day Geom. Mean Concen.	Max. 30-Day Geom. Mean Concentration	
			[cts./100 mL]	[%]
Beaver Creek (at the Mouth)	**0502**	**9/11/92**	**536.8**	**66.5**

Figure C-1. Hydrologic Calibration of Middle Fork Holston River at USGS 03475000 (WY 92 & 93)

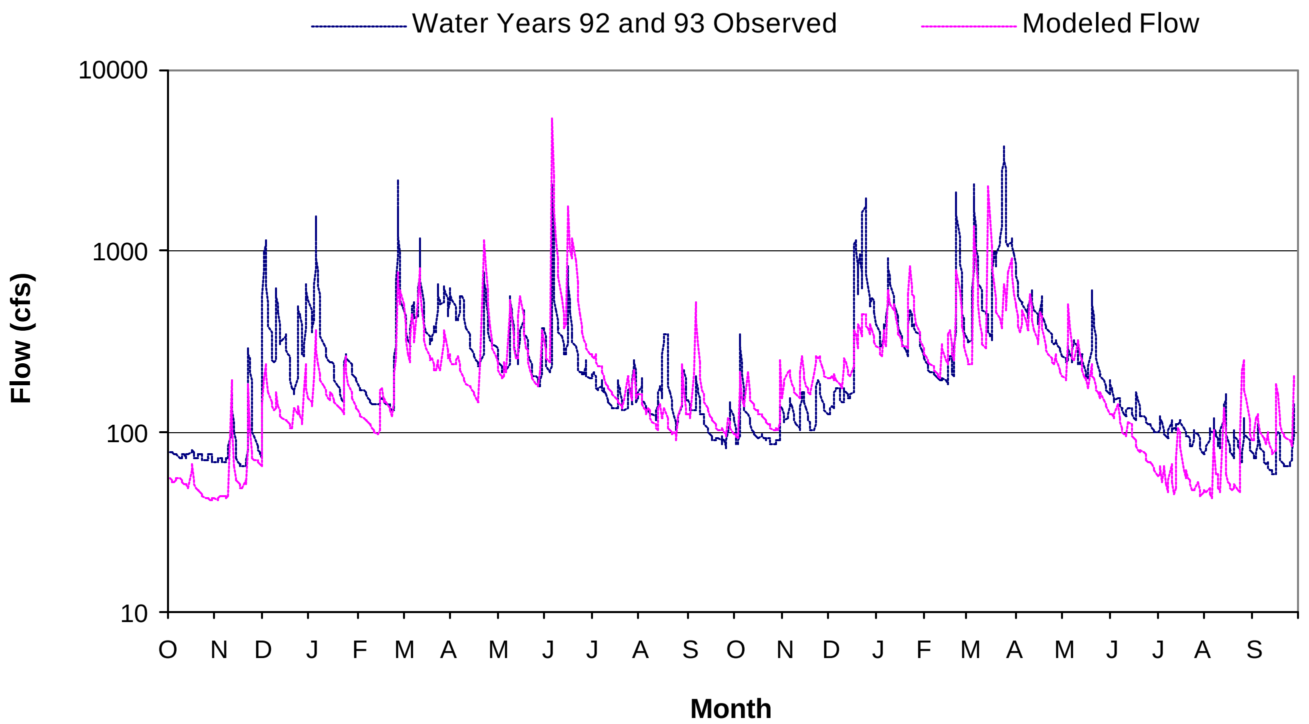


Figure C-2. Hydrologic Calibration of Middle Fork Holston River at USGS 03475000 (WY 94 & 95)

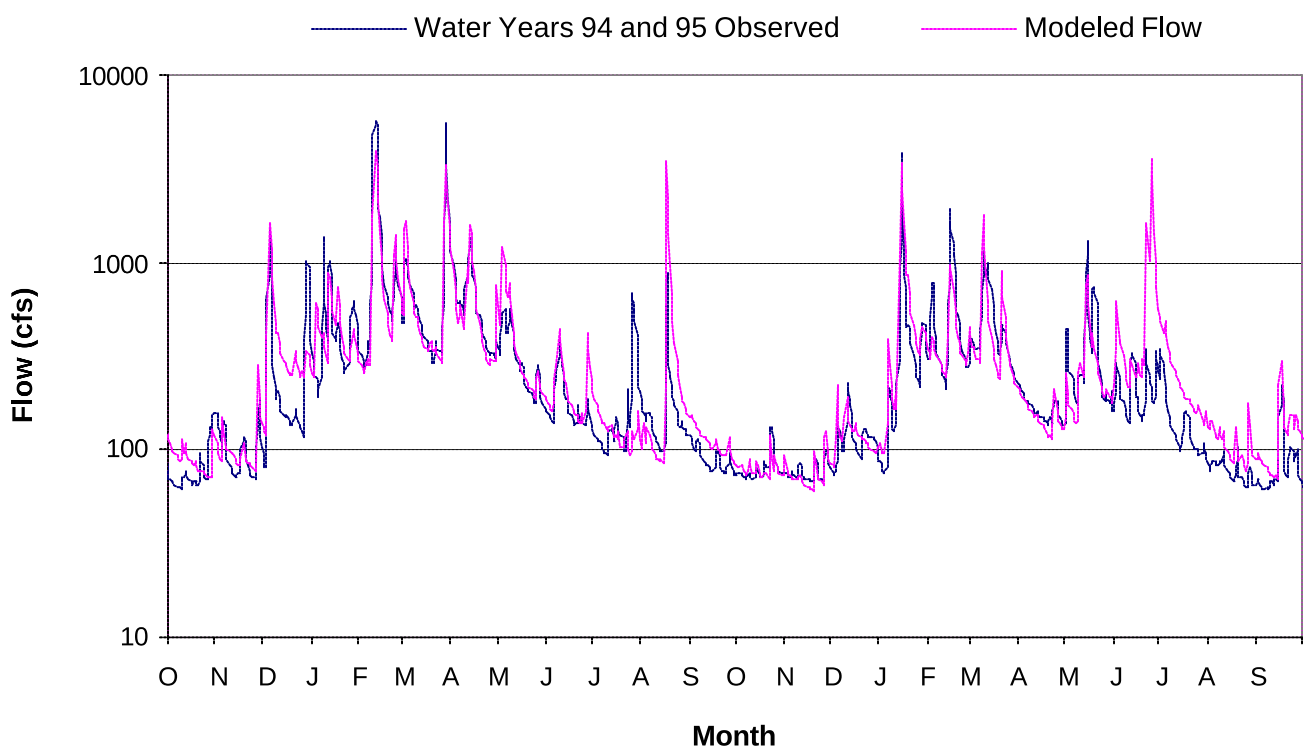


Figure C-3. Hydrologic Calibration of Middle Fork Holston River at USGS 03475000 (WY 96 & 97)

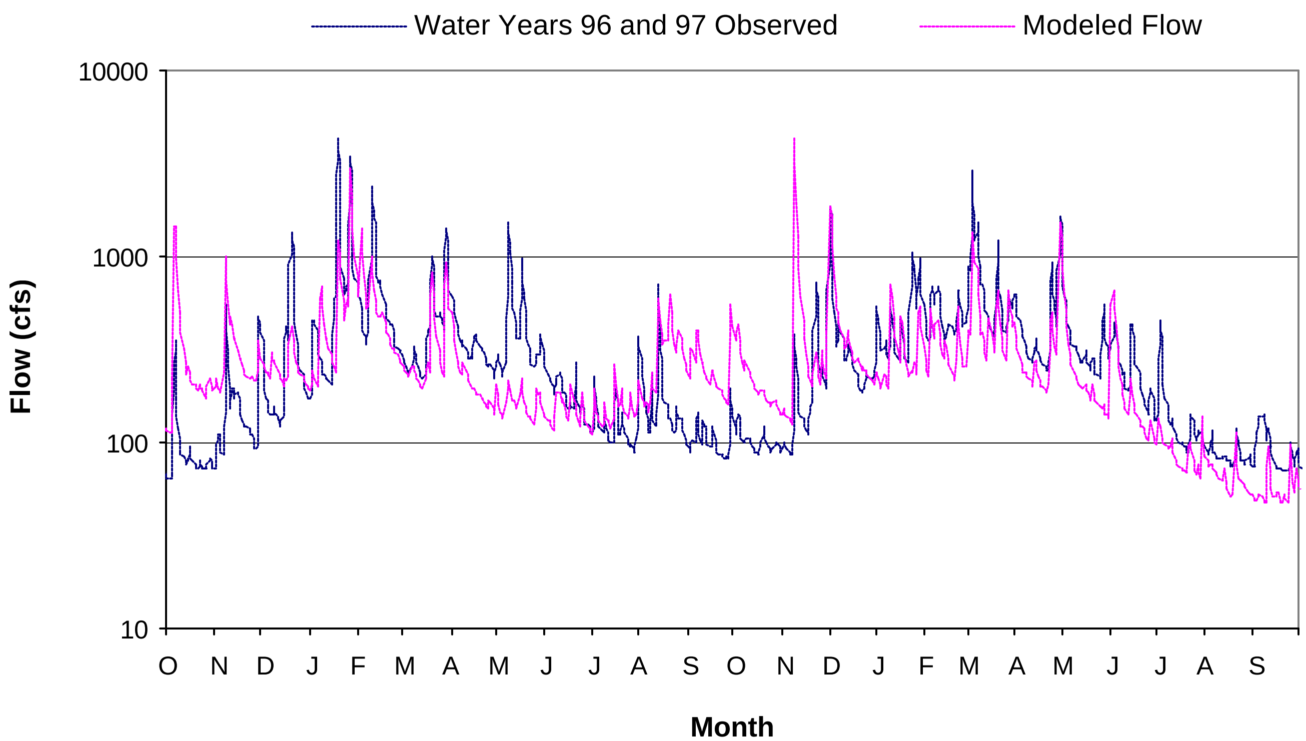


Figure C-4. Hydrologic Calibration of Middle Fork Holston River at USGS 03475000 (WY 98 & 99)

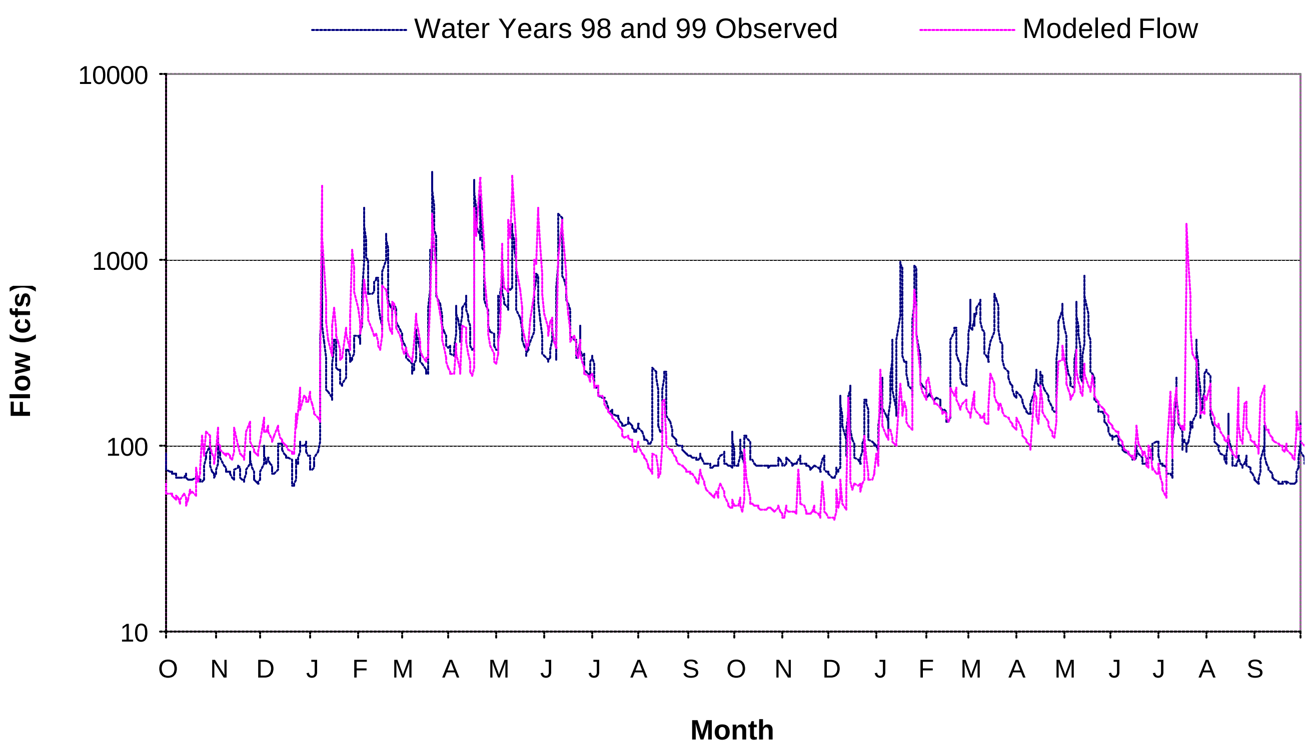
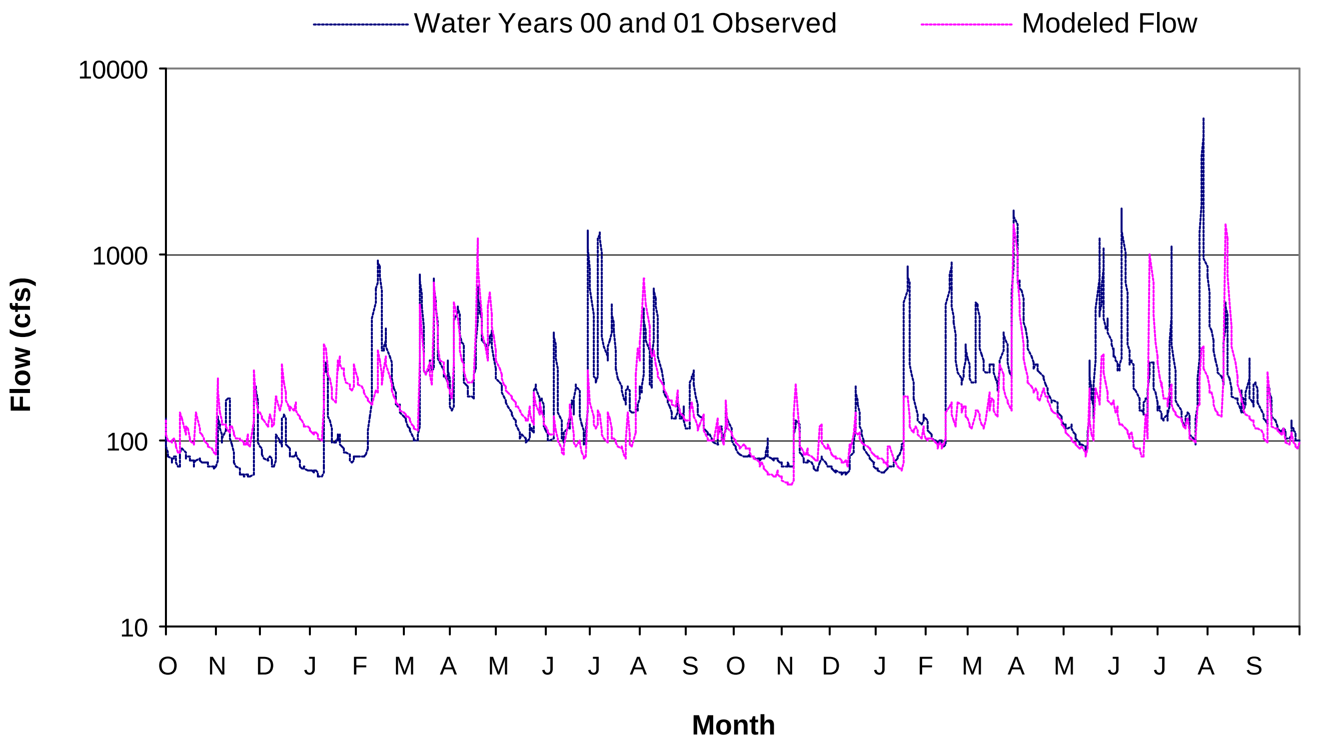


Figure C-5. Hydrologic Calibration of Middle Fork Holston River at USGS 03475000 (WY 00 & 01)



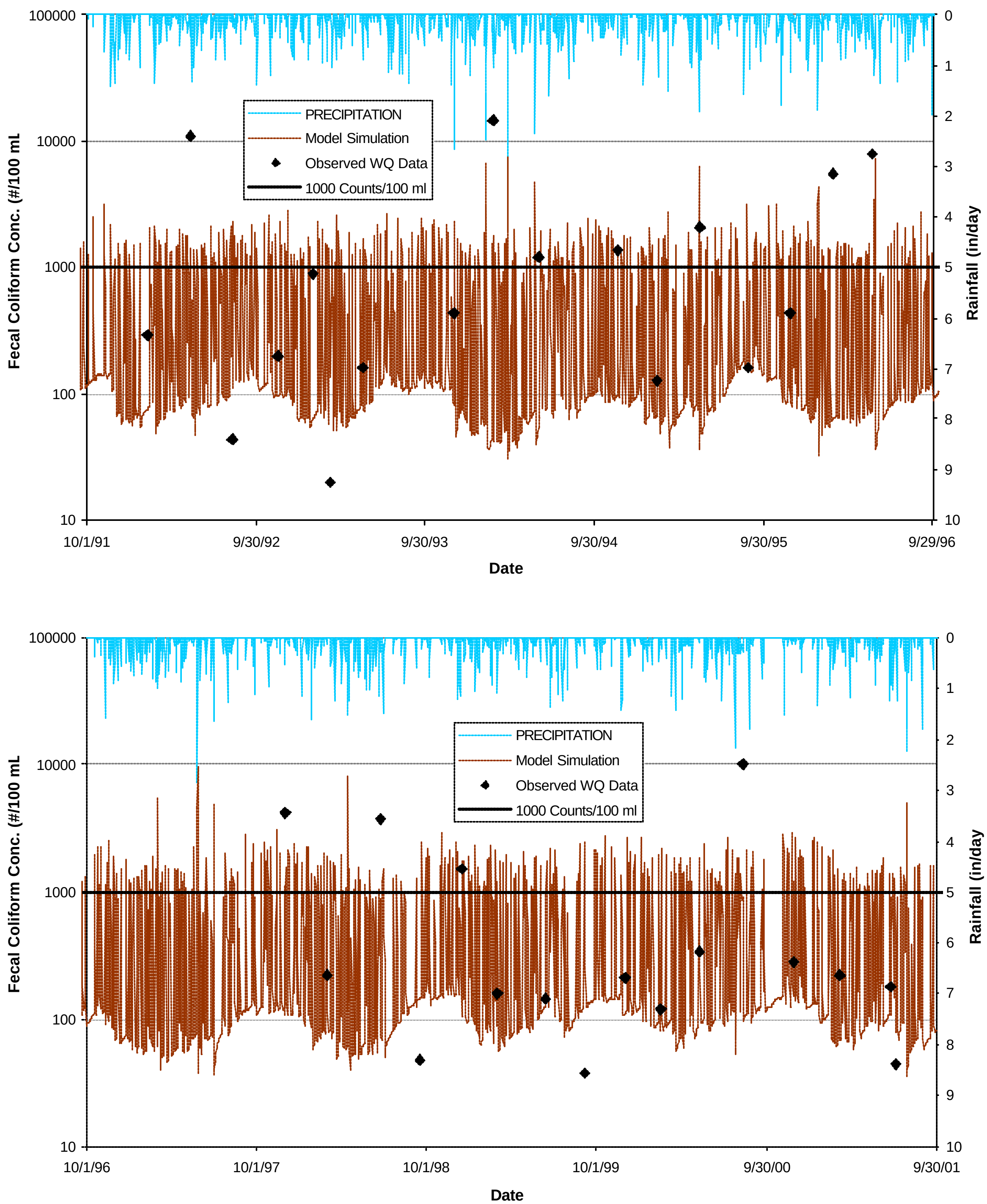


Figure C-6. Water Quality Calibration of Beaver Creek at the Mouth (BEAVE001.0SU)

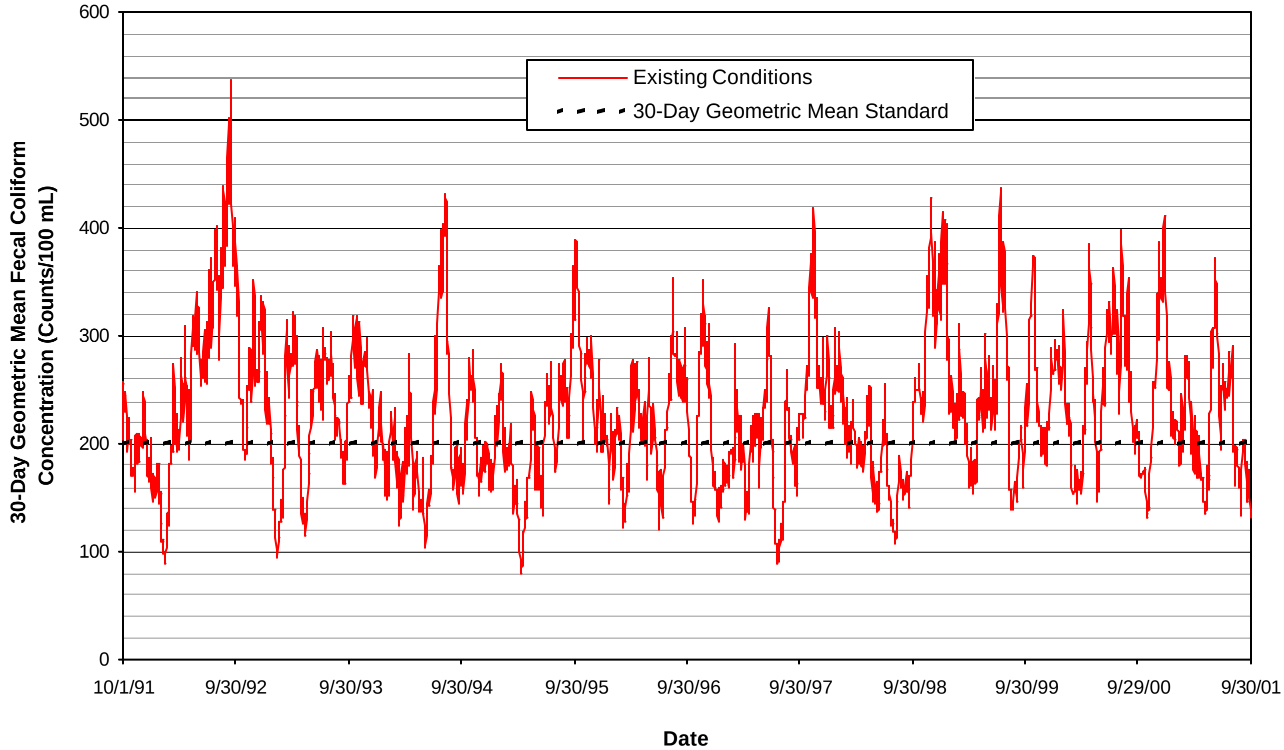


Figure C-7. Simulated 30-Day Geometric Mean Fecal Coliform Concentrations for Beaver Creek at the Mouth (BEAVE001.0SU) for Existing Conditions.

APPENDIX D

Load Duration Curve Methodology

LOAD DURATION CURVE METHOD

A duration curve is a cumulative frequency graph that represents the percentage of time during which the value of a given parameter is equaled or exceeded. Load duration curves are developed from flow duration curves and are useful for TMDL analysis:

Note: The following was based on information from Nevada Division of Environmental Protection, Bureau of Water Quality Planning website (Nevada, 2003):

- Load duration curves can serve as TMDL targets, thereby establishing allowable loading to waterbodies over the entire range of flow.

- Pollutant monitoring data, plotted on a load duration curve, provide a visual depiction of stream water quality with respect to allowable loads. The frequency and magnitude of exceedances are also illustrated.

- Load duration curves can be used to characterize the flow conditions under which exceedances occur. For example, exceedances that occur in the 0% to 10% area of the curve may be considered to represent extreme high flow problems that may be beyond feasible management solutions. Exceedances in the 99% to 100% area reflect extreme drought conditions.

- Different loading mechanisms can dominate at different flow regimes. Exceedances of the load duration curve during high flow conditions may indicate excessive nonpoint source loading associated with rain events, while exceedances at the lower flows can indicate point source problems.

D.1 Development of Flow Duration Curves

Flow duration curves are developed for a waterbody from daily discharges of flow over a period of record. In general, there is a higher level of confidence that curves derived from data over a long period of record correctly represent the entire range of flow. The preferred method of flow duration curve computation uses daily mean data from USGS continuous-record stations located on the waterbody of interest. For ungaged streams, alternative methods must be used to estimate daily mean flow. These include: 1) drainage area extrapolation of data from a nearby continuous-record station of similar size and topography; and 2) calculation of daily mean flow using a dynamic computer model, such as LSPC.

Flow duration curves for pathogen impaired waterbodies were derived from hydrologic simulations based on parameters derived from calibration at USGS Station No. 03475000, located on Middle Fork Holston River near Meadowview, Virginia. The data used included the period of record from 7/1/88 – 9/31/01. The flow duration curve for Beaver Creek at mile 0.1 (mouth) is shown in Figure D-1.

D.2 Development of Load Duration Curves

Fecal coliform and E. coli load duration curves were developed for Beaver Creek at the mouth from the flow duration curve developed in Section D.1 and available water quality monitoring data. Load duration curves were developed using the following procedure (Beaver Creek at the mouth, fecal coliform, is shown as an example):

1. Load-duration curves were generated for Beaver Creek at the mouth by applying the fecal coliform target concentration of 900 cts./100 mL (1,000 cts./100mL - MOS) to each of the ranked flows used to generate the flow duration curve (ref.: Section D.1) and plotting the results. The fecal coliform target load corresponding to each ranked daily mean flow is:

   $$(\text{Target Load})_{\text{Beaver Ck}} = (900 \text{ cts./100 mL}) \times (Q) \times (UCF)$$

   where: Q = daily mean flow
   UCF = the required unit conversion factor

   For E. coli, the target concentration of 847 cts./100 mL was applied to generate load duration curves corresponding to the E. coli water quality standard (see Section 5.0).

2. Daily loads were calculated for each of the water quality samples collected at the monitoring station (ref.: Table A-1) by multiplying the sample concentration by the derived daily mean flow for the sampling date and the required unit conversion factor.

   Note: 1) In order to be consistent for all analyses, the derived daily mean flow was used to compute sampling data loads, even if measured ("instantaneous") flow data was available for some sampling dates.

3. Using the flow duration curves developed in Step 1, the "percent of days the flow was exceeded" (PDFE) was determined for each sampling event. Each sample load was then plotted on the load duration curves developed in Step 2 according to the PDFE. The resulting fecal coliform and E. coli load duration curves for Beaver Creek at the mouth are shown in Figures D-2 and D-3.

4. For cases where the existing load exceeded the water quality standard, the reduction corresponding to each sample load was determined through comparison with the target load corresponding to the PDFE. The geometric means of the calculated reductions of existing fecal coliform load and E. coli load, respectively, required to meet the TMDL targets were considered to be the required load reductions for the Lower Beaver Creek, Tennessee, subwatershed (see Tables D-1 and D-2).

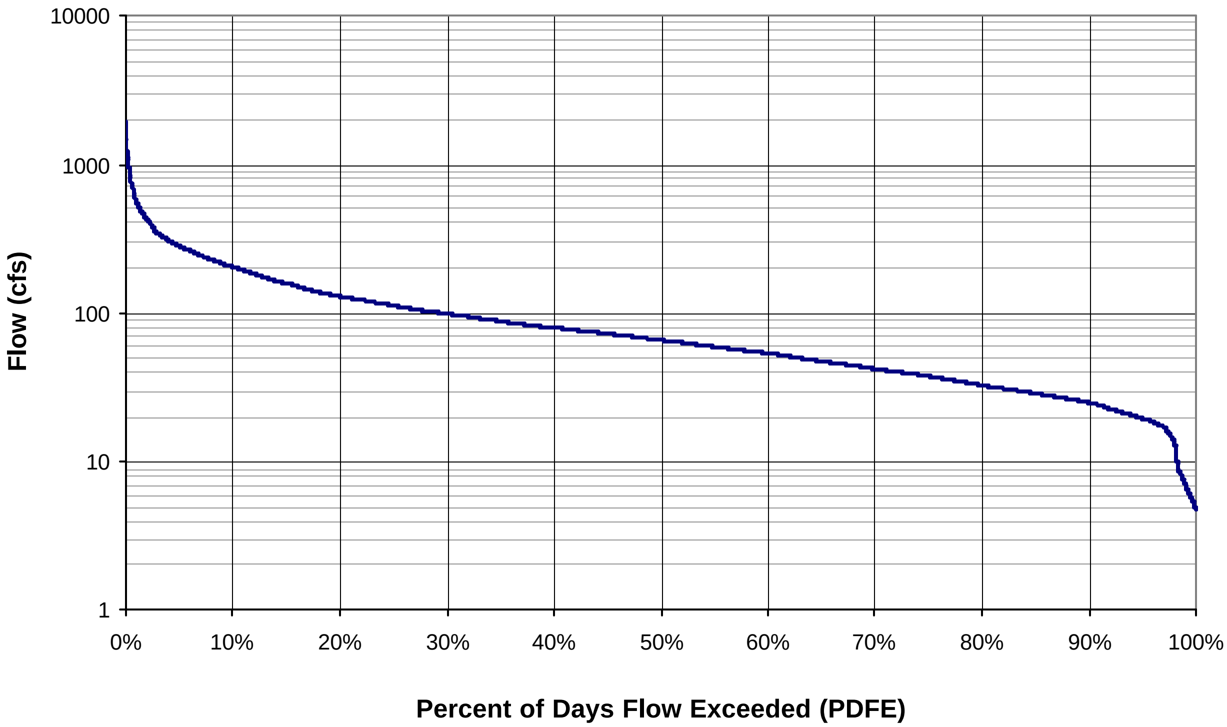


Figure D-1. Flow Duration Curve for Beaver Creek at the Mouth (mile 0.1)

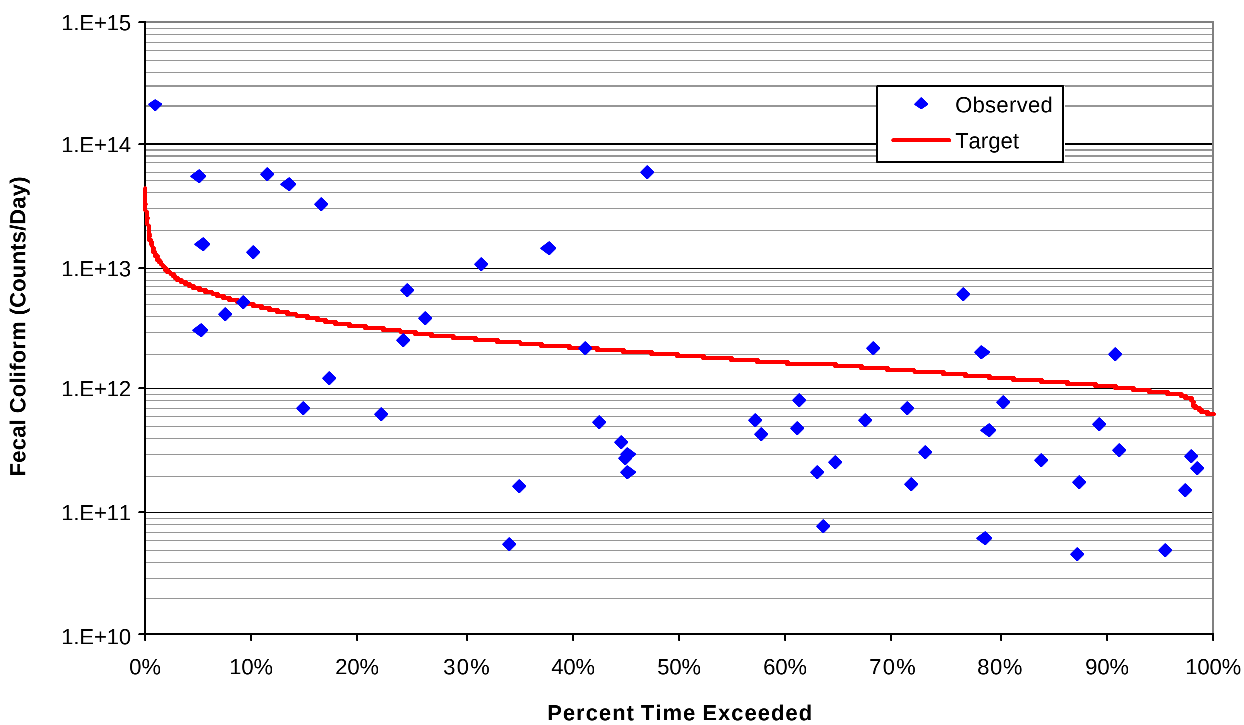


Figure D-2. Fecal Coliform Load Duration Curve for Beaver Creek at the Mouth (mile 0.1)

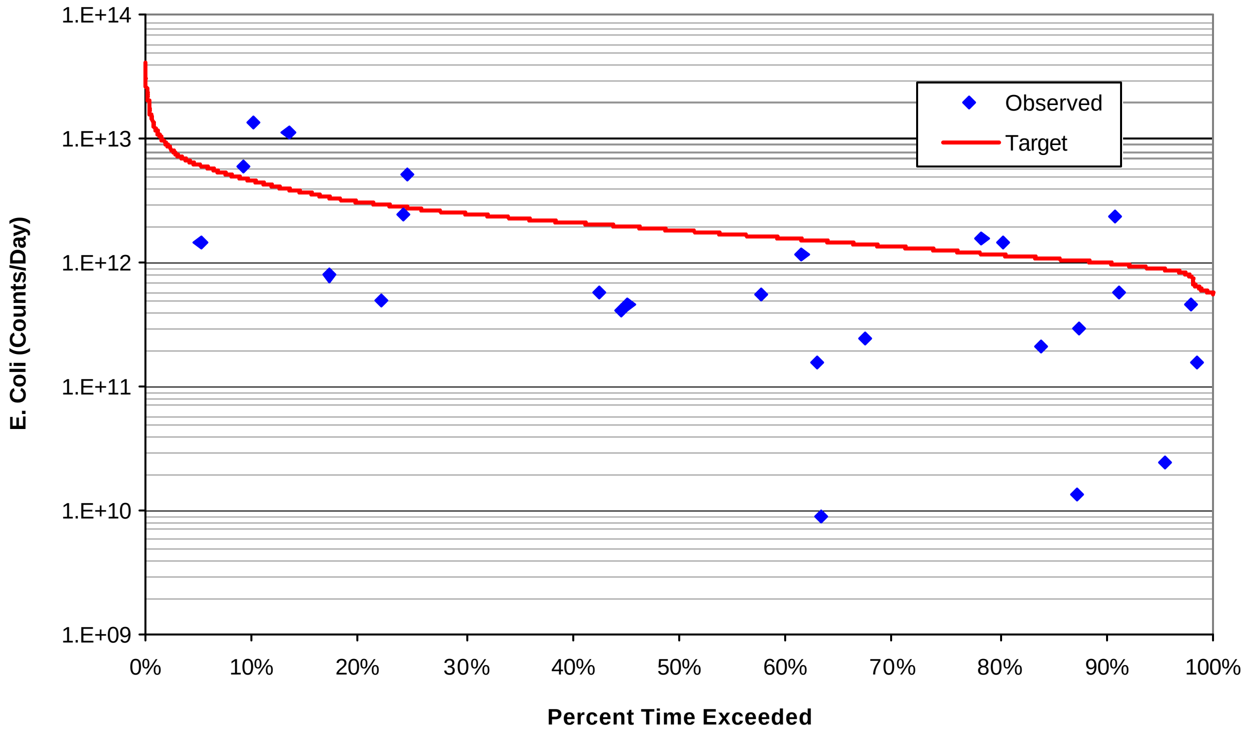


Figure D-3. E. Coli Load Duration Curve for Beaver Creek at the Mouth (mile 0.1)

Table D-1. Required Load Reduction for Beaver Creek at the Mouth (mile 0.1) – Fecal Coliform Analysis

Sample Date	Flow	PDFE	Fecal Coliform			
			Sample Conc.	Sample Load	Target Load	Required Load Reduction
	[cfs]	[%]	[cts/100 ml]	[cts/day]	[cts/day]	[%]
7/26/88	111.038	34.98%	60	1.630E+11	2.445E+12	**NR**
10/25/88	56.5	78.99%	330	4.562E+11	1.244E+12	**NR**
1/4/89	48.6	89.28%	430	5.111E+11	1.070E+12	**NR**
7/24/89	63.5	71.58%	110	1.710E+11	1.399E+12	**NR**
11/13/89	75.2	61.04%	264	4.858E+11	1.656E+12	**NR**
2/12/90	260	7.39%	660	4.193E+12	5.718E+12	**NR**
8/15/90	70.8	64.59%	150	2.597E+11	1.558E+12	**NR**
5/13/91	92.6	46.85%	26000	5.889E+13	2.038E+12	96.5
8/12/91	95.0	45.06%	120	2.791E+11	2.093E+12	**NR**
2/10/92	79.2	57.16%	290	5.621E+11	1.745E+12	**NR**
5/13/92	210	11.54%	11000	5.641E+13	4.616E+12	91.8
8/10/92	56.8	78.54%	44	6.119E+10	1.252E+12	**NR**
11/16/92	62.4	73.05%	200	3.055E+11	1.375E+12	**NR**
2/2/93	101	41.14%	890	2.195E+12	2.219E+12	**NR**
3/11/93	113	34.13%	20	5.509E+10	2.479E+12	**NR**
5/18/93	182	14.68%	160	7.112E+11	4.001E+12	**NR**
12/1/93	74.9	61.27%	440	8.066E+11	1.650E+12	**NR**
2/23/94	578	0.90%	14700	2.077E+14	1.272E+13	93.9
6/1/94	130	26.25%	1220	3.884E+12	2.865E+12	26.2
11/22/94	66.9	68.17%	1360	2.228E+12	1.474E+12	33.8
2/13/95	94.9	45.16%	126	2.926E+11	2.090E+12	**NR**
5/17/95	295	5.42%	2100	1.516E+13	6.498E+12	57.1
8/29/95	39.0	97.35%	160	1.528E+11	8.598E+11	**NR**
11/27/95	63.8	71.31%	440	6.872E+11	1.406E+12	**NR**
2/27/96	105	37.73%	5500	1.418E+13	2.320E+12	83.6
5/22/96	169	16.51%	7800	3.233E+13	3.730E+12	88.5
12/2/97	59.0	76.59%	4200	6.063E+12	1.299E+12	78.6
3/3/98	78.9	57.57%	224	4.323E+11	1.737E+12	**NR**
6/25/98	118	31.44%	3700	1.069E+13	2.600E+12	75.7
9/17/98	42.2	95.44%	48	4.953E+10	9.287E+11	**NR**
12/15/98	57.0	78.37%	1500	2.093E+12	1.256E+12	40.0
3/2/99	95.6	44.65%	160	3.743E+11	2.106E+12	**NR**
6/15/99	49.9	87.45%	146	1.784E+11	1.099E+12	**NR**
9/7/99	50.1	87.18%	38	4.658E+10	1.103E+12	**NR**
12/2/99	52.6	83.90%	210	2.703E+11	1.158E+12	**NR**
2/17/00	72.9	62.85%	120	2.140E+11	1.605E+12	**NR**
5/11/00	67.6	67.49%	340	5.622E+11	1.488E+12	**NR**
8/10/00	192	13.41%	10000	4.692E+13	4.223E+12	91.0

Table D-1. Required Load Reduction for Beaver Creek at the Mouth (mile 0.1) – Fecal Coliform Analysis (Cont.)

Sample Date	Flow	PDFE	Fecal Coliform			
			Sample Conc.	Sample Load	Target Load	Required Load Reduction
	[cfs]	[%]	[cts/100 ml]	[cts/day]	[cts/day]	[%]
11/28/00	46.6	91.13%	280	3.192E+11	1.026E+12	**NR**
3/7/01	98.4	42.53%	220	5.300E+11	2.168E+12	**NR**
6/26/01	144	21.96%	180	6.357E+11	3.179E+12	**NR**
7/17/01	72.2	63.34%	44	7.778E+10	1.591E+12	**NR**
7/17/02	55.3	80.24%	570	7.713E+11	1.218E+12	**NR**
8/20/02	47.0	90.80%	1700	1.955E+12	1.035E+12	47.1
9/11/02	31.7	98.42%	300	2.327E+11	6.981E+11	**NR**
10/23/02	37.1	97.91%	310	2.814E+11	8.170E+11	**NR**
11/13/02	224	10.15%	2400	1.315E+13	4.933E+12	62.5
1/15/03	94.8	45.25%	90	2.088E+11	2.088E+12	**NR**
2/18/03	298	5.26%	420	3.063E+12	6.563E+12	**NR**
3/12/03	164	17.29%	300	1.204E+12	3.612E+12	**NR**
4/15/03	234	9.22%	900	5.153E+12	5.153E+12	**NR**
5/12/03	136	24.50%	2000	6.656E+12	2.995E+12	55.0
6/25/03	137	24.19%	780	2.615E+12	3.017E+12	**NR**
8/12/03	303	5.01%	7500	5.561E+13	6.673E+12	88.0
				Geometric Mean		**64.8**

NR = Not Required

Table D-2. Required Load Reduction for Beaver Creek at the Mouth (mile 0.1) – E. Coli Analysis

Sample Date	Flow	PDFE	E. Coli			
			Sample Conc.	Sample Load	Target Load	Required Load Reduction
	[cfs]	[%]	[cts/100 ml]	[cts/day]	[cts/day]	[%]
3/3/98	78.9	57.57%	299	5.771E+11	8.453E+11	**NR**
9/17/98	42.2	95.44%	24	2.477E+10	4.520E+11	**NR**
12/15/98	57.0	78.37%	1120	1.563E+12	6.111E+11	24.4
3/2/99	95.6	44.65%	179	4.188E+11	1.025E+12	**NR**
6/15/99	49.9	87.45%	249	3.042E+11	5.351E+11	**NR**
9/7/99	50.1	87.18%	11	1.348E+10	5.369E+11	**NR**
12/2/99	52.6	83.90%	166	2.136E+11	5.637E+11	**NR**
2/17/00	72.9	62.85%	89	1.587E+11	7.811E+11	**NR**
5/11/00	67.6	67.49%	152	2.513E+11	7.242E+11	**NR**
8/10/00	192	13.41%	2419	1.135E+13	2.055E+12	65.0
11/28/00	46.6	91.13%	517	5.894E+11	4.993E+11	**NR**
3/7/01	98.4	42.53%	249	5.998E+11	1.055E+12	**NR**
6/26/01	144	21.96%	144	5.086E+11	1.547E+12	**NR**
7/17/01	72.2	63.34%	5	8.839E+09	7.743E+11	**NR**
7/17/02	55.3	80.24%	1090	1.475E+12	5.927E+11	22.3
8/20/02	47.0	90.80%	2110	2.427E+12	5.037E+11	59.9
9/11/02	31.7	98.42%	200	1.551E+11	3.397E+11	**NR**
10/23/02	37.1	97.91%	520	4.721E+11	3.976E+11	**NR**
11/13/02	224	10.15%	2430	1.332E+13	2.401E+12	65.1
12/3/02	74.6	61.49%	630	1.150E+12	7.995E+11	**NR**
1/15/03	94.8	45.25%	200	4.639E+11	1.016E+12	**NR**
2/18/03	298	5.26%	200	1.458E+12	3.194E+12	**NR**
3/12/03	164	17.29%	200	8.026E+11	1.758E+12	**NR**
4/15/03	234	9.22%	1080	6.184E+12	2.508E+12	21.6
5/12/03	136	24.50%	1610	5.358E+12	1.458E+12	47.4
6/25/03	137	24.19%	740	2.481E+12	1.468E+12	**NR**
				Geometric Mean		**39.1**

NR = Not Required

APPENDIX E

Determination of WLAs & LAs

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), nonpoint source loads (Load Allocations), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time, toxicity, or <u>other appropriate measure</u>.

For fecal coliform TMDLs in each impaired subwatershed, WLA terms include:

- $[\sum WLAs]_{WWTF}$ is the allowable load associated with discharges of NPDES permitted WWTFs located in impaired subwatersheds. Since NPDES permits for these facilities specify that treated wastewater must meet instream water quality standards at the point of discharge, no additional load reduction is required. WLAs for WWTFs are calculated from the facility design flow and the Monthly Average permit limit.

- $[\sum WLAs]_{CAFO}$ is the allowable load for all CAFOs in an impaired subwatershed. Since discharges from a CAFO liquid waste handling facility to waters of the state during a chronic or catastrophic rainfall event (in excess of a 25-year, 24-hour rainfall event), or as a result of an unpermitted discharge, upset, or bypass of the system, are not to cause or contribute to an exceedance of Tennessee water quality standards, the WLA = 0.

- $[\sum WLAs]_{MS4}$ is the required load reduction for discharges from MS4s. Fecal coliform loading from MS4s is the result of buildup/wash-off processes associated with storm events. The percent load reductions for MS4s are considered to be equal to the load reductions developed for TMDLs.

LA terms include:

- $[\sum LAs]_{DS}$ is the allowable fecal coliform load from "other direct sources". These sources include leaking septic systems, leaking collection systems, illicit discharges, and animals access to streams. The LA specified for all sources of this type is zero counts/day (or to the maximum extent practicable).

- $[\sum LAs]_{SW}$ represents the required reduction in fecal coliform loading from nonpoint sources indirectly going to surface waters from all land use areas (except areas covered by a MS4 permit) as a result of the buildup/wash-off processes associated with storm events. The percent load reductions for precipitation-induced nonpoint sources are considered to be equal to the load reductions developed for TMDLs (and specified for MS4s).

Explicit MOS has already been incorporated into TMDL development as stated in Appendix C & Appendix D. TMDLs, WLAs, & LAs are applied to the entire HUC-12 subwatershed. WLAs & LAs for Lower Beaver Creek, Tennessee, are summarized in Table E-1.

Table E-1. WLAs & LAs for Beaver Creek, Tennessee

Impaired Waterbody	HUC-12 Subwatershed (06010102____)	WLAs					LAs	
		WWTFs[a] (Monthly Avg.)		Leaking Collection Systems[b]	CAFO	MS4s[c]	Precipitation Induced Nonpoint Sources	Other Direct Sources[d]
		Fecal Coliform	E. Coli					
		[cts./day]	[cts./day]	[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
Beaver Creek at the Mouth (mile 0.1)	**0502**	**1.136×10^8**	**7.157×10^7**	**0**	**NA**	**66.5**	**66.5**	**0**

Note: NA = Not applicable.

a. WLAs for WWTFs expressed as fecal coliform and E. coli loads (counts/day).

b. The objective for leaking collection systems is a waste load allocation of zero. It is recognized, however, that a WLA of 0 counts/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in coliform loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for pathogens.

c. Applies to any MS4 discharge loading in the HUC-12 subwatershed.

d. The objective for all "other direct sources" is a load allocation of zero. It is recognized, however, that for leaking septic systems a LA of 0 counts/day may not be practical. For these sources, the LA is interpreted to mean a reduction in coliform loading by the application of best management practices, consistent with the requirement that these sources not contribute to a violation of the water quality standard for pathogens.

APPENDIX F

Public Notice of Proposed Total Maximum Daily Loads (TMDLs) for Pathogens in the South Fork Holston River Watershed (HUC 06010102)

DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR PATHOGENS IN THE SOUTH FORK HOLSTON RIVER WATERSHED (HUC 06010102), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed total maximum daily load (TMDL) for pathogens in the South Fork Holston River watershed, located in northeast Tennessee. Section 303(d) of the Clean Water Act requires states to develop TMDLs for waters on their impaired waters list. TMDLs must determine the allowable pollutant load that the water can assimilate, allocate that load among the various point and nonpoint sources, include a margin of safety, and address seasonality.

Beaver Creek is listed on Tennessee's final 1998 303(d) list and Final 2002 303(d) list as not supporting designated use classifications due, in part, to discharge of pathogens from pasture land, urban runoff/storm sewers, and sources outside state borders. The TMDL utilizes Tennessee's general water quality criteria, recently collected site specific water quality data, continuous flow data from a USGS discharge monitoring station located in proximity to the watershed, and a calibrated dynamic water quality model to establish allowable loadings of pathogens which will result in reduced in-stream concentrations and attainment of water quality standards. The TMDL requires reductions on the order of 66.5% for the Beaver Creek watershed.

The proposed South Fork Holston River pathogen TMDL can be downloaded from the following website:

http://www.state.tn.us/environment/wpc/tmdl/

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Pollution Control staff:

Dennis M. Borders, P.E., Watershed Management Section
Telephone: 615-532-0706

Sherry H. Wang, Ph.D., Watershed Management Section
Telephone: 615-532-0656

Persons wishing to comment on the proposed TMDL are invited to submit their comments in writing no later than August 23, 2004 to:

Division of Water Pollution Control
Watershed Management Section
7th Floor L & C Annex
401 Church Street
Nashville, TN 37243-1534

All comments received prior to that date will be considered when revising the TMDL for final submittal to the U.S. Environmental Protection Agency.

The TMDL and supporting information are on file at the Division of Water Pollution Control, 7th Floor L & C Annex, 401 Church Street, Nashville, Tennessee. They may be inspected during normal office hours. Copies of the information on file are available on request.

APPENDIX G

Public Comments Received

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August 23, 2004

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Dennis M. Borders, P.E.
Division of Water Pollution Control
Watershed Management Section
401 Church Street
L & C Annex, 7th Floor
Nashville, TN 37243-1534

Re: Proposed Total Maximum Daily Load (TMDL)
For Pathogens
South Fork Holston River Watershed (HUC 06010102)

Dear Mr. Borders:

We are writing this letter on behalf of the Cities of Bristol, Tennessee, and Bristol, Virginia, to present the Cities' comments relating to the above referenced TMDL. The comments are as follows:

1. On page vii, the water quality goal includes the fecal coliform standard from an outdated State of Tennessee Water Quality Standards. Since the new General Water Quality Criteria, January 2004, does not include a fecal coliform standard, it should not be a goal of this TMDL. Technical experts and the Environmental Protection Agency agree that the fecal coliform test is a poor indicator of pathogenic pollution. The goal of the TMDL should be based upon the E. coli test.
2. Similarly in Section 5.0 on page 5, the stated goal includes the old fecal coliform standard. As discussed in #1 above, the TMDL goal should not include fecal coliform.
3. On page 7 in Section 5.0, the titles to Tables 2 and 3 indicate that the tables refer to pathogens, yet both tables include references to Nutrients. The reference to Nutrients should be removed.
4. Similar to the comments #1 & #2 above, the paragraph at the top of page 9 should be modified to omit fecal coliform as a stated goal of the TMDL.

Mr. Dennis M. Borders
August 23, 2004
Page 2

5. In Section 7.1.1 on page 11, the second paragraph indicates that the collection system of Bristol, TN and Bristol, VA "has historically been a significant contributor to coliform impairment in the Beaver Creek watershed." There appears to be no data to support that the sewer system overflows that periodically occur in the watershed are "significant" contributors to coliform impairment. Many of the overflows occur during wet weather events when the overflow is diluted and flows in Beaver Creek are elevated. In fact, studies of Beaver Creek performed by the cities in the early 80's indicated that even combined system overflows (that are now eliminated) were difficult to isolate as significant coliform contributors. Furthermore, approximately 56% of the overflows reported are outside of the Beaver Creek drainage basin and have no direct effect on Beaver Creek's water quality. The word "significant" should be omitted from this sentence.
6. In Section 7.2.1 Wildlife on page 14, the report indicates that the coliform contribution from wildlife is estimated by doubling the estimated number of deer. This estimate may significantly underestimate the contribution from wildlife given the number of ducks, geese, beaver, raccoon, muskrat, mice, other birds, and other mammals in the area. The waterfowl, in particular, have a better chance of depositing fecal material directly in the creek and have coliform production per animal per day greater than that of deer.
7. The required load reduction of 66.5% listed in Table 8 on page 20 is based on fecal coliform modeling. This may be influenced considerably by false positive readings that frequently occur in the fecal coliform test. The TMDL should use E. coli for this waste load reduction.
8. In Section 9.1.1 on page 22, fecal coliform permit excursions from the Bristol STP #2 discharge are referenced. Improvements to the treatment plant's disinfection system are stated to have been completed in 2001. These improvements were actually completed in June of 1999 at a cost of approximately $1.2 million. Since completion of this project the cities have significantly improved compliance with the fecal permit limit. Considering Bristol's treatment facility does not discharge to Beaver Creek, but to the South Holston River, effluent data is not relevant to this TMDL. Please remove the reference to any permit excursions associated with the plant effluent.
9. In Section 9.1.1 on page 22, the paragraph indicates "the collection system continues to be **plagued** by wet weather overflows". Of the bypasses/overflows reported in accordance with the permit, only 26% occurred in the Beaver Creek watershed during the December 1999 to September 2003 period and 44% occurred during the May 1995 to September 2003 period. The TDML should accurately present this information. Also with all of the collection system improvements the cities have completed involving reduction of overflows, this language is overly harsh. The recently completed surge basin project, at a cost of $2.8 million, has greatly reduced overflows at the Main Lift Station and mitigated I/I impact to the treatment facility. Please replace the words "be plagued by" with "have".

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10. In Section 9.1.2 on page 23, the last paragraph indicates, "...this TMDL document will require effluent or instream monitoring...". The TMDL itself cannot require much of anything and it is not clear that the Small MS4 permit requires any instream monitoring.
11. The TMDL would benefit by including fecal coliform and E. coli data from a stream segment that is not impacted by agricultural, urban or other man-made influences.

Very truly yours,

R. Scott Heflinger, P.E.

pc: Mr. Bill Sorah
Mr. Matthew Dake
Mr. John Bowling

APPENDIX H

Response to Public Comments

<u>Responses to the Cities of Bristol, Tennessee and Bristol, Virginia Comments</u>

Note: responses correspond to numbered comments (see Appendix G)

1. The use of the fecal coliform standard for development of pathogen TMDLs is consistent with EPA's pathogen TMDL protocol and Tennessee's current methodology. There is a larger data set over a longer period of record for fecal coliform relative to E. coli on Beaver Creek at the mouth, providing for a more thorough and detailed analysis. Many impaired streams in Tennessee have little or no available E. coli data for TMDL analyses. In addition, the dual standard methodology ensures that pathogen TMDLs developed in Tennessee are not less protective than those developed in the past.

2. See # 1 above.

3. Tables 2 and 3 are informational in nature and present the complete 303(d) listing and assessment information, respectively, for Beaver Creek. The reference to Table 2 in the first paragraph of Section 4.0, page 4, has been edited and the title of Table 2 has been changed to provide clarification.

4. See # 1 above.

5. Actually, the data support the presumption that overflows are significant contributors to loading and subsequent exceedances of maximum daily (instantaneous) in-stream pathogen standards during wet weather overflow events. A plot of fecal coliform vs. flow for the period July 1989 – July 2001 (see Figure 1) indicates a direct relationship between flow and concentration: as flow increases, concentration increases. In addition, when hydrograph separation is conducted on Beaver Creek simulated flow data, analyses of samples indicates that most exceedances occur during stormflow events (see Figure 2).

   Section 7.1.1, page 11, has been changed to "…has historically been a significant source of coliform loading to the Beaver Creek watershed during these overflow events."

6. Only source identification will confirm this. The State of Virginia conducted bacteria source tracking (BST) at the state line in conjunction with their Beaver Creek bacteria TMDL; however, they apparently did not differentiate wildlife by species (or did not report results). The Division of Water Pollution Control encourages the Cities of Bristol, Tennessee and Bristol, Virginia to conduct BST and/or other source identification activities to support appropriate BMP implementations to reduce pathogen loading in Beaver Creek.

7. See # 1 above.

8. Comment noted. The references to effluent water quality and related permit excursions have been eliminated.

9. Section 9.1.1 has been edited to remove the word "plagued" from the text.

10. The City of Bristol, Tennessee has been issued coverage under the General Permit for Small Municipal Separate Storm Sewer Systems, permit number TNS075183. The following are excerpts from the general permit:

3. SPECIAL CONDITIONS

3.1 Discharges to Water Quality Impaired Waters

3.1.1 Applicability: You must:

3.1.1.1 ***Determine whether storm water discharge from any part of the MS4 significantly contributes directly or indirectly to a 303(d) listed (i.e., impaired) waterbody.*** Water quality impaired waters means any segment of surface waters that has been identified by the division as failing to support classified uses***. If you have discharges meeting these criteria, you must comply with Part 3.1.1.2 and 3.1.2***; if you do not, the remainder of this Part 3.1 does not apply to you.

3.1.1.2 ***If you have "303(d)" discharges described above, you must also determine whether a Total Maximum Daily Load (TMDL) has been developed by the division and approved by EPA for the listed waterbody.*** If there is a TMDL, you must comply with both Parts 3.1.2 and 3.1.3; if no TMDL has been approved, ***Part 3.1.3 does not apply until a TMDL has been approved.***

3.1.2 Water Quality Controls for Discharges to Impaired Waterbodies. The storm water management program review submitted to the division must include a section describing how your program will control the discharge of the pollutants of concern. This section must identify the measures and BMPs that will collectively control the discharge of the pollutants of concern. The measures should be presented in order of priority with respect to controlling the pollutants of concern.

3.1.3 ***Consistency with Total Maximum Daily Load (TMDL). If a TMDL has been approved for any waterbody into which you discharge, you must follow the procedure below and report on these activities in annual reports to the division:***

3.1.3.1 Determine whether the approved TMDL is for a pollutant likely to be found in storm water discharges from your MS4.

3.1.3.2 ***Determine whether the TMDL includes a pollutant wasteload allocation (WLA), implementation recommendations, or other performance requirements specifically for storm water discharges from your MS4.***

3.1.3.3 Determine whether the TMDL addresses a flow regime likely to occur during periods of storm water discharge.

3.1.3.4 ***After the determinations above have been made and if it is found that your MS4 must implement specific provisions of the TMDL, evaluate whether the implementation of existing storm water control measures is meeting the TMDL provisions, or if additional control measures are necessary.***

3.1.3.5 Document all control measures currently being implemented or planned to be implemented. Include a schedule of implementation for all planned controls. ***Provide your rationale (e.g., calculations, assessments, reports and/or other evidence) that shows that you will comply with the TMDL provisions***.

For control measures that are expected to be implemented and evaluated beyond the term of this permit, you should also include longer schedule of implementation as necessary to describe the control measure.

3.1.3.6 ***Describe a method to evaluate whether the storm water controls are adequate to meet the requirements of the TMDL.***

3.1.3.7 If the evaluation shows that additional or modified controls are necessary, describe the type and schedule for the control additions/revisions.

Note, in particular, the bolded, italicized portions of the above excerpts. Section 3.1.3.2 specifically addresses TMDL implementation recommendations and Section 3.1.3.6 requires a method to evaluate whether storm water controls are adequate to meet the requirements of the TMDL. The fundamental requirement of the TMDL is improvement of water quality such that Beaver Creek supports its designated use classifications. Effluent or in-stream monitoring is the only method for documenting improvement in water quality and attainment of water quality standards.

11. The following table provides a summary of water quality data collected from ecoregion sites in the Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f) level IV ecoregion in Tennessee:

	Fecal Coliform	E. coli
Number of data points	63	42
Mean	162	132
Median	64	41

Ecoregion sites are reference streams chosen to represent the best attainable conditions for all streams with similar characteristics in a given subregion (TDEC, 2000). Reference condition represents a set of expectations for physical habitat, general water quality, and the health of biological communities in the absence of human disturbance and pollution. Selection criteria for reference sites included minimal impairment and representativeness.

No ecoregion sites were available in the Southern Dissected Ridges and Knobs (67i) level IV ecoregion.

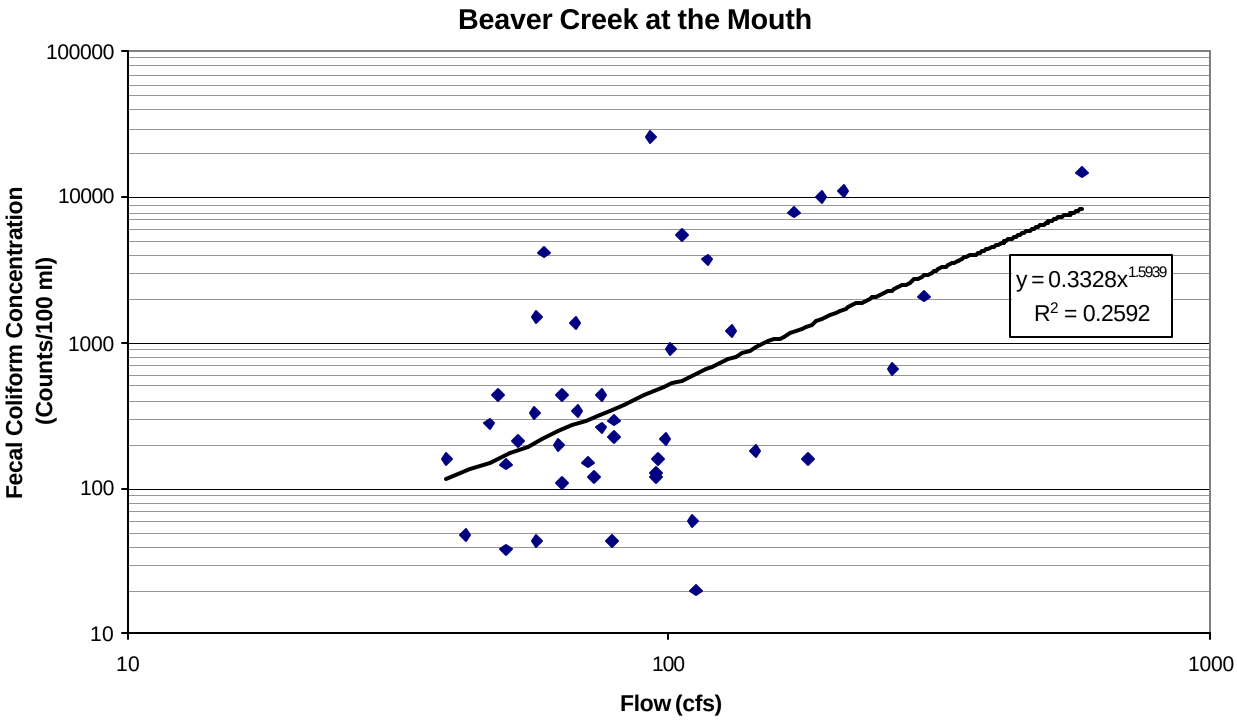

Figure 1.

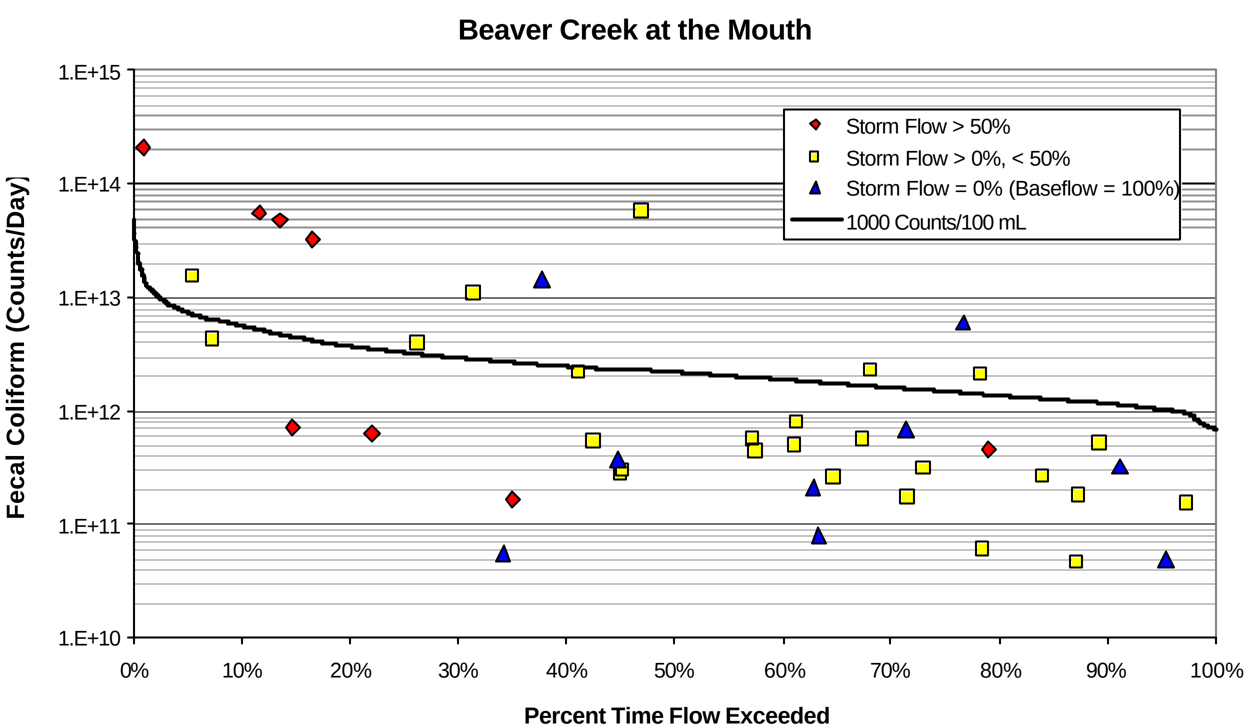

Figure 2.