TOTAL MAXIMUM DAILY LOAD (TMDL)

for

Pathogens

in the

Hiwassee River Watershed (HUC 06020002)

Bradley, Hamilton, McMinn, Meigs, Monroe,

Polk, and Rhea Counties, Tennessee

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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
DWPC	Division of Water Pollution Control
E. coli	Escherichia coli
EPA	Environmental Protection Agency
FCLES	Fecal Coliform Loading Estimation Spreadsheet
GIS	Geographic Information System
HSPF	Hydrological Simulation Program - Fortran
HUC	Hydrologic Unit Code
LA	Load Allocation
LDC	Load Duration Curve
LSPC	Loading Simulation Program in C^{++}
MGD	Million Gallons per Day
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
MS4	Municipal Separate Storm Sewer System
MST	Microbial Source Tracking
NMP	Nutrient Management Plan
NOV	Notice of Violation
NPS	Nonpoint Source
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PCR	Polymerase Chain Reaction
PDFE	Percent of Days Flow Exceeded
PFGE	Pulsed Field Gel Electrophoresis
Rf3	Reach File v.3
RILR	Required In-stream Load Reduction
RM	River Mile
SSO	Sanitary Sewer Overflow
STP	Sewage Treatment Plant
SWMP	Storm Water Management Program
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
UCF	Unit Conversion Factor
USDA	United States Department of Agriculture
UWA	Unified Watershed Assessment
WCS	Watershed Characterization System
WLA	Waste Load Allocation
WQS	Water Quality Standard
WWTF	Wastewater Treatment Facility

SUMMARY SHEET

Total Maximum Daily Load for Pathogens in Selected Waterbodies of the Hiwassee River Watershed (HUC 06020002)

Impaired Waterbody Information

State: Tennessee
Counties: Bradley, McMinn, Meigs, Monroe, and Polk
Watershed: Hiwassee River (HUC 06020002)
Constituents of Concern: Pathogens

Impaired Waterbodies Addressed in This Document:

Waterbody ID	Waterbody	RM not Fully Supporting
TN06020002001 – 0100	AGENCY CREEK	32.7
TN06020002008 – 1000	HIWASSEE RIVER	7.7
TN06020002009 – 0200	FILLAUER CREEK	7.4
TN06020002009 – 0300	WOOLEN MILL BRANCH	3.92
TN06020002009 – 2000	SOUTH MOUSE CREEK	6.5
TN06020002012 – 0200	LITTLE CHATATA CREEK	14.3
TN06020002012 – 1000	CHATATA CREEK	19.62
TN06020002018 – 0100	HAWKINS BRANCH	1.86
TN06020002018 – 0200	DAIRY BRANCH	1.78
TN06020002082 – 0200	LITTLE CHESTUEE CREEK	13.3
TN06020002082 – 2000	CHESTUEE CREEK	17.9
TN06020002083 – 1000	OOSTANAULA CREEK	5.7
TN06020002083 – 2000	OOSTANAULA CREEK	21.1
TN06020002083 – 3000	OOSTANAULA CREEK	7.4
TN06020002083 – 4000	OOSTANAULA CREEK	8.5
TN06020002083 – 5000	OOSTANAULA CREEK	6.2
TN06020002084 – 1000	NORTH MOUSE CREEK	38.36
TN06020002085 – 1000	SPRING CREEK	33.8
TN06020002087 – 1000	ROGERS CREEK	21.6
TN06020002088 – 1000	PRICE CREEK	6.9

Designated Uses:

The designated use classifications for all impaired waterbodies in the Hiwassee River watershed include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. Use classifications for Hiwassee River from the mouth to mile 23.9, Oostanaula Creek from the mouth to mile 37.5, North Mouse Creek from the mouth to mile 30.1, and Spring Creek include industrial water supply. Use classifications for Hiwassee River from the mouth to mile 23.9, Oostanaula Creek from the mouth to mile 26.0, Oostanaula Creek from mile 33.8 to mile 37.5, and North Mouse Creek from the mouth to mile 10.0 include domestic water supply. Lastly, use classifications for Hiwassee River from the mouth to mile 23.9 include navigation.

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. 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.

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 Final 2004 303(d) list as impaired due to E. coli. TMDLs are developed for impaired waterbodies on a HUC-12 or smaller subwatershed basis. For Oostanaula Creek, the TMDL analysis was revised due to the availability of new data. This revised TMDL supersedes the Fecal Coliform TMDL approved by EPA in 2002.

Analysis/Methodology:

The Hiwassee River watershed TMDLs were developed using three methodologies (below) to assure compliance with the E. Coli 126 counts/100 mL geometric mean and 941 counts/100 mL maximum standards while also incorporating the fecal coliform 200 counts/100 mL geometric mean and 1,000 counts/100 mL maximum concentration as surrogates. Fecal coliform data were used to support a landuse process-based modeling effort where best professional judgment deemed it appropriate.

Dynamic Loading Model Method
The Loading Simulation Program C++ (LSPC) was used to simulate the buildup and washoff of the surrogate 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 surrogate fecal coliform target concentrations (standard - MOS) calculated for impaired subwatersheds.

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 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 E. coli and the surrogate fecal coliform (standard - MOS).

Geometric Mean Method
For waterbodies with samples collected at sufficient number and frequency (minimum of 5 samples in a 30 day period), load reductions were determined by simple calculation of the geometric mean to meet the 30-day geometric mean target concentrations for E. coli and the surrogate fecal coliform (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 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

Drainage Area and/or HUC-12 Subwatershed (03150101__)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs[a] (Monthly Avg.) E. Coli	Leaking Collection Systems[b]	CAFOs	MS4s[c]	Precipitation Induced Nonpoint Sources	Other Direct Sources[d]
			[% Red.]	[cts./day]	[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
Agency Creek (0605)	Agency Creek	TN06020002001 – 0100	**96.0**	**NA[e]**	**NA**	**NA**	**NA**	**96.0**	**0**
0602	Hiwassee River	TN06020002008 – 1000	**65.9**	**1.636×10^{11}**	**0**	**NA**	**NA**	**65.9**	**0**
0603	Fillauer Creek	TN06020002009 – 0200	**>92.4**	**NA[e]**	**0**	**NA**	**>85.7**	**>85.7**	**0**
	Woolen Mill Branch	TN06020002009 – 0300		**NA[e]**	**0**	**NA**	**>65.0**	**>65.0**	**0**
	South Mouse Creek	TN06020002009 – 2000		**9.542×10^{5}**	**0**	**NA**	**>92.4**	**>92.4**	**0**
Little Chatata Creek (0601)	Little Chatata Creek	TN06020002012 – 0200	**87.2**	**NA[e]**	**0**	**NA**	**87.2**	**87.2**	**0**
Chatata Creek (0601)	Chatata Creek	TN06020002012 – 1000	**92.7**	**NA[e]**	**0**	**NA**	**92.7**	**92.7**	**0**
Hawkins Branch (0305)	Hawkins Branch	TN06020002018 – 0100	**90.2**	**NA[e]**	**NA**	**NA**	**NA**	**90.2**	**0**
Dairy Branch (0305)	Dairy Branch	TN06020002018 – 0200	**92.9**	**NA[e]**	**NA**	**NA**	**NA**	**92.9**	**0**
0501	Little Chestuee Creek	TN06020002082 – 0200	**89.5**	**NA[e]**	**NA**	**NA**	**NA**	**89.5**	**0**
	Chestuee Creek	TN06020002082 – 2000		**1.193×10^{9}**	**0**	**NA**	**NA**	**87.9**	**0**
0702	Oostanaula Creek	TN06020002083 – 1000	**72.2**	**1.350×10^{10}**	**0**	**0**	**NA**	**17.8**	**0**
	Oostanaula Creek	TN06020002083 – 2000		**1.350×10^{10}**	**0**	**NA**	**38.4**	**38.4**	**0**
	Oostanaula Creek	TN06020002083 – 3000		**1.350×10^{10}**	**0**	**NA**	**72.2**	**72.2**	**0**
0701	Oostanaula Creek	TN06020002083 – 4000	**54.2**	**NA[e]**	**0**	**NA**	**54.2**	**54.2**	**0**
	Oostanaula Creek	TN06020002083 – 5000		**NA[e]**	**NA**	**NA**	**NA**	**54.2**	**0**

Summary of TMDLs, WLAs, & LAs for Impaired Waterbodies (Cont.)

HUC-12 Subwatershed (06020002__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs[a] (Monthly Avg.) E. Coli	Leaking Collection Systems[b]	CAFOs	MS4s[c]	Precipitation Induced Nonpoint Sources	Other Direct Sources[d]
			[% Red.]	[cts./day]	[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
0801	North Mouse Creek	TN06020002084 – 1000	**84.3**	**2.018×10^9**	**0**	**0**	**84.3**	**84.3**	**0**
0802	North Mouse Creek	TN06020002084 – 1000	**84.3**	**7.839×10^9**	**0**	**0**	**84.3**	**84.3**	**0**
0803	Spring Creek	TN06020002085 – 1000	**87.8**	**8.109×10^7**	**NA**	**NA**	**NA**	**87.8**	**0**
0604	Rogers Creek	TN06020002087 – 1000	**90.0**	**5.735×10^7**	**NA**	**NA**	**NA**	**90.0**	**0**
Price Creek (0605)	Price Creek	TN06020002088 – 1000	**81.9**	**5.247×10^9**	**0**	**NA**	**NA**	**81.9**	**0**

Note: NA = Not applicable.
a. WLAs for WWTFs expressed as 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 E. coli.
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 E. coli.
e. Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permit.

PATHOGEN TOTAL MAXIMUM DAILY LOAD (TMDL)
HIWASSEE RIVER WATERSHED (HUC 06020002)

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 waterbodies in the Hiwassee River Watershed identified on the Final 2004 303(d) list as not supporting designated uses due to Escherichia coli (E. coli). Portions of the Hiwassee Watershed lie in Tennessee, Georgia, and North Carolina. This document addresses only impaired waterbodies in Tennessee. TMDL analyses are performed primarily on a 12-digit hydrologic unit area (HUC-12) basis. In some cases, where appropriate, TMDLs are developed for an impaired waterbody drainage area only.

Oostanaula Creek, with a Fecal Coliform TMDL developed and approved by EPA in 2002, has been revised based on recent monitoring data. Oostanaula Creek represents five of the E. coli-impaired waterbody segments on the Final 2004 303(d) List. Therefore, this TMDL document presents the analyses of 20 E. coli-impaired waterbody segments.

3.0 WATERSHED DESCRIPTION

The Hiwassee River watershed (HUC 06020002) is located in Southeast Tennessee (Figure 1) and lies within the Level III Ridge and Valley (67) and Blue Ridge Mountains (66) ecoregions. The impaired subwatersheds lie in the Level IV Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f), Southern Shale Valleys (67g), and Southern Dissected Ridges and Knobs (67i) ecoregions as shown in Figure 2 (USEPA, 1997):

- Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f) is a heterogeneous ecoregion composed predominantly of limestone and cherty dolomite. Landforms include undulating valleys as well as low rolling hills and ridges, with elevations ranging from 700 feet in the south to 2000 feet on the highest hills in the north. The soils are variable in productivity and landcover ranges from areas of intensive agriculture to thick forest. Most of the Ridge and Valley's urban areas are located in 67f.

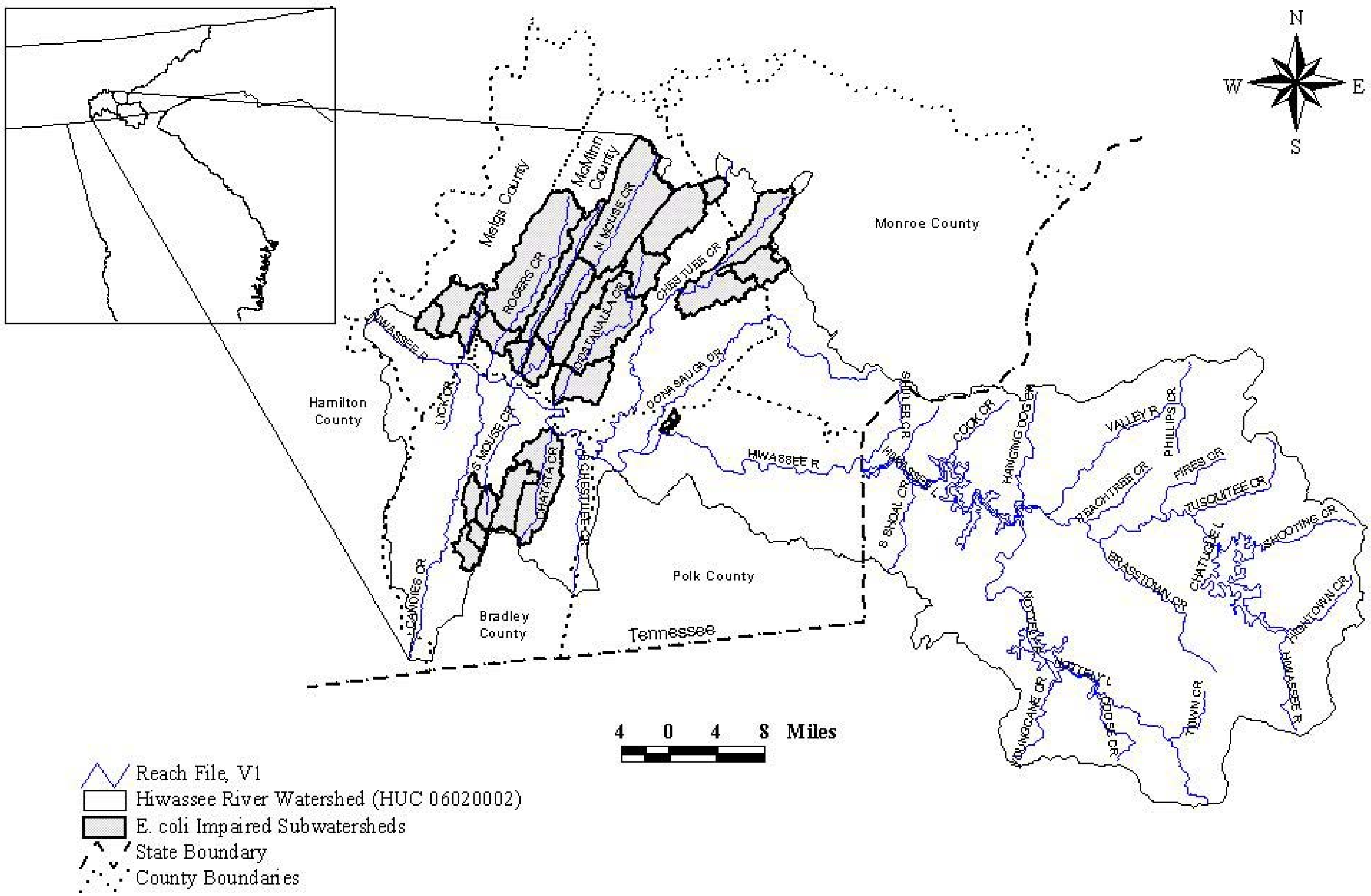

Figure 1. Location of the Hiwassee River Watershed and E. coli Impaired Subwatersheds.

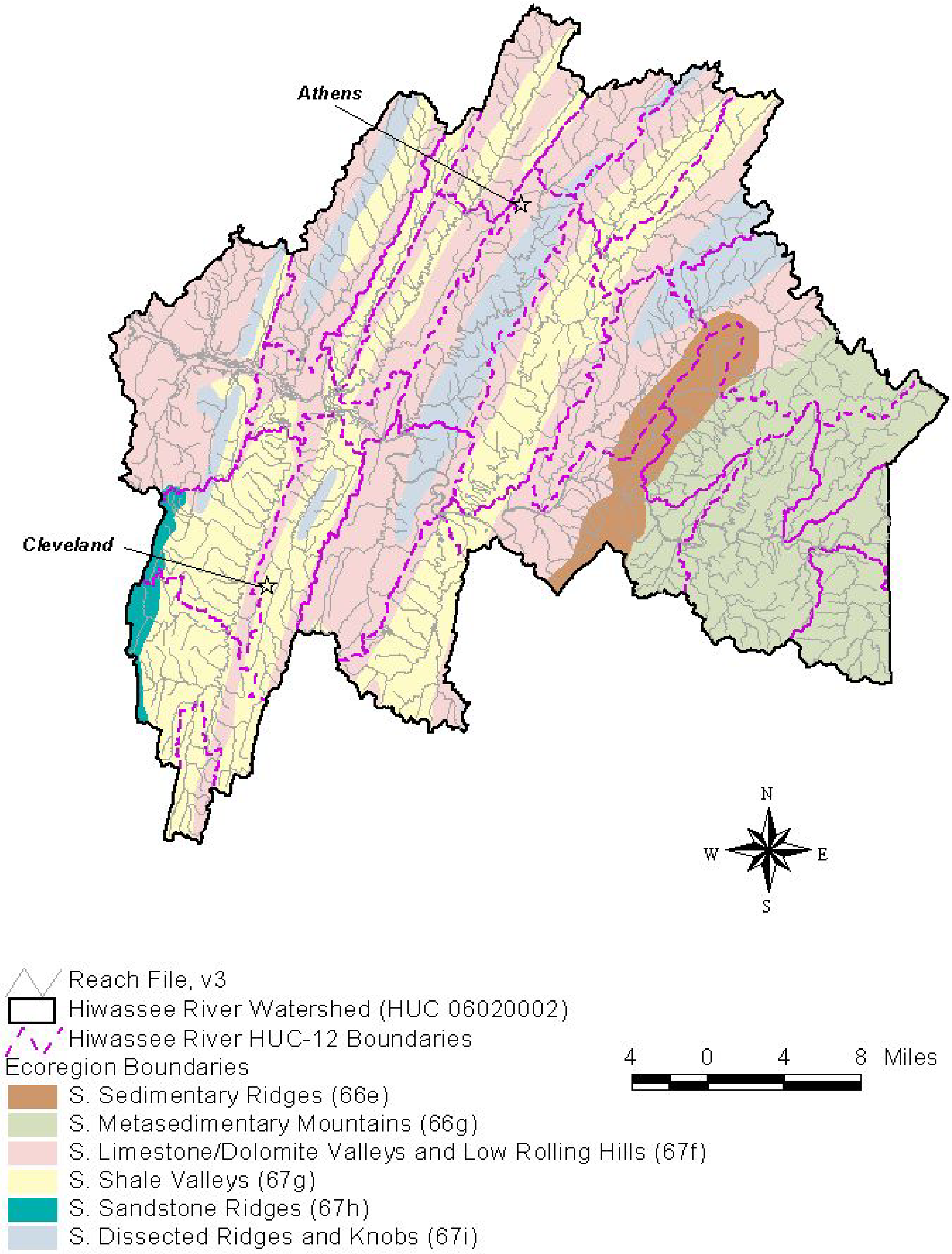

Figure 2. Level IV Ecoregions in the Hiwassee River Watershed

- Southern Shale Valleys (67g) consists of lowlands, rolling valleys, and some slopes and hilly areas that are dominated by fine-grained rock, primarily shale. Local relief is generally 100-400 feet. Soils are slightly acidic or neutral, well drained or excessively drained. The steeper slopes in the ecoregion are used for pasture or have reverted to brush and forested land, while hay and crops are grown on the foot slopes and bottom land.

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

The Hiwassee River watershed, located in Bradley, Hamilton, McMinn, Meigs, Monroe, Polk, and Rhea Counties, Tennessee, has a drainage area of approximately 1007 square miles (mi^2) in Tennessee. Watershed land use distribution is based on the Multi-Resolution Land Characteristic (MRLC) databases derived from Landsat Thematic Mapper digital images from the period 1990-1993. Although changes in the land use of the Hiwassee River watershed have occurred since 1993 as a result of development, this is the most current land use data available. Land use for the Hiwassee River watershed is summarized in Table 1 and shown in Figure 3. Predominate land use in the Hiwassee River watershed is forest (73.1%) followed by agriculture (22.9%). Urban areas represent approximately 3.2% of the total drainage area of the watershed. Details of land use distribution of E. coli-impaired subwatersheds in the Hiwassee River watershed are presented in Appendix A.

4.0 PROBLEM DEFINITION

The State of Tennessee's Final 2004 303(d) list (TDEC, 2005) was approved by the U.S. Environmental Protection Agency (EPA), Region IV in August of 2005. The list identified 20 waterbody segments in the Hiwassee River watershed as not fully supporting designated use classifications due to Escherichia coli (E. coli), a pathogen indicator. The designated use classifications for these waterbodies include fish and aquatic life, irrigation, livestock watering & wildlife, recreation, industrial water supply, domestic water supply and navigation.

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 E. coli and fecal coliform groups are indicators of the presence of pathogens in a stream.

The waterbody segments listed in Table 2 were 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

Table 1. MRLC Land Use Distribution – Hiwassee River Watershed

Land Use	Area	
	[acres]	[%]
Deciduous Forest	200,723	31.1
Emergent Herbaceous Wetlands	1,116	0.2
Evergreen Forest	124,565	19.3
High Intensity Commercial/ Industrial/Transportation	4,450	0.7
High Intensity Residential	1,617	0.3
Low Intensity Residential	8,882	1.4
Mixed Forest	137,160	21.3
Open Water	5,512	0.9
Other Grasses (Urban/recreational)	3,766	0.6
Pasture/Hay	118,188	18.3
Quarries/Strip Mines/ Gravel Pits	317	0.0*
Row Crops	29,476	4.6
Transitional	4,905	0.8
Woody Wetlands	3,861	0.6
Total	**644,538**	**100.00**

* < 0.05%

5.0 WATER QUALITY GOAL

As previously stated, the designated use classifications for the Hiwassee River waterbodies include fish & aquatic life, recreation, irrigation, livestock watering & wildlife, industrial water supply, and domestic water supply. Of the use classifications with numeric criteria for E. coli, 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, 2004). 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.

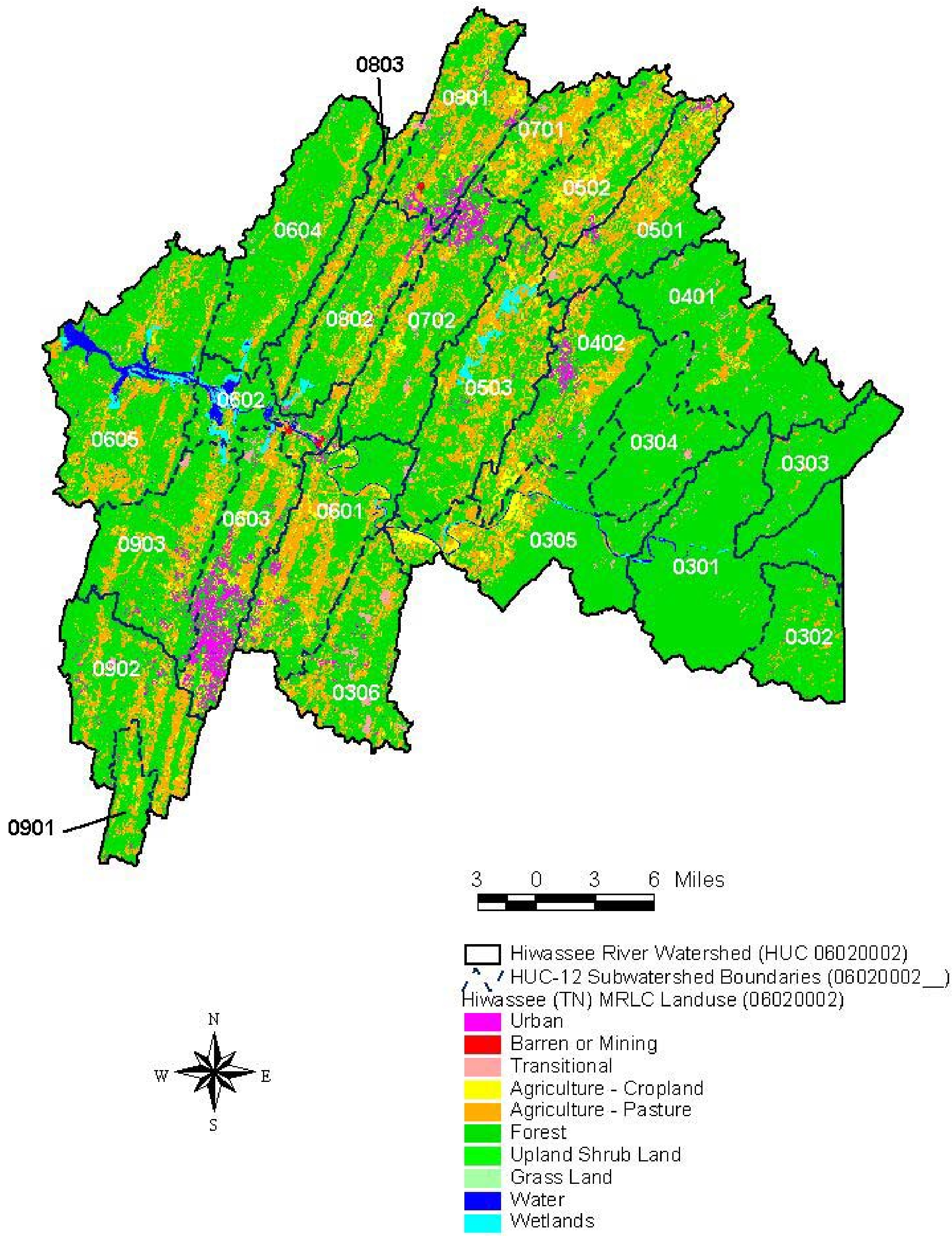

Figure 3. Land Use Characteristics of the Hiwassee River Watershed

Table 2. Final 2004 303(d) List for E. coli – Hiwassee River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	CAUSE / TMDL Priority	Pollutant Source
TN06020002001 - 0100	AGENCY CREEK	32.7	Escherichia coli	Pasture Grazing
TN06020002008 – 1000	HIWASSEE RIVER	7.7	Escherichia coli	Collection System Failure Pasture Grazing
TN06020002009 - 0200	FILLAUER CREEK	7.4	Alteration in stream-side or littoral vegetative cover Siltation Escherichia coli	Discharges from MS4 area Collection System Failure
TN06020002009 - 0300	WOOLEN MILL BRANCH	3.92	Alteration in stream-side or littoral vegetative cover Organic Enrichment Escherichia coli	Discharges from MS4 area Illicit Connections to Storm Sewers Collection System Failure
TN06020002009 – 2000	SOUTH MOUSE CREEK	6.5	Unknown Toxicity Siltation Physical Substrate Habitat Alterations Escherichia coli	Discharges from MS4 area Channelization Streambank Modification/ Destabilization Collection System Failure
TN06020002012 – 0200	LITTLE CHATATA CREEK	14.3	Siltation Alteration in stream-side or littoral vegetative cover Escherichia coli	Discharges from MS4 area Pasture Grazing
TN06020002012 – 1000	CHATATA CREEK	19.62	Siltation Physical Substrate Habitat Alterations Escherichia coli	Discharges from MS4 area Pasture Grazing
TN06020002018 – 0100	HAWKINS BRANCH	1.86	Escherichia coli	Pasture Grazing
TN06020002018 – 0200	DAIRY BRANCH	1.78	Escherichia coli	Source Undetermined
TN06020002082 – 0200	LITTLE CHESTUEE CREEK	13.3	Escherichia coli	Pasture Grazing
TN06020002082 – 2000	CHESTUEE CREEK	17.9	Escherichia coli	Pasture Grazing
TN06020002083 – 1000	OOSTANAULA CREEK	5.7	Escherichia coli	Pasture Grazing

Table 2. Final 2004 303(d) List for E. coli – Hiwassee River Watershed (Cont.)

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	CAUSE / TMDL Priority	Pollutant Source
TN06020002083 – 2000	OOSTANAULA CREEK	21.1	Escherichia coli	Pasture Grazing
TN06020002083 – 3000	OOSTANAULA CREEK	7.4	Phosphate Siltation Escherichia coli	Municipal Point Source Discharge Discharge from MS4 area
TN06020002083 – 4000	OOSTANAULA CREEK	8.5	Escherichia coli	Pasture Grazing
TN06020002083 – 5000	OOSTANAULA CREEK	6.2	Escherichia coli	Pasture Grazing
TN06020002084 - 1000	NORTH MOUSE CREEK	38.36	Escherichia coli	Pasture Grazing Discharges from MS4 area
TN06020002085 - 1000	SPRING CREEK	33.8	Escherichia coli	Pasture Grazing
TN06020002087 - 1000	ROGERS CREEK	21.6	Alterations in stream-side or littoral vegetation Escherichia coli	Pasture Grazing
TN06020002088 - 1000	PRICE CREEK	6.9	Escherichia coli	Pasture Grazing

Table 3. Water Quality Assessment of Waterbodies Impaired Due to E. coli - Hiwassee River Watershed

Waterbody ID	Segment Name	Comments
TN06020002001 - 0100	AGENCY CREEK	2003 TDEC pathogen station at mile 2.1 (Big Springs Road and Calhoun Road). G. M. of 5 E. coli samples = 2827. All five samples exceeded 1,000. Also 2003 TDEC pathogen station on Allen Branch at mile 0.27 (Highway 58). G. M. of 5 samples = 1836. Four out of five samples exceeded 1,000.
TN06020002008 - 1000	HIWASSEE RIVER	TDEC ambient monitoring station at mile 13.4 (d/s South Mouse Creek). 2003 TDEC ambient station at mile 13.4 (d/s of I-75). Three out of 18 E. coli samples over 1,000.
TN06020002009 - 0200	FILLAUER CREEK	2003 TDEC pathogen station at mile 0.3 (Mouse Creek Road). G.M. of six samples = 792. Four out of six E. coli samples over 1,000.
TN06020002009 - 0300	WOOLEN MILL BRANCH	Two fish kill in the stream due to sewage overflows. Illicit industrial discharges. Stream choked with algae.
TN06020002009 – 2000	SOUTH MOUSE CREEK	2003 TDEC pathogen station at mile 12.7 (Raider Road). G.M. of six samples = 1482. Five out of six E. coli samples over 1,000.
TN06020002012 – 0200	LITTLE CHATATA CREEK	2003 TDEC pathogen station at mile 0.3 (Tasso Road). G.M. of six samples = 880. Three out of six E. coli samples over 940.
TN06020002012 – 1000	CHATATA CREEK	2003 TDEC pathogen station at mile 2.0 (Chatata Valley Road). G.M. of six samples = 1457. Six out of six E. coli samples over 940.
TN06020002018 – 0100	HAWKINS BRANCH	2003 TDEC pathogen station at mile 1.3 (Old Patty Road). Seven E. coli sample out of nine over 940.
TN06020002018 – 0200	DAIRY BRANCH	2003 TDEC pathogen station at mile 1.2 (Old Patty Road). Four E. coli sample out of eight over 940.
TN06020002082 – 0200	LITTLE CHESTUEE CREEK	2003 TDEC pathogen station at mile 0.7 (Hwy 460). E. coli G.m. = 1074. Three out of five E. coli samples over 940.
TN06020002082 – 2000	CHESTUEE CREEK	2003 TDEC pathogen station at mile 45.2 (Hwy 460). E. coli G.M. = 934. Two E. coli sample out of five over 940. TDEC chemical monitoring station at mile 42.5. E. coli elevated - - 14 observations, all at or above standard.
TN06020002083 – 1000	OOSTANAULA CREEK	2003 TDEC chemical station at mile 5.8 (Sanford Road). One E. coli sample out of five over 940. TDEC pathogen survey. 1998.
TN06020002083 – 2000	OOSTANAULA CREEK	2003 TDEC chemical station at mile 5.8 (Sanford Road). One E. coli sample out of five over 940. 1998 TDEC fecal data.
TN06020002083 – 3000	OOSTANAULA CREEK	2003 TDEC chemical station at mile 28.4 (Long Mill Road). Five E. coli samples out of seventeen over 940. 1999 TDEC fecal data from watershed monitoring.

Table 3. Water Quality Assessment of Waterbodies Impaired Due to Pathogens - Hiwassee River Watershed (Cont.)

Waterbody ID	Segment Name	Comments
TN06020002083 – 4000	OOSTANAULA CREEK	319 Program project in this area.
TN06020002083 – 5000	OOSTANAULA CREEK	No recent data for this section. TDEC station at County Road 350. Pathogens elevated.
TN06020002084 - 1000	NORTH MOUSE CREEK	2003 TDEC chemical station at mile 4.2 (Hwy 28). Two E. coli samples out of eleven over 940. 2003 TDEC chemical station at mile 24.3 (Rocky Mount Union Chapel Road). Three E. coli sample out of twenty-one over 940. 1999 TDEC chemical stations at miles 24.3 & 24.8. Bugs O.K., but E. coli exceeds criteria.
TN06020002085 - 1000	SPRING CREEK	2003 TDEC chemical station at mile 3.8 (Sanford Road/Hillsview Road). E. coli g.m. = 814. Two E. coli sample out of five over 940. 2003 TDEC chemical station at mile 15.6 (Old Decatur Road). E. coli g.m. = 926. Three E. coli samples out of five over 940.
TN06020002087 - 1000	ROGERS CREEK	2003 TDEC chemical station at mile ? (Sanford Road). E. coli g.m. = 547. No E. coli samples out of five over 940. 2003 TDEC chemical station at mile 14.2 (Hwy 30). E. coli g.m. = 1125. Three E. coli samples out of five over 940.
TN06020002088 - 1000	PRICE CREEK	2003 TDEC chemical station at mile 4.4 (Shiloh Road). E. coli g.m. = 624. Two E. coli samples out of five over 940.

> 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. T he 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.

None of the impaired waterbodies in the Hiwassee River watershed have been classified as either Tier II or Tier III streams.

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.

In addition to utilizing the E. coli water quality standards (with MOS) as the targets, these TMDLs utilize fecal coliform as a surrogate for determining attainment of the E. coli standard because of the demonstrated high correlation between E. coli and fecal coliform in the Hiwassee River watershed and sub-ecoregions in which the subject E. coli-impaired subwatersheds lie. In the Hiwassee River watershed, E. coli and fecal coliform are well correlated (R = 0.914) when evaluating all available data (204 observations) from E. coli-impaired subwatersheds. In the state of Tennessee, E. coli and fecal coliform are well correlated (R = 0.902) when evaluating all available ecoregion data (623 observations). Furthermore, as described in Section 3.0, the E. coli-impaired subwatersheds in the Hiwassee River watershed (HUC 06020002) lie entirely within level IV ecoregions 67f, 67g, and 67i. The correlation between E. coli and fecal coliform in level III ecoregion 67 is good (R = 0.785) and the correlations between E. coli and fecal coliform in level IV ecoregions 67f (R = 0.773) and 67g (R = 0.818) are also good. There were no ecoregion data available in level IV ecoregion 67i.

Therefore, this TMDL employs both the E. coli water quality standard and the surrogate fecal coliform criteria by determining the amount of load reduction required to comply with each of four criteria: 1) the geometric mean standard for E. coli of 126 counts/100 mL, 2) the E. coli sample maximum of 941 counts/100 mL, 3) the geometric mean for fecal coliform of 200 counts/100 mL, and 4) the fecal coliform sample maximum of 1,000 counts/100 mL. The fecal coliform surrogate is most frequently used when insufficient monitoring data is available for E. coli or when analysis of E. coli monitoring data suggests that a listed segment is not impaired. The most protective (or highest percent of load reduction) from all applicable 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.

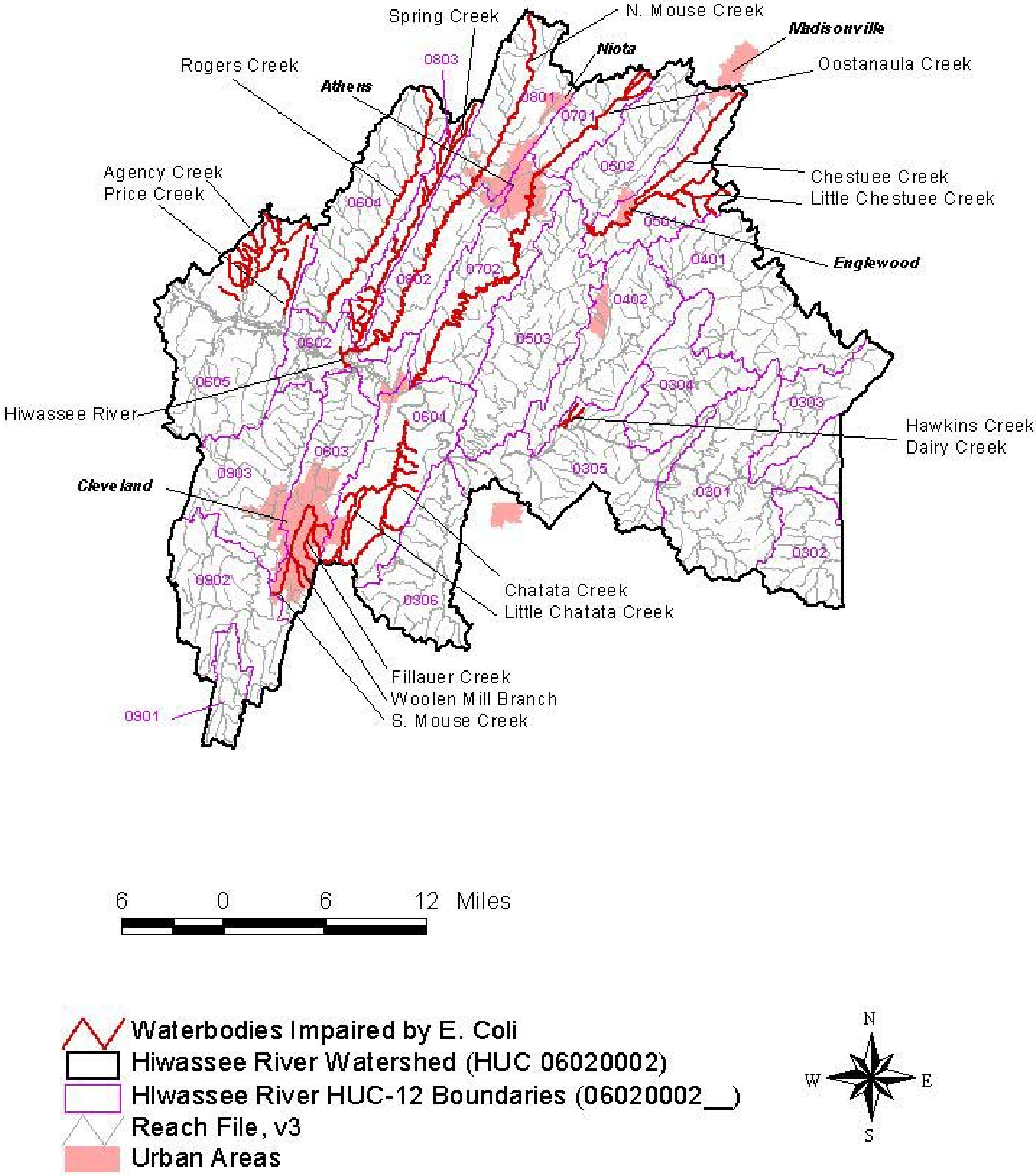

Figure 4. Waterbodies Impaired by E. Coli (as Documented on the Final 2004 303(d) List)

6.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM GOAL

There are multiple water quality monitoring stations that provide data for waterbodies identified as impaired for E. coli in the Hiwassee River watershed.

- Agency Creek Subwatershed:
  - AGENC002.1ME – Agency Creek, at Big Springs Calhoun Rd.
- Hiwassee River Subwatershed:
  - HIWAS013.4MM – Hiwassee River, below Olin and Bowater outfalls
  - HIWAS015.6MM – Hiwassee River, u/s Cleveland Utilities STP outfall
- South Mouse Creek Subwatershed:
  - SMOUS012.7BR – South Mouse Creek, at Raider
  - FILLA000.3BR – Fillauer Creek, at South Mouse Creek Rd.
  - WMILL000.8BR – Woolen Mill Branch, at 2nd and Worth Streets in Cleveland, d/s of Maytag
- Chatata Creek Subwatershed:
  - CHATA000.5BR – Chatata Creek, at Chatata Valley Rd. bridge embayment on Upper River Rd.
  - LCHAT000.3BR – Little Chatata Creek, at Tasso Rd.
- Hawkins Branch Subwatershed:
  - HAWKI000.3PO – Hawkins Branch, at USFS tree farm, last right off Hwy 411 before Hiwassee River
  - HAWKI001.3PO – Hawkins Branch, at Old Patty Rd., off Hwy 411 at Delano
- Dairy Branch Subwatershed:
  - DAIRY000.4PO – Dairy Branch, at USFS tree farm, last right off Hwy 411 before Hiwassee River
  - DAIRY001.2PO – Dairy Branch, at Old Patty Rd., off Hwy 411 at Delano
- Chestuee Creek Subwatershed:
  - CHEST042.5MM – Chestuee Creek, 0.1 mi u/s of Englewood STP outfall
  - LCHES001.6MM – Little Chestuee Creek, along Hwy 460
- Oostanaula Creek Subwatershed:
  - OOSTA005.8MM – Oostanaula Creek, at Sanford Rd. bridge
  - OOSTA026.6MM – Oostanaula Creek, below Cedar Springs tributary, 3.5 mi d/s of AUB WWTP outfall
  - OOSTA028.4MM – Oostanaula Creek, at Long Mill Rd. bridge
  - OOSTA030.0MM – Oostanaula Creek, 200' below AUB WWTP outfall
  - OOSTA030.1MM – Oostanaula Creek, just u/s of AUB WWTP outfall
  - OOSTA033.6MM – Oostanaula Creek, dead end of Spruce Street @ manhole
  - OOSTA035.1MM – Oostanaula Creek, behind Johnson Controls @ end of road

- North Mouse Creek Subwatershed:
    - NMOUS004.2MM – North Mouse Creek at Co Hwy 28 bridge
    - NMOUS024.3MM – North Mouse Creek, at Rocky Mount Union Chapel Rd. bridge, d/s of the WWTP
- Spring Creek Subwatershed:
    - SPRIN003.8MM – Spring Creek, d/s Sanford Rd./Hillsview Rd.
    - SPRIN015.6MM – Spring Creek, at Old Decatur Rd.
- Rogers Creek Subwatershed:
    - ROGER002.7MM – Rogers Creek, d/s Sanford Hwy 50
    - ROGER014.2MM – Rogers Creek, u/s at Hwy 30 (David Lillard Memor.)
- Price Creek Subwatershed:
    - PRICE004.4ME – Price Creek, at Shiloh Rd.

The locations of these monitoring stations are shown in Figure 5. Water quality monitoring results for these stations are tabulated in Appendix B and summarized in Table 4. Examination of the data shows exceedances of the 941 counts/100 mL maximum E. coli standard and the 1,000 counts/100 mL maximum fecal coliform criterion at nearly every monitoring station where fecal coliform or E. coli samples were collected. There were not enough data to determine compliance with the geometric mean standard for E. coli at many of the monitoring stations; however, for those monitoring stations with enough data, most indicated exceedance of the geometric mean criterion as well. There were not enough data to calculate the geometric mean concentrations for the surrogate fecal coliform at any of the monitoring stations.

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 E. coli 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 (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.

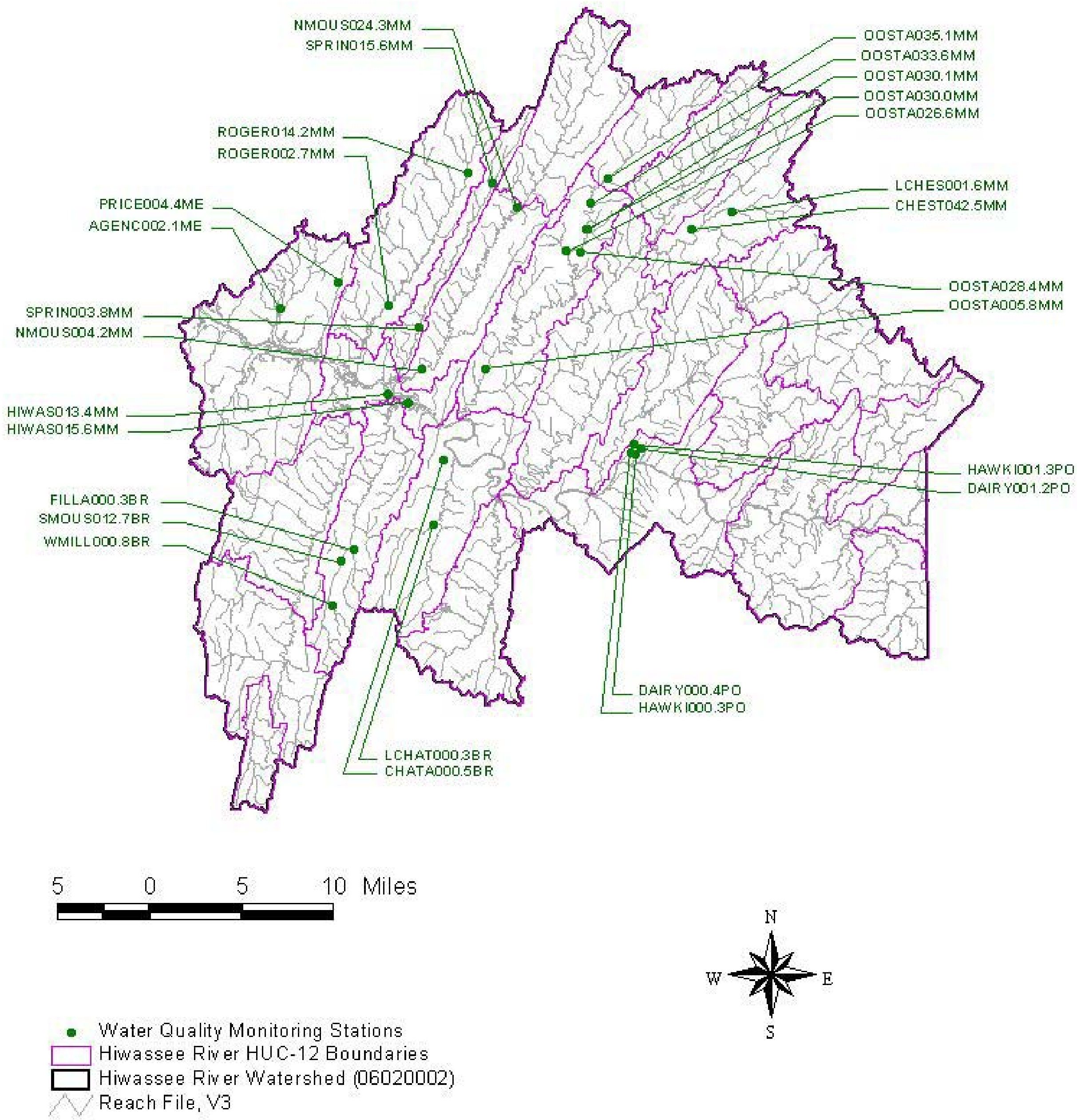

Figure 5. Water Quality Monitoring Stations in the Hiwassee River Watershed

Table 4. Summary of Water Quality Monitoring Data

Monitoring Station	E. Coli (Max WQ Criteria = 941 Counts/100 mL)						Fecal Coliform (Max WQ Criteria = 1000 Counts/100 mL)					
	Data Pts.	Date Range	[Counts/100 mL]			Exceed Max WQ Crit.	Data Pts.	Date Range	[Counts/100 mL]			Exceed Max. WQ Crit.
			Min.	Avg.	Max.				Min.	Avg.	Max.	
AGENC002.1ME	5	6/03-7/03	1299	3703	9800	5	NA	NA	NA	NA	NA	NA
HIWAS013.4MM	19	12/98-3/04	3	>468	>2400	4	18	12/98-3/04	7	893	5000	3
HIWAS015.6MM	10	4/98-9/99	13	62	260	0	10	4/98-9/99	30	94	240	0
FILLA000.3BR	6	5/03-6/03	54.6	>1226	>2419	4	NA	NA	NA	NA	NA	NA
WMILL000.8BR	1	3/04	>2419	>2419	>2419	1	NA	NA	NA	NA	NA	NA
SMOUS012.7BR	6	5/03-6/03	727	>1580	>2419	5	NA	NA	NA	NA	NA	NA
LCHAT000.3BR	6	5/03-6/03	378	946	1413	3	NA	NA	NA	NA	NA	NA
CHATA000.5BR	12	8/02-5/04	82	>2841	23590	5	12	8/02-5/04	92	3053	25000	3
HAWKI000.3PO	9	12/02-11/03	4	534	1553	2	9	12/02-11/03	8	664	2000	3
HAWKI001.3PO	10	12/02-2/04	113	>2165	7540	6	10	12/02-2/04	66	4270	22000	7
DAIRY000.4BR	8	2/03-11/03	63	>3436	21720	3	8	2/03-11/03	60	3065	17000	3
DAIRY001.2BR	9	2/03-2/04	6	>5174	36540	5	9	2/03-2/04	10	4604	17000	5
LCHES001.6MM	5	5/03-6/03	648	>1209	>2419	3	NA	NA	NA	NA	NA	NA
CHEST042.5MM	19	3/98-11/99, 5/03-6/03	120	625	1986	3	14	3/98-11/03	90	447	1030	1
OOSTA005.8MM	5	10/02-1/04	219	663	1986	1	5	10/02-1/04	176	627	1900	1
OOSTA026.6MM	21	3/02-6/04	30	387	1690	2	23	3/02-6/04	40	849	10000	3
OOSTA028.4MM	28	12/98-6/04	1	>699	>2419	6	83	12/82-6/96, 12/98-6/04	10	5776	150000	34
OOSTA030.0MM	21	10/02-6/04	40	586	2900	4	23	3/02-6/04	80	1389	12000	6
OOSTA030.1MM	21	10/02-6/04	80	573	2500	5	23	3/02-6/04	50	1480	14000	6

Table 4. Summary of Water Quality Monitoring Data (Cont.)

Monitoring Station	E. Coli (Max WQ Criteria = 941 Counts/100 mL)						Fecal Coliform (Max WQ Criteria = 1000 Counts/100 mL)					
	Data Pts.	Date Range	[Counts/100 mL]			Exceed Max WQ Crit.	Data Pts.	Date Range	[Counts/100 mL]			Exceed Max. WQ Crit.
			Min.	Avg.	Max.				Min.	Avg.	Max.	
OOSTA033.6MM	11	7/03-6/04	210	946	2750	3	11	7/03-6/04	250	1138	2140	6
OOSTA035.1MM	11	7/03-6/04	40	554	2610	2	11	7/03-6/04	50	756	2500	3
NMOUS004.2MM	12	8/02-5/04	100	1329	8620	2	12	8/02-5/04	88	1412	9000	2
SPRIN003.8MM	5	6/03-7/03	517	845	1120	2	NA	NA	NA	NA	NA	NA
SPRIN015.6MM	5	6/03-7/03	686	939	1119	3	NA	NA	NA	NA	NA	NA
ROGER002.7MM	5	6/03-7/03	435	559	770	0	NA	NA	NA	NA	NA	NA
ROGER014.2MM	5	6/03-7/03	816	1153	1413	3	NA	NA	NA	NA	NA	NA
PRICE004.4MM	5	6/03-7/03	248	824	1986	2	NA	NA	NA	NA	NA	NA

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 were ten (10) NPDES permitted WWTFs in the impaired subwatersheds of the Hiwassee River watershed authorized to discharge treated sanitary wastewater during the TMDL analysis period. These facilities are tabulated in Table 5 and the locations are shown in Figure 6. Five (5) of the ten facilities are sewage treatment plants (STPs) serving municipalities and three of the five (Cleveland Utilities STP [TN0024121], AUB-Oostanaula Creek STP [TN0024201], and AUB-North Mouse Creek STP [TN0067539]) are major facilities with design capacities of greater than 1.0 million gallons per day (MGD). The E. coli and fecal coliform permit limits for discharges from these WWTFs are in accordance with the criteria specified in the 2004 and 1999 State of Tennessee water quality standards (TDEC, 2004 and TDEC, 1999, respectively) (ref.: Section 5.0). The Hill Meat Processing facility (TN0028371) is no longer active.

Table 5. WWTFs Permitted to Discharge Treated Sanitary Wastewater in Hiwassee River Watershed Impaired Subwatersheds

NPDES Permit No.	Facility Name	Receiving Stream
TN0021938	Englewood STP	Chestuee Creek, mile 42.4
TN0024121	Cleveland Utilities STP	Hiwassee River, mile 15.4
TN0024201	AUB-Oostanaula Creek STP	Oostanaula Creek, mile 30.1
TN0025470	Niota STP	Little North Mouse Creek, mile 3.5
TN0028371	Hill Meat Processing	South Mouse Creek, mile 19.4
TN0028886	Athens Ramada Inn	Liberty Branch, mile 0.6
TN0029483	E. K. Baker School	Spring Creek, mile 18.7
TN0029491	Riceville Elementary School	Dry Valley Branch, mile 5.4
TN0067539	AUB-North Mouse Creek STP	North Mouse Creek, mile 24.7
TN0067555	Rogers Creek Elementary School	Rogers Creek, mile 12.5

Non-permitted point sources of (potential) E. coli contamination of surface waters associated with STP collection systems include leaking collection systems and sanitary sewer overflows (SSOs).

7.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

Municipal Separate Storm Sewer Systems (MS4s) are considered to be point sources of E. coli. 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 Hiwassee 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*

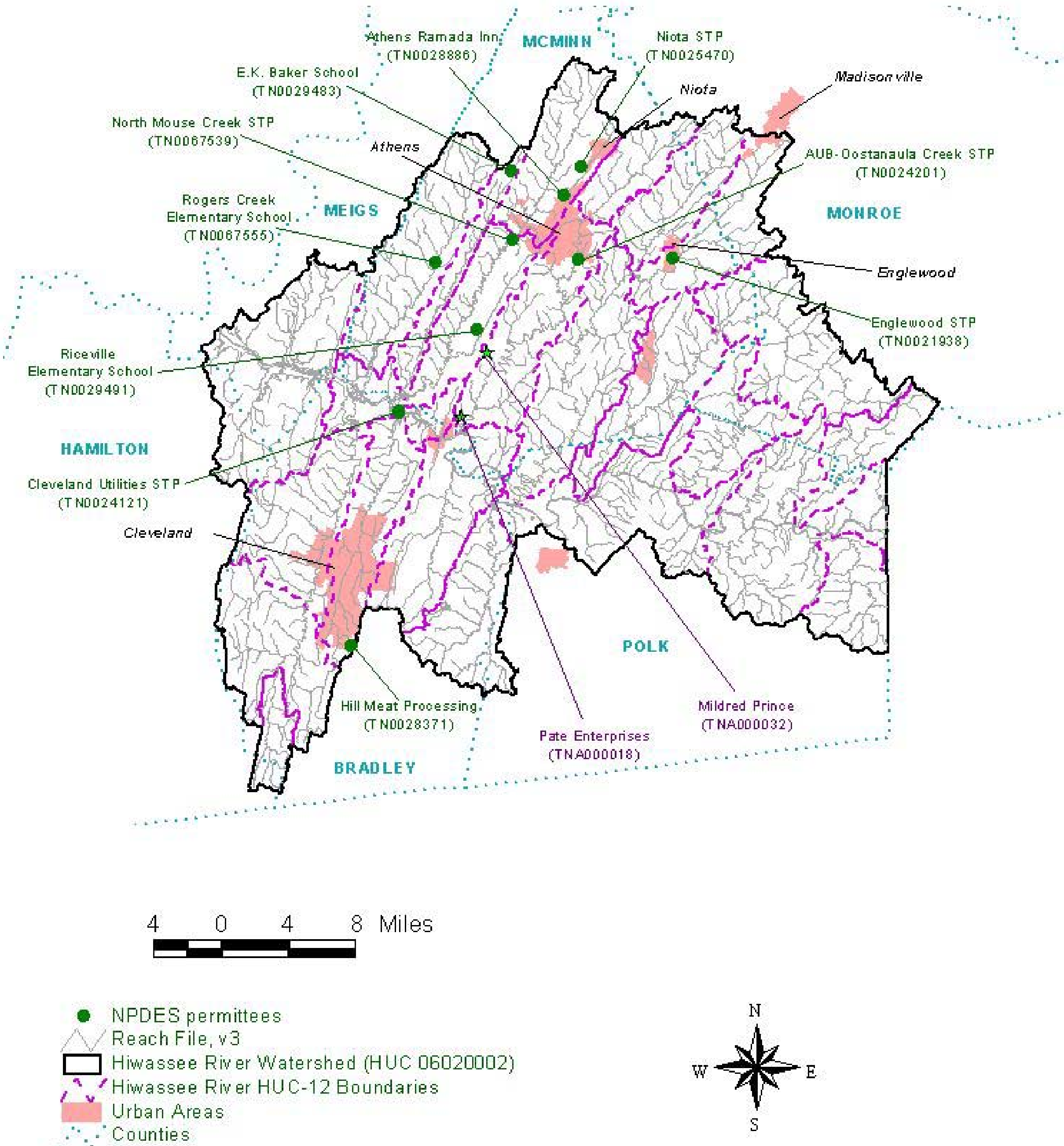

Figure 6. NPDES Regulated Point Sources in the Hiwassee River Watershed

Storm Sewer Systems (TDEC, 2003). 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. Athens, Cleveland, Bradley County, and Hamilton County are covered under Phase II of the NPDES Storm Water Program. However, there are no Hiwassee River watershed E. coli-impaired waterbodies in Hamilton County. The Tennessee Department of Transportation (TDOT) is 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/.

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, 2002a). 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.

As of July 2, 2004, there were 5 Class II CAFOs in the Hiwassee River watershed with coverage under the general NPDES permit. Two of these CAFOs are located in E. coli-impaired subwatersheds: Pate Enterprises (TNA000018) and Mildred Prince (TNA000032) poultry operations located in the Oostanaula Creek subwatershed. The locations of the two CAFOs are shown in Figure 6. As of December 2004, both permits have been terminated. Pate Enterprises has received a “No Potential to Discharge” determination. There are no Class I CAFOs with individual permits located in the watershed.

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 E. coli loading are primarily associated with agricultural and urban land uses. The vast majority of waterbodies identified on the Final 2004 303(d) list as impaired due to E. coli 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.

Potential data sources related to livestock operations include the 2002 Census of Agriculture, which was compiled for the Hiwassee Watershed utilizing the Watershed Characterization System (WCS). WCS is an Arcview geographic information system (GIS) based program developed by USEPA Region IV to facilitate watershed characterization and TMDL development. Livestock information provided in WCS is based on the ratio of watershed pasture area to county pasture area applied to the livestock population within the county. Livestock data for E. coli-impaired watersheds are summarized in Table 6. Populations were rounded to the nearest 50 poultry, 25 cows, 10 horses, and 5 hogs and sheep.

7.2.3 Failing Septic Systems

Some coliform loading in the Hiwassee River watershed can be attributed to failure of septic systems and illicit discharges of raw sewage. Estimates from 1997 county census data of people in E. coli-impaired subwatersheds of the Hiwassee River watershed utilizing septic systems were compiled using the WCS and are summarized in Table 7. In eastern 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.

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. Woolen Mill Branch has the highest percentage of urban land area for impaired waterbodies in the Hiwassee River watershed, with 67.0%. Land use for the Hiwassee River impaired drainage areas is summarized in Figures 7-16 and tabulated in Appendix A.

Table 6. Livestock Distribution in the Hiwassee River Watershed

Subwatershed	Livestock Population (WCS)					
	Beef Cow	Milk Cow	Poultry	Hogs	Sheep	Horses
Agency Creek	1200	150	0	0	0	70
Hiwassee River	475	200	519000	10	5	120
Fillauer Creek	0	0	3350	0	0	30
Woolen Mill Branch	0	0	14600	0	0	20
South Mouse Creek	150	50	295900	5	0	100
Little Chatata Creek	1350	475	2654700	30	15	40
Chatata Creek	1500	425	2917550	35	20	170
Hawkins Branch	100	100	344000	0	0	10
Dairy Branch	50	50	221400	0	0	10
Little Chestuee Creek	650	275	34350	15	10	50
Chestuee Creek	1850	775	299600	40	10	200
Oostanaula Creek (Mouth)	200	75	62150	5	0	60
Oostanaula Creek (Mile 5.7)	900	400	292750	25	0	130
Oostanaula Creek (Mile 26.6)	175	75	58700	5	0	50
Oostanaula Creek (Mile 34.2)	1050	450	347150	30	0	90
Oostanaula Creek (Mile 42.7)	125	50	17100	5	0	20
North Mouse Creek	2700	1175	889150	75	5	370
Spring Creek	3175	1375	1042750	85	0	90
Rogers Creek	3425	1475	1109800	90	0	260
Price Creek	325	50	1350	0	0	30

Table 7. Population on Septic Systems in the Hiwassee River Watershed

Subwatershed	Population on Septic Systems
Agency Creek	526
Hiwassee River	3427
Fillauer Creek	414
Woolen Mill Branch	234
South Mouse Creek	1587
Little Chatata Creek	1373
Chatata Creek	4477
Hawkins Branch	27
Dairy Branch	13
Little Chestuee Creek	423
Chestuee Creek	2151
Oostanaula Creek (Mouth)	762
Oostanaula Creek (Mile 5.7)	1571
Oostanaula Creek (Mile 26.6)	528
Oostanaula Creek (Mile 34.2)	1104
Oostanaula Creek (Mile 42.7)	146
North Mouse Creek	4401
Spring Creek	1043
Rogers Creek	3065
Price Creek	217

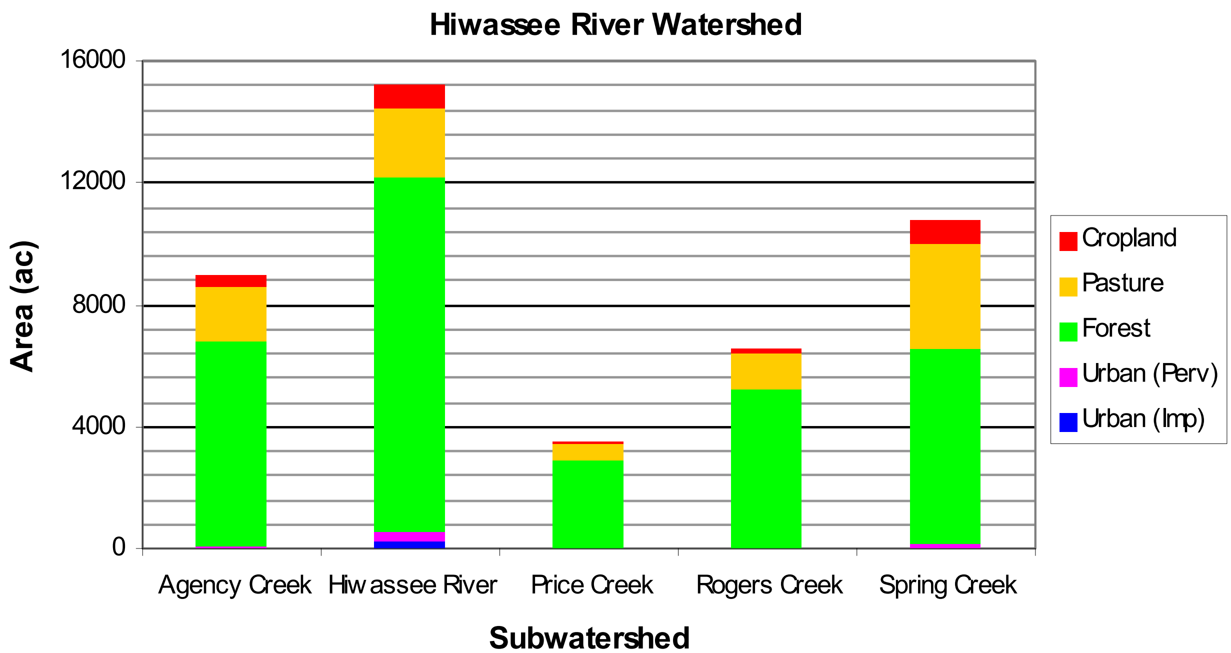

Figure 7. **Land Use Area of the Agency Creek, Hiwassee River, Price Creek, Rogers Creek, and Spring Creek Subwatersheds, Hiwassee River Watershed.**

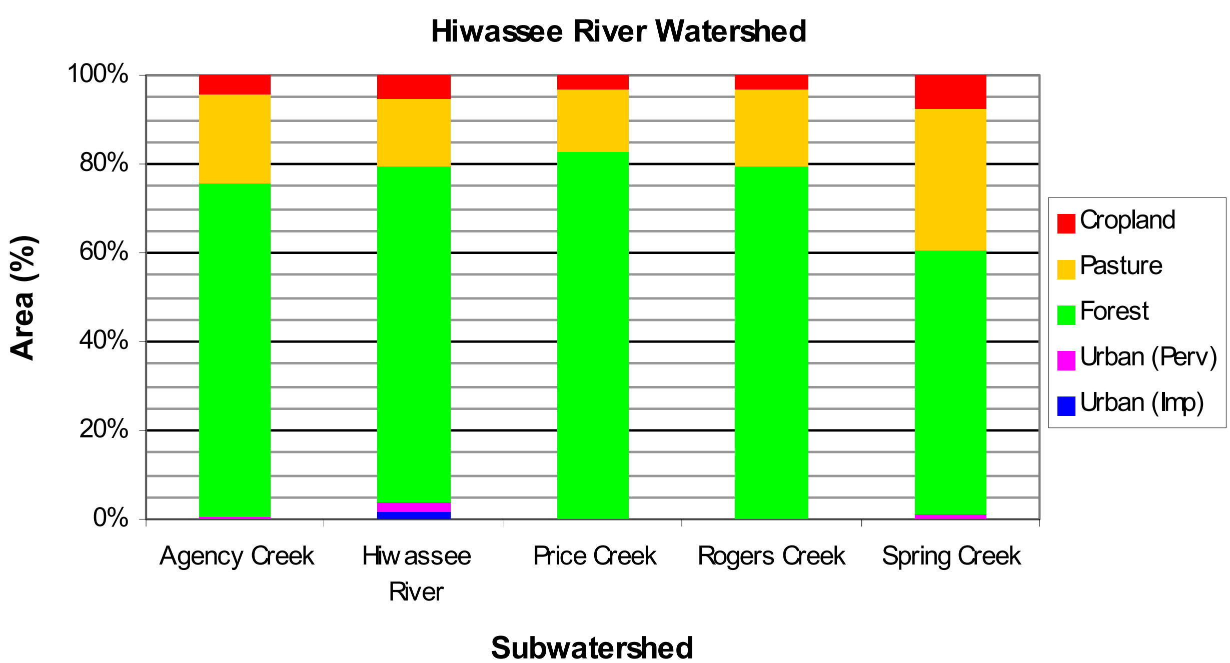

Figure 8. **Land Use Percent of the Agency Creek, Hiwassee River, Price Creek, Rogers Creek, and Spring Creek Subwatersheds, Hiwassee River Watershed.**

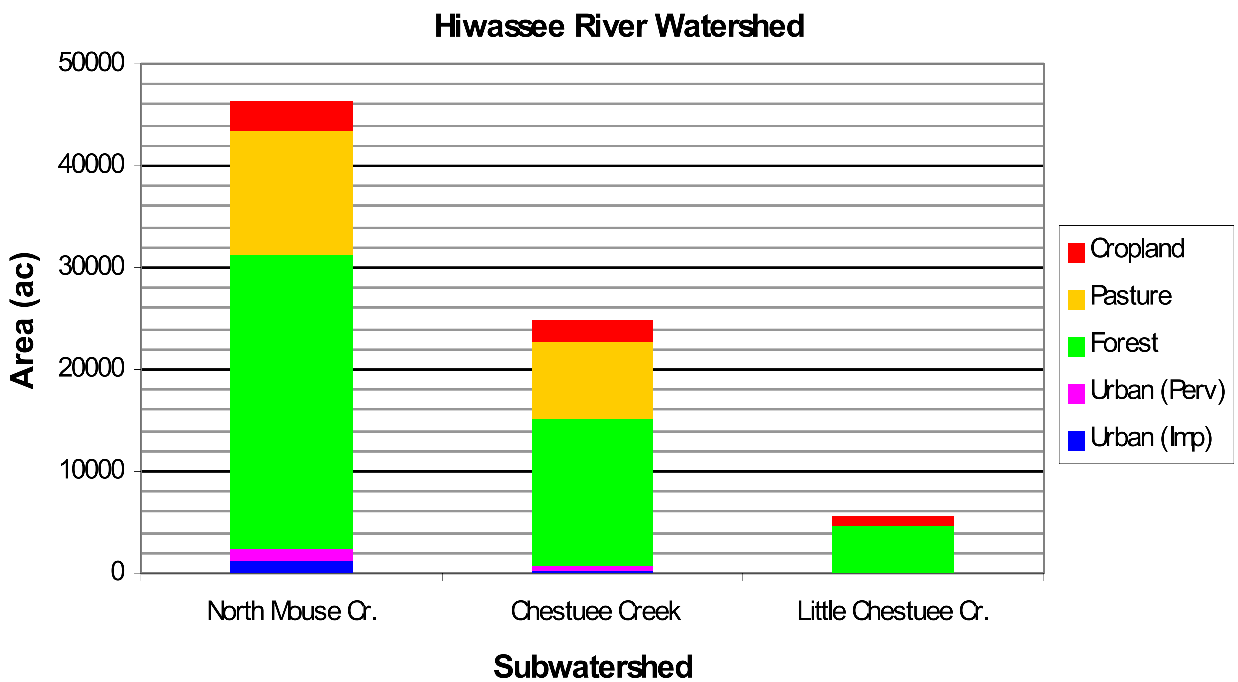

Figure 9. Land Use Area of the North Mouse Creek, Chestuee Creek, and Little Chestuee Creek Subwatersheds, Hiwassee River Watershed.

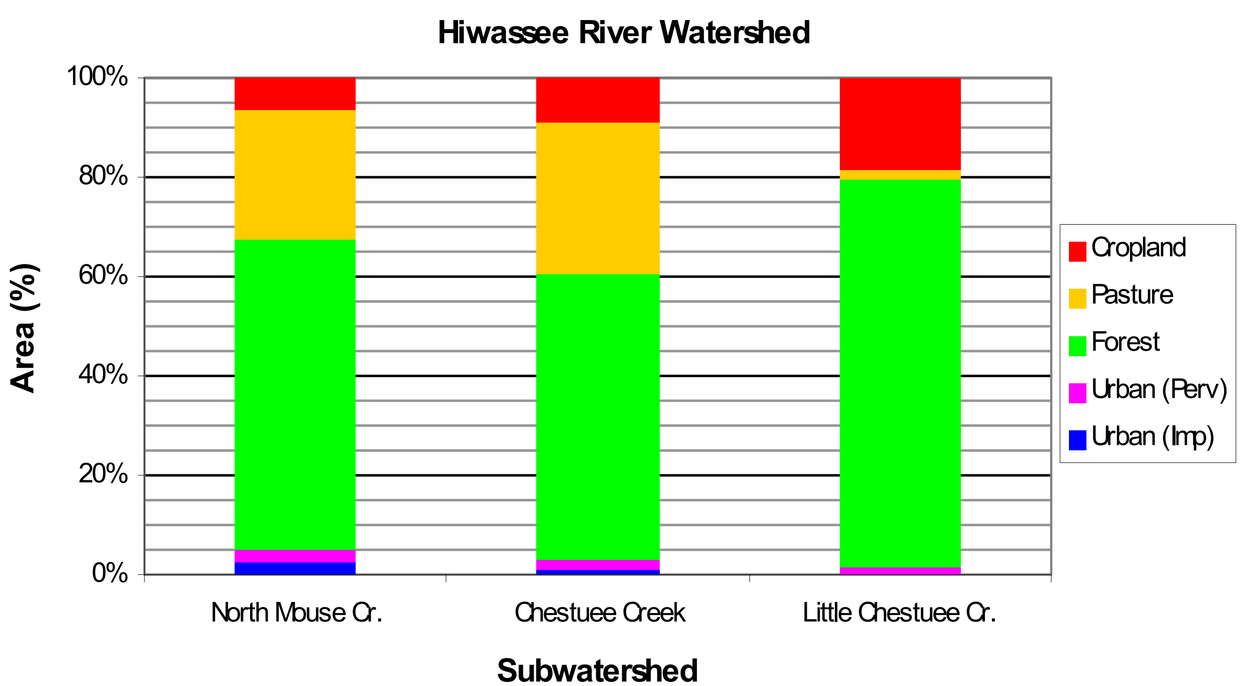

Figure 10. Land Use Percent of the North Mouse Creek, Chestuee Creek, and Little Chestuee Creek Subwatersheds, Hiwassee River Watershed.

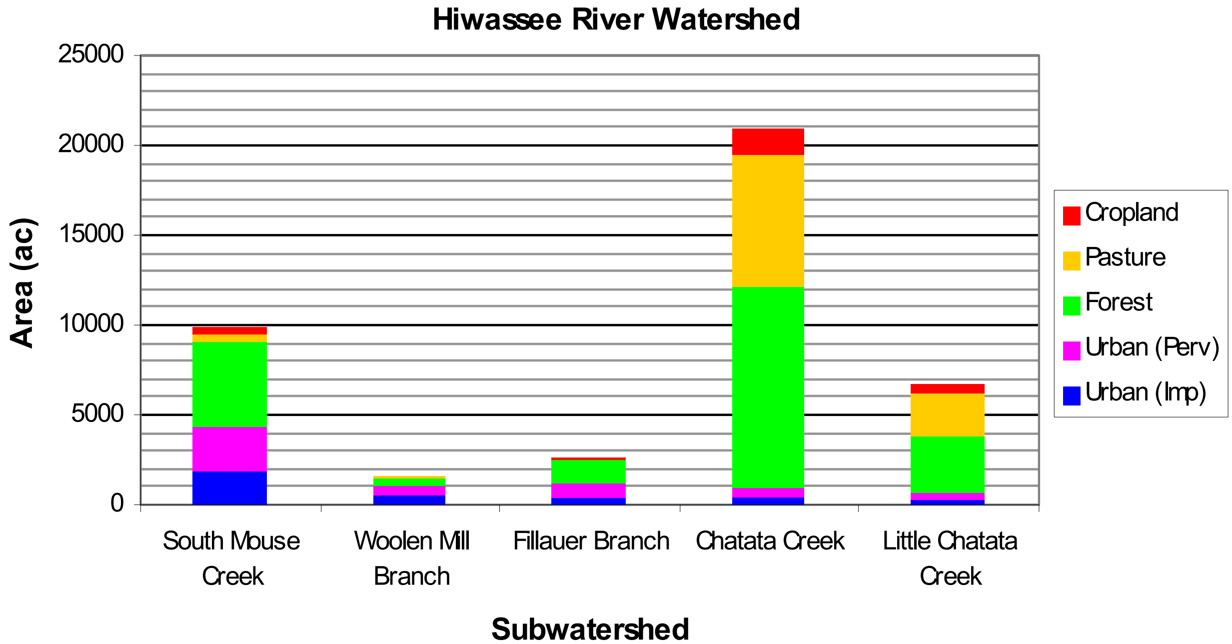

Figure 11. Land Use Area of the South Mouse Creek, Woolen Mill Branch, Fillauer Branch, Chatata Creek, and Little Chatata Creek Subwatersheds, Hiwassee River Watershed.

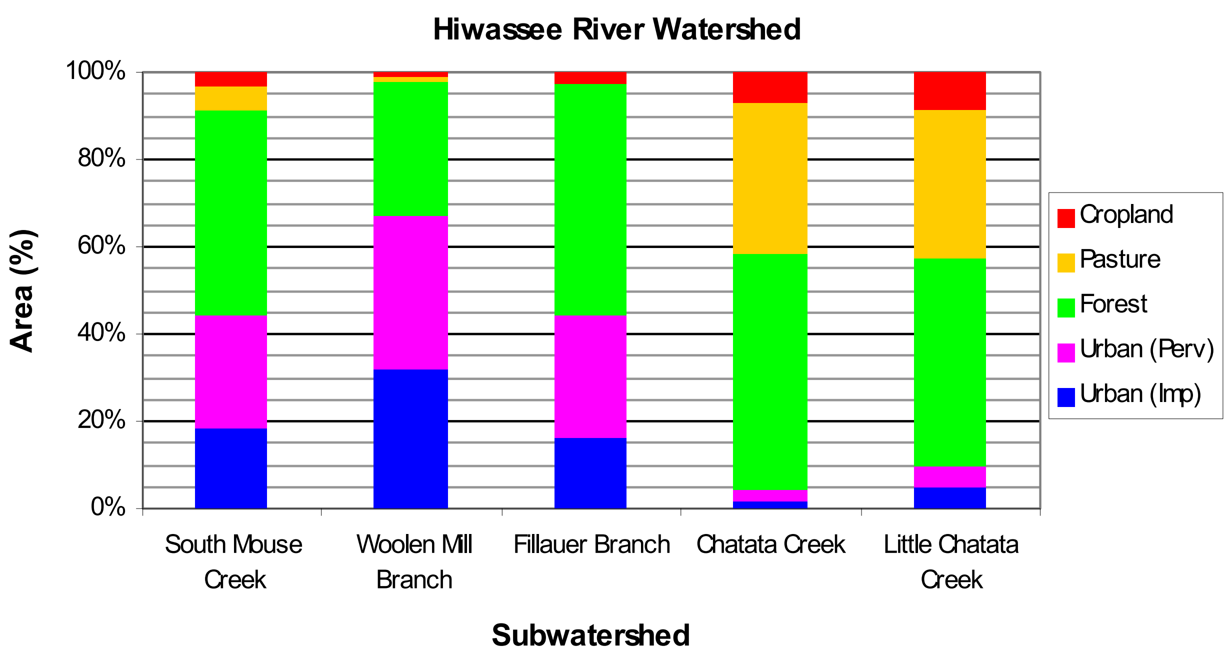

Figure 12. Land Use Percent of the South Mouse Creek, Woolen Mill Branch, Fillauer Branch, Chatata Creek, and Little Chatata Creek Subwatersheds, Hiwassee River Watershed.

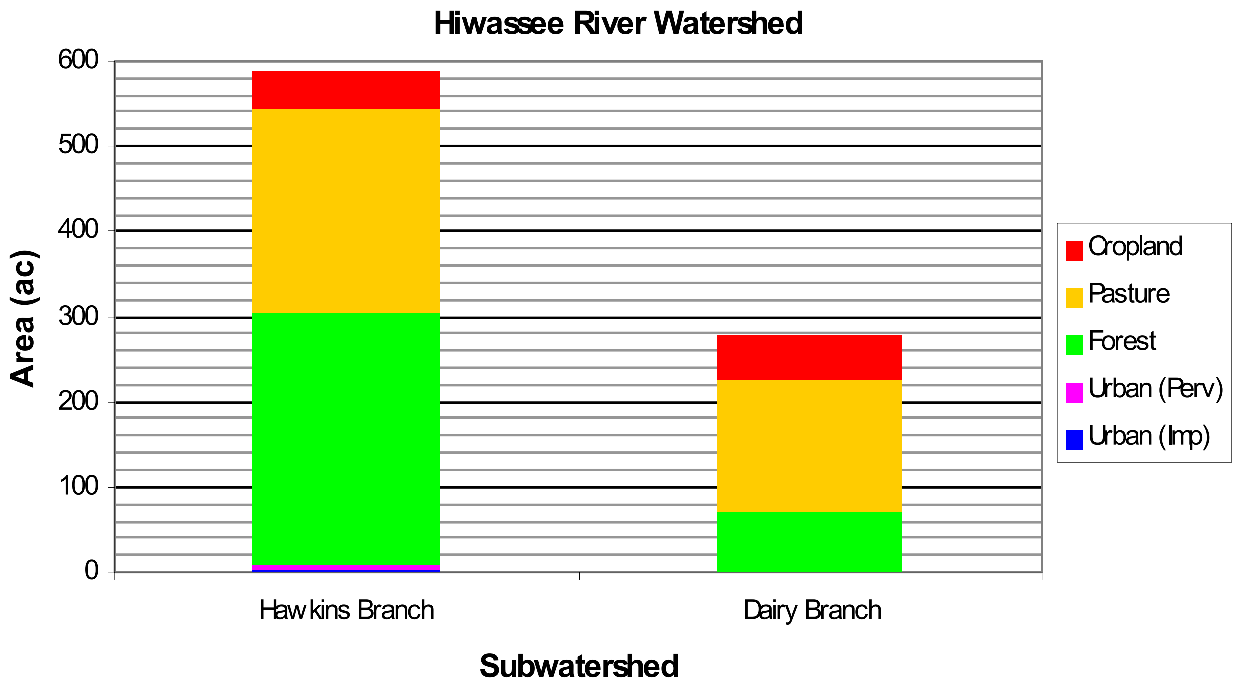

Figure 13. Land Use Area of the Hawkins Branch and Dairy Branch Subwatersheds, Hiwassee River Watershed.

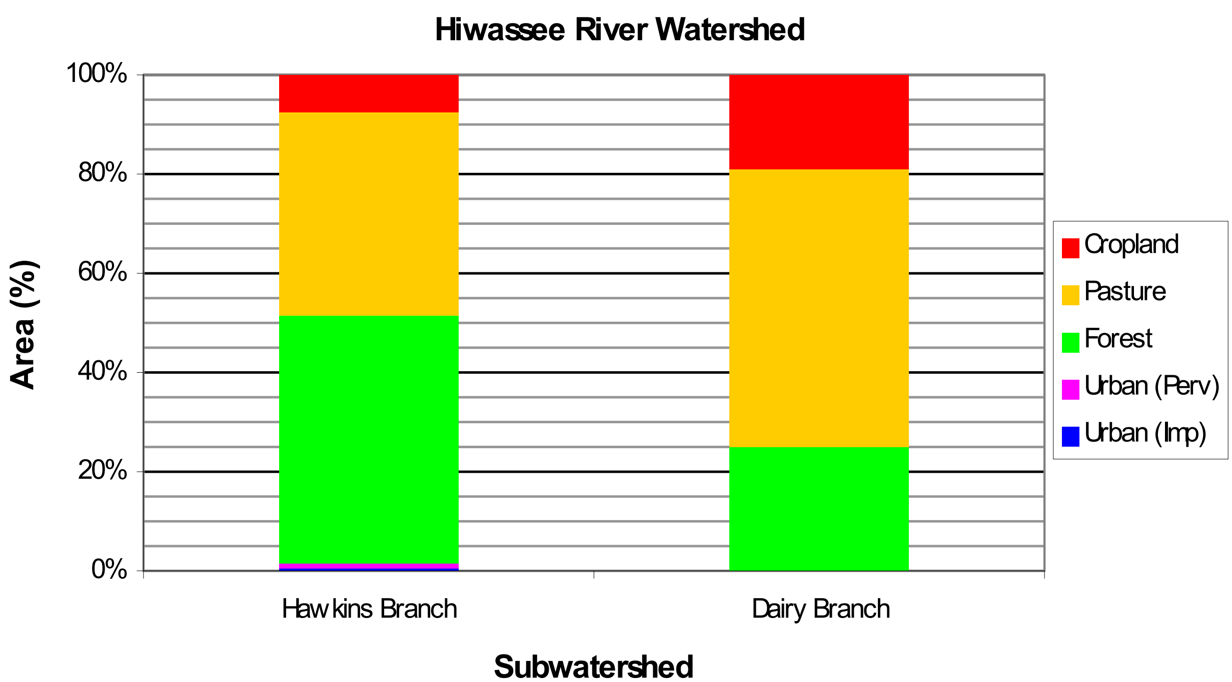

Figure 14. Land Use Percent of the Hawkins Branch and Dairy Branch Subwatersheds, Hiwassee River Watershed.

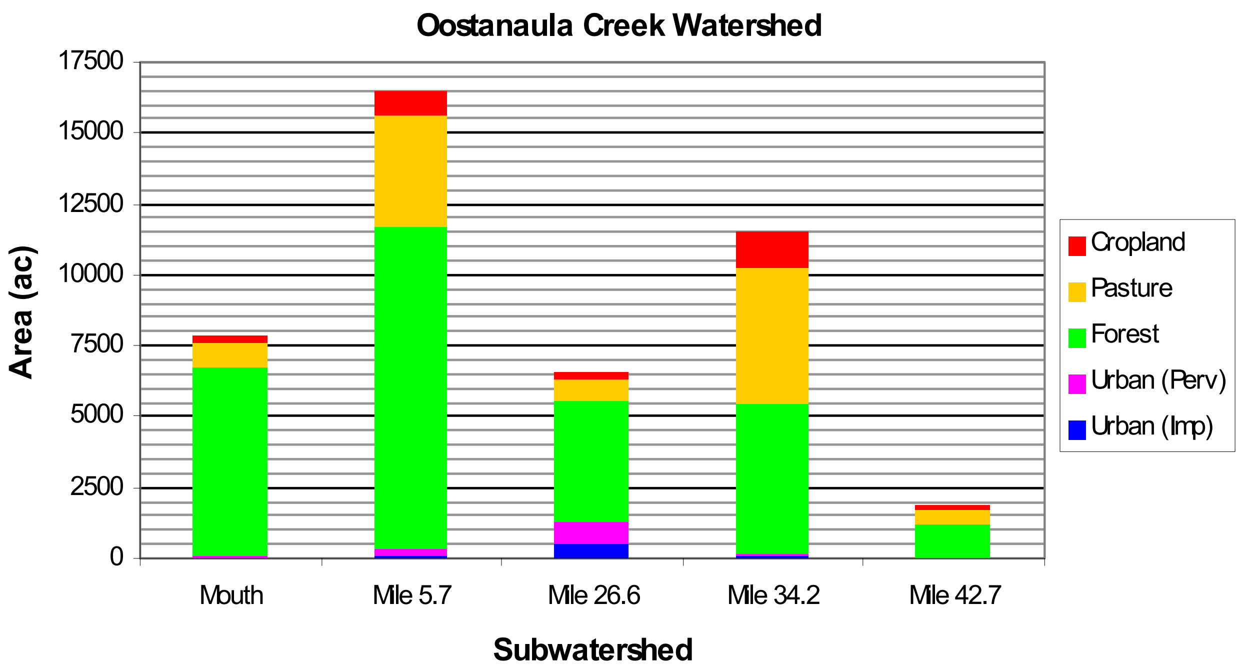

Figure 15. Land Use Area of the Oostanaula Creek Subwatersheds, Hiwassee River Watershed.

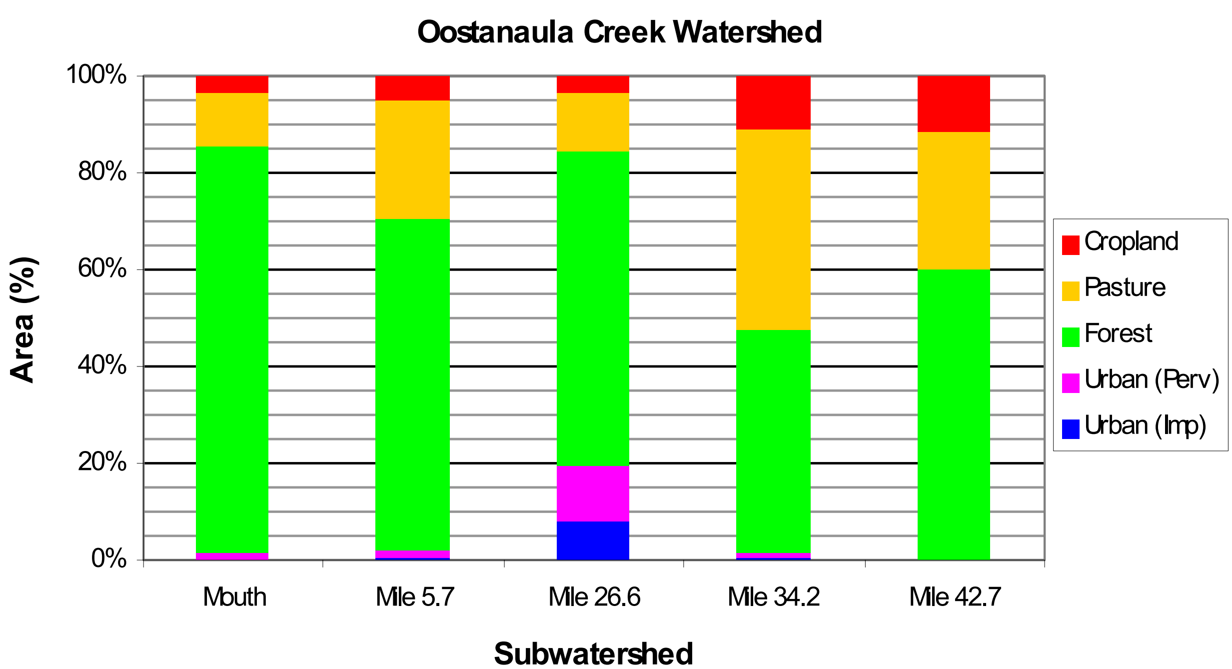

Figure 16. Land Use Percent of the Oostanaula Creek Subwatersheds, Hiwassee River Watershed.

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 other appropriate measure.

This document describes pathogen TMDL, Waste Load Allocation (WLA), and Load Allocation (LA) development for waterbodies identified as impaired due to E. coli on the Final 2004 303(d) list. TMDL analyses are performed primarily on a 12-digit hydrologic unit area (HUC-12) basis for subwatersheds containing waterbodies identified as impaired due to E. coli on the 2004 list. In cases where impaired streams are located in the upstream portion of a subwatershed, TMDLs are developed for the impaired drainage areas only (e.g., Little Chatata Creek subwatershed). The E. coli-impaired subwatersheds in the Hiwassee River watershed are shown in Figure 4.

8.1 Expression of TMDLs, WLAs, & LAs

In this document, the pathogen TMDL is expressed as the percent reduction in instream loading required to decrease existing E. coli or fecal coliform concentrations to desired target levels. Target concentrations are equal to the desired water quality goals (see Section 5.0) minus the appropriate MOS. WLAs & LAs for precipitation-induced loading sources are also expressed as required percent reductions in E. coli loading. Allocations for loading that are independent of precipitation (WLAs for WWTFs and LAs for “other direct sources”) are expressed as counts/day.

8.2 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 TMDLs for the Hiwassee River watershed were developed using three methodologies to assure compliance with the E. coli 126 counts/100 mL geometric mean and 941 counts/100 mL maximum standards while also incorporating the fecal coliform 200 counts/100 mL geometric mean and 1,000 counts/100 mL maximum concentration as surrogates (ref.: Section 5.0).

8.2.1 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 Hiwassee River E. coli-impaired waterbodies are presented in Appendix C.

8.2.2 Dynamic Loading Model Method

In order to demonstrate compliance with the surrogate fecal coliform 200 counts/100 mL geometric mean, a dynamic loading model was utilized 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 E. coli-impaired waters in the Hiwassee River 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 D.

8.2.3 Geometric Mean Calculation

For waterbodies with samples collected at sufficient number and frequency (minimum of 5 samples in a 30 day period), load reductions were determined by simple calculation of the geometric mean to achieve compliance with the 30-day geometric mean standard for E. coli of 126 counts/100 mL and/or the 30-day geometric mean concentration for the surrogate fecal coliform of 200 counts/100 mL.

8.3 Critical Conditions and Seasonal Variation

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.

8.3.1 Dynamic Loading Model Method

The ten-year period from July 1, 1994 to June 30, 2004 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. Seasonal variation was incorporated by using varying monthly loading rates and daily meteorological data for the same ten-year period.

The 30-day critical period is the period preceding the highest simulated exceedance 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 Chatata Creek and Chestuee Creek, the highest exceedances of the 30-day geometric means occurred during the 30-day period 10/24 – 11/22/98. For North Mouse Creek, the highest exceedance of the 30-day geometric mean occurred during the 30-day period 10/25 – 11/23/98. Lastly, for Oostanaula Creek at the mouth, mile 5.7, mile 26.6, and mile 34.2, the highest exceedances of the 30-day geometric means occurred during the 30-day periods 8/25 – 9/23/96, 8/25 – 9/23/96, 8/24 – 9/22/96, and 10/23 – 11/21/98, respectively.

8.3.2 Load Duration Curve Method

Critical conditions are accounted for in the load duration curve analysis by using the entire period of flow and water quality data available for the impaired waterbodies. Water quality data have been collected during all flow ranges. Based on the positions of the water quality exceedances on the load duration curves (primarily between the 10% and 40% duration intervals with a secondary prevalence between 0% and 60%), runoff during wet weather events is the probable dominant delivery mode for E. coli (see Section 9.3).

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. Water quality data were collected during all seasons.

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.

An explicit MOS, equal to 10% of the E. coli and fecal coliform water quality goals (ref.: Section 5.0), was utilized for TMDL analysis each of the three analysis methodologies. Explicit MOS and the resulting target concentrations are shown in Table 8.

Table 8. Explicit MOS and Target Concentrations

Pollutant	WQ Goal Type	WQ Goal [cts./100mL]	Explicit MOS [cts./100mL]	Target [cts./100mL]
E. coli	Maximum	941	94	847
	30-Day Geometric Mean	126	13	113
Fecal Coliform	Maximum	1,000	100	900
	30-Day Geometric Mean	200	20	180

An implicit MOS was utilized in the dynamic loading model analysis methodology. This implicit MOS included 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.

8.5 Determination of TMDLs

Load reductions were developed for most of the Hiwassee River watershed E. coli-impaired waterbodies using Load Duration Curves (LDCs) to achieve compliance with the maximum target concentrations (Appendix C), for both E. coli and fecal coliform. Load reductions were also developed for Chatata Creek, Chestuee Creek, North Mouse Creek, and the five Oostanaula Creek waterbodies using the Dynamic Loading Model to achieve compliance with the 30-day geometric mean target concentration (Appendix D). In addition, for waterbodies (e.g., Rogers Creek) with samples collected at sufficient number and frequency (minimum of 5 samples in a 30 day period), load reductions were determined by simple calculation of the geometric mean to achieve compliance with the 30-day geometric mean target concentration.

For the Hiwassee River mainstem waterbody, flows were not simulated due to unsuitable conditions for modeling, therefore, LDCs could not be developed and load reductions could not be determined using the dynamic loading model. The waterbody segment, on the lower section of the Hiwassee River, is influenced by backwater from Chickamauga Lake, having the hydrodynamic characteristics of a reservoir rather than a free-flowing river. Load reductions for this waterbody were calculated based on simple 90th percentiles of water quality samples, for both E. coli and fecal coliform.

Woolen Mill Branch has only a single sample for E. coli. Load reduction for this waterbody was calculated based on a simple calculation of the reduction required for the single sample to achieve compliance with the maximum target concentration for E. coli.

The instream load reductions determined by these methodologies (load duration curves, dynamic loading model, geometric mean calculations, and simple calculations) were compared and the largest required load reduction was selected as the TMDL for each E. coli-impaired waterbody. TMDL load reductions for the Hiwassee River waterbodies are shown in Table 9.

For Oostanaula Creek, the 2002 EPA-approved Fecal Coliform TMDL was updated and revised with recently collected water quality data (see Appendix E).

8.6 Determination of WLAs & LAs

WLAs & LAs are developed in Appendix F for point sources and nonpoint sources respectively. TMDLs, WLAs, & LAs for Hiwassee River watershed impaired waterbodies are summarized in Table 10.

Table 9. Determination of TMDLs for Impaired Waterbodies, Hiwassee River Watershed

Drainage Area and/or HUC-12 Subwatershed (03150101__)	Impaired Waterbody Name	Impaired Waterbody ID	Required Load Reduction				
			Dynamic Loading Model [%] (Fecal Coliform)	Load Duration Curve [%]		Geometric Mean (E. Coli)	TMDL [%]
				E. Coli	Fecal Coliform		
Agency Creek (0605)	Agency Creek	TN06020002001 - 0100	**NA**	88.2	**NA**	**96.0**	**96.0**
0602	Hiwassee River	TN06020002008 - 1000	**NA**	29.4	**65.9**	**NA**	**65.9**
0603	Fillauer Creek	TN06020002009 - 0200	**NA**	>59.2	**NA**	**>85.7**	**>85.7**
	Woolen Mill Branch	TN06020002009 - 0300	**NA**	**NA**	**NA**	**NA**	**>65.0**[1]
	South Mouse Creek	TN06020002009 - 2000	**NA**	>61.5	**NA**	**>92.4**	**>92.4**
Little Chatata Creek (0601)	Little Chatata Creek	TN06020002012 - 0200	**NA**	33.1	**NA**	**87.2**	**87.2**
Chatata Creek (0601)	Chatata Creek	TN06020002012 - 1000	**92.7**	77.3	82.5	**NA**	**92.7**
Hawkins Branch (0305)	Hawkins Branch	TN06020002018 - 0100	**NA**	>75.0	**90.2**	**NA**	**90.2**
Dairy Branch (0305)	Dairy Branch	TN06020002018 - 0200	**NA**	>90.8	**92.9**	**NA**	**92.9**
0501	Little Chestuee Creek	TN06020002082 - 0200	**NA**	56.2	**NA**	**89.5**	**89.5**
	Chestuee Creek	TN06020002082 - 2000	75.8	53.3[2]	0.0	**87.9**	**87.9**
0702	Oostanaula Creek	TN06020002083 - 1000	17.8	**NA**	**NA**	**NA**	**17.8**
	Oostanaula Creek	TN06020002083 - 2000	28.6	**38.4**	31.2	**NA**	**38.4**
	Oostanaula Creek	TN06020002083 - 3000	34.1	64.7	**72.2**	**NA**	**72.2**[3]
0701	Oostanaula Creek	TN06020002083 - 4000	28.6	32.2	**54.2**	**NA**	**54.2**
	Oostanaula Creek	TN06020002083 - 5000	**NA**	**NA**	**NA**	**NA**	**54.2**[4]

Table 9. Determination of TMDLs for Impaired Waterbodies, Hiwassee River Watershed (Cont.)

Drainage Area and/or HUC-12 Subwatershed (03150101__)	Impaired Waterbody Name	Impaired Waterbody ID	Required Load Reduction				
			Dynamic Loading Model [%] (Fecal Coliform)	Load Duration Curve [%]		Geometric Mean (E. Coli)	TMDL [%]
				E. Coli	Fecal Coliform		
0801	North Mouse Creek	TN06020002084 - 1000	**84.3**	79.6	80.3	**NA**	**84.3**
0802	North Mouse Creek	TN06020002084 - 1000	**84.3**	79.6	80.3	**NA**	**84.3**
0803	Spring Creek	TN06020002085 - 1000	**NA**	22.3	**NA**	**87.8**	**87.8**
0604	Rogers Creek	TN06020002087 - 1000	**NA**	40.1	**NA**	**90.0**	**90.0**
Price Creek (0605)	Price Creek	TN06020002088 - 1000	**NA**	46.5	**NA**	**81.9**	**81.9**

[1] Woolen Mill Branch percent reduction based on single E. coli sample exceeding 941 counts/100 mL.
[2] Chestuee Creek at Mile 42.5 (2003 data)
[3] Multiple water quality monitoring stations on this waterbody segment – TMDL percent reduction based on fecal coliform LDC analysis at Mile 30.1 (see Appendix D).
[4] Percent reduction based on model results at TN06020002083 - 4000 (no data in impaired waterbody).

Table 10. WLAs & LAs for Hiwassee River, Tennessee

Drainage Area and/or HUC-12 Subwatershed (03150101__)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs[a] (Monthly Avg.) E. Coli	Leaking Collection Systems[b]	CAFOs	MS4s[c]	Precipitation Induced Nonpoint Sources	Other Direct Sources[d]
			[% Red.]	[cts./day]	[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
Agency Creek (0605)	Agency Creek	TN06020002001 – 0100	**96.0**	**NA[e]**	**NA**	**NA**	**NA**	**96.0**	**0**
0602	Hiwassee River	TN06020002008 – 1000	**65.9**	**1.636×10^{11}**	**0**	**NA**	**NA**	**65.9**	**0**
0603	Fillauer Creek	TN06020002009 – 0200	**>92.4**	**NA[e]**	**0**	**NA**	**>85.7**	**>85.7**	**0**
	Woolen Mill Branch	TN06020002009 – 0300		**NA[e]**	**0**	**NA**	**>65.0**	**>65.0**	**0**
	South Mouse Creek	TN06020002009 – 2000		**9.542×10^{5}**	**0**	**NA**	**>92.4**	**>92.4**	**0**
Little Chatata Creek (0601)	Little Chatata Creek	TN06020002012 – 0200	**87.2**	**NA[e]**	**0**	**NA**	**87.2**	**87.2**	**0**
Chatata Creek (0601)	Chatata Creek	TN06020002012 – 1000	**92.7**	**NA[e]**	**0**	**NA**	**92.7**	**92.7**	**0**
Hawkins Branch (0305)	Hawkins Branch	TN06020002018 – 0100	**90.2**	**NA[e]**	**NA**	**NA**	**NA**	**90.2**	**0**
Dairy Branch (0305)	Dairy Branch	TN06020002018 – 0200	**92.9**	**NA[e]**	**NA**	**NA**	**NA**	**92.9**	**0**
0501	Little Chestuee Creek	TN06020002082 – 0200	**89.5**	**NA[e]**	**NA**	**NA**	**NA**	**89.5**	**0**
	Chestuee Creek	TN06020002082 – 2000		**1.193×10^{9}**	**0**	**NA**	**NA**	**87.9**	**0**
0702	Oostanaula Creek	TN06020002083 – 1000	**72.2**	**1.350×10^{10}**	**0**	**0**	**NA**	**17.8**	**0**
	Oostanaula Creek	TN06020002083 – 2000		**1.350×10^{10}**	**0**	**NA**	**28.6**	**28.6**	**0**
	Oostanaula Creek	TN06020002083 – 3000		**1.350×10^{10}**	**0**	**NA**	**72.2**	**72.2**	**0**
0701	Oostanaula Creek	TN06020002083 – 4000	**54.2**	**NA[e]**	**0**	**NA**	**54.2**	**54.2**	**0**
	Oostanaula Creek	TN06020002083 – 5000		**NA[e]**	**NA**	**NA**	**NA**	**54.2**	**0**

Table 10. WLAs & LAs for Hiwassee River, Tennessee (Cont.)

Drainage Area and/or HUC-12 Subwatershed (03150101__)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs[a] (Monthly Avg.) E. Coli	Leaking Collection Systems[b]	CAFOs	MS4s[c]	Precipitation Induced Nonpoint Sources	Other Direct Sources[d]
			[% Red.]	[cts./day]	[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
0801	North Mouse Creek	TN06020002084 – 1000	**84.3**	**2.018×10^9**	**0**	**0**	**84.3**	**84.3**	**0**
0802	North Mouse Creek	TN06020002084 – 1000	**84.3**	**7.839×10^9**	**0**	**0**	**84.3**	**84.3**	**0**
0803	Spring Creek	TN06020002085 – 1000	**87.8**	**8.109×10^7**	**NA**	**NA**	**NA**	**87.8**	**0**
0604	Rogers Creek	TN06020002087 – 1000	**90.0**	**5.735×10^7**	**NA**	**NA**	**NA**	**90.0**	**0**
Price Creek (0605)	Price Creek	TN06020002088 – 1000	**81.9**	**5.247×10^9**	**0**	**NA**	**NA**	**81.9**	**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 E. coli.
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 E. coli.
e. Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permit.

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 impaired waterbodies in the Hiwassee River watershed through reduction of excessive E. coli 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.

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.

In order to meet water quality criteria for the Hiwassee River, Chestuee Creek, Oostanaula Creek, Little North Mouse Creek, and North Mouse Creek, the Cleveland Utilities STP, Englewood STP, AUB-Oostanaula Creek STP, Niota STP, and AUB-North Mouse STP, respectively, must meet the provisions of their NPDES permits, including elimination of bypasses and overflows or continuation of the absence of these excursions.

9.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

For existing and future 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, 2003) 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 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.

In order to evaluate SWMP effectiveness and demonstrate compliance with specified WLAs, MS4s must develop and implement appropriate monitoring programs. Instream monitoring, at locations selected to best represent the effectiveness of BMPs, must include analytical monitoring of pollutants of concern as well as stream surveys to evaluate biological integrity. A detailed plan describing the monitoring program must be submitted to the Division of Water Pollution Control Chattanooga Field Office within 12 months of the approval date of this TMDL. Implementation of the monitoring program must commence within 6 months of plan approval by the Field Office. The monitoring program shall comply with the monitoring, recordkeeping, and reporting requirements of *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2003).

9.1.3 NPDES Regulated Concentrated Animal Feeding Operations (CAFOs)

WLAs provided to CAFOs will be implemented through NPDES Permit No. TNA000000, General NPDES Permit for *Class II Concentrated Animal Feeding Operation* or the facility's individual permit. Among the provisions of the general permit are:

- Development and implementation of a site-specific Nutrient Management Plan (NMP) that:
    - Includes best management practices (BMPs) and procedures necessary to implement applicable limitations and standards;
    - Ensures adequate storage of manure, litter, and process wastewater including provisions to ensure proper operation and maintenance of the storage facilities.
    - Ensures proper management of mortalities (dead animals);
    - Ensures diversion of clean water, where appropriate, from production areas;
    - Identifies protocols for manure, litter, wastewater and soil testing;
    - Establishes protocols for land application of manure, litter, and wastewater;
    - Identifies required records and record maintenance procedures.

  The NMP must submitted to the State for approval and a copy kept on-site.

- Requirements regarding manure, litter, and wastewater land application BMPs.

- Requirements for the design, construction, operation, and maintenance of CAFO liquid waste management systems that are constructed, modified, repaired, or placed into operation after April 13, 2006. Final design plans and specifications for these systems must meet or exceed standards in the NRCS Field Office Technical Guide and other guidelines as accepted by the Departments of Environment and Conservation, or Agriculture.

Provisions of individual CAFO permits are similar. NPDES Permit No. TNA000000, *Class II Concentrated Animal Feeding Operation General Permit* is available on the TDEC website at http://www.state.tn.us/environment/wpc/programs/cafo/.

9.2 Nonpoint Sources

The Tennessee Department of Environment & Conservation (TDEC) has no direct regulatory authority over most nonpoint source discharges. Reductions of E. coli 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. 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 Hiwassee River watershed to reduce the amount of coliform bacteria transported to surface waters from agricultural sources. These BMPs (e.g., animal waste management systems, waste utilization, stream stabilization, fencing, heavy use area treatment, livestock exclusion, etc.) may have contributed to reductions in in-stream concentrations of coliform bacteria in one or more Hiwassee River E. coli-impaired subwatersheds during the TMDL evaluation period. The TDA keeps a database of BMPs implemented in Tennessee. Those listed in the Hiwassee River watershed are shown in Figure 17. 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.

A Unified Watershed Assessment (UWA) is ongoing to assess agricultural operations in upper Oostanaula Creek and improve water quality through improved planning, assessment, and funding for and establishment of BMPs. A multi-agency cooperative effort, the UWA focuses resources on agricultural sources in the prioritized subwatersheds of Oostanaula Creek and utilizes Agricultural Resource Funding administered by NRCS to install BMPS on farms. The participating agencies are TDA, TDEC, the Tennessee Valley Authority (TVA), and U.S. Department of Agriculture (USDA) NRCS.

It is further recommended that BMPs be utilized to reduce the amount of coliform bacteria transported to surface waters from agricultural sources. Various types of BMPs should be established and maintained and their performance (in source reduction) evaluated over a period of at least two years prior to recommendations for utilization for subsequent 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.

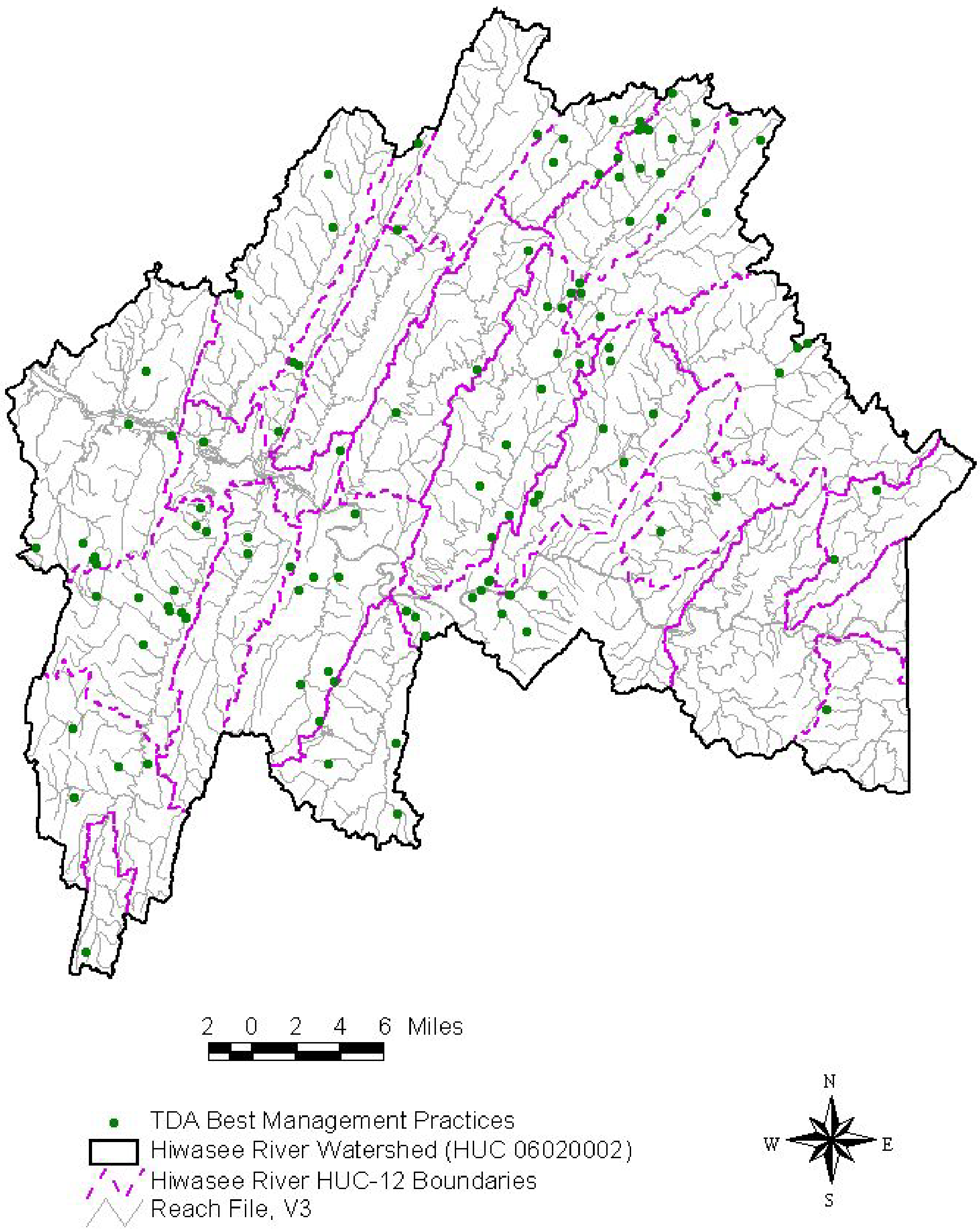

Figure 17. Tennessee Department of Agriculture Best Management Practices located in the Hiwassee River Watershed

9.3 Example Application of Load Duration Curves for Implementation Planning

The Load Duration Curve methodology (Appendix C) 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 E. coli by differentiating between point and non-point problems. The load duration curve analysis can be utilized for implementation planning. The E. coli load duration curve for Chatata Creek at Mile 0.5 (Figure 18) was analyzed to determine the frequency with which water quality monitoring data exceed the E. coli target maximum concentration of 847 counts/100 mL (standard – MOS) under five flow conditions (low, dry, mid- range, moist, and high). Observation of the plot suggests the Chatata Creek watershed is impacted primarily by non-point-type sources.

Table 11 presents Load Duration Curve analysis statistics for E. coli and example 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 implementation strategy for the Chatata Creek watershed will require BMPs targeting primarily non-point sources (dominant under high flow/runoff conditions). The implementation strategies listed in Table 11 are a subset of the categories of BMPs and implementation strategies available for application to the Hiwassee River subwatersheds for reduction of E. coli loading and mitigation of water quality impairment.

See Appendix C for a detailed discussion of the Load Duration Curve Methodology applied to Hiwassee River subwatersheds.

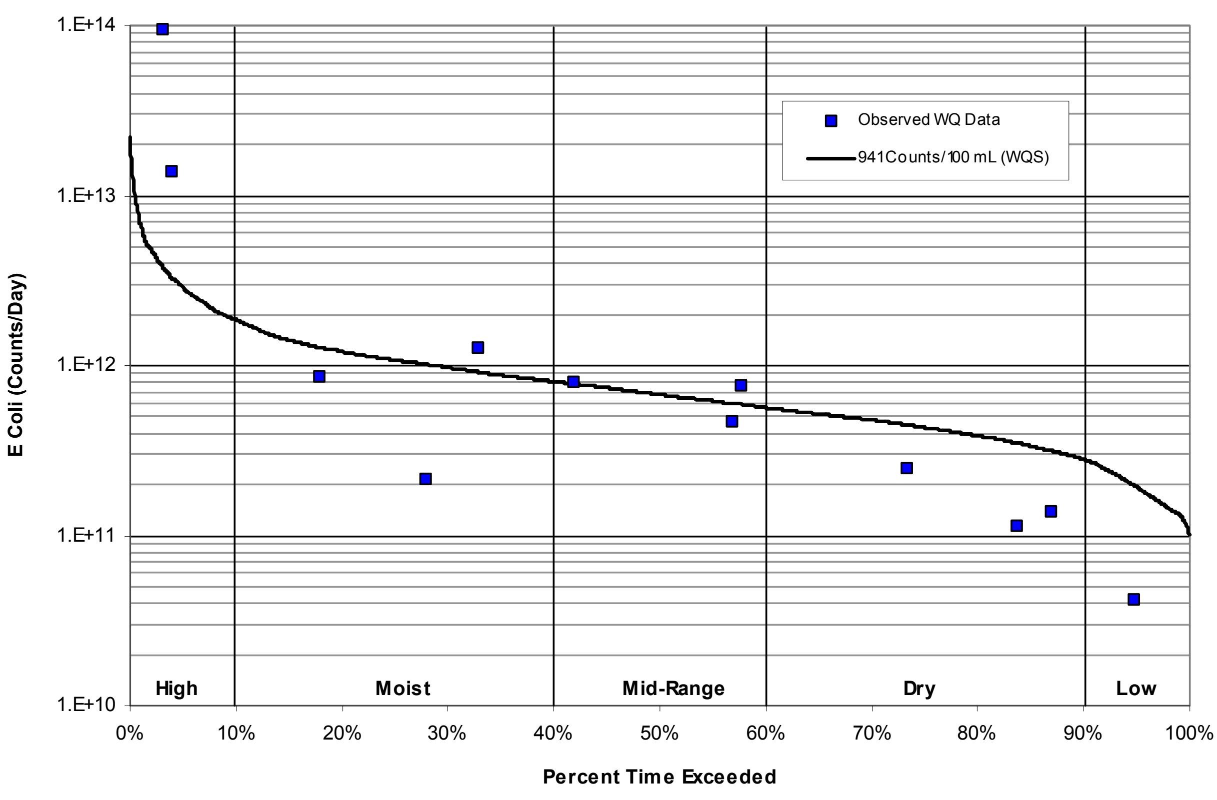

Figure 18. Load Duration Curve for Implementation Planning.

Table 11. Example Implementation Strategies

Flow Condition	High	Moist	Mid-range	Dry	Low
% Time Flow Exceeded	0-10	10-40	40-60	60-90	90-100
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[1]			M	H	H
Pasture Management/Land Application of Manure[1]	H	H	M	L	
Riparian Buffers[1]		H	H	H	
Potential for source area contribution under given hydrologic condition (H: High; M: Medium; L: Low)					

[1] Example Best Management Practices (BMPs) for Agricultural Source reduction. Actual BMPs applied may vary.

9.4 Additional Monitoring

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

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.

Additional monitoring and assessment activities are recommended for the Hiwassee River watershed E. coli-impaired subwatersheds to verify the assessment status of the stream reaches identified on the Final 2004 303(d) list as impaired due to E. coli. If it is determined that these stream reaches are still not fully supporting designated uses, then sufficient data to enable development of a TMDL must be acquired. In addition, collection of pathogen data at sufficient frequency to support calculation of the geometric mean, as described in Tennessee's General Water Quality Criteria (TDEC, 2004), is encouraged.

Many of the subject waterbodies have limited sampling data (5-6 samples) collected during a single 30-day period that is not representative of the full range of flow conditions. These waterbodies are Agency Creek, Fillauer Creek, South Mouse Creek, Little Chatata Creek, Little Chestuee Creek, Spring Creek, Rogers Creek, and Price Creek. For each waterbody, the sampling period is in the late May to early July 2003 timeframe. All samples were collected at flows in the moist flow range, representing high-flow conditions, typical of nonpoint sources. Therefore, these waterbodies do not have adequate data to establish conditions during other flow regimes, including those indicative of point source issues (low flows). In addition, Woolen Mill Branch has only a single sample for E. coli. Additional monitoring must be completed before a reliable assessment of impairment can be conducted, thereby identifying source response under varying flow conditions.

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, Microbial Source Tracking (MST) is one approach to determining the sources of fecal pollution and pathogens affecting a waterbody. Those methods that use bacteria as target organisms are also known as Bacterial Source Tracking (BST) methods. This technology is recommended for source identification in E. coli impaired waterbodies.

Bacterial Source Tracking is a collective term used for various emerging biochemical, chemical, and molecular methods that have been developed to distinguish sources of human and non-human fecal pollution in environmental samples (Shah, 2004). In general, these methods rely on genotypic (also known as "genetic fingerprinting"), or phenotypic (relating to the physical characteristics of an organism) distinctions between the bacteria of different sources. Three primary genotypic techniques are available for BST: ribotyping, pulsed field gel electrophoresis (PFGE), and polymerase chain reaction (PCR). Phenotypic techniques generally involve an antibiotic resistance analysis (Hyer, 2004).

The USEPA has published a fact sheet that discusses BST methods and presents examples of BST application to TMDL development and implementation (USEPA, 2002b). Various BST projects and descriptions of the application of BST techniques used to guide implementation of effective BMPs to remove or reduce fecal contamination are presented. The fact sheet can be found on the following EPA website: http://www.epa.gov/owm/mtb/bacsortk.pdf.

A multi-disciplinary group of researchers is developing and testing a series of different microbial assay methods based on real-time PCR to detect fecal bacterial concentrations and host sources in water samples (McKay, 2005). The assays have been used in a study of fecal contamination and have proven useful in identification of areas where cattle represent a significant fecal input and in development of BMPs. It is expected that these types of assays could have broad applications in monitoring fecal impacts from Animal Feeding Operations, as well as from wildlife and human sources.

A similar project has been initiated to determine sources and concentrations of fecal bacteria in Chatata and Oostanaula Creeks using real-time PCR. Multiple sampling sites have been identified in each watershed. Samples will be analyzed for fecal coliform, total Bacteroides (AllBac), human Bacteroides (HuBac) and bovine Bacteroides (BoBac). The lead organizations include the University of Tennessee, Center for Environmental Biotechnology and the Departments of Earth and Planetary Sciences and Civil and Environmental Engineering, in cooperation with TDEC, Athens Utility Board, McMinn County, and the Cities of Athens and Cleveland.

9.6 Evaluation of TMDL Implementation Effectiveness

The effectiveness of the TMDL implementation 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 E. coli 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 E. coli 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 TMDLs for the Hiwassee River watershed were 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 TMDLs was posted on the TDEC 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 TMDLs (similar to the website announcement) was included in one of the NPDES permit Public Notice mailings which was sent to approximately 90 interested persons or groups who have requested this information.

3) Draft copies of the proposed TMDLs were sent to the city of Athens, the city of Cleveland, Bradley County, and the Tennessee Department of Transportation.

4) Letters were sent to WWTFs located in E. coli-impaired subwatersheds in the Hiwassee River watershed, permitted to discharge treated effluent containing E. coli, advising them of the proposed TMDLs and their availability on the TDEC website. The letters also stated that a copy of the draft TMDL document would be provided on request. Letters were sent to the following facilities:

    Englewood STP (TN0021938)
    Cleveland Utilities STP (TN0024121)
    AUB-Oostanaula Creek STP (TN0024201)
    Niota STP (TN0025470)
    Athens Ramada Inn (TN0028886)
    E. K. Baker School (TN0029483)
    Riceville Elementary School (TN0029491)
    AUB-North Mouse Creek STP (TN0067539)
    Rogers Creek Elementary School (TN0067555)

No written comments were received during the proposed TMDL public comment period. No requests to hold public meetings were received regarding the proposed TMDLs as of close of business on December 26, 2005.

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

Land Use Distribution in the Hiwassee River Watershed

Table A-1. MRLC Land Use Distribution of Hiwassee River Subwatersheds

Land Use	Hiwassee River Subwatersheds									
	Agency Creek		Price Creek		Rogers Creek		Spring Creek		Hiwassee River	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	3260	36.4	1464	41.7	16813	52.1	4329	40.1	4385	28.8
Emergent Herbaceous Wetlands	21	0.2	0	0.0	1	0.0	0	0.0	161	1.1
Evergreen Forest	1838	20.5	827	23.5	5264	16.3	787	7.3	3089	20.3
High Intensity Commercial/Industrial/Transp.	12	0.1	0	0.0	25	0.1	15	0.1	229	1.5
High Intensity Residential	0	0	0	0	0	0	0	0	24	0.2
Low Intensity Residential	31	0.3	3	0.1	55	0.2	30	0.3	179	1.2
Mixed Forest	1531	17.1	613	17.4	5337	16.5	1248	11.6	2360	15.5
Open Water	0	0.0	1	0.0	20	0.1	2	0.0	769	5.0
Other Grasses (Urban/recreation; e.g. parks)	10	0.1	0	0.0	8	0.0	14	0.1	133	0.9
Pasture/Hay	1798	20.1	491	14.0	3719	11.5	3452	32.0	2293	15.0
Quarries/Strip Mines/Gravel Pits	0	0.0	0	0.0	14	0.0	12	0.1	155	1.0
Row Crops	364	4.1	110	3.1	616	1.9	812	7.5	806	5.3
Transitional	0	0.0	0	0.0	210	0.7	94	0.9	105	0.7
Woody Wetlands	98	1.1	6	0.2	189	0.6	0	0.0	557	3.7
Total	8963	100.0	3515	100.0	32271	100.0	10795	100.0	15245	100.0

Table A-1. MRLC Land Use Distribution of Hiwassee River Subwatersheds (Cont.)

Land Use	Hiwassee River Subwatersheds									
	North Mouse Creek		Chestuee Creek		Little Chestuee Creek		Hawkins Branch		Dairy Branch	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	11684	25.2	4753	19.1	1448	25.3	93	15.8	20	7.2
Emergent Herbaceous Wetlands	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Evergreen Forest	7053	15.2	4034	16.2	1334	23.3	66	11.2	26	9.3
High Intensity Commercial/Industrial/Transp.	1173	2.5	98	0.4	8	0.1	0	0.0	0	0.0
High Intensity Residential	220	0.5	45	0.2	0	0.0	0	0.0	0	0.0
Low Intensity Residential	805	1.7	361	1.5	14	0.2	9	1.5	0	0.0
Mixed Forest	9308	20.1	5255	21.1	1673	29.3	134	22.7	19	6.8
Open Water	22	0.0	17	0.1	4	0.1	1	0.2	4	1.4
Other Grasses (Urban/recreation; e.g. parks)	430	0.9	222	0.9	0	0.0	0	0.0	0	0.0
Pasture/Hay	12175	26.3	7697	30.9	1052	18.4	241	40.8	155	55.6
Quarries/Strip Mines/Gravel Pits	84	0.2	0	0.0	0	0.0	0	0.0	0	0.0
Row Crops	2985	6.4	2195	8.8	134	2.3	44	7.5	53	19.0
Transitional	141	0.3	223	0.9	51	0.9	1	0.2	0	0.0
Woody Wetlands	238	0.5	0	0.0	0	0.0	0	0.0	0	0.0
Total	46322	100.0	24901	100.0	5719	100.0	590	100.0	279	100.0

Table A-1. MRLC Land Use Distribution of Hiwassee River Subwatersheds (Cont.)

Land Use	Hiwassee River Subwatersheds									
	South Mouse Creek		Woolen Mill Branch		Fillauer Branch		Chatata Creek		Little Chatata Creek	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	1599	16.2	185	12.0	495	18.9	5888	28.1	1530	22.8
Evergreen Forest	746	7.6	43	2.8	203	7.7	2030	9.7	482	7.2
High Intensity Commercial/Industrial/Transp.	996	10.1	318	20.6	163	6.2	299	1.4	263	3.9
High Intensity Residential	826	8.4	226	14.6	226	8.6	58	0.3	53	0.8
Low Intensity Residential	2536	25.7	486	31.5	767	29.2	508	2.4	335	5.0
Mixed Forest	1433	14.5	136	8.8	435	16.6	3049	14.6	912	13.6
Open Water	6	0.1	4	0.3	1	0.1	2	0.0	1	0.0
Other Grasses (Urban/recreation; e.g. parks)	868	8.8	110	7.1	266	10.1	321	1.5	242	3.6
Pasture/Hay	495	5.0	13	0.8	3	0.1	7324	35.0	2307	34.5
Row Crops	340	3.5	18	1.1	66	2.5	1444	6.9	570	8.5
Transitional	5	0.1	3	0.2	2	0.1	8	0.0	1	0.0
Total	9851	100.0	1542	100.0	2625	100.0	20931	100.0	6696	100.0

Table A-1. MRLC Land Use Distribution of Hiwassee River Subwatersheds (Cont.)

Land Use	Hiwassee River Subwatersheds									
	Oostanaula Creek (Mile 42.7)		Oostanaula Creek (Mile 34.2)		Oostanaula Creek (Mile 26.6)		Oostanaula Creek (Mile 5.7)		Oostanaula Creek at the Mouth	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	460	23.9	1538	13.4	925	14.2	5244	31.8	2785	35.3
Evergreen Forest	251	13.1	1632	14.2	1369	20.9	2266	13.8	2070	26.2
High Intensity Commercial/Industrial/Transp.	0	0.0	48	0.4	331	5.1	56	0.3	0	0.0
High Intensity Residential	0	0.0	0	0.0	168	2.6	7	0.0	0	0.0
Low Intensity Residential	1	0.1	28	0.2	775	11.9	192	1.2	11	0.1
Mixed Forest	433	22.6	2111	18.3	1609	24.6	3653	22.2	1788	22.7
Open Water	9	0.5	10	0.1	3	0.0	8	0.0	0	0.0
Other Grasses (Urban/recreation; e.g. parks)	0	0.0	14	0.1	328	5.0	130	0.8	0	0.0
Pasture/Hay	546	28.5	4754	41.3	804	12.3	4009	24.3	847	10.7
Quarries/Strip Mines/Gravel Pits	0	0.0	0	0.0	0	0.0	0	0.0	6	0.1
Row Crops	219	11.4	1288	11.2	223	3.4	820	5.0	293	3.7
Transitional	0	0.0	93	0.8	0	0.0	97	0.6	89	1.1
Total	1921	100.0	11517	100.0	6535	100.0	16482	100.0	7890	100.0

APPENDIX B

Water Quality Monitoring Data

There are a number of water quality monitoring stations that provide data for waterbodies identified as impaired for E. coli in the Hiwassee River watershed. The location of these monitoring stations is shown in Figures 4-10. Monitoring data recorded at these stations for E. coli and fecal coliform are tabulated in Table B-1.

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed

Monitoring Station	Date	E. Coli [cts./100 mL]	Fecal Coliform [cts./100 mL]
AGENC002.1ME	6/10/03	**1299**	**NA**
	6/23/03	**1986**	**NA**
	6/25/03	**3190**	**NA**
	7/9/03	**9800**	**NA**
	7/10/03	**2240**	**NA**
HIWAS013.4MM	12/15/98	**980**	860
	3/9/99	170	770
	6/8/99	2	13
	9/14/99	19	16
	12/14/99	13	430
	3/15/00	260	**3900**
	6/19/00	4	15
	9/5/00	9	19
	12/4/00	93	93
	3/14/01	**>2400**	**5000**
	9/11/01	4	38
	3/25/02	170	190
	9/4/02	3	7
	12/17/02	52	160
	3/26/03	40	56
	6/17/03	**2400**	**2100**
	9/8/03	27	**NA**
	12/2/03	54	70
	3/9/04	**1200**	770
HIWAS015.6MM	4/27/98	27	70
	4/28/98	51	104
	7/13/98	20	34
	7/14/98	17	110
	7/15/98	13	112
	5/3/99	260	240
	5/4/99	120	140
	8/30/99	36	60
	8/31/99	25	30
	9/1/99	48	39

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli [cts./100 mL]	Fecal Coliform [cts./100 mL]
FILLA000.3BR	5/28/03	**>2419**	**NA**
	6/2/03	54.6	**NA**
	6/5/03	770	**NA**
	6/9/03	**1732**	**NA**
	6/11/03	**1299**	**NA**
	6/23/03	**1080**	**NA**
WMILL000.8BR	3/3/04	**>2419**	**NA**
SMOUS012.7BR	5/28/03	727	**NA**
	6/2/03	**1413**	**NA**
	6/5/03	**1413**	**NA**
	6/9/03	**>2419**	**NA**
	6/11/03	**1986**	**NA**
	6/23/03	**1520**	**NA**
LCHAT000.3BR	5/28/03	**980**	**NA**
	6/2/03	920	**NA**
	6/5/03	866	**NA**
	6/9/03	**1119**	**NA**
	6/11/03	**1413**	**NA**
	6/23/03	378	**NA**
CHATA000.5BR	8/27/02	200	92
	10/21/02	410	770
	11/12/02	**23590**	**25000**
	12/18/02	200	460
	1/28/03	740	270
	3/24/03	630	560
	4/29/03	**1320**	**1500**
	5/19/03	**4000**	**5200**
	8/19/03	**1210**	850
	11/4/03	310	560
	1/13/04	**960**	640
	5/11/04	520	730

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli	Fecal Coliform
		[cts./100 mL]	[cts./100 mL]
HAWKI000.3PO	12/30/02	4	8
	2/24/03	**1553**	**1500**
	3/17/03	61	70
	5/14/03	921	630
	6/4/03	96	84
	7/21/03	76	80
	8/27/03	150	400
	10/7/03	649	**2000**
	11/20/03	**1300**	**1200**
HAWKI001.3PO	12/30/02	**>2419**	**2800**
	2/24/03	**7540**	**7800**
	3/17/03	152	138
	5/14/03	**>2419**	**3600**
	6/4/03	260	400
	7/21/03	**>2419**	**22000**
	8/27/03	**2590**	**2700**
	10/7/03	816	**1200**
	11/20/03	**2920**	**2000**
	2/11/04	113	66
DAIRY000.4BR	2/24/03	**21720**	**17000**
	3/17/03	308	470
	5/14/03	**1553**	**2300**
	6/4/03	488	600
	7/21/03	291	360
	8/27/03	649	930
	10/7/03	63	60
	11/20/03	**>2419**	**2800**
DAIRY001.2BR	2/24/03	**36540**	**17000**
	3/17/03	6	10
	5/14/03	**>2419**	**11600**
	6/4/03	**>2419**	**4200**
	7/21/03	328	300
	8/27/03	7	20
	10/7/03	8	10
	11/20/03	**>2419**	**5300**
	2/11/04	**>2419**	**3000**

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli [cts./100 mL]	Fecal Coliform [cts./100 mL]
LCHES001.6MM	5/28/03	727	**NA**
	6/2/03	648	**NA**
	6/5/03	**1203**	**NA**
	6/9/03	**1046**	**NA**
	6/11/03	**>2419**	**NA**
CHEST042.5MM	3/2/98	249	168
	3/11/98	411	350
	4/13/98	770	660
	4/14/98	**1120**	**1030**
	4/15/98	687	690
	11/30/98	172	172
	12/1/98	157	130
	2/23/99	460	170
	5/17/99	870	600
	5/18/99	210	970
	8/16/99	250	560
	8/17/99	820	570
	11/15/99	120	90
	11/17/99	160	100
	5/28/03	547	**NA**
	6/2/03	517	**NA**
	6/5/03	**1553**	**NA**
	6/9/03	**1986**	**NA**
	6/11/03	816	**NA**
OOSTA005.8MM	10/22/02	411	300
	2/19/03	**1986**	**1900**
	8/20/03	461	340
	11/5/03	219	420
	1/14/04	236	176

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli	Fecal Coliform
		[cts./100 mL]	[cts./100 mL]
OOSTA026.6MM	3/26/02	**NA**	**10000**
	5/22/02	**NA**	400
	10/1/02	30	120
	10/29/02	610	**1210**
	11/19/02	350	140
	12/17/02	160	290
	1/21/03	30	120
	2/25/03	560	50
	3/25/03	80	60
	4/29/03	130	200
	6/3/03	720	960
	6/17/03	**1600**	960
	7/30/03	450	560
	9/3/03	50	140
	10/1/03	50	40
	11/18/03	400	460
	12/9/03	340	380
	1/26/04	**1690**	**1850**
	2/9/04	200	880
	3/15/04	320	230
	4/26/04	210	180
	5/24/04	60	150
	6/14/04	90	140
OOSTA028.4MM	12/16/82	**NA**	**19200**
	3/8/83	**NA**	**1290**
	6/7/83	**NA**	420
	9/20/83	**NA**	**4400**
	12/13/83	**NA**	**3300**
	3/13/84	**NA**	**14500**
	6/12/84	**NA**	100
	9/11/84	**NA**	230
	12/11/84	**NA**	**8700**
	3/12/85	**NA**	420
	9/10/85	**NA**	**2300**

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli [cts./100 mL]	Fecal Coliform [cts./100 mL]
OOSTA028.4MM	12/10/85	**NA**	280
	3/11/86	**NA**	30
	6/18/86	**NA**	670
	9/23/86	**NA**	400
	12/9/86	**NA**	**150000**
	3/10/87	**NA**	**40000**
	6/9/87	**NA**	**1730**
	9/15/87	**NA**	70
	12/8/87	**NA**	400
	3/15/88	**NA**	10
	6/7/88	**NA**	720
	9/13/88	**NA**	800
	12/13/88	**NA**	200
	3/7/89	**NA**	**12000**
	6/7/89	**NA**	**4500**
	3/15/90	**NA**	**15000**
	6/13/90	**NA**	980
	9/11/90	**NA**	**3000**
	12/12/90	**NA**	30
	3/12/91	**NA**	**3000**
	6/11/91	**NA**	460
	9/10/91	**NA**	**1000**
	12/4/91	**NA**	**26000**
	6/9/92	**NA**	**31000**
	6/10/92	**NA**	**31000**
	9/15/92	**NA**	420
	12/9/92	**NA**	480
	3/31/93	**NA**	**14700**
	6/23/93	**NA**	**1400**
	12/6/93	**NA**	**12800**
	3/14/94	**NA**	810
	6/20/94	**NA**	**1400**
	9/13/94	**NA**	960
	12/12/94	**NA**	**1320**
	3/13/95	**NA**	**1260**
	6/12/95	**NA**	**7600**

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli [cts./100 mL]	Fecal Coliform [cts./100 mL]
OOSTA028.4MM	9/18/95	**NA**	**2700**
	12/11/95	**NA**	250
	3/18/96	**NA**	**1600**
	6/10/96	**NA**	**17000**
	12/15/98	**>2419**	**8000**
	3/9/99	**2400**	**2900**
	5/24/99	**NA**	**3900**
	6/8/99	200	97
	6/14/99	**NA**	200
	7/19/99	**NA**	670
	8/11/99	**NA**	280
	9/13/99	**2400**	240
	12/7/99	820	830
	3/7/00	370	600
	6/12/00	140	200
	9/19/00	870	930
	12/11/00	160	320
	3/13/01	**2400**	**8700**
	9/11/01	200	170
	3/25/02	1	10
	10/22/02	260	270
	2/19/03	**1553**	**1800**
	7/30/03	560	250
	8/20/03	411	440
	9/3/03	120	300
	10/1/03	70	380
	11/5/03	365	220
	11/18/03	400	690
	12/9/03	310	320
	1/14/04	345	220
	1/26/04	**1650**	**1720**
	2/9/04	600	850
	3/15/04	250	300
	4/26/04	160	480
	5/24/04	80	170
	6/14/04	60	80

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli [cts./100 mL]	Fecal Coliform [cts./100 mL]
OOSTA030.0MM	3/26/02	**NA**	**12000**
	5/22/02	**NA**	**2900**
	10/1/02	160	550
	10/29/02	**2900**	**6000**
	11/19/02	550	710
	12/17/02	300	210
	1/21/03	300	410
	2/25/03	340	250
	3/25/03	60	120
	4/29/03	40	240
	6/3/03	**1200**	**1300**
	6/17/03	**1740**	**1680**
	7/30/03	120	270
	9/3/03	90	220
	10/1/03	150	210
	11/18/03	60	80
	12/9/03	170	160
	1/26/04	**2760**	**2850**
	2/9/04	150	190
	3/15/04	100	280
	4/26/04	920	870
	5/24/04	140	270
	6/14/04	50	330
OOSTA030.1MM	3/26/02	**NA**	**14000**
	5/22/02	**NA**	**3500**
	10/1/02	130	510
	10/29/02	**2500**	**6000**
	11/19/02	**1350**	560
	12/17/02	510	420
	1/21/03	190	230
	2/25/03	380	220
	3/25/03	100	100
	4/29/03	100	230
	6/3/03	600	840

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli [cts./100 mL]	Fecal Coliform [cts./100 mL]
OOSTA030.1MM	6/17/03	**1740**	**1560**
	7/30/03	240	380
	9/3/03	90	130
	10/1/03	130	260
	11/18/03	80	50
	12/9/03	220	200
	1/26/04	**1990**	**2200**
	2/9/04	**980**	**1200**
	3/15/04	250	370
	4/26/04	180	310
	5/24/04	200	360
	6/14/04	80	400
OOSTA033.6MM	7/30/03	**2750**	**2140**
	9/3/03	410	500
	10/1/03	400	870
	11/18/03	**1200**	**1180**
	12/9/03	890	740
	1/26/04	**2090**	**2120**
	2/9/04	800	1000
	3/15/04	210	250
	4/26/04	880	**1130**
	5/24/04	520	**1100**
	6/14/04	250	**1490**
OOSTA035.1MM	7/30/03	**1250**	**1850**
	9/3/03	100	310
	10/1/03	290	720
	11/18/03	40	120
	12/9/03	190	120
	1/26/04	**2610**	**2500**
	2/9/04	100	100
	3/15/04	280	330
	4/26/04	720	**1410**
	5/24/04	380	810
	6/14/04	130	50

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli [cts./100 mL]	Fecal Coliform [cts./100 mL]
NMOUS004.2MM	8/27/02	100	200
	10/21/02	310	380
	11/12/02	**8620**	**9000**
	12/18/02	100	130
	1/28/03	200	88
	3/24/03	410	200
	4/29/03	200	370
	5/19/03	**4570**	**5000**
	8/19/03	410	800
	11/4/03	310	320
	1/13/04	410	330
	5/11/04	310	130
SPRIN003.8MM	6/10/03	517	**NA**
	6/23/03	770	**NA**
	6/25/03	**1120**	**NA**
	7/9/03	**1046**	**NA**
	7/10/03	770	**NA**
SPRIN015.6MM	6/10/03	**980**	**NA**
	6/23/03	**1046**	**NA**
	6/25/03	866	**NA**
	7/9/03	686	**NA**
	7/10/03	**1119**	**NA**
ROGER002.7MM	6/10/03	517	**NA**
	6/23/03	435	**NA**
	6/25/03	613	**NA**
	7/9/03	461	**NA**
	7/10/03	770	**NA**
ROGER014.2MM	6/10/03	920	**NA**
	6/23/03	816	**NA**
	6/25/03	**1203**	**NA**
	7/9/03	**1413**	**NA**
	7/10/03	**1413**	**NA**

Table B-1. Water Quality Monitoring Data – Hiwassee River Watershed (Cont.)

Monitoring Station	Date	E. Coli	Fecal Coliform
		[cts./100 mL]	[cts./100 mL]
PRICE004.4ME	6/10/03	547	**NA**
	6/23/03	248	**NA**
	6/25/03	360	**NA**
	7/9/03	**980**	**NA**
	7/10/03	**1986**	**NA**

APPENDIX C

Load Duration Curve Development
and
Determination of Required Load Reductions

A flow duration curve is a cumulative frequency graph, constructed from historic flow data at a particular location, that represents the percentage of time a particular flow rate is equaled or exceeded. When a water quality target (or criterion) concentration is applied to the flow duration curve, the resulting load duration curve (LDC) represents the allowable pollutant loading in a waterbody over the entire range of flow. Pollutant monitoring data, plotted on the LDC, provides a visual depiction of stream water quality as well as the frequency and magnitude of any exceedances. Load duration curve intervals can be grouped into several broad categories or zones, in order to provide additional insight about conditions and patterns associated with the impairment. For example, the duration curve could be divided into five zones: high flows (exceeded 0-10% of the time), moist conditions (10-40%), median or mid-range flows (40-60%), dry conditions (60-90%), and low flows (90-100%). Impairments observed in the low flow zone typically indicate the influence of point sources, while those further left on the LDC (representing zones of higher flow) generally reflect potential nonpoint source contributions (Stiles, 2003).

C.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) regression equations (using drainage area as the independent variable) developed from continuous record stations in the same ecoregion; 2) drainage area extrapolation of data from a nearby continuous-record station of similar size and topography; and 3) calculation of daily mean flow using a dynamic computer model, such as the Loading Simulation Program C++ (LSPC).

Flow duration curves for impaired waterbodies in the Hiwassee River Watershed were derived from LSPC hydrologic simulations based on parameters derived from calibration at USGS Station No. 03565500, located on Oostanaula Creek near Sanford, located at mile 5.7 on Oostanaula Creek (see Appendix D for details of calibration). The data used, in each case, included the period of record from 7/1/94 – 6/30/04. For example, a flow-duration curve for North Mouse Creek at RM 4.2 was constructed using simulated daily mean flow for the period from 7/1/94 through 6/30/04 (RM 4.2 corresponds to the location of monitoring station NMOUS004.2MM). This flow duration curve is shown in Figure C-13 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record (the highest daily mean flow during this period is exceeded 0% of the time and the lowest daily mean flow is equaled or exceeded 100% of the time). Flow duration curves for other impaired waterbodies were derived using a similar procedure and are shown in Figures C-1 thru C-16. Flow duration curves were not developed for the Hiwassee River mainstem impaired waterbody due to unsuitable conditions for modeling.

C.2 Development of Load Duration Curves and Determination of Required Load Reductions

E. coli and fecal coliform load duration curves for impaired waterbodies in the Hiwassee River Watershed were developed from the flow duration curves developed in Section C.1 and available water quality monitoring data. Load duration curves were developed using the following procedure (North Mouse Creek is shown as an example):

1. A target load duration curve was generated for North Mouse Creek 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 C.1) and plotting the results. The fecal coliform target maximum load corresponding to each ranked daily mean flow is:

$(\text{Target Load})_{\text{North Mouse Creek}}$ = (900 cts./100 mL) x (Q) x (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 monitoring station NMOUS004.2MM (ref.: Table B-1) by multiplying the sample concentration by the daily mean flow for the sampling date and the required unit conversion factor. NMOUS004.2MM was selected for LDC analysis because it was the monitoring station on North Mouse Creek with the most exceedances of the target concentration.

   Note: 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 C.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 1 according to the PDFE. The resulting fecal coliform and E. coli load duration curves for are shown in Figures C-45 and C-46.

4. For cases where the existing load exceeded the target maximum load at a particular PDFE, the reduction required to reduce the sample load to the target load was calculated.

5. The 90^{th} percentile value for all of the fecal coliform sampling data at NMOUS004.2MM monitoring site was determined. If the 90^{th} percentile value exceeded the target maximum fecal coliform concentration, the reduction required to reduce the 90^{th} percentile value to the target maximum concentration was calculated.

6. Step 5 was repeated for E. coli data at NMOUS004.2MM.

7. For cases where five or more samples were collected over a period of not more than 30 consecutive days, the geometric mean fecal coliform concentration was determined and compared to the target geometric mean fecal coliform concentration of 180 cts/100 mL (200 cts/100mL – MOS). If the sample geometric mean exceeded the target geometric mean concentration, the reduction required to reduce the sample geometric mean value to the target geometric mean concentration was calculated.

8. Step 7 was repeated for the E. coli data at NMOUS004.2MM.

9. The load reductions required to meet the target maximum and target 30-day geometric mean concentrations of both fecal coliform and E. coli were compared and the load reduction of the greatest magnitude selected as the TMDL for North Mouse Creek. The determination of required load reductions for North Mouse Creek is shown in Tables C-30 and C-31.

Load duration curves and required load reductions of other impaired waterbodies were derived in a similar manner and are shown in Figures C-17 through C-49 and Tables C-1 through C-34. For the Hiwassee River mainstem impaired waterbody, where flows were not simulated due to unsuitable conditions for modeling (ref.: Section 8.5), load duration curves could not be developed. However, required load reductions were derived according to step 5 and are shown in Tables C-35 through C-38.

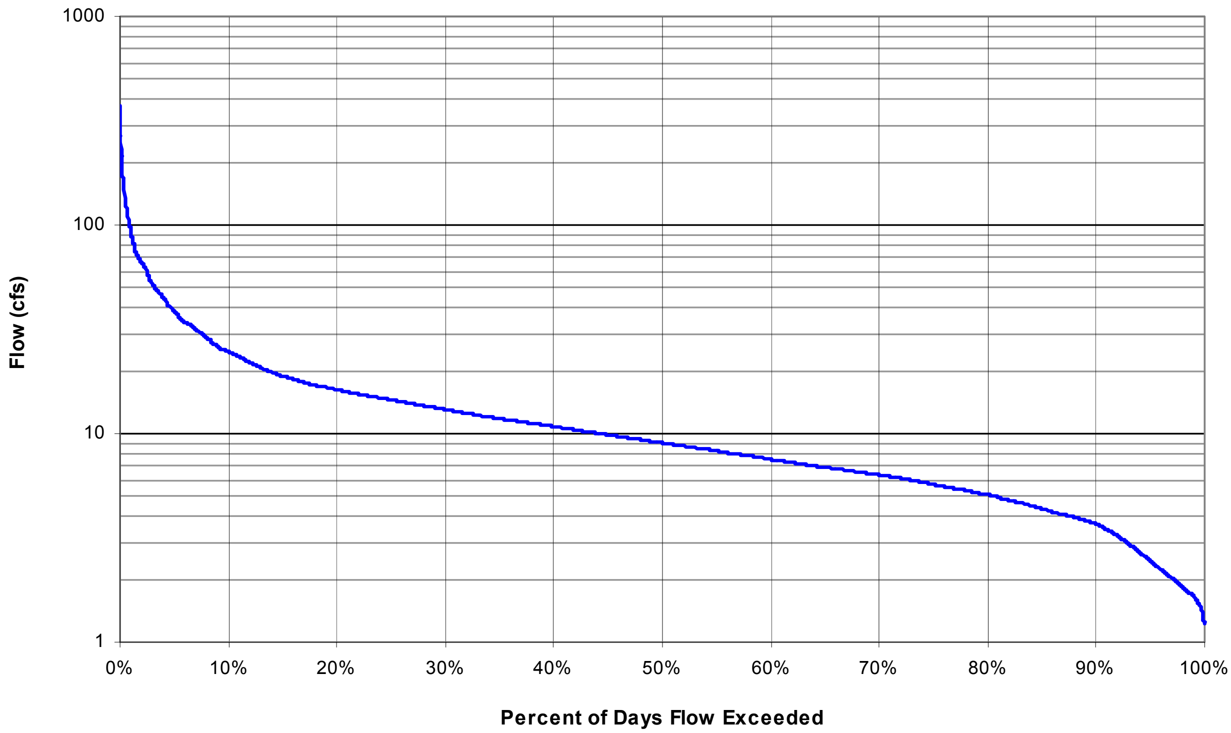


Figure C-1. Flow Duration Curve for Agency Creek at Mile 2.1

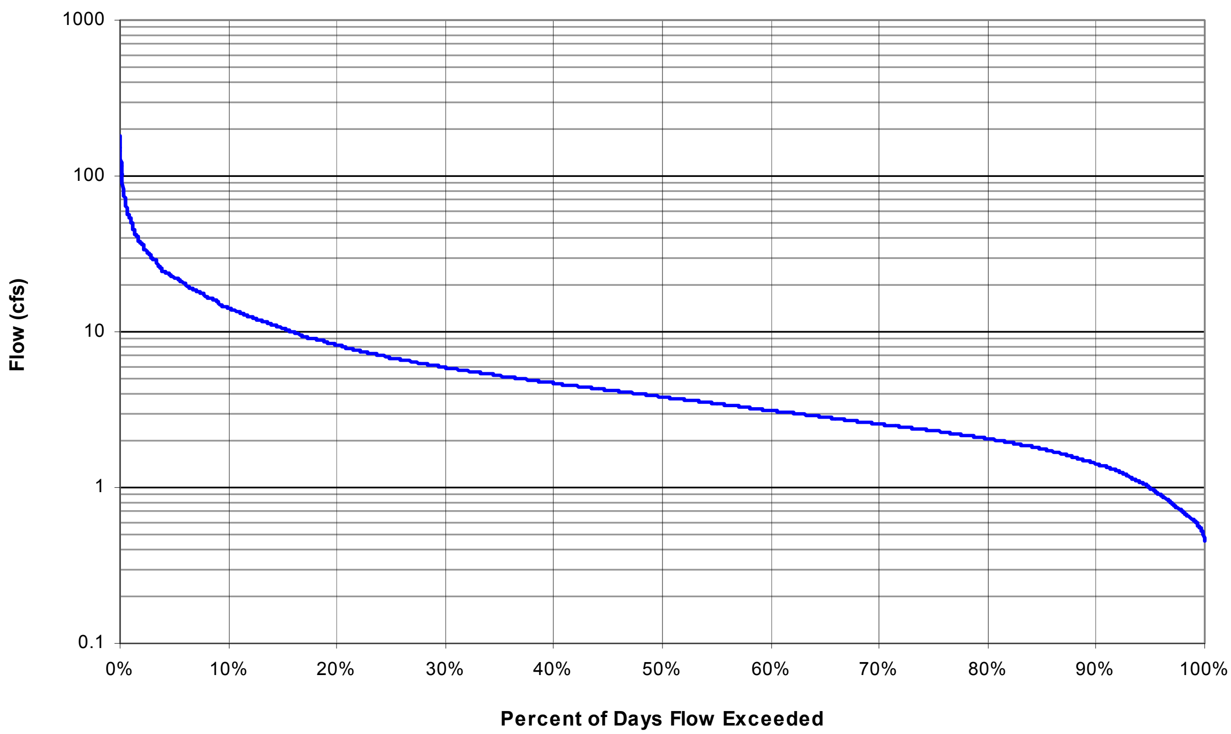


Figure C-2. Flow Duration Curve for Fillauer Branch at Mile 0.3

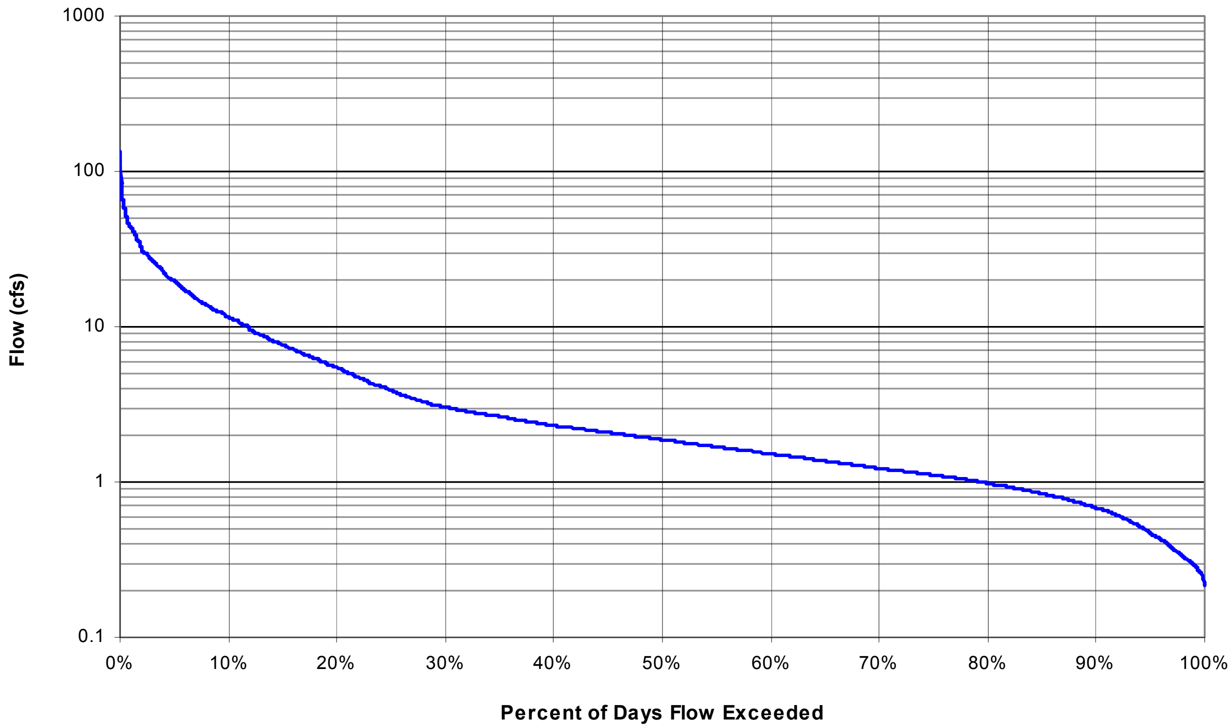


Figure C-3. Flow Duration Curve for Woolen Mill Branch at Mile 0.8

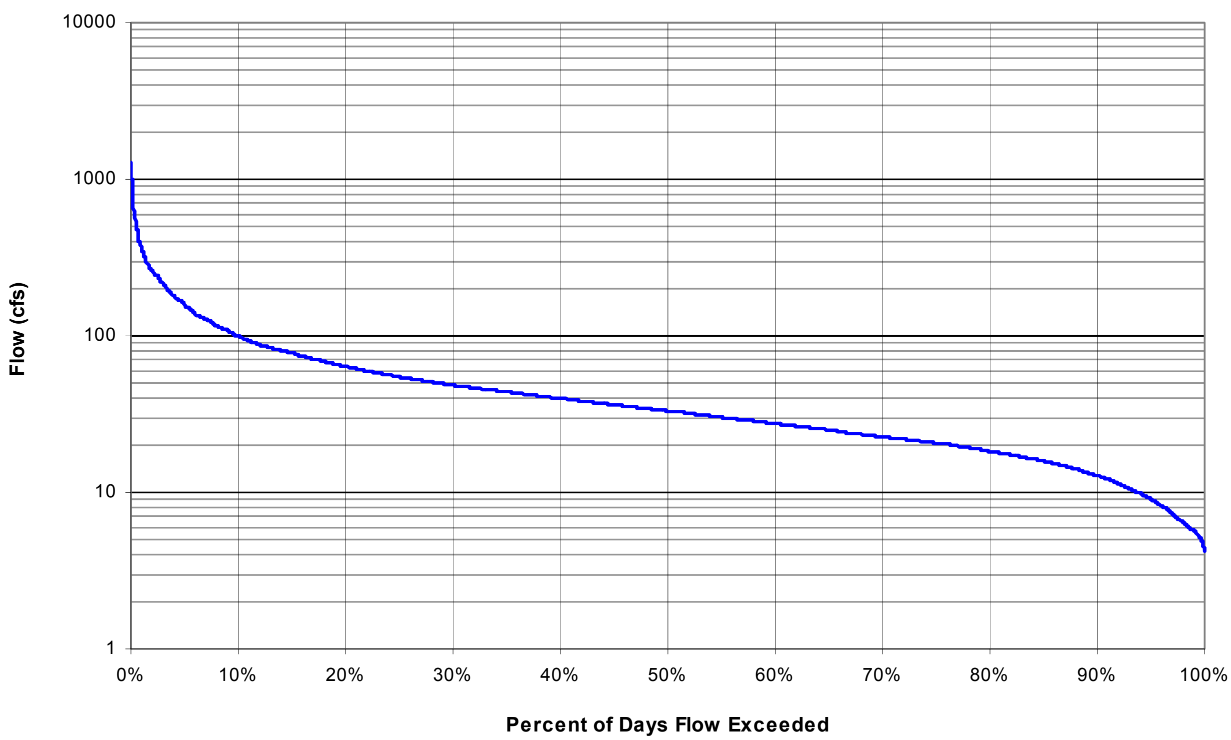


Figure C-4. Flow Duration Curve for South Mouse Creek at Mile 12.7

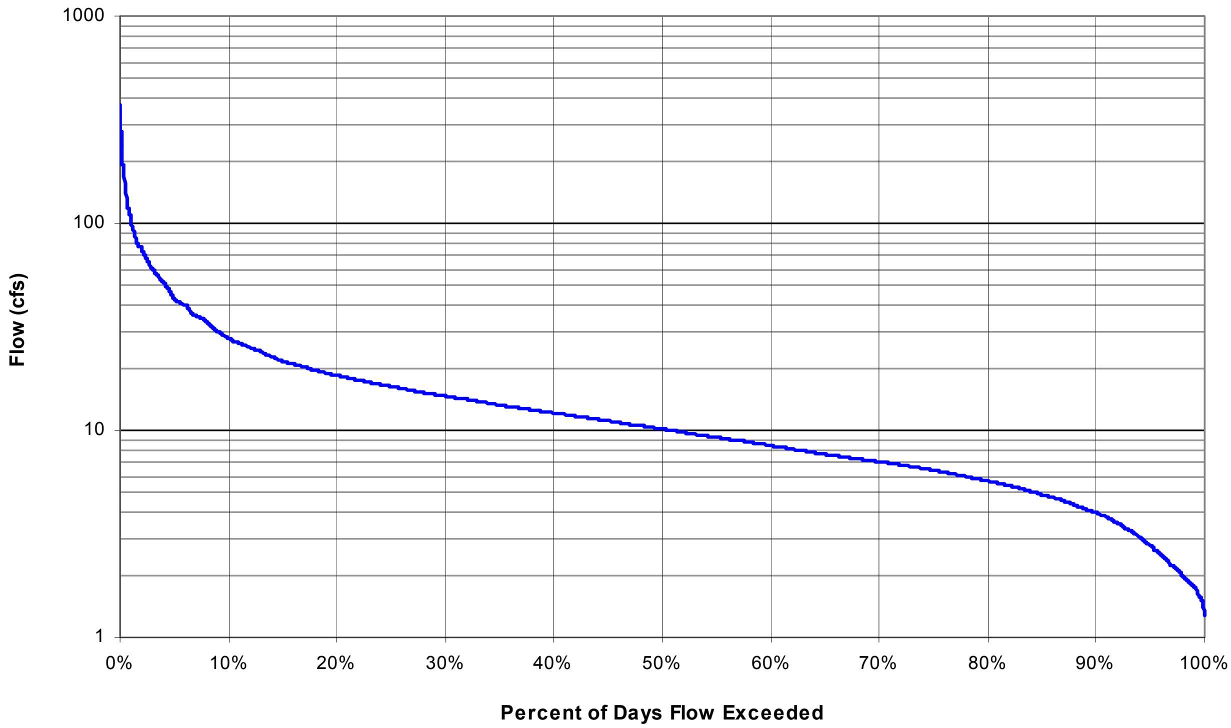


Figure C-5. Flow Duration Curve for Little Chatata Creek at Mile 0.3

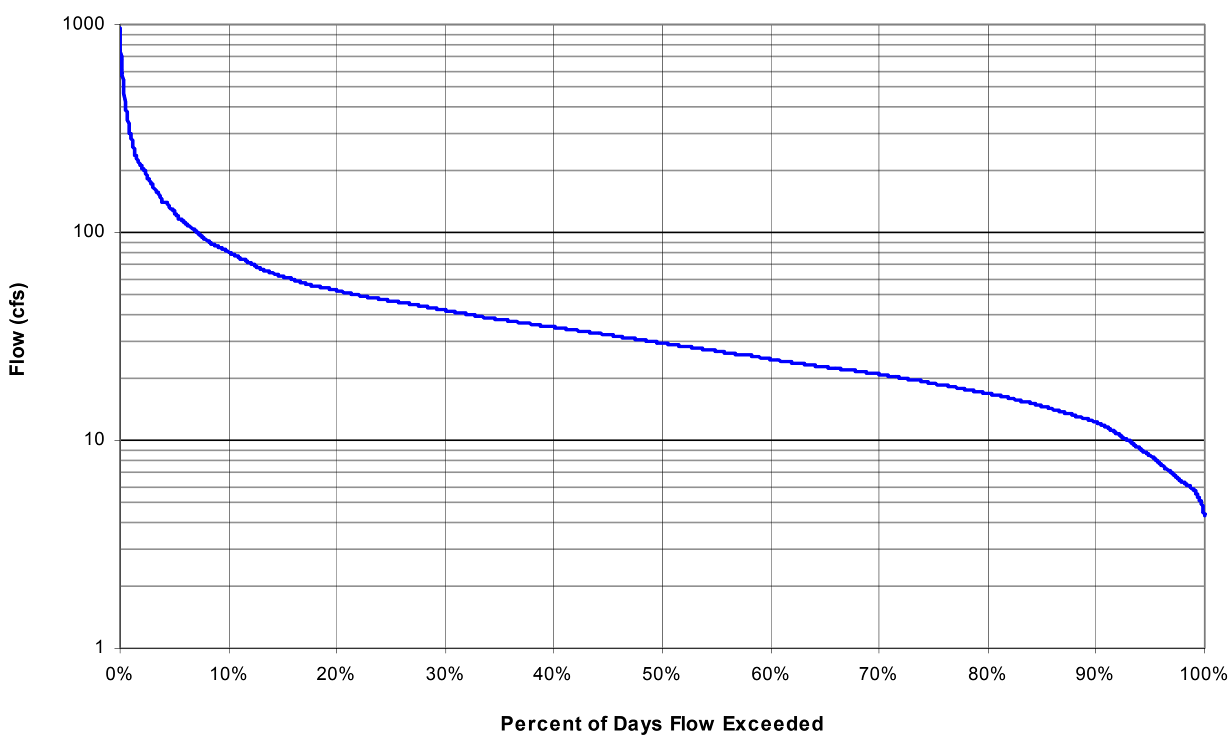


Figure D-6. Flow Duration Curve for Chatata Creek at Mile 0.5

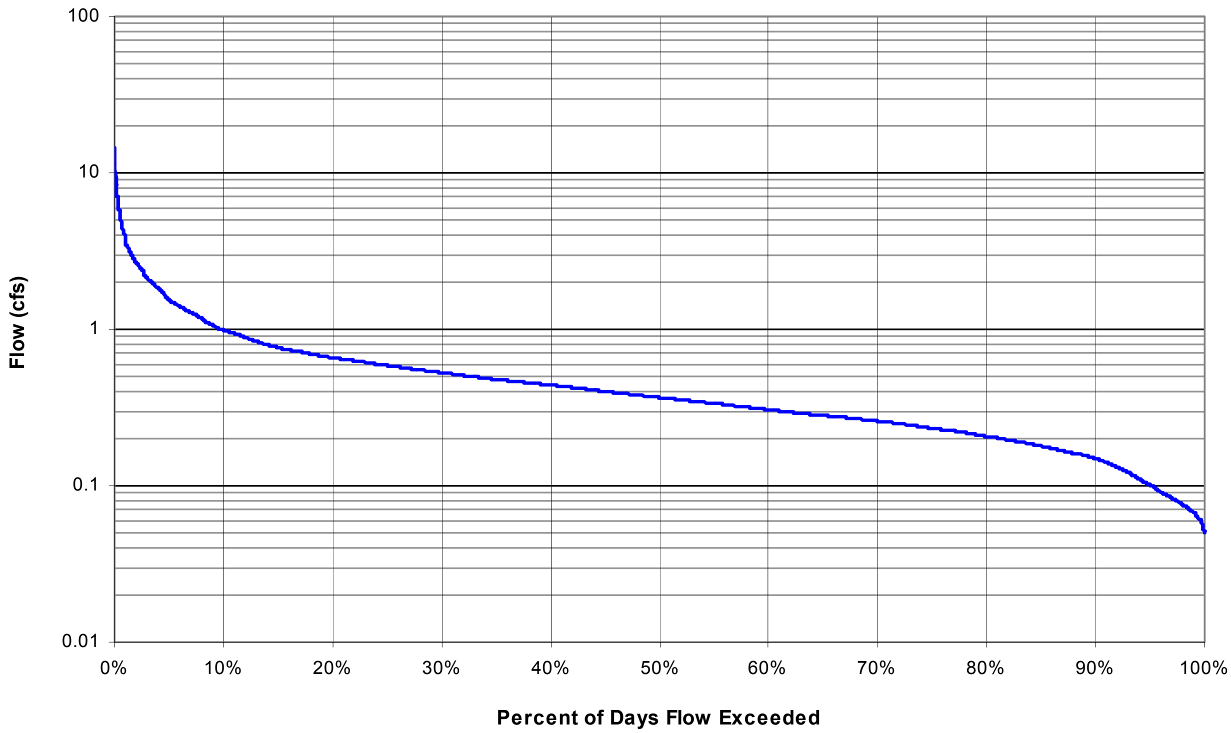


Figure C-7. Flow Duration Curve for Hawkins Branch at Mile 1.3

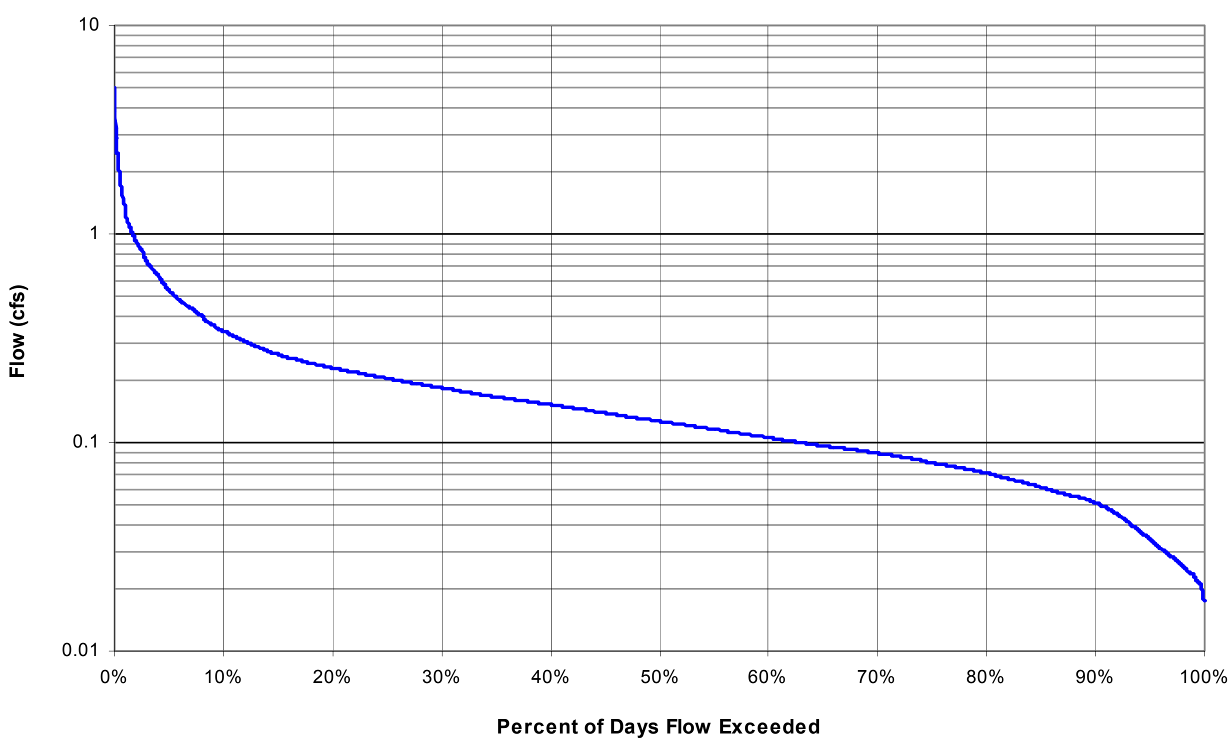


Figure C-8. Flow Duration Curve for Dairy Branch at Mile 1.2

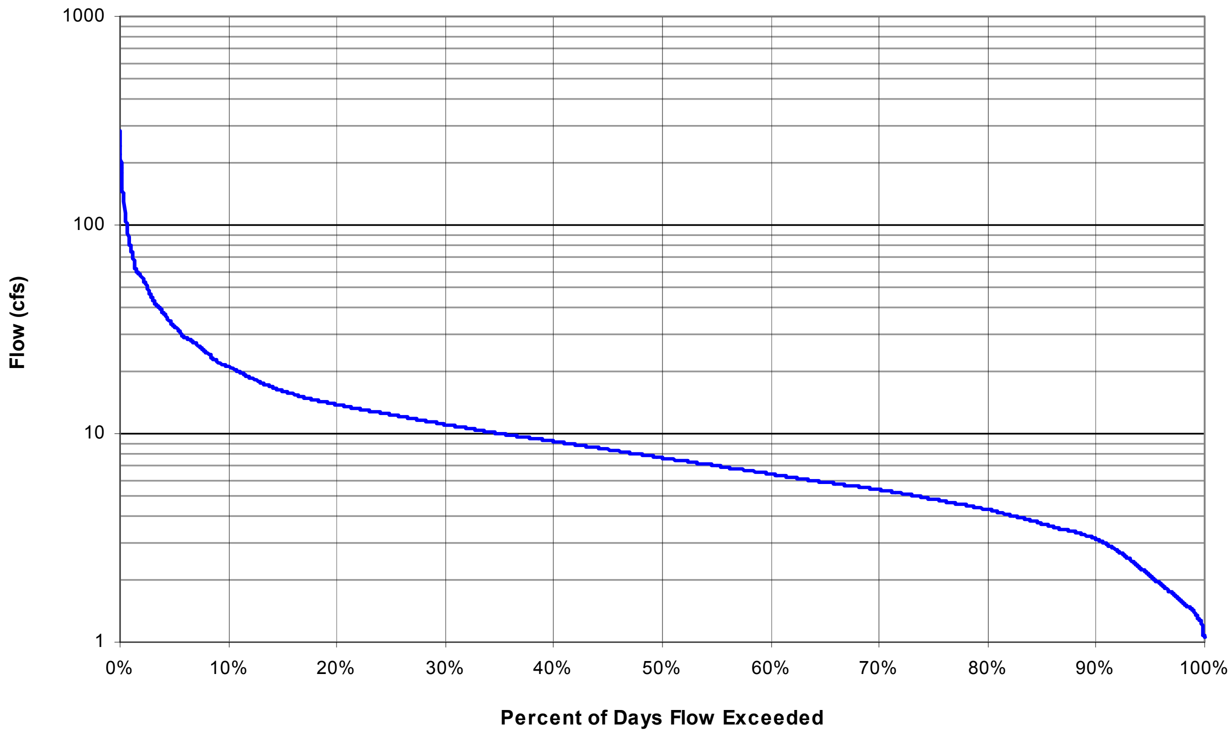


Figure C-9. Flow Duration Curve for Little Chestuee Creek at Mile 1.6

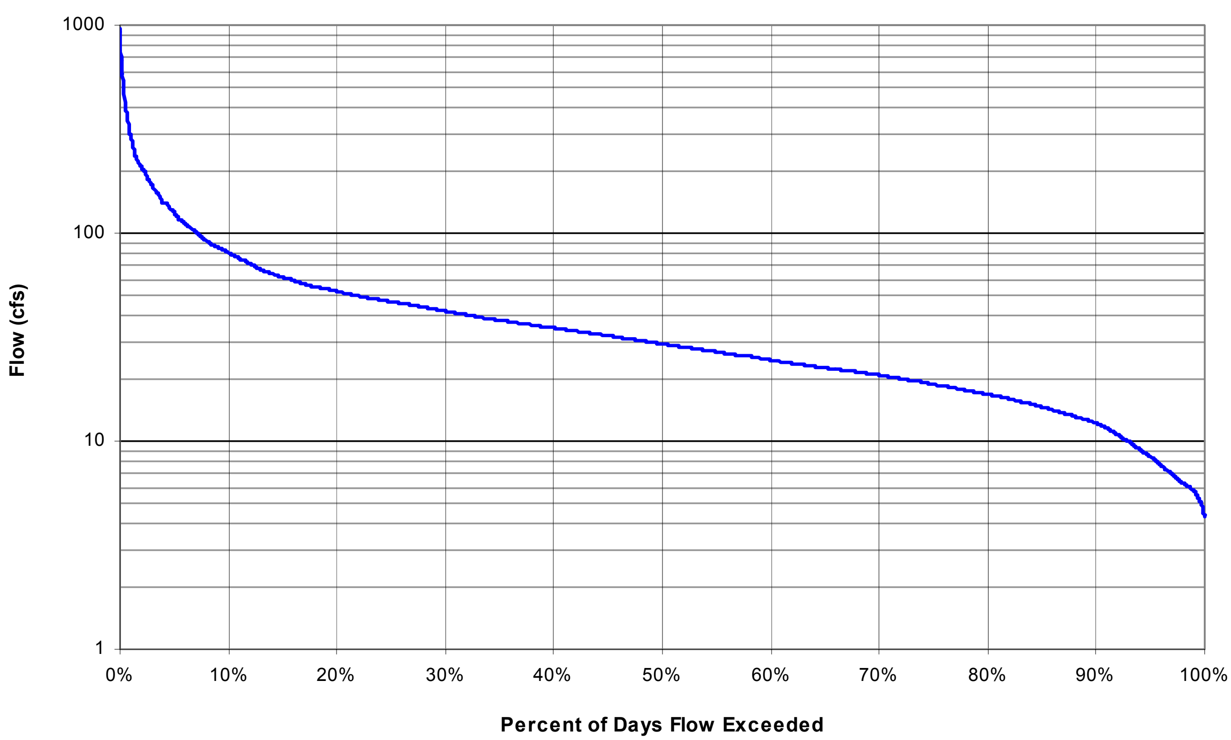


Figure C-10. Flow Duration Curve for Chestuee Creek at Mile 45.2

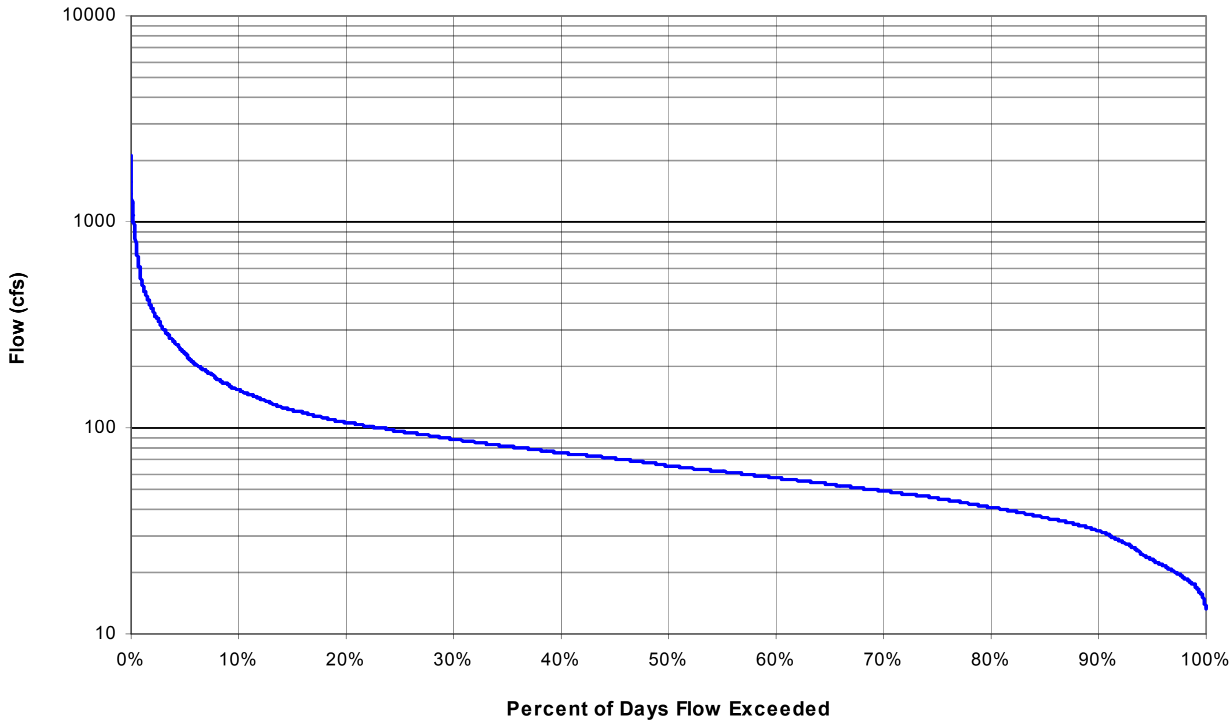


Figure C-11. Flow Duration Curve for Oostanaula Creek at Mile 5.7

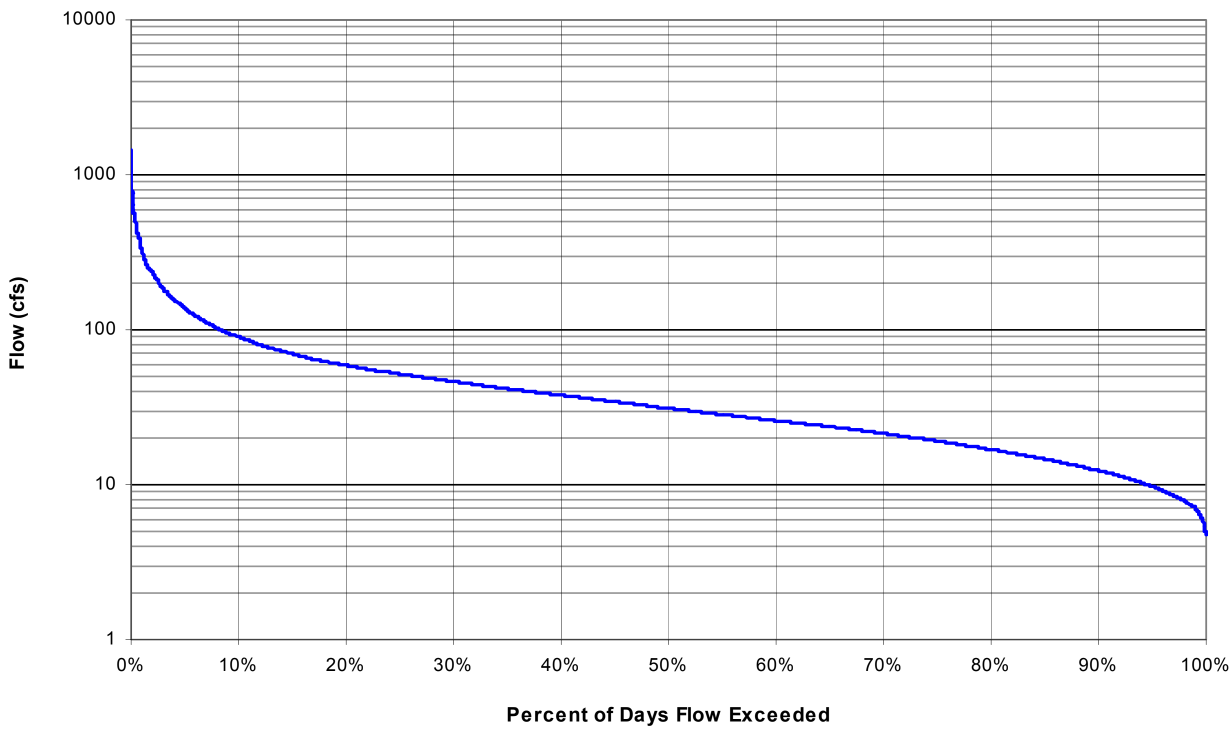


Figure C-12. Flow Duration Curve for Oostanaula Creek at Mile 28.4

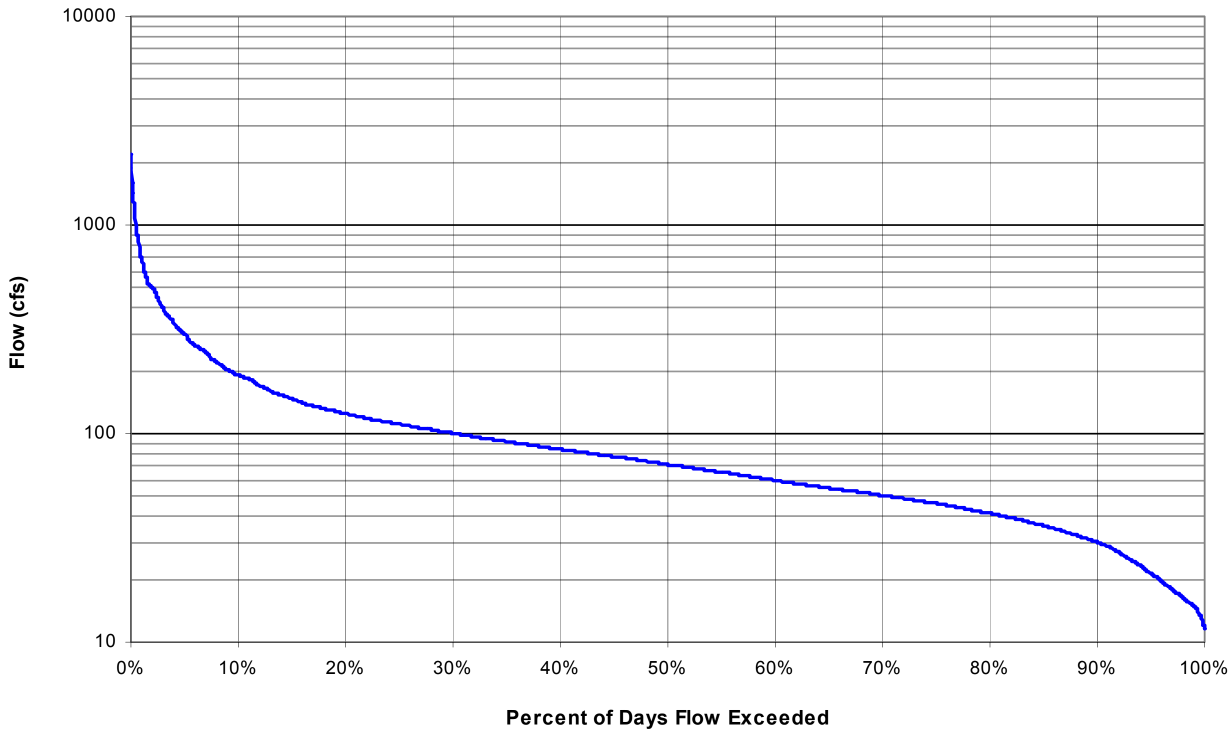


Figure C-13. Flow Duration Curve for North Mouse Creek at Mile 4.2

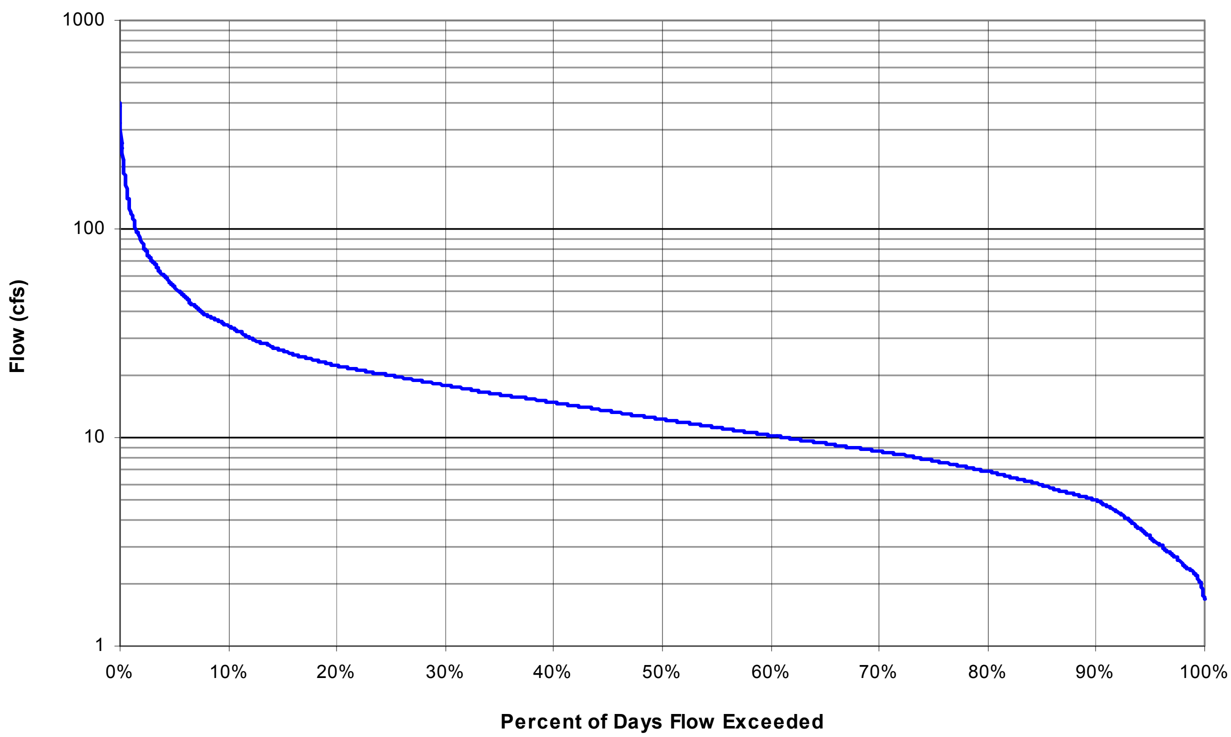


Figure C-14. Flow Duration Curve for Spring Creek at Mile 15.6

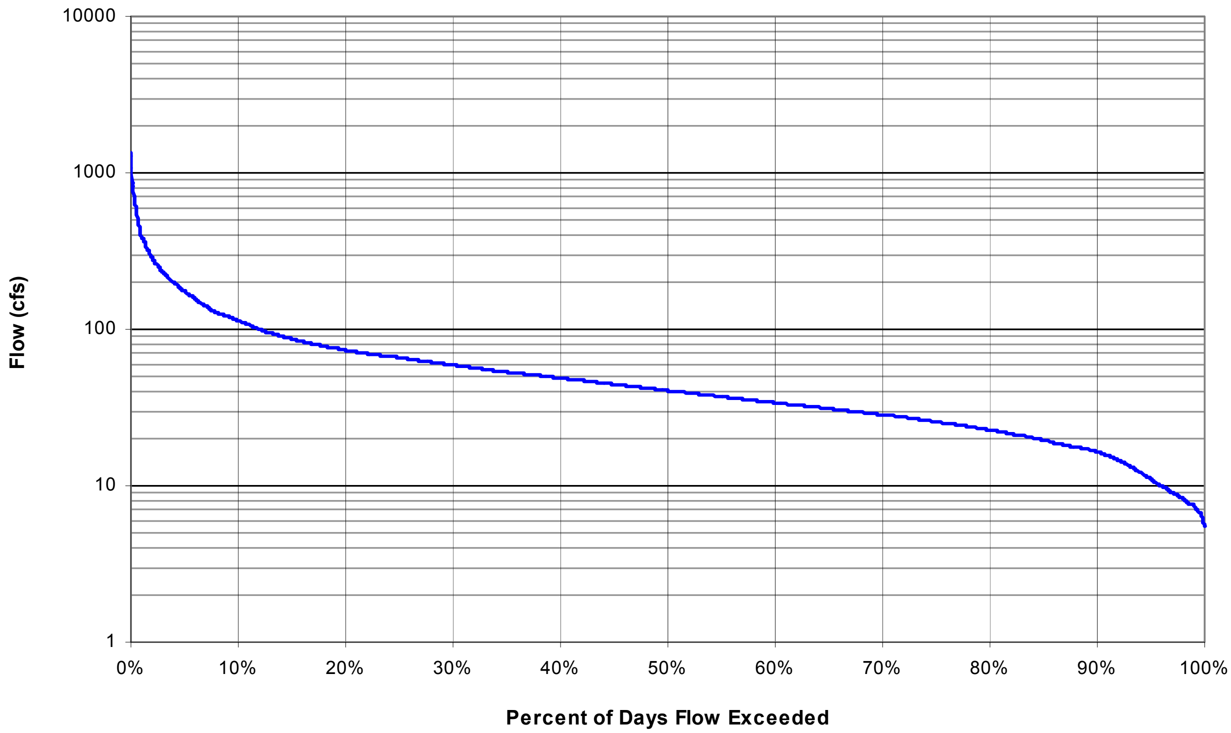


Figure C-15. Flow Duration Curve for Rogers Creek at Mile 14.2

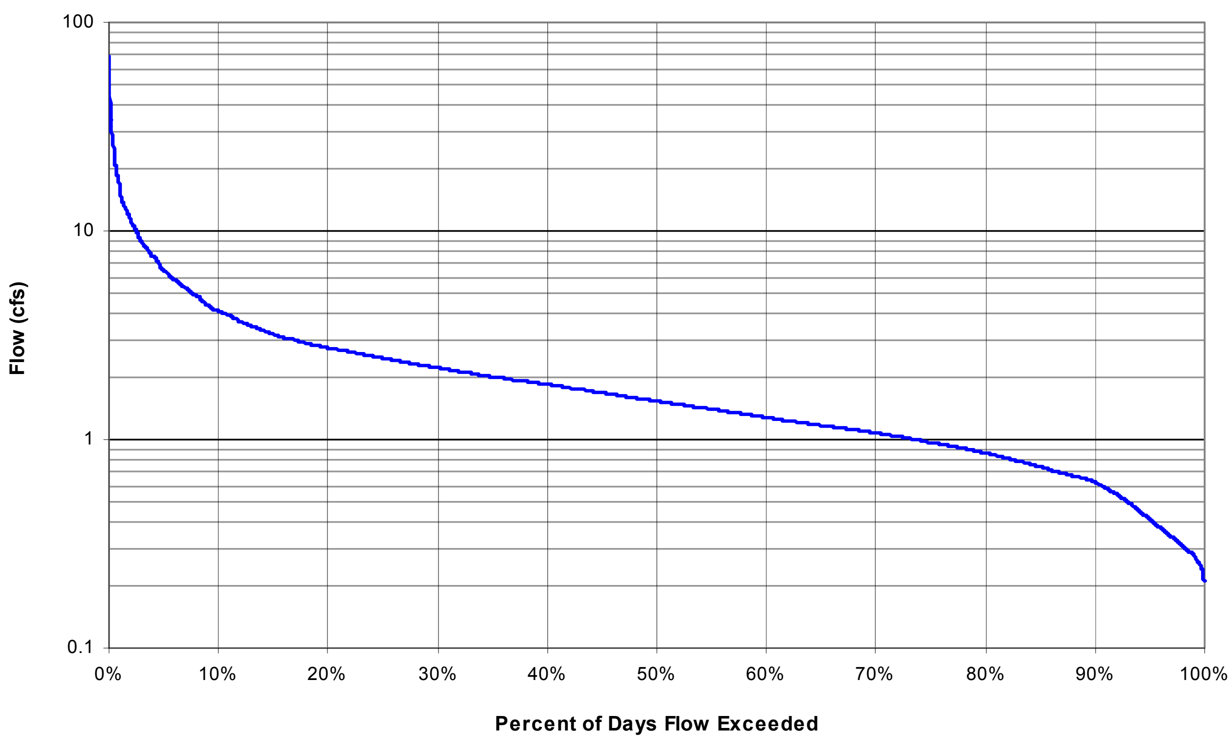


Figure C-16. Flow Duration Curve for Price Creek at Mile 4.4

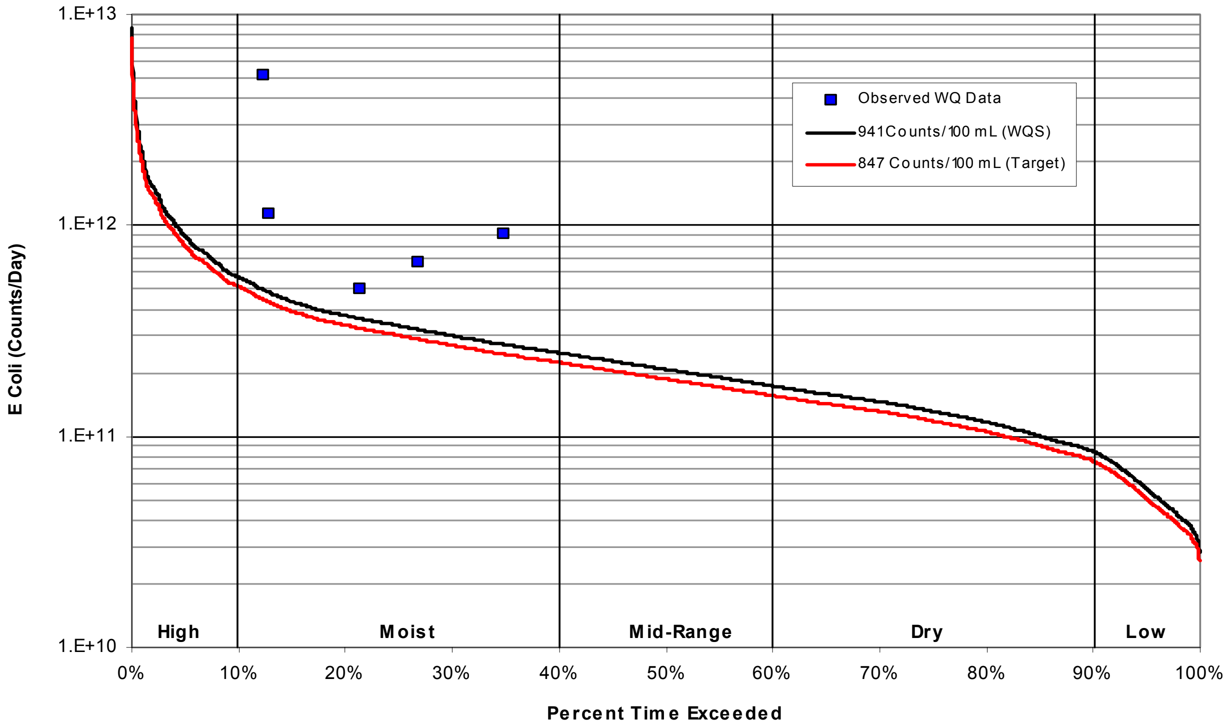


Figure C-17. E. Coli Load Duration Curve for Agency Creek at Mile 2.1

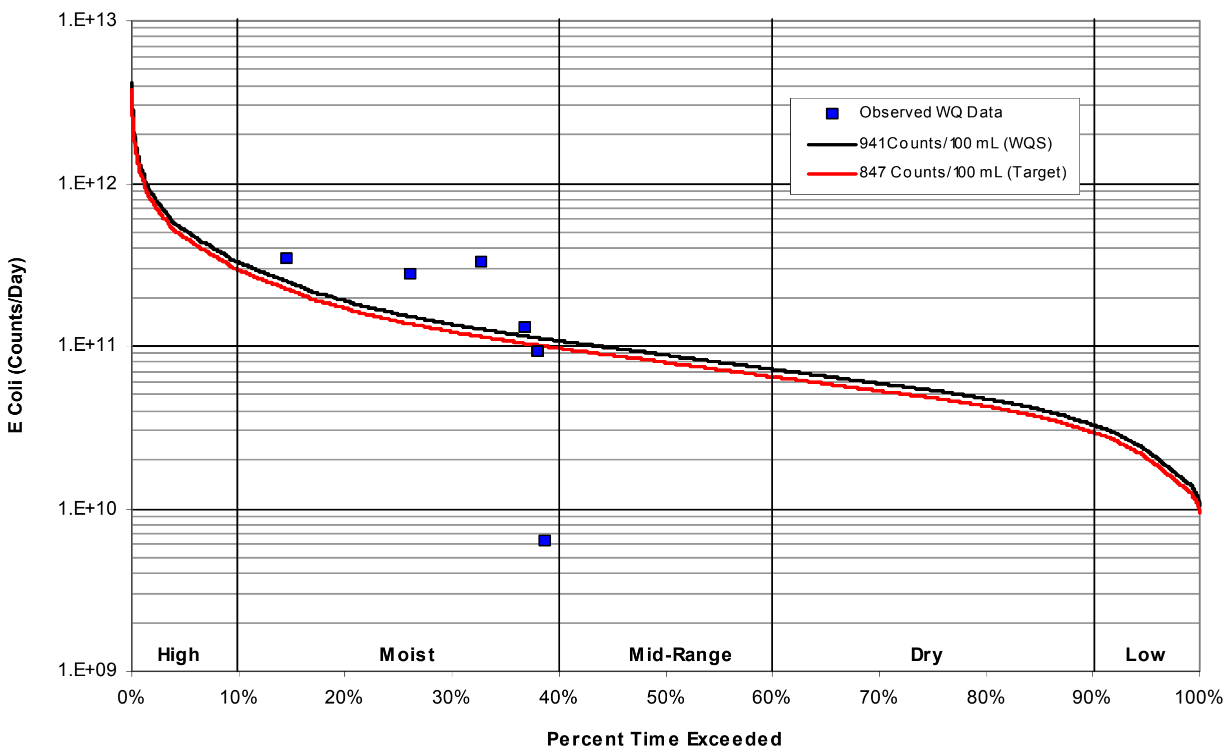


Figure C-18. E. Coli Load Duration Curve for Fillauer Branch at Mile 0.3

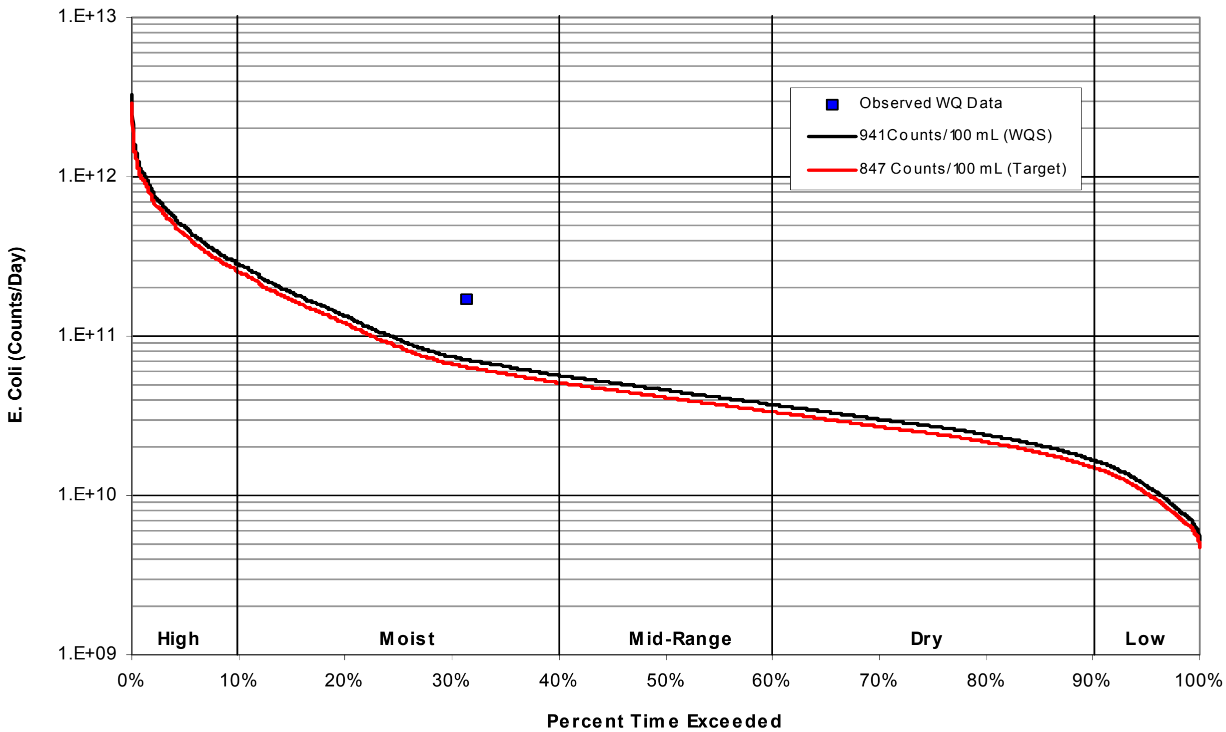


Figure C-19. E. Coli Load Duration Curve for Woolen Mill Branch at Mile 0.8

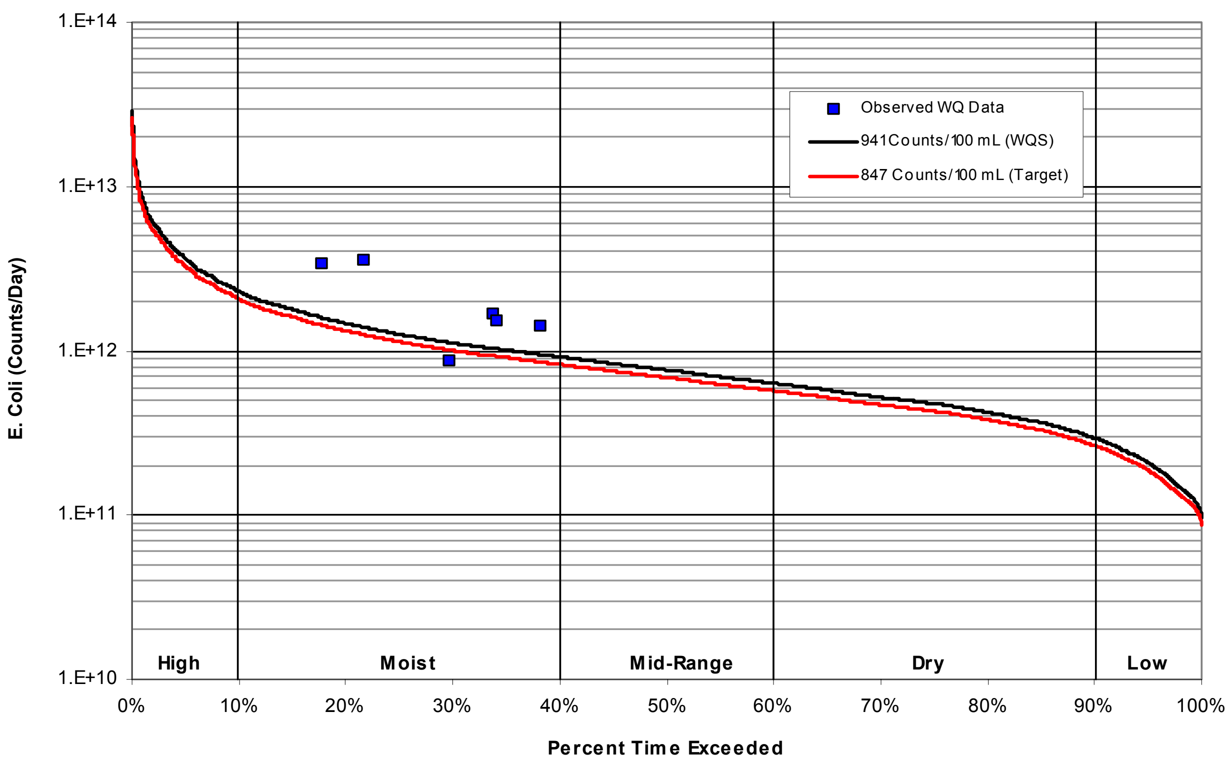


Figure C-20. E. Coli Load Duration Curve for South Mouse Creek at Mile 12.7

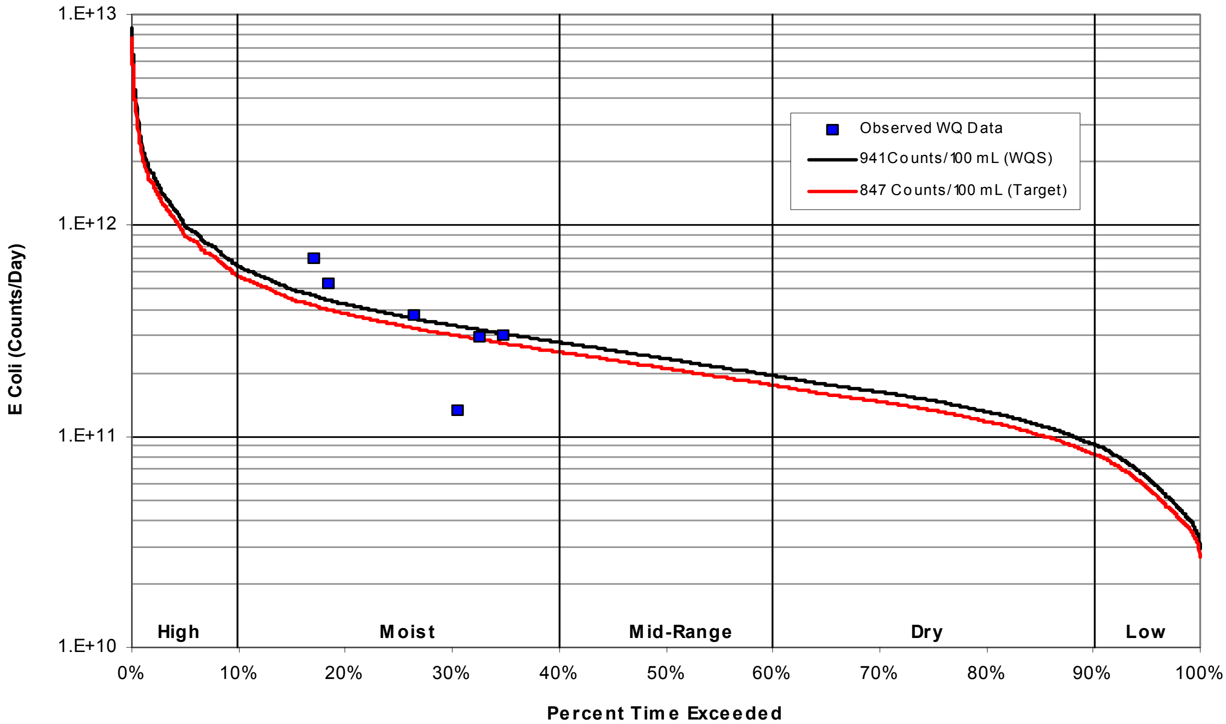


Figure C-21. E. Coli Load Duration Curve for Little Chatata Creek at Mile 0.3

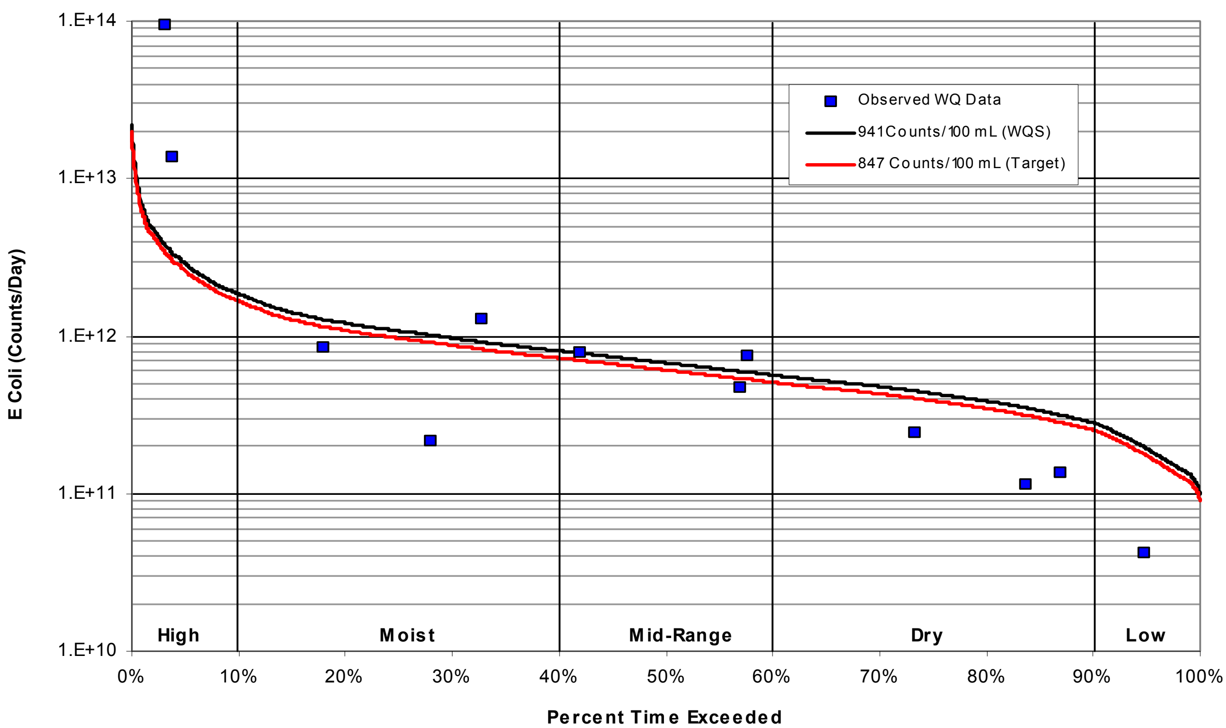


Figure C-22. E. Coli Load Duration Curve for Chatata Creek at Mile 0.5

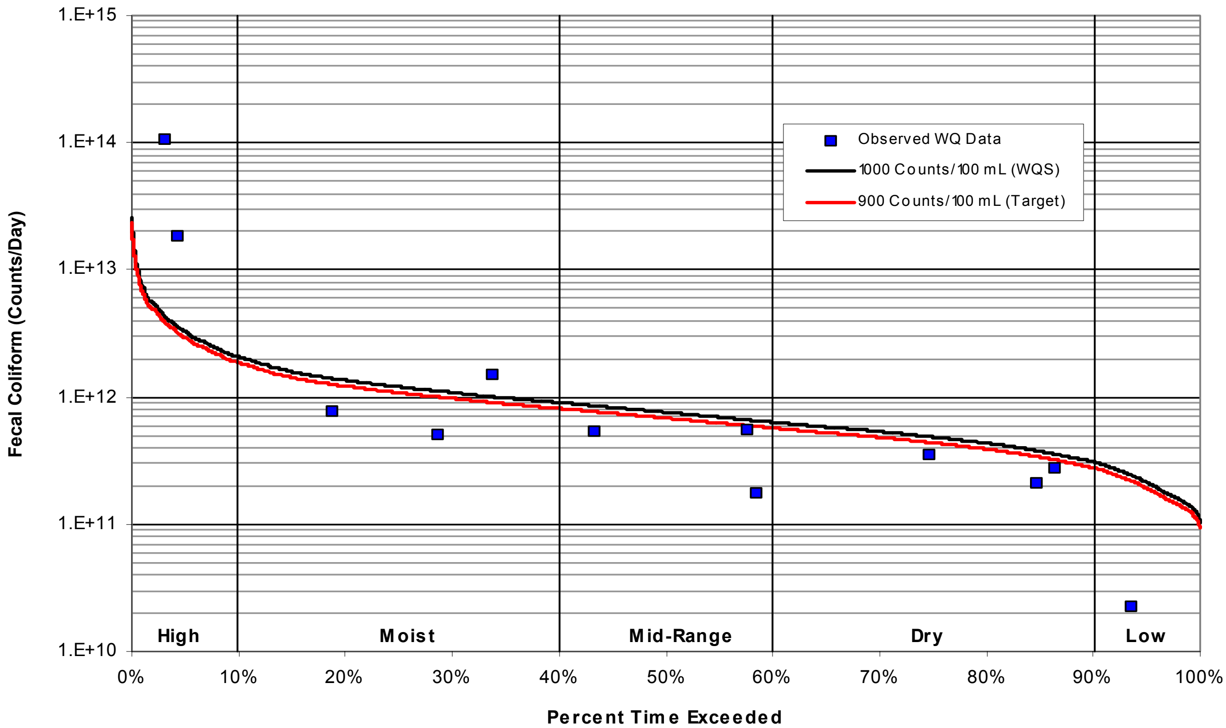


Figure C-23. Fecal Coliform Load Duration Curve for Chatata Creek at Mile 0.5

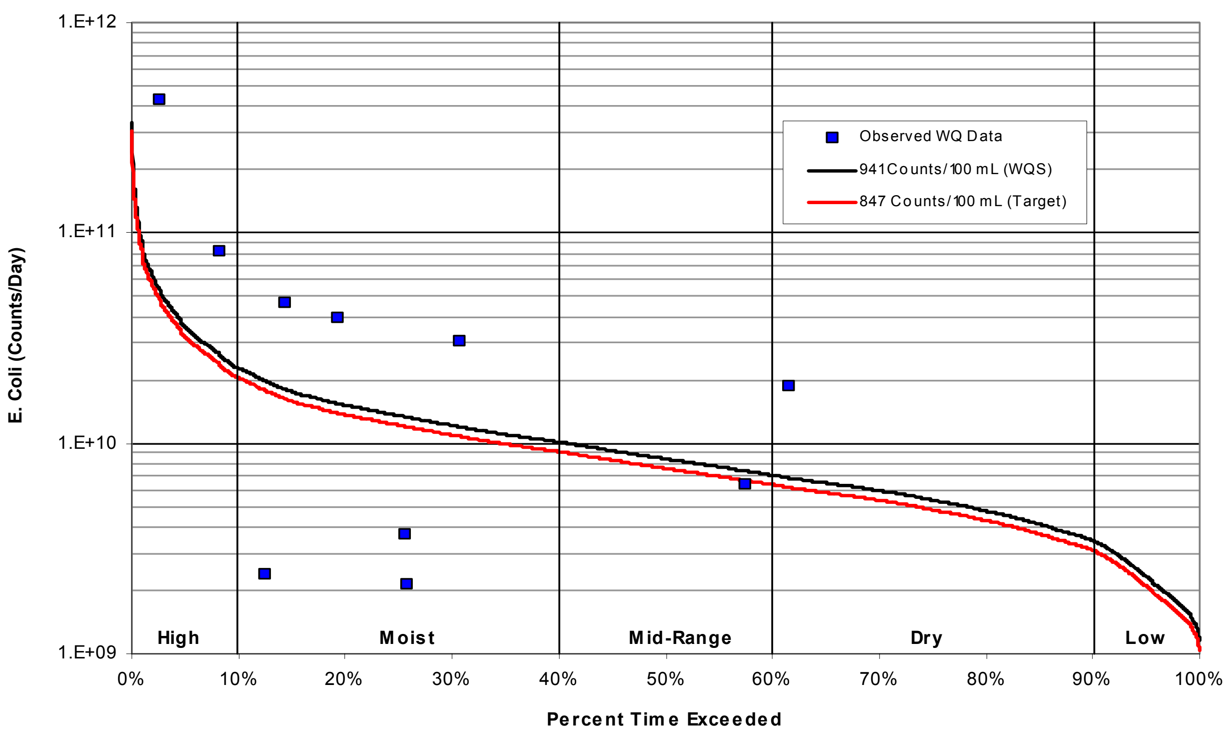


Figure C-24. E. Coli Load Duration Curve for Hawkins Branch at Mile 1.3

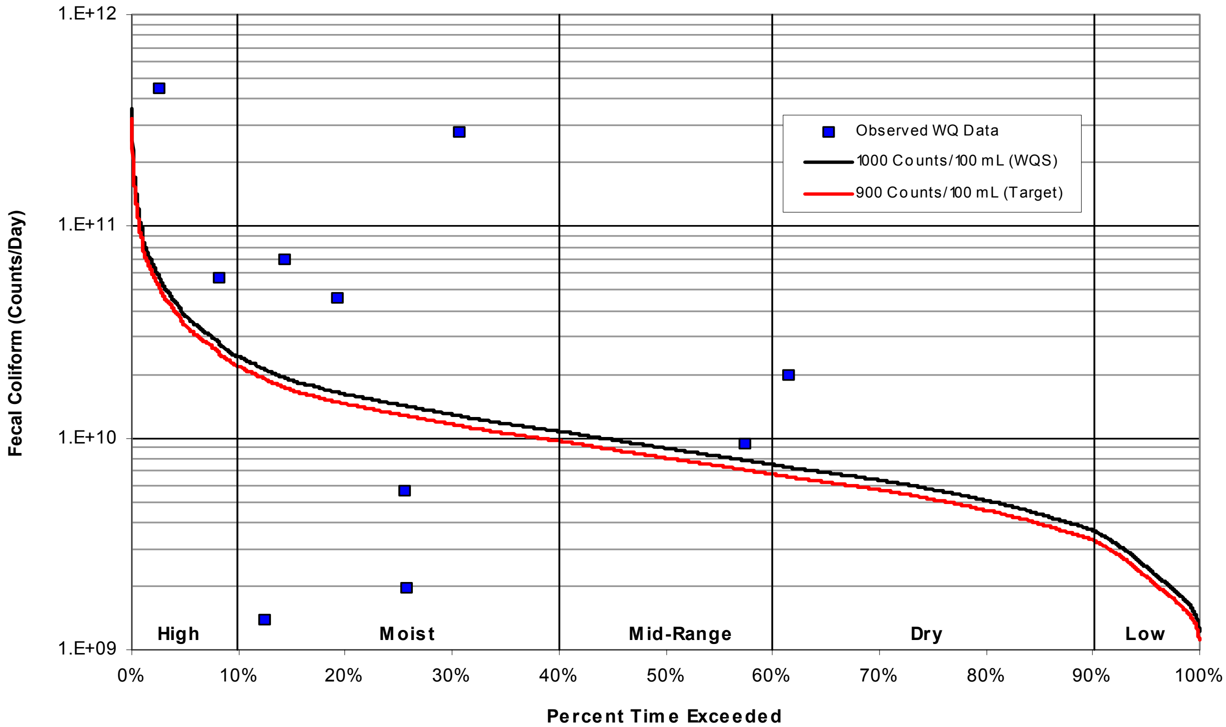


Figure C-25. Fecal Coliform Load Duration Curve for Hawkins Branch at Mile 1.3

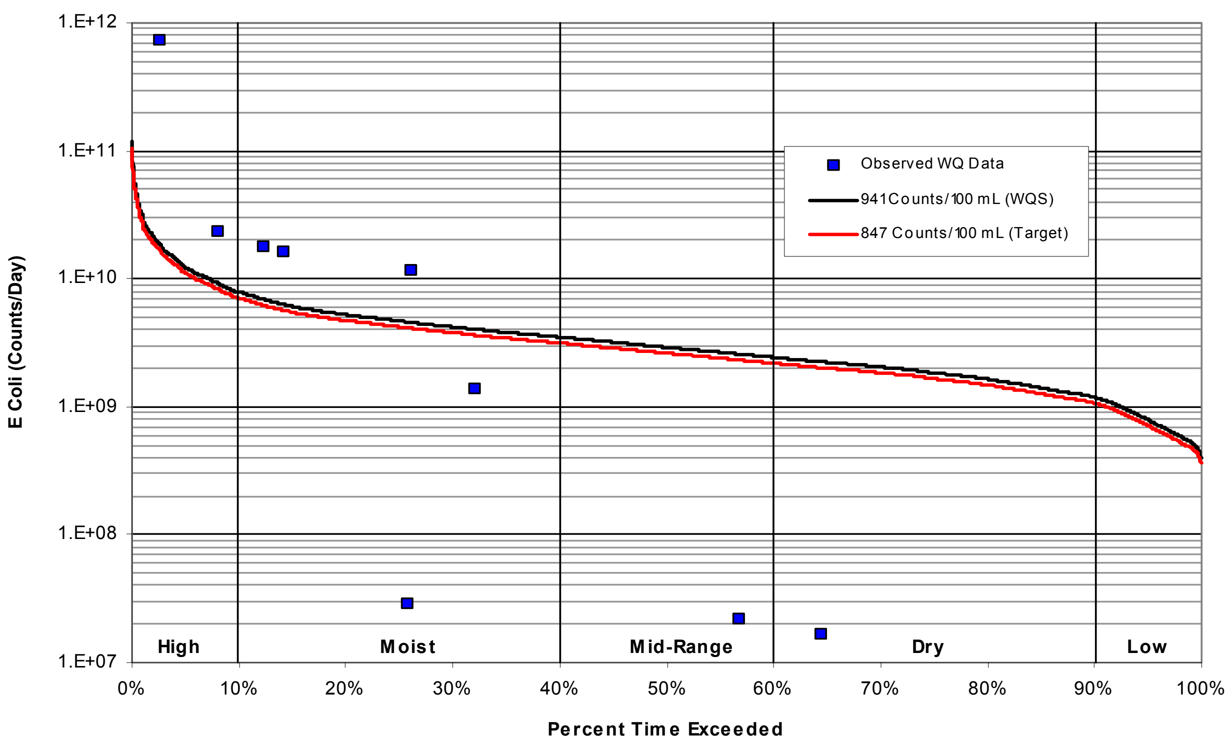


Figure C-26. E. Coli Load Duration Curve for Dairy Branch at Mile 1.2

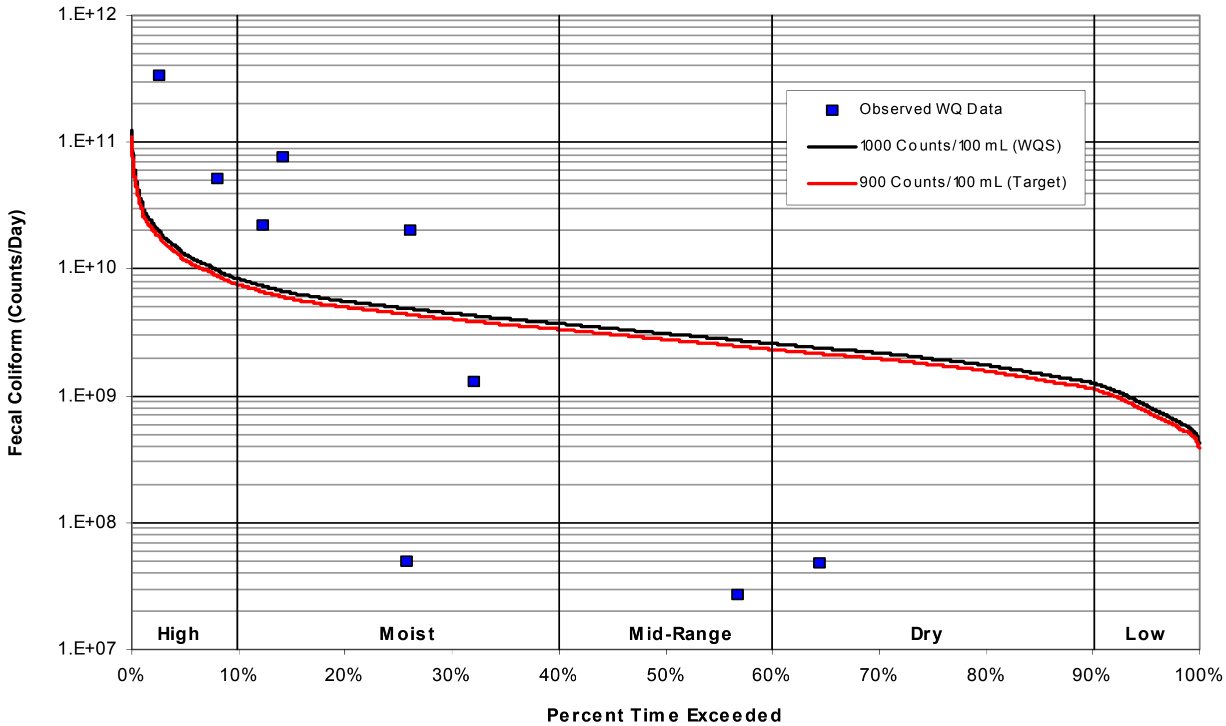


Figure C-27. Fecal Coliform Load Duration Curve for Dairy Branch at Mile 1.2

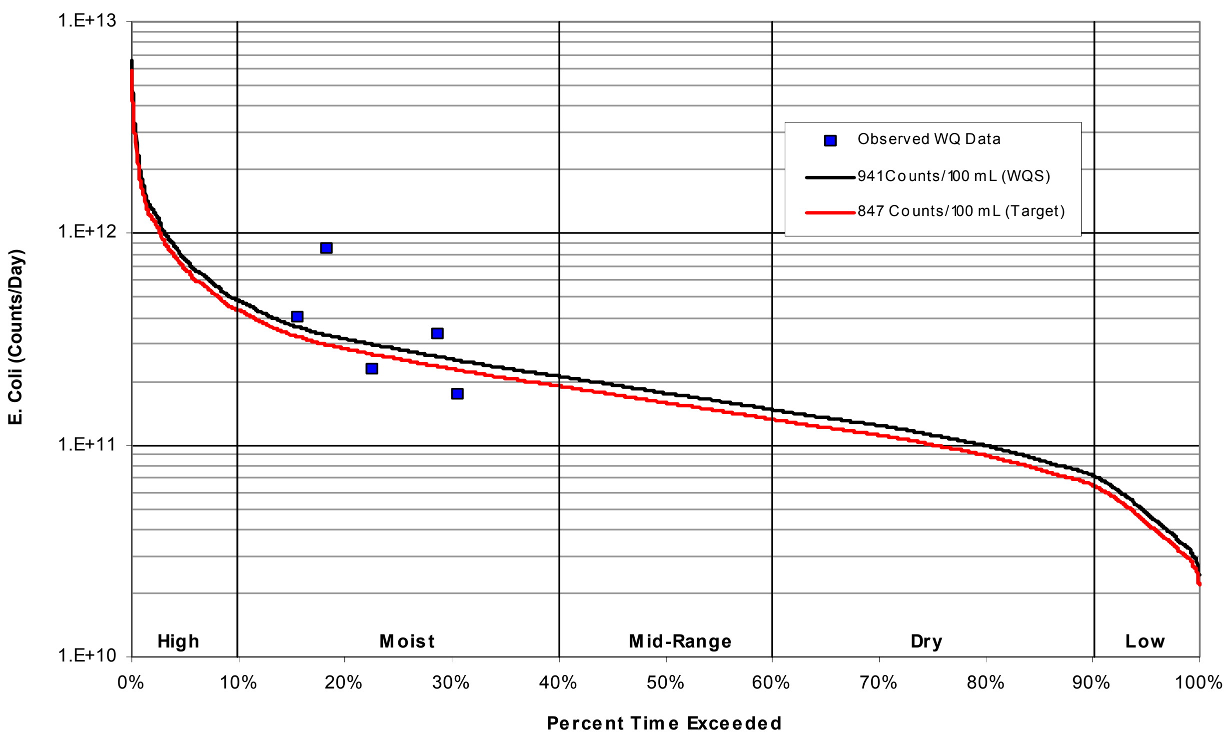


Figure C-28. E. Coli Load Duration Curve for Little Chestuee Creek at Mile 1.6

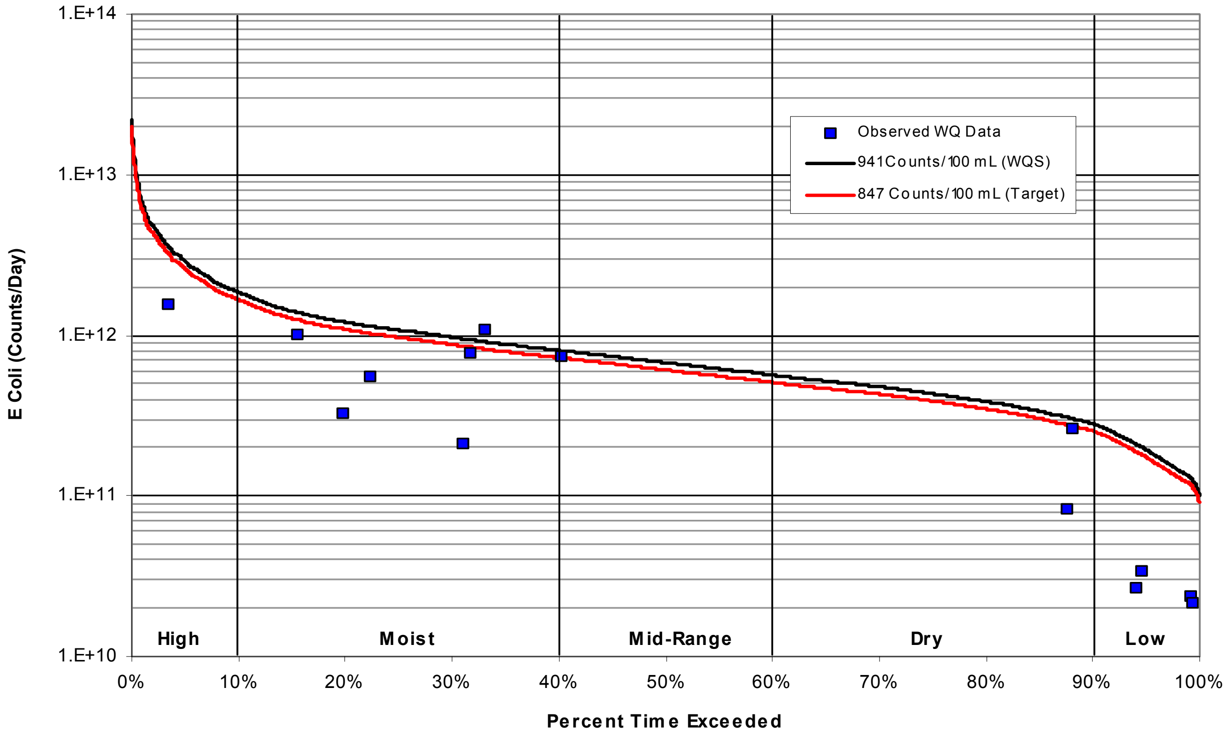


Figure C-29. E. Coli Load Duration Curve for Chestuee Creek at Mile 45.2

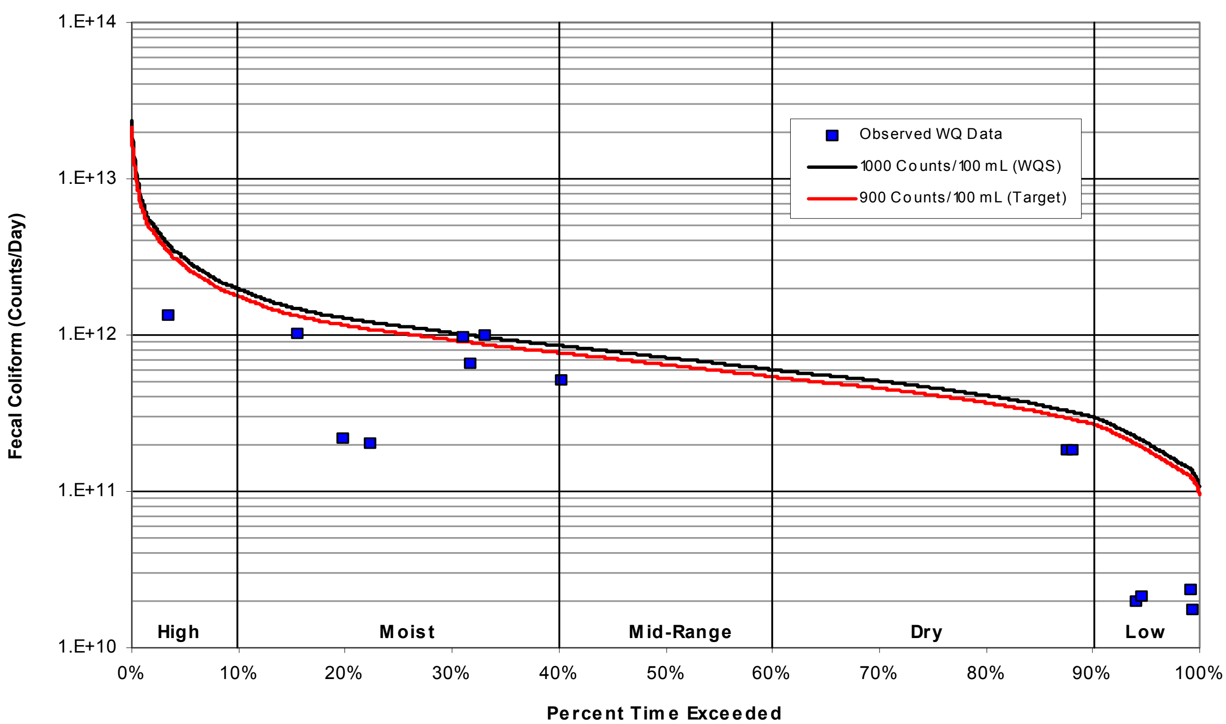


Figure C-30. Fecal Coliform Load Duration Curve for Chestuee Creek at Mile 45.2

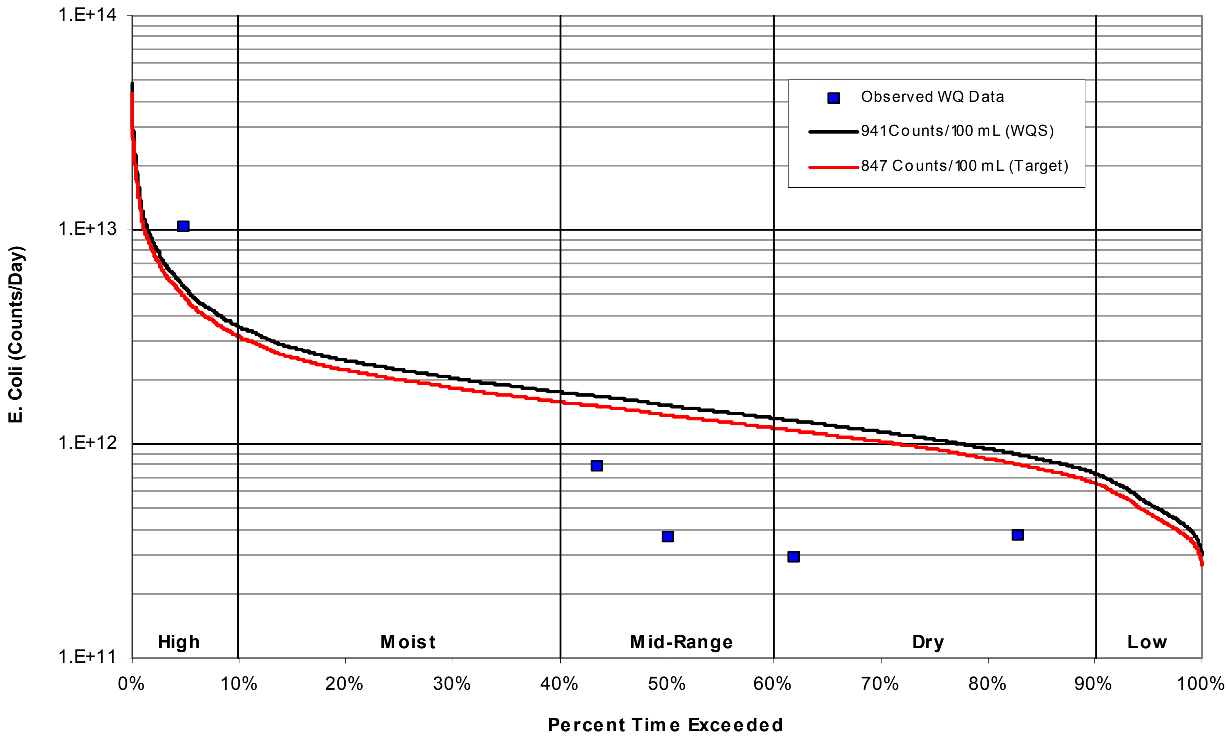


Figure C-31. E. Coli Load Duration Curve for Oostanaula Creek at Mile 5.7

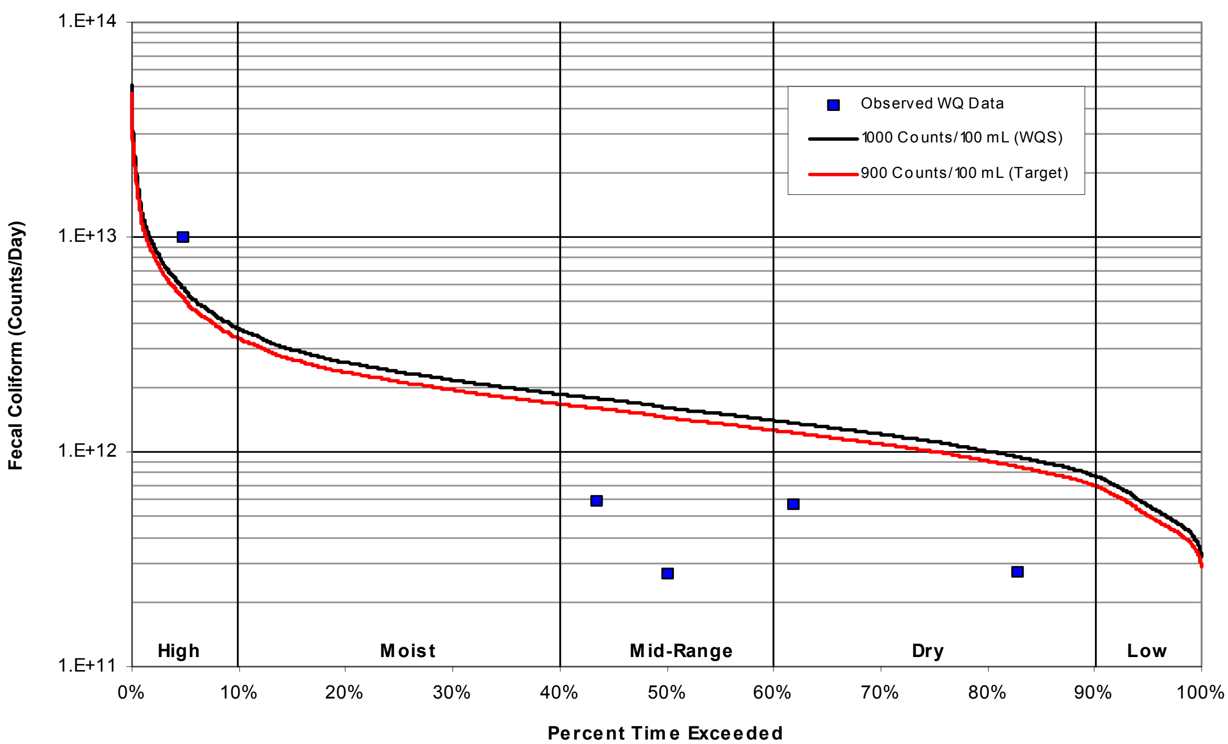


Figure C-32. Fecal Coliform Load Duration Curve for Oostanaula Creek at Mile 5.7

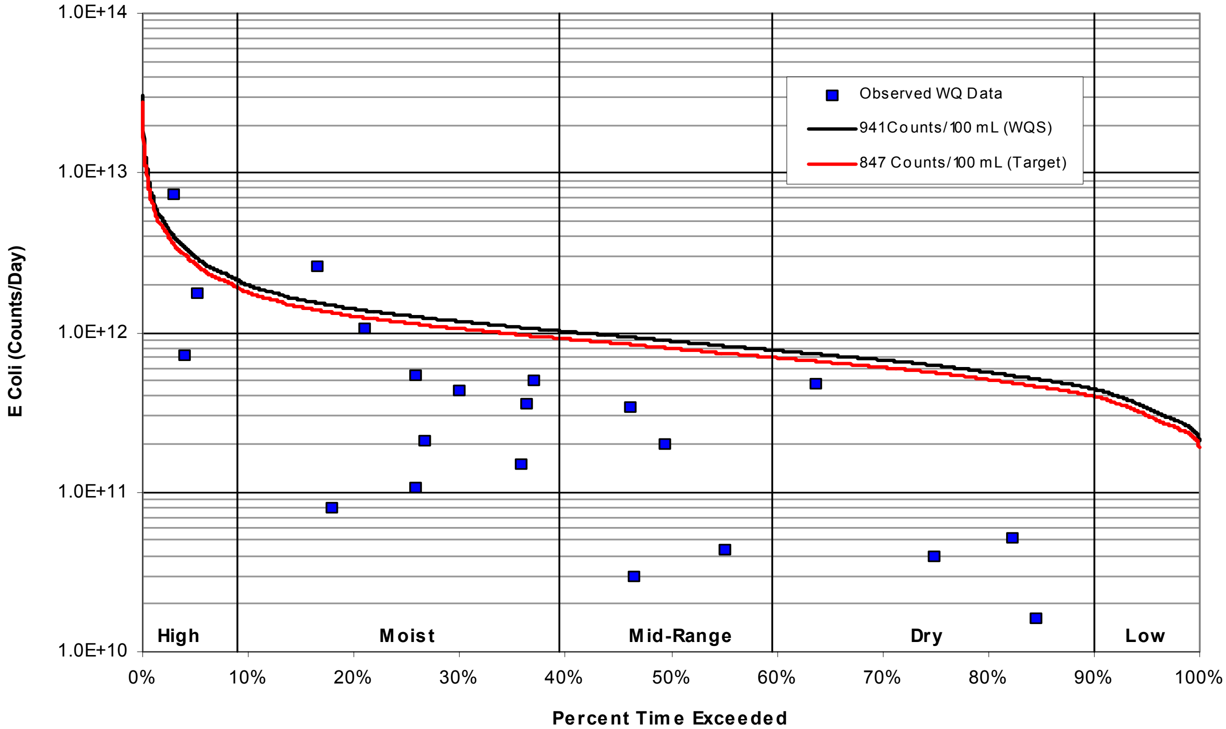


Figure C-33. E. Coli Load Duration Curve for Oostanaula Creek at Mile 26.6

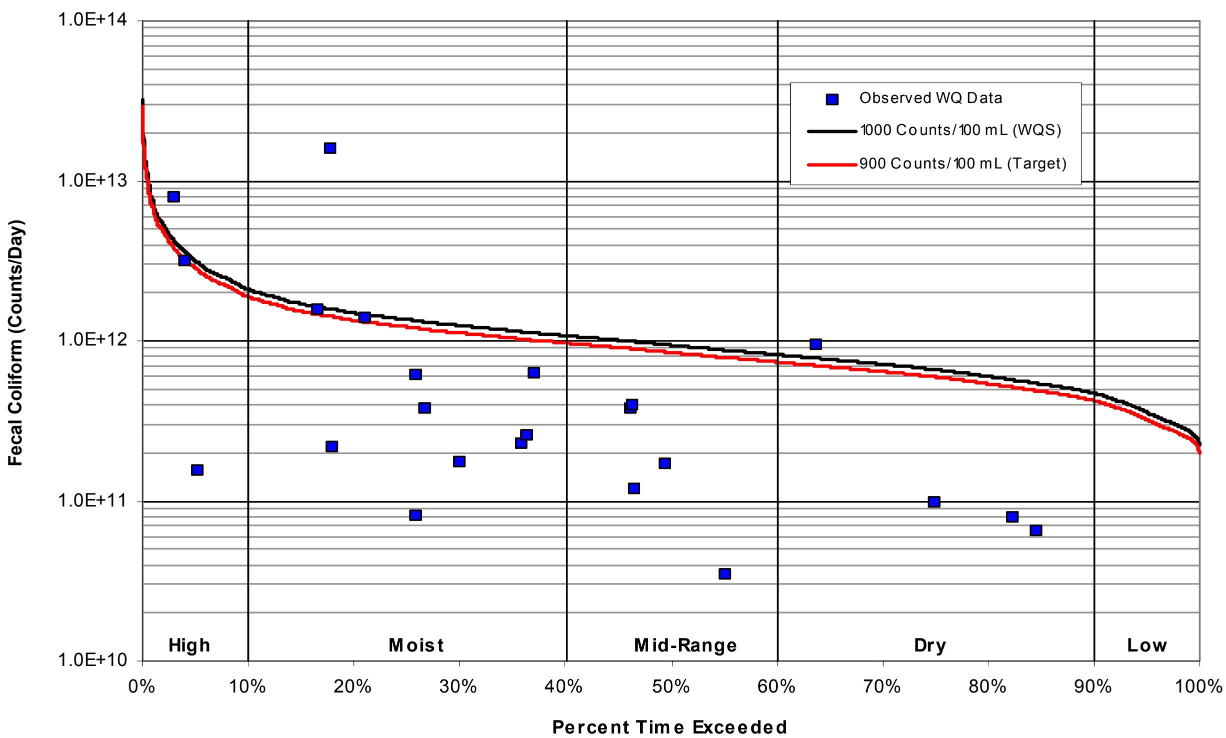


Figure C-34. Fecal Coliform Load Duration Curve for Oostanaula Creek at Mile 26.6

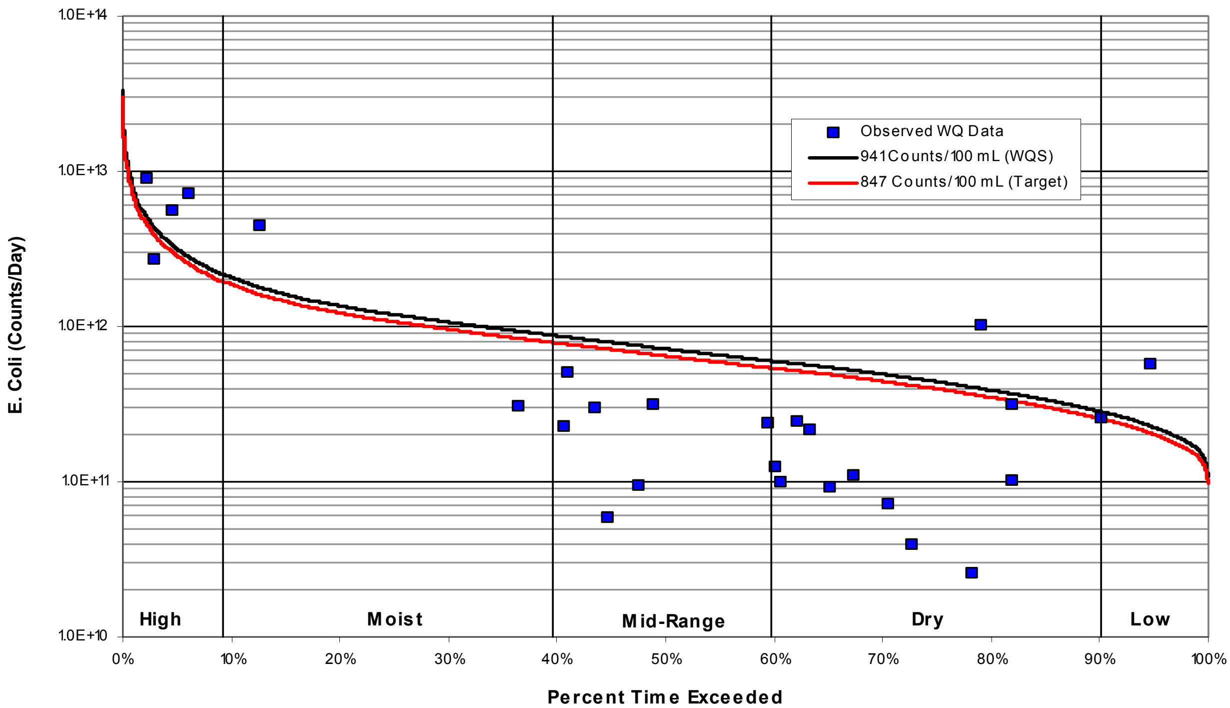


Figure C-35. E. Coli Load Duration Curve for Oostanaula Creek at Mile 28.4

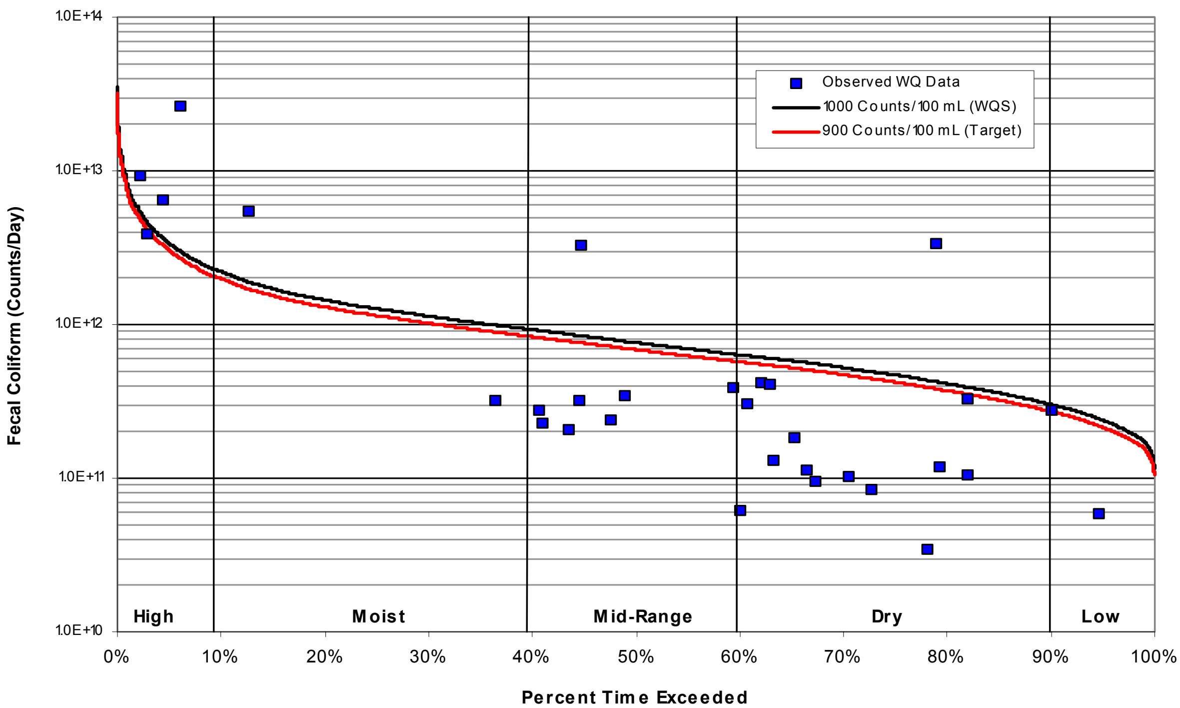


Figure C-36. Fecal Coliform Load Duration Curve for Oostanaula Creek at Mile 28.4

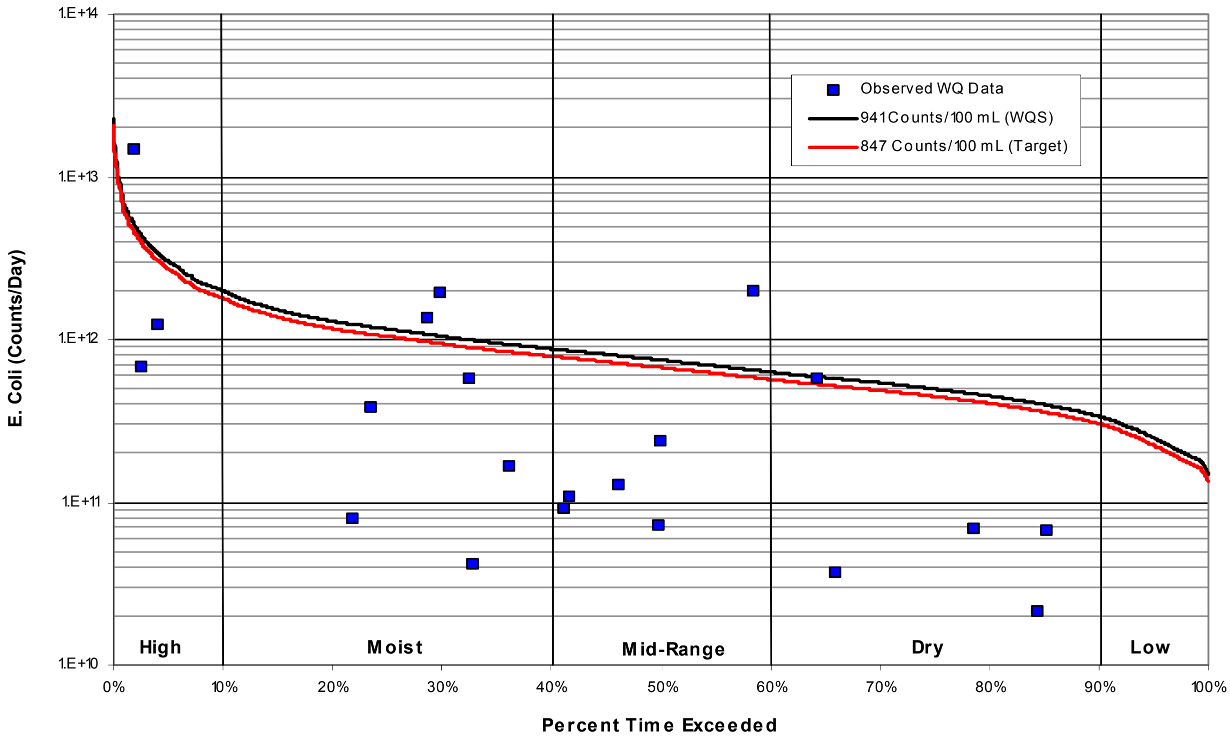


Figure C-37. E. Coli Load Duration Curve for Oostanaula Creek at Mile 30.0

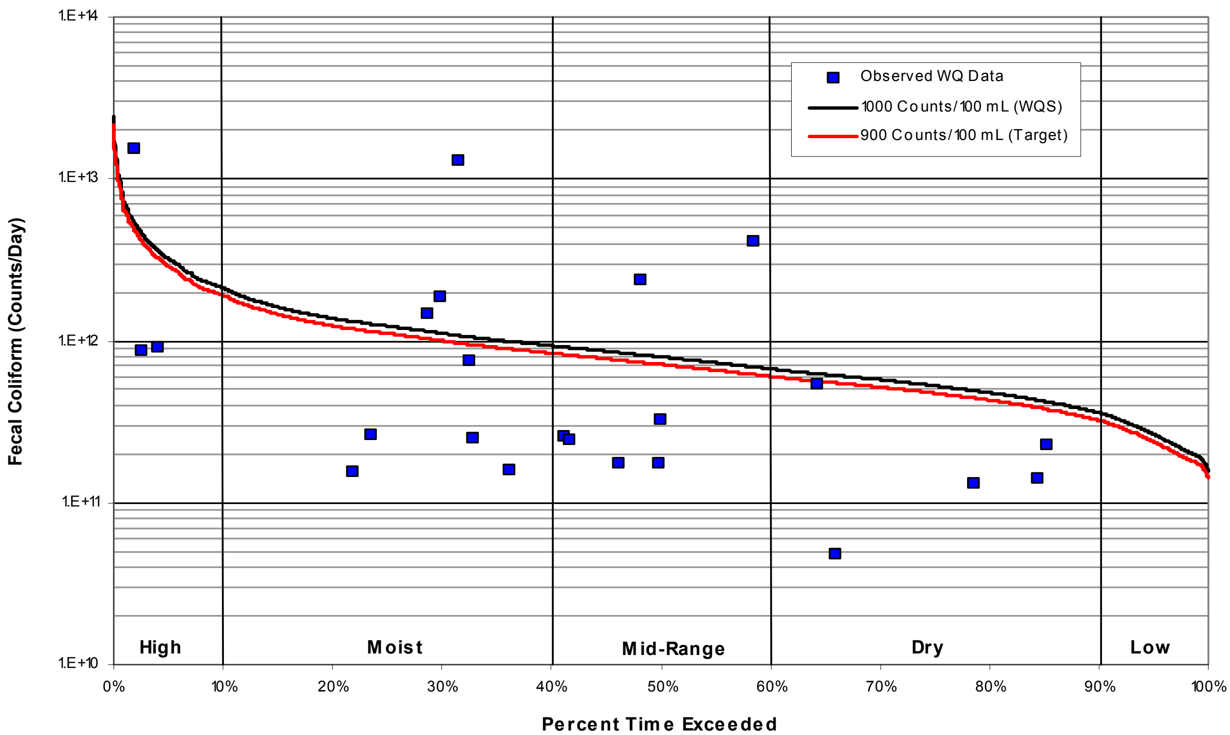


Figure C-38. Fecal Coliform Load Duration Curve for Oostanaula Creek at Mile 30.0

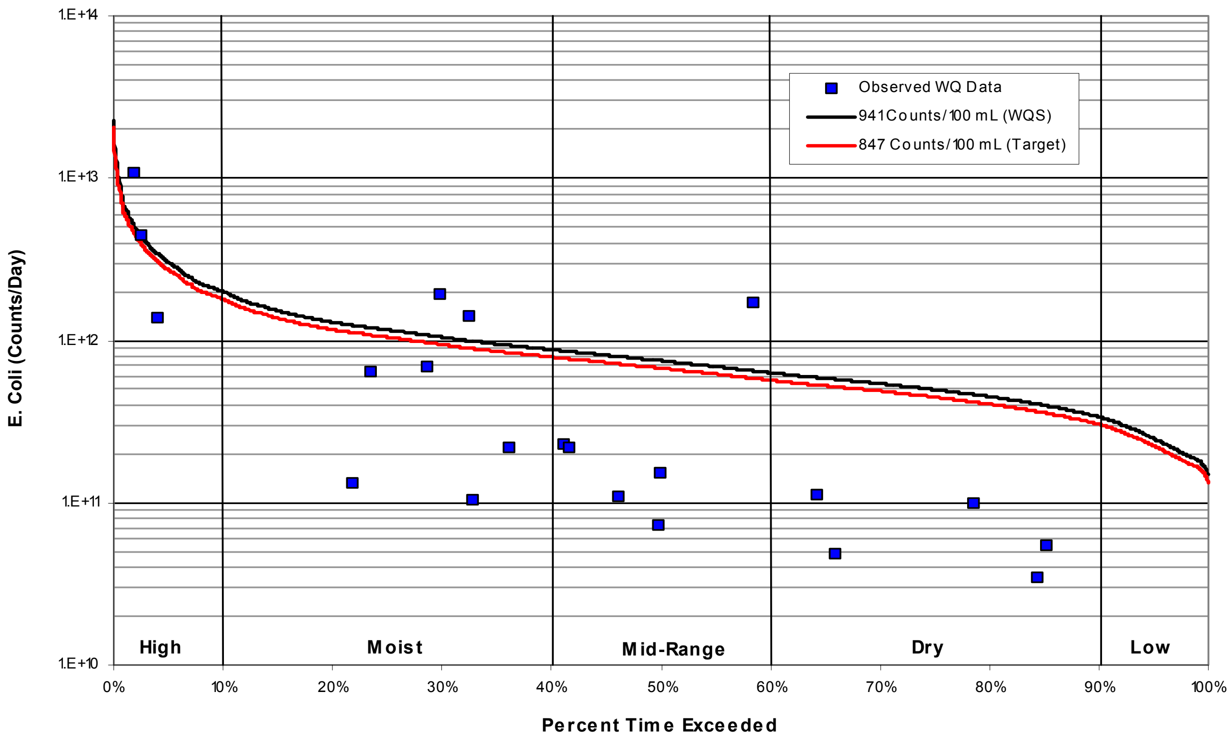


Figure C-39. E. Coli Load Duration Curve for Oostanaula Creek at Mile 30.1

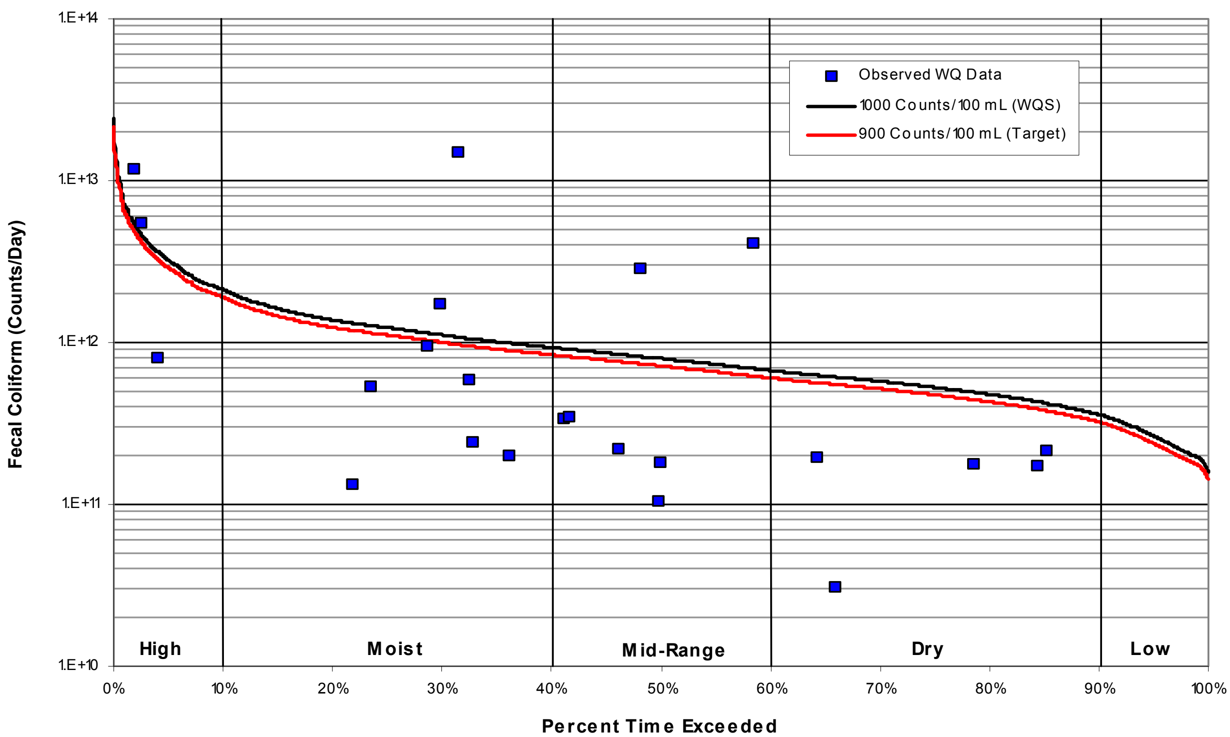


Figure C-40. Fecal Coliform Load Duration Curve for Oostanaula Creek at Mile 30.1

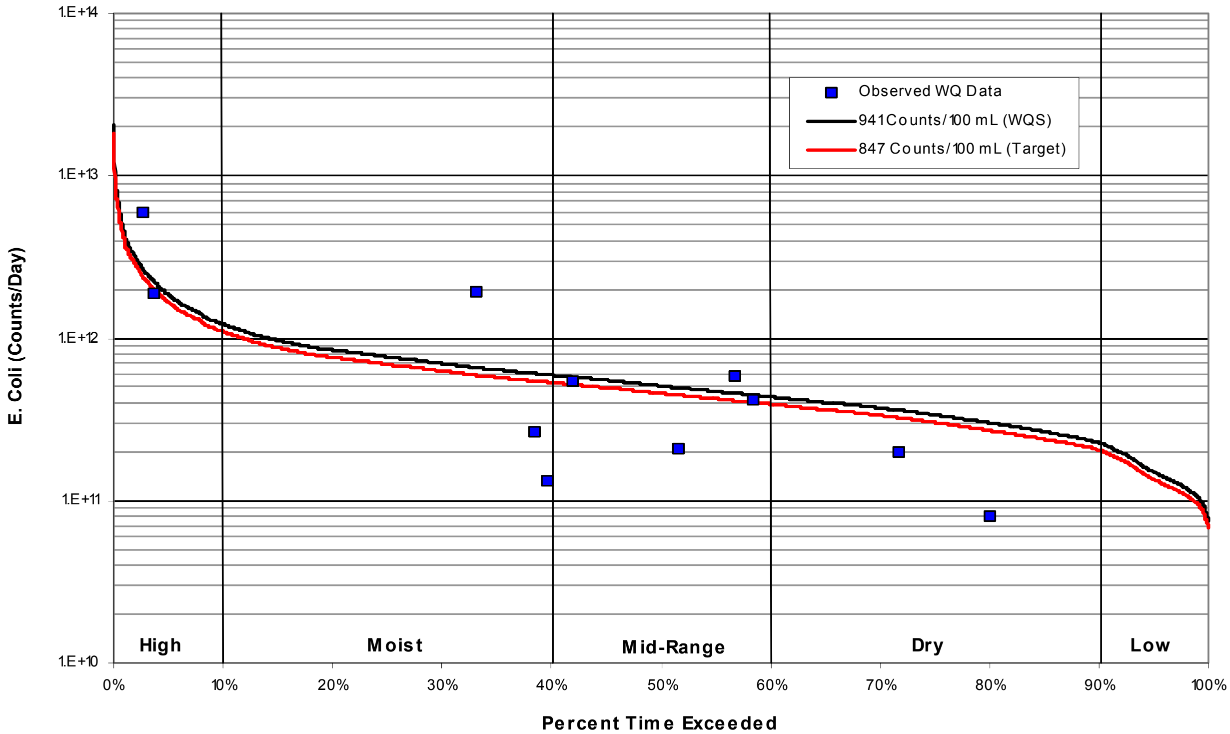


Figure C-41. E. Coli Load Duration Curve for Oostanaula Creek at Mile 33.6

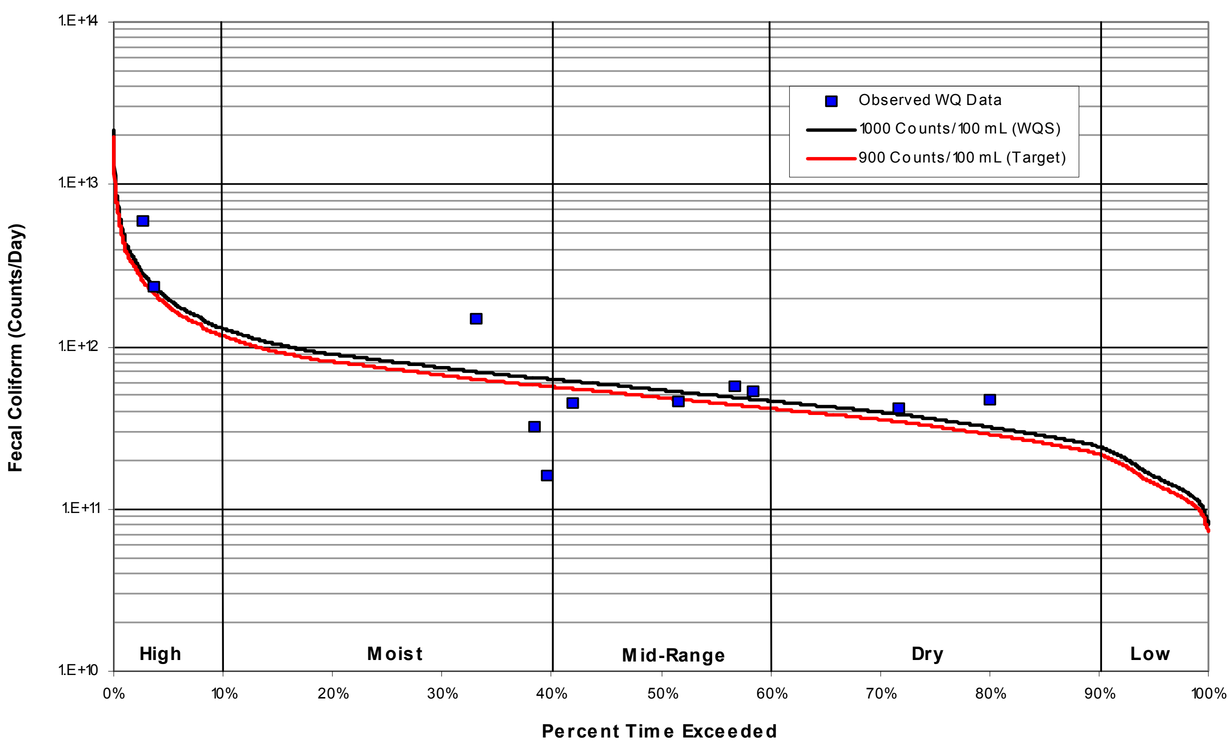


Figure C-42. Fecal Coliform Load Duration Curve for Oostanaula Creek at Mile 33.6

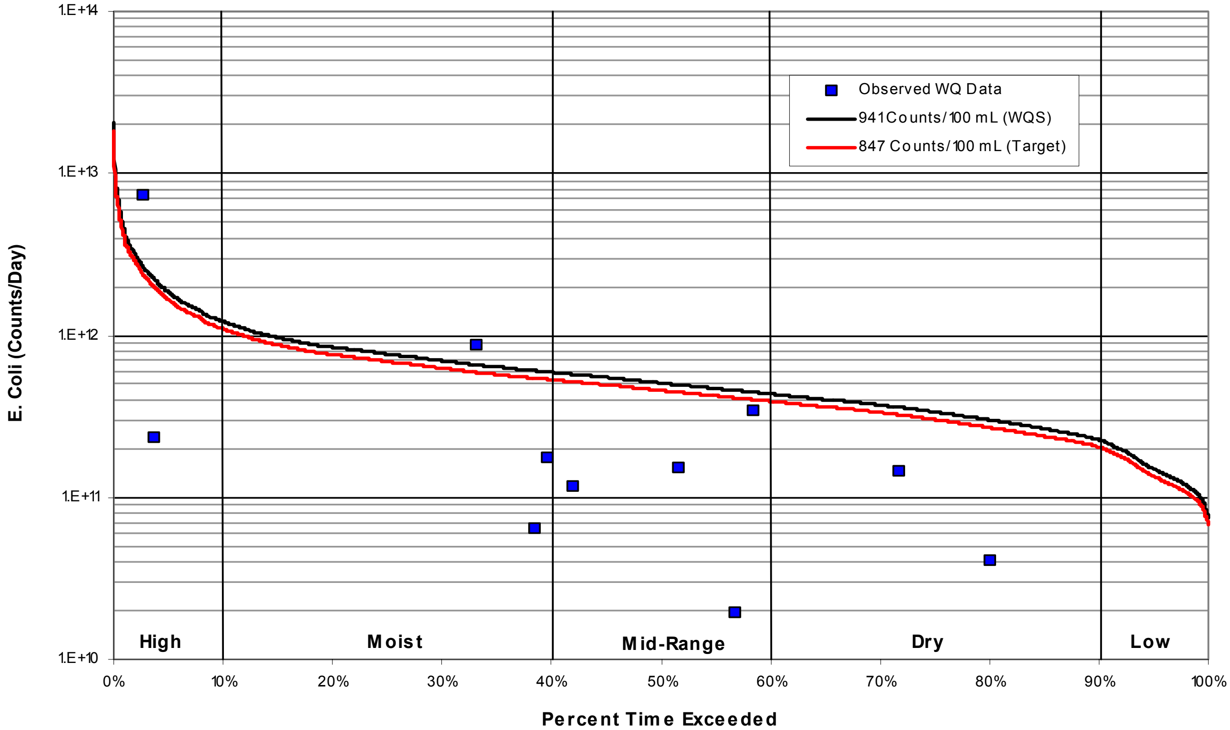


Figure C-43. E. Coli Load Duration Curve for Oostanaula Creek at Mile 35.1

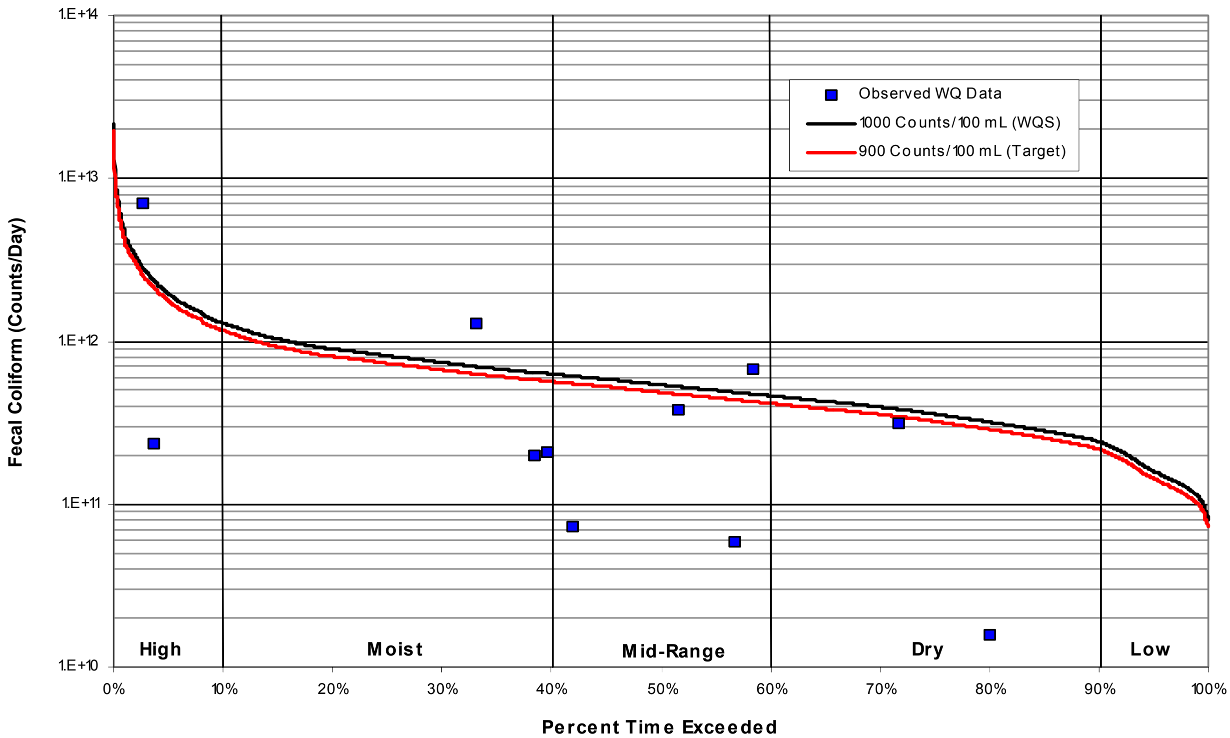


Figure C-44. Fecal Coliform Load Duration Curve for Oostanaula Creek at Mile 35.1

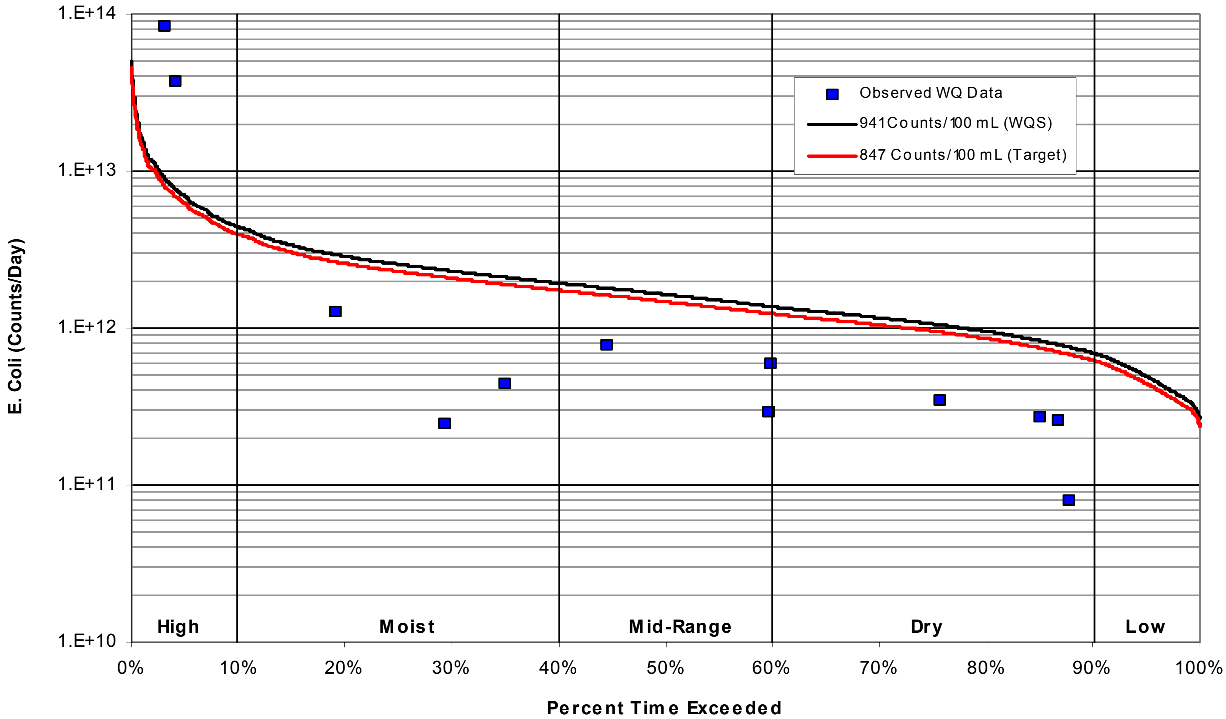


Figure C-45. E. Coli Load Duration Curve for North Mouse Creek at Mile 4.2

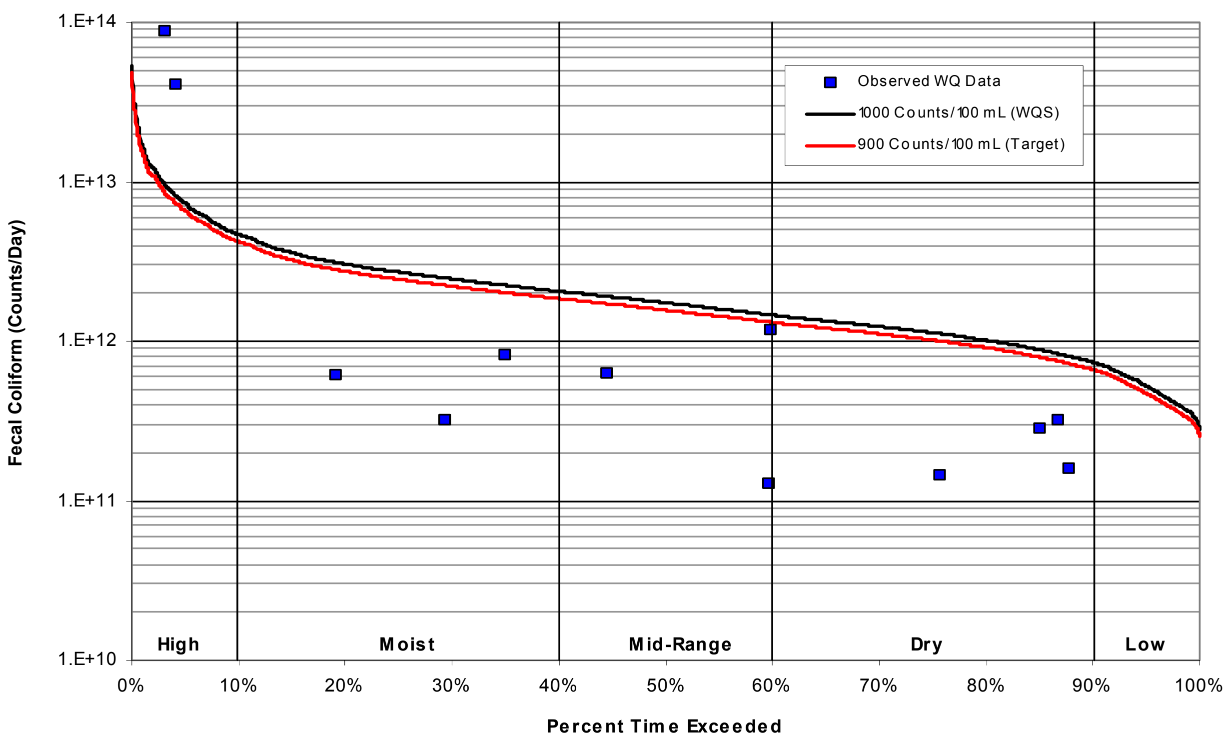


Figure C-46. Fecal Coliform Load Duration Curve for North Mouse Creek at Mile 4.2

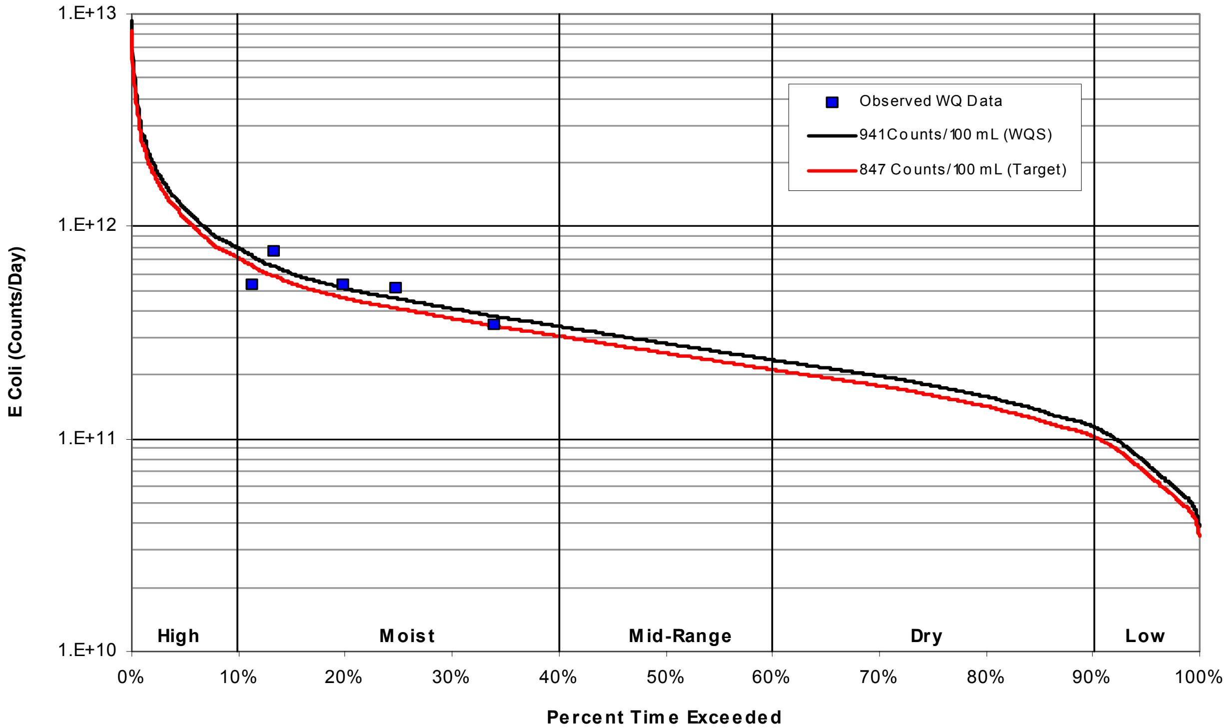


Figure C-47. E. Coli Load Duration Curve for Spring Creek at Mile 15.6

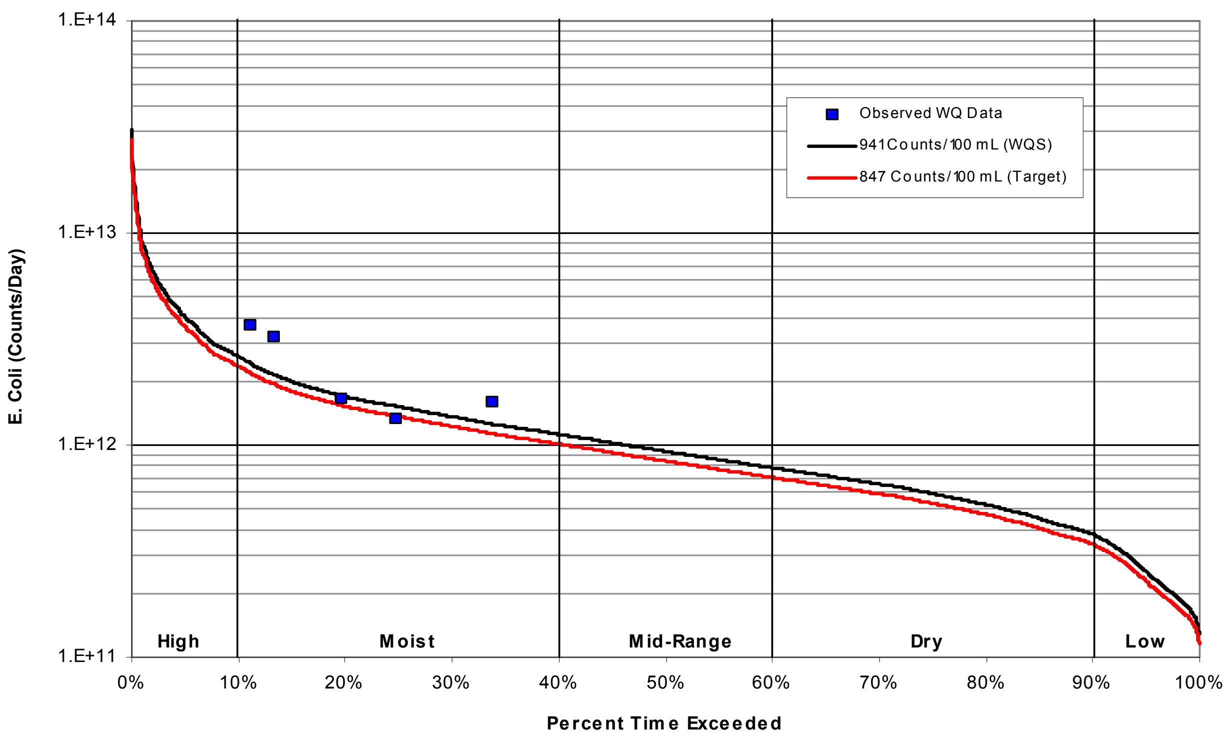


Figure C-48. E. Coli Load Duration Curve for Rogers Creek at Mile 14.2

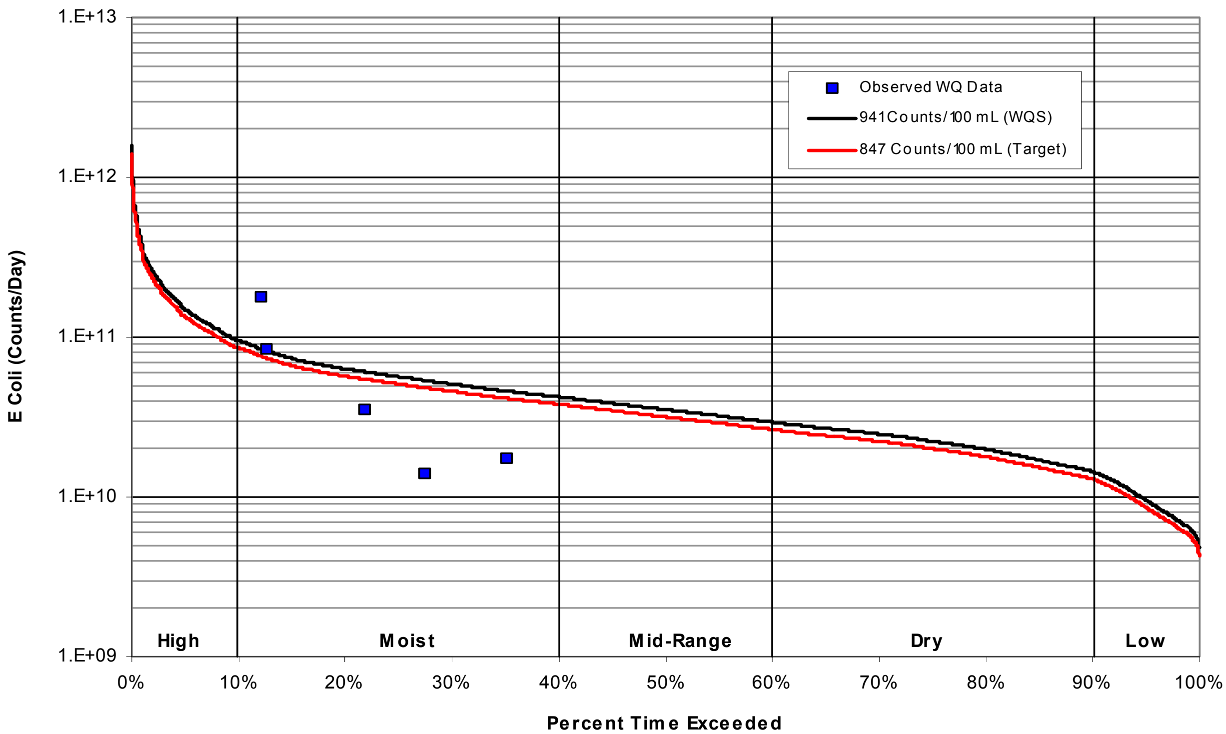


Figure C-49. E. Coli Load Duration Curve for Price Creek at Mile 4.4

Table C-1. Required Load Reduction for Agency Creek at Mile 2.1 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
12.24%	21.6	7/9/2003	**9800**	**91.4**		
12.76%	21	7/10/2003	**2240**	**62.2**		
21.38%	15.7	6/10/2003	**1299**	**34.8**		
26.72%	14	6/23/2003	**1986**	**57.4**		
34.82%	11.8	6/25/2003	**3190**	**73.4**	**2827**	**96.0**
	90th Percentile (all)		**7156**	**88.2**		

Table C-2. Required Load Reduction for Fillauer Branch at Mile 0.3 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
14.43%	10.8708	6/11/2003	**1299**	**34.8**		
26.09%	6.60191	6/9/2003	**1732**	**51.1**		
32.71%	5.51426	5/28/2003	**>2419**	**>65.0**		
36.74%	5.00405	6/23/2003	**1080**	**21.6**		
38.05%	4.87425	6/5/2003	770	**NR**		
38.74%	4.80342	6/2/2003	54.6	**NR**	**>792**	**>85.7**
	90th Percentile (all)		**2076**	**>59.2**		

Table C-3. Required Load Reduction for Woolen Mill Branch at Mile 0.8 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
31.399%	2.90026	3/3/04	**>2419**	**>65.0**
	90th Percentile		**NA**	

Table C-4. Required Load Reduction for South Mouse Creek at Mile 12.7 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
17.66%	70.0191	6/11/2003	**1986**	**57.4**		
21.60%	60.568	6/9/2003	**>2419**	**>65.0**		
29.67%	48.8541	5/28/2003	727			
33.75%	45.0305	6/23/2003	**1520**	**44.3**		
34.03%	44.7699	6/5/2003	**1413**	**40.1**		
38.13%	41.236	6/2/2003	**1413**	**40.1**	**>1482**	**>92.4**
	90th Percentile (all)		**>2203**	**>61.5**		

Table C-5. Required Load Reduction for Little Chatata Creek at Mile 0.3 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
17.00%	20.2991	6/11/2003	**1413**	**40.1**		
18.34%	19.3147	6/9/2003	**1119**	**24.3**		
26.34%	15.7877	5/28/2003	**980**	**13.6**		
30.50%	14.469	6/23/2003	378	**NR**		
32.52%	13.9591	6/5/2003	866	**NR**		
34.74%	13.3282	6/2/2003	920	**NR**	**881**	**87.2**
	90th Percentile (all)		**1266**	**33.1**		

Table C-6. Required Load Reduction for Chatata Creek at Mile 0.5 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
3.12%	173.757	11/12/2002	**23590**	**96.4**
4.22%	147.161	5/19/2003	**4000**	**78.8**
18.70%	57.0607	3/24/2003	630	**NR**
28.69%	45.6767	12/18/2002	200	**NR**
33.75%	41.1418	4/29/2003	**1320**	**35.8**
43.25%	34.9013	1/13/2004	**960**	**11.8**
57.51%	27.095	8/19/2003	**1210**	**30.0**
58.50%	26.6846	1/28/2003	740	**NR**
74.62%	19.9954	5/11/2004	520	**NR**
84.62%	15.5471	11/4/2003	310	**NR**
86.45%	14.5339	10/21/2002	410	**NR**
93.54%	9.95873	8/27/2002	200	**NR**
	90^{th} Percentile (all)		**3732**	**77.3**

Table C-7. Required Load Reduction for Chatata Creek at Mile 0.5 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
3.12%	173.757	11/12/2002	**25000**	**96.4**
4.22%	147.161	5/19/2003	**5200**	**82.7**
18.70%	57.0607	3/24/2003	560	**NR**
28.69%	45.6767	12/18/2002	460	**NR**
33.75%	41.1418	4/29/2003	**1500**	**40.0**
43.25%	34.9013	1/13/2004	640	**NR**
57.51%	27.095	8/19/2003	850	**NR**
58.50%	26.6846	1/28/2003	270	**NR**
74.62%	19.9954	5/11/2004	730	**NR**
84.62%	15.5471	11/4/2003	560	**NR**
86.45%	14.5339	10/21/2002	770	**NR**
93.54%	9.95873	8/27/2002	92	**NR**
	90^{th} Percentile (all)		**4830**	**82.5**

Table C-8. Required Load Reduction for Hawkins Branch at Mile 1.3 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.60%	2.35495	2/24/2003	**7540**	**88.8**
8.13%	1.16161	11/20/2003	**2920**	**71.0**
12.43%	0.86617	2/11/2004	113	**NR**
14.34%	0.78699	5/14/2003	**>2419**	**>65.0**
19.30%	0.67145	12/30/2002	**>2419**	**>65.0**
25.51%	0.58102	6/4/2003	260	**NR**
25.73%	0.57939	3/17/2003	152	**NR**
30.61%	0.52254	7/21/2003	**>2419**	**>65.0**
57.35%	0.32174	10/7/2003	816	**NR**
61.48%	0.298	8/27/2003	**2590**	**67.3**
	90th Percentile (all)		**>3382**	**>75.0**

Table C-9. Required Load Reduction for Hawkins Branch at Mile 1.3 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.60%	2.35495	2/24/2003	**7800**	**88.5**
8.13%	1.16161	11/20/2003	**2000**	**55.0**
12.43%	0.86617	2/11/2004	66	**NR**
14.34%	0.78699	5/14/2003	**3600**	**75.0**
19.30%	0.67145	12/30/2002	**2800**	**67.9**
25.51%	0.58102	6/4/2003	400	**NR**
25.73%	0.57939	3/17/2003	138	**NR**
30.61%	0.52254	7/21/2003	**22000**	**95.9**
57.35%	0.32174	10/7/2003	**1200**	**25.0**
61.48%	0.298	8/27/2003	**2700**	**66.7**
	90th Percentile (all)		**9220**	**90.2**

Table C-10. Required Load Reduction for Dairy Branch at Mile 1.2 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.60%	0.81414	2/24/2003	**36540**	**97.7**
8.08%	0.40091	11/20/2003	**>2419**	**>65.0**
12.29%	0.30002	2/11/2004	**>2419**	**>65.0**
14.21%	0.27309	5/14/2003	**>2419**	**>65.0**
25.65%	0.20028	3/17/2003	6	**NR**
26.01%	0.19891	6/4/2003	**>2419**	**>65.0**
31.97%	0.17513	7/21/2003	328	**NR**
56.78%	0.11195	10/7/2003	8	**NR**
64.44%	0.09738	8/27/2003	7	**NR**
	90th Percentile (all)		**>9243**	**>90.8**

Table C-11. Required Load Reduction for Dairy Branch at Mile 1.2 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.60%	0.81414	2/24/2003	**17000**	**94.7**
8.08%	0.40091	11/20/2003	**5300**	**83.0**
12.29%	0.30002	2/11/2004	**3000**	**70.0**
14.21%	0.27309	5/14/2003	**11600**	**92.2**
25.65%	0.20028	3/17/2003	10	**NR**
26.01%	0.19891	6/4/2003	**4200**	**78.6**
31.97%	0.17513	7/21/2003	300	**NR**
56.78%	0.11195	10/7/2003	10	**NR**
64.44%	0.09738	8/27/2003	20	**NR**
	90th Percentile (all)		**12680**	**92.9**

Table C-12. Required Load Reduction for Little Chestuee Creek at Mile 2.1 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
15.52%	15.7048	6/9/2003	**1046**	**19.0**		
18.26%	14.3745	6/11/2003	**>2419**	**>65.0**		
22.42%	13.0274	5/28/2003	727	**NR**		
28.63%	11.4005	6/5/2003	**1203**	**29.6**		
30.58%	10.9573	6/2/2003	648	**NR**	**>1074.8**	**>89.5**
	90th Percentile (all)		**>1933**	**>56.2**		

Table C-13. Required Load Reduction for Chestuee Creek at Mile 42.5 (1998-1999) – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
3.42%	155.5	3/11/1998	411	**NR**
15.44%	60.5	4/15/1998	687	**NR**
19.68%	53.2	3/2/1998	249	**NR**
22.28%	49.4	2/23/1999	460	**NR**
30.99%	41.3	5/18/1999	210	**NR**
31.76%	40.8	4/13/1998	770	**NR**
33.07%	39.6	4/14/1998	**1120**	**24.4**
40.27%	34.9	5/17/1999	870	**NR**
87.57%	13.4	8/16/1999	250	**NR**
88.07%	13.1	8/17/1999	820	**NR**
94.01%	9.1	11/15/1999	120	**NR**
94.58%	8.7	11/17/1999	160	**NR**
99.12%	5.7	11/30/1998	172	**NR**
99.23%	5.6	12/1/1998	157	**NR**
	90th Percentile (all)		855	0.0

Table C-14. Required Load Reduction for Chestuee Creek at Mile 42.5 (2003) – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
14.95%	61.3916	6/9/2003	**1986**	**57.4**		
19.05%	53.8887	6/11/2003	816	**NR**		
22.23%	49.4649	5/28/2003	547	**NR**		
28.83%	43.426	6/5/2003	**1553**	**45.5**		
30.80%	41.45	6/2/2003	517	**NR**	**934**	**87.9**
	90th Percentile (all)		**1813**	**53.3**		

Table C-15. Required Load Reduction for Chestuee Creek at Mile 42.5 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
3.42%	155.529	3/11/1998	350	**NR**
15.44%	60.5171	4/15/1998	690	**NR**
19.68%	53.1557	3/2/1998	168	**NR**
22.28%	49.3872	2/23/1999	170	**NR**
30.99%	41.2541	5/18/1999	970	**NR**
31.76%	40.8243	4/13/1998	660	**NR**
33.07%	39.5972	4/14/1998	**1030**	12.6
40.27%	34.9085	5/17/1999	600	**NR**
87.57%	13.4245	8/16/1999	560	**NR**
88.07%	13.1375	8/17/1999	570	**NR**
94.01%	9.11817	11/15/1999	90	**NR**
94.58%	8.74417	11/17/1999	100	**NR**
99.12%	5.66696	11/30/1998	172	**NR**
99.23%	5.55664	12/1/1998	130	**NR**
	90th Percentile (all)		886	0.0

Table C-16. Required Load Reduction for Oostanaula Creek at Mile 5.7 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli Sample Conc.	E. Coli Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
4.74%	237.598	2/9/2003	**1986**	**57.4**
43.39%	72.639	8/20/2003	461	**NR**
50.07%	65.525	1/14/2004	239	**NR**
61.79%	55.823	11/5/2003	219	**NR**
82.81%	38.783	10/22/2002	411	**NR**
	90th Percentile (all)		**1376**	**38.4**

Table C-17. Required Load Reduction for Oostanaula Creek at Mile 5.7 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform Sample Conc.	Fecal Coliform Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
4.74%	237.598	2/9/2003	**1900**	**52.6**
43.39%	72.639	8/20/2003	340	**NR**
50.07%	65.525	1/14/2004	176	**NR**
61.79%	55.823	11/5/2003	420	**NR**
82.81%	38.783	10/22/2002	300	**NR**
	90th Percentile (all)		**1308**	**31.2**

Table C-18. Required Load Reduction for Oostanaula Creek at Mile 26.6 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.85%	177.204	1/26/2004	**1690**	**49.9**
4.02%	147.471	2/9/2004	200	**NR**
5.15%	127.382	2/25/2003	560	**NR**
16.56%	66.7518	6/17/2003	**1600**	**47.1**
17.90%	64.6496	9/3/2003	50	**NR**
21.05%	59.6118	6/3/2003	720	**NR**
25.76%	54.8426	3/25/2003	80	**NR**
25.81%	54.8113	11/18/2003	400	**NR**
26.75%	53.7173	12/17/2002	160	**NR**
29.95%	51.0811	11/19/2002	350	**NR**
35.78%	46.664	4/29/2003	130	**NR**
36.33%	46.2359	3/15/2004	320	**NR**
37.01%	45.7707	7/30/2003	450	**NR**
46.07%	40.8052	12/9/2003	340	**NR**
46.51%	40.4335	1/21/2003	30	**NR**
49.36%	38.8447	4/26/2004	210	**NR**
55.16%	35.7121	10/1/2003	50	**NR**
63.70%	31.9908	10/29/2002	610	**NR**
74.82%	27.1331	5/24/2004	60	**NR**
82.32%	23.3038	6/14/2004	90	**NR**
84.45%	22.1901	10/1/2002	30	**NR**
	90th Percentile (all)		720	0.0

Table C-19. Required Load Reduction for Oostanaula Creek at Mile 26.6 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.85%	177.204	1/26/2004	**1850**	**51.4**
4.02%	147.471	2/9/2004	880	**NR**
5.15%	127.382	2/25/2003	50	**NR**
16.56%	66.7518	6/17/2003	960	**NR**
17.68%	64.8794	3/26/2002	**10000**	**91.0**
17.90%	64.6496	9/3/2003	140	**NR**
21.05%	59.6118	6/3/2003	960	**NR**
25.76%	54.8426	3/25/2003	60	**NR**
25.81%	54.8113	11/18/2003	460	**NR**
26.75%	53.7173	12/17/2002	290	**NR**
29.95%	51.0811	11/19/2002	140	**NR**
35.78%	46.664	4/29/2003	200	**NR**
36.33%	46.2359	3/15/2004	230	**NR**
37.01%	45.7707	7/30/2003	560	**NR**
46.07%	40.8052	12/9/2003	380	**NR**
46.35%	40.5731	5/22/2002	400	**NR**
46.51%	40.4335	1/21/2003	120	**NR**
49.36%	38.8447	4/26/2004	180	**NR**
55.16%	35.7121	10/1/2003	40	**NR**
63.70%	31.9908	10/29/2002	**1210**	**25.6**
74.82%	27.1331	5/24/2004	150	**NR**
82.32%	23.3038	6/14/2004	140	**NR**
84.45%	22.1901	10/1/2002	120	**NR**
	90^{th} Percentile (all)		**1160**	**22.4**

Table C-20. Required Load Reduction for Oostanaula Creek at Mile 28.4 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.17%	221.52	1/26/2004	**1650**	**48.7**
2.89%	187.21	2/9/2004	600	**NR**
4.47%	147.88	2/19/2003	**1553**	**45.5**
6.07%	122.7	3/13/2001	**2400**	**64.7**
12.59%	77.25	3/9/1999	**2400**	**64.7**
36.35%	40.56	12/9/2003	310	**NR**
38.32%	39.09	3/25/2002	1	**NR**
40.57%	37.43	3/15/2004	250	**NR**
40.97%	37.13	7/30/2003	560	**NR**
43.45%	35.41	1/14/2004	345	**NR**
44.55%	34.61	10/1/2003	70	**NR**
47.55%	32.73	9/3/2003	120	**NR**
48.84%	31.76	8/20/2003	411	**NR**
59.32%	26.24	3/7/2000	370	**NR**
59.99%	25.88	6/8/1999	200	**NR**
60.64%	25.65	4/26/2004	160	**NR**
62.03%	25.04	11/18/2003	400	**NR**
63.22%	24.49	11/5/2003	365	**NR**
65.18%	23.65	12/11/2000	160	**NR**
67.26%	22.72	9/11/2001	200	**NR**
70.55%	21.11	6/12/2000	140	**NR**
72.62%	20.17	5/24/2004	80	**NR**
78.15%	17.66	6/14/2004	60	**NR**
78.98%	17.31	12/15/1998	**>2419**	**>65.0**
81.93%	15.96	10/22/2002	260	**NR**
81.96%	15.95	12/7/1999	820	**NR**
90.05%	12.29	9/19/2000	870	**NR**
94.69%	9.9	9/13/1999	**2400**	**64.7**
	90th Percentile (all)		**>2400**	**>64.7**

Table C-21. Required Load Reduction for Oostanaula Creek at Mile 28.4 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.17%	221.52	1/26/2004	**1720**	**47.7**
2.89%	187.21	2/9/2004	850	**NR**
4.47%	147.88	2/19/2003	**1800**	**50.0**
6.07%	122.7	3/13/2001	**8700**	**89.7**
12.59%	77.25	3/9/1999	**2900**	**69.0**
36.35%	40.56	12/9/2003	320	**NR**
38.32%	39.09	3/25/2002	10	**NR**
40.57%	37.43	3/15/2004	300	**NR**
40.97%	37.13	7/30/2003	250	**NR**
43.45%	35.41	1/14/2004	220	**NR**
44.55%	34.61	10/1/2003	380	**NR**
44.75%	34.48	5/24/1999	**3900**	**76.9**
47.55%	32.73	9/3/2003	300	**NR**
48.84%	31.76	8/20/2003	440	**NR**
59.32%	26.24	3/7/2000	600	**NR**
59.99%	25.88	6/8/1999	97	**NR**
60.64%	25.65	4/26/2004	480	**NR**
62.03%	25.04	11/18/2003	690	**NR**
62.84%	24.65	7/19/1999	670	**NR**
63.22%	24.49	11/5/2003	220	**NR**
65.18%	23.65	12/11/2000	320	**NR**
66.46%	23.09	6/14/1999	200	**NR**
67.26%	22.72	9/11/2001	170	**NR**
70.55%	21.11	6/12/2000	200	**NR**
72.62%	20.17	5/24/2004	170	**NR**
78.15%	17.66	6/14/2004	80	**NR**
78.98%	17.31	12/15/1998	**8000**	**88.8**
79.21%	17.2	8/11/1999	280	**NR**
81.93%	15.96	10/22/2002	270	**NR**
81.96%	15.95	12/7/1999	830	**NR**
90.05%	12.29	9/19/2000	930	**NR**
94.69%	9.9	9/13/1999	240	**NR**
	90^{th} Percentile (all)		**2790**	**67.7**

Table C-22. Required Load Reduction for Oostanaula Creek at Mile 30.0 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli Sample Conc.	E. Coli Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
1.83%	221.52	1/26/2004	**2760**	**69.3**
2.55%	187.21	2/9/2004	150	**NR**
4.00%	148.57	2/25/2003	340	**NR**
21.74%	53.87	3/25/2003	60	**NR**
23.52%	51.88	12/17/2002	300	**NR**
28.69%	46.75	6/3/2003	**1200**	**29.4**
29.81%	45.72	6/17/2003	**1740**	**51.3**
32.38%	43.2	11/19/2002	550	**NR**
32.74%	43.04	4/29/2003	40	**NR**
36.05%	40.56	12/9/2003	170	**NR**
41.12%	37.43	3/15/2004	100	**NR**
41.58%	37.13	7/30/2003	120	**NR**
46.04%	34.61	10/1/2003	150	**NR**
49.82%	32.73	9/3/2003	90	**NR**
49.99%	32.61	1/21/2003	300	**NR**
58.42%	28.26	10/29/2002	**2900**	**70.8**
64.28%	25.65	4/26/2004	920	**NR**
65.89%	25.04	11/18/2003	60	**NR**
78.57%	20.17	5/24/2004	140	**NR**
84.29%	17.66	6/14/2004	50	**NR**
85.16%	17.22	10/1/2002	160	**NR**
	90th Percentile (all)		**1740**	**51.3**

Table C-23. Required Load Reduction for Oostanaula Creek at Mile 30.0 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
1.83%	221.52	1/26/2004	**2850**	**68.4**
2.55%	187.21	2/9/2004	190	**NR**
4.00%	148.57	2/25/2003	250	**NR**
21.74%	53.87	3/25/2003	120	**NR**
23.52%	51.88	12/17/2002	210	**NR**
28.69%	46.75	6/3/2003	**1300**	**30.8**
29.81%	45.72	6/17/2003	**1680**	**46.4**
31.43%	44.07	3/26/2002	**12000**	**92.5**
32.38%	43.2	11/19/2002	710	**NR**
32.74%	43.04	4/29/2003	240	**NR**
36.05%	40.56	12/9/2003	160	**NR**
41.12%	37.43	3/15/2004	280	**NR**
41.58%	37.13	7/30/2003	270	**NR**
46.04%	34.61	10/1/2003	210	**NR**
48.10%	33.46	5/22/2002	**2900**	**69.0**
49.82%	32.73	9/3/2003	220	**NR**
49.99%	32.61	1/21/2003	410	**NR**
58.42%	28.26	10/29/2002	**6000**	**85.0**
64.28%	25.65	4/26/2004	870	**NR**
65.89%	25.04	11/18/2003	80	**NR**
78.57%	20.17	5/24/2004	270	**NR**
84.29%	17.66	6/14/2004	330	**NR**
85.16%	17.22	10/1/2002	550	**NR**
	90th Percentile (all)		**2890**	**68.9**

Table C-24. Required Load Reduction for Oostanaula Creek at Mile 30.1 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
1.83%	221.52	1/26/2004	**1990**	**57.4**
2.55%	187.21	2/9/2004	**980**	**13.6**
4.00%	148.57	2/25/2003	380	**NR**
21.74%	53.87	3/25/2003	100	**NR**
23.52%	51.88	12/17/2002	510	**NR**
28.69%	46.75	6/3/2003	600	**NR**
29.81%	45.72	6/17/2003	**1740**	**51.3**
32.38%	43.2	11/19/2002	**1350**	**37.3**
32.74%	43.04	4/29/2003	100	**NR**
36.05%	40.56	12/9/2003	220	**NR**
41.12%	37.43	3/15/2004	250	**NR**
41.58%	37.13	7/30/2003	240	**NR**
46.04%	34.61	10/1/2003	130	**NR**
49.82%	32.73	9/3/2003	90	**NR**
49.99%	32.61	1/21/2003	190	**NR**
58.42%	28.26	10/29/2002	**2500**	**66.1**
64.28%	25.65	4/26/2004	180	**NR**
65.89%	25.04	11/18/2003	80	**NR**
78.57%	20.17	5/24/2004	200	**NR**
84.29%	17.66	6/14/2004	80	**NR**
85.16%	17.22	10/1/2002	130	**NR**
	90th Percentile (all)		**1740**	**51.3**

Table C-25. Required Load Reduction for Oostanaula Creek at Mile 30.1 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
1.83%	221.52	1/26/2004	**2200**	**59.1**
2.55%	187.21	2/9/2004	**1200**	**33.3**
4.00%	148.57	2/25/2003	220	**NR**
21.74%	53.87	3/25/2003	100	**NR**
23.52%	51.88	12/17/2002	420	**NR**
28.69%	46.75	6/3/2003	840	**NR**
29.81%	45.72	6/17/2003	**1560**	**42.3**
31.43%	44.07	3/26/2002	**14000**	**93.6**
32.38%	43.2	11/19/2002	560	**NR**
32.74%	43.04	4/29/2003	230	**NR**
36.05%	40.56	12/9/2003	200	**NR**
41.12%	37.43	3/15/2004	370	**NR**
41.58%	37.13	7/30/2003	380	**NR**
46.04%	34.61	10/1/2003	260	**NR**
48.10%	33.46	5/22/2002	**3500**	**74.3**
49.82%	32.73	9/3/2003	130	**NR**
49.99%	32.61	1/21/2003	230	**NR**
58.42%	28.26	10/29/2002	**6000**	**85.0**
64.28%	25.65	4/26/2004	310	**NR**
65.89%	25.04	11/18/2003	50	**NR**
78.57%	20.17	5/24/2004	360	**NR**
84.29%	17.66	6/14/2004	400	**NR**
85.16%	17.22	10/1/2002	510	**NR**
	90th Percentile (all)		**3240**	**72.2**

Table C-26. Required Load Reduction for Oostanaula Creek at Mile 33.6 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.628%	115.919	1/26/2004	**2090**	**59.5**
3.723%	96.0258	2/9/2004	800	**NR**
33.151%	28.471	7/30/2003	**2750**	**69.2**
38.489%	26.2992	9/3/2003	410	**NR**
39.584%	25.992	3/15/2004	210	**NR**
41.911%	25.0027	12/9/2003	890	**NR**
51.547%	21.5081	10/1/2003	400	**NR**
56.721%	19.8617	11/18/2003	**1200**	**29.4**
58.363%	19.3883	4/26/2004	880	**NR**
71.640%	15.6601	5/24/2004	520	**NR**
80.044%	13.0269	6/14/2004	250	**NR**
	90th Percentile (all)		**2090**	**59.5**

Table C-27. Required Load Reduction for Oostanaula Creek at Mile 33.6 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.628%	115.919	1/26/2004	**2120**	**57.5**
3.723%	96.0258	2/9/2004	1000	**NR**
33.151%	28.471	7/30/2003	**2140**	**57.9**
38.489%	26.2992	9/3/2003	500	**NR**
39.584%	25.992	3/15/2004	250	**NR**
41.911%	25.0027	12/9/2003	740	**NR**
51.547%	21.5081	10/1/2003	870	**NR**
56.721%	19.8617	11/18/2003	**1180**	**23.7**
58.363%	19.3883	4/26/2004	**1130**	**20.4**
71.640%	15.6601	5/24/2004	**1100**	**18.2**
80.044%	13.0269	6/14/2004	**1490**	**39.6**
	90th Percentile (all)		**2120**	**57.5**

Table C-28. Required Load Reduction for Oostanaula Creek at Mile 35.1 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.628%	115.919	1/26/2004	**2610**	**67.5**
3.723%	96.0258	2/9/2004	100	**NR**
33.151%	28.471	7/30/2003	**1250**	**32.2**
38.489%	26.2992	9/3/2003	100	**NR**
39.584%	25.992	3/15/2004	280	**NR**
41.911%	25.0027	12/9/2003	190	**NR**
51.547%	21.5081	10/1/2003	290	**NR**
56.721%	19.8617	11/18/2003	40	**NR**
58.363%	19.3883	4/26/2004	720	**NR**
71.640%	15.6601	5/24/2004	380	**NR**
80.044%	13.0269	6/14/2004	130	**NR**
	90th Percentile (all)		**1250**	**32.2**

Table C-29. Required Load Reduction for Oostanaula Creek at Mile 35.1 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
2.628%	115.919	1/26/2004	**2500**	**64.0**
3.723%	96.0258	2/9/2004	100	**NR**
33.151%	28.471	7/30/2003	**1850**	**51.4**
38.489%	26.2992	9/3/2003	310	**NR**
39.584%	25.992	3/15/2004	330	**NR**
41.911%	25.0027	12/9/2003	120	**NR**
51.547%	21.5081	10/1/2003	720	**NR**
56.721%	19.8617	11/18/2003	120	**NR**
58.363%	19.3883	4/26/2004	**1410**	**36.2**
71.640%	15.6601	5/24/2004	810	**NR**
80.044%	13.0269	6/14/2004	50	**NR**
	90th Percentile (all)		**1850**	**51.4**

Table C-30. Required Load Reduction for North Mouse Creek at Mile 4.2 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
3.01%	399.445	11/12/2002	**8620**	**90.2**
4.02%	334.746	5/19/2003	**4570**	**81.5**
19.05%	127.615	3/24/2003	410	**NR**
29.35%	101.868	12/18/2002	100	**NR**
34.88%	91.9124	4/29/2003	200	**NR**
44.46%	78.0895	1/13/2004	410	**NR**
59.62%	60.1605	1/28/2003	200	**NR**
59.73%	60.0222	8/19/2003	410	**NR**
75.72%	45.641	5/11/2004	310	**NR**
85.08%	36.0408	11/4/2003	310	**NR**
86.67%	34.2459	10/21/2002	310	**NR**
87.76%	32.9522	8/27/2002	100	**NR**
	90th Percentile (all)		**4154**	**79.6**

Table C-31. Required Load Reduction for North Mouse Creek at Mile 4.2 – Fecal Coliform Analysis

PDFE	Flow	Sample Date	Fecal Coliform	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]
3.01%	399.445	11/12/2002	**9000**	**90.0**
4.02%	334.746	5/19/2003	**5000**	**82.0**
19.05%	127.615	3/24/2003	200	**NR**
29.35%	101.868	12/18/2002	130	**NR**
34.88%	91.9124	4/29/2003	370	**NR**
44.46%	78.0895	1/13/2004	330	**NR**
59.62%	60.1605	1/28/2003	88	**NR**
59.73%	60.0222	8/19/2003	800	**NR**
75.72%	45.641	5/11/2004	130	**NR**
85.08%	36.0408	11/4/2003	320	**NR**
86.67%	34.2459	10/21/2002	380	**NR**
87.76%	32.9522	8/27/2002	200	**NR**
	90th Percentile (all)		**4580**	**80.3**

Table C-32. Required Load Reduction for Spring Creek at Mile 15.6 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
11.17%	31.9232	7/9/2003	686	**NR**		
13.30%	28.2467	7/10/2003	**1119**	**24.3**		
19.68%	22.3502	6/10/2003	**980**	**13.6**		
24.75%	19.9739	6/23/2003	**1046**	**19.0**		
33.95%	16.3868	6/25/2003	866	**NR**	**926**	**87.8**
	90th Percentile (all)		**1090**	**22.3**		

Table C-33. Required Load Reduction for Rogers Creek at Mile 14.2 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
11.09%	106.415	7/9/2003	**1413**	**40.1**		
13.28%	93.6615	7/10/2003	**1413**	**40.1**		
19.57%	74.3695	6/10/2003	920	**NR**		
24.67%	66.5143	6/23/2003	816	**NR**		
33.75%	54.4824	6/25/2003	**1203**	**29.6**	**1125**	**90.0**
	90th Percentile (all)		**1413**	**40.1**		

Table C-34. Required Load Reduction for Price Creek at Mile 4.4 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[cts/100 ml]	[%]	[cts/day]	[%]
12.02%	3.67979	7/10/2003	**1986**	**57.4**		
12.62%	3.55444	7/9/2003	**980**	**13.6**		
21.74%	2.64973	6/10/2003	547	**NR**		
27.38%	2.33407	6/23/2003	248	**NR**		
35.12%	1.99627	6/25/2003	360	**NR**	**625**	**81.9**
	90th Percentile (all)		**1584**	**46.5**		

Table C-35. Required Load Reduction for Hiwassee River at Mile 13.4 – E. Coli Analysis

Sample Date	E. Coli	
	Sample Conc.	Required Load Reduction
	[cts/100 ml]	[%]
12/15/98	**980**	**13.6**
3/9/99	170	**NR**
6/8/99	2	**NR**
9/14/99	19	**NR**
12/14/99	13	**NR**
3/15/00	260	**NR**
6/19/00	4	**NR**
9/5/00	9	**NR**
12/4/00	93	**NR**
3/14/01	**>2400**	**>64.7**
9/11/01	4	**NR**
3/25/02	170	**NR**
9/4/02	3	**NR**
12/17/02	52	**NR**
3/26/03	40	**NR**
6/17/03	**2400**	**64.7**
9/8/03	27	**NR**
12/2/03	54	**NR**
3/9/04	**1200**	**29.4**
90th Percentile (all)	**1440**	**29.4**

Table C-36. Required Load Reduction for Hiwassee River at Mile 13.4 – Fecal Coliform Analysis

Sample Date	Fecal Coliform	
	Sample Conc.	Required Load Reduction
	[cts/100 ml]	[%]
12/15/98	860	**NR**
3/9/99	770	**NR**
6/8/99	13	**NR**
9/14/99	16	**NR**
12/14/99	430	**NR**
3/15/00	**3900**	**76.9**
6/19/00	15	**NR**
9/5/00	19	**NR**
12/4/00	93	**NR**
3/14/01	**5000**	**82.0**
9/11/01	38	**NR**
3/25/02	190	**NR**
9/4/02	7	**NR**
12/17/02	160	**NR**
3/26/03	56	**NR**
6/17/03	**2100**	**57.1**
12/2/03	70	**NR**
3/9/04	770	**NR**
90th Percentile (all)	**2640**	**65.9**

Table C-37. Required Load Reduction for Hiwassee River at Mile 15.6 – E. Coli Analysis

Sample Date	E. Coli	
	Sample Conc.	Required Load Reduction
	[cts/100 ml]	[%]
4/27/98	27	**NR**
4/28/98	51	**NR**
7/13/98	20	**NR**
7/14/98	17	**NR**
7/15/98	13	**NR**
5/3/99	260	**NR**
5/4/99	120	**NR**
8/30/99	36	**NR**
8/31/99	25	**NR**
9/1/99	48	**NR**
90th Percentile (all)	120	0.0

Table C-38. Required Load Reduction for Hiwassee River at Mile 15.6 – Fecal Coliform Analysis

Sample Date	Fecal Coliform	
	Sample Conc.	Required Load Reduction
	[cts/100 ml]	[%]
4/27/98	70	**NR**
4/28/98	104	**NR**
7/13/98	34	**NR**
7/14/98	110	**NR**
7/15/98	112	**NR**
5/3/99	240	**NR**
5/4/99	140	**NR**
8/30/99	60	**NR**
8/31/99	30	**NR**
9/1/99	39	**NR**
90th Percentile (all)	140	0.0

APPENDIX D

Dynamic Loading Model Methodology

DYNAMIC LOADING MODEL METHOD

D.1 Model Selection

The Loading Simulation Program C++ (LSPC) was selected for TMDL analysis of E. coli-impaired waters in the Hiwassee 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.

D.2 Model Set Up

The Chatata Creek, Chestuee Creek, Oostanaula Creek, and North Mouse Creek watersheds were 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 HUC-12 delineations, 303(d)-listed waterbodies, and water quality monitoring stations. 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. Results of the WCS characterization was 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 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 Chattanooga Airport meteorological station was available for the time period from January 1970 through June 2004. Meteorological data for a selected 11-year period was used for all simulations. The first year of this period was used for model stabilization with simulation data from the subsequent 10-year period (7/1/94 – 6/30/04) used for TMDL analysis.

D.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.

D.3.1 Hydrologic Calibration

Hydrologic calibration of the watershed model involves comparison of simulated streamflow to historic streamflow data from U. S. Geological Survey (USGS) stream gaging stations for the same period of time. A USGS continuous record station located in the Oostanaula Creek 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 Oostanaula Creek near Sanford, USGS Station 03565500, are shown in Table D-1 and Figure D-1.

D.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 <u>initial</u> 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.

D.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.

D.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.

D.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.

D.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. 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, 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, and 1.38×10^8 counts/day/chicken (NCSU, 1994).

D.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 D.3.2.2.1) are also included in these rates.

D.3.2.2.4 Urban Development

Urban land use represented in the MRLC database includes areas classified as: high intensity commercial, industrial, transportation; high intensity residential; and low density 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 1.0×10^9 to 1.2×10^{10} counts/acre-day and is assumed constant within each subwatershed throughout the year.

D.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 <u>initial</u> 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.

D.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 Hiwassee River E. coli-impaired subwatersheds was performed at monitoring locations with adequate water quality data for model calibration. The results of the Hiwassee River subwatershed water quality calibrations for Chatata Creek, Chestuee Creek, Oostanaula Creek, and North Mouse Creek are shown in Figures D-2 through D-5, respectively. Results show that the model adequately simulates peaks in fecal coliform bacteria in response to rainfall events and pollutant loading dynamics.

D.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.

D.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 (Chatata Creek, Chestuee Creek, Oostanaula Creek, and North Mouse Creek) coincided with HUC-12 subwatersheds, water quality monitoring stations, and the outlets (endpoints) of 303(d)-Listed segments. The waterbody segments were at the "pour points" of these subwatersheds. In addition, the pour points coinciding with water quality monitoring stations had sufficient fecal coliform data for water quality calibration. Existing loads and required load reductions were determined on a subwatershed basis for the Chatata Creek, Chestuee Creek, Oostanaula Creek, and North Mouse Creek waterbodies.

The results of the 10-year simulation used to determine existing conditions for Chatata Creek, Chestuee Creek, Oostanaula Creek, and North Mouse Creek are shown in Figures D-6 through D-9, respectively.

D.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:

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

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>.

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 the subwatershed at the pour point of the 303(d)-Listed segment of Chatata Creek, the simulated 30-day geometric mean concentration for the existing loading condition (ref.: Section D.5) is 2461 counts/100 mL. The required instream load reduction is calculated by:

$$\text{TMDL} = \text{RILR} = \frac{(2461 \text{ cts/100 mL}) - (180 \text{ cts/100 mL})}{(2461 \text{ cts/100 mL})} \times 100$$

TMDL = RILR = 92.7%

Required load reductions are summarized in Table D-2 for modeled subwatersheds.

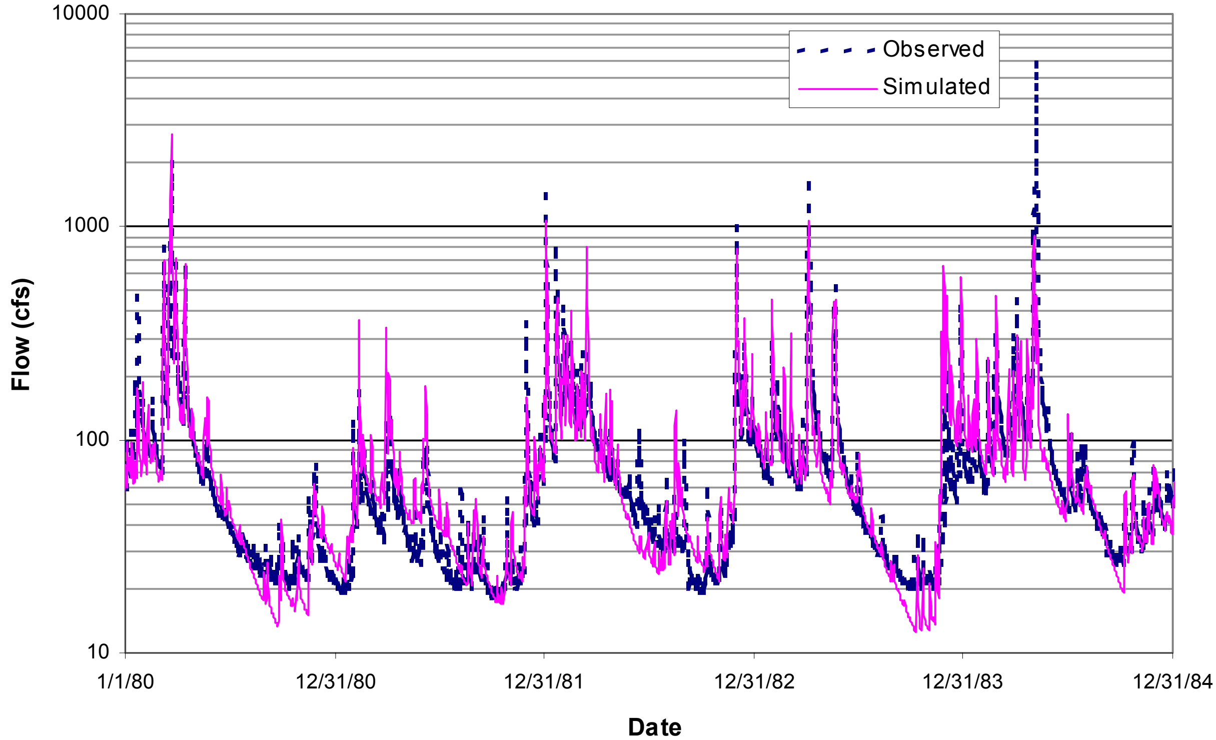
Table D-1. Hydrologic Calibration Summary: Oostanaula Cr. near Sanford (USGS 03565500)

Simulation Name:	OosCAP05		
(Chattanooga Airport Raingage)	Oostanaula Cr. near Sanford (USGS 03565500)	**Watershed Area (ac):**	36480.00
Period for Flow Analysis			
Begin Date:	**01/01/80**	**Baseflow PERCENTILE:**	2.5
End Date:	**12/31/89**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**163.22**	Total Observed In-stream Flow:	**157.99**
Total of highest 10% flows:	**68.93**	Total of Observed highest 10% flows:	**71.81**
Total of lowest 50% flows:	**28.96**	Total of Observed Lowest 50% flows:	**27.01**
Simulated Summer Flow Volume (months 7-9):	**16.63**	Observed Summer Flow Volume (7-9):	**15.35**
Simulated Fall Flow Volume (months 10-12):	**30.75**	Observed Fall Flow Volume (10-12):	**25.59**
Simulated Winter Flow Volume (months 1-3):	**74.61**	Observed Winter Flow Volume (1-3):	**68.62**
Simulated Spring Flow Volume (months 4-6):	**41.23**	Observed Spring Flow Volume (4-6):	**48.43**
Total Simulated Storm Volume:	**130.47**	Total Observed Storm Volume:	**124.96**
Simulated Summer Storm Volume (7-9):	**8.64**	Observed Summer Storm Volume (7-9):	**7.28**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**3.31**	10	
Error in 50% lowest flows:	**7.23**	10	
Error in 10% highest flows:	**-4.01**	15	
Seasonal volume error - Summer:	**8.33**	30	
Seasonal volume error - Fall:	**20.16**	30	
Seasonal volume error - Winter:	**8.73**	30	
Seasonal volume error - Spring:	**-14.86**	30	
Error in storm volumes:	**4.41**	20	

Table D-2. TMDLs for Hiwassee River Waterbodies – Surrogate Fecal Coliform 30-Day Geometric Mean Target

Impaired Waterbody Name	Waterbody ID	Existing Conditions		TMDL - Required Load Reduction
		Date(s) of Max. 30-Day Geom. Mean Concen.	Max. 30-Day Geom. Mean Concentration [cts./100 mL]	[%]
Chatata Creek	TN06020002012 – 1000	11/22/98	2461	92.7
Chestuee Creek	TN06020002082 – 2000	11/22/98	750	75.8
Oostanaula Creek (Mouth)	TN06020002083 – 1000	9/23/96	219	17.8
Oostanaula Creek (Mile 5.7)	TN06020002083 – 2000	9/23/96	252	28.6
Oostanaula Creek (Mile 26.6)	TN06020002083 – 3000	9/22/96	273	34.1
Oostanaula Creek (Mile 34.2)	TN06020002083 – 4000	7/6/03	252	28.6
Oostanaula Creek (Mile 42.7)	TN06020002083 – 5000	NA*	NA*	28.6*
North Mouse Creek	TN06020002084 – 1000	11/23/98	1145	84.3

* No data in impaired waterbody. Percent reduction based on results at Mile 34.2.



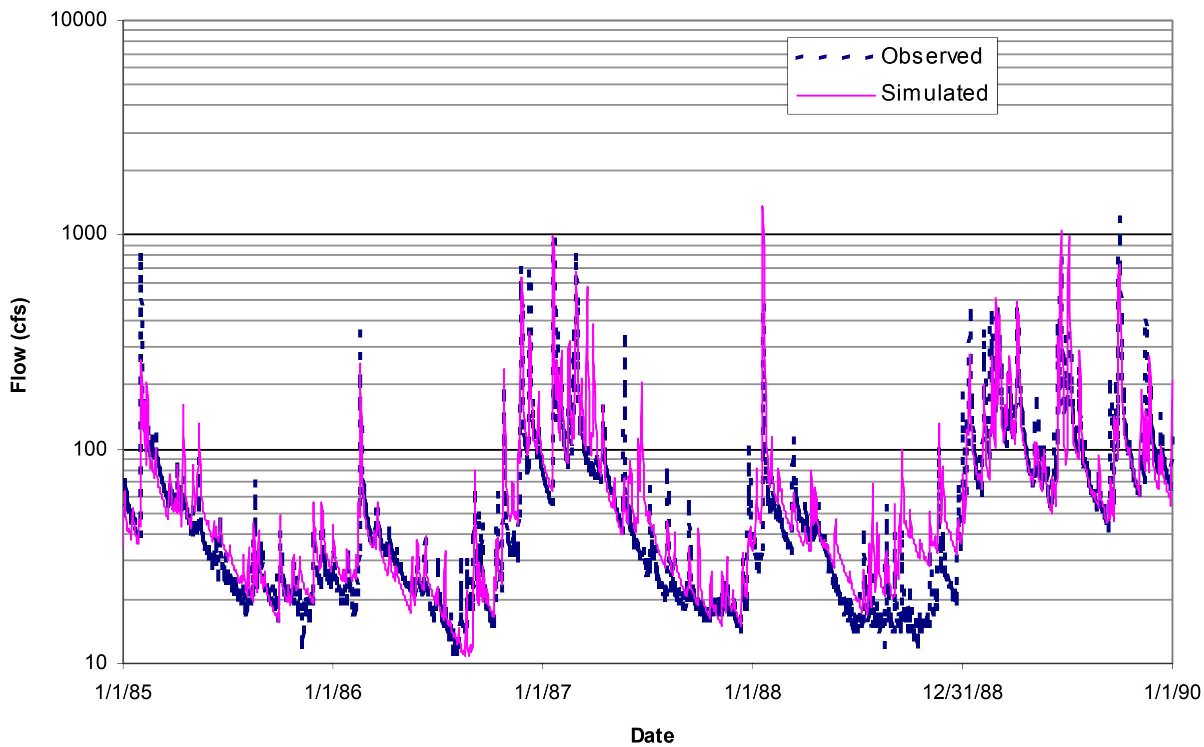


Figure D-1. Hydrologic Calibration: Oostanaula Cr. near Sanford, USGS 03565500 (1980-1989)

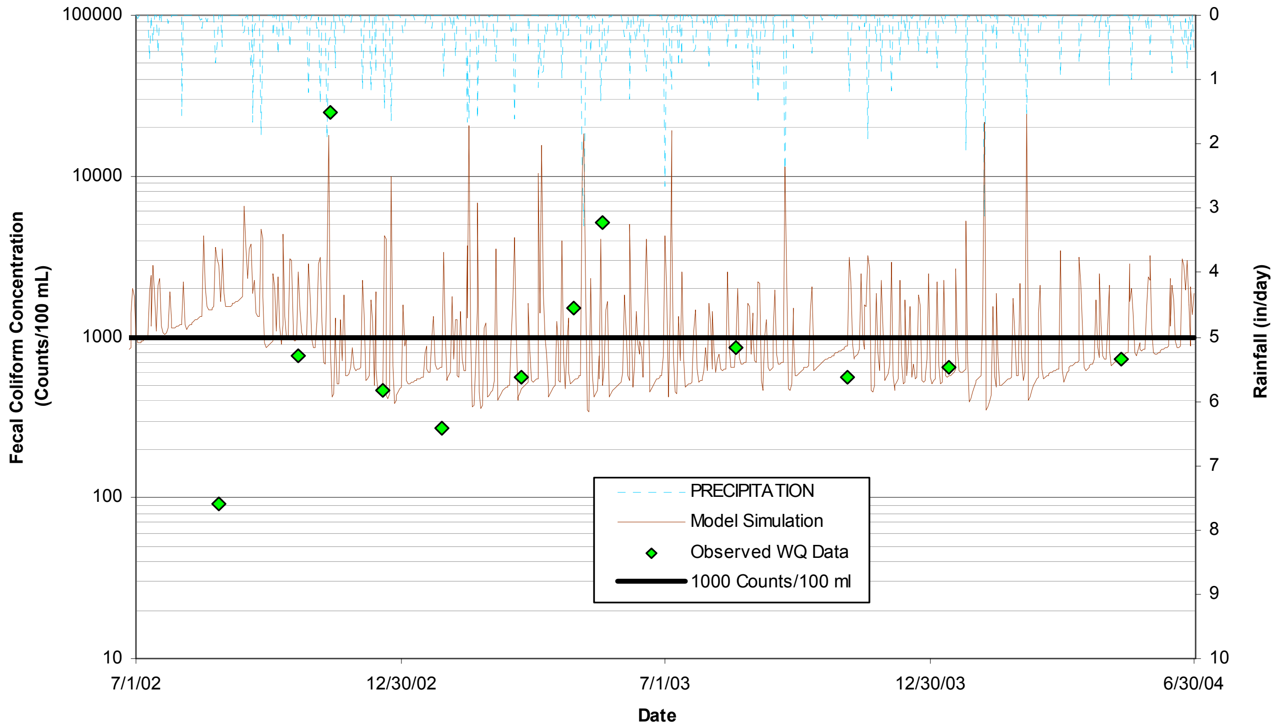


Figure D-2. Water Quality Calibration of Chatata Creek at Mile 0.5 (CHATA000.5BR)

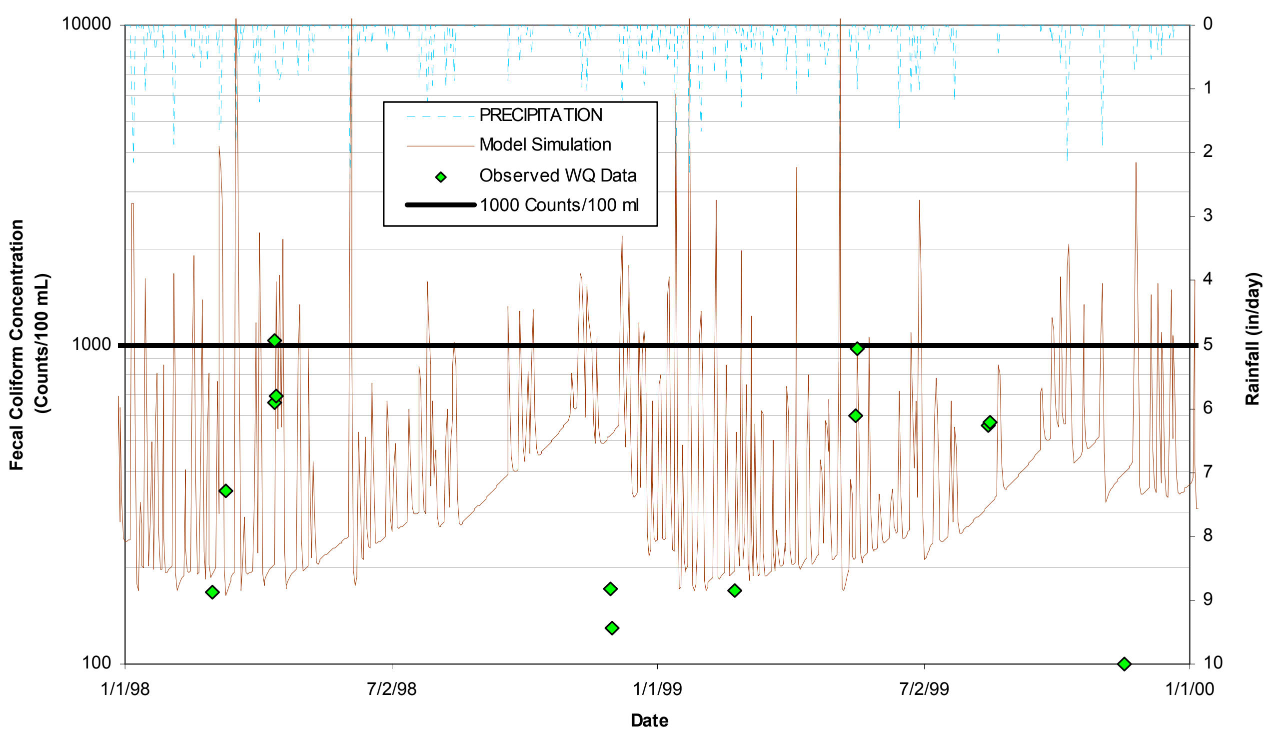


Figure D-3. Water Quality Calibration of Chestuee Creek at Mile 42.5 (CHEST042.5MM)

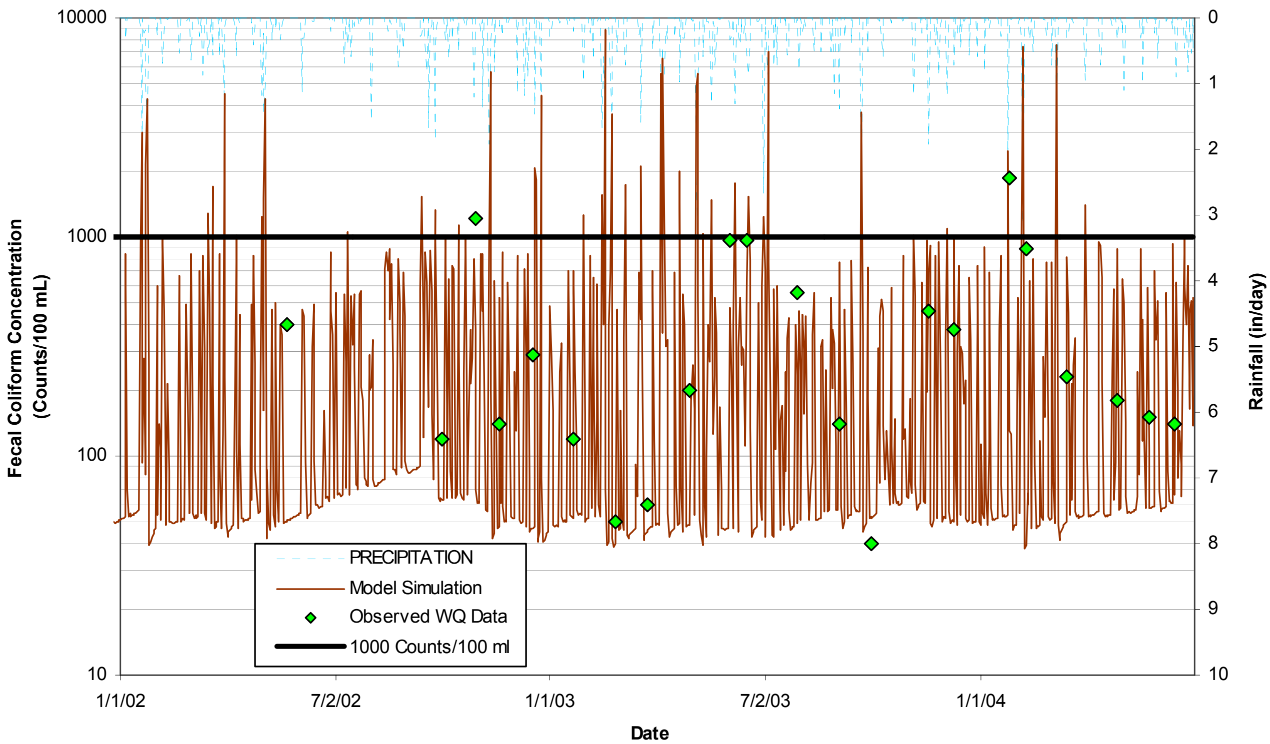


Figure D-4. Water Quality Calibration of Oostanaula Creek at Mile 26.6 (OOSTA026.6MM)

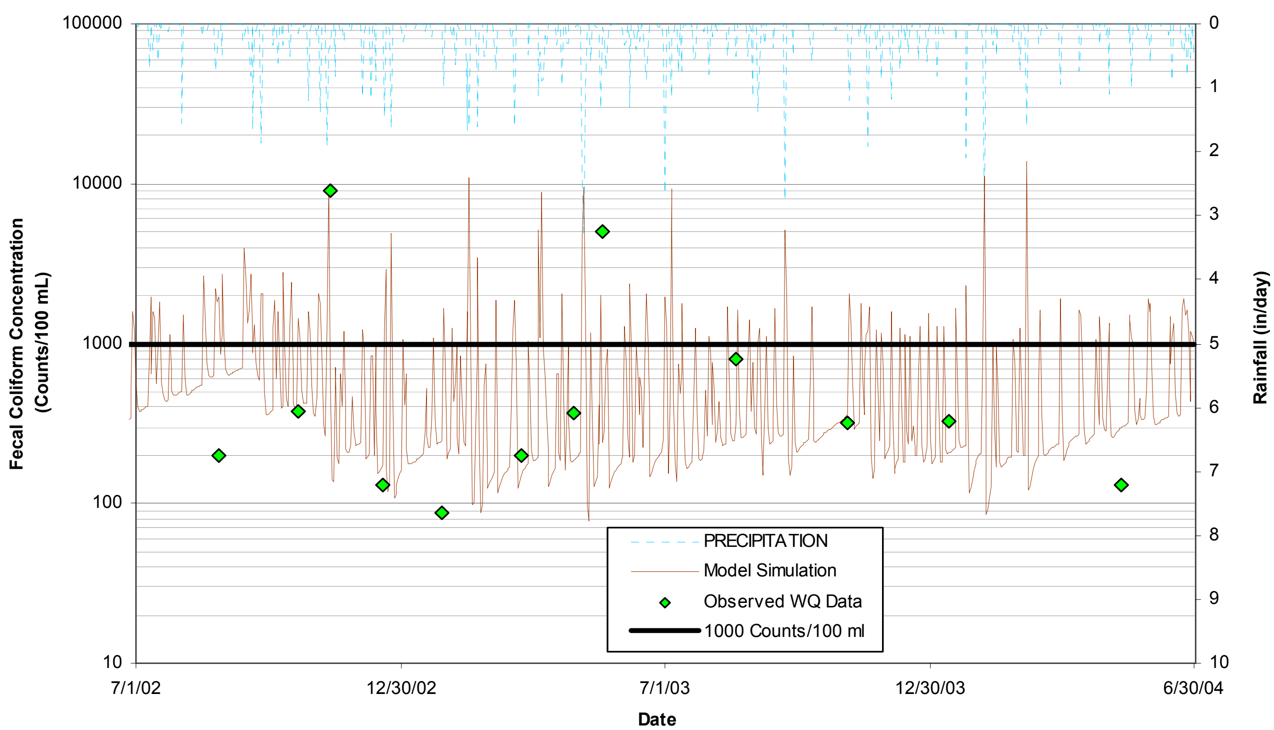


Figure D-5. Water Quality Calibration of North Mouse Creek at Mile 4.2 (NMOUS004.2MM)

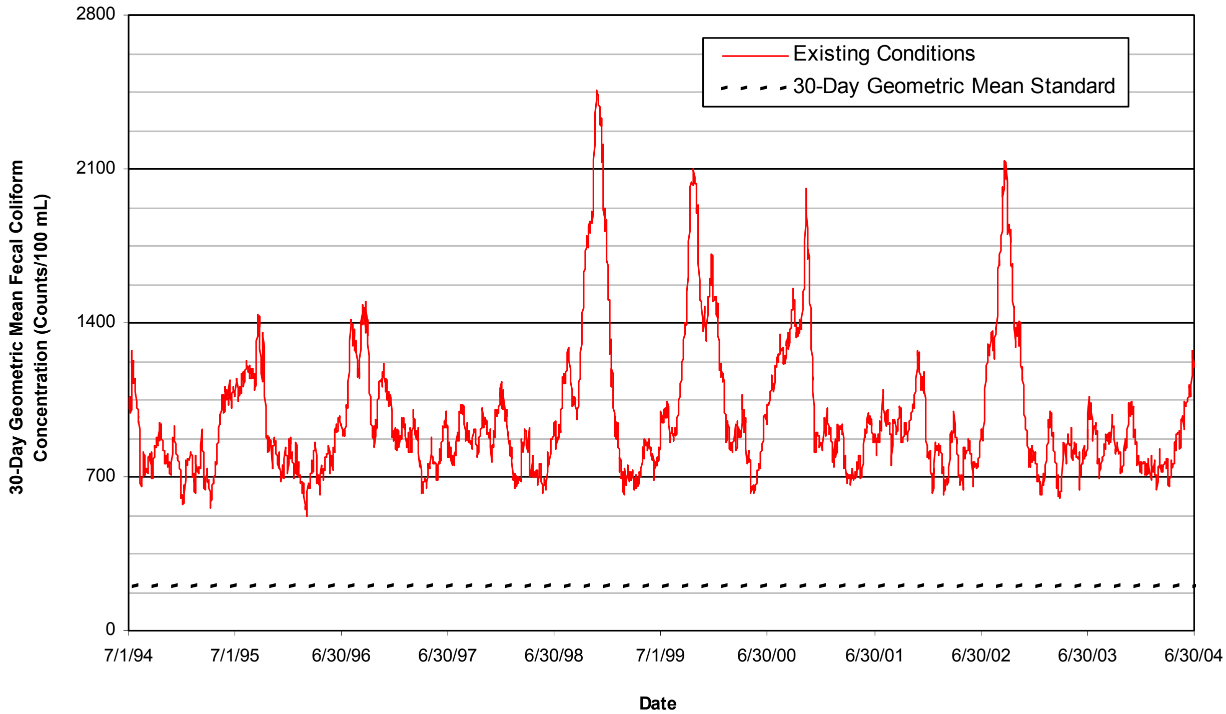


Figure D-6. Simulated 30-Day Geometric Mean Fecal Coliform Concentrations for Chatata Creek at the Mouth for Existing Conditions.

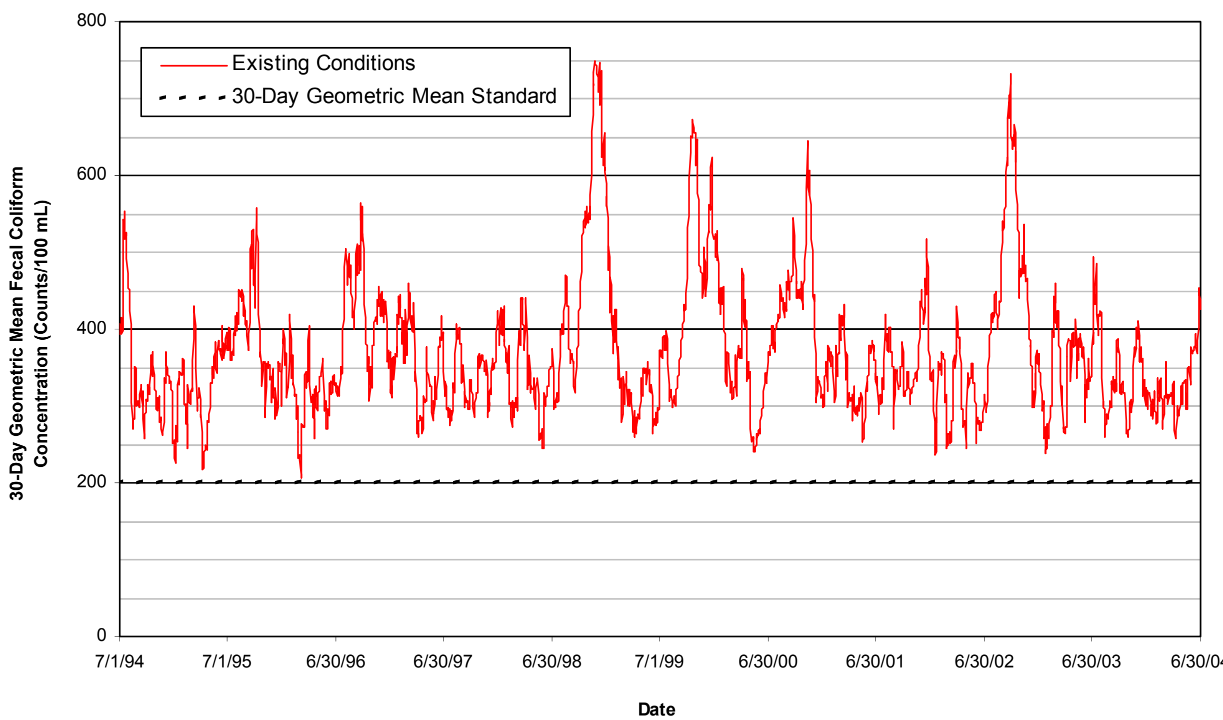


Figure D-7. Simulated 30-Day Geometric Mean Fecal Coliform Concentrations for Chestuee Creek at the Confluence with Middle Creek for Existing Conditions.

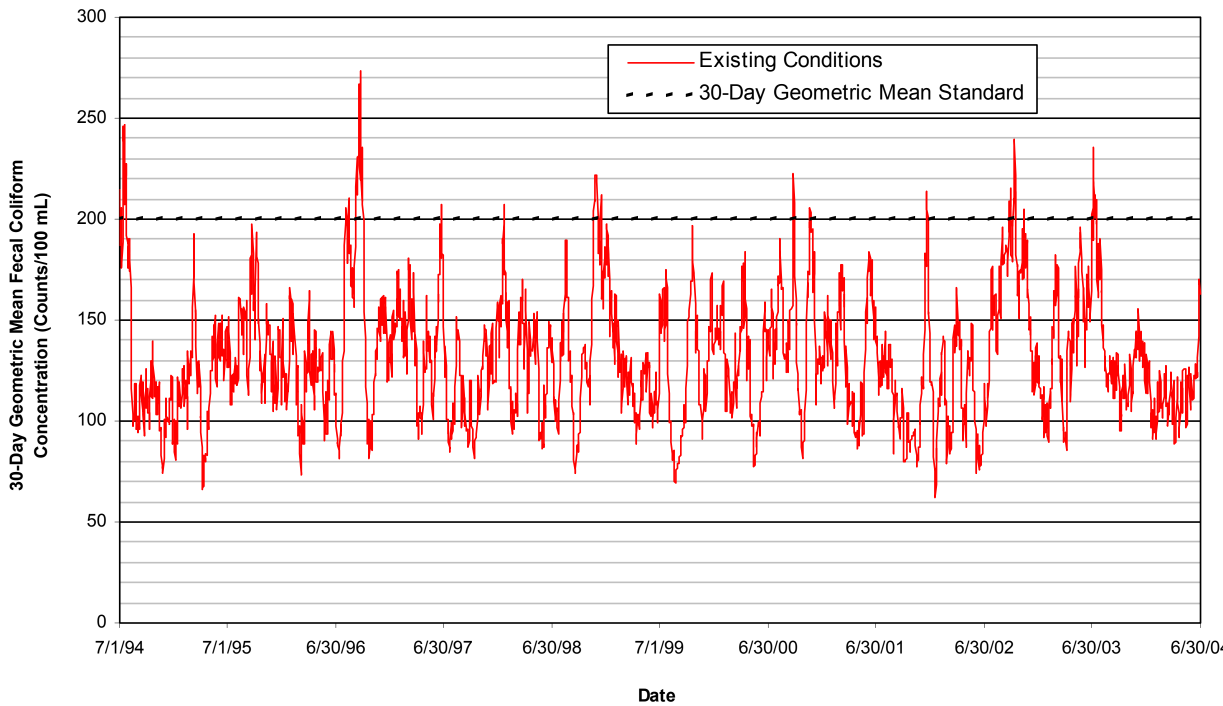


Figure D-8. Simulated 30-Day Geometric Mean Fecal Coliform Concentrations for Oostanaula Creek at Mile 26.6 for Existing Conditions.

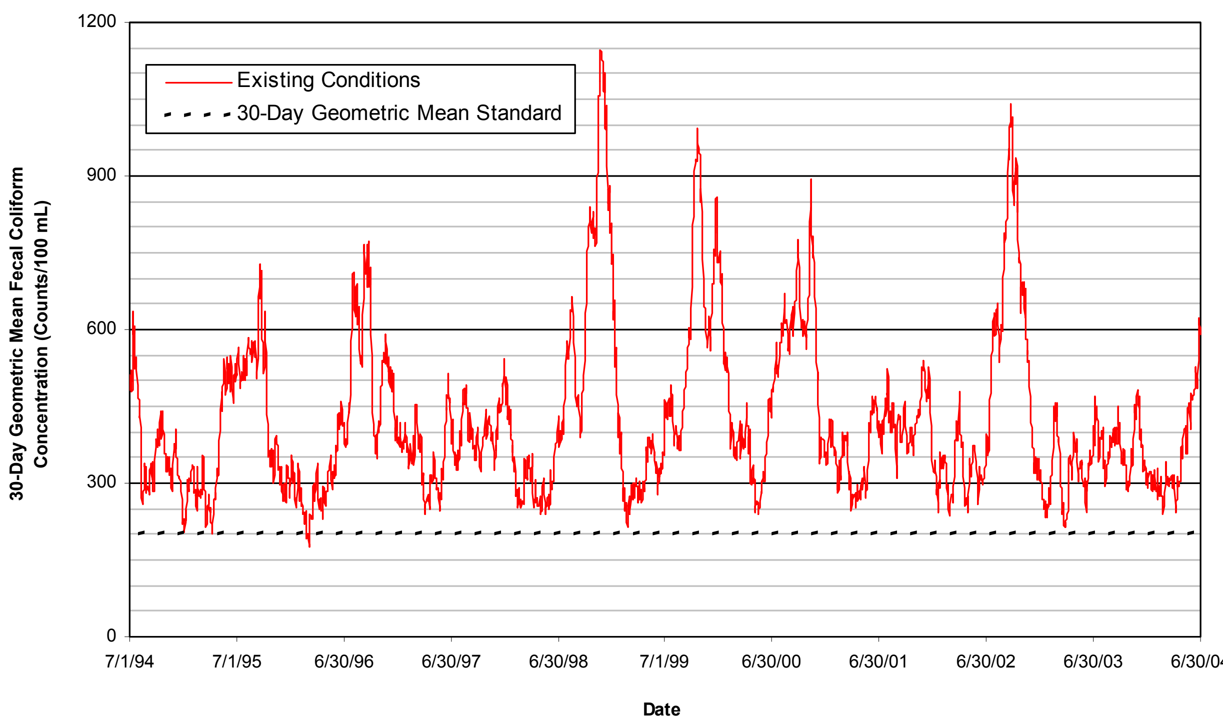


Figure D-9. Simulated 30-Day Geometric Mean Fecal Coliform Concentrations for North Mouse Creek at the Mouth for Existing Conditions.

APPENDIX E

Oostanaula Creek TMDL Revisited

REVISED OOSTANAULA CREEK TMDL

TDEC's Division of Water Pollution Control (DWPC) previously developed a fecal coliform TMDL for Oostanaula Creek based on water quality data collected at Mile 28.4 during the period December 1982 through September 1999. USEPA approved the Oostanaula Creek TMDL in May of 2002. The 2002 EPA-approved Fecal Coliform TMDL stated the following: "Fecal coliform grab samples, collected quarterly at the sampling station at mile 28.4 on Oostanaula Creek in the Hiwassee River watershed were used for comparison with the simulated daily model results. Water quality calibration was conducted at mile 28.4 and extended, through model simulation, to the mouth of Oostanaula Creek to complete the TMDL evaluation." The required reduction at mile 28.4, according to the model simulation, was 96.5%. The subsequent reduction of pathogen (fecal coliform) loading to Oostanaula Creek was 98% at the mouth.

Additional pathogen data (E. coli and fecal coliform) collected at mile 28.4 and other monitoring locations on Oostanaula Creek warrants re-examination and revision of the Oostanaula Creek TMDL. Data were collected approximately quarterly for the period 12/82-9/99 for the 2002 EPA-approved Fecal Coliform TMDL at Oostanaula Creek at Mile 28.4. However, nine samples (9/96-9/98) had only sample month and year recorded with sample data because original lab sheets had been misplaced and data spreadsheets did not provide the day of the month these samples were collected. These 9 samples were used in the original analysis, with minimal influence on model results; however, for current Load Duration Curve analysis, the daily flow associated with each sample is critical to the analysis and also was not recorded with the samples. Therefore, these data were not utilized in the current analysis. Data collected after the original TMDL analysis, during the period 12/98-6/04, were used for comparison to the original TMDL (12/82-6/96) by Load Duration Curve analysis (Figure E-1). LDC analysis was chosen because the method provides qualitative and quantitative graphical data representations that are more easily compared than model simulations.

Table E-1 presents the summary results from LDC analyses of historic versus current pathogen data (fecal coliform) at Oostanaula Creek Mile 28.4. Figure E-1 clearly shows significant improvement has been achieved for pathogen loading in Oostanaula Creek. While required load reduction has been reduced from over 95% to approximately 70%, loading has apparently been reduced by nearly an order of magnitude. The numerical results of the LDC analysis are comparable to the previous TMDL model results (EPA-approved TMDL) versus the current TMDL analysis (see Table 8, and Appendices C and D). Complete LDC results are presented in Table C-19 for the current analysis and Table E-2 for the 2002 EPA approved analysis.

Table E-1. Comparison of Fecal Coliform LDC Analyses for Oostanaula Creek Mile 28.4

TMDL Analysis	**2002 EPA-approved**	**Current Analysis (2005)**
Sample Dates	12/82 – 6/96	12/98 – 6/04
Number of Samples	51	32
Number > 1000 Counts/100 mL	28 (54.9%)	6 (18.8%)
90th Percentile (Counts/100 mL) (High Flows)	73,000	6,630
90th Percentile (Counts/100 mL) (Moist Conditions)	27,800	2,384
90th Percentile (Counts/100 mL) (Mid-Range Flows)	13,190	1,260
90th Percentile (Counts/100 mL) (Dry Conditions)	6,990	788
90th Percentile (Counts/100 mL) (Low Flows)	3,770	861
90th Percentile (Counts/100 mL) (All Data)	19,200	2,790
Required Reduction (%)	95.3	67.7

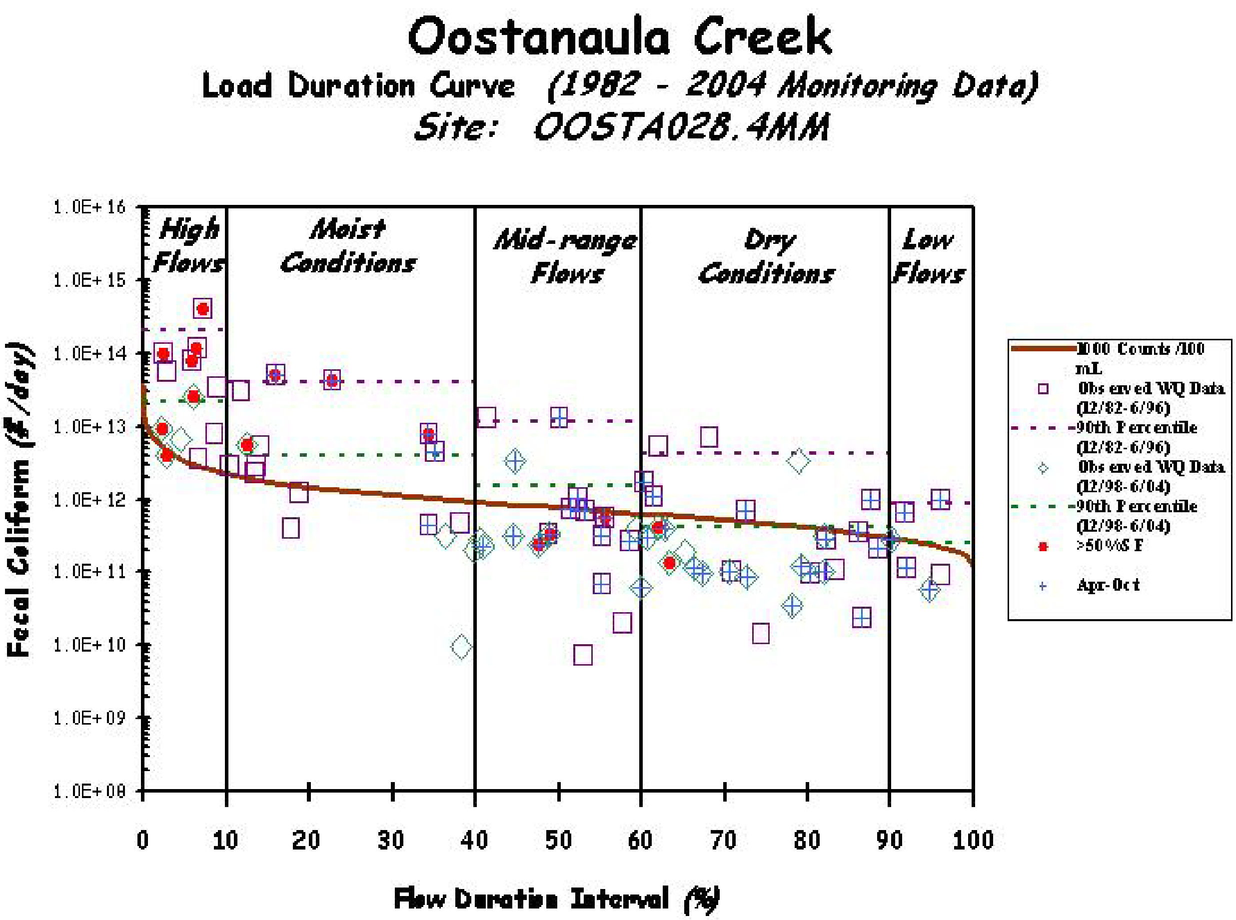


Figure E-1. Oostanaula Creek mile 28.4 historical versus recent fecal coliform monitoring data.

Table E-2. Required Load Reduction for Oostanaula Creek at Mile 28.4 – Fecal Coliform Analysis (2002 EPA Approved TMDL)

Sample Date	Flow	PDFE	Fecal Coliform	
			Sample Conc.	Required Load Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
12/16/82	209.68	2.451%	**19200**	**95.3**
3/7/89	189.10	2.837%	**12000**	**92.5**
12/4/91	124.70	5.861%	**26000**	**96.5**
3/10/87	116.77	6.496%	**40000**	**97.8**
3/8/83	115.80	6.558%	**1290**	**30.2**
12/9/86	109.30	7.205%	**150000**	**99.4**
12/13/83	98.05	8.512%	**3300**	**72.7**
3/31/93	95.35	8.935%	**14700**	**93.9**
12/12/94	88.31	10.391%	**1320**	**31.8**
3/15/90	81.57	11.685%	**15000**	**94.0**
3/13/95	75.12	13.365%	**1260**	**28.6**
3/18/96	74.26	13.564%	**1600**	**43.8**
3/12/91	73.12	13.925%	**3000**	**70.0**
6/10/92	67.04	15.966%	**31000**	**97.1**
12/11/95	62.98	17.820%	250	**NR**
3/14/94	61.21	18.728%	810	**NR**
6/9/92	54.68	22.598%	**31000**	**97.1**
6/12/95	42.35	34.246%	**7600**	**88.2**
6/7/83	42.24	34.370%	420	**NR**
6/7/89	41.53	35.042%	**4500**	**80.0**
12/9/92	39.19	38.166%	480	**NR**
3/13/84	36.86	41.339%	**14500**	**93.8**
3/12/85	31.84	48.706%	420	**NR**
6/10/96	31.08	50.062%	**17000**	**94.7**
9/13/94	30.40	51.319%	960	**NR**
6/20/94	29.81	52.389%	**1400**	**35.7**
3/15/88	29.54	52.875%	10	**NR**
6/13/90	29.33	53.161%	980	**NR**
6/12/84	28.29	55.189%	100	**NR**
6/11/91	28.25	55.251%	460	**NR**
9/13/88	28.13	55.587%	800	**NR**
12/12/90	27.09	57.554%	30	**NR**
9/15/92	26.50	58.673%	420	**NR**
9/18/95	25.77	60.341%	**2700**	**66.7**

Table E-2. Required Load Reduction for Oostanaula Creek at Mile 28.4 – Fecal Coliform Analysis (2002 EPA Approved TMDL) (Cont.)

Sample Date	Flow	PDFE	Fecal Coliform	
			Sample Conc.	Required Load Reduction
	[cfs]	[%]	[cts/100 ml]	[%]
6/9/87	25.28	61.399%	**1730**	**48.0**
12/11/84	25.05	61.996%	**8700**	**89.7**
12/6/93	22.47	67.745%	**12800**	**93.0**
12/13/88	21.06	70.707%	200	**NR**
6/23/93	20.27	72.349%	**1400**	**35.7**
3/11/86	19.45	74.340%	30	**NR**
9/11/84	16.73	80.276%	230	**NR**
6/7/88	15.92	82.068%	720	**NR**
12/10/85	15.42	83.263%	280	**NR**
9/10/91	14.12	86.100%	1000	**NR**
9/15/87	13.96	86.424%	70	**NR**
9/11/90	13.46	87.631%	**3000**	**70.0**
6/18/86	13.08	88.427%	670	**NR**
9/10/85	11.62	91.501%	**2300**	**60.9**
9/23/86	11.48	91.824%	400	**NR**
9/20/83	9.20	95.918%	**4400**	**79.5**
12/8/87	9.13	96.055%	400	**NR**
	90th Percentile (all)		**19200**	**95.3**

APPENDIX F

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 other appropriate measure.

For pathogen TMDLs in each impaired subwatershed, WLA terms include:

- $[\Sigma WLAs]_{WWTF}$ 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.

- $[\Sigma WLAs]_{CAFO}$ is the allowable load for all CAFOs in an impaired subwatershed. All wastewater discharges from a CAFO to waters of the state of Tennessee are prohibited, except when either chronic or catastrophic rainfall events cause an overflow of process wastewater from a facility properly designed, constructed, maintained, and operated to contain:
    - All process wastewater resulting from the operation of the CAFO (such as wash water, parlor water, watering system overflow, etc.); plus,
    - All runoff from a 25-year, 24-hour rainfall event for the existing CAFO or new dairy or cattle CAFOs; or all runoff from a 100-year, 24-hour rainfall event for a new swine or poultry CAFO.

    Therefore, a WLA of zero has been assigned to this class of facilities.

- $[\Sigma WLAs]_{MS4}$ is the required load reduction for discharges from MS4s. E. coli 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:

- $[\Sigma LAs]_{DS}$ is the allowable E. coli 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).

- $[\Sigma LAs]_{SW}$ represents the required reduction in E. coli 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 and Appendix E. TMDLs, WLAs, & LAs are applied to the entire subwatershed. WLAs & LAs for Hiwassee River waterbodies are summarized in Table F-1.

Table F-1. WLAs & LAs for Hiwassee River, Tennessee

Drainage Area and/or HUC-12 Subwatershed (03150101__)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs[a] (Monthly Avg.) E. Coli	Leaking Collection Systems[b]	CAFOs	MS4s[c]	Precipitation Induced Nonpoint Sources	Other Direct Sources[d]
			[% Red.]	[cts./day]	[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
Agency Creek (0605)	Agency Creek	TN06020002001 – 0100	**96.0**	**NA[e]**	**NA**	**NA**	**NA**	**96.0**	**0**
0602	Hiwassee River	TN06020002008 – 1000	**65.9**	**1.636×10^{11}**	**0**	**NA**	**NA**	**65.9**	**0**
0603	Fillauer Creek	TN06020002009 – 0200	**>92.4**	**NA[e]**	**0**	**NA**	**>85.7**	**>85.7**	**0**
	Woolen Mill Branch	TN06020002009 – 0300		**NA[e]**	**0**	**NA**	**>65.0**	**>65.0**	**0**
	South Mouse Creek	TN06020002009 – 2000		**9.542×10^{5}**	**0**	**NA**	**>92.4**	**>92.4**	**0**
Little Chatata Creek (0601)	Little Chatata Creek	TN06020002012 – 0200	**87.2**	**NA[e]**	**0**	**NA**	**87.2**	**87.2**	**0**
Chatata Creek (0601)	Chatata Creek	TN06020002012 – 1000	**92.7**	**NA[e]**	**0**	**NA**	**92.7**	**92.7**	**0**
Hawkins Branch (0305)	Hawkins Branch	TN06020002018 – 0100	**90.2**	**NA[e]**	**NA**	**NA**	**NA**	**90.2**	**0**
Dairy Branch (0305)	Dairy Branch	TN06020002018 – 0200	**92.9**	**NA[e]**	**NA**	**NA**	**NA**	**92.9**	**0**
0501	Little Chestuee Creek	TN06020002082 – 0200	**89.5**	**NA[e]**	**NA**	**NA**	**NA**	**89.5**	**0**
	Chestuee Creek	TN06020002082 – 2000		**1.193×10^{9}**	**0**	**NA**	**NA**	**87.9**	**0**
0702	Oostanaula Creek	TN06020002083 – 1000	**72.2**	**1.350×10^{10}**	**0**	**0**	**NA**	**17.8**	**0**
	Oostanaula Creek	TN06020002083 – 2000		**1.350×10^{10}**	**0**	**NA**	**38.4**	**38.4**	**0**
	Oostanaula Creek	TN06020002083 – 3000		**1.350×10^{10}**	**0**	**NA**	**72.2**	**72.2**	**0**
0701	Oostanaula Creek	TN06020002083 – 4000	**54.2**	**NA[e]**	**0**	**NA**	**54.2**	**54.2**	**0**
	Oostanaula Creek	TN06020002083 – 5000		**NA[e]**	**NA**	**NA**	**NA**	**54.2**	**0**

Table F-1. WLAs & LAs for Hiwassee River, Tennessee (Cont.)

HUC-12 Subwatershed (06020002__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs[a] (Monthly Avg.) E. Coli	Leaking Collection Systems[b]	CAFOs	MS4s[c]	Precipitation Induced Nonpoint Sources	Other Direct Sources[d]
			[% Red.]	[cts./day]	[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
0801	North Mouse Creek	TN06020002084 – 1000	**84.3**	**2.018×10^9**	**0**	**0**	**84.3**	**84.3**	**0**
0802	North Mouse Creek	TN06020002084 – 1000	**84.3**	**7.839×10^9**	**0**	**0**	**84.3**	**84.3**	**0**
0803	Spring Creek	TN06020002085 – 1000	**87.8**	**8.109×10^7**	**NA**	**NA**	**NA**	**87.8**	**0**
0604	Rogers Creek	TN06020002087 – 1000	**90.0**	**5.735×10^7**	**NA**	**NA**	**NA**	**90.0**	**0**
Price Creek (0605)	Price Creek	TN06020002088 – 1000	**81.9**	**5.247×10^9**	**0**	**NA**	**NA**	**81.9**	**0**

Note: NA = Not Applicable.

a. WLAs for WWTFs expressed as 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 E. coli.

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 E. coli.

e. Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permit.

APPENDIX G

Public Notice of Proposed Total Maximum Daily Load (TMDL) for Pathogens in the Hiwassee River Watershed (HUC 06020002)

DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR PATHOGENS IN THE HIWASSEE RIVER WATERSHED (HUC 06020002), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed total maximum daily load (TMDL) for pathogens in the Hiwassee River watershed, located in southeastern 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.

Twenty (20) waterbodies, listed on Tennessee's Final 2004 303(d) list as not supporting designated use classifications due, in part, to discharge of E. coli from municipal point sources, collection system failures, pasture grazing, and illicit connections to storm sewers, are addressed in the TMDL. 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 the Hiwassee River watershed, and a calibrated dynamic water quality model to establish allowable loadings of E. coli which will result in reduced in-stream concentrations and attainment of water quality standards. The TMDL requires reductions on the order of 54% - 96% for the impaired waterbodies.

The proposed Hiwassee River pathogen TMDL document 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 December 26, 2005 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.