TOTAL MAXIMUM DAILY LOAD (TMDL)

for

E. Coli

in the

Little Tennessee River Watershed (HUC 06010204)

Blount, Loudon, and Monroe Counties, Tennessee

FINAL

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Submitted March 23, 2006
Approved by EPA Region 4 – April 10, 2006

V.17.3.2.2.3.1

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ADB	Assessment Database
AFO	Animal Feeding Operation
BMP	Best Management Practices
BST	Bacteria Source Tracking
CAFO	Concentrated Animal Feeding Operation
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CFU	Colony Forming Units
DEM	Digital Elevation Model
DWPC	Division of Water Pollution Control
E. coli	Escherichia coli
EPA	Environmental Protection Agency
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
NHD	National Hydrography Dataset
NMP	Nutrient Management Plan
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
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
TWRA	Tennessee Wildlife Resources Agency
USGS	United States Geological Survey
UCF	Unit Conversion Factor
WCS	Watershed Characterization System
WLA	Waste Load Allocation
WWTF	Wastewater Treatment Facility

SUMMARY SHEET

Total Maximum Daily Load for E. coli in Little Tennessee River Watershed (HUC 06010204)

Impaired Waterbody Information

State: Tennessee
Counties: Blount, Loudon, and Monroe
Watershed: Little Tennessee River (HUC 06010204)
Constituents of Concern: E. coli

Impaired Waterbodies Addressed in This Document:

Waterbody ID	Waterbody	Miles Impaired
TN06010204002 – 1000	FORK CREEK	19.3
TN06010204004 – 1000	BAT CREEK	19.1
TN06010204042 - 1000	NINEMILE CREEK	17.1
TN06010204043 – 1000	BAKER CREEK	39.9
TN06010204045 - 1000	NOTCHY CREEK	11.2

Designated Uses:

The designated use classifications for waterbodies in the Little Tennessee River Watershed include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation.

Water Quality Targets:

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. In addition, the concentration of the E. coli group in any individual sample taken from a lake, reservoir, State Scenic River, or Tier II or III stream (1200-4-3-.06) shall not exceed 487 colony forming units per 100 mL. The concentration of the E. coli group in any individual sample taken from any other waterbody shall not exceed 941 colony forming units per 100 mL.

TMDL Scope:

Waterbodies identified on the Final 2004 303(d) list as impaired due to E. coli. TMDLs were developed for impaired waterbodies on a HUC-12 subwatershed or waterbody drainage area basis.

Analysis/Methodology:

The TMDLs for impaired waterbodies in the Little Tennessee River Watershed were developed using a load duration curve methodology to assure compliance with the E. Coli 126 CFU/100 mL geometric mean and the 487 CFU/100 mL maximum water quality criteria for Tier II waterbodies and 941 CFU/100 mL maximum water quality criteria for non-Tier II waterbodies. 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 region of the waterbody flow regime represented by these existing loads. Load duration curves were used to determine the load reductions required to meet desired maximum concentrations for E. coli. When sufficient data were available, load reductions were also determined based on geometric mean criteria.

Critical Conditions:

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

Seasonal Variation:

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

Margin of Safety (MOS):

Explicit MOS = 10% of the E. coli water quality criteria for each impaired subwatershed or drainage area.

Summary of TMDLs, WLAs, & LAs for Impaired Waterbodies

HUC-12 Subwatershed (06010204__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs [a]		CAFOs	MS4s [d]	Precipitation Induced Nonpoint Sources	Other Direct Sources [e]
				Monthly Avg.	Daily Max.				
			[% Red.]	[CFU/day]	[CFU/day]	[CFU/day]	[% Red.]	[% Red.]	[CFU/day]
0205	Ninemile Creek	TN06010204042 – 1000	40.7	8.107×10^{7}	6.055×10^{8}	0	46.8	46.8	0
0409	Notchy Creek	TN06010204045 – 1000	82.5	NA	NA	NA	NA	84.3	0
0502	Baker Creek	TN06010204043 - 1000	86.1	8.584×10^{7} [c]	6.411×10^{8} [c]	NA	87.6	87.6	0
0504	Bat Creek	TN06010204004 – 1000	>91.7	4.101×10^{9} [b]	3.063×10^{10} [b]	NA	>92.6	>92.6	0
0505	Fork Creek	TN06010204002 – 1000	>93.7	NA	NA	0	NA	>94.4	0

Notes: NA = Not Applicable.

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

b. The WLA listed is for the subwatershed and is equal to the sum of the WLAs for the individual facilities. WLAs for individual WWTFs corresponds to existing E. coli permit limits at facility design flow.

c. The WLAs listed apply to NPDES permitted discharges from WWTFs only. Pathogen loading due to collection system failure is considered to be unpermitted point source loading from the municipal WWTF. With respect to pathogen loading from leaking collection systems, a WLA of zero is assigned. It is recognized, however, that a WLA of 0 CFU/day may not be practical. For these unpermitted sources, the WLA is interpreted to mean a reduction in pathogen 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.

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

e. 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 CFU/day may not be practical. For these sources, the LA is interpreted to mean a reduction in pathogen 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.

PROPOSED E. COLI TOTAL MAXIMUM DAILY LOAD (TMDL) LITTLE TENNESSEE RIVER WATERSHED (HUC 06010204)

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

3.0 WATERSHED DESCRIPTION

The Little Tennessee River Watershed (HUC 06010204) is located in Eastern Tennessee (Figure 1), primarily in Blount and Monroe Counties. The Little Tennessee River Watershed lies within two Level III ecoregions (Blue Ridge Mountains, Ridge and Valley) and contains seven Level IV ecoregions as shown in Figure 2 (USEPA, 1997):

- **The Southern Sedimentary Ridges (66e)** in Tennessee include some of the westernmost foothill areas of the Blue Ridges Mountains ecoregion, such as the Bean, Starr, Chilhowee, English, Stone, Bald, and Iron Mountain areas. Slopes are steep, and elevations are generally 1000-4500 feet. The rocks are primarily Cambrian-age sedimentary (shale, sandstone, siltstone, quartzite, conglomerate), although some lower stream reachs occur on limestone. Soils are predominantly friable loams and fine sandy loams with variable amounts of sandstone rock fragments, and support mostly mixed oak and oak-pine forests.

- **Limestone Valleys and Coves (66f)** are small but distinct lowland areas of the Blue Ridge, with elevations mostly between 1500 and 2500 feet. About 450 million years ago, older Blue Ridge rocks to the east were forced up and over younger rocks to the west. In places, the Precambrian rocks have eroded through to Cambrian or

Ordovician-age limestones, as seen especially in isolated, deep cove areas that are surrounded by steep mountains. The main areas of limestone include the Mountain City lowland area and Shady Valley in the north; and Wear Cove, Tuckaleechee Cove, and Cades Cove of the Great Smoky Mountains in the south. Hay and pasture, with some tobacco patches on small farms, are typical land uses.

- **The Southern Metasedimentary Mountains (66g)** are steep, dissected, biologically-diverse mountains that include Clingmans Dome (6643 feet), the highest point in Tennessee. The Precambrian-age metamorphic and sedimentary geologic materials are generally older and more metamorphosed than the Southern Sedimentary Ridges (66e) to the west and north. The Appalachian oak forests and, at higher elevations, the northern hardwoods forests include a variety of oaks and pines, as well as silverbell, hemlock, yellow poplar, basswood, buckeye, yellow birch, and beech. Spruce-fir forests, found generally above 5500 feet, have been affected greatly over the past twenty-five years by the balsam woolly aphid. The Copper Basin, in the southeast corner of Tennessee, was the site of copper mining and smelting from the 1850's to 1987, and once left more than fifty square miles of eroded earth.

- **The Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f)** form a heterogeneous region composed predominantly of limestone and cherty dolomite. Landforms are mostly low rolling ridges and valleys, and the solids vary in their productivity. Landcover includes intensive agriculture, urban and industrial, or areas of thick forest. White oak forests, bottomland oak forests, and sycamore-ash-elm riparian forests are the common forest types, and grassland barrens intermixed with cedar-pine glades also occur here.

- **The Southern Shale Valleys (67g)** consist of lowlands, rolling valleys, and slopes and hilly areas that are dominated by shale materials. The northern areas are associated with Ordovician-age calcareous shale, and the well-drained soils are often slightly acid to neutral. In the south, the shale valleys are associated with Cambrian-age shales that contain some narrow bands of limestone, but the soils tend to be strongly acid. Small farms and rural residences subdivide the land. The steeper slopes are used for pasture or have reverted to brush and forested land, while small fields of hay, corn , tobacco, and garden crops are grown on the foot slopes and bottomland.

- **The Southern Sandstone Ridges (67h)** ecoregion encompasses the major sandstone ridges, but these ridges also have areas of shale and siltstone. The steep, forested chemistry of streams flowing down the ridges can vary greatly depending on the geologic material. The higher elevation ridges are in the north, including Wallen Ridge, Powell Mountain, Clinch Mountain, and Bays Mountain. White Oak Mountain in the south has some sandstone on the west side, but abundant shale and limestone as well. Grindstone Mountain, capped by the Gizzard Group sandstone, is the only remnant of Pennsylvanian-age strata in the Ridge and Valley of Tennessee.

- **The Southern Dissected Ridges and Knobs (67i)** contain more crenulated, broken, or hummocky ridges, compared to smoother, more sharply pointed sandstone ridges. Although shale is common, there is a mixture and interbedding of geologic materials. The ridges on the east side of Tennessee's Ridge and Valley tend to be associated with the Ordovician-age Sevier shale, Athens shale, and Holston and Lenoir limestones. These can include calcareous shale, limestone, siltstone, sandstone, and conglomerate. In the central and western part of the ecoregion, the shale ridges are associated with the Cambrian-age Rome Formation: shale and siltstone with beds of sandstone. Chestnut oak forests and pine forests are typical for the higher elevations of the ridges, with areas of white oak, mixed mesophytic forest, and tulip poplar on the lower slopes, knobs, and draws.

The Little Tennessee River Watershed, located in Blount, Loudon, and Monroe Counties, Tennessee, has a drainage area of approximately 781 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 Little Tennessee River Watershed have occurred since 1993 as a result of development, this is the most current land use data available. Land use for the Little Tennessee River Watershed is summarized in Table 1 and shown in Figure 3. Predominant land use in the Little Tennessee River Watershed is forest (79%) followed by pasture (13%). Urban areas represent less than 1% of the total drainage area of the watershed. Details of land use distribution of impaired subwatersheds in the Little Tennessee River Watershed are presented in Appendix A.

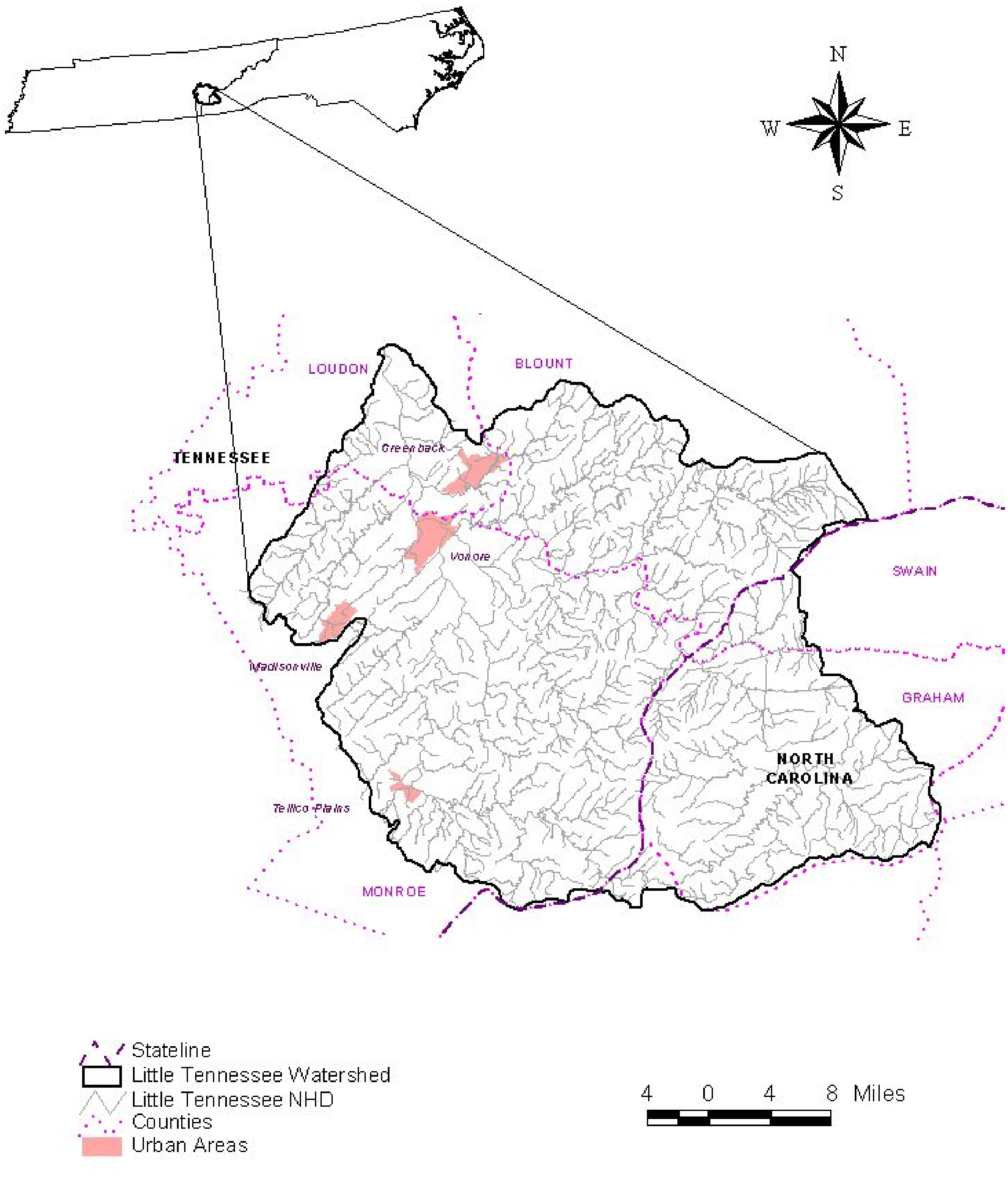

Figure 1. Location of the Little Tennessee River Watershed.

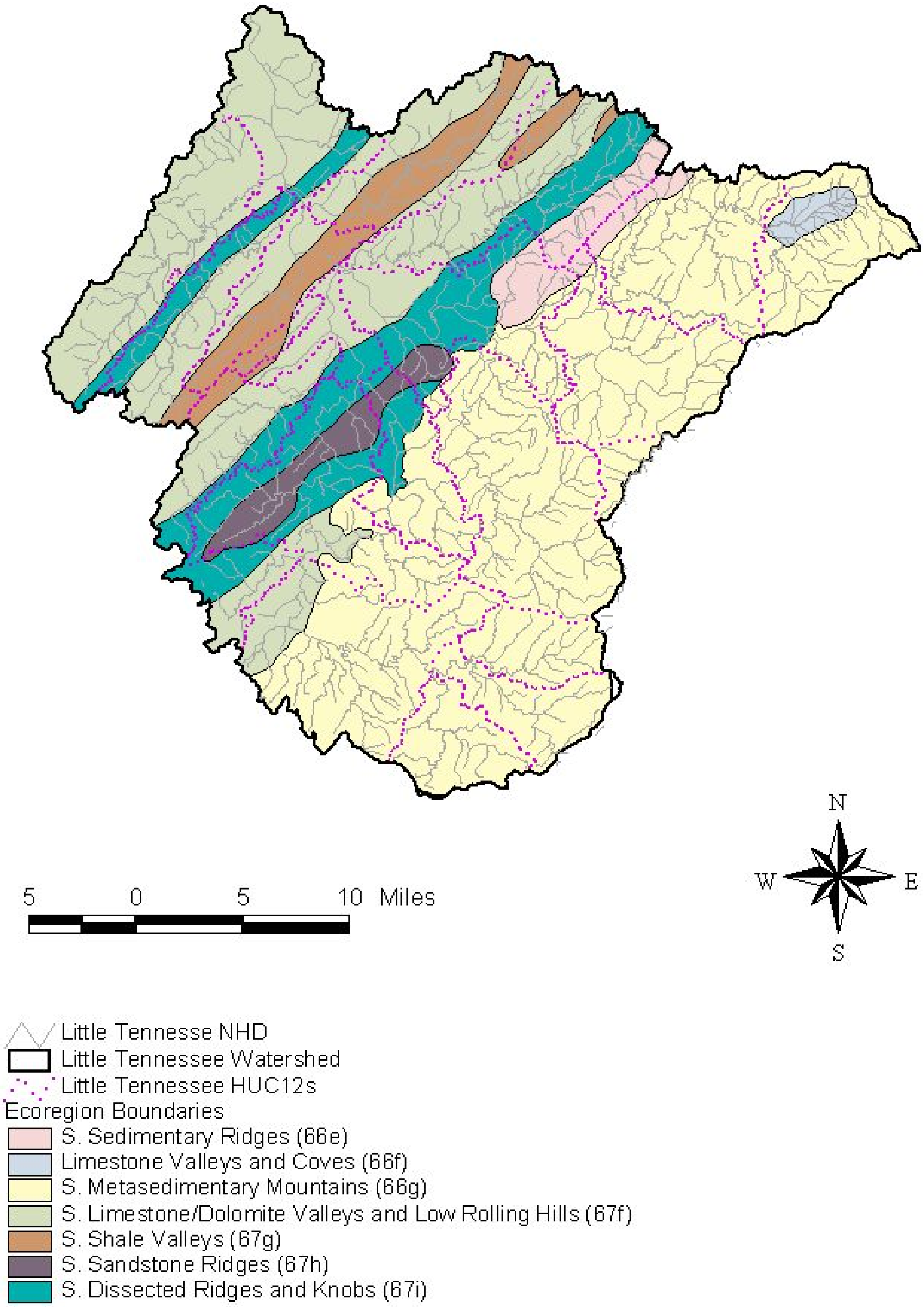

Figure 2. Level IV Ecoregions in the Little Tennessee River Watershed.

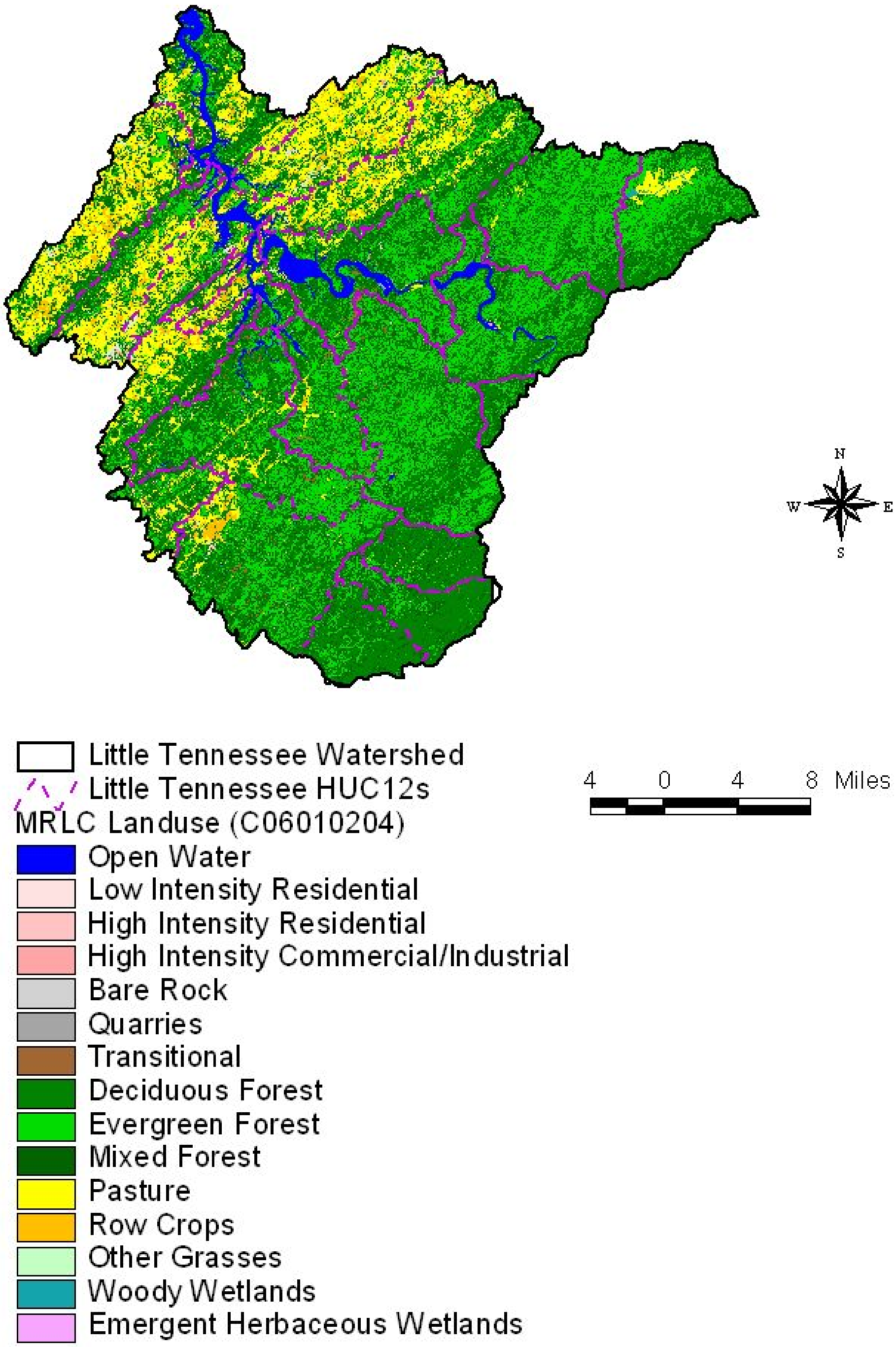

Figure 3. Land Use Characteristics of the Little Tennessee River Watershed.

Table 1. MRLC Land Use Distribution – Little Tennessee River Watershed

Land Use	Area	
	[acres]	[%]
Bare Rock/Sand/Clay	4	0.0
Deciduous Forest	150,805	30.2
Emergent Herbaceous Wetlands	26	0.0
Evergreen Forest	136,228	27.3
High Intensity Commercial/Industrial/ Transportation	1,235	0.3
High Intensity Residential	107	0.0
Low Intensity Residential	1,914	0.4
Mixed Forest	107,254	21.5
Open Water	16,047	3.2
Other Grasses (Urban/recreational)	1,134	0.2
Pasture/Hay	64,772	13.0
Quarries/Strip Mines/ Gravel Pits	0	0.0
Row Crops	17,366	3.5
Transitional	2,383	0.5
Woody Wetlands	270	0.1
Total	**499,545**	**100.0**

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. This list identified portions of five waterbodies in the Little Tennessee River Watershed as not supporting designated use classifications due, in part, to E. coli (see Table 2 & Figure 4). The designated use classifications for these waterbodies include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation.

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.

5.0 WATER QUALITY CRITERIA & TMDL TARGET

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

The portion of Ninemile Creek within the Kyker Bottoms Wildlife Refuge has been designated as a Tier II stream. As of February 2, 2006, none of the other E. coli impaired waterbodies in the Little Tennessee River Watershed have been classified as either Tier II or Tier III streams.

The geometric mean standard for the E. coli group of 126 colony forming units per 100 ml (CFU/100 ml) and the sample maximum of 487 CFU/100 ml have been selected as the appropriate numerical targets for TMDL development for impaired waterbodies classified as Tier II streams. The geometric mean standard for the E. coli group of 126 colony forming units per 100 ml (CFU/100 ml) and the sample maximum of 941 CFU/100 ml have been selected as the appropriate numerical targets for TMDL development for the other impaired waterbodies.

Table 2 Final 2004 303(d) List for E. coli Impaired Waterbodies – Little Tennessee River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN06010204002 – 1000	FORK CREEK	19.3	Nitrates Siltation Escherichia coli	Pasture Grazing
TN06010204004 – 1000	BAT CREEK	19.1	Escherichia coli	Minor Municipal Point Source Pasture Grazing
TN06010204042 – 1000	NINEMILE CREEK	17.1	Escherichia coli	Pasture Grazing
TN06010204043 – 1000	BAKER CREEK	39.9	Escherichia coli	Pasture Grazing
TN06010204045 – 1000	NOTCHY CREEK	11.2	Escherichia coli	Pasture Grazing

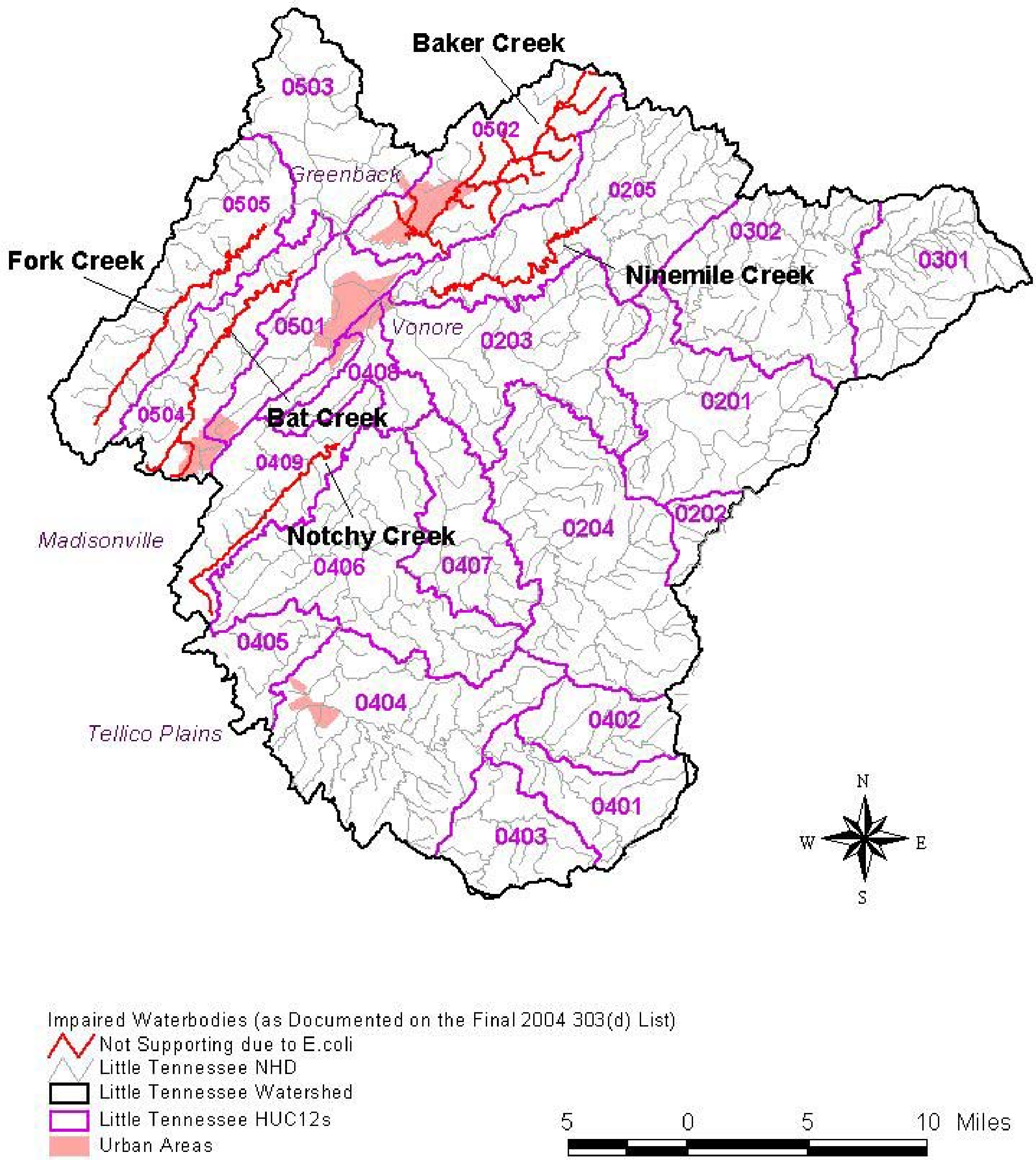

Figure 4. Waterbodies Impaired by E. Coli (as Documented on the Final 2004 303(d) List).

6.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

There are several water quality monitoring stations that provide data for waterbodies identified as impaired for E. coli in the Little Tennessee River Watershed:

- Fork Creek Subwatershed:
  - FORK004.6MO – Fork Creek, at Harrison Rd.
  - FORK006.5MO – Fork Creek, at Eve Mills Rd.
  - FORK014.8MO – Fork Creek, in vicinity of Hwy 322 bridge
- Bat Creek Subwatershed:
  - BAT008.1MO – Bat Creek, at Wright Rd.
  - BAT019.3MO – Bat Creek, at Hiwassee College Rd. bridge
- Ninemile Creek Subwatershed:
  - CENTE000.3BT – Centenary Creek, at Indian Warpath Rd.
  - LNINE000.5BT – Little Ninemile Creek, at Chota Rd.
  - NINEM004.8BT – Ninemile Creek, at Trigonia Rd.
- Baker Creek Subwatershed:
  - BAKER008.9LO – Baker Creek, at Hwy 95
  - BAKER017.5BT – Baker Creek, in vicinity of Springview Rd.
- Notchy Creek Subwatershed:
  - NOTCH002.5MO – Notchy Creek, at Griffith Branch Rd.

The location of these monitoring stations is shown in Figure 5. Water quality monitoring results for these stations are tabulated in Appendix C. Examination of the data shows exceedances of the 487 CFU/100 mL (Tier II) and 941 CFU/100 mL (non-Tier II) maximum E. coli standard at many monitoring stations. Water quality monitoring results for those stations with 10% or more of samples exceeding water quality maximum criteria are summarized in Table 3.

There were not enough data to calculate the geometric mean at each monitoring station. Whenever a minimum of 5 samples was collected at a given monitoring station over a period of not more than 30 consecutive days, the geometric mean was calculated.

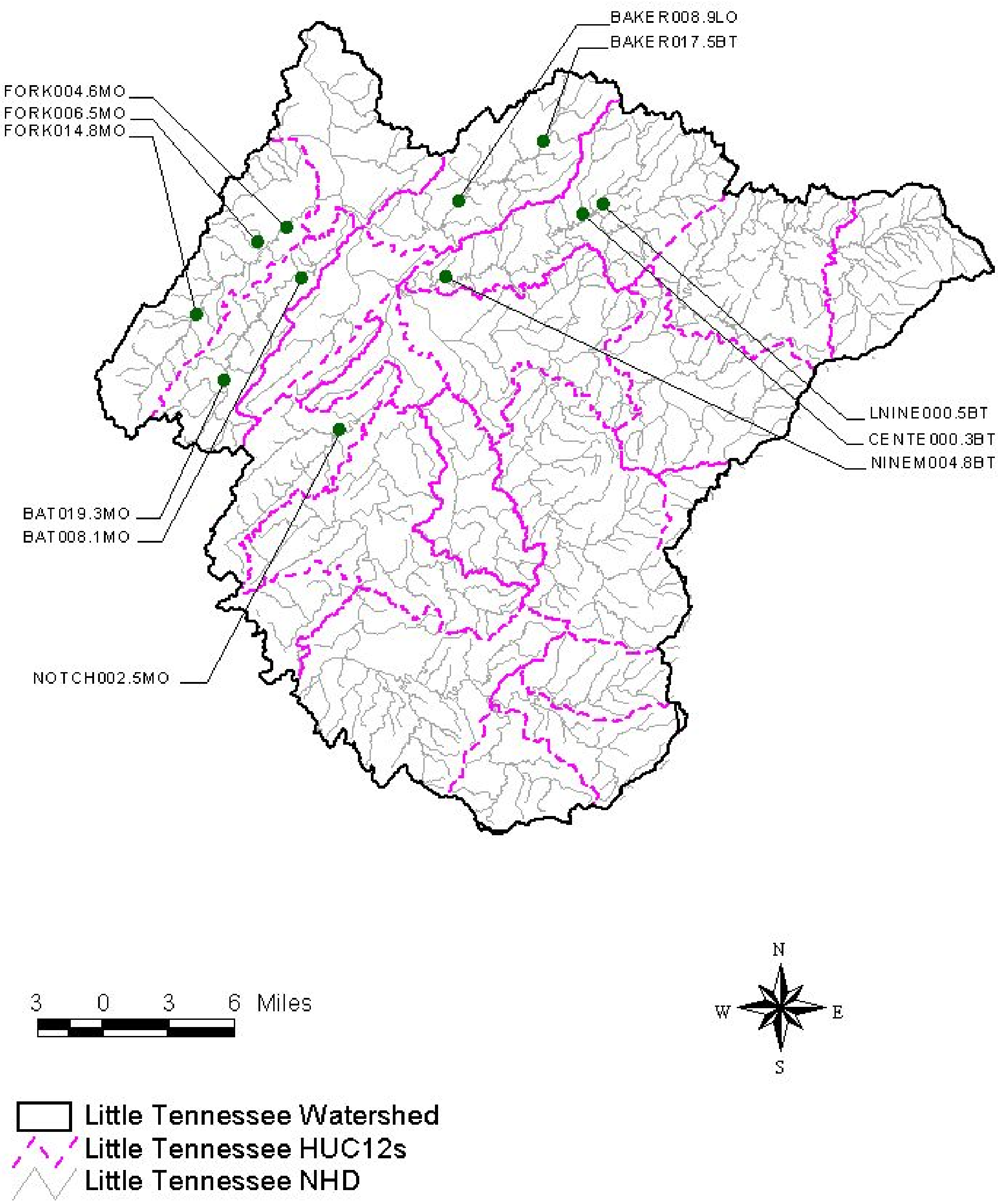

Figure 5. Water Quality Monitoring Stations in the Little Tennessee River Watershed

Table 3 Summary of TDEC Water Quality Monitoring Data

Monitoring Station	Date Range	E. Coli (Max WQ Target = 941 Counts/100 mL)**				
		Data Pts.	Min. [CFU/100 ml]	Avg. [CFU/100 ml]	Max. [CFU/100 ml]	No. Exceed. WQ Max. Target
FORK006.5MO	2003	10	1,120	1,792	>2,419	10
FORK014.8MO	2003	10	194	614	>2,419	2
BAT008.1MO	1999 – 2003	15	260	954	>2,419	4
BAT019.3MO	2003	10	649	1,428	>2,419	8
BAKER008.9LO	1999 – 2003	15	154	573	>2,419	2
BAKER017.5BT	2003	10	517	768	1,300	1
NINEM004.8BT	1999 – 2003	15	79	217	548	1
NOTCH002.5MO	1999 – 2003	15	365	958	>2,419	5

** Maximum water quality target is 487 CFU/100 mL for Tier II waterbodies and 941 CFU/100 mL for other waterbodies.

7.0 SOURCE ASSESSMENT

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

Under the Clean Water Act, sources are classified as either point or nonpoint sources. Under 40 CFR §122.2, a point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. The National Pollutant Discharge Elimination System (NPDES) program regulates point source discharges. Point sources can be described by three broad categories: 1) NPDES regulated municipal and industrial wastewater treatment facilities (WWTFs); 2) NPDES regulated industrial and municipal storm water discharges; and 3) NPDES regulated Concentrated Animal Feeding Operations (CAFOs). A TMDL must provide Waste Load Allocations (WLAs) for all NPDES regulated point sources. Nonpoint sources are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. For the purposes of this TMDL, all sources of pollutant loading not regulated by NPDES permits are considered nonpoint sources. The TMDL must provide a Load Allocation (LA) for these sources.

7.1 Point Sources

7.1.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

Both treated and untreated sanitary wastewater contain coliform bacteria. There are 8 WWTFs in the Little Tennessee River Watershed that have NPDES permits authorizing the discharge of treated sanitary wastewater. Four of these facilities are located in impaired subwatersheds or drainage areas (see Table 4 & Figure 6). The permit limits for discharges from these WWTFs are in accordance with the coliform criteria specified in Tennessee Water Quality Standards for the protection of the recreation use classification.

Note: As stated in Section 5.0, the current coliform criteria are expressed in terms of E. coli concentration, whereas previous criteria were expressed in terms of fecal coliform and E. coli concentration. Due to differences in permit issuance dates, some permits still have fecal coliform limits instead of E. coli. As permits are reissued, limits for fecal coliform will be replaced by E. coli limits.

Table 4 NPDES Permitted WWTFs in Impaired Subwatersheds or Drainage Areas

NPDES Permit No.	Facility	Design Flow [MGD]	Receiving Stream
TN0062243	Greenback School	0.018	Unnamed tributary to Baker Creek at RM 5.9
TN0062391	Lanier Elementary School	0.017	Ninemile Creek at RM 13.9
TN0025020	Madisonville STP	0.8	Bat Creek at RM 19.3
TN0054909	Hiwassee College STP	0.06	Bat Creek at RM 16.4

* Long term average flow is used for industrial facilities.

Effluent monitoring data, submitted on Discharge Monitoring Reports (DMRs) for the period from November 2003 to November 2005, were examined for facilities that are located in HUC-12 subwatersheds containing waterbodies impaired for pathogens. During this period, the Madisonville STP experienced no exceedances of the coliform criteria of their permit. However, according to a Compliance Evaluation Inspection conducted in September 2005, review of DMRs for the Madisonville STP shows that average effluent flow at the STP was consistently reported at more than 80 percent of the design capacity. The effluent flow values, combined with continued plant violations (in areas other than bacteria levels), suggest that the Madisonville STP needs a treatment plant upgrade. The Town of Madisonville has hired a consulting engineer to address these issues.

DMRs are not required for “package plants” such as those in operation at the Hiwassee College STP and Greenback and Lanier Elementary Schools. Monthly Operation Reports (MORs) are submitted to the local Environmental Field Office.

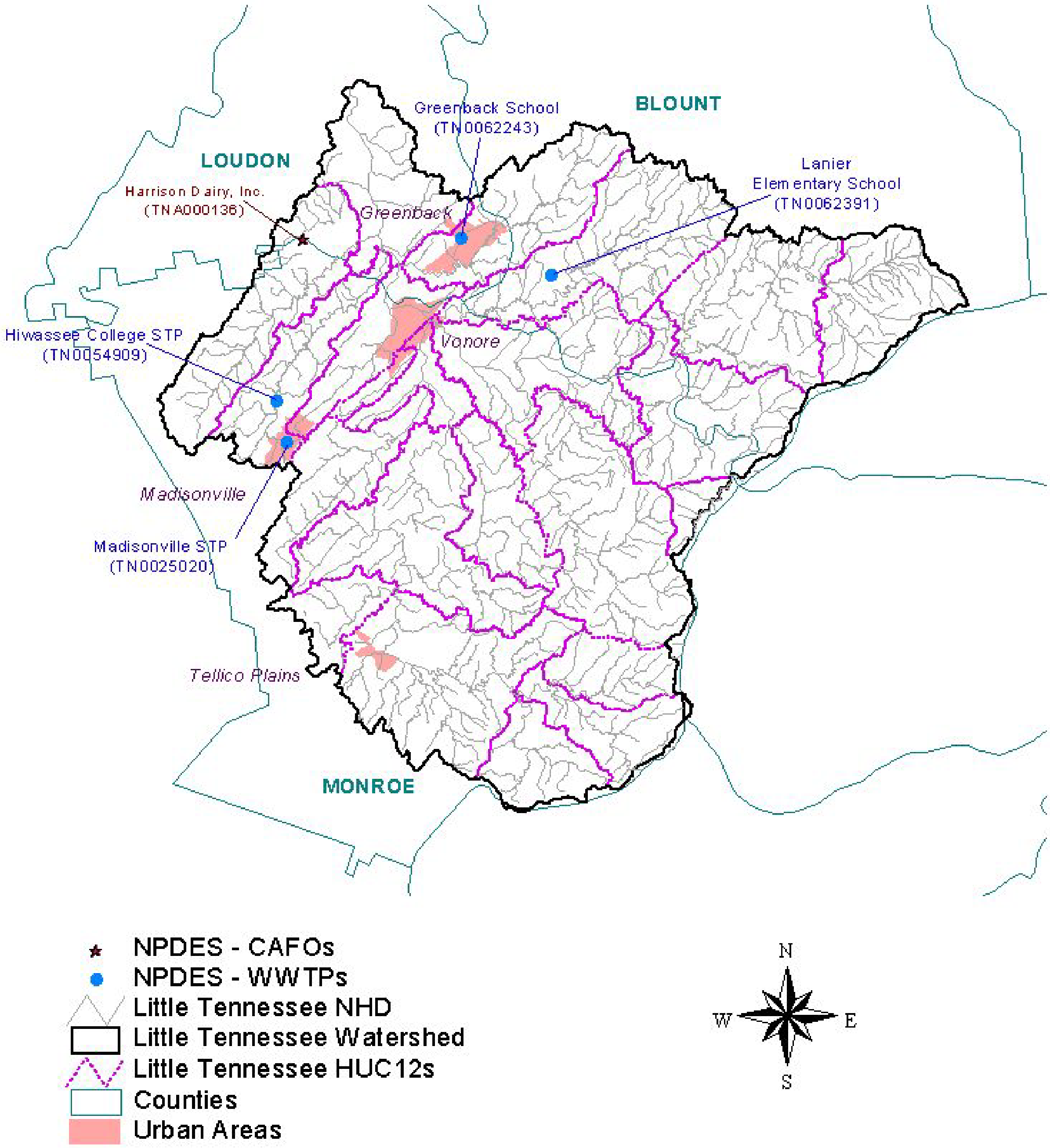

Figure 6. NPDES Regulated Point Sources in and near Impaired Subwatersheds and Drainage Areas of the Little Tennessee River Watershed.

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 large or medium (Phase I) MS4s in the Little Tennessee River Watershed. As of March 2003, small MS4s serving urbanized areas, or having the potential to exceed instream water quality standards, are required to obtain a permit under the *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2002). 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. Blount County and Loudon County are covered under Phase II of the NPDES Storm Water Program. The Tennessee Department of Transportation (TDOT) is also being issued Phase II 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 May 11, 2005, there is one Class II CAFO in the Little Tennessee River Watershed with coverage under the general NPDES permit. Harrison Dairy, Inc., (TNA000136) is located in the Fork Creek watershed. 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 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.

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 often have direct access to waterbodies and can provide a concentrated source of coliform bacteria loading directly to a stream.

Data sources related to livestock operations include the 2002 Census of Agriculture, which was compiled for the Little Tennessee River 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 5. Populations were rounded to the nearest 25 cows, 50 poultry, and 5 hogs, sheep, and horses.

7.2.3 Failing Septic Systems

Some coliform loading in the Little Tennessee 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 the Little Tennessee River Watershed utilizing septic systems were compiled using the WCS and are summarized in Table 6. In middle and 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. All impaired subwatersheds in the Little Tennessee River Watershed have less than 3.0% urban land use. Land use for the Little Tennessee impaired drainage areas is summarized in Figures 7 and 8 and tabulated in Appendix A.

Table 5 Livestock Distribution in the Little Tennessee River Watershed

HUC-12 Subwatershed (06010204__) or Drainage Area	Livestock Population (WCS)					
	Beef Cow	Milk Cow	Poultry	Hogs	Sheep	Horse
0205 (Ninemile Ck)	1,625	150	150	35	45	375
0409 (Notchy Ck)	600	175	50	15	15	125
0502 (Baker Ck)	1,575	350	100	20	110	535
0504 (Bat Ck)	725	225	50	15	25	180
0505 (Fork Ck)	1,225	375	100	20	65	380

Table 6 Population on Septic Systems in the Little Tennessee River Watershed

HUC-12 Subwatershed (06010204__) or Drainage Area	Population on Septic Systems
0205 (Ninemile Ck)	8,756
0409 (Notchy Ck)	1,175
0502 (Baker Ck)	6,106
0504 (Bat Ck)	1,772
0505 (Fork Ck)	2,853

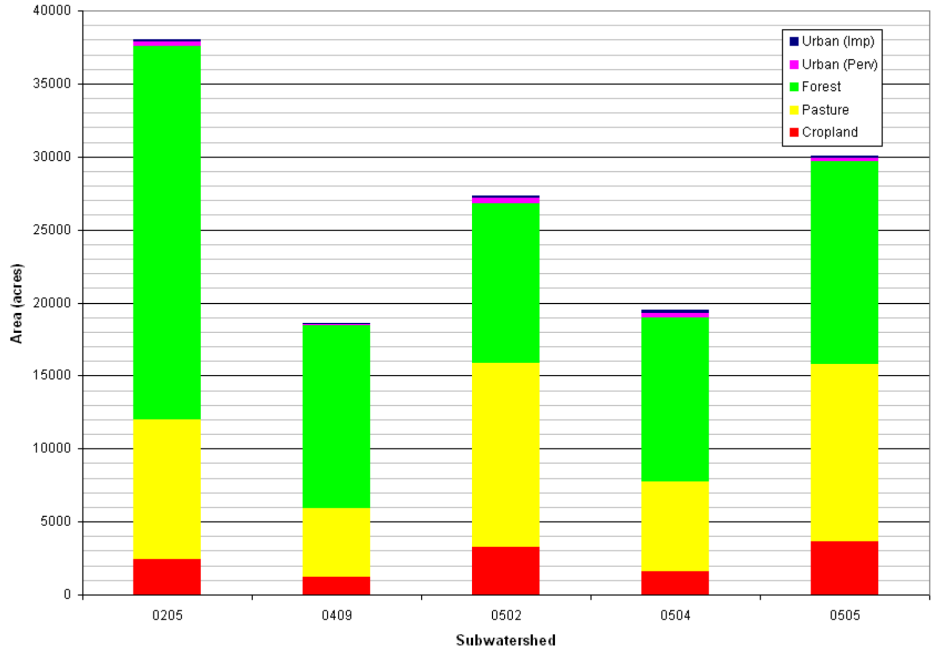

Figure 7. **Land Use Area of Little Tennessee Pathogen-Impaired Subwatersheds**

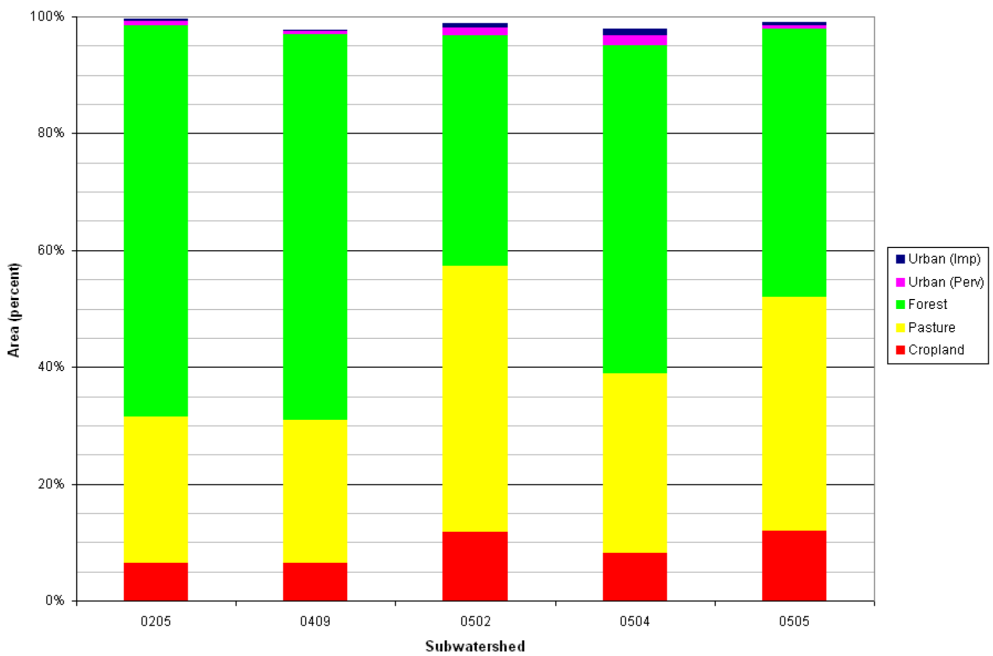

Figure 8. **Land Use Percent of the Little Tennessee Pathogen-Impaired Subwatersheds**

8.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOADS

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

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

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

This document describes 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.

8.1 Expression of TMDLs, WLAs, & LAs

In this document, TMDLs are expressed as the percent reduction in instream loading required to decrease existing E. coli concentrations to desired target levels. WLAs & LAs for precipitation-induced loading sources are also expressed as required percent reductions in E. coli loading. Allocations for loading that is independent of precipitation (WLAs for WWTFs and LAs for “other direct sources”) are expressed as CFU/day.

8.2 Area Basis for TMDL Analysis

The primary area unit of analysis for TMDL development was the HUC-12 subwatershed containing one or more waterbodies assessed as impaired due to E. coli (as documented on the 2004 303(d) List). In some cases, however, TMDLs were developed for an impaired waterbody drainage area only. Determination of the appropriate area to use for analysis (see Table 7) was based on a careful consideration of a number of relevant factors, including: 1) location of impaired waterbodies in the HUC-12 subwatershed; 2) land use type and distribution; 3) water quality monitoring data; and 4) the assessment status of other waterbodies in the HUC-12 subwatershed.

Table 7 Determination of Analysis Areas for TMDL Development

HUC-12 Subwatershed (06010204____)	Impaired Waterbody	Area
0205	Ninemile Creek	HUC-12
0409	Notchy Creek	HUC-12
0502	Baker Creek	HUC-12
0504	Bat Creek	HUC-12
0505	Fork Creek	HUC-12

Note: HUC-12 = HUC-12 Subwatershed
DA = Waterbody Drainage Area

8.3 TMDL Analysis Methodology

TMDLs for the Little Tennessee River Watershed were developed using load duration curves for analysis of impaired HUC-12 subwatersheds or specific waterbody drainage areas. A load duration curve (LDC) 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 are considered to be well suited for analysis of periodic monitoring data collected by grab sample. LDCs were developed at monitoring site locations in impaired waterbodies and an overall load reduction calculated to meet E. coli targets according to the methods described in Appendix C.

8.4 Critical Conditions and Seasonal Variation

The critical condition for non-point source E. coli loading is an extended dry period followed by a rainfall runoff event. During the dry weather period, E. coli 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 the TMDL analysis.

The ten-year period from October 1, 1994 to September 30, 2004 was used to simulate flow. This 10-year period contained a range of hydrologic conditions that included both low and high streamflows. 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. In all subwatersheds, water quality data have been collected during most flow ranges. Based on the location of the water quality exceedances on the load duration curves, no one delivery mode for E. oli appears to be dominant (see Section 9.3 and Table 9).

Seasonal variation was incorporated in the load duration curves by using the entire simulation period and all water quality data collected at the monitoring stations. The water quality data were not collected during all seasons.

8.5 Margin of Safety

There are two methods for incorporating MOS in TMDL analysis: a) implicitly incorporate the MOS using conservative model assumptions; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. For development of pathogen TMDLs in the Little Tennessee River Watershed, an explicit MOS, equal to 10% of the E. coli water quality targets (ref.: Section 5.0), was utilized for determination of WLAs and LAs:

Instantaneous Maximum (Tier II):	MOS = 49 CFU/100 ml
Instantaneous Maximum (non-Tier II):	MOS = 94 CFU/100 ml
30-Day Geometric Mean:	MOS = 13 CFU/100 ml

8.6 Determination of TMDLs

E. coli load reductions were calculated for impaired segments in the Little Tennessee River Watershed using Load Duration Curves to evaluate compliance with the maximum target concentrations according to the procedure in Appendix C. When sufficient data were available, load reductions were also developed to achieve compliance with the 30-day geometric mean target concentrations. Both instream load reductions (where applicable) for a particular waterbody were compared and the largest required load reduction was selected as the TMDL. These TMDL load reductions for impaired segments are shown in Table 8 and are applied according to the areas specified in Table 7. In cases where the geometric mean could not be developed, it is assumed that achieving the load reduction based on the maximum target concentrations should result in attainment of the geometric mean criteria.

8.7 Determination of WLAs & LAs

WLAs for MS4s and LAs for precipitation induced sources of E. coli loading were determined according to the procedures in Appendix C. These allocations represent the higher load reductions necessary to achieve instream targets <u>after application of the explicit MOS</u>. WLAs for existing WWTFs are equal to their existing NPDES permit limits. Since WWTF permit limits require that E. coli concentrations must comply with water quality criteria (TMDL targets) at the point of discharge and recognition that loading from these facilities are generally small in comparison to other loading sources, further reductions were not considered to be warranted. WLAs for CAFOs and LAs for "other direct sources" (non-precipitation induced) are equal to zero. WLAs, & LAs are summarized in Table 8.

Note: The WLA for WWTFs in Subwatershed 060102040504 is the total allocation for the two facilities located in the subwatershed. The WLA for each individual facility was determined using existing permit limits and design flow.

Table 8 TMDLs, WLAs, & LAs for Impaired Subwatersheds and Drainage Areas in the Little Tennessee River Watershed

HUC-12 Subwatershed (06010204__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs [a]		CAFOs	MS4s [d]	Precipitation Induced Nonpoint Sources	Other Direct Sources [e]
				Monthly Avg.	Daily Max.				
			[% Red.]	[CFU/day]	[CFU/day]	[CFU/day]	[% Red.]	[% Red.]	[CFU/day]
0205	Ninemile Creek	TN06010204042 – 1000	40.7	8.107×10^7	6.055×10^8	0	46.8	46.8	0
0409	Notchy Creek	TN06010204045 – 1000	82.5	NA	NA	NA	NA	84.3	0
0502	Baker Creek	TN06010204043 – 1000	86.1	8.584×10^7 [c]	6.411×10^8 [c]	NA	87.6	87.6	0
0504	Bat Creek	TN06010204004 - 1000	>91.7	4.101×10^9 [b]	3.063×10^{10} [b]	NA	>92.6	>92.6	0
0505	Fork Creek	TN06010204002 – 1000	>93.7	NA	NA	0	NA	>94.4	0

Notes: NA = Not Applicable.

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

b. The WLA listed is for the subwatershed and is equal to the sum of the WLAs for the individual facilities. WLAs for individual WWTFs corresponds to existing E. coli permit limits at facility design flow.

c. The WLAs listed apply to NPDES permitted discharges from WWTFs only. Pathogen loading due to collection system failure is considered to be unpermitted point source loading from the municipal WWTF. With respect to pathogen loading from leaking collection systems, a WLA of zero is assigned. It is recognized, however, that a WLA of 0 CFU/day may not be practical. For these unpermitted sources, the WLA is interpreted to mean a reduction in pathogen 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.

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

e. 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 CFU/day may not be practical. For these sources, the LA is interpreted to mean a reduction in pathogen 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.

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 Little Tennessee River Watershed through reduction of excessive pathogen loading. Adaptive management methods, within the context of the State's rotating watershed management approach, will be used to modify TMDLs, WLAs, and LAs as required to meet water quality goals.

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, including elimination of bypasses and overflows. 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 derived from facility design flows and permitted E. coli limits and are expressed as average loads in CFU per day.

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 <u>describe methods to evaluate whether storm water controls are adequate to meet the WLA</u>.

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 Knoxville 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. The 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/CAFO_GP_04.pdf

9.2 Nonpoint Sources

The Tennessee Department of Environment & Conservation (TDEC) has no direct regulatory authority over most nonpoint source discharges. Reductions of pathogen loading from nonpoint sources (NPS) will be achieved using a phased approach. Voluntary, incentive-based mechanisms will be used to implement NPS management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the targeted impaired waters. Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs. 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.

Local citizen-led and implemented management measures offer the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. An excellent example of stakeholder involvement and action for the implementation of the nonpoint source load allocations (LAs) specified in an approved TMDL is described in *Guidance for Development of a Total Maximum Daily Load Implementation Plan for Fecal Coliform Reduction* (SCWA, 2004), prepared by the Sinking Creek Watershed Alliance. This document details the cooperative effort of a number of stakeholders and governmental entities to develop an implementation plan for the restoration of water quality in Sinking Creek, near Johnson City, Tennessee. Plan development was funded, in part, through a TDEC 604(b) grant and a Tennessee Department of Agriculture (TDA) Nonpoint source Program 319 grant. The plan is based on land use and pollutant source identification surveys and considers public education & participation, funding resources, in-stream monitoring, best management practices (BMPs), and stakeholder responsibilities. Recommendations for future activities include verification of chemical/biological findings through Bacteria Source Tracking (BST) research, implementation of appropriate BMPs, post implementation monitoring to verify reduction of pollutant loading.

BMPs have been utilized in the Little Tennessee 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 the Little Tennessee River Watershed during the TMDL evaluation period. The TDA keeps a database of BMPs implemented in Tennessee. Those listed in the Little Tennessee River Watershed are shown in Figure 9. It is recommended that additional information (e.g., livestock access to streams, manure application practices, etc.) be provided and evaluated to better identify and quantify agricultural sources of coliform bacteria loading in order to minimize uncertainty in future modeling efforts.

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

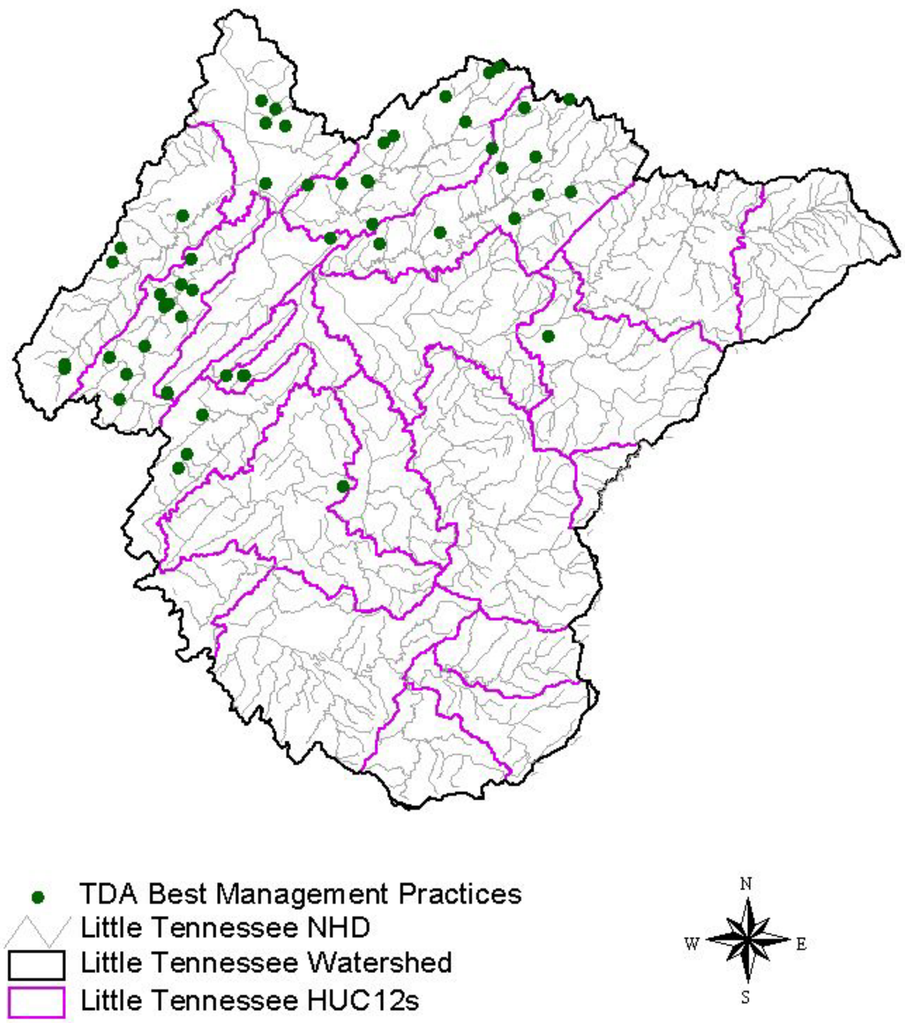

Figure 9. Tennessee Department of Agriculture Best Management Practices located in the Little Tennessee River Watershed.

9.3 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 pathogens by differentiating between point and nonpoint problems. The E. coli load duration analysis was utilized for implementation planning. The E. coli load duration curve for each pathogen-impaired subwatershed (Figures C-2 through C-4) was analyzed to determine the frequency with which water quality monitoring data exceed the E. coli target maximum concentration of 941 CFU/100 mL under five flow conditions (low, dry, mid- range, moist, and high).

Table 9 presents targeted implementation strategies for each source category covering the entire range of flow (Stiles, 2003). Each implementation strategy addresses a range of flow conditions and targets point sources, nonpoint sources, or a combination of each. Results indicate the implementation strategy for all subwatersheds will require BMPs targeting a variety of sources. The implementation strategies listed in Table 9 are a subset of the categories of BMPs and implementation strategies available for application to the pathogen-impaired Little Tennessee subwatersheds for reduction of pathogen loading and mitigation of water quality impairment.

Table 9 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.

See Appendix C for a detailed discussion of the Load Duration Curve Methodology applied to the Little Tennessee River Watershed.

9.4 Additional Monitoring

Documenting progress in reducing the quantity of pathogens entering the Little Tennessee 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 targets for E. coli. Future monitoring activities should be representative of all seasons and a full range of flow and meteorological conditions. Monitoring activities should also be adequate to assess water quality using the 30-day geometric mean standard.

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 all impaired waterbodies in the Little Tennessee River Watershed. An intensive short-term sampling effort (e.g. 10 samples in 60 days) was undertaken in all of the impaired waterbodies. While this sampling allowed for the 30-day geometric mean to be calculated, no other sampling events have occurred in the past five years for Fork Creek. For Bat Creek and Baker Creek, other sampling events have occurred, but at different sampling locations (further downstream) than the intensive sampling effort. Also, this intensive sampling was not representative of all seasons and flow conditions. Once additional monitoring representing all seasons and a full range of flow and meteorological conditions has been obtained, the required load reductions may be revised.

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 pathogen 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. Other BST projects have been conducted or are currently in progress throughout the state of Tennessee, as presented in sessions of the Thirteenth Tennessee Water Resources Symposium (Lawrence, 2003) and the Fifteenth Tennessee Water Resources Symposium (Bailey, 2005; Baldwin, 2005; Farmer, 2005).

9.6 Evaluation of TMDL Implementation Effectiveness

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

10.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed pathogen TMDLs for the Little Tennessee River Watershed was placed on Public Notice for a 35-day period and comments solicited. Steps that were taken in this regard include:

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

2) Notice of the availability of the proposed TMDLs (similar to the website announcement) was included in one of the NPDES permit Public Notice mailings which is sent to approximately 90 interested persons or groups who have requested this information.

3) Letters were sent to WWTFs located in E. coli-impaired subwatersheds or drainage areas in the Little Tennessee River Watershed, permitted to discharge treated effluent containing pathogens, 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. A letter was sent to the following facilities:

   Greenback School (TN0062243)
   Hiwassee College STP (TN0054909)
   Lanier Elementary School (TN0062391)
   Madisonville STP (TN0025020)

4) A draft copy of the proposed TMDL was sent to those MS4s that are wholly or partially located in pathogen-impaired subwatersheds. A draft copy was sent to the following entities:

   Blount County, Tennessee (TNS075116)
   Loudon County, Tennessee (TNS075591)
   Tennessee Dept. of Transportation (TNS077585)

5) A letter was sent to local stakeholder groups in the Little Tennessee River Watershed advising them of the proposed E. coli TMDLs and their availability on the TDEC website. The letter also stated that a written copy of the draft TMDL document would be provided upon request. A letter was sent to the following local stakeholder group:

   Watershed Association of the Tellico Reservoir (WATeR)

6) A letter was sent to attendees of the January 24th Public Meeting for the Little Tennessee River Watershed advising them of the proposed E. coli TMDLs and their availability on the TDEC website. The letter also stated that a written copy of the draft TMDL document would be provided upon request.

11.0 FURTHER INFORMATION

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

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

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

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APPENDIX A

Land Use Distribution in the Little Tennessee River Watershed

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

Land Use	HUC-12 Subwatershed (06010204__)					
	0205		0409		0502	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	8,369.0	21.9	5,019.0	26.4	2,920.3	10.5
Evergreen Forest	8,381.0	22.0	3,067.9	16.1	3,605.5	13.0
High Intensity Commercial/Industrial/Transp.	127.0	0.3	42.5	0.2	171.9	0.6
High Intensity Residential	6.7	0.0	0.2	0.0	19.1	0.1
Low Intensity Residential	303.3	0.8	108.3	0.6	371.0	1.3
Mixed Forest	8,695.7	22.8	4,342.3	22.8	4,010.0	14.5
Open Water	138.6	0.4	441.7	2.3	335.4	1.2
Other Grasses (Urban/recreation; e.g. parks)	48.5	0.1	34.9	0.2	385.9	1.4
Pasture/Hay	9,597.9	25.2	4,671.9	24.5	12,635.4	45.6
Row Crops	2,432.3	6.4	1,244.3	6.5	3,235.2	11.7
Transitional	56.0	0.1	69.8	0.4	0.0	0.0
Total	38,156.0	100.0	19,024.9	100.0	27,689.6	100.0

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

Land Use	HUC-12 Subwatershed (06010204__)			
	0504		0505	
	[acres]	[%]	[acres]	[%]
Deciduous Forest	3,608.6	18.1	4,630.9	15.3
Evergreen Forest	3,433.1	17.2	3,164.2	10.4
High Intensity Commercial/Industrial/Transp.	203.3	1.0	156.6	0.5
High Intensity Residential	42.7	0.2	3.1	0.0
Low Intensity Residential	319.8	1.6	203.0	0.7
Mixed Forest	3,937.1	19.8	5,682.7	18.7
Open Water	410.3	2.1	289.8	1.0
Other Grasses (Urban/recreation; e.g. parks)	140.6	0.7	216.2	0.7
Pasture/Hay	6,147.9	30.9	12,177.1	40.2
Row Crops	1,615.5	8.1	3,611.0	11.9
Transitional	66.1	0.3	181.9	0.6
Total	19,924.9	100.0	30,316.5	100.0

APPENDIX B

Water Quality Monitoring Data

There are a number of water quality monitoring stations that provide data for waterbodies identified as impaired for pathogens in the Little Tennessee River Watershed. The location of these monitoring stations is shown in Figure 5. Monitoring data recorded by TDEC at these stations are tabulated in Table B-1.

Table B-1. TDEC Water Quality Monitoring Data – Little Tennessee River Subwatersheds

Monitoring Station	Date	E. Coli [cts./100 mL]
BAKER008.9LO	4/13/99	249
	6/23/99	1203
	8/25/99	>2419
	10/20/99	387
	12/7/99	154
	8/20/03	326
	8/28/03	345
	9/2/03	238
	9/9/03	313
	9/16/03	770
	9/29/03	866
	10/2/03	248
	10/6/03	548
	10/9/03	231
	10/13/03	299
BAKER017.5BT	8/20/03	517
	8/28/03	649
	9/2/03	866
	9/9/03	921
	9/16/03	921
	9/29/03	1300
	10/2/03	649
	10/6/03	548
	10/9/03	579
	10/13/03	727
BAT008.1MO	4/13/99	260
	6/23/99	1986
	8/25/99	461
	10/20/99	387
	12/7/99	1553

Table B-1 (Cont.). TDEC Water Quality Monitoring Data – Little Tennessee River Subwatersheds

Monitoring Station	Date	E. Coli [cts./100 mL]
BAT008.1MO (continued)	8/20/03	649
	8/28/03	727
	9/2/03	770
	9/9/03	387
	9/16/03	1986
	9/29/03	>2419
	10/2/03	361
	10/6/03	921
	10/9/03	866
	10/13/03	579
BAT019.3MO	8/20/03	1203
	8/28/03	980
	9/2/03	>2419
	9/9/03	866
	9/16/03	1733
	9/29/03	1734
	10/2/03	1300
	10/6/03	>2419
	10/9/03	980
	10/13/03	649
CENTE000.3BT	8/24/99	96
	8/20/03	276
	8/28/03	236
	9/2/03	435
	9/9/03	250
	9/16/03	613
	9/29/03	345
	10/2/03	365
	10/6/03	206
	10/9/03	172
	10/13/03	112
FORK004.6MO	4/13/99	517
	6/23/99	178
	8/25/99	380
	10/20/99	613
	12/7/99	58

Table B-1 (Cont.). TDEC Water Quality Monitoring Data – Little Tennessee River Subwatersheds

Monitoring Station	Date	E. Coli [cts./100 mL]
FORK006.5MO	8/20/03	1553
	8/28/03	1300
	9/2/03	1414
	9/9/03	1120
	9/16/03	1733
	9/29/03	>2419
	10/2/03	>2419
	10/6/03	>2419
	10/9/03	>2419
	10/13/03	1120
FORK014.8MO	8/20/03	1120
	8/28/03	210
	9/2/03	387
	9/9/03	365
	9/16/03	326
	9/29/03	>2419
	10/2/03	365
	10/6/03	387
	10/9/03	194
	10/13/03	365
LNINE000.5BT	8/14/99	81
	8/20/03	147
	8/28/03	81
	9/2/03	93
	9/9/03	77
	9/16/03	101
	9/29/03	135
	10/2/03	105
	10/6/03	84
	10/9/03	77
	10/13/03	42

Table B-1 (Cont.). TDEC Water Quality Monitoring Data – Little Tennessee River Subwatersheds

Monitoring Station	Date	E. Coli [cts./100 mL]
NINEM004.8BT	4/13/99	158
	6/23/99	345
	8/25/99	194
	10/20/99	548
	12/7/99	79
	8/20/03	228
	8/28/03	249
	9/2/03	137
	9/9/03	153
	9/16/03	365
	9/29/03	228
	10/2/03	166
	10/6/03	126
	10/9/03	147
	10/13/03	126
NOTCH002.5MO	4/13/99	548
	6/23/99	1203
	8/25/99	921
	10/20/99	1553
	12/7/99	613
	7/15/03	1300
	7/29/03	1046
	8/14/03	>2419
	9/9/03	613
	9/22/03	579
	9/25/03	866
	10/2/03	921
	10/6/03	613
	10/9/03	816
	10/23/03	365

APPENDIX C

Load Duration Curve Development and Determination of Required Load Reductions

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

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

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

C.1 Development of TMDLs

E. coli TMDLs, WLAs, and LAs were developed for impaired subwatersheds and drainage areas in the Little Tennessee River Watershed using Load Duration Curves (LDCs) to determine the reduction in pollutant loading required to decrease existing, instream E. coli concentrations to target levels. TMDLs are expressed as required percent reductions in pollutant loading.

C.1.1 Development of Flow Duration Curves

A flow duration curve is a cumulative frequency graph, constructed from historic flow data at a particular location, that represents the percentage of time a particular flow rate is equaled or exceeded. Flow duration curves are developed for a waterbody from daily discharges of flow over a period of record. In general, there is a higher level of confidence that curves derived from data over a long period of record correctly represent the entire range of flow. The preferred method of flow duration curve computation uses daily mean data from USGS continuous-record stations located on the waterbody of interest. For ungaged streams, alternative methods must be used to estimate daily mean flow. These include: 1) regression equations (using drainage area as the independent variable) developed from continuous record stations in the same ecoregion; 2) drainage area extrapolation of data from a nearby continuous-record station of similar size and topography; and 3) calculation of daily mean flow using a dynamic computer model, such as the Loading Simulation Program C++ (LSPC).

Flow duration curves for impaired waterbodies in the Little Tennessee River Watershed were derived from LSPC hydrologic simulations based on parameters derived from calibration at USGS Station No. 03466228, located on Sinking Creek at Afton, Tennessee, in the Nolichucky watershed (see Appendix D for details of calibration). For example, a flow-duration curve for Ninemile Creek at RM 4.8 was constructed using simulated daily mean flow for the period from 10/1/94 through 9/31/04 (RM 4.8 corresponds to the location of monitoring station NINEM004.8BT). This flow duration curve is shown in Figure C-1 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record (the highest daily mean flow during this period is exceeded 0% of the time and the lowest daily mean flow is equaled or exceeded 100% of the time). Flow duration curves for other impaired waterbodies were derived using a similar procedure.

C.1.2 Development of Load Duration Curves and Determination of TMDLs

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

E. coli load duration curves for impaired waterbodies in the Little Tennessee River Watershed were developed from the flow duration curves developed in Section C.1.1, E. coli target concentrations, and available water quality monitoring data. Load duration curves and required load reductions were developed using the following procedure (Ninemile Creek is shown as an example):

1. A target load-duration curve (LDC) was generated for Ninemile Creek by applying the E. coli target concentration of 487 CFU/100 mL to each of the ranked flows used to generate the flow duration curve (ref.: Section D.1) and plotting the results. The E. coli target maximum load corresponding to each ranked daily mean flow is:

   $$(\text{Target Load})_{\text{Ninemile Creek}} = (487 \text{ CFU/100 mL}) \times (Q) \times (UCF)$$

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

2. Daily loads were calculated for each of the water quality samples collected at monitoring station NINEM004.8BT (ref.: Table B-1) by multiplying the sample concentration by the daily mean flow for the sampling date and the required unit conversion factor. NINEM004.8BT was selected for LDC analysis because it was the monitoring station on Ninemile Creek with the most exceedances of the target concentration.

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

   Example – 10/20/99 sampling event:
   Modelled Flow = 17.04 cfs
   Concentration = 548 CFU/100 mL
   Daily Load = 2.28×10^{11} CFU/day

3. Using the flow duration curves developed in C.1.1, the "percent of days the flow was exceeded" (PDFE) was determined for each sampling event. Each sample load was then plotted on the load duration curves developed in Step 1 according to the PDFE. The resulting E. coli load duration curve for is shown in Figure C-2.

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

   Example – 10/20/99 sampling event:
   Target Concentration = 487 CFU/100 mL
   Measured Concentration = 548 CFU/100 mL
   Reduction to Target = 11.1%

5. The 90th percentile value for all of the E. coli sampling data at NINEM004.8BT monitoring site was determined. If the 90th percentile value exceeded the target maximum E. coli concentration, the reduction required to reduce the 90th percentile value to the target maximum concentration was calculated (Table C-1).

   Example: *Target Concentration = 487 CFU/100 mL*
   90th Percentile Concentration = 357 CFU/100 mL
   Reduction to Target = None Required

6. For cases where five or more samples were collected over a period of not more than 30 consecutive days, the geometric mean E. coli concentration was determined and compared to the target geometric mean E. coli concentration of 126 CFU/100 mL. If the sample geometric mean exceeded the target geometric mean concentration, the reduction required to reduce the sample geometric mean value to the target geometric mean concentration was calculated.

   Example: *Sampling Period = 9/16/03 – 10/13/03*
   Geometric Mean Concentration = 178.40 CFU/100 mL
   Target Concentration = 126 CFU/100 mL
   Reduction to Target = 29.4%

7. The load reductions required to meet the target maximum (Step 5) and target 30-day geometric mean concentrations (Step 6) of E. coli were compared and the load reduction of the greatest magnitude selected as the TMDL for Ninemile Creek.

Load duration curves, required load reductions, and TMDLs of other impaired waterbodies were derived in a similar manner and are shown in Figures C-3 through C-4 and Tables C-2 through C-6.

C.2 Development of WLAs & LAs

As previously discussed, a TMDL can be expressed as the sum of all point source loads (WLAs), nonpoint source loads (LAs), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

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

Expanding the terms:

$$TMDL = [\sum WLAs]_{WWTF} + [\sum WLAs]_{MS4} + [\sum WLAs]_{CAFO} + [\sum LAs]_{DS} + [\sum LAs]_{SW} + MOS$$

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

- $[\sum WLAs]_{WWTF}$ is the allowable load associated with discharges of NPDES permitted WWTFs located in impaired subwatersheds or drainage areas. Since NPDES permits for these facilities specify that treated wastewater must meet instream water quality standards at the point of discharge, no additional load reduction is required. WLAs for WWTFs are calculated from the facility design flow and the Monthly Average permit limit.
- $[\sum WLAs]_{CAFO}$ is the allowable load for all CAFOs in an impaired subwatershed or drainage area. All wastewater discharges from a CAFO to waters of the state of Tennessee are prohibited, except when either chronic or catastrophic rainfall events cause an overflow of process wastewater from a facility properly designed, constructed, maintained, and operated to contain:
  - o All process wastewater resulting from the operation of the CAFO (such as wash water, parlor water, watering system overflow, etc.); plus,
  - o All runoff from a 25-year, 24-hour rainfall event for the existing CAFO or new dairy or cattle CAFOs; or all runoff from a 100-year, 24-hour rainfall event for a new swine or poultry CAFO.

  Therefore, a WLA of zero has been assigned to this class of facilities.
- $[\sum WLAs]_{MS4}$ is the required load reduction for discharges from MS4s. E. coli loading from MS4s is the result of buildup/wash-off processes associated with storm events.

LA terms include:

- $[\sum LAs]_{DS}$ is the allowable E. coli load from “other direct sources”. These sources include leaking septic systems, leaking collection systems, illicit discharges, and animals access to streams. The LA specified for all sources of this type is zero CFU/day (or to the maximum extent practicable).
- $[\sum LAs]_{SW}$ represents the required reduction in E. coli loading from nonpoint sources indirectly going to surface waters from all land use areas (except areas covered by a MS4 permit) as a result of the buildup/wash-off processes associated with storm events.

Since WWTFs discharges must comply with instream water quality criteria (TMDL target) at the point of discharge, $[\sum WLAs]_{CAFO} = 0$, and $[\sum LAs]_{DS} = 0$, the expression relating TMDLs to precipitation-based point and nonpoint sources may be simplified to:

$$TMDL – MOS = [\sum WLAs]_{MS4} + [\sum LAs]_{SW}$$

WLAs for MS4s and LAs for precipitation-based nonpoint sources are equal and expressed as the percent reduction in loading required to decrease instream E. coli concentrations to TMDL target values minus MOS. As stated in Section 8.4, an explicit MOS, equal to 10% of the E. coli water quality targets (ref.: Section 5.0), was utilized for determination of the WLAs and LAs:

Instantaneous Maximum (Tier II):

Target – MOS = (487 CFU/100 ml) – 0.1(487 CFU/100 ml)

Target – MOS = 438 CFU/100 ml

Instantaneous Maximum (non-Tier II):

Target – MOS = (941 CFU/100 ml) – 0.1(941 CFU/100 ml)

Target – MOS = 847 CFU/100 ml

30-Day Geometric Mean: Target – MOS = (126 CFU/100 ml) – 0.1(126 CFU/100 ml)

Target – MOS = 113 CFU/100 ml

C.2.1 Determination of WLAs for MS4s & LAs for Precipitation-Based Nonpoint Sources

WLAs for MS4s and LAs for precipitation-based nonpoint sources were developed using methods similar to those described in C.1.2 (again, using Ninemile Creek as an example):

8. An allocation LDC was generated for Ninemile Creek by applying the E. coli "target – MOS" concentration of 438 CFU/100 mL to each of the ranked flows used to generate the flow duration curve (ref.: Section D.1) and plotting the results on the target LDC developed in Step 1. The E. coli target maximum allocated load corresponding to each ranked daily mean flow is:

   $(\text{Target Load - MOS})_{\text{Ninemile Creek}}$ = (438 CFU/100 mL) x (Q) x (UCF)

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

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

   Example – 10/20/99 sampling event:
   Target Concentration -- MOS = 438 CFU/100 mL
   Measured Concentration = 548 CFU/100 mL
   Reduction to Target -- MOS = 20.1%

10. If the 90th percentile value for all of the E. coli sampling data at NINEM004.8BT monitoring site (calculated in Step 5) exceeded the "target maximum – MOS" E. coli concentration, the reduction required to reduce the 90th percentile value to the "target maximum – MOS" concentration was calculated (Table C-1).

    Example: *Target Concentration -- MOS = 438 CFU/100 mL*
    90th Percentile Concentration = 357 CFU/100 mL
    Reduction to Target -- MOS = None Required

11. For cases where five or more samples were collected over a period of not more than 30 consecutive days, the geometric mean E. coli concentration was determined and compared to the "target geometric mean E. coli concentration – MOS" of 113 CFU/100 mL. If the sample geometric mean exceeded the "target geometric mean – MOS" concentration, the reduction required to reduce the sample geometric mean value to the "target geometric mean – MOS" concentration was calculated.

    Example: *Sampling Period = 9/16/03 – 10/13/03*
    Geometric Mean Concentration = 178.40 CFU/100 mL
    Target Concentration -- MOS = 113 CFU/100 mL
    Reduction to Target -- MOS = 36.7%

12. The load reductions required to meet the "target maximum – MOS" (Step 10) and "target 30-day geometric mean – MOS" concentrations (Step 11) of E. coli were compared and the load reduction of the greatest magnitude selected as the WLA for MS4s and/or LA for precipitation-based nonpoint sources for Ninemile Creek.

Load duration curves, required load reductions, WLAs for MS4s, and LAs for precipitation-based nonpoint sources of other impaired waterbodies were derived in a similar manner and are shown in Figures C-3 through C-4 and Tables C-2 through C-6. TMDLs, WLAs, & LAs for impaired subwatersheds and drainage areas in the Little Tennessee River Watershed are summarized in Table C-7.

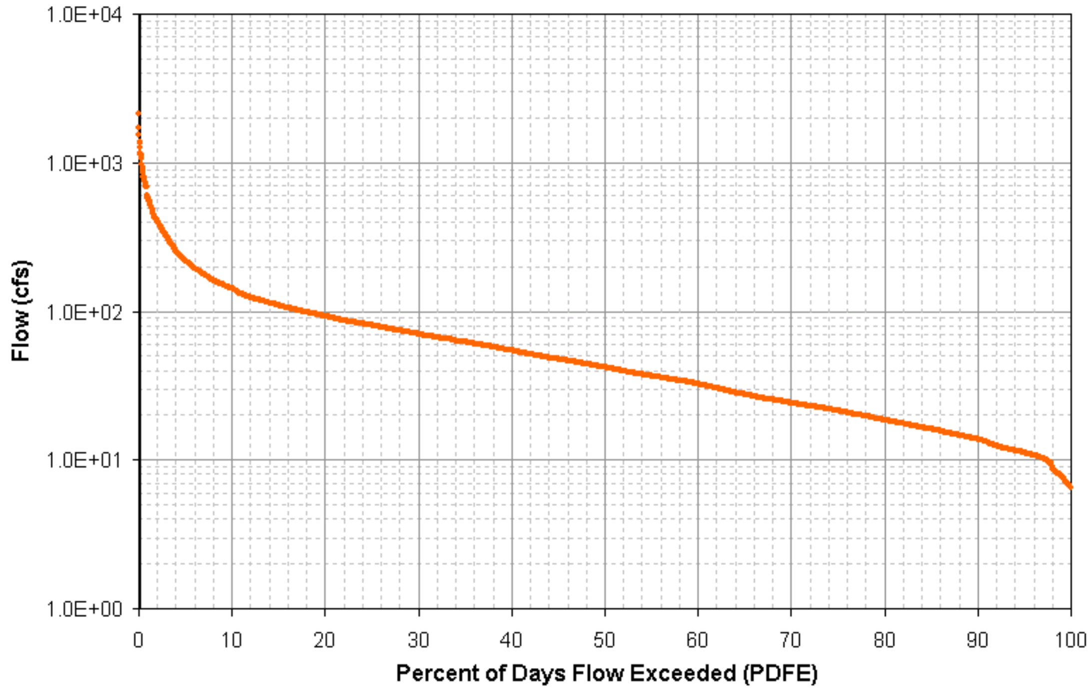

Figure C-1. Flow Duration Curve for Ninemile Creek at Mile 4.8

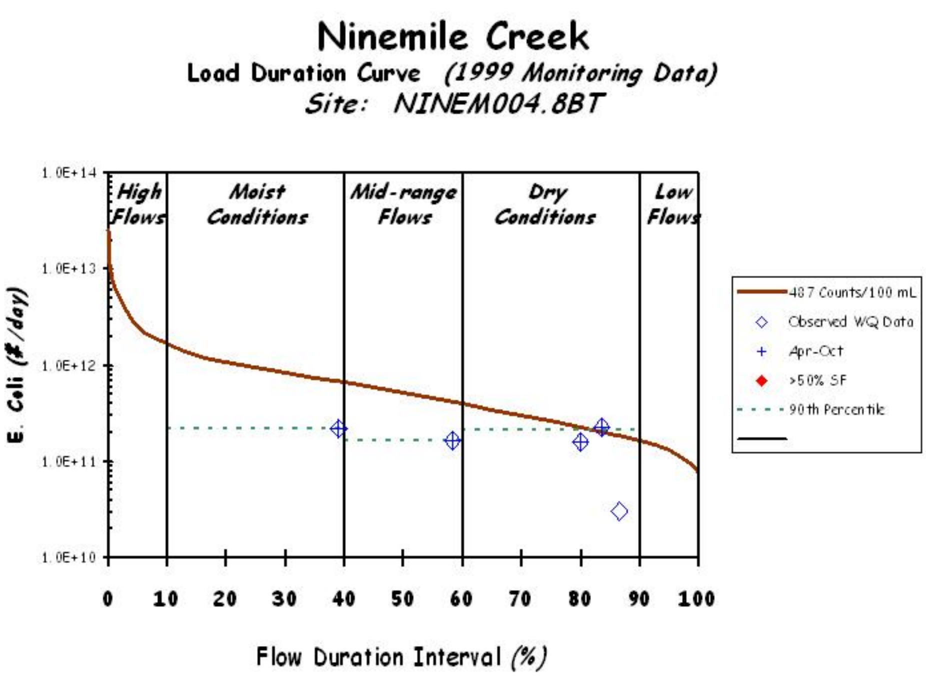

Figure C-2. E. Coli Load Duration Curve for Ninemile Creek at Mile 4.8

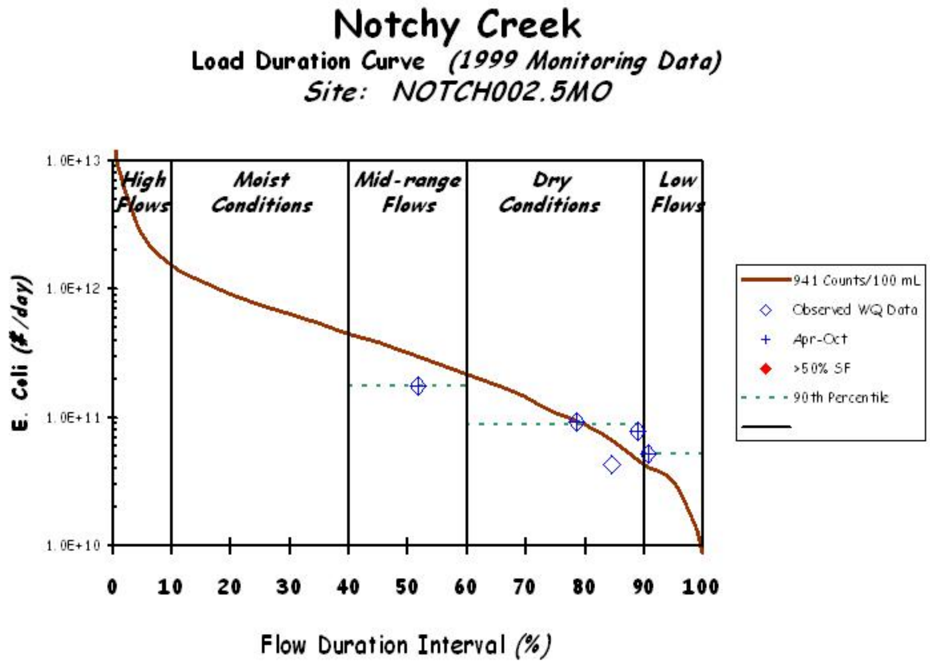

Figure C-3. E. Coli Load Duration Curve for Notchy Creek at Mile 2.5

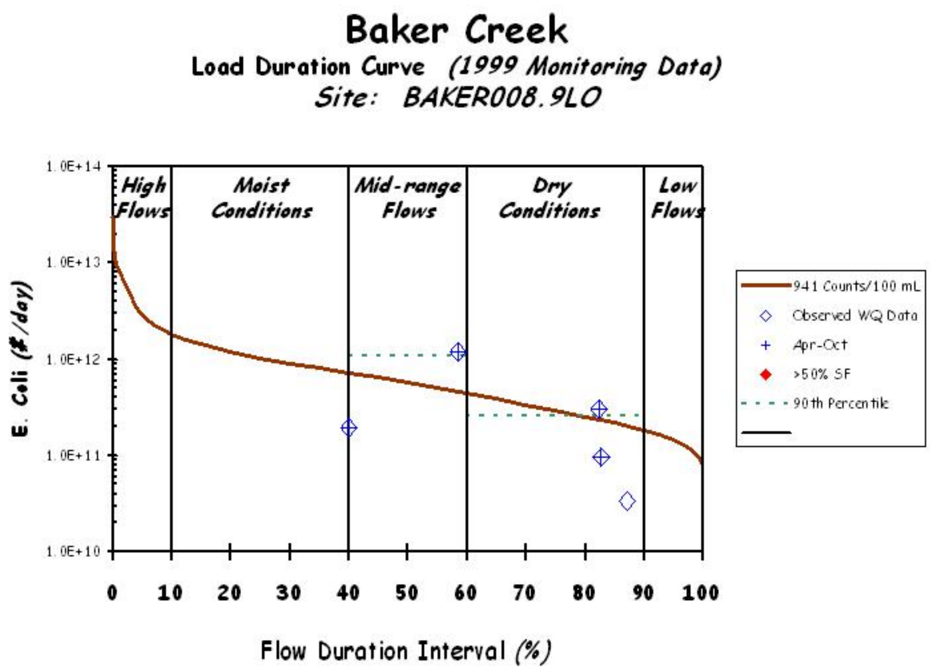

Figure C-4. E. Coli Load Duration Curve for Baker Creek at Mile 8.9

Table C-1. Required Load Reduction for Ninemile Creek – Mile 4.8

Sample Date	Flow	PDFE	Sample Concentration	Required Reduction		Geometric Mean[a]	Required Reduction	
				Sample to Target (487 CFU/100 ml)	Sample to Target – MOS (438 CFU/100 ml)		Sample to Target (126 CFU/100 ml)	Sample to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]	[CFU/100 ml]	[%]	[%]
4/13/99	57.75	39.1%	158	**NR**	**NR**			
6/23/99	19.10	80.0%	345	**NR**	**NR**			
8/25/99	35.16	58.3%	194	**NR**	**NR**			
10/20/99	17.04	83.7%	548	11.1	20.1			
12/7/99	15.70	86.6%	79	**NR**	**NR**			
8/20/03	47.52	46.7%	228	**NR**	**NR**			
8/28/03	35.17	58.3%	249	**NR**	**NR**			
9/2/03	36.02	57.2%	137	**NR**	**NR**			
9/9/03	43.06	50.3%	153	**NR**	**NR**			
9/16/03	35.91	57.4%	365	**NR**	**NR**	212.60	**40.7**	**46.8**
9/29/03	68.91	30.9%	228	**NR**	**NR**			
10/2/03	52.90	42.4%	166	**NR**	**NR**	196.04	35.7	42.4
10/6/03	42.88	50.5%	126	**NR**	**NR**	192.79	34.6	41.4
10/9/03	38.31	54.5%	147	**NR**	**NR**	184.27	31.6	38.7
10/13/03	35.54	57.8%	126	**NR**	**NR**	178.40	29.4	36.7
90th Percentile Concentration			**357**	**NR**	**NR**			

Note: NR = No reduction required
[a] Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.
[b] Reductions for individual samples (shaded area) are included for reference only.

Table C-2. Required Load Reduction for Notchy Creek – Mile 2.5

Sample Date	Flow	PDFE	Sample Concentration	Required Reduction		Geometric Mean[a]	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target – MOS (847 CFU/100 ml)		Sample to Target (126 CFU/100 ml)	Sample to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]	[CFU/100 ml]	[%]	[%]
4/13/99	13.22	51.6%	548	**NR**	**NR**			
6/23/99	1.97	89.4%	1,203	21.8	29.6			
8/25/99	4.45	76.7%	921	**NR**	8.0			
10/20/99	2.13	88.4%	1,553	39.4	45.5			
12/7/99	2.90	84.3%	613	**NR**	**NR**			
8/20/03	25.72	32.2%	1,300	27.6	34.8			
8/28/03	8.40	63.1%	1,046	10.0	19.0			
9/2/03	17.88	42.9%	>2,419	>61.1	>65.0			
9/9/03	14.09	50.0%	613	**NR**	**NR**			
9/16/03	242.82	1.9%	579	**NR**	**NR**			
9/29/03	32.56	25.6%	866	**NR**	2.2			
10/2/03	15.70	46.9%	921	**NR**	8.0			
10/6/03	10.91	56.7%	613	**NR**	**NR**	704.49	82.1	84.0
10/9/03	9.18	61.1%	816	**NR**	**NR**	721.96	**82.5**	**84.3**
10/13/03	6.31	70.0%	365	**NR**	**NR**	680.21	81.5	83.4
90th Percentile Concentration			**1,452**	**>35.2**	**>41.7**			

Note: NR = No reduction required
[a] Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.
[b] Reductions for individual samples (shaded area) are included for reference only.

Table C-3. Required Load Reduction for Baker Creek – Mile 8.9

Sample Date	Flow	PDFE	Sample Concentration	Required Reduction: Sample to Target (941 CFU/100 ml)	Required Reduction: Sample to Target – MOS (847 CFU/100 ml)	Geometric Mean[a]	Required Reduction: Sample to Target (126 CFU/100 ml)	Required Reduction: Sample to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]	[CFU/100 ml]	[%]	[%]
4/13/99	31.48	40.1%	249	**NR**	**NR**			
6/23/99	10.17	82.5%	1,203	21.8	29.6			
8/25/99	20.06	58.5%	>2,419	>61.1	>65.0			
10/20/99	10.10	82.8%	387	**NR**	**NR**			
12/7/99	8.81	87.3%	154	**NR**	**NR**			
8/20/03	26.52	47.5%	326	**NR**	**NR**			
8/28/03	19.75	59.1%	345	**NR**	**NR**			
9/2/03	20.85	56.9%	238	**NR**	**NR**			
9/9/03	23.71	51.9%	313	**NR**	**NR**			
9/16/03	20.20	58.2%	770	**NR**	**NR**	364.69	65.5	69.0
9/29/03	36.15	34.0%	866	**NR**	2.2			
10/2/03	28.15	45.0%	248	**NR**	**NR**	415.07	69.6	72.8
10/6/03	23.29	52.6%	548	**NR**	**NR**	490.41	**74.3**	**77.0**
10/9/03	20.97	56.5%	231	**NR**	**NR**	432.58	70.9	73.9
10/13/03	19.44	59.8%	299	**NR**	**NR**	429.29	70.6	73.7
90th Percentile Concentration			**1,068**	**11.9**	**20.7**			

Note: NR = No reduction required

a Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.

b Reductions for individual samples (shaded area) are included for reference only.

Table C-4. Required Load Reduction for Baker Creek – Mile 17.5

Sample Date	Flow	PDFE	Sample Concentration	Required Reduction		Geometric Mean[a]	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target – MOS (847 CFU/100 ml)		Sample to Target (126 CFU/100 ml)	Sample to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]	[CFU/100 ml]	[%]	[%]
8/20/03	8.20	48.4%	517	**NR**	**NR**			
8/28/03	6.10	60.0%	649	**NR**	**NR**			
9/2/03	6.37	58.3%	866	**NR**	2.2			
9/9/03	7.27	53.1%	921	**NR**	8.0			
9/16/03	6.20	59.4%	921	**NR**	8.0	755.71	83.3	85.0
9/29/03	11.10	34.5%	1,300	27.6	34.8			
10/2/03	8.66	45.7%	649	**NR**	**NR**	908.75	**86.1**	**87.6**
10/6/03	7.17	53.7%	548	**NR**	**NR**	829.27	84.8	86.4
10/9/03	6.46	57.8%	579	**NR**	**NR**	781.08	83.9	85.5
10/13/03	5.99	60.9%	727	**NR**	**NR**	750.89	83.2	85.0
90th Percentile Concentration			**959**	**1.87**	**11.7**			

Note: NR = No reduction required
[a] Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.
[b] Reductions for individual samples (shaded area) are included for reference only.

Table C-5. Required Load Reduction for Bat Creek – Mile 19.3

Sample Date	Flow	PDFE	Sample Concentration	Required Reduction: Sample to Target (941 CFU/100 ml)	Required Reduction: Sample to Target – MOS (847 CFU/100 ml)	Geometric Mean[a]	Required Reduction: Sample to Target (126 CFU/100 ml)	Required Reduction: Sample to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]	[CFU/100 ml]	[%]	[%]
8/20/03	7.15	57.4%	1,203	21.8	29.6			
8/28/03	5.65	66.5%	980	4.0	13.6			
9/2/03	7.01	58.2%	>2,419	>61.1	>65.0			
9/9/03	7.82	53.7%	866	**NR**	2.2			
9/16/03	6.07	63.7%	1,733	45.7	51.1	1,337.48	90.6	>91.6
9/29/03	13.09	32.4%	1,734	45.7	51.2			
10/2/03	8.32	51.2%	1,300	27.6	34.8	1,522.61	**91.7**	**>92.6**
10/6/03	6.49	61.2%	>2,419	>61.1	65.0	1,522.61	**91.7**	**>92.6**
10/9/03	5.89	65.0%	980	4.0	13.6	1,414.80	91.1	92.0
10/13/03	5.57	67.2%	649	**NR**	**NR**	1,348.39	90.7	91.6
90th Percentile Concentration			**>2,419**	**>61.1**	**>65.0**			

Note: NR = No reduction required
[a] Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.
[b] Reductions for individual samples (shaded area) are included for reference only.

Table C-6. Required Load Reduction for Fork Creek – Mile 6.5

Sample Date	Flow	PDFE	Sample Concentration	Required Reduction		Geometric Mean[a]	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target – MOS (847 CFU/100 ml)		Sample to Target (126 CFU/100 ml)	Sample to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]	[CFU/100 ml]	[%]	[%]
8/20/03	25.97	47.4%	1,553	39.4	45.5			
8/28/03	19.35	59.2%	1,300	27.6	34.8			
9/2/03	20.22	57.3%	1,414	33.5	40.1			
9/9/03	23.27	51.5%	1,120	16.0	24.4			
9/16/03	19.81	58.1%	1,733	45.7	51.1	1,408.37	91.1	92.0
9/29/03	35.74	33.6%	>2,419	>61.1	>65.0			
10/2/03	30.03	41.5%	>2,419	>61.1	>65.0	>1,742.40	>92.8	>93.5
10/6/03	25.86	47.5%	>2,419	>61.1	>65.0	>1,939.92	>93.5	>94.2
10/9/03	23.61	50.9%	>2,419	>61.1	>65.0	>2,012.61	**>93.7**	**>94.4**
10/13/03	22.04	53.9%	1,120	16.0	24.4	>2,012.61	**>93.7**	**>94.4**
90th Percentile Concentration			**>2,419**	**>61.1**	**>65.0**			

Note: NR = No reduction required
[a] Geometric Mean is calculated whenever 5 or more samples are collected over a period of not more than 30 consecutive days.
[b] Reductions for individual samples (shaded area) are included for reference only.

Table C-7 TMDLs, WLAs, & LAs for Little Tennessee River Watershed

HUC-12 Subwatershed (06010204__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs [a]		CAFOs	MS4s [d]	Precipitation Induced Nonpoint Sources	Other Direct Sources [e]
				Monthly Avg.	Daily Max.				
			[% Red.]	[CFU/day]	[CFU/day]	[CFU/day]	[% Red.]	[% Red.]	[CFU/day]
0205	Ninemile Creek	TN06010204042 – 1000	40.7	8.107×10^7	6.055×10^8	0	46.8	46.8	0
0409	Notchy Creek	TN06010204045 – 1000	82.5	NA	NA	NA	NA	84.3	0
0502	Baker Creek	TN06010204043 – 1000	86.1	8.584×10^7 [c]	6.411×10^8 [c]	NA	87.6	87.6	0
0504	Bat Creek	TN06010204004 - 1000	>91.7	4.101×10^9 [b]	3.063×10^{10} [b]	NA	>92.6	>92.6	0
0505	Fork Creek	TN06010204002 – 1000	>93.7	NA	NA	0	NA	>94.4	0

Notes: NA = Not Applicable.

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

b. The WLA listed is for the subwatershed and is equal to the sum of the WLAs for the individual facilities. WLAs for individual WWTFs corresponds to existing E. coli permit limits at facility design flow.

c. The WLAs listed apply to NPDES permitted discharges from WWTFs only. Pathogen loading due to collection system failure is considered to be unpermitted point source loading from the municipal WWTF. With respect to pathogen loading from leaking collection systems, a WLA of zero is assigned. It is recognized, however, that a WLA of 0 CFU/day may not be practical. For these unpermitted sources, the WLA is interpreted to mean a reduction in pathogen 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.

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

e. 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 CFU/day may not be practical. For these sources, the LA is interpreted to mean a reduction in pathogen 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.

APPENDIX D

Hydrodynamic Modeling Methodology

HYDRODYNAMIC MODELING METHODOLOGY

D.1 Model Selection

The Loading Simulation Program C++ (LSPC) was selected for flow simulation of pathogen-impaired waters in the subwatersheds of the Little Tennessee River Watershed. LSPC is a watershed model capable of performing flow routing through stream reaches. LSPC is a dynamic watershed model based on the Hydrologic Simulation Program - Fortran (HSPF)

D.2 Model Set Up

The Little Tennessee River Watershed was delineated into subwatersheds in order to facilitate model hydrologic calibration. Boundaries were constructed so that subwatershed "pour points" coincided with HUC-12 delineations, 303(d)-listed waterbodies, and water quality monitoring stations. Watershed delineation was based on the NHD stream coverage and Digital Elevation Model (DEM) data. This discretization facilitates simulation of daily flows at water quality monitoring stations.

Several computer-based tools were utilized to generate input data for the LSPC model. The Watershed Characterization System (WCS), a geographic information system (GIS) tool, was used to display, analyze, and compile available information to support hydrology model simulations for selected subwatersheds. This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics.

An important factor influencing model results is the precipitation data contained in the meteorological data files used in these simulations. Weather data from multiple meteorological stations were available for the time period from January 1970 through August 2004. Meteorological data for a selected 11-year period were used for all simulations. The first year of this period was used for model stabilization with simulation data from the subsequent 10-year period (10/1/94 – 9/30/04) used for TMDL analysis.

D.3 Model Calibration

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

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

The results of the hydrologic calibration for Sinking Creek at Afton, Tennessee, USGS Station 03466228, are shown in Table D-1 and Figures D-1 and D-2.

Table D-1. Hydrologic Calibration Summary: Sinking Creek (USGS 03466228)

		15.17498776	
Simulation Name:	USGS03466228	**Simulation Period:**	
		Watershed Area (ac):	9715.10
Period for Flow Analysis			
Begin Date:	**10/01/90**	**Baseflow PERCENTILE:**	2.5
End Date:	**09/30/00**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**122.33**	Total Observed In-stream Flow:	**130.90**
Total of highest 10% flows:	**41.48**	Total of Observed highest 10% flows:	**45.73**
Total of lowest 50% flows:	**25.77**	Total of Observed Lowest 50% flows:	**27.02**
Simulated Summer Flow Volume (months 7-9):	**16.07**	Observed Summer Flow Volume (7-9):	**17.40**
Simulated Fall Flow Volume (months 10-12):	**16.69**	Observed Fall Flow Volume (10-12):	**17.49**
Simulated Winter Flow Volume (months 1-3):	**51.48**	Observed Winter Flow Volume (1-3):	**57.25**
Simulated Spring Flow Volume (months 4-6):	**38.09**	Observed Spring Flow Volume (4-6):	**38.77**
Total Simulated Storm Volume:	**98.72**	Total Observed Storm Volume:	**104.08**
Simulated Summer Storm Volume (7-9):	**10.14**	Observed Summer Storm Volume (7-9):	**10.64**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**-6.55**	10	
Error in 50% lowest flows:	**-4.62**	10	
Error in 10% highest flows:	**-9.29**	15	
Seasonal volume error - Summer:	**-7.60**	30	
Seasonal volume error - Fall:	**-4.58**	30	
Seasonal volume error - Winter:	**-10.08**	30	
Seasonal volume error - Spring:	**-1.75**	30	
Error in storm volumes:	**-5.15**	20	
Error in summer storm volumes:	**-4.65**	50	

Criteria for Median Monthly Flow Comparisons	
Lower Bound (Percentile):	25
Upper Bound (Percentile):	75

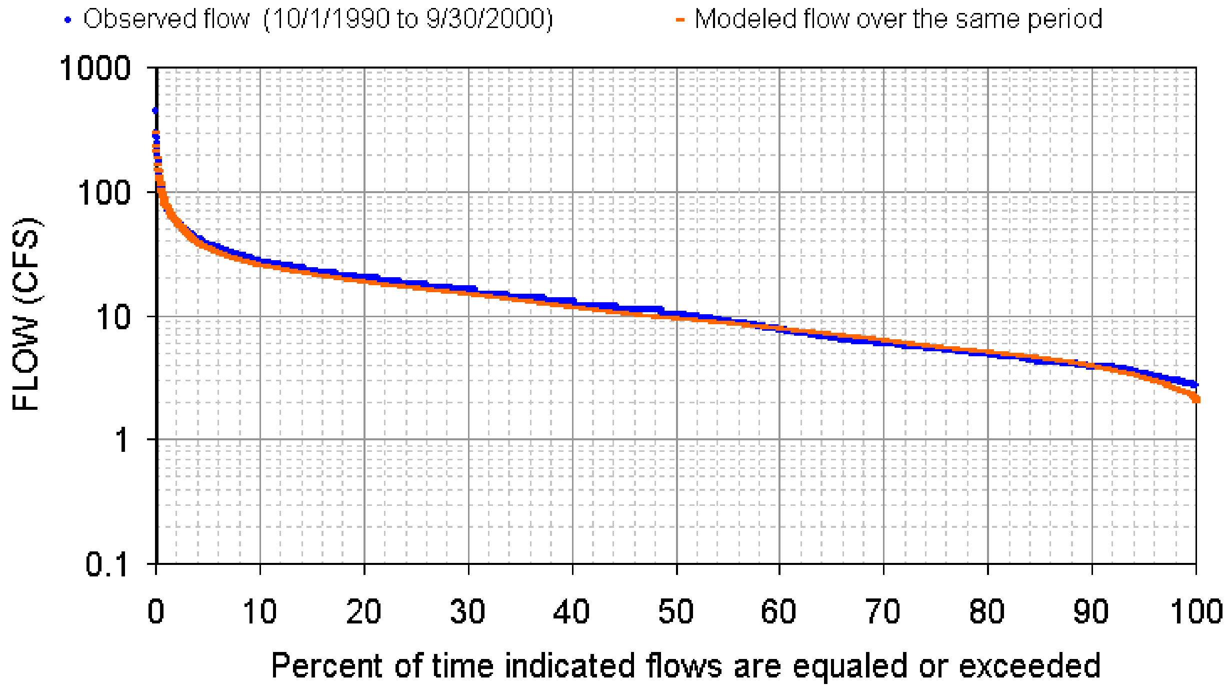

Figure D-1. Hydrologic Calibration: Sinking Creek, USGS 03466228 (WYs1991-2000)

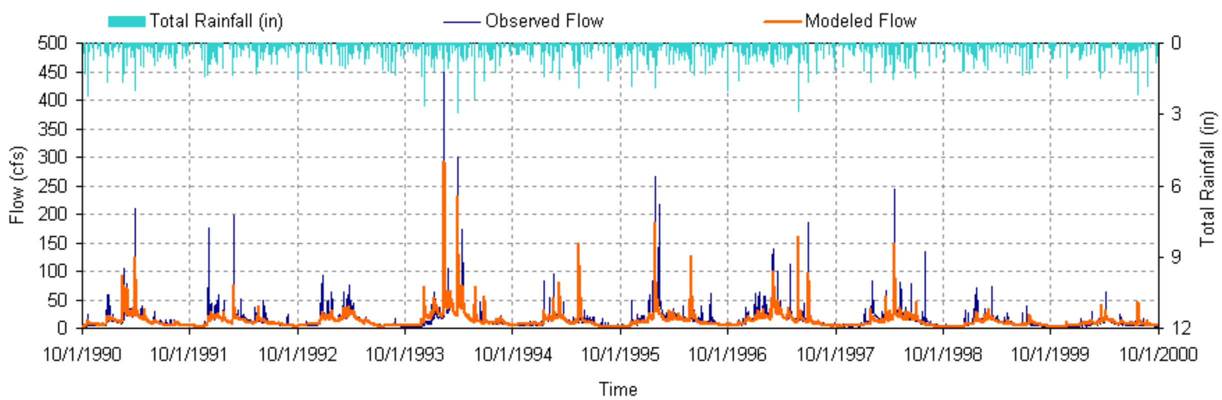

Figure D-2. 10-Year Hydrologic Comparison: Sinking Creek, USGS 03466228

APPENDIX E

Public Notice Announcement

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR E. COLI IN LITTLE TENNESSEE RIVER WATERSHED (HUC 06010204), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed Total Maximum Daily Load (TMDL) for E. coli in the Little Tennessee River watershed, located in eastern Tennessee. Section 303(d) of the Clean Water Act requires states to develop TMDLs for waters on their impaired waters list. TMDLs must determine the allowable pollutant load that the water can assimilate, allocate that load among the various point and nonpoint sources, include a margin of safety, and address seasonality.

A number of waterbodies in the Little Tennessee River watershed are listed on Tennessee's Final 2004 303(d) list as not supporting designated use classifications due, in part, to discharge of pathogens from pasture land and livestock in stream. The TMDL utilizes Tennessee's general water quality criteria, continuous flow data from a USGS discharge monitoring station located in proximity to the watershed, site specific water quality monitoring data, a calibrated hydrologic model, load duration curves, and an appropriate Margin of Safety (MOS) to establish allowable loadings of pathogens which will result in the reduced in-stream concentrations and attainment of water quality standards. The TMDL requires reductions of pathogen loading on the order of 40-94% in the listed waterbodies.

The proposed Little Tennessee River E. coli TMDL may be downloaded from the 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:

Vicki S. Steed, P.E., Watershed Management Section
Telephone: 615-532-0707

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

Persons wishing to comment on the proposed TMDLs are invited to submit their comments in writing no later than March 13, 2006 to:

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

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

The TMDL and supporting information are on file at the Division of Water Pollution Control, 6th Floor, L & C Annex, 401 Church Street, Nashville, Tennessee. They may be inspected during normal office hours. Copies of the information on file are available on request.