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.

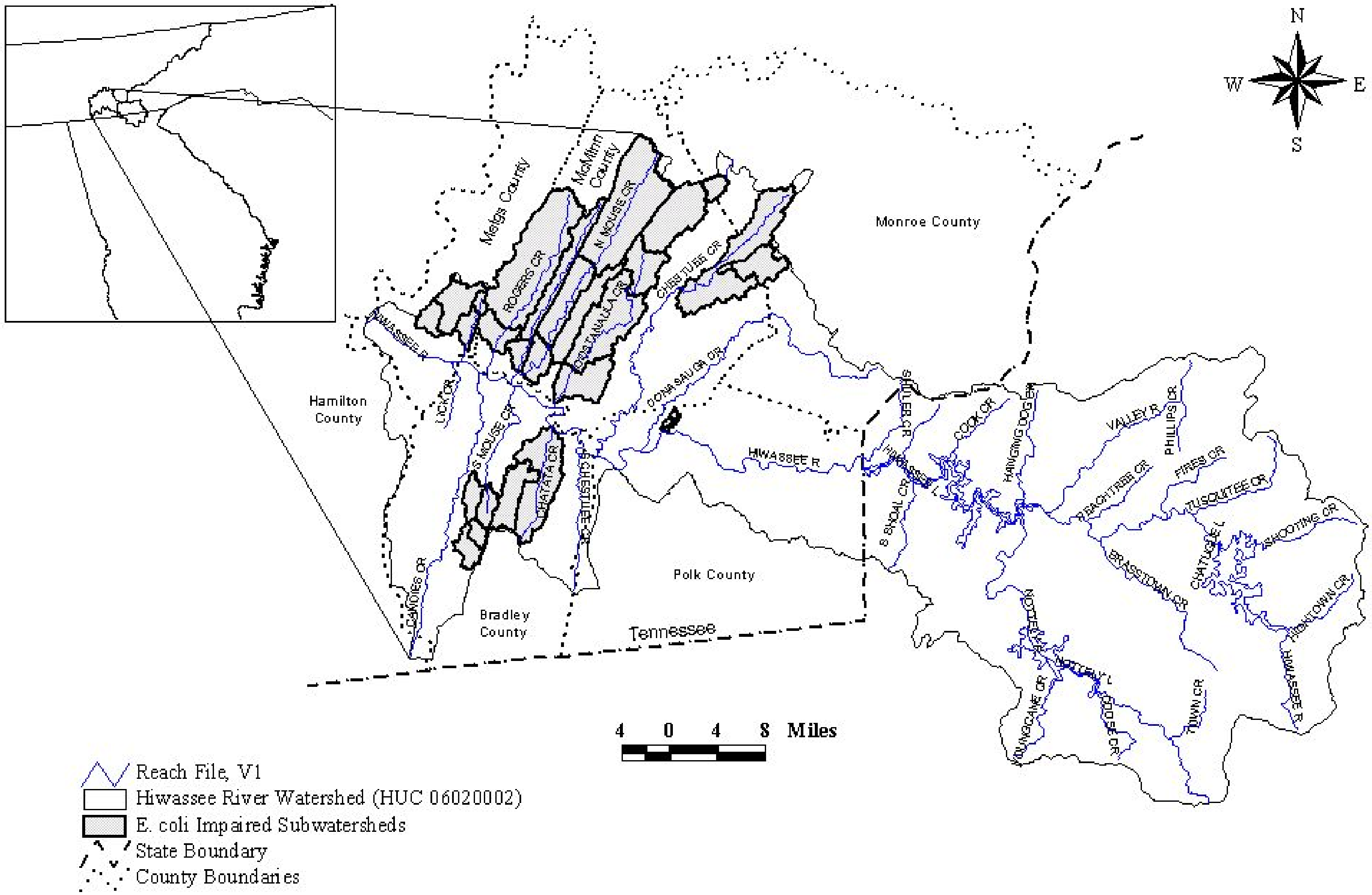

Figure 1. Location of the Hiwassee River Watershed and E. coli Impaired Subwatersheds.

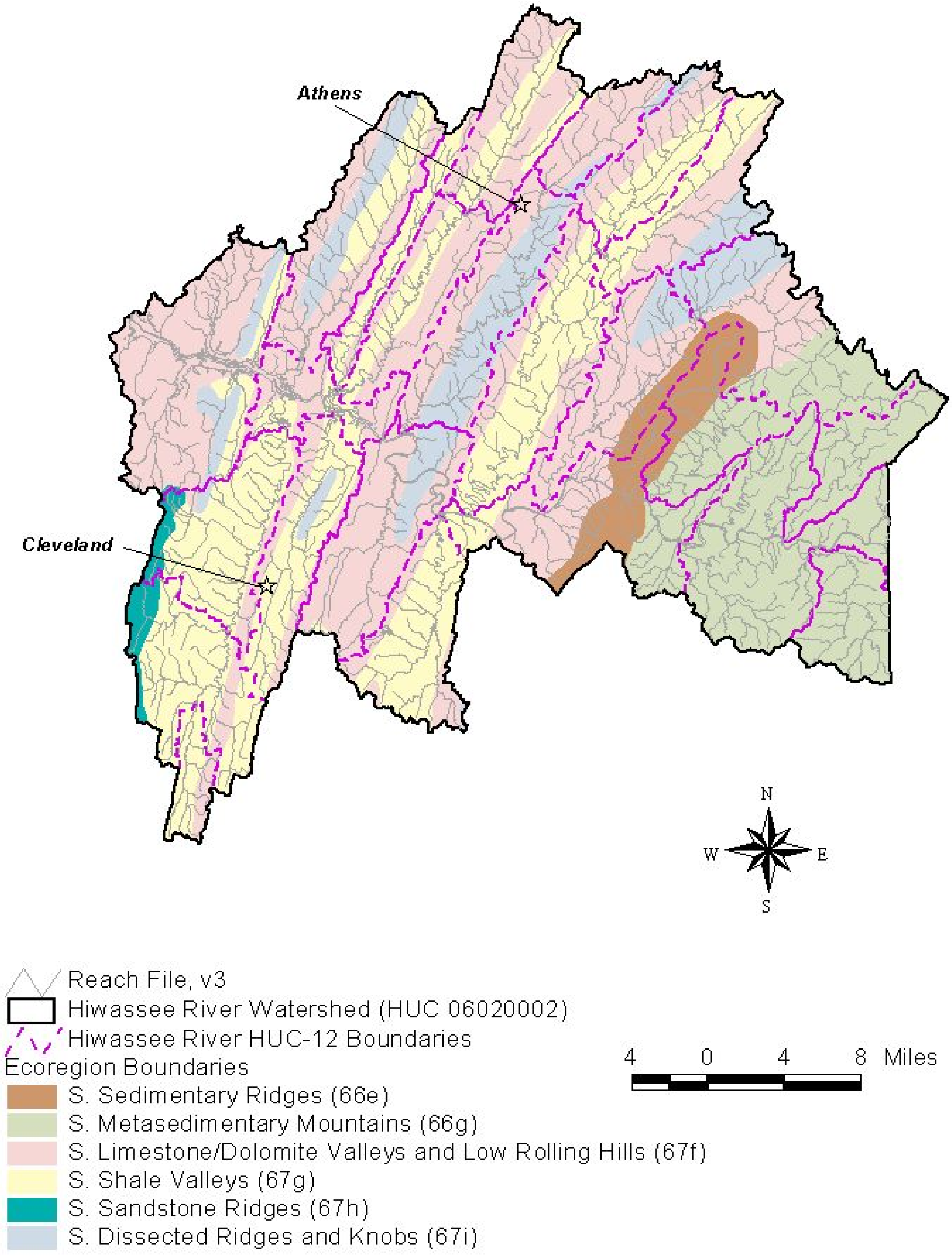

Figure 2. Level IV Ecoregions in the Hiwassee River Watershed

- 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.

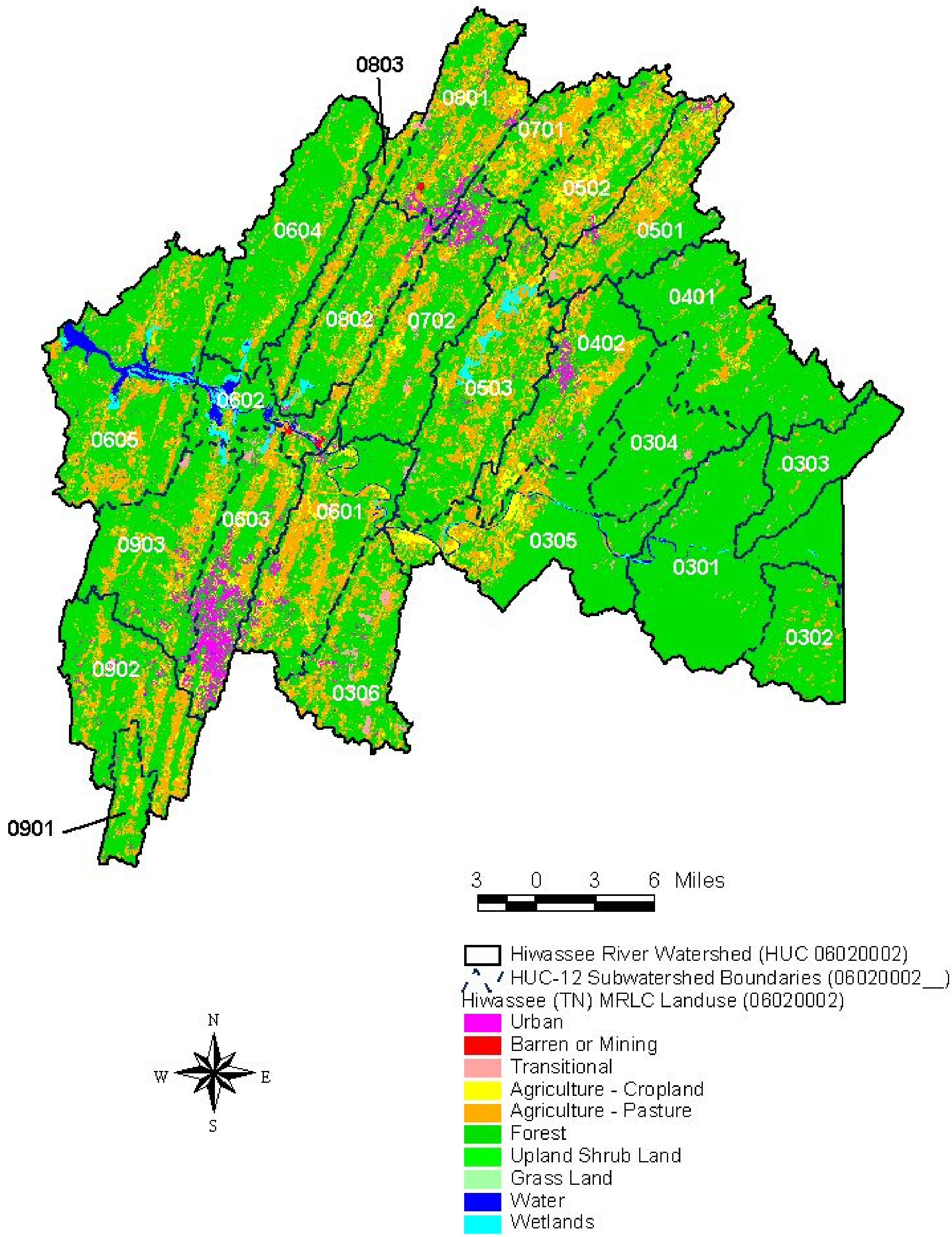

Figure 3. Land Use Characteristics of the Hiwassee River Watershed

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.

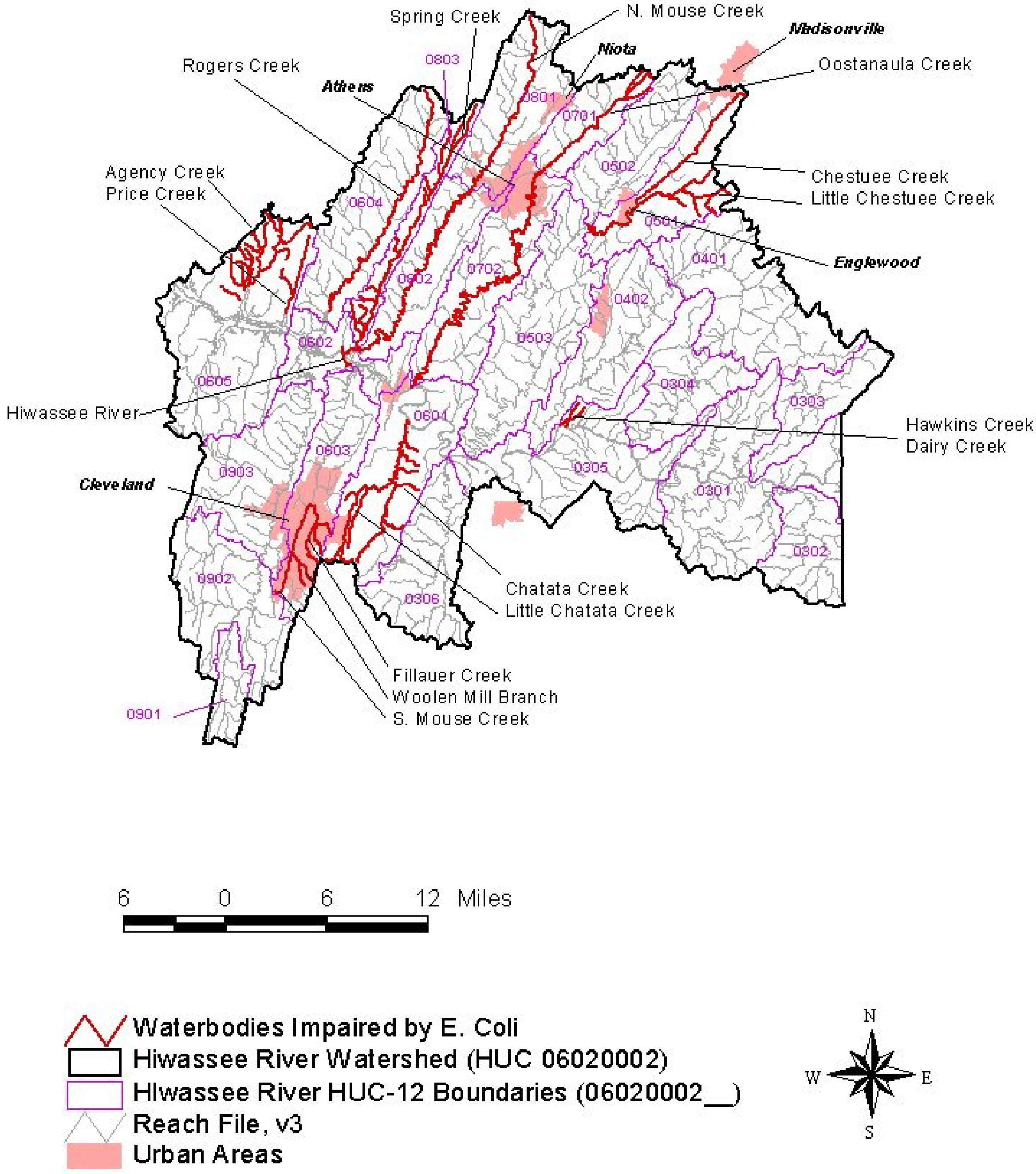

Figure 4. Waterbodies Impaired by E. Coli (as Documented on the Final 2004 303(d) List)

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.

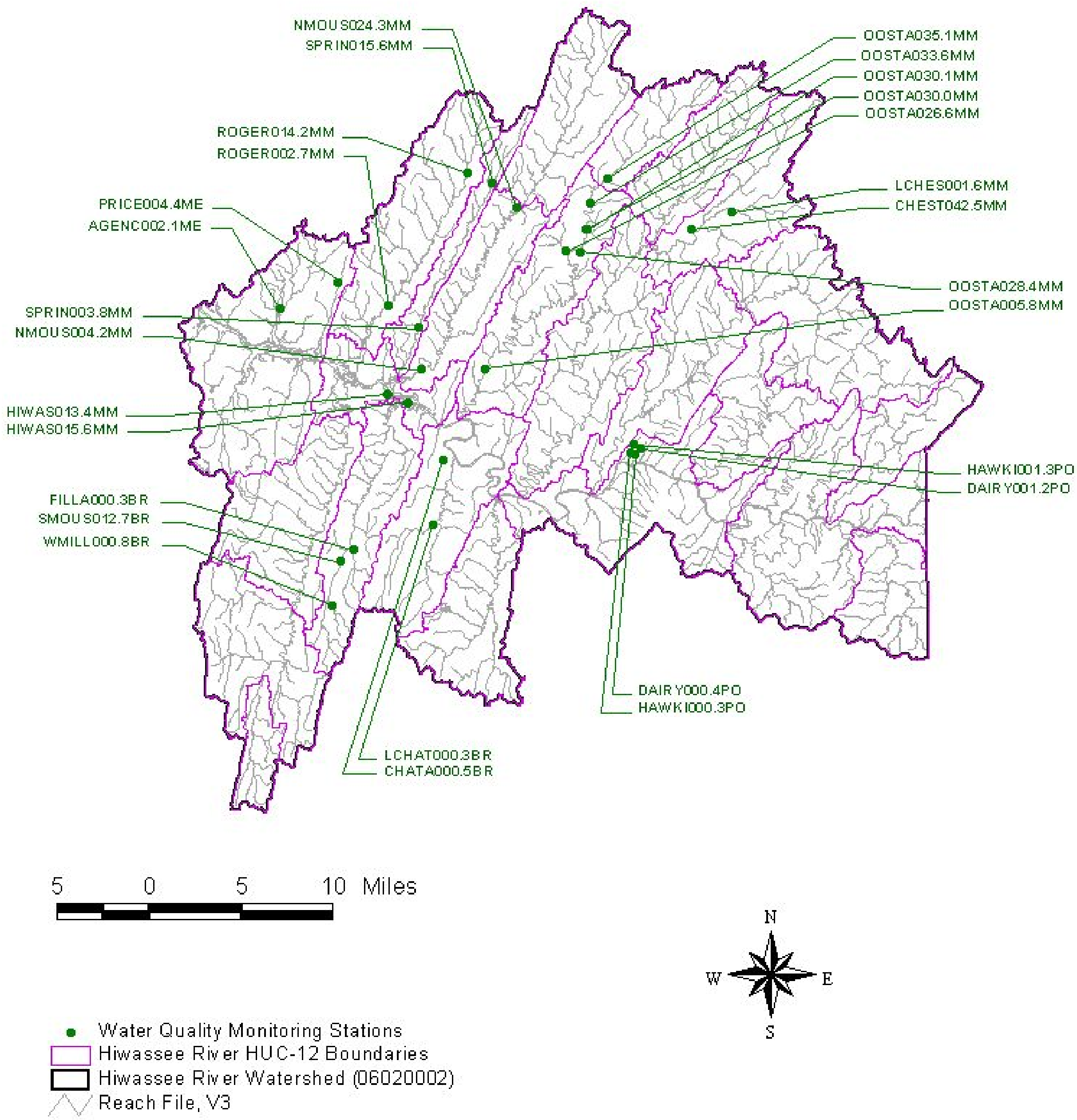

Figure 5. Water Quality Monitoring Stations in the Hiwassee River Watershed

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] Min.	Avg.	Max.	Exceed Max WQ Crit.	Data Pts.	Date Range	[Counts/100 mL] Min.	Avg.	Max.	Exceed Max. WQ Crit.
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*

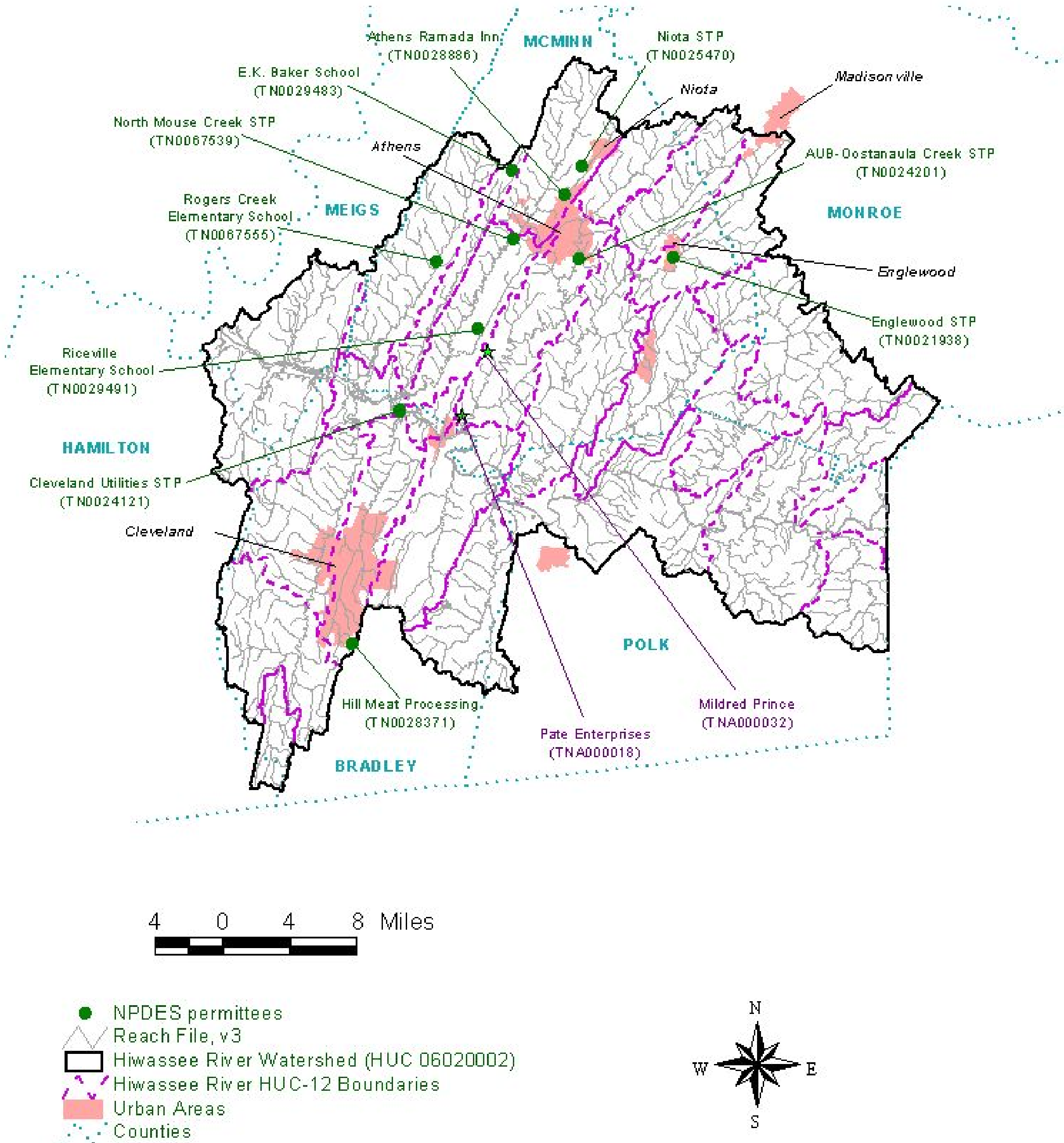

Figure 6. NPDES Regulated Point Sources in the Hiwassee River Watershed

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

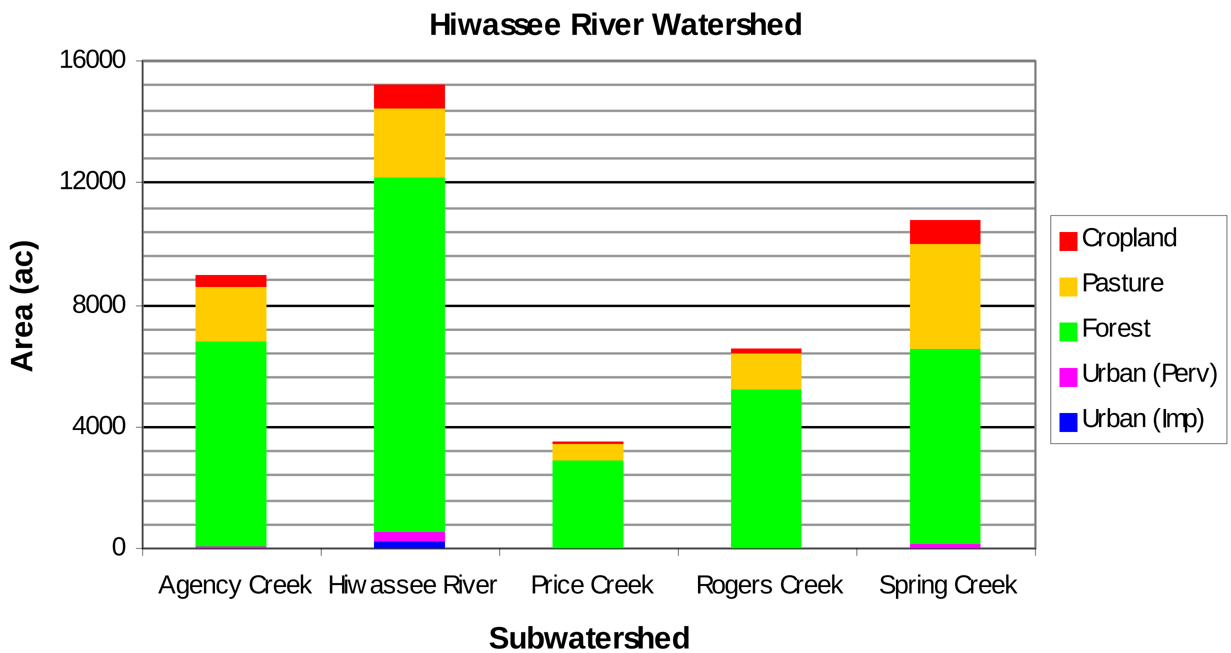

Figure 7. **Land Use Area of the Agency Creek, Hiwassee River, Price Creek, Rogers Creek, and Spring Creek Subwatersheds, Hiwassee River Watershed.**

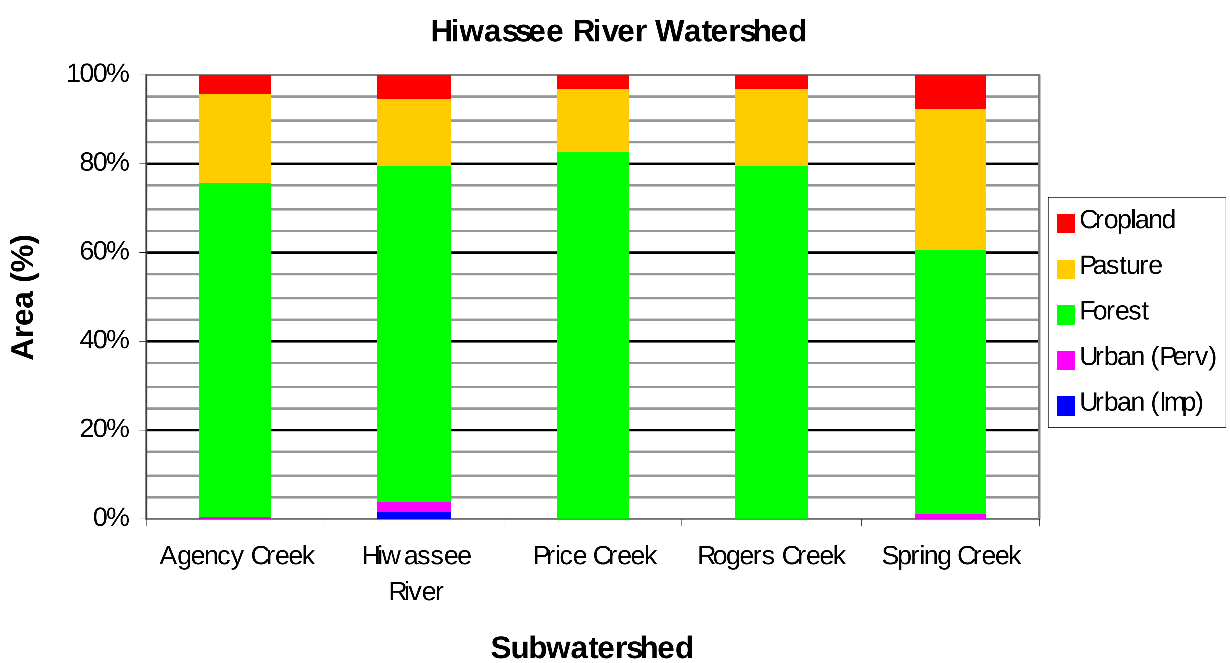

Figure 8. **Land Use Percent of the Agency Creek, Hiwassee River, Price Creek, Rogers Creek, and Spring Creek Subwatersheds, Hiwassee River Watershed.**

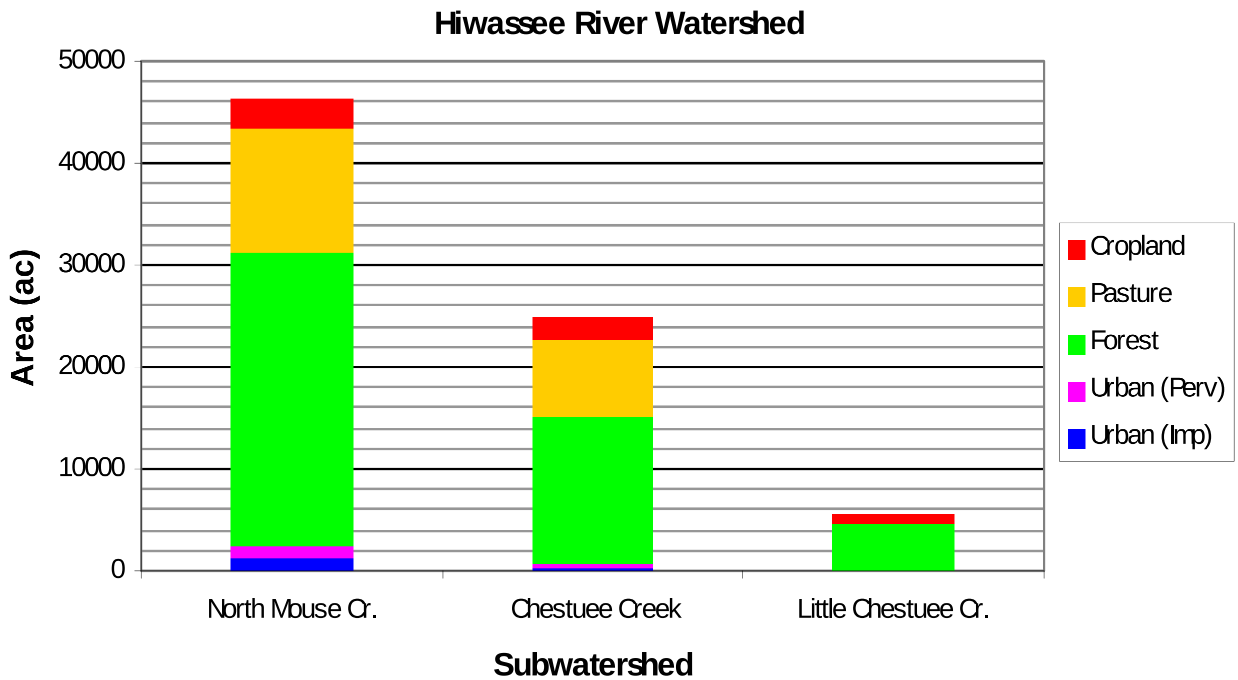

Figure 9. Land Use Area of the North Mouse Creek, Chestuee Creek, and Little Chestuee Creek Subwatersheds, Hiwassee River Watershed.

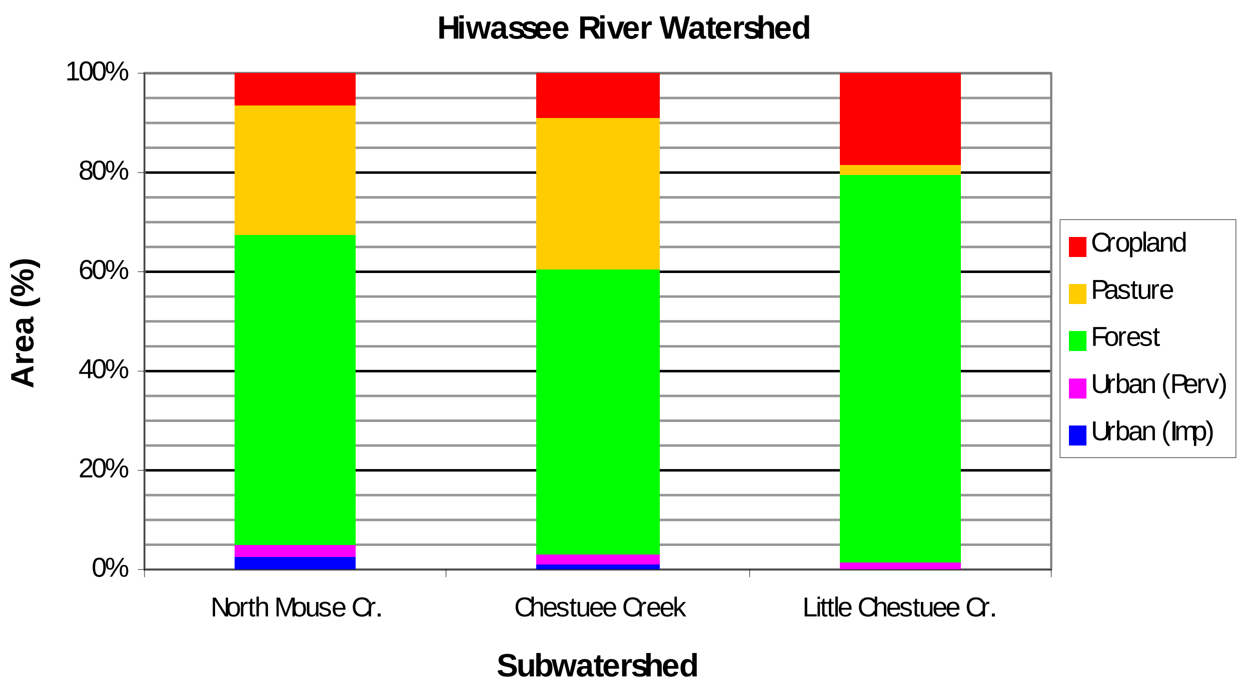

Figure 10. Land Use Percent of the North Mouse Creek, Chestuee Creek, and Little Chestuee Creek Subwatersheds, Hiwassee River Watershed.

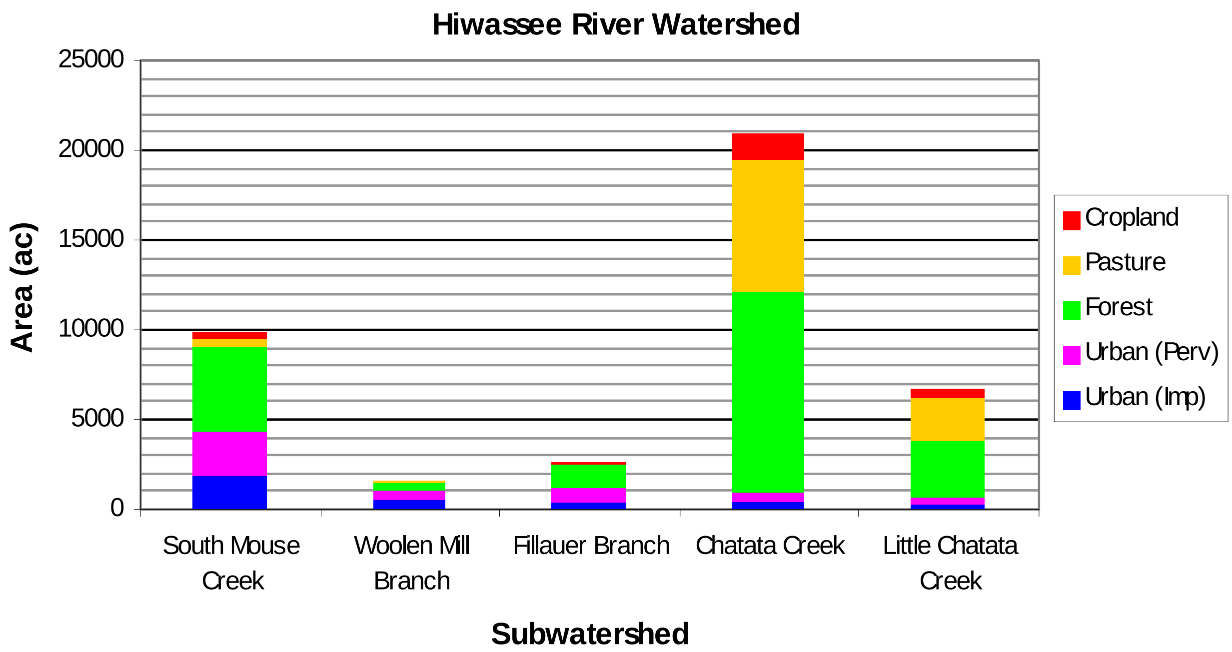

Figure 11. Land Use Area of the South Mouse Creek, Woolen Mill Branch, Fillauer Branch, Chatata Creek, and Little Chatata Creek Subwatersheds, Hiwassee River Watershed.

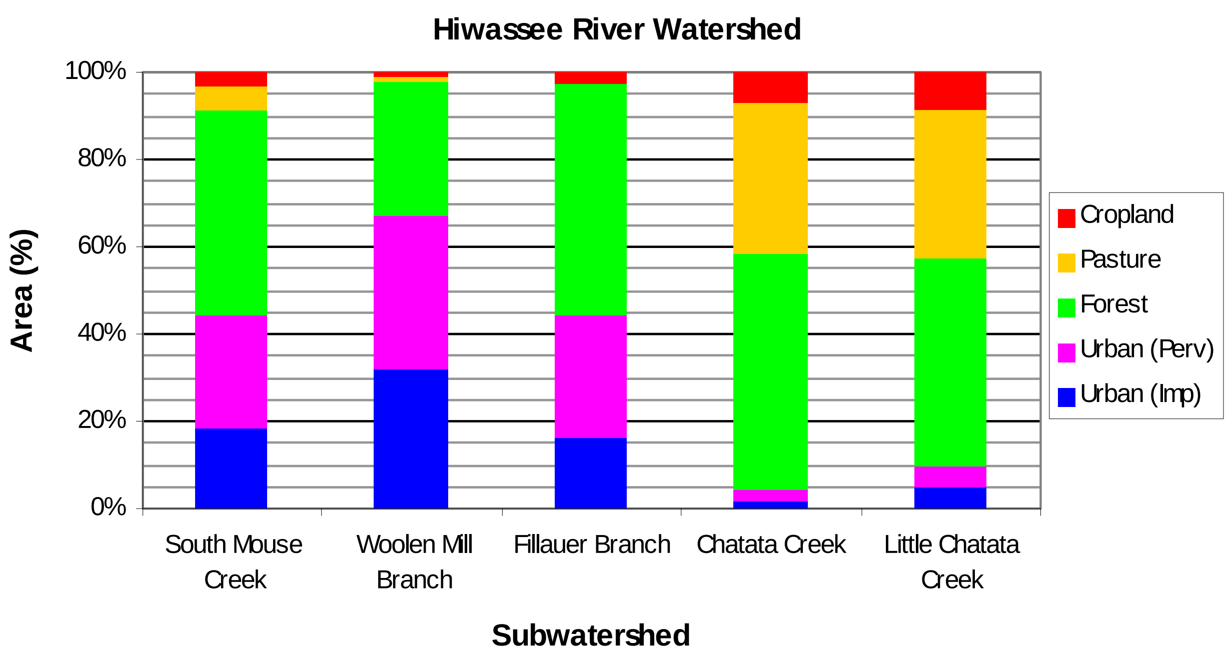

Figure 12. Land Use Percent of the South Mouse Creek, Woolen Mill Branch, Fillauer Branch, Chatata Creek, and Little Chatata Creek Subwatersheds, Hiwassee River Watershed.

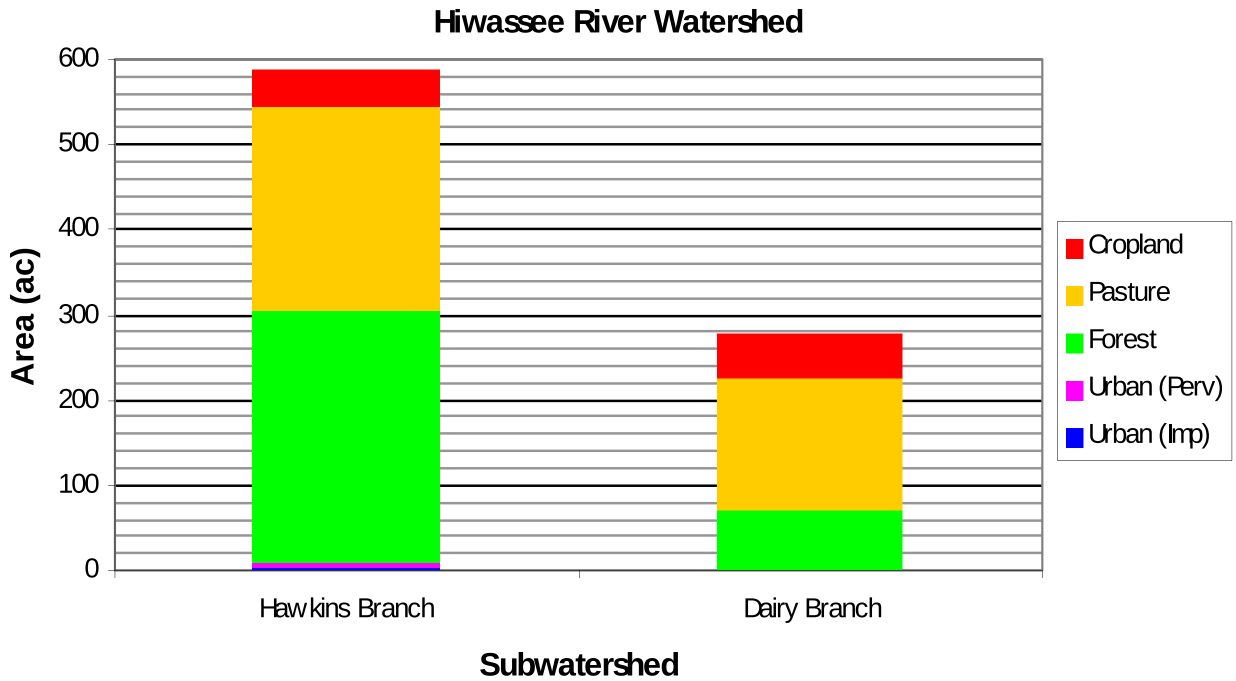

Figure 13. **Land Use Area of the Hawkins Branch and Dairy Branch Subwatersheds, Hiwassee River Watershed.**

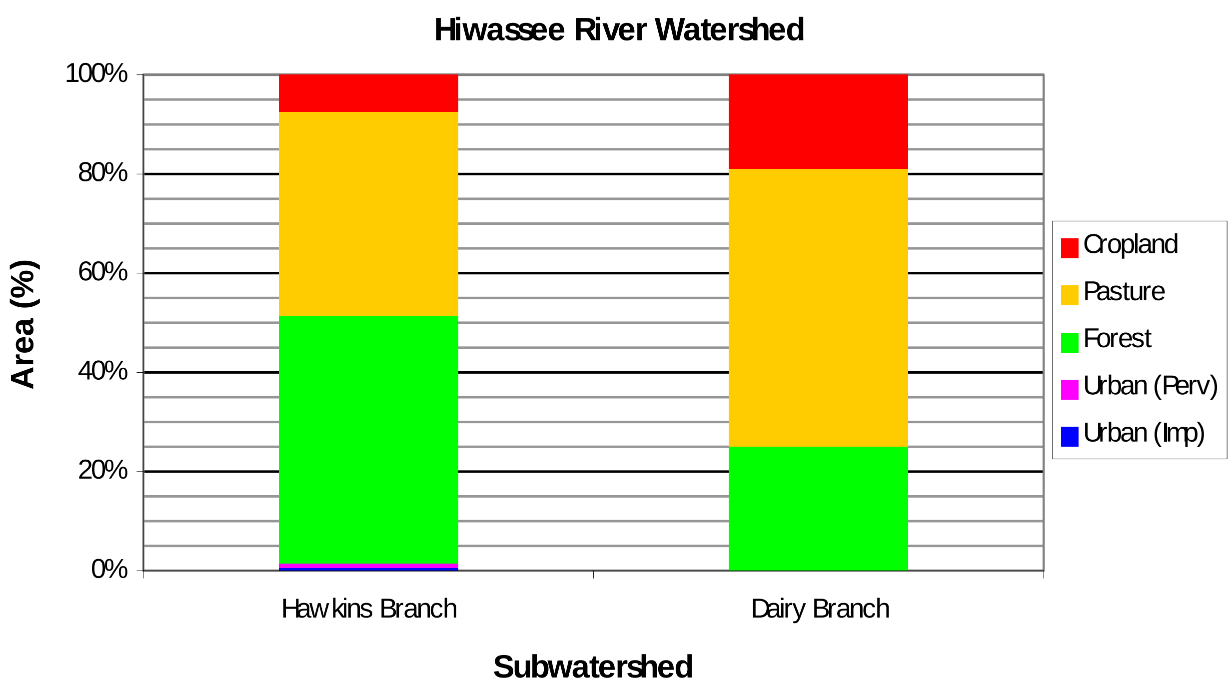

Figure 14. **Land Use Percent of the Hawkins Branch and Dairy Branch Subwatersheds, Hiwassee River Watershed.**

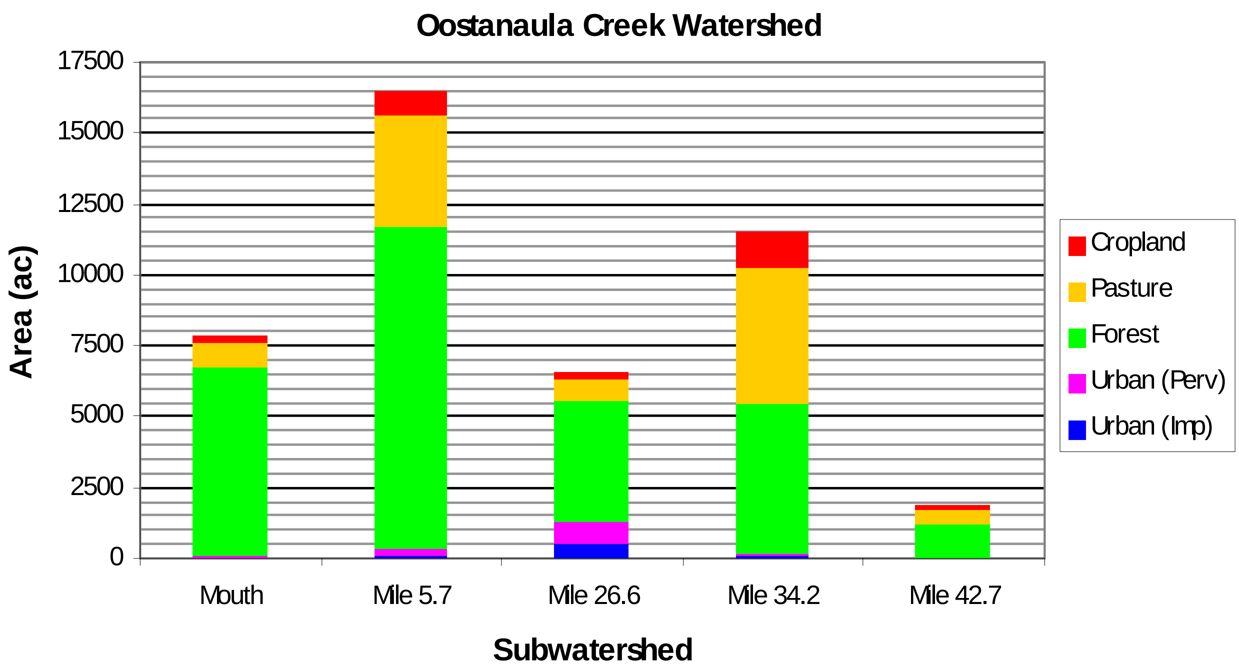

Figure 15. Land Use Area of the Oostanaula Creek Subwatersheds, Hiwassee River Watershed.

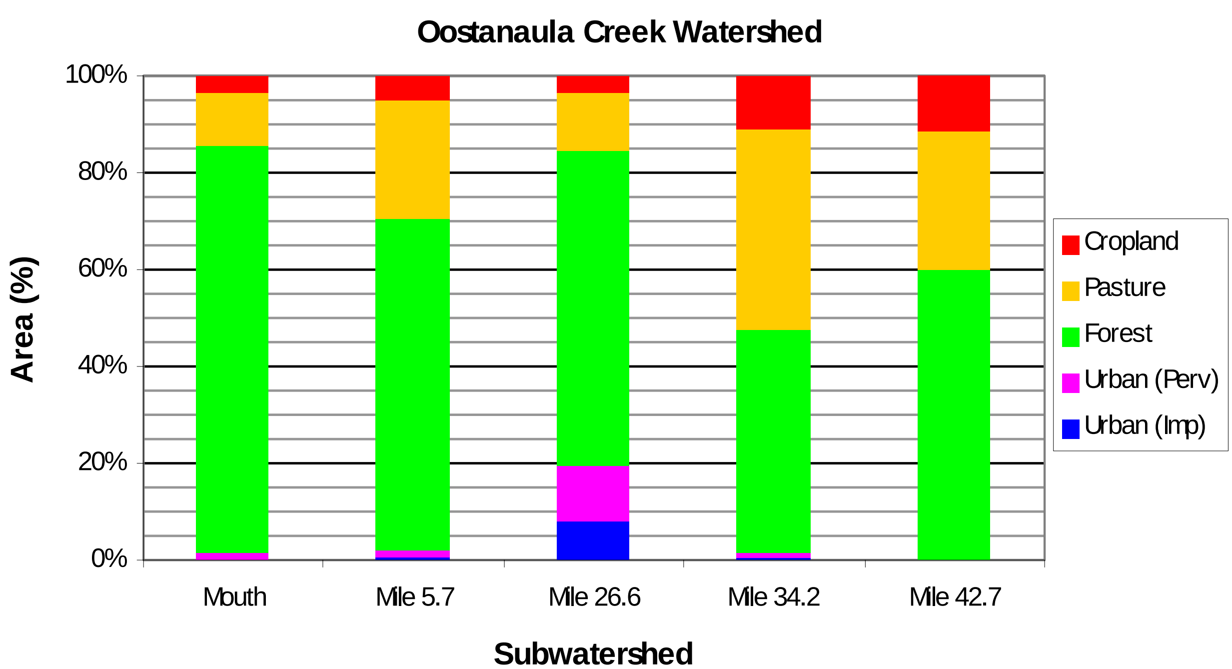

Figure 16. Land Use Percent of the Oostanaula Creek Subwatersheds, Hiwassee River Watershed.

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 90^{th} 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 x 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 x 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 x 10^{9}**	**0**	**NA**	**NA**	**87.9**	**0**
0702	Oostanaula Creek	TN06020002083 – 1000	**72.2**	**1.350 x 10^{10}**	**0**	**0**	**NA**	**17.8**	**0**
	Oostanaula Creek	TN06020002083 – 2000		**1.350 x 10^{10}**	**0**	**NA**	**28.6**	**28.6**	**0**
	Oostanaula Creek	TN06020002083 – 3000		**1.350 x 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.

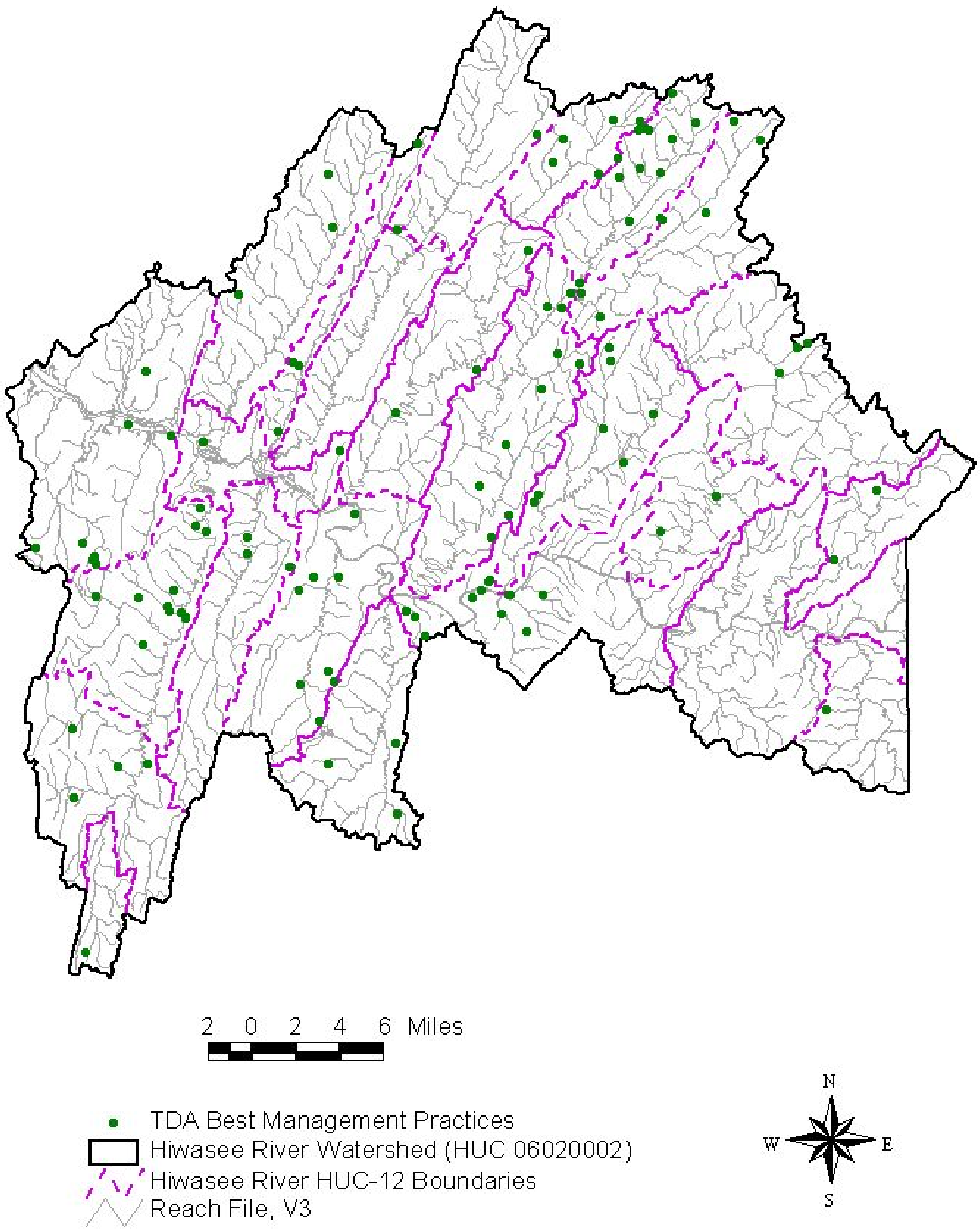

Figure 17. Tennessee Department of Agriculture Best Management Practices located in the Hiwassee River Watershed

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.

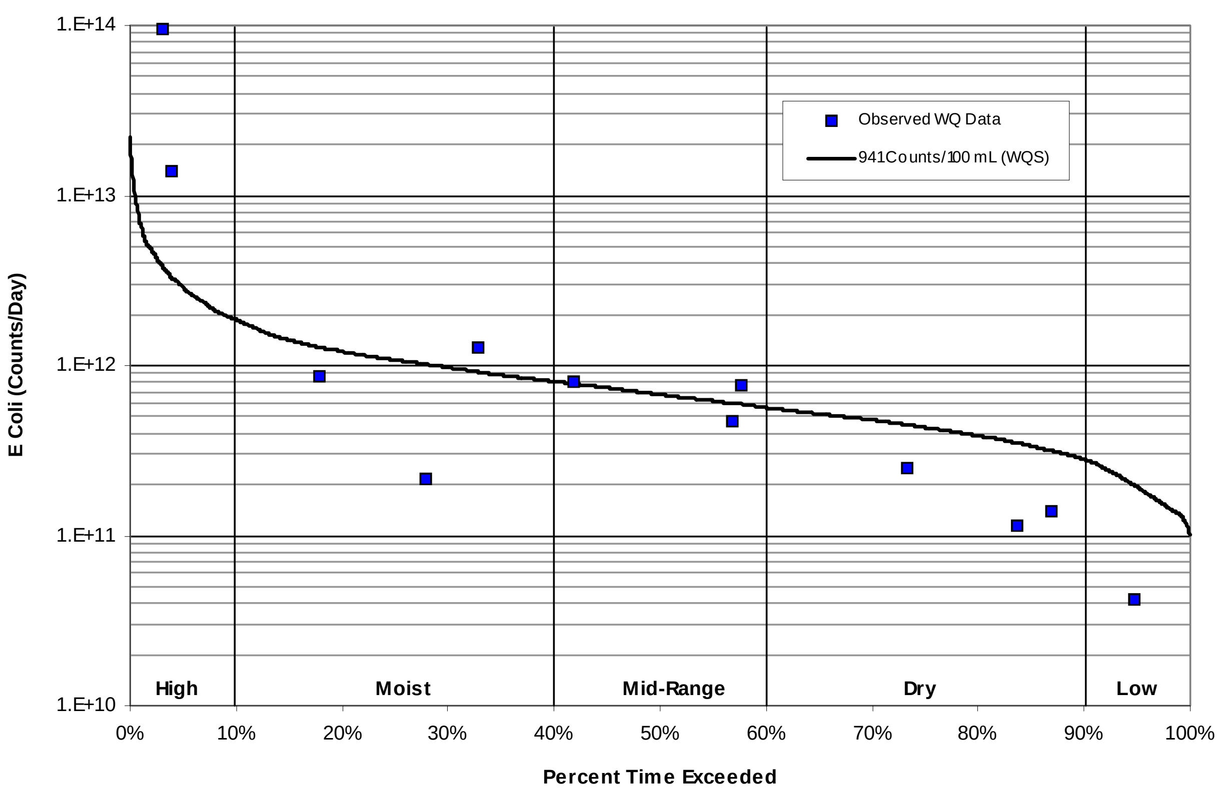

Figure 18. Load Duration Curve for Implementation Planning.

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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