TOTAL MAXIMUM DAILY LOAD (TMDL)

for

E. Coli

in the

Guntersville Lake Watershed (HUC 06030001)

Franklin, Grundy, and

Marion Counties, Tennessee

FINAL

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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
CS	(Sanitary Sewer) Collection Systems
DA	Drainage Area
DEM	Digital Elevation Model
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^{++}
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
RM	River Mile
SSO	Sanitary Sewer Overflow
STP	Sewage Treatment Plant
SWMP	Storm Water Management Plan
TDA	Tennessee Department of Agriculture
TDEC	Tennessee Department of Environment & Conservation
TDOT	Tennessee Department of Transportation
TMDL	Total Maximum Daily Load
TWRA	Tennessee Wildlife Resources Agency
USGS	United States Geological Survey
UCF	Unit Conversion Factor
UT	Unnamed Tributary
UTK	University of Tennessee, Knoxville
WCS	Watershed Characterization System
WLA	Waste Load Allocation
WWTF	Wastewater Treatment Facility

SUMMARY SHEET

Total Maximum Daily Load for E. Coli in Selected Waterbodies of the Guntersville Lake Watershed (HUC 06030001)

Impaired Waterbody Information

State: Tennessee
Counties: Franklin, Grundy, and Marion
Watershed: Guntersville Lake (HUC 06030001)
Constituents of Concern: E. coli

Impaired Waterbodies Addressed in This Document (from the Final 2006 303(d) List):

Waterbody ID	Waterbody	RM not Fully Supporting
TN06030001057 – 0511	UNNAMED TRIB TO LAUREL LAKE	0.5
TN06030001057 – 0811	HEDDEN BRANCH	1.5
TN06030001057 – 0812	CLOUSE HILL BRANCH	1.9
TN06030001057 – 0815	LITTLE FIERY GIZZARD CREEK	3.7

Designated Uses:

The designated use classifications for all impaired waterbodies in the Guntersville Lake watershed include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. Use classifications for the unnamed tributary to Laurel Lake include domestic water supply and industrial water supply.

Water Quality Goal:

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

> The concentration of the E. coli group shall not exceed 126 colony forming units per 100 ml, as a geometric mean based on a minimum of 5 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. 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.

Note: At the time of this TMDL analysis, high quality waters were designated as Tier II and Tier III streams. The proposed revised water quality standards redefine high quality waters as Exceptional Tennessee Waters. For further information on Tennessee's current general water quality standards, see:

http://www.state.tn.us/sos/rules/1200/1200-04/1200-04-03.pdf.

For further information on the proposed revised general water quality standards and Tennessee's Antidegradation Statement, including the definition of Exceptional Tennessee Waters, see:

http://state.tn.us/environment/wpc/publications/1200_04_03_2nd_draft.pdf.

TMDL Scope:

Waterbodies identified on the Final 2006 303(d) List as impaired due to E. coli. TMDLs were developed for impaired waterbodies on a waterbody drainage area basis.

Analysis/Methodology:

The TMDLs for impaired waterbodies in the Guntersville Lake watershed were developed using a load duration curve methodology to assure compliance with the E. coli 126 CFU/100 mL geometric mean and the 941 CFU/100 mL maximum water quality criteria. 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 also used to determine percent load reduction goals to meet the target maximum loading for E. coli. When sufficient data were available, load reductions were also determined based on the geometric mean criterion.

Critical Conditions:

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

For each impaired waterbody, critical conditions were determined by evaluating the percent load reduction goals, for each hydrologic flow zone, to meet the target (TMDL) loading for E. coli. The percent load reduction goal of the greatest magnitude corresponds with the critical flow zone.

Seasonal Variation:

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

Margin of Safety (MOS):

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

TMDLs, WLAs, & LAs

Summary of TMDLs, WLAs, & LAs for Impaired Waterbodies

HUC-12 Subwatershed (06030001__)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs[a]			LAs
					WWTFs[b]	Collection Systems	MS4s[c]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/d/ac]	[CFU/d/ac]
0201	Unnamed Tributary to Laurel Lake	TN06030001057 – 0511	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	0	NA	$9.08 \times 10^{7} * Q$
0202	Hedden Branch	TN06030001057 – 0811	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	0	NA	$1.91 \times 10^{7} * Q$
	Clouse Hill Branch	TN06030001057 – 0812	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	0	NA	$2.97 \times 10^{7} * Q$
	Little Fiery Gizzard Creek	TN06030001057 – 0815	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	4.276×10^{8}	0	NA	$1.05 \times 10^{7} * Q - 2.16 \times 10^{5}$

Note: *NA = Not applicable.*
Q = Mean Daily In-stream Flow (cfs).

a. *There are no CAFOs in impaired subwatersheds of the Guntersville Lake watershed.*

b. *WLAs for WWTFs expressed as E. coli loads (CFU/day). Future WWTFs must meet water quality standards as specified in their NPDES permits.*

c. *There are currently no MS4s in impaired subwatersheds of the Guntersville Lake watershed. Future MS4s will be assigned waste load allocations (WLAs) consistent with load allocations (LAs) assigned to precipitation induced nonpoint sources.*

E. COLI TOTAL MAXIMUM DAILY LOAD (TMDL) GUNTERSVILLE LAKE WATERSHED (HUC 06030001)

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 Tennessee waterbodies in the Guntersville Lake watershed identified on the Final 2006 303(d) List as not supporting designated uses due to Escherichia coli (E. coli). TMDL analyses were performed on a waterbody drainage area basis for impaired waterbodies in Tennessee.

3.0 WATERSHED DESCRIPTION

The northern portion (approximately 17%) of the Guntersville Lake watershed (HUC 06030001) is located in southern middle Tennessee (Figure 1), with the largest portion in northern Alabama (82%), and a small portion in Georgia (1%). The Guntersville Lake watershed, in Tennessee, lies within the Level III Southwestern Appalachians (68) ecoregion as shown in Figure 2 (USEPA, 1997). The impaired subwatersheds lie in the Level IV Cumberland Plateau (68a) ecoregion. Detailed information about the Guntersville Lake watershed, including descriptions of Level IV ecoregions, will be posted, when it becomes available (approximately mid-2008), at:

http://state.tn.us/environment/wpc/watershed/wsmplans/

The Guntersville Lake watershed, located in Franklin, Grundy, and Marion Counties, Tennessee; Blount, Cullman, De Kalb, Etowah, Jackson, and Marshall Counties, Alabama; and Dade County, Georgia; has a drainage area of approximately 1984 square miles (mi^2). 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 Guntersville Lake watershed have occurred since 1993 as a result of development, this is the most current land use data readily available for GIS-interfaced hydrologic model input. Land use for the Guntersville Lake watershed is summarized in Table 1 and shown in Figure 3. Predominate land use in the Guntersville Lake watershed is forest (70.6%) followed by agriculture (28.0%). Urban areas represent approximately 1.4% of the total drainage area of the watershed. Details of land use distribution of E. coli-impaired subwatersheds in the Guntersville Lake watershed are presented in Appendix A.

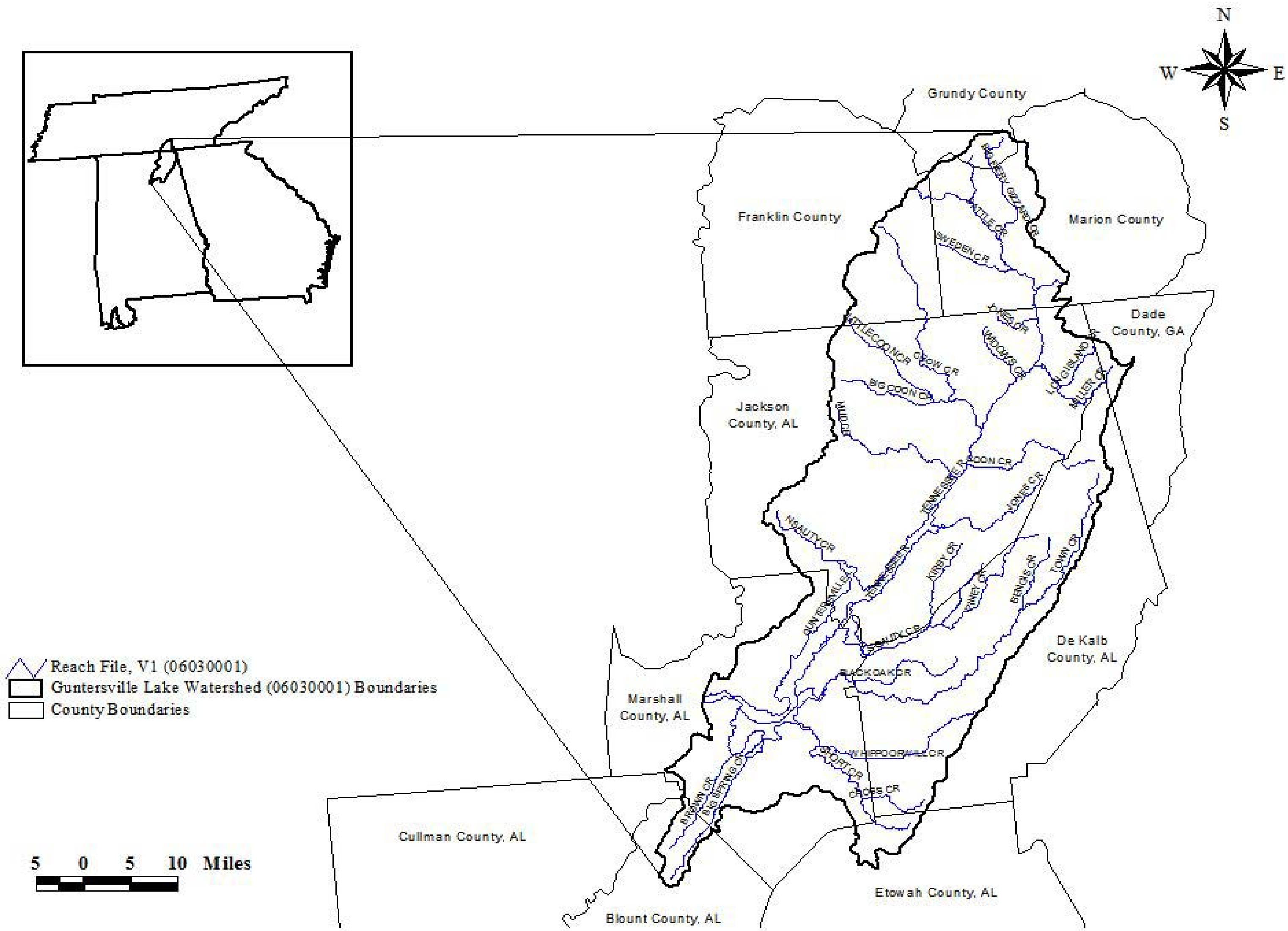

Figure 1. Location of the Guntersville Lake Watershed.

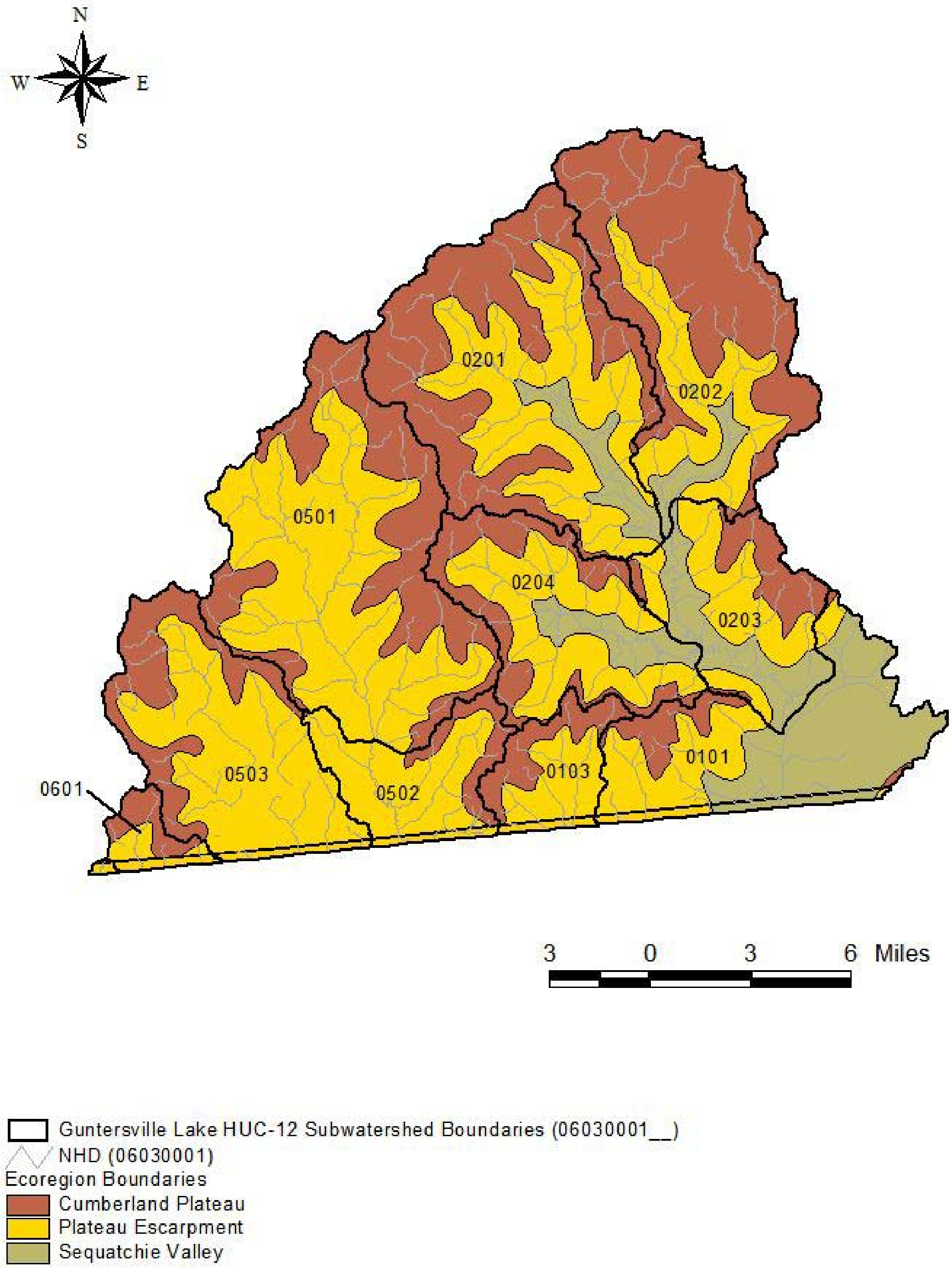

Figure 2. Level IV Ecoregions in the Guntersville Lake Watershed, Tennessee.

Table 1. MRLC Land Use Distribution – Guntersville Lake Watershed

Land Use	Area	
	[acres]	[%]
Bare Rock/Sand/Clay	3	0.0*
Deciduous Forest	479,587	37.8
Emergent Herbaceous Wetlands	2,325	0.2
Evergreen Forest	109,611	8.6
High Intensity Commercial/ Industrial/Transportation	5,840	0.5
High Intensity Residential	833	0.1
Low Intensity Residential	5,527	0.4
Mixed Forest	216,724	17.1
Open Water	65,716	5.2
Other Grasses (Urban/recreational)	2,186	0.2
Pasture/Hay	198,718	15.7
Quarries/Strip Mines/Gravel Pits	529	0.0*
Row Crops	156,288	12.3
Transitional	5,497	0.4
Woody Wetlands	20,173	1.6
Total	**1,269,556**	**100.00**

* < 0.05%

4.0 PROBLEM DEFINITION

The State of Tennessee's Final 2006 303(d) List (TDEC, 2006), http://state.tn.us/environment/wpc/publications/303d2006.pdf, was approved by the U.S. Environmental Protection Agency (EPA), Region IV in October of 2006. The list identified four (4) waterbody segments in the Guntersville Lake watershed as not fully supporting designated use classifications due, in part, to E. coli. See Table 2 and Figure 4. The designated use classifications for these waterbodies include fish and aquatic life, irrigation, livestock watering & wildlife, recreation, domestic water supply, and industrial water supply.

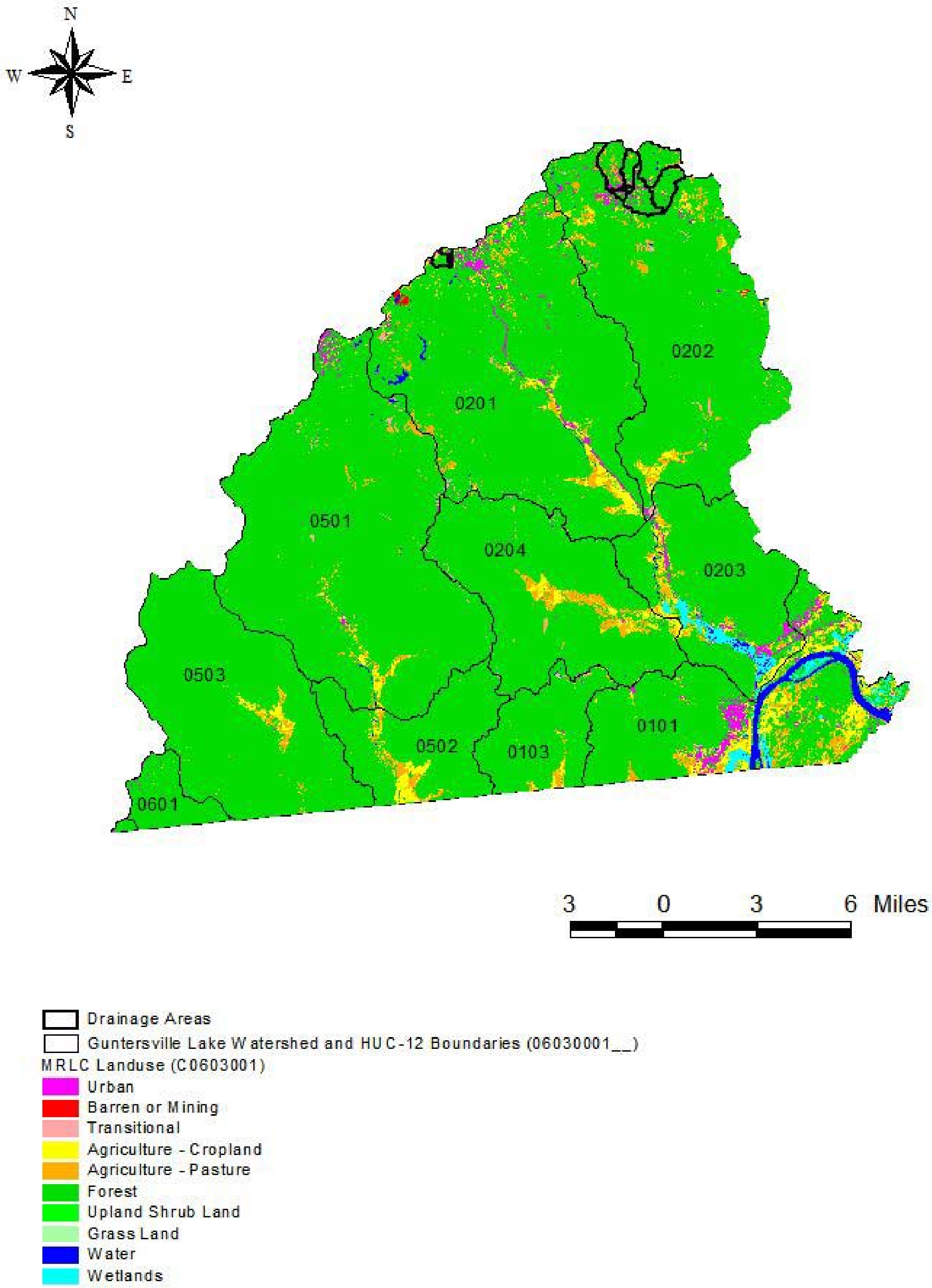

Figure 3. Land Use Characteristics of the Guntersville Lake Watershed, Tennessee.

Table 2. Final 2006 303(d) List for E. coli – Guntersville Lake Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	CAUSE / TMDL Priority	Pollutant Source
TN060300010057 – 0511	UNNAMED TRIB TO LAUREL LAKE	0.5	Nonpriority Organics Escherichia coli	Collection System Failure Waste Storage Tank Leaks
TN06030001057 – 0811	HEDDEN BRANCH	1.5	Escherichia coli	Pasture Grazing Septic Tanks
TN06030001057 – 0812	CLOUSE HILL BRANCH	1.9	Escherichia coli	Septic Tanks
TN06030001057 – 0815	LITTLE FIERY GIZZARD CREEK	3.7	Escherichia coli	Pasture Grazing Septic Tanks

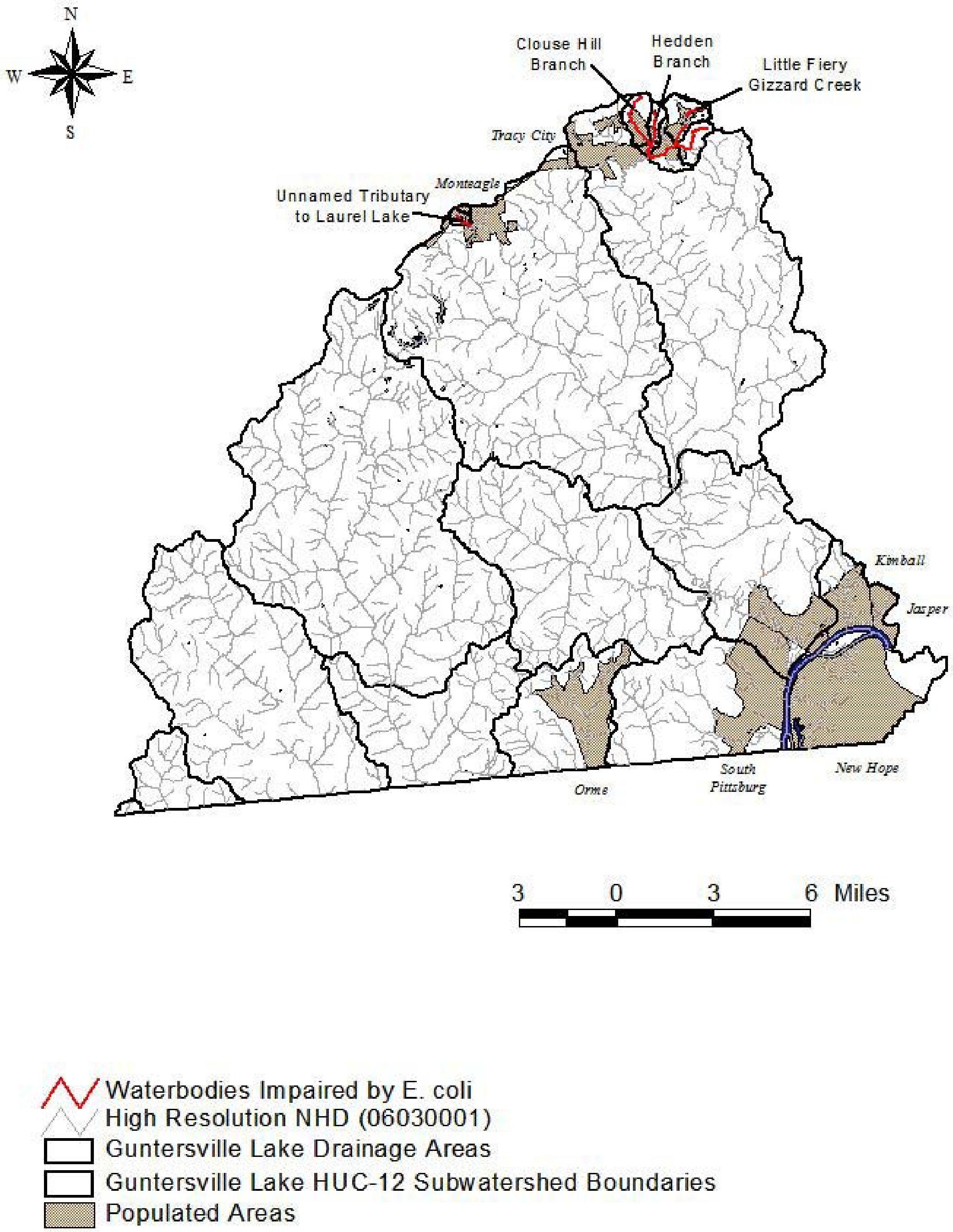

Figure 4. Waterbodies Impaired by E. Coli (as Documented on the Final 2006 303(d) List).

5.0 WATER QUALITY CRITERIA & TMDL TARGET

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

As of December 10, 2007, the only E. coli impaired waterbody in the Guntersville Lake watershed designated as either State Scenic River, Tier II, or Tier III streams is the headwaters portion of Little Fiery Gizzard Creek in the Grundy Lakes State Recreation Area. However, there are no E. coli data available on Little Fiery Gizzard Creek within the boundaries of the Grundy Lakes State Recreation Area to calculate potential load reduction goals. In addition, limited E. coli data collected from LFGIZ003.0GY, downstream from Grundy Lakes State Recreation Area, suggest that the portion of the waterbody within the recreation area is not impaired.

For further information concerning Tennessee's general water quality criteria and Tennessee's Antidegradation Statement, including the definition of high quality waters, see:

http://www.state.tn.us/sos/rules/1200/1200-04/1200-04-03.pdf.

The geometric mean standard for the E. coli group of 126 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 E. coli impaired waterbodies in the Guntersville Lake watershed.

6.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

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

- HUC-12 060300010201:
  - Site A – Unnamed Tributary to Laurel Lake
- HUC-12 060300010202:
  - HEDDE000.5GY – Hedden Branch, downstream of intersection of 10th and Hwy 41
  - CHILL000.1GY – Clouse Hill Branch, at US 41 and Railroad Avenue
  - LFGIZ002.2GY – Little Fiery Gizzard Creek, upstream of confluence with UT at Hwy 41
  - LFGIZ003.0GY – Little Fiery Gizzard Creek, at Tracy City Lake Road

The locations of these monitoring stations are shown in Figure 5. Water quality monitoring results for these stations are tabulated in Appendix B. Examination of the data shows exceedances of the 941 CFU /100 mL maximum E. coli standard at four of the five monitoring stations. Water quality monitoring results are summarized in Table 3.

Two of the water quality monitoring stations (Table 3 and Appendix B) have at least one E. coli sample value reported as >2400. In addition, at one of the two sites, the maximum E. coli sample value is >2400. For the purpose of calculating summary data statistics, TMDLs, Waste Load

Allocations (WLAs), and Load Allocations (LAs), these data values are treated as (equal to) 2400. Therefore, the calculated results are considered to be estimates. Future E. coli sample analyses at all sites should follow established protocol. See Section 9.4.

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

Table 3. Summary of Water Quality Monitoring Data

Monitoring Station	E. Coli (Single Sample Max. WQ Target = 941 CFU/100 mL)					
	Data Pts.	Date Range	[CFU/100 mL]			Exceed WQ Max. Target
			Min.	Avg.	Max.	
Site A	2	9/98-10/98	33	1010	1986	1
HEDDE000.5GY	30	5/00-1/06	10.9	423	2419.2	3
CHILL000.1GY	30	5/00-6/06	27.2	496	>2400	5
LFGIZ002.2GY	18	5/00-2/02	20	371	1400	3
LFGIZ003.0GY	8	5/00-7/00	2	10	40	0

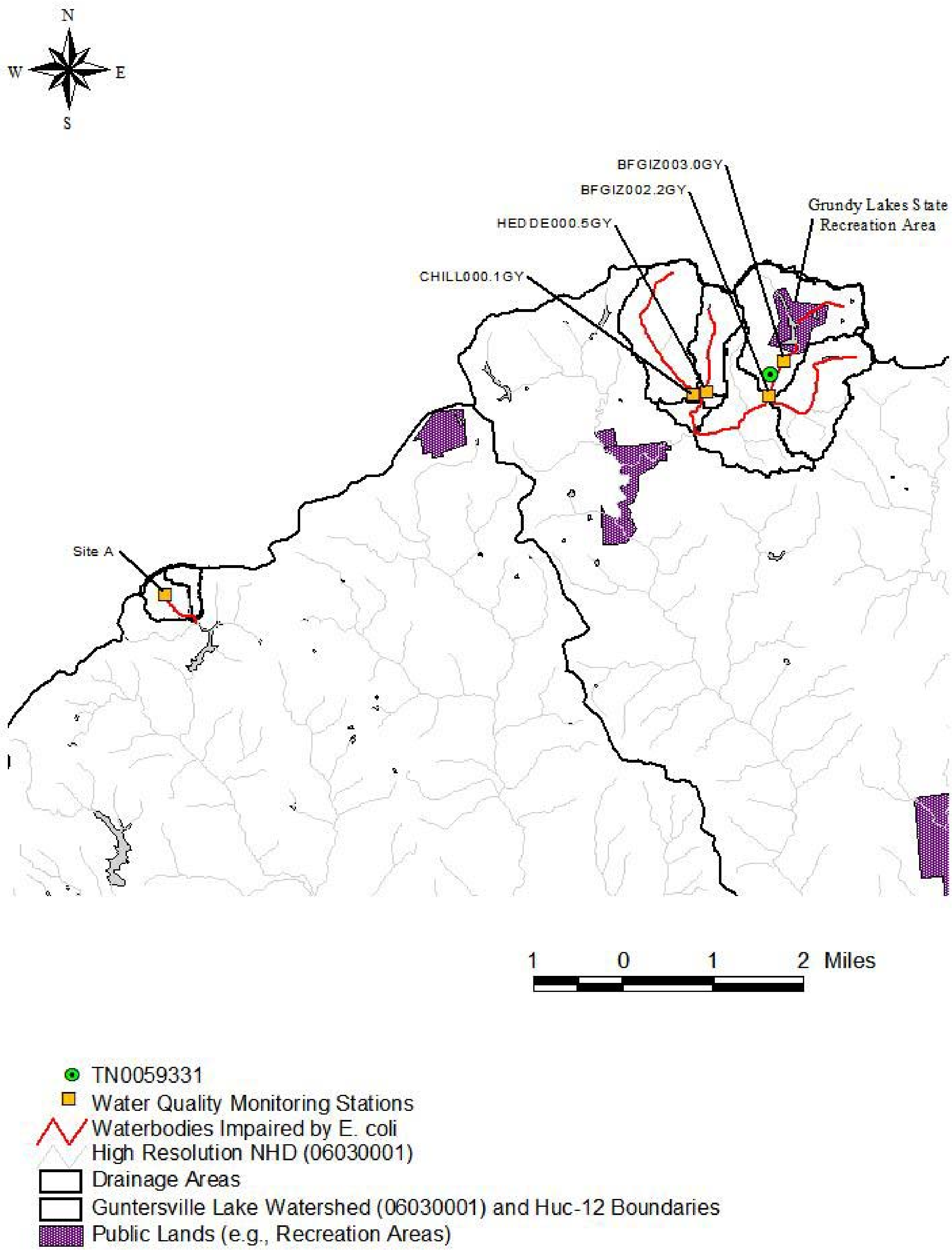

Figure 5. Monitoring Stations located in the Guntersville Lake Watershed.

7.0 SOURCE ASSESSMENT

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

Under the Clean Water Act, sources are classified as either point or nonpoint sources. Under 40 CFR §122.2 (http://www.epa.gov/epacfr40/chapt-I.info/chi-toc.htm), 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 (http://cfpub1.epa.gov/npdes/index.cfm) regulates point source discharges. Point sources can be described by three broad categories: 1) NPDES regulated municipal (http://cfpub1.epa.gov/npdes/home.cfm?program_id=13) and industrial (http://cfpub1.epa.gov/npdes/home.cfm?program_id=14) wastewater treatment facilities (WWTFs); 2) NPDES regulated industrial and municipal storm water discharges (http://cfpub1.epa.gov/npdes/home.cfm?program_id=6); and 3) NPDES regulated Concentrated Animal Feeding Operations (CAFOs) (http://cfpub1.epa.gov/npdes/home.cfm?program_id=7). A TMDL must provide 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 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 was one (1) NPDES permitted WWTF in the impaired subwatersheds of the Guntersville Lake watershed authorized to discharge treated sanitary wastewater during the TMDL analysis period. This facility, the Grundy County – Tracy Manufacturing Company, NPDES permit number TN0059331, discharges treated domestic wastewater to a dry ditch to an unnamed tributary to Little Fiery Gizzard Creek at mile 2.6. The permit limits for discharges from this WWTF are in accordance with the coliform criteria specified in Tennessee Water Quality Standards for protection of the recreation use classification.

Non-permitted point sources of (potential) E. coli contamination of surface waters associated with STP collection systems include leaking collection systems (LCSs) and sanitary sewer overflows (SSOs). The Tracy City sanitary sewage collection system, located in the Little Fiery Gizzard and Hedden Branch subwatersheds, is serviced by the Monteagle STP, located (and discharging) outside of impaired subwatersheds of the Guntersville Lake watershed.

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.

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. Phase I of the EPA storm water program (http://cfpub.epa.gov/npdes/stormwater/swphases.cfm#phase1) requires large and medium MS4s to obtain NPDES storm water permits. Large and medium MS4s are those located in incorporated places or counties serving populations greater than 100,000 people. At present, there are no MS4s of this size in the Guntersville Lake watershed.

As of March 2003, regulated small MS4s in Tennessee must also obtain NPDES permits in accordance with the Phase II storm water program (http://cfpub.epa.gov/npdes/stormwater/swphases.cfm#phase2). A small MS4 is designated as *regulated* if: a) it is located within the boundaries of a defined urbanized area that has a residential population of at least 50,000 people and an overall population density of 1,000 people per square mile; b) it is located outside of an urbanized area but within a jurisdiction with a population of at least 10,000 people, a population density of 1,000 people per square mile, and has the potential to cause an adverse impact on water quality; or c) it is located outside of an urbanized area but contributes substantially to the pollutant loadings of a physically interconnected MS4 regulated by the NPDES storm water program. Most regulated small MS4s in Tennessee obtain coverage under the *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (http://state.tn.us/environment/wpc/ppo/TN%20Small%20MS4%20Modified%20General%20Permit%202003.pdf), (TDEC, 2003). There are no permitted Phase II MS4s located in the drainage areas of (E. coli) 303(d)-listed waterbodies in the Guntersville Lake watershed.

The Tennessee Department of Transportation (TDOT) has been issued an individual MS4 permit (TNS077585) that authorizes discharges of storm water runoff from State road and interstate highway right-of-ways that TDOT owns or maintains, discharges of storm water runoff from TDOT owned or operated facilities, and certain specified non-storm water discharges. This permit covers all eligible TDOT discharges statewide, including those located outside of urbanized areas. TDOT's individual MS4 permit may be obtained from the Tennessee Department of Environment and Conservation (TDEC) website: http://state.tn.us/environment/wpc/stormh2o/TNS077585.pdf.

For information regarding storm water permitting in Tennessee, see the TDEC website: 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 E. coli 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* (http://state.tn.us/environment/wpc/programs/cafo/CAFO_GP_04.pdf), while larger, Class I CAFOs are required to obtain an individual NPDES permit.

There was one Class II CAFO (TNA000086) in the Guntersville Lake watershed with coverage under the general NPDES permit during the TMDL analysis period. This CAFO was terminated in November, 2004. There were no Class I CAFOs with individual permits located in the watershed.

7.2 Nonpoint Sources

Nonpoint sources of coliform bacteria are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. These sources generally, but not always, involve accumulation of coliform bacteria on land surfaces and wash off as a result of storm events. Nonpoint sources of E. coli loading are primarily associated with agricultural and urban land uses. The vast majority of waterbodies identified on the Final 2006 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 (i.e., deer and other wildlife) often have direct access to waterbodies and can provide a concentrated source of coliform bacteria loading directly to a stream.

Data sources related to livestock operations include the 2002 Census of Agriculture (http://www.nass.usda.gov/census/census02/volume1/tn/index2.htm). Livestock data, for counties containing E. coli-impaired subwatersheds, are summarized in Table 4. Note that, due to confidentiality issues, any tabulated item that identifies data reported by a respondent or allows a respondent's data to be accurately estimated or derived is suppressed and coded with a 'D' (USDA, 2004).

7.2.3 Failing Septic Systems

Some coliform loading in the Guntersville Lake watershed can be attributed to failure of septic systems and illicit discharges of raw sewage. Estimates from 2000 county census data of people in E. coli-impaired subwatersheds of the Guntersville Lake watershed utilizing septic systems were compiled using the WCS and are summarized in Table 5. In southern middle Tennessee, it is estimated that there are approximately 2.37 people per household on septic systems, some of which can be reasonably assumed to be failing. As with livestock in streams, discharges of raw sewage provide a concentrated source of coliform bacteria directly to waterbodies.

Table 4. Livestock Distribution in the Guntersville Lake Watershed

County Name	Livestock Population (2002 Census of Agriculture)*						
	Beef Cow	Milk Cow	Hogs	Sheep	Poultry (Layers)	Poultry (Broilers)	Horses
Grundy	2,939	633	25	(D)	(D)	2,084,176	421
Marion	(D)	(D)	(D)	237	640	925,015	398

* In keeping with the provisions of Title 7 of the United States Code, no data are published in the 2002 Census of Agriculture that would disclose information about the operations of an individual farm or ranch. Any tabulated item that identifies data reported by a respondent or allows a respondent's data to be accurately estimated or derived is suppressed and coded with a 'D' (USDA, 2004).

7.2.4 Urban Development

Nonpoint source loading of coliform bacteria from urban land use areas is attributable to multiple sources. These include: stormwater runoff, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, leaking septic systems, and domestic animals. Impervious surfaces in urban areas allow runoff to be conveyed to streams quickly, without interaction with soils and groundwater. The Drainage Area for the Unnamed Tributary to Laurel Lake (Monteagle area) has the highest percentage of urban land area for impaired subwatersheds in the Guntersville Lake watershed, with 19.9%. Land use for the Guntersville Lake impaired drainage areas is summarized in Figures 6-7 and tabulated in Appendix A.

Table 5. Population on Septic Systems in the Guntersville Lake Watershed

Drainage Area	Population on Septic Systems
UT to Laurel Lake	35
Hedden Branch	310
Clouse Hill Branch	197
Little Fiery Gizzard Creek	417

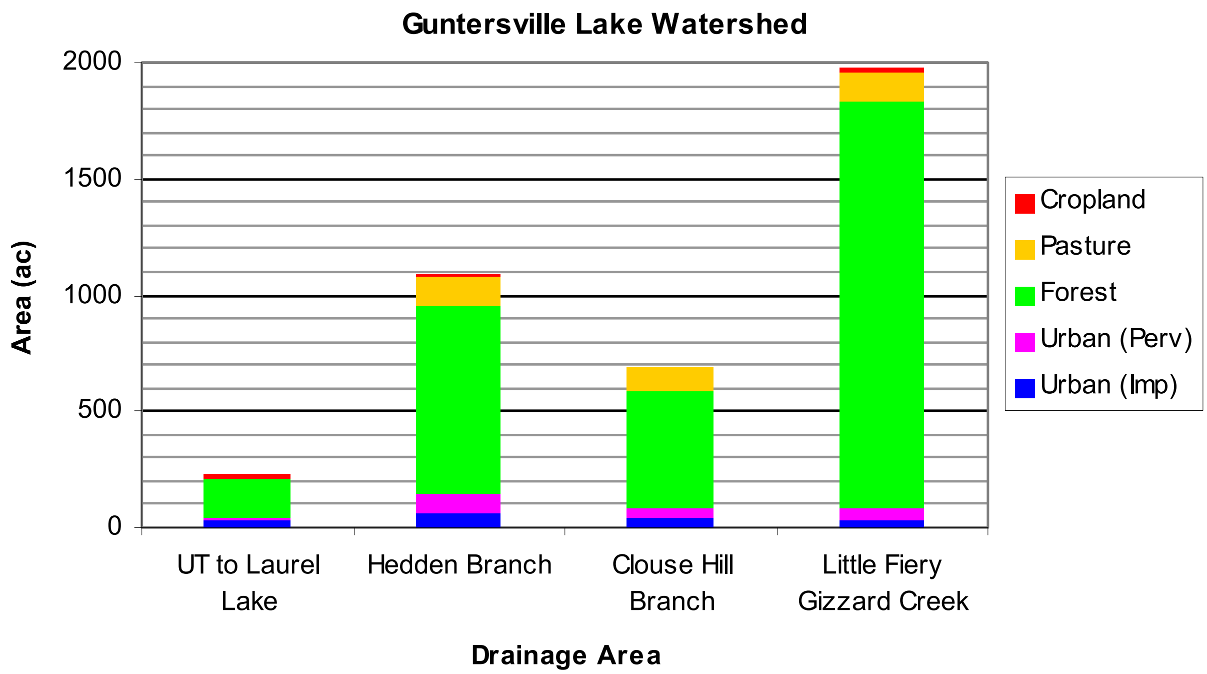

Figure 6. **Land Use Area of Guntersville Lake Watershed Drainage Areas Unnamed Tributary to Laurel Lake, Hedden Branch, Clouse Hill Branch, and Little Fiery Gizzard Creek.**

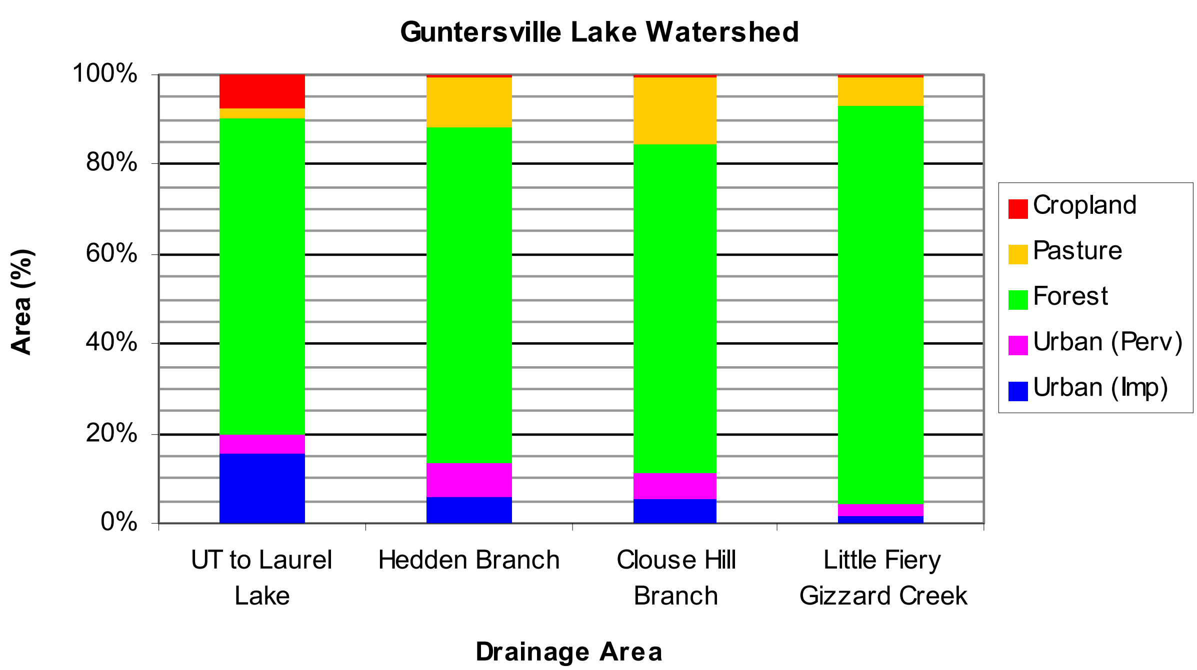

Figure 7. **Land Use Percent of Guntersville Lake Watershed Drainage Areas Unnamed Tributary to Laurel Lake, Hedden Branch, Clouse Hill Branch, and Little Fiery Gizzard Creek.**

8.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOAD

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

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

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) (http://www.epa.gov/epacfr40/chapt-I.info/chi-toc.htm) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure.

This document describes TMDL, Waste Load Allocation (WLA), Load Allocation (LA), and Margin of Safety (MOS) development for waterbodies identified as impaired due to E. coli on the Final 2006 303(d) List.

8.1 Expression of TMDLs, WLAs, & LAs

In this document, the E. coli TMDL is a daily load expressed as a function of mean daily flow (daily loading function). For implementation purposes, corresponding percent load reduction goals (PLRGs) to decrease E. coli loads to TMDL target levels, within each respective flow zone, are also expressed. WLAs & LAs for precipitation-induced loading sources are also expressed as daily loading functions in CFU/day/acre. 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 E. coli TMDL development is the HUC-12 subwatershed containing one or more waterbodies assessed as impaired due to E. coli (as documented on the Final 2006 303(d) List). In some cases, however, TMDLs are developed for an impaired waterbody drainage area only. Determination of the appropriate area to use for analysis (see Table 6) 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. The waterbody drainage area was chosen as the appropriate area unit of analysis for TMDL development for all E. coli impaired waterbodies in the Guntersville Lake watershed

8.3 TMDL Analysis Methodology

TMDLs for the Guntersville Lake watershed were developed using load duration curves for analysis of impaired 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 daily loading functions were expressed for TMDLs, WLAs, LAs, and MOS. In addition, load reductions (PLRGs) for each flow zone were calculated for prioritization of implementation measures according to the methods described in Appendix E.

Table 6. Determination of Analysis Areas for TMDL Development

HUC-12 Subwatershed (06030001)	Impaired Waterbody	Area*
0201	UT to Laurel Lake	DA
0202	Hedden Branch	DA
	Clouse Hill Branch	DA
	Little Fiery Gizzard Creek	DA

* DA = Drainage Area

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 analyses.

The ten-year period from October 1, 1996 to September 30, 2006 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 analyses by using the entire period of flow and water quality data available for the impaired waterbodies.

In two of the subwatersheds, Hedden Branch and Clouse Hill Branch, water quality data have been collected during most flow ranges. For the unnamed tributary to Laurel Lake and Little Fiery Gizzard Creek, most or all water quality data have been collected during the low flow range. For each subwatershed, the critical flow zone has been identified based on the incremental levels of impairment relative to the target loads. However, the critical flow zones for the unnamed tributary to Laurel Lake and Little Fiery Gizzard Creek are based on insufficient data and may not accurately indicate the flow regime and the subsequent primary sources contributing to impairment. Based on the location of the water quality exceedances on the load duration curves, no one delivery mode for E. coli appears to be dominant (see Sections 9.1.2 and 9.1.3 and Appendix E).

Seasonal variation was incorporated in the load duration curves by using the entire 10-year simulation period and all water quality data collected at the monitoring stations. Water quality data were collected during all seasons.

8.5 Margin of Safety

There are two methods for incorporating an MOS in the 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 E. coli TMDLs in the Guntersville Lake 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: 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 Guntersville Lake watershed using LDCs to evaluate compliance with the single sample maximum target concentrations according to the procedure in Appendix C. These TMDL load reductions for impaired segments and subsequent subwatersheds are shown in Table 7.

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 available loading after application of the explicit MOS. 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 (with few exceptions in Tennessee) and recognition that loading from these facilities is generally small in comparison to other loading sources, further reductions are 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 7.

Table 7. WLAs & LAs for Guntersville Lake, Tennessee

HUC-12 Subwatershed (06030001__)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs[a]			LAs
					WWTFs[b]	Collection Systems	MS4s[c]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/d/ac]	[CFU/d/ac]
0201	Unnamed Tributary to Laurel Lake	TN06030001057 – 0511	2.30×10^{10} * Q	2.30×10^{9} * Q	NA	0	NA	9.08×10^{7} * Q
0202	Hedden Branch	TN06030001057 – 0811	2.30×10^{10} * Q	2.30×10^{9} * Q	NA	0	NA	1.91×10^{7} * Q
	Clouse Hill Branch	TN06030001057 – 0812	2.30×10^{10} * Q	2.30×10^{9} * Q	NA	0	NA	2.97×10^{7} * Q
	Little Fiery Gizzard Creek	TN06030001057 – 0815	2.30×10^{10} * Q	2.30×10^{9} * Q	4.28×10^{8}	0	NA	1.05×10^{7} * Q - 2.16×10^{5}

Note: NA = Not applicable.
Q = Mean Daily In-stream Flow (cfs).
a. There are no CAFOs in impaired subwatersheds of the Guntersville Lake watershed.
b. WLAs for WWTFs expressed as E. coli loads (CFU/day). Future WWTFs must meet water quality standards as specified in their NPDES permits.
c. There are currently no MS4s in impaired subwatersheds of the Guntersville Lake watershed. Future MS4s will be assigned waste load allocations (WLAs) consistent with load allocations (LAs) assigned to precipitation induced nonpoint sources.

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 Guntersville Lake watershed through reduction of excessive E. coli loading. Adaptive management methods, within the context of the State's rotating watershed management approach, will be used to modify TMDLs, WLAs, and LAs as required to meet water quality goals.

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 non-governmental levels to be successful.

9.1 Application of Load Duration Curves for Implementation Planning

The Load Duration Curve (LDC) methodology (Appendix C) is a form of water quality analysis and presentation of data that aids in guiding implementation by targeting management strategies for appropriate flow conditions. One of the strengths of this method is that it can be used to interpret possible delivery mechanisms of E. coli by differentiating between point and non-point source problems. The load duration curve analysis can be utilized for implementation planning. See Cleland (2003) for further information on duration curves and TMDL development, and: http://www.tmdls.net/tipstools/docs/TMDLsCleland.pdf

9.1.1 Flow Zone Analysis for Implementation Planning

A major advantage of the duration curve framework in TMDL development is the ability to provide meaningful connections between allocations and implementation efforts (USEPA, 2006). Because the flow duration interval serves as a general indicator of hydrologic condition (i.e., wet versus dry and to what degree), allocations and reduction goals can be linked to source areas, delivery mechanisms, and the appropriate set of management practices. The use of duration curve zones (e.g., high flow, moist, mid-range, dry, and low flow) allows the development of allocation tables (USEPA, 2006) (Appendix E), which can be used to guide potential implementation actions to most effectively address water quality concerns.

For the purposes of implementation strategy development, available E. coli data are grouped according to flow zones, with the number of flow zones determined by the HUC-12 subwatershed or drainage area size, the total contributing area (for non-headwater HUC-12s), and/or the baseflow characteristics of the waterbody. In general, for drainage areas greater than 40 square miles, the duration curves will 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%). For smaller drainage areas, flows occurring in the low flow zone (baseflow conditions) are often extremely low and difficult to measure accurately. In many small drainage areas, extreme dry conditions are characterized by zero flow for a significant percentage of time. For this reason, the low flow zone is best characterized as a broader range of conditions (or percent time) with subsequently fewer flow zones. Therefore, for most HUC-12 subwatersheds and drainage areas less than 40 square miles, the duration curves will be divided into four zones (Figure 8): high flows (exceeded 0-10% of the time), moist conditions (10-40%), median or mid-range flows (40-70%), and low flows (70-100%). Some small (<40 mi^2) waterbody drainage areas have sustained baseflow (no

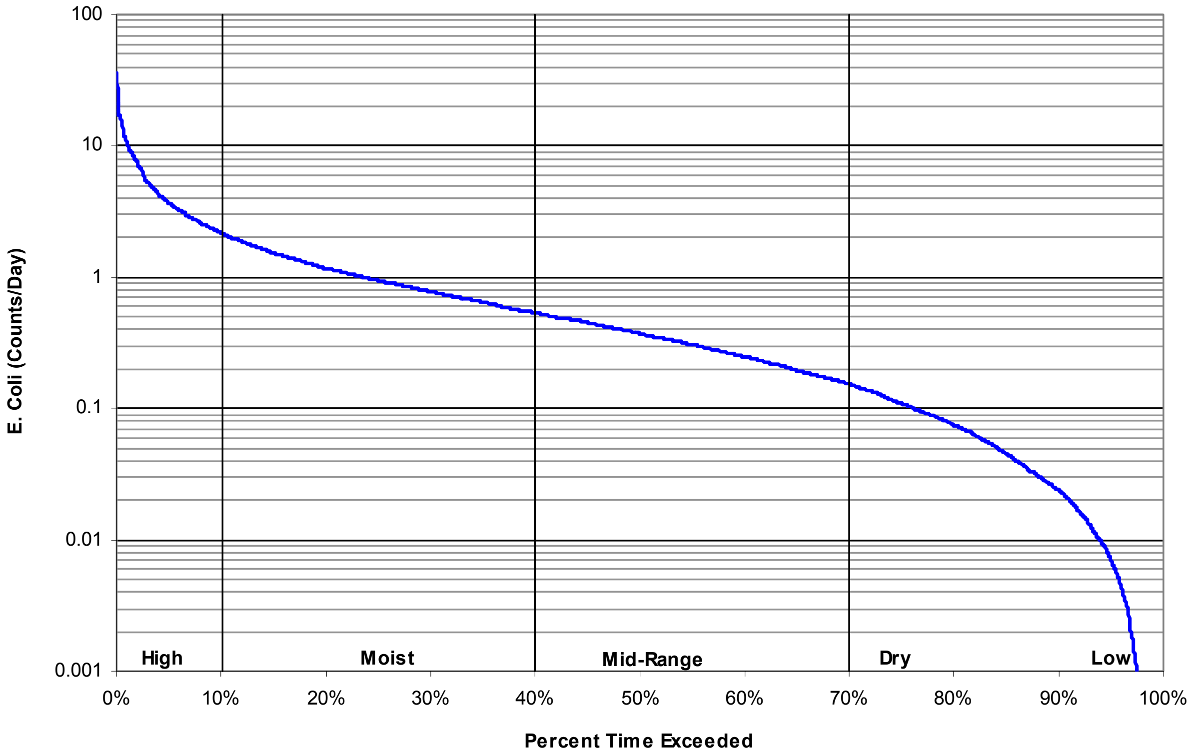

Figure 8. Four-Zone Flow Duration Curve for Hedden Creek at RM 0.5.

zero flows) throughout their period of record. For these waterbodies, the duration curves will be divided into five zones.

Given adequate data, results (allocations and percent load reduction goals) will be calculated for all flow zones; however, less emphasis is placed on the upper 10% flow range for pathogen (E. coli) TMDLs and implementation plans. The highest 10 percent flows, representing flood conditions, are considered non-recreational conditions: unsafe for wading and swimming. Humans are not expected to enter the water due to the inherent hazard from high depths and velocities during these flow conditions. As a rule of thumb, the *USGS Field Manual for the Collection of Water Quality Data* (Lane, 1997) advises its personnel not to attempt to wade a stream for which values of depth (ft) multiplied by velocity (ft/s) equal or exceed 10 ft^2/s to collect a water sample. Few observations are typically available to estimate loads under these adverse conditions due to the difficulty and danger of sample collection. Therefore, in general, the 0-10% flow range is beyond the scope of pathogen TMDLs and subsequent implementation strategies.

9.1.2 Existing Loads and Percent Load Reductions

Each impaired waterbody has a characteristic set of pollutant sources and existing loading conditions that vary according to flow conditions. In addition, maximum allowable loading (assimilative capacity) of a waterbody varies with flow. Therefore, existing loading, allowable loading, and percent load reduction expressed at a single location on the LDC (for a single flow condition) do not appropriately represent the TMDL in order to address all sources under all flow conditions (i.e., at all times) to satisfy implementation objectives. The LDC approach provides a methodology for determination of assimilative capacity and existing loading conditions of a waterbody for each flow zone. Subsequently, each flow zone, and the sources contributing to impairment under the corresponding flow conditions, can be evaluated independently. Lastly, the critical flow zone (with the highest percent load reduction goal) can be identified for prioritization of implementation actions.

Existing loading is calculated for each individual water quality sample as the product of the sample flow (cfs) times the single sample E. coli concentration (times a conversion factor). A percent load reduction is calculated for each water quality sample as that required to reduce the existing loading to the product of the sample flow (cfs) times the single sample maximum water quality standard (times a conversion factor). For samples with negative percent load reductions (non-exceedance: concentration below the single sample maximum water quality criterion), the percent reduction is assumed to be zero. The percent load reduction goal (PLRG) for a given flow zone is calculated as the mean of all the percent load reductions for a given flow zone. See Appendix E.

9.1.3 Critical Conditions

The critical condition for each impaired waterbody is defined as the flow zone with the largest PLRG, excluding the “high flow” zone because these extremely high flows are not representative of recreational flow conditions, as described in Section 9.1.1. If the PLRG in this zone is greater than all the other zones, the zone with the second highest PLRG will be considerd the critical flow zone. The critical conditions are such that if water quality standards were met under those conditions, they would likely be met overall.

9.2 Point Sources

9.2.1 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. With few exceptions, 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.

9.2.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

For future regulated discharges from municipal separate storm sewer systems (MS4s), WLAs will be implemented through Phase I & II MS4 permits. These permits will require the development and implementation of a Storm Water Management Plan (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. Both the *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2003) and the TDOT individual MS4 permit (TNS077585) require SWMPs to include minimum control measures. The permits also contain requirements regarding control of discharges of pollutants of concern into impaired waterbodies, implementation of provisions of approved TMDLs, and descriptions of methods to evaluate whether storm water controls are adequate to meet the requirements of approved TMDLs.

For guidance on the six minimum control measures for MS4s regulated under Phase I or Phase II, a series of fact sheets are available at:

http://cfpub1.epa.gov/npdes/stormwater/swfinal.cfm?program_id=6

For further information on Tennessee's *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems*, see: http://state.tn.us/environment/wpc/ppo/TN%20Small%20MS4%20Modified%20General%20Permit%202003.pdf

In order to evaluate SWMP effectiveness and demonstrate compliance with specified WLAs, MS4s must develop and implement appropriate monitoring programs. An effective monitoring program could include:

- Effluent monitoring at selected outfalls that are representative of particular land uses or geographical areas that contribute to pollutant loading before and after implementation of pollutant control measures.

- Analytical monitoring of pollutants of concern (e.g., monthly) in receiving waterbodies, both upstream and downstream of MS4 discharges, over an extended period of time. In addition, intensive collection of pollutant monitoring data during the recreation season (June – September) at sufficient frequency to support calculation of the geometric mean.

When applicable, the appropriate Division of Water Pollution Control Environmental Field Office should be consulted for assistance in the determination of monitoring strategies, locations, frequency, and methods within 12 months after the approval date of TMDLs or designation as a regulated MS4. Details of monitoring plans and monitoring data should be included in annual reports required by MS4 permits.

9.2.3 NPDES Regulated Concentrated Animal Feeding Operations (CAFOs)

WLAs provided to most 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. Provisions of the general permit include development and implementation of Nutrient Management Plan (NMPs), requirements regarding land application BMPs, and requirements for CAFO liquid waste management systems. For further information, see: http://state.tn.us/environment/wpc/permits/cafo.shtml.

Provisions of individual CAFO permits are similar.

9.3 Nonpoint Sources

The Tennessee Department of Environment & Conservation has no direct regulatory authority over most nonpoint source (NPS) discharges. Reductions of E. coli loading from nonpoint sources 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.

Local citizen-led and implemented management measures have the potential to provide the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. The Southeast Tennessee Resource Conservation and Development (RC&D) Council is a U. S. Department of Agriculture (USDA) program administered by the Natural Resources Conservation Service. This program helps people on a local level, with the assistance of a Federal Coordinator, to work together with many local organizations, county and city governments and conservation districts to implement natural resource protection and community development. Once a specific area has been authorized by the Secretary of Agriculture, that area is eligible for assistance through its RC&D council.

RC&D council projects involving water are designed to help improve surface and groundwater quality and quantity. Projects may include watershed management; construction or rehabilitation of irrigation, flood control, and water drainage systems; construction or rehabilitation of aquaculture, wastewater treatment and purification systems; installation of buffer strips; and efficient use of aquifers.

The Southeast Tennessee RC&D council area includes 12 Tennessee counties: Bledsoe, Bradley, Grundy, Hamilton, Loudon, Marion, McMinn, Meigs, Monroe, Polk, Rhea and Sequatchie.

9.3.1 Urban Nonpoint Sources

Management measures to reduce pathogen loading from urban nonpoint sources are similar to those recommended for MS4s (Sect. 9.2.2). Specific categories of urban nonpoint sources include stormwater, illicit discharges, septic systems, pet waste, and wildlife:

Stormwater: Most mitigation measures for stormwater are not designed specifically to reduce bacteria concentrations (ENSR, 2005). Instead, BMPs are typically designed to remove sediment and other pollutants. Bacteria in stormwater runoff are, however, often attached to particulate matter. Therefore, treatment systems that remove sediment may also provide reductions in bacteria concentrations.

Illicit discharges: Removal of illicit discharges to storm sewer systems, particularly of sanitary wastes, is an effective means of reducing pathogen loading to receiving waters (ENSR, 2005). These include intentional illegal connections from commercial or residential buildings, failing septic systems, and improper disposal of sewage from campers and boats.

Septic systems: When properly installed, operated, and maintained, septic systems effectively reduce pathogen concentrations in sewage. To reduce the release of pathogens, practices can be employed to maximize the life of existing systems, identify failed systems, and replace or remove failed systems (USEPA, 2005a). Alternatively, the installation of public sewers may be appropriate.

Pet waste: If the waste is not properly disposed of, these bacteria can wash into storm drains or directly into water bodies and contribute to pathogen impairment. Encouraging pet owners to properly collect and dispose of pet waste is the primary means for reducing the impact of pet waste (USEPA, 2002b).

Wildlife: Reducing the impact of wildlife on pathogen concentrations in waterbodies generally requires either reducing the concentration of wildlife in an area or reducing their proximity to the waterbody (ENSR, 2005). The primary means for doing this is to eliminate human inducements for congregation. In addition, in some instances population control measures may be appropriate.

Two additional urban nonpoint source resource documents provided by EPA are:

National Management Measures to Control Nonpoint Source Pollution from Urban Areas (http://www.epa.gov/owow/nps/urbanmm/index.html) helps citizens and municipalities in urban areas protect bodies of water from polluted runoff that can result from everyday activities. The scientifically sound techniques it presents are among the best practices known today. The guidance will also help states to implement their nonpoint source control programs and municipalities to implement their Phase II Storm Water Permit Programs (Publication Number EPA 841-B-05-004, November 2005).

The Use of Best Management Practices (BMPs) in Urban Watersheds (http://www.epa.gov/nrmrl/pubs/600r04184/600r04184chap1.pdf) is a comprehensive literature review on commonly used urban watershed Best Management Practices (BMPs) that heretofore was not consolidated. The purpose of this document is to serve as an information source to individuals and agencies/municipalities/watershed management groups/etc. on the existing state of BMPs in urban stormwater management (Publication Number EPA/600/R-04/184, September 2004).

9.3.2 Agricultural Nonpoint Sources

BMPs have been utilized in the Guntersville Lake watershed to reduce the amount of coliform bacteria transported to surface waters from agricultural sources. These BMPs (e.g., pasture and hayland establishment, cropland conversion, fencing for livestock exclusion, etc.) may have contributed to reductions in in-stream concentrations of coliform bacteria in one or more Guntersville Lake waterbodies during the TMDL evaluation period. The Tennessee Department of Agriculture (TDA) keeps a database of BMPs implemented in Tennessee. Those listed in the Guntersville Lake 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 TMDL analysis efforts.

It is further recommended that additional BMPs be implemented and monitored to document performance in reducing coliform bacteria loading to surface waters from agricultural sources. Demonstration sites for various types of BMPs should be established and maintained and their performance (in source reduction) evaluated over a period of at least two years prior to recommendations for utilization for subsequent implementation. 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.

For additional information on agricultural BMPs in Tennessee, see: http://state.tn.us/agriculture/nps/bmpa.html

An additional agricultural nonpoint source resource provided by EPA is *National Management Measures to Control Nonpoint Source Pollution from Agriculture* (http://www.epa.gov/owow/nps/agmm/index.html): a technical guidance and reference document for use by State, local, and tribal managers in the implementation of nonpoint source pollution management programs. It contains information on the best available, economically achievable means of reducing pollution of surface and ground water from agriculture (EPA 841-B-03-004, July 2003).

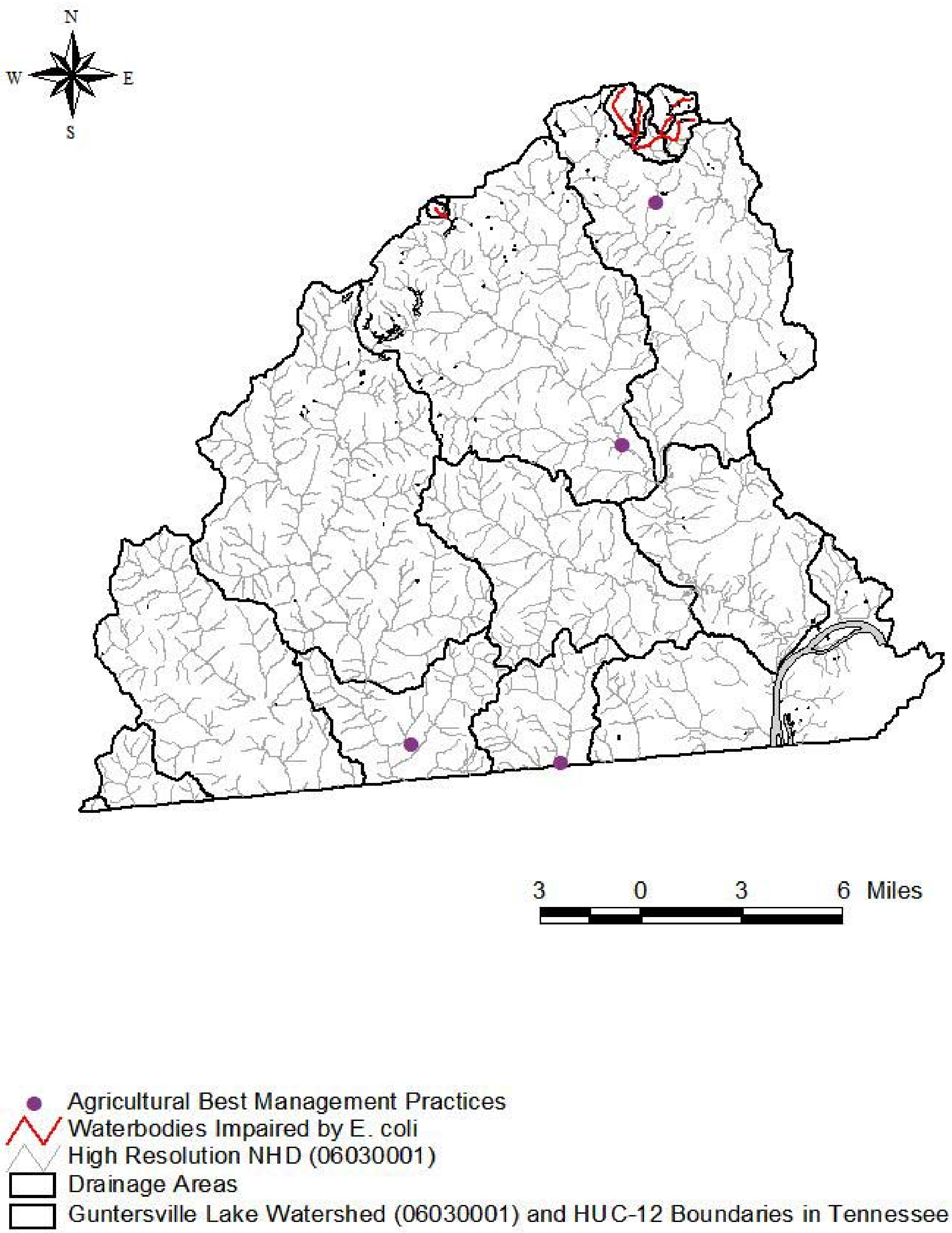

Figure 9. Tennessee Department of Agriculture Best Management Practices in the Guntersville Lake Watershed.

9.3.3 Other Nonpoint Sources

Additional nonpoint source references (not specifically addressing urban and/or agricultural sources) provided by EPA include:

National Management Measures to Control Nonpoint Source Pollution from Forestry (http://www.epa.gov/owow/nps/forestrymgmt/) helps forest owners protect lakes and streams from polluted runoff that can result from forestry activities. These scientifically sound techniques are the best practices known today. The report will also help states to implement their nonpoint source control programs (EPA 841-B-05-001, May 2005).

In addition, the EPA website, http://www.epa.gov/owow/nps/bestnpsdocs.html, contains a list of guidance documents endorsed by the Nonpoint Source Control Branch at EPA headquarters. The list includes documents addressing urban, agriculture, forestry, marinas, stream restoration, nonpoint source monitoring, and funding.

9.4 Additional Monitoring

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 in-stream water quality targets for E. coli.

9.4.1 Water Quality Monitoring

Activities recommended for the Guntersville Lake watershed:

Verify the assessment status of stream reaches identified on the Final 2006 303(d) List as impaired due to E. coli. If it is determined that these stream reaches are still not fully supporting designated uses, then sufficient data to enable development of TMDLs should be acquired. TMDLs will be revisited on 5-year watershed cycle as described above.

Evaluate the effectiveness of implementation measures (see Sect. 9.6). Includes BMP performance analysis and monitoring by permitees and stakeholders. Where required TMDL loading reduction has been fully achieved, adequate data to support delisting should be collected.

Provide additional data (e.g., monthly monitoring data, year-round) to characterize water quality conditions under all flow regimes (zones) for sites with limited monitoring data and/or data collected exclusively during dry weather, low flow conditions (i.e., geometric mean data). In addition, analyses of existing data at several monitoring sites on unlisted waterbodies in the Guntersville Lake watershed suggest levels of impairment. In some cases, additional data are required for listing determination.

Continue ambient (long-term) monitoring at appropriate sites and key locations.

Comprehensive water quality monitoring activities include sampling during all seasons and a broad range of flow and meteorological conditions. In addition, collection of E. coli data at sufficient frequency to support calculation of the geometric mean, as described in Tennessee's General Water Quality Criteria (TDEC, 2004a), is encouraged. Finally, for individual monitoring locations, where historical E. coli data are greater than 1000 colonies/100 mL (or future samples are anticipated to be), a 1:100 dilution should be performed as described in Protocol A of the *Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water*

(TDEC, 2004b).

9.4.2 Source Identification

An important aspect of E. coli load reduction activities is the accurate identification of the actual sources of pollution. In cases where the sources of E. coli impairment are not readily apparent, Microbial Source Tracking (MST) is one approach to determining the sources of fecal pollution and E. coli affecting a waterbody. Those methods that use bacteria as target organisms are also known as Bacterial Source Tracking (BST) methods. This technology is recommended for source identification in E. coli impaired waterbodies.

Bacterial Source Tracking is a collective term used for various 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 at the University of Tennessee, Knoxville (UTK) has developed and tested a series of different microbial assay methods based on real-time PCR to detect fecal bacterial concentrations and host sources in water samples (Layton, 2006). 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. Additional information can be found on the following UTK website: http://web.utk.edu/~hydro/JournalPapers/Layton06AEM.pdf.

A good example of this in west Tennessee: the City of Memphis conducted a Microbial Source Tracking Study for South Cypress Creek, in the Nonconnah Creek watershed (Lawrence, 2003), to identify fecal sources in an urban watershed. The Institute for Environmental Health (IEH), in Seattle, WA, assisted with the project and conducted ribotyping on E. coli strains from fecal coliform samples. In addition, a library of known sources was supplemented with local data by the collection of scat samples for better matching of bacteria sources. The results indicated that human sources (including raw sewage) accounted for less than 20% of the total occurrences of E. coli from fecal samples. Avian and wild animal sources were the primary sources of fecal contributions to South Cypress Creek. The report can be found at the following websites: http://www.cityofmemphis.org/pdf_forms/MicrobialSourceTrackingStudy.pdf and http://www.cityofmemphis.org/pdf_forms/MicrobialSourceTrackingStudyFigures.pdf.

9.5 Source Area Implementation Strategy

Implementation strategies are organized according to the dominant landuse type and the sources associated with each (Table 8 and Appendix E). Each drainage area is grouped and targeted for implementation based on this source area organization. Three primary categories are identified: predominantly urban, predominantly agricultural, and mixed urban/agricultural. See Appendix A for information regarding landuse distribution of impaired subwatersheds. For the purpose of implementation evaluation, urban is defined as residential, commercial, and industrial landuse areas with predominate source categories such as point sources (WWTFs), collection systems/septic systems (including SSOs and CSOs), and urban stormwater runoff associated with MS4s. Agricultural is defined as cropland and pasture, with predominate source categories associated with livestock and manure management activities. A fourth category (infrequent) is associated with forested (including non-agricultural undeveloped and unaltered [by humans]) landuse areas with the predominate source category being wildlife.

Table 8. Source area types for waterbody drainage area analyses.

Waterbody ID	Source Area Type*			
	Urban	Agricultural	Mixed	Forested
UT to Laurel Lake	Ò			
Hedden Branch			Ò	
Clouse Hill Branch			Ò	
Little Fiery Gizzard Creek			Ò	

* All waterbodies potentially have significant source contributions from other source type/landuse areas.

All impaired waterbodies and corresponding drainage areas have been classified according to their respective source area types in Table 8. The implementation for each area will be prioritized according to the guidance provided in Sections 9.5.1 and 9.5.2, below. For all impaired waterbodies, the determination of source area types serves to identify the predominant sources contributing to impairment (i.e., those that should be targeted initially for implementation). However, it is not intended to imply that sources in other landuse areas are not contributors to impairment and/or to grant an exemption from addressing other source area contributions with implementation strategies and corresponding load reduction. For mixed use areas, implementation will follow the guidance established for both urban and agricultural areas, at a minimum.

Appendix E provides source area implementation examples for urban and agricultural subwatersheds, development of percent load reduction goals, and determination of critical flow zones (for implementation prioritization) for E. coli impaired waterbodies. Load duration curve analyses (TMDLs, WLAs, LAs, and MOS) and percent load reduction goals for all flow zones for all E. coli impaired waterbodies in the Guntersville Lake watershed are summarized in Table E-7.

9.5.1 Urban Source Areas

For impaired waterbodies and corresponding drainage areas classified as predominantly urban, implementation strategies for E. coli load reduction will initially and primarily target source categories similar to those listed in Table 9 (USEPA, 2006). Table 9 presents example urban area management practices and the corresponding potential relative effectiveness under each of the hydrologic flow zones. Each implementation strategy addresses a range of flow conditions and targets point sources, non-point sources, or a combination of each. For each waterbody, the existing loads and corresponding PLRG for each flow zone are calculated according to the method described in Section E.4. The resulting determination of the critical flow zone further focuses the types of urban management practices appropriate for development of an effective load reduction strategy for a particular waterbody.

9.5.2 Agricultural Source Areas

For impaired waterbodies and corresponding drainage areas classified as predominantly agricultural, implementation strategies for E. coli load reduction will initially and primarily target source categories similar to those listed in Table 10 (USDA, 1988). Table 10 presents example agricultural area management practices and the corresponding potential relative effectiveness under each of the hydrologic flow zones. Each implementation strategy addresses a range of flow conditions and targets point sources, non-point sources, or a combination of each. For each waterbody, the existing loads and corresponding PLRG for each flow zone are calculated according to the method described in Section E.4. The resulting determination of the critical flow zone further focuses the types of agricultural management practices appropriate for development of an effective load reduction strategy for a particular waterbody.

9.5.3 Forestry Source Areas

There are no impaired waterbodies with corresponding drainage areas classified as source area type predominantly forested, with the predominate source category being wildlife, in the Guntersville Lake watershed.

Table 9. Example Urban Area Management Practice/Hydrologic Flow Zone Considerations.

Management Practice	Duration Curve Zone (Flow Zone)				
	High	Moist	Mid-Range	Dry	Low
Bacteria source reduction					
Remove illicit discharges			L	M	H
Address pet & wildlife waste		H	M	M	L
Combined sewer overflow management					
Combined sewer separation		H	M	L	
CSO prevention practices		H	M	L	
Sanitary sewer system					
Infiltration/Inflow mitigation	H	M	L	L	
Inspection, maintenance, and repair		L	M	H	H
SSO repair/abatement	H	M	L		
Illegal cross-connections					
Septic system management					
Managing private systems		L	M	H	M
Replacing failed systems		L	M	H	M
Installing public sewers		L	M	H	M
Storm water infiltration/retention					
Infiltration basin		L	M	H	
Infiltration trench		L	M	H	
Infiltration/Biofilter swale		L	M	H	
Storm Water detention					
Created wetland		H	M	L	
Low impact development					
Disconnecting impervious areas		L	M	H	
Bioretention	L	M	H	H	
Pervious pavement		L	M	H	
Green Roof		L	M	H	
Buffers		H	H	H	
New/existing on-site wastewater treatment systems					
Permitting & installation programs		L	M	H	M
Operation & maintenance programs		L	M	H	M
Other					
Point source controls		L	M	H	H
Landfill control		L	M	H	
Riparian buffers		H	H	H	
Pet waste education & ordinances		M	H	H	L
Wildlife management		M	H	H	L
Inspection & maintenance of BMPs	L	M	H	H	L

Note: Potential relative importance of management practice effectiveness under given hydrologic condition (*H: High, M: Medium, L: Low*)

Table 10. Example Agricultural Area Management Practice/Hydrologic Flow Zone Considerations.

Management Practice	Duration Curve Zone (Flow Zone)				
	High	Moist	Mid-Range	Dry	Low
Grazing Management					
Prescribed Grazing (528A)	H	H	M	L	
Pasture & Hayland Mgmt (510)	H	H	M	L	
Deferred Grazing (352)	H	H	M	L	
Planned Grazing System (556)	H	H	M	L	
Proper Grazing Use (528)	H	H	M	L	
Proper Woodland Grazing (530)	H	H	M	L	
Livestock Access Limitation					
Livestock Exclusion (472)			M	H	H
Fencing (382)			M	H	H
Stream Crossing			M	H	H
Alternate Water Supply					
Pipeline (516)			M	H	H
Pond (378)			M	H	H
Trough or Tank (614)			M	H	H
Well (642)			M	H	H
Spring Development (574)			M	H	H
Manure Management					
Managing Barnyards	H	H	M	L	
Manure Transfer (634)	H	H	M	L	
Land Application of Manure	H	H	M	L	
Composting Facility (317)	H	H	M	L	
Vegetative Stabilization					
Pasture & Hayland Planting (512)	H	H	M	L	
Range Seeding (550)	H	H	M	L	
Channel Vegetation (322)	H	H	M	L	
Brush (& Weed) Mgmt (314)	H	H	M	L	

Table 10. Example Agricultural Area Management Practice/Hydrologic Flow Zone Considerations (Cont.)

Management Practice	Duration Curve Zone (Flow Zone)				
	High	Moist	Mid-Range	Dry	Low
Vegetative Stabilization (cont'd)					
Conservation Cover (327)		H	H	H	
Riparian Buffers (391)		H	H	H	
Critical Area Planting (342)		H	H	H	
Wetland restoration (657)		H	H	H	
CAFO Management					
Waste Management System (312)	H	H	M		
Waste Storage Structure (313)	H	H	M		
Waste Storage Pond (425)	H	H	M		
Waste Treatment Lagoon (359)	H	H	M		
Mulching (484)	H	H	M		
Waste Utilization (633)	H	H	M		
Water/Sediment Control Basin (638)	H	H	M		
Filter Strip (393)	H	H	M		
Sediment Basin (350)	H	H	M		
Grassed Waterway (412)	H	H	M		
Diversion (362)	H	H	M		
Heavy Use Area Protection (561)					
Constructed Wetland (656)					
Dikes (356)	H	H	M		
Lined Waterway or Outlet (468)	H	H	M		
Roof Runoff Mgmt (558)	H	H	M		
Floodwater Diversion (400)	H	H	M		
Terrace (600)	H	H	M		

Note: Potential relative importance of management practice effectiveness under given hydrologic condition (*H: High, M: Medium, L: Low*)

Note: Numbers in parentheses are the U.S. Soil Conservation Service practice number.

9.6 Evaluation of TMDL Implementation Effectiveness

Evaluation of the effectiveness of TMDL implementation strategies should be conducted on multiple levels, as appropriate:

- HUC-12 or waterbody drainage area (i.e., TMDL analysis location)
- Subwatersheds or intermediate sampling locations
- Specific landuse areas (urban, pasture, etc.)
- Specific facilities (WWTF, CAFO, uniquely identified portion of MS4, etc.)
- Individual BMPs

In order to conduct an implementation effectiveness analysis on measures to reduce E. coli source loading, monitoring results should be evaluated in one of several ways. Sampling results can be compared to water quality standards (e.g., load duration curve analysis) for determination of impairment status, results can be compared on a before and after basis (temporal), or results can be evaluated both upstream and downstream of source reduction measures or source input (spatial). Considerations include period of record, data collection frequency, representativeness of data, and sampling locations.

In general, periods of record greater than 5 years (given adequate sampling frequency) can be evaluated for determination of relative change (trend analysis). For watersheds in second or successive TMDL cycles, data collected from multiple cycles can be compared. If implementation efforts have been initiated to reduce loading, evaluation of routine monitoring data may indicate improving or worsening conditions over time and corresponding effectiveness of implementation efforts.

Water quality data for implementation effectiveness analysis can be presented in multiple ways. For example, Figure 10 shows fecal coliform concentration data statistics for Oostanaula Creek at mile 28.4 (Hiwassee River watershed) for a historical (2002) TMDL analysis period versus a recent post-implementation period of sampling data (revised TMDL). The individual flow zone analyses are presented in a box and whisker plot of recent [2] versus historical [1] data. Figure 11 shows a load duration curve analysis (of recent versus historical data) of fecal coliform loading statistics for Oostanaula Creek. Lastly, Figure 12 shows best fit curve analyses of flow (percent time exceeded) versus fecal coliform loading relationships (regressions) plotted against the LDC of the single sample maximum water quality standard. Note that Figures 10-12 present the same data, from approved TMDLs (2 cycles), each clearly illustrating improving conditions between historical and recent periods.

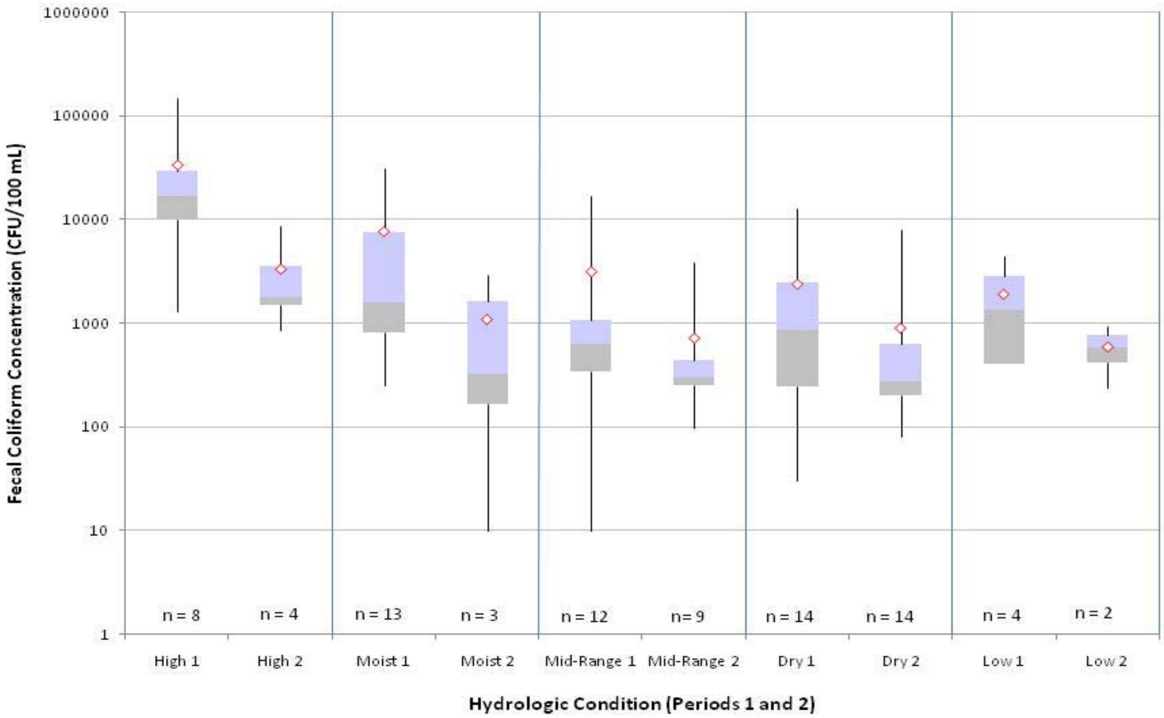

Figure 10. Oostanaula Creek TMDL implementation effectiveness (box and whisker plot).

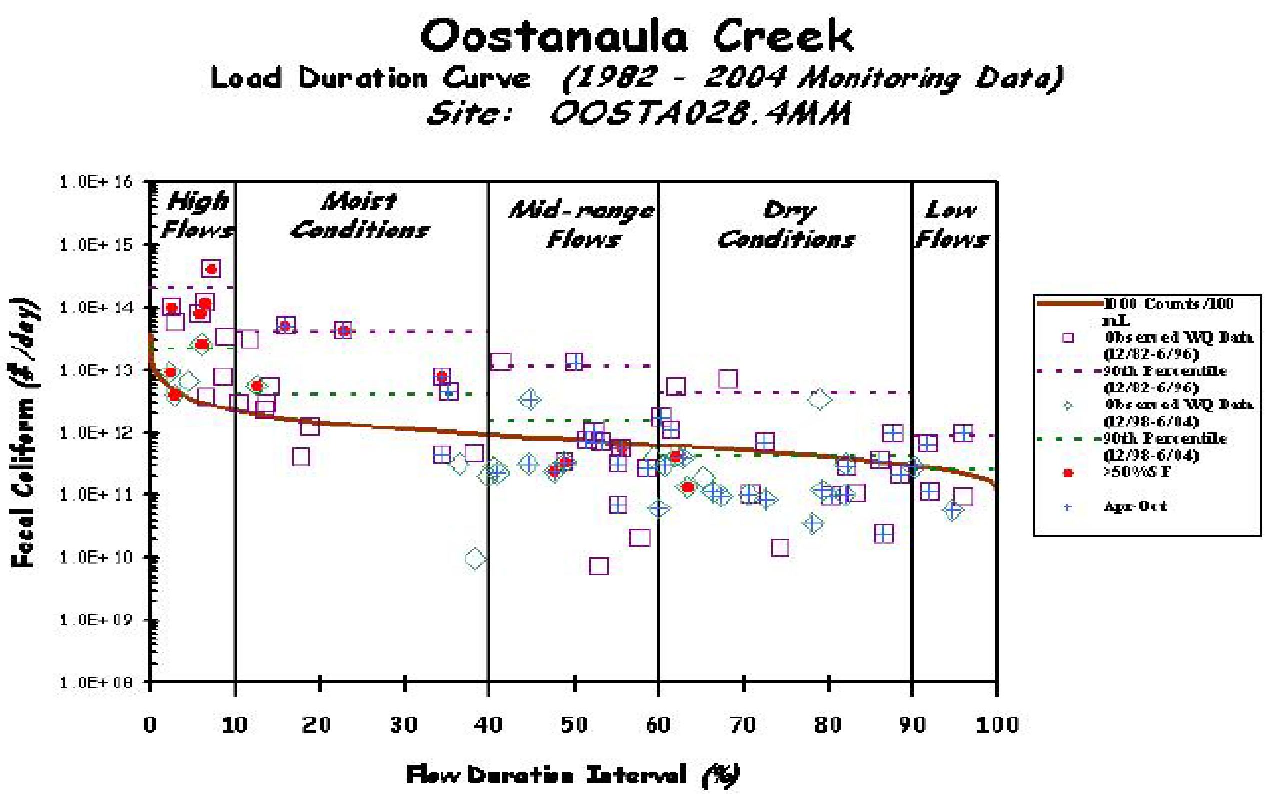

Figure 11. Oostanaula Creek TMDL implementation effectiveness (LDC analysis).

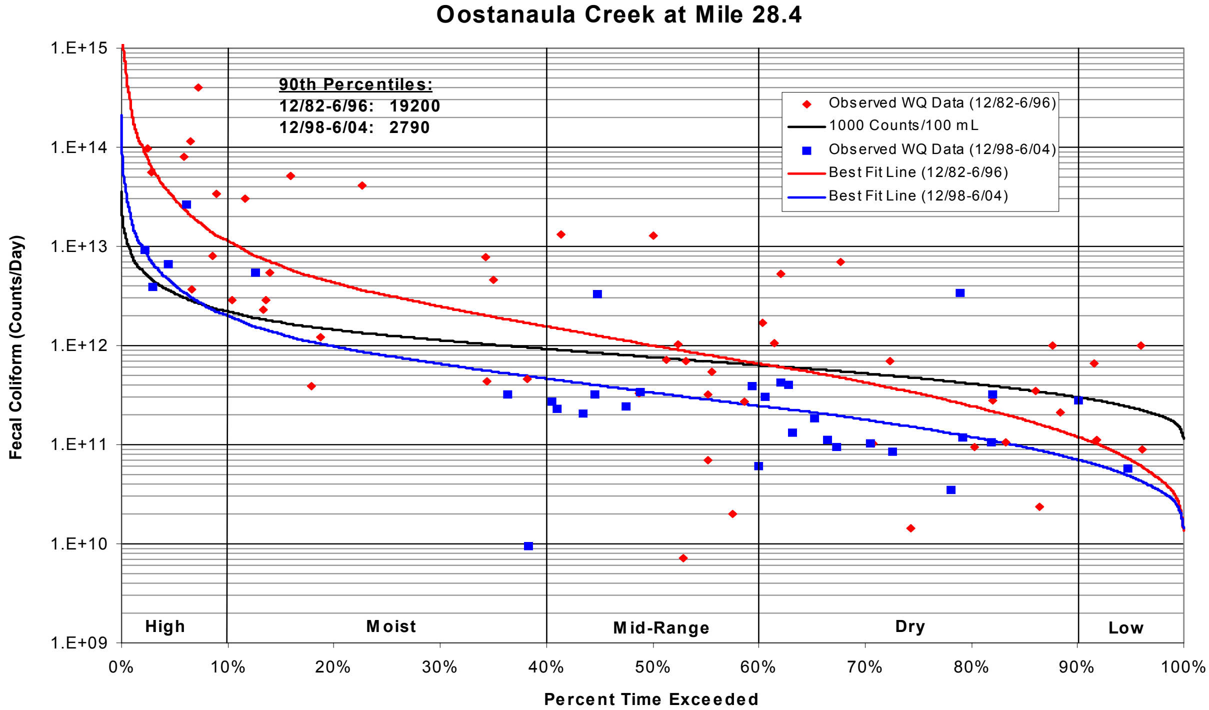

Figure 12. Oostanaula Creek TMDL implementation effectiveness (LDC regression analysis).

10.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed E. coli TMDLs for the Guntersville Lake watershed were placed on Public Notice for a 35-day period and comments solicited. Steps that were taken in this regard included:

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

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

3) A draft copy of the proposed TMDLs was sent to the Tennessee Department of Transportation.

4) A letter was sent to the Grundy County–Tracy Manufacturing Company (TN0059331), located in an E. coli-impaired subwatershed in the Guntersville Lake watershed, advising them of the proposed TMDLs and their availability on the TDEC website. The letter also stated that a copy of the draft TMDL document would be provided on request.

5) A letter was sent to the local stakeholder group in the Guntersville Lake watershed advising them of the proposed E. coli TMDLs and their availability on the TDEC website. The letter also stated that copies of the draft TMDL document would be provided upon request. A letter was sent to the following local stakeholder group:

   The Southeast Tennessee Resource Conservation and Development Council

No written comments were received during the proposed TMDL public comment period. No requests to hold public meetings were received regarding the proposed TMDLs as of close of business on February 22, 2008.

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 Guntersville Lake Watershed

Table A-1. MRLC Land Use Distribution of Guntersville Lake Subwatersheds

Land Use	Drainage Area (DA)							
	UT to Laurel Lake		Hedden Branch		Clouse Hill Branch		Little Fiery Gizzard Creek	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	105.6	46.3	516.1	47.6	379.8	54.6	1202.9	60.8
Evergreen Forest	10.7	4.7	60.3	5.6	21.1	3.0	120.5	6.1
High Intensity Commercial/Indus-trial/Transportation	43.6	19.1	54.7	5.0	36.0	5.2	18.9	1.0
High Intensity Residential	0.2	0.1	7.8	0.7	3.8	0.5	2.9	0.1
Low Intensity Residential	1.6	0.7	81.6	7.5	38.9	5.6	60.3	3.0
Mixed Forest	40.0	17.5	209.2	19.3	107.2	15.4	366.6	18.5
Open Water	0	0.0	0	0.0	0	0.0	12.2	0.6
Other Grasses (Urban/recreational; e.g., parks, lawn)	4.7	2.1	26.2	2.4	1.3	0.2	53.4	2.7
Pasture/Hay	4.4	1.9	122.3	11.3	104.7	15.0	125.6	6.4
Row Crops	17.3	7.6	6.7	0.6	3.1	0.4	13.8	0.7
Transitional	0.0	0.0	0.2	0.0*	0.2	0.0*	0	0.0
Total	228.1	100.0	1085.0	100.0	696.2	100.0	1977.1	100.0

* <0.05

APPENDIX B

Water Quality Monitoring Data

There are a number of water quality monitoring stations that provide data for waterbodies identified as impaired for E. coli in the Guntersville Lake watershed. The location of these monitoring stations is shown in Figure 5. Monitoring data recorded at these stations for E. coli are tabulated in Table B-1.

Table B-1. Water Quality Monitoring Data – Guntersville Lake Watershed

Monitoring Station	Date	E. Coli [CFU/100 mL]
Site A	9/22/1998	**1986**
	10/28/1998	33
HEDDE000.5GY	5/23/2000	**2400**
	5/30/2000	160
	6/6/2000	460
	6/13/2000	460
	6/20/2000	310
	6/27/2000	200
	7/5/2000	200
	7/11/2000	550
	7/17/2000	550
	7/25/2000	250
	8/2/2000	330
	8/9/2000	340
	8/15/2000	120
	8/23/2000	240
	8/29/2000	260
	9/6/2000	110
	9/13/2000	240
	2/11/2002	180
	7/13/2005	488.4
	8/17/2005	**1203.31**
	9/19/2005	78.9
	10/17/2005	10.9
	11/1/2005	14.5
	12/8/2005	290.9
	1/9/2006	290.9
	3/2/2006	387.3
	3/27/2006	16.1
	5/4/2006	123.3
	6/13/2006	**2419.2**
	1/30/2006	13.4

Table B-1. Water Quality Monitoring Data – Guntersville Lake Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
CHILL000.1GY	5/23/2000	**2400**
	5/30/2000	180
	6/6/2000	870
	6/13/2000	410
	6/20/2000	370
	6/27/2000	460
	7/5/2000	89
	7/11/2000	690
	7/17/2000	100
	7/25/2000	60
	8/2/2000	**1200**
	8/9/2000	490
	8/15/2000	170
	8/23/2000	190
	8/29/2000	180
	9/6/2000	280
	9/13/2000	**1200**
	2/11/2002	130
	7/13/2005	**1732.87**
	8/17/2005	816.4
	9/19/2005	172.5
	10/17/2005	51.2
	11/1/2005	30.1
	12/8/2005	167.8
	1/9/2006	98.8
	1/30/2006	146.7
	3/2/2006	435.2
	3/27/2006	27.2
	5/4/2006	178.5
	6/12/2006	**1553.07**
LFGIZ002.2GY	5/23/2000	**1000**
	5/30/2000	18
	6/6/2000	52
	6/12/2000	**1100**
	6/20/2000	39
	6/27/2000	35
	7/5/2000	98
	7/11/2000	60

Table B-1. Water Quality Monitoring Data – Guntersville Lake Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
LFGIZ002.2GY	7/17/2000	520
	7/25/2000	400
	8/2/2000	120
	8/9/2000	160
	8/15/2000	54
	8/23/2000	**1400**
	8/29/2000	870
	9/6/2000	550
	9/13/2000	190
	2/11/2002	20
LFGIZ003.0GY	5/23/2000	40
	5/30/2000	5
	6/6/2000	8
	6/13/2000	7
	6/20/2000	10
	6/27/2000	2
	7/5/2000	3
	7/11/2000	3

APPENDIX C

Load Duration Curve Development and Determination of Daily Loading

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), 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:

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

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) (http://www.epa.gov/epacfr40/chapt-I.info/chi-toc.htm) 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 in the Guntersville Lake watershed using Load Duration Curves (LDCs). Daily loads for TMDLs, WLAs, and LAs are expressed as a function of daily mean in-stream flow (daily loading function).

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 flows over an extended 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 U.S. Geological Survey (USGS) continuous-record stations (http://waterdata.usgs.gov/tn/nwis/sw) 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 Guntersville Lake watershed were derived from LSPC hydrologic simulations based on parameters derived from calibration at USGS Station 03566525, North Chickamauga Creek near Montlake. See Appendix D for details of calibration. The data used included the period of record from 11/1/00 – 9/30/06. The calibration was subsequently applied to impaired waterbodies to simulate 10 years of flow data. For example, a flow-duration curve for Hedden Branch at mile 0.5 was constructed using simulated daily mean flow for the period from 10/1/96 through 9/30/06 (mile 0.5 corresponds to the location of monitoring station HEDDE000.5GY). 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 Required Load Reductions

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 Guntersville Lake watershed were developed from the flow duration curves developed in Section C.1.1, E. coli target concentrations, and available water quality monitoring data. LDCs and daily loading functions were developed using the following procedure (Hedden Branch at mile 0.5, station HEDDE000.5GY, is shown as an example):

1. A target load duration curve (LDC) was generated for Hedden Branch by applying the E. coli target concentration of 941 CFU/100 mL to each of the ranked flows used to generate the flow duration curve (ref.: Section C.1.1) and plotting the results. The E. coli target maximum load corresponding to each ranked daily mean flow is:

   $(\text{Target Load})_{\text{HEDDEN}}$ = (941 CFU/100 mL) x (Q) x (UCF)

   where: Target Load = TMDL (CFU/day)
   Q = daily mean in-stream flow (cfs)
   UCF = the required unit conversion factor

   TMDL = $2.30 \times 10^{10} \times Q$

2. Daily loads were calculated for each of the water quality samples collected at monitoring station HEDDE000.5GY (ref.: Table B-1) by multiplying the sample concentration by the daily mean flow for the sampling date and the required unit conversion factor. HEDDE000.5GY was selected for LDC analysis because it has numerous sampling points, well distributed across the full range of flow conditions, and multiple 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 were available for some sampling dates.

   Example (8/17/05 sampling event):
   Modeled Flow = 1.104 cfs
   Concentration = 1203.3 CFU/100 mL
   Daily Load = 3.249×10^{10}

3. Using the flow duration curves developed in Section 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 LDCs developed in Step 1 according to the PDFE. The resulting E. coli LDC for Hedden Branch at mile 0.5 is shown in Figure C-2.

LDCs of other impaired waterbodies were derived in a similar manner and are shown in Appendix E.

C.2 Development of WLAs, LAs and MOS

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:

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

For E. coli TMDLs in each impaired subwatershed, WLA terms include:

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

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

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

- $[\Sigma WLAs]_{MS4}$ is the allowable E. coli load for discharges from MS4s. E. coli loading from MS4s is the result of buildup/wash-off processes associated with storm events.

LA terms include:

- $[\Sigma LAs]_{DS}$ is the allowable E. coli load from "other direct sources". These sources include leaking septic 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 feasible).

- $[\Sigma LAs]_{SW}$ is the allowable E. coli load 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 (i.e., precipitation induced).

Since $[WLAs]_{CAFO} = 0$, and $[LAs]_{DS} = 0$, the expression relating TMDLs to precipitation-based point and nonpoint sources may be simplified to:

$$TMDL - MOS = [\Sigma WLAs]_{WWTF} + [WLAs]_{MS4} + [\Sigma LAs]_{SW}$$

As stated in Section 8.5, an explicit MOS, equal to 10% of the E. coli water quality targets (ref.: Section 5.0), was utilized for determination of the percent load reductions necessary to achieve the WLAs and LAs:

Instantaneous Maximum (lake, reservoir, State Scenic River, Tier II, and Tier III):

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

Target – MOS = 438 CFU/100 ml

Instantaneous Maximum (other):

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 Daily Load Calculation

Since WWTFs discharge must comply with instream water quality criteria (TMDL target) at the point of discharge, WLAs for WWTFs are expressed as a constant term. In addition, WLAs for MS4s and LAs for precipitation-based nonpoint sources are equal on a per unit area basis and may be expressed as the daily allowable load per unit area (acre) resulting from a decrease in in-stream E. coli concentrations to TMDL target values minus MOS:

$[WLAs]_{MS4} = LA = (TMDL – MOS – [WLAs]_{WWTF}) / DA$

where: DA = waterbody drainage area (acres)

Using Hedden Branch as an example:

$TMDL_{HEDDEN} = (941 \text{ CFU/100 mL}) \times (Q) \times (UCF)$

$= 2.30 \times 10^{10} \times Q$

$MOS_{HEDDEN} = TMDL \times 0.10$

$MOS = 2.30 \times 10^{9} \times Q$

$WLA[MS4]_{HEDDEN} = LA_{HEDDEN}$

$= \{TMDL – MOS – WLA[WWTFs]\} / DA$

$= \{(2.30 \times 10^{10} \times Q) – (2.30 \times 10^{9} \times Q) – (0)\} / (1{,}085)$

$WLA[MS4] = LA = 1.908 \times 10^{7} \times Q$

TMDLs, WLAs, LAs, and MOS for other impaired subwatersheds and drainage areas were derived in a similar manner and are summarized in Table C-1.

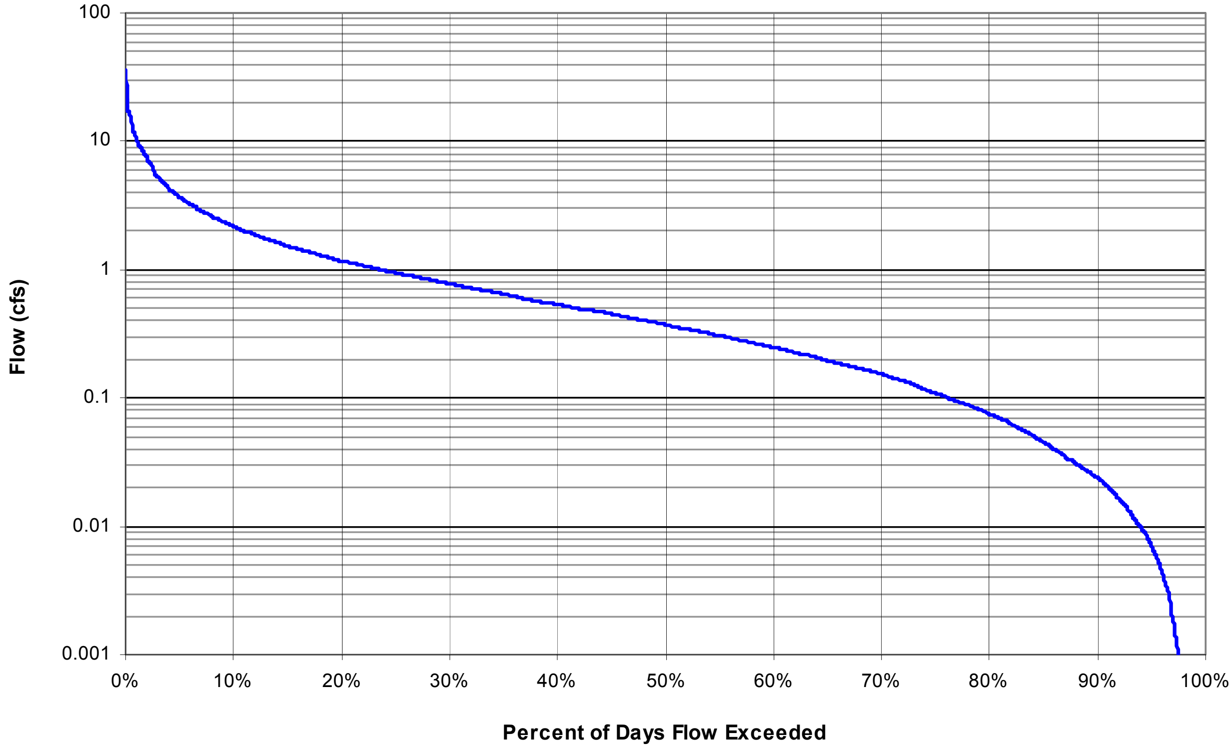

Figure C-1. Flow Duration Curve for Hedden Branch at Mile 0.5

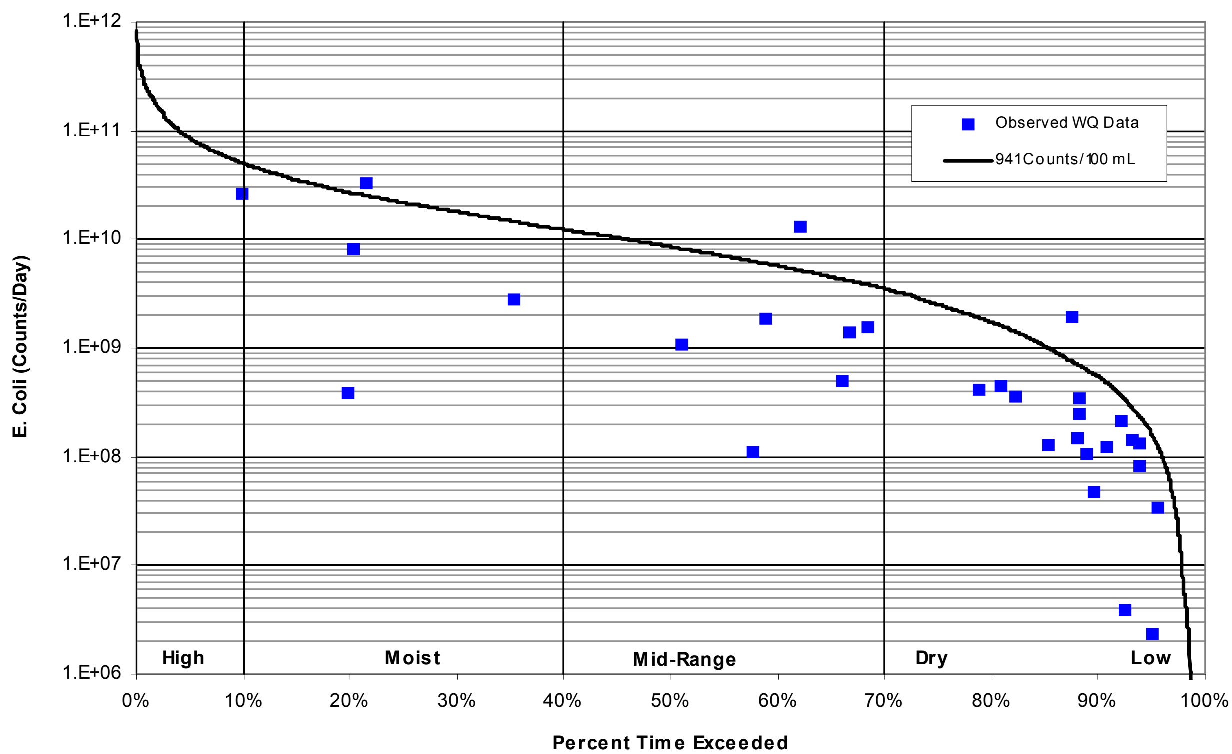

Figure C-2. E. Coli Load Duration Curve for Hedden Branch at Mile 0.5

Table C-1. TMDLs, WLAs, & LAs for Guntersville Lake Watershed

HUC-12 Subwatershed (06030001__)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs[a]			LAs
					WWTFs[b]	Collection Systems	MS4s[c]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/d/ac]	[CFU/d/ac]
0201	Unnamed Tributary to Laurel Lake	TN06030001057 – 0511	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	0	NA	$9.08 \times 10^{7} * Q$
0202	Hedden Branch	TN06030001057 – 0811	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	0	NA	$1.91 \times 10^{7} * Q$
	Clouse Hill Branch	TN06030001057 – 0812	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	NA	0	NA	$2.97 \times 10^{7} * Q$
	Little Fiery Gizzard Creek	TN06030001057 – 0815	$2.30 \times 10^{10} * Q$	$2.30 \times 10^{9} * Q$	4.28×10^{8}	0	NA	$1.05 \times 10^{7} * Q - 2.16 \times 10^{5}$

Note: *NA = Not applicable.*
Q = Mean Daily In-stream Flow (cfs).

a. *There are no CAFOs in impaired subwatersheds of the Guntersville Lake watershed.*
b. *WLAs for WWTFs expressed as E. coli loads (CFU/day). Future WWTFs must meet water quality standards as specified in their NPDES permits.*
c. *There are currently no MS4s in impaired subwatersheds of the Guntersville Lake watershed. Future MS4s will be assigned waste load allocations (WLAs) consistent with load allocations (LAs) assigned to precipitation induced nonpoint sources.*

APPENDIX D

Hydrodynamic Modeling Methodology

D.1 Model Selection

The Loading Simulation Program C++ (LSPC) was selected for flow simulation of E. coli-impaired waters in the Guntersville Lake 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 impaired waterbodies were 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, USGS monitoring stations (see Section C.1), and water quality monitoring stations. Watershed delineation was based on the National Hydrography Dataset (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 water quality model simulations for selected subwatersheds. This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics.

An important factor influencing model results is the precipitation data contained in the meteorological data files used in these simulations. Weather data from the Chattanooga Airport and Monteagle meteorological stations were available for the time period from January 1970 through December 2006. Meteorological data for a selected 11-year period was used for all simulations. The first year of this period was used for model stabilization with simulation data from the subsequent 10-year period (10/1/96 – 9/30/06) used for TMDL analyses.

D.3 Model Calibration

Hydrologic calibration of the watershed model involves comparison of simulated streamflow to historic streamflow data from USGS stream gaging stations for the same period of time. A USGS continuous record station located in the Guntersville Lake watershed was selected as the basis of the hydrology calibration. The calibration involved comparison of simulated and observed hydrographs until discrepancies in statistical stream volumes and flows were minimized, 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 North Chickamauga Creek near Montlake, USGS Station 03566525, are shown in Table D-1 and Figure D-1, respectively.

Table D-1. Hydrologic Calibration Summary: North Chickamauga Creek near Montlake (USGS 03566525)

Simulation Name:	**NChick11 (calibration)**	**Simulation Period:**	
	North Chickamauga Creek near Montlake (USGS 03566525)	**Watershed Area (ac):**	21367.00
Period for Flow Analysis			
Begin Date:	**10/01/01**	**Baseflow PERCENTILE:**	2.5
End Date:	**09/30/06**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**260.69**	Total Observed In-stream Flow:	**276.51**
Total of highest 10% flows:	**146.33**	Total of Observed highest 10% flows:	**155.48**
Total of lowest 50% flows:	**17.32**	Total of Observed Lowest 50% flows:	**17.15**
Simulated Summer Flow Volume (months 7-9):	**34.11**	Observed Summer Flow Volume (7-9):	**33.56**
Simulated Fall Flow Volume (months 10-12):	**80.78**	Observed Fall Flow Volume (10-12):	**72.41**
Simulated Winter Flow Volume (months 1-3):	**88.90**	Observed Winter Flow Volume (1-3):	**105.02**
Simulated Spring Flow Volume (months 4-6):	**56.89**	Observed Spring Flow Volume (4-6):	**65.52**
Total Simulated Storm Volume:	**260.42**	Total Observed Storm Volume:	**275.43**
Simulated Summer Storm Volume (7-9):	**34.05**	Observed Summer Storm Volume (7-9):	**33.30**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**-5.72**	10	
Error in 50% lowest flows:	**0.98**	10	
Error in 10% highest flows:	**-5.88**	15	
Seasonal volume error - Summer:	**1.65**	30	
Seasonal volume error - Fall:	**11.56**	30	
Seasonal volume error - Winter:	**-15.35**	30	
Seasonal volume error - Spring:	**-13.17**	30	
Error in storm volumes:	**-5.45**	20	
Error in summer storm volumes:	**2.25**	50	

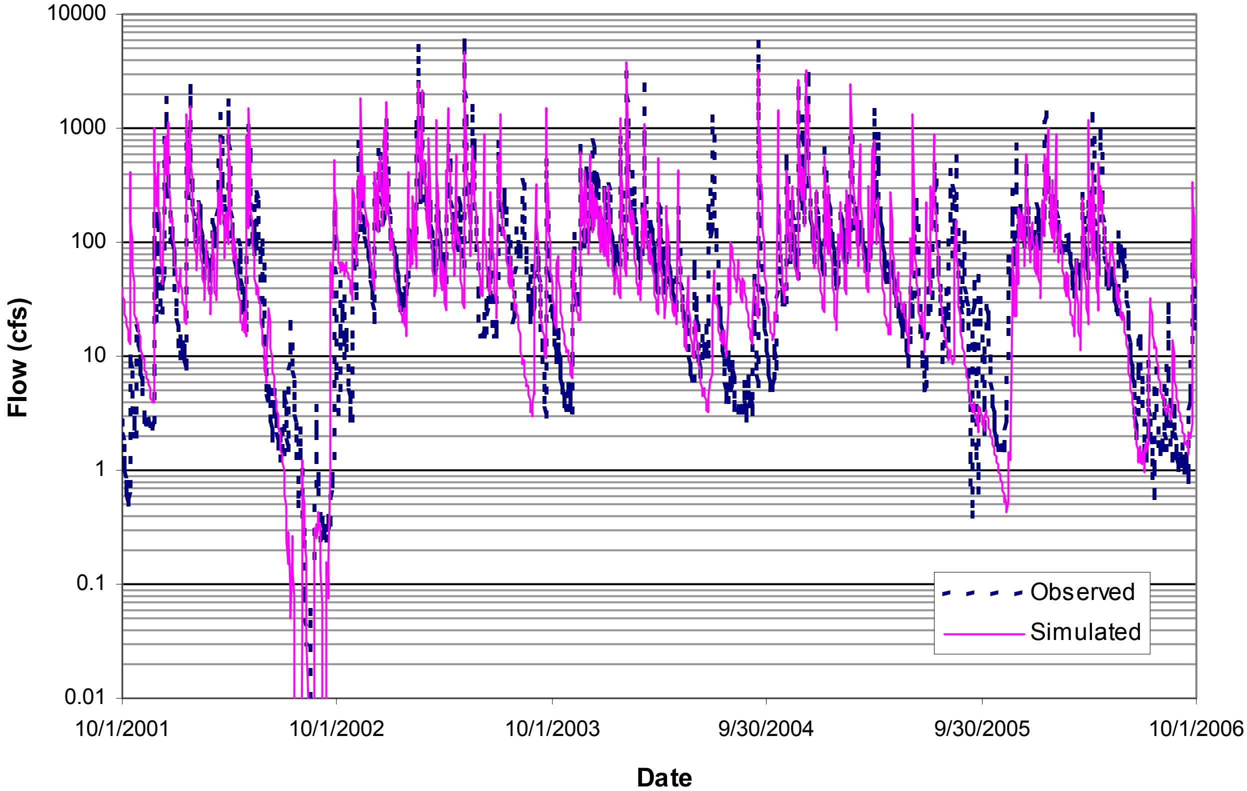

Figure D-1. Hydrologic Calibration: North Chickamauga Creek near Montlake (USGS 03566525)

APPENDIX E

Source Area Implementation Strategy

All impaired waterbodies and corresponding drainage areas have been classified according to their respective source area types in Section 9.5, Table 8. The implementation for each area will be prioritized according to the guidance provided in Sections 9.5.1 and 9.5.2, with examples provided in Sections E.1 and E.2, below. For all impaired waterbodies, the determination of source area types serves to identify the predominant sources contributing to impairment (i.e., those that should be targeted initially for implementation). However, it is not intended to imply that sources in other landuse areas are not contributors to impairment and/or to grant an exemption from addressing other source area contributions with implementation strategies and corresponding load reduction. For mixed use areas, implementation will follow the guidance established for both urban and agricultural areas, at a minimum.

E.1 Urban Source Areas

For impaired waterbodies and corresponding drainage areas identified as predominantly urban source area types, the following example for Clouse Hill Branch provides guidance for implementation analysis:

The Clouse Hill Branch drainage area, a subwatershed of HUC-12 060300010202, lies partially within the city of Tracy City. The drainage area for Clouse Hill Branch at mile 0.1 is approximately 689 acres (1.08 mi^2) and zero flows occur during a significant percentage of time under baseflow conditions. Therefore, four flow zones were used for the duration curve analysis (see Sect. 9.1.1). The landuse for Clouse Hill Branch is approximately 11.1% urban, as defined above. In addition, the Final 2006 303(d) List includes Septic Tanks as the only Pollutant Source category for Clouse Hill Branch. Therefore, the predominate landuse type and sources are urban.

Note: Agricultural areas make up greater than 15% of the total area; therefore, Clouse Hill Branch is listed in the Mixed use source area type in Section 9.5, Table 8.

The flow duration curve for Clouse Hill Branch was constructed using simulated daily mean flow for the period from 10/1/96 through 9/30/06. This flow duration curve is shown in Figure E-1 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record. Flow duration curves for other impaired waterbodies were developed using a similar procedure (Appendix C) and are shown in Figures E-3 and E-5 to E-6.

The E. coli LDC for Clouse Hill Branch at Mile 0.1 (Figure E-2) was analyzed to determine the frequency with which observed daily water quality loads exceed the E. coli target maximum daily loading (941 CFU/100 mL x flow [cfs] x conversion factor) under four flow conditions (low, mid-range, moist, and high). Mile 0.1 corresponds to the location of monitoring station CHILL000.1GY. Observation of the plot indicates that exceedances occur under all flow zones with the exception of the moist conditions, indicating the Clouse Hill Branch watershed is impacted by point and non-point-type sources. LDCs for other impaired waterbodies were developed using a similar procedure (Appendix C) and are shown in Figures E-4 and E-7 to E-8.

Critical conditions for the Clouse Hill Branch drainage area occur during mid-range flows, indicative of both point and non-point source contributions (see Table E-3, Section E.4). However, the high and low flow conditions also have exceedances of water quality criteria. In addition, exceedances of the E. coli water quality standard are relatively well-distributed across the full range of flows and all flow zones, though the magnitude of exceedances varies.

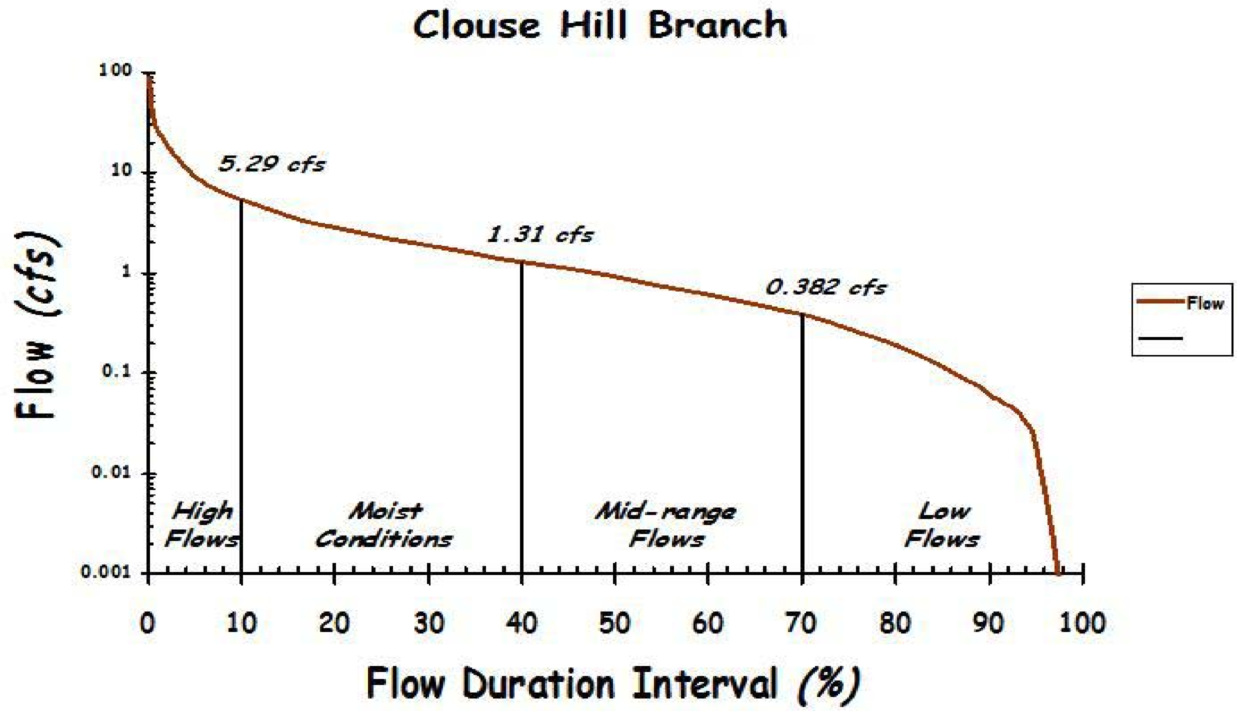

Figure E-1. Flow Duration Curve for Clouse Hill Branch.

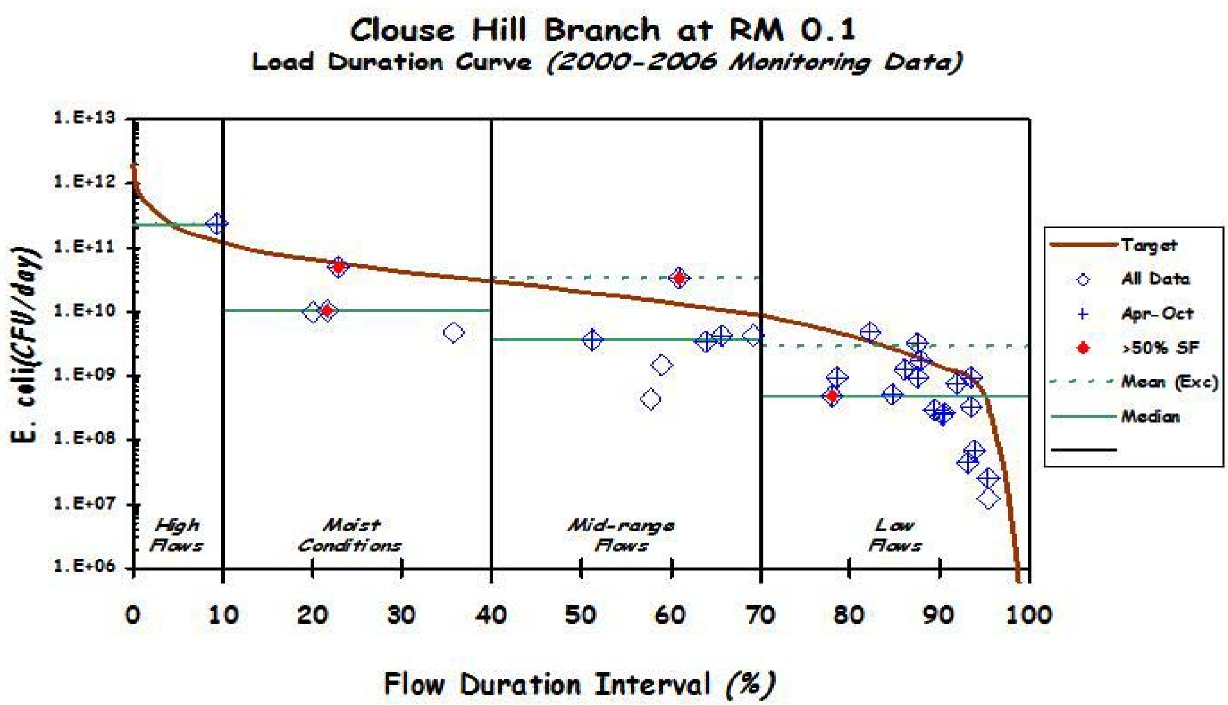

Figure E-2. E. Coli Load Duration Curve for Clouse Hill Branch at Mile 0.1.

According to hydrograph separation analysis, exceedances occur during stormflow events and non-storm (baseflow) periods. These factors indicate that point sources and non-point sources are contributors to impairment in the Clouse Hill Branch watershed. Therefore, it is reasonable to say that point and non-point type sources contribute to exceedances of the E. coli standard in Clouse Hill Branch.

Results indicate the implementation strategy for the Clouse Hill Branch drainage area will require BMPs targeting point sources (dominant under low flow/baseflow conditions) and non-point sources (dominant under high flow/runoff conditions). Table E-1 presents an allocation table of LDC analysis statistics for Clouse Hill Branch E. coli and implementation strategies for each source category covering the entire range of flow (Stiles, 2003). The implementation strategies listed in Table E-1 are a subset of the categories of BMPs and implementation strategies available for application to the Guntersville Lake watershed for reduction of E. coli loading and mitigation of water quality impairment from urban sources. Targeted implementation strategies and LDC analysis statistics for other impaired waterbodies and corresponding drainage areas identified as predominantly urban source area types can be derived from the information and results available in Tables 9 and E-7.

Table E-7 presents LDC analyses (TMDLs, WLAs, LAs, and MOS) and PLRGs for all flow zones for all E. coli impaired waterbodies in the Guntersville Lake watershed.

E.2 Agricultural Source Areas

For impaired waterbodies and corresponding drainage areas identified as predominantly agricultural source area types, the following example for Hedden Branch provides guidance for implementation analysis:

The Hedden Branch drainage area, a subwatershed of HUC-12 060300010202, lies in a mixed-use area in Grundy County, TN. The drainage area for Hedden Branch at mile 0.5 is approximately 289 acres (0.45 mi^2) and zero flows occur during a significant percentage of time under baseflow conditions. Therefore, four flow zones were used for the duration curve analysis (see Sect. 9.1.1). The landuse for Hedden Branch is approximately 12% agricultural, as defined above. In addition, the Final 2006 303(d) List includes Pasture Grazing as a Pollutant Source category for Hedden Branch. Therefore, a predominate landuse type and subsequent sources are agricultural.

Note: Urban areas make up greater than 13% of the total area; therefore, Hedden Branch is listed in the Mixed use source area type in Section 9.5, Table 8.

The flow duration curve for Hedden Branch was constructed using simulated daily mean flow for the period from 10/1/96 through 9/30/06. This flow duration curve is shown in Figure E-3 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record. Flow duration curves for other impaired waterbodies were developed using a similar procedure (see Appendix C) and are shown in Figures E-5 to E-6.

The E. coli LDC for Hedden Branch at Mile 0.5 (Figure E-4) was analyzed to determine the frequency with which observed daily water quality loads exceed the E. coli target maximum daily loading (941 CFU/100 mL x flow [cfs] x conversion factor) under four flow conditions (low, mid-range, moist, and high). Mile 0.5 corresponds to the location of monitoring station HEDDE000.5GY. Observation of the plot indicates that exceedances occur under all flow zones with the exception of high flow conditions, indicating the Hedden Branch watershed is impacted by point and non-point-type sources. LDC s for other impaired waterbodies were developed using a similar procedure (Appendix C) and are shown in Figures E-7 to E-8.

Table E-1. Load Duration Curve Summary for Urban Source Area Implementation Strategies (Example: Clouse Hill Branch drainage area, HUC-12 060300010202) (4 Flow Zones).

Hydrologic Condition		High	Moist	Mid-range*	Low
% Time Flow Exceeded		0-10	10-40	40-70	70-100
Clouse Hill Branch (060300010202)	Number of Samples	1	4	7	18
	% > 941 CFU/100 mL[1]	100	0.0	14.3	16.7
	Load Reduction[2]	45.7%	0.0%	8.7%	4.6%
TMDL (CFU/day)		2.06E+11	5.29E+10	1.71E+10	2.69E+09
Margin of Safety (CFU/day)		2.06E+10	5.29E+09	1.71E+09	2.69E+08
WLA (WWTFs) (CFU/day)		NA	NA	NA	NA
WLAs (MS4s) (CFU/day/acre)[3]		NA	NA	NA	NA
LA (CFU/day/acre)[3]		2. 67E+07	6.84E+06	2.22E+06	3.48E+05
Implementation Strategies[4]					
Municipal NPDES			L	M	H
Stormwater Management			H	H	
SSO Mitigation		H	H	M	
Collection System Repair			L	M	H
Septic System Repair			L	M	M
Potential for source area contribution under given flow condition (H: High; M: Medium; L: Low)					

* The Low flow zone represents the critical conditions for E. coli loading in the Clouse Hill Branch subwatershed.
[1] Tennessee Maximum daily water quality criterion for E. coli.
[2] Reductions (percent) based on mean of observed percent load reductions in range.
[3] LAs and MS4s are expressed as daily load per unit area in order to provide for future changes in the distribution of LAs and MS4s (WLAs).
[4] Watershed-specific Best Management Practices for Urban Source reduction. Actual BMPs applied may vary and should not be limited according to this grouping.

Critical conditions for the Hedden Branch drainage area occur during mid-range flows; however, exceedances of the E. coli water quality standard occur in the moist and low flow zones (see Table E-3, Section E.4).

According to hydrograph separation analysis, exceedances occur during stormflow events and non-storm (baseflow) periods. These factors indicate that point sources and non-point sources are contributors to impairment in the Hedden Branch watershed. Therefore, it is reasonable to say that point and non-point type sources contribute to exceedances of the E. coli standard in Hedden Branch.

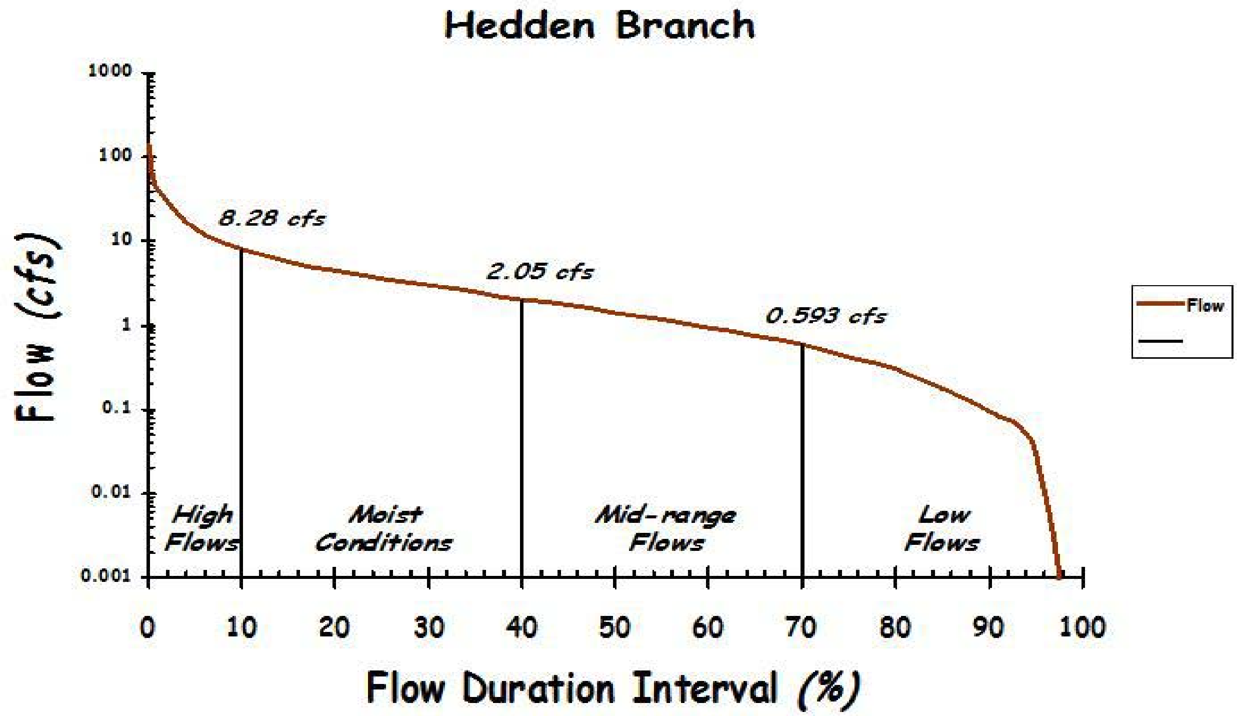

Figure E-3. Flow Duration Curve for Hedden Branch.

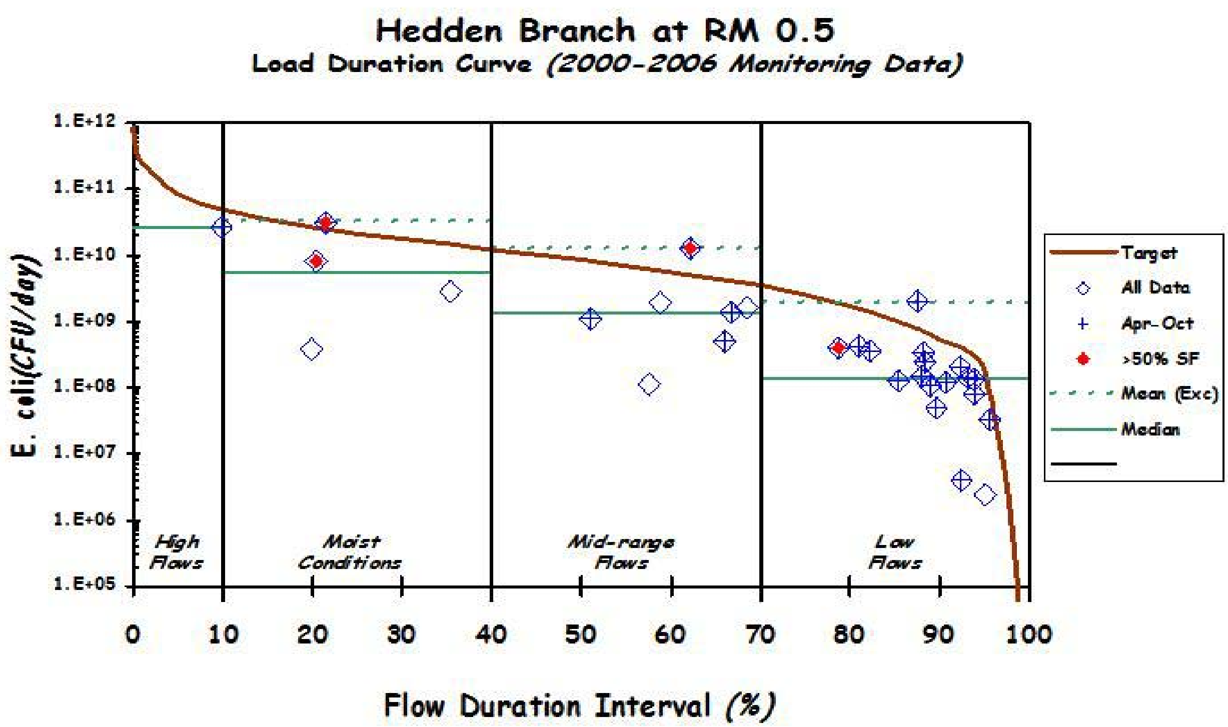

Figure E-4. E. Coli Load Duration Curve for Hedden Branch at Mile 0.5.

Results indicate the implementation strategy for the Hedden Branch watershed will require BMPs targeting point-type sources (dominant under low flow/baseflow conditions) and non-point sources (dominant under high flow/runoff conditions). Table E-2 presents an allocation table of Load Duration Curve analysis statistics for Hedden Branch E. coli and targeted implementation strategies for each source category covering the entire range of flow (Stiles, 2003). The implementation strategies listed in Table E-2 are a subset of the categories of BMPs and implementation strategies available for application to the Guntersville Lake watershed for reduction of E. coli loading and mitigation of water quality impairment from agricultural sources. Targeted implementation strategies and LDC analysis statistics for other impaired waterbodies and corresponding drainage areas identified as predominantly agricultural source area types can be derived from the information and results available in Tables 10 and E-7.

Table E-7 presents LDC analyses (TMDLs, WLAs, LAs, and MOS) and PLRGs for all flow zones for all E. coli impaired waterbodies in the Guntersville Lake watershed.

Table E-2. Load Duration Curve Summary for Agricultural Source Area Implementation Strategies (Example: Hedden Branch drainage area, HUC-12 060300010202) (4 Flow Zones).

Hydrologic Condition		High	Moist	Mid-range*	Low
% Time Flow Exceeded		0-10	10-40	40-70	70-100
Hedden Branch (060300010202)	Number of Samples	1	4	7	18
	% > 941 CFU/100 mL[1]	0.0	25.0	14.3	5.6
	Load Reduction[2]	0.0	5.4	8.7	3.4
TMDL (CFU/day)		9.15E+10	2.37E+10	7.64E+09	1.13E+09
Margin of Safety (CFU/day)		9.15E+09	2.37E+09	7.64E+08	1.13E+08
WLA (WWTFs) (CFU/day)		NA	NA	NA	NA
WLA (MS4s) (CFU/day/acre)[3]		NA	NA	NA	NA
LAs (CFU/day/acre)[3]		7.59E+06	1.97E+06	6.33E+05	9.35E+04
Implementation Strategies[4]					
Pasture and Hayland Management		H	H	M	L
Livestock Exclusion				M	H
Fencing				M	H
Manure Management		H	H	M	L
Riparian Buffers		L	M	H	M
Potential for source area contribution under given flow condition (H: High; M: Medium; L: Low)					

* The Mid-range flow zone represents the critical conditions for E. coli loading in the Hedden Branch subwatershed.
[1] Tennessee Maximum daily water quality criterion for E. coli.
[2] Reductions (percent) based on mean of observed percent load reductions in range.
[3] LAs and MS4s are expressed as daily load per unit area in order to provide for future changes in the distribution of LAs and MS4s (WLAs).
[4] Example Best Management Practices for Agricultural Source reduction. Actual BMPs applied may vary and should not be limited according to this grouping.

E.3 Forestry Source Areas

There are no impaired waterbodies with corresponding drainage areas classified as source area type predominantly forested, with the predominate source category being wildlife, in the Guntersville Lake watershed.

E.4 Calculation of Percent Load Reduction Goals and Determination of Critical Flow Zones

In order to facilitate implementation, corresponding percent reductions in loading required to decrease existing, in-stream E. coli loads to TMDL target levels (percent load reduction goals) were calculated. The following example is from Hedden Branch at mile 0.5:

1. For each flow zone, the mean of the percent exceedances of individual loads relative to their respective target maximum loads (at their respective PDFEs) was calculated. Each negative percent exceedance was assumed to be equal to zero.

   Example: Under Low Flow Conditions (Moist Flow Zone):

Date	Sample Conc. (CFU/100 mL)	Flow (cfs)	Existing Load (CFU/Day)	Target (TMDL) Load (CFU/Day)	Percent Reduction
1/30/06	13.4	1.17	3.85E+08	2.69E+10	0 (-6887)
12/8/05	290.9	1.15	8.20E+09	2.65E+10	0 (-223)
8/17/05	1203.31	1.10	3.25E+10	2.53E+10	21.8
2/11/02	180	0.638	2.81E+09	1.47E+10	0 (-423)
Percent Load Reduction Goal (PLRG) for Low-Flow Zone (Mean)					**5.4**

2. The PLRGs calculated for each of the flow zones, not including the high flow zone, were compared and the PLRG of the greatest magnitude indicates the critical flow zone for prioritizing implementation actions for Hedden Branch.

   Example: High Flow Zone Percent Load Reduction Goal = 0.0%
   Moist Flow Zone Percent Load Reduction Goal = 5.4%
   Mid-Range Flow Zone Percent Load Reduction Goal = 8.7%
   Low Flow Zone Percent Load Reduction Goal = 3.4%

   Therefore, the critical flow zone for prioritization of Hedden Branch implementation activities is the Mid-range Flow Zone and subsequently actions targeting both point and non-point source controls.

PLRG s and critical flow zones of the other impaired waterbodies were derived in a similar manner and are shown in Table E-7.

Table E-3. Summary of Critical Conditions for impaired waterbodies in the Guntersville Lake watershed.

Waterbody ID	Moist	Mid-range	Low
UT to Laurel Lake			ò
Hedden Branch		ò	
Clouse Hill Branch		ò	
Little Fiery Gizzard Creek			ò

Geometric Mean Data

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/100mL. 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: Monitoring Location = Hedden Branch
Sampling Period = 7/05/00 – 8/02/00
Geometric Mean Concentration = 346 CFU/100 mL
Target Concentration = 126 CFU/100 mL
Reduction to Target = 63.6%

For impaired waterbodies where monitoring data are limited to geometric mean data only, results can be utilized for general indication of relative impairment and, when plotted on a load duration curve, may indicate areas for prioritization of implementation efforts. For impaired waterbodies where both types of data are available, geometric mean data were utilized to supplement the results of the individual flow zone calculations.

For Guntersville Lake impaired waterbodies Hedden Branch, Clouse Hill Branch, and Little Fiery Gizzard Creek, geometric mean data are available and percent load reductions have been calculated. See Tables E-4 to E-6, respectively. Maximum percent reductions calculated from geometric mean data and calculated percent reductions for daily loading for the critical flow zones, for each waterbody, are reported in Table E-7. The highest percent reduction (bolded) for each represents the PLRG for the waterbody.

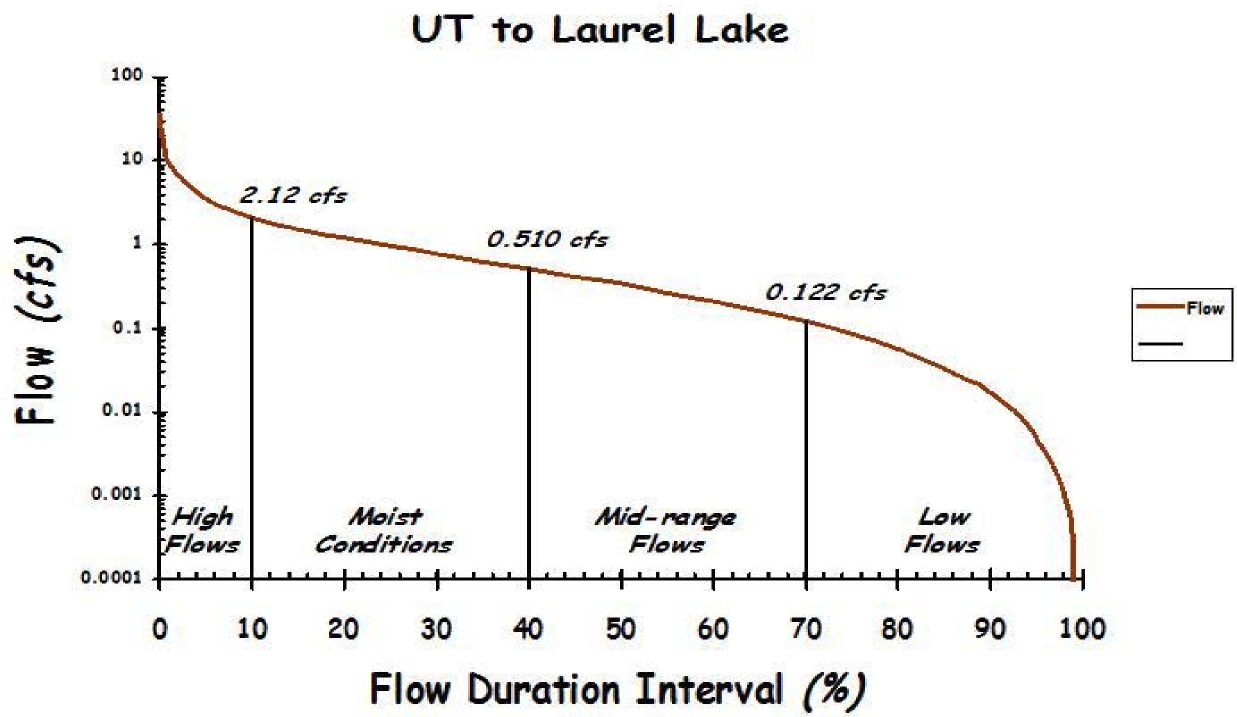

Figure E-5. Flow Duration Curve for the Unnamed Tributary to Laurel Lake.

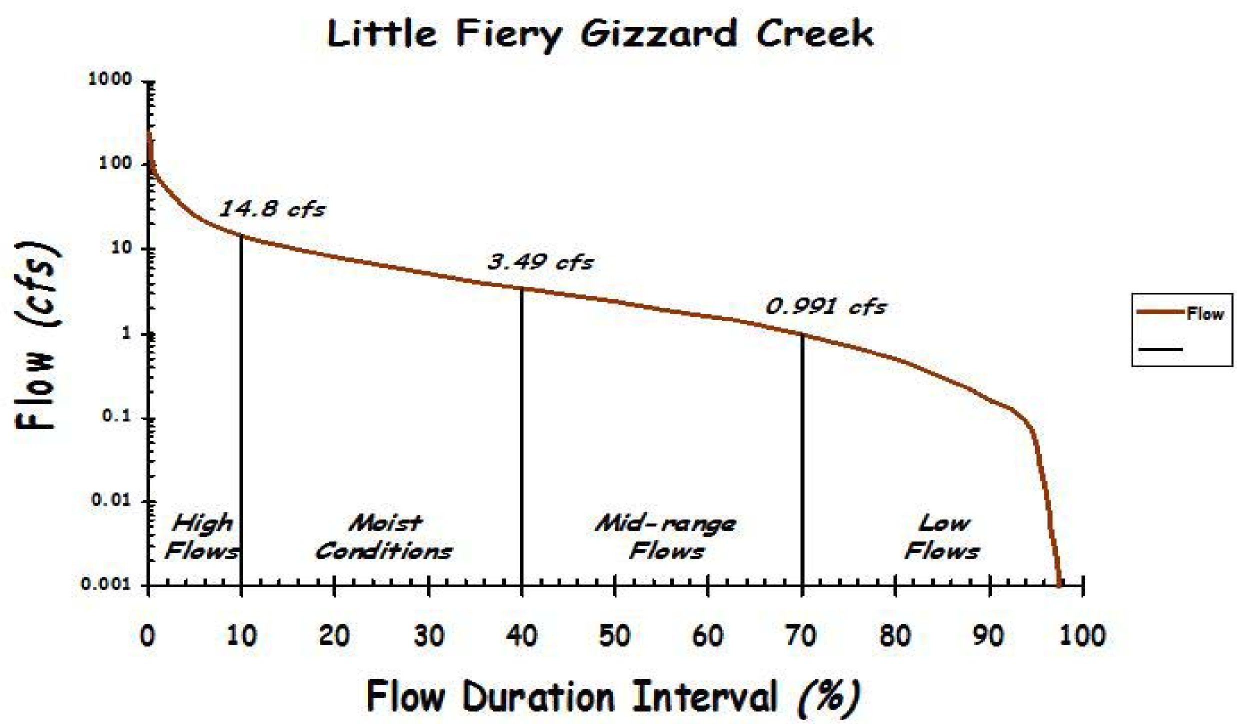

Figure E-6. Flow Duration Curve for Little Fiery Gizzard Creek.

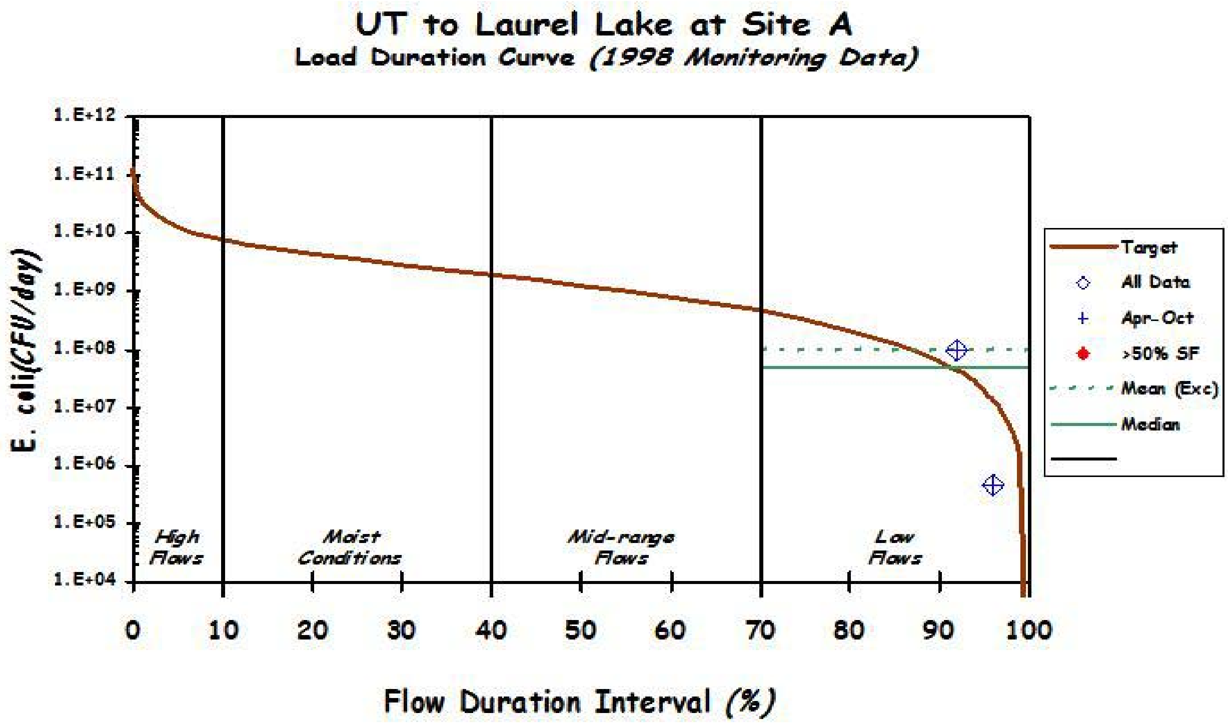

Figure E-7. E. Coli Load Duration Curve for Unnamed Tributary to Laurel Lake at Site A.

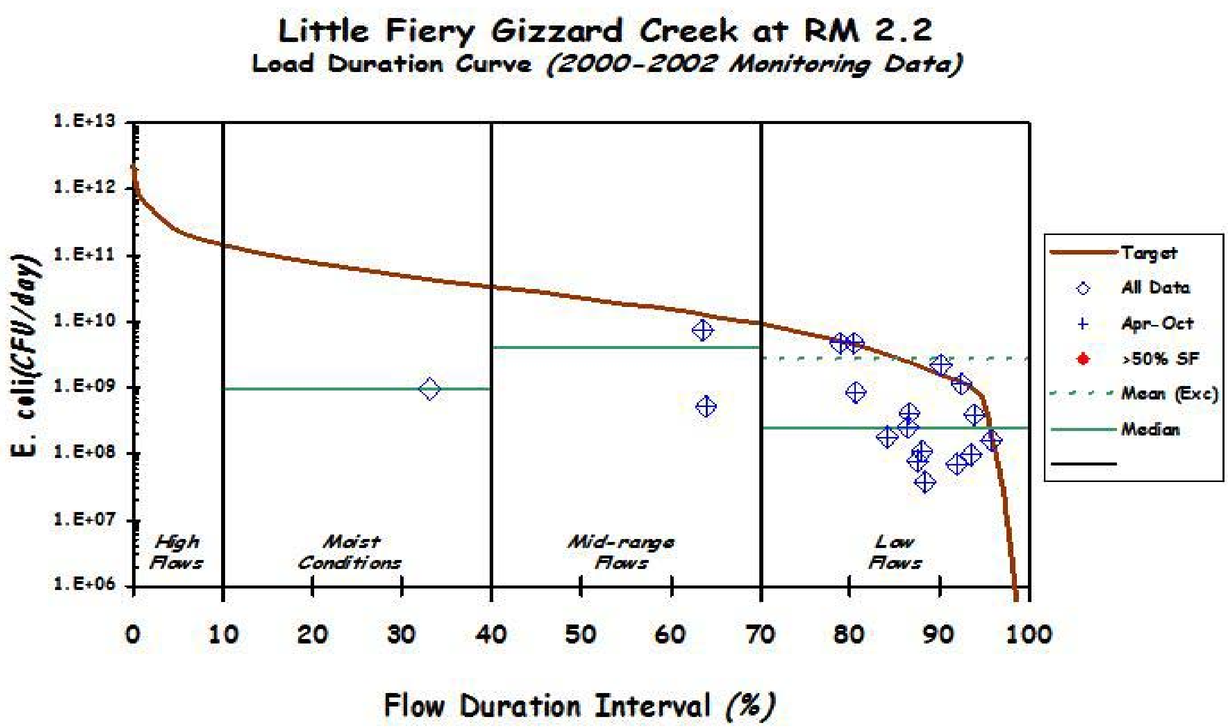

Figure E-8. E. Coli Load Duration Curve for Little Fiery Gizzard Creek at Mile 2.2.

Table E-4. Load Reduction Based on Geometric Mean Data – Hedden Branch at Mile 0.5

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Percent Reduction
	(cfs)	(%)	(CFU/100 mL)	(CFU/100 mL)	(%)
5/23/00	0.225	62.1%	2400		
5/30/00	0.0272	88.9%	160		
6/6/00	0.0302	88.3%	460		
6/13/00	0.0125	93.1%	460		
6/20/00	0.181	66.7%	310	**478.9**	**73.7**
6/27/00	0.0308	88.0%	200	291.3	56.8
7/5/00	0.0833	78.8%	200	304.6	58.6
7/11/00	0.0158	92.2%	550	315.7	60.1
7/17/00	0.0100	93.9%	550	327.2	61.5
7/25/00	0.0055	95.6%	250	313.4	59.8
8/2/00	0.0101	93.9%	330	346.5	63.6
8/9/00	0.0299	88.3%	340	385.2	67.3
8/15/00	0.0434	85.3%	120	284.1	55.7
8/23/00	0.0211	90.7%	240	240.7	47.7
8/29/00	0.0693	81.0%	260	242.6	48.1
9/6/00	0.187	66.0%	110	194.7	35.3
9/13/00	0.0612	82.3%	240	181.6	30.6

Table E-5. Load Reduction Based on Geometric Mean Data – Clouse Hill Branch at Mile 0.1

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Percent Reduction
	(cfs)	(%)	(CFU/100 mL)	(CFU/100 mL)	(%)
5/23/00	0.582	60.8%	2400		
5/30/00	0.0676	89.4%	180		
6/6/00	0.0813	87.9%	870		
6/13/00	0.0329	93.4%	410		
6/20/00	0.465	65.7%	370	**563.9**	**77.7**
6/27/00	0.0853	87.5%	460	405.2	68.9
7/5/00	0.220	78.0%	89	352.0	64.2
7/11/00	0.0449	91.9%	690	336.0	62.5
7/17/00	0.0291	93.9%	100	253.4	50.3
7/25/00	0.0174	95.3%	60	176.1	28.5
8/2/00	0.0320	93.5%	1200	213.4	40.9
8/9/00	0.103	86.1%	490	300.1	58.0
8/15/00	0.121	84.6%	170	226.8	44.4
8/23/00	0.0568	90.6%	190	257.8	51.1
8/29/00	0.214	78.6%	180	321.2	60.8
9/6/00	0.509	63.9%	280	240.1	47.5
9/13/00	0.159	82.2%	1200	287.2	56.1

Table E-6. Load Reduction Based on Geometric Mean Data – Little Fiery Gizzard Creek at Mile 2.2

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Percent Reduction
	(cfs)	(%)	(CFU/100 mL)	(CFU/100 mL)	(%)
5/23/00	0.195	80.4%	1000		
5/30/00	0.0829	88.4%	18		
6/6/00	0.0865	88.1%	52		
6/13/00	0.0423	92.5%	1100		
6/20/00	0.547	63.9%	39	132.1	4.6
6/27/00	0.0925	87.5%	35	67.5	0.0
7/5/00	0.105	86.4%	98	94.8	0.0
7/11/00	0.0482	92.0%	60	97.5	0.0
7/17/00	0.0307	93.8%	520	84.0	0.0
7/25/00	0.0163	95.8%	400	133.8	5.8
8/2/00	0.0324	93.6%	120	171.1	26.4
8/9/00	0.103	86.6%	160	188.8	33.2
8/15/00	0.135	84.1%	54	184.8	31.8
8/23/00	0.0650	90.2%	1400	225.3	44.1
8/29/00	0.225	78.9%	870	263.2	52.1
9/6/00	0.554	63.6%	550	356.9	64.7
9/13/00	0.188	80.7%	190	**369.3**	**65.9**

Table E-7. Summary of TMDLs, MOS, WLAs, & LAs expressed as daily loads for impaired waterbodies in the Guntersville Lake watershed (HUC 06030001)

Waterbody Description	Hydrologic Condition			Flow[a]	PLRG[b]		TMDL	MOS	WLAs[c]			LAs
	Flow Zone	PDFE Range	Flow Range		Daily	Geo-mean			WWTFs[d]	CS	MS4s	
		(%)	(cfs)	(cfs)	(%)	(%)	[CFU/d]	[CFU/d]	[CFU/d]	[CFU/d]	[CFU/d/ac]	[CFU/d/ac]
Unnamed Tributary to Laurel Lake Waterbody ID: **TN06030001057–0511** HUC-12: 0201	High Flows	0–10	2.12 - 35.0	3.63	NA	NA	8.349E+10	8.349E+09	NA	0	NA	3.296E+07
	Moist	10-40	0.510 - 2.12	0.981	NA		2.256E+10	2.256E+09	NA	0	NA	8.906E+06
	Mid-Range	40–70	0.122 - 0.510	0.267	NA		6.141E+09	6.141E+08	NA	0	NA	2.424E+06
	Low Flows	70–100	0.0 - 0.122	0.0327	**26.3**		7.521E+08	7.521E+07	NA	0	NA	2.969E+05
Hedden Branch Waterbody ID: **TN06030001057–0811** HUC-12: 0202	High Flows	0–10	2.38 - 39.6	3.98	0.0	**73.7**	9.154E+10	9.154E+09	NA	0	NA	7.593E+06
	Moist	10–40	0.586 - 2.38	1.03	5.4		2.369E+10	2.369E+09	NA	0	NA	1.965E+06
	Mid-Range	40–70	0.168 - 0.586	0.332	8.7		7.636E+09	7.636E+08	NA	0	NA	6.334E+05
	Low Flows	70–100	0.0 - 0.168	0.0490	4.6		1.127E+09	1.127E+08	NA	0	NA	9.348E+04
Clouse Hill Branch Waterbody ID: **TN06030001057–0812** HUC-12: 0202	High Flows	0–10	5.29 - 88.0	8.96	45.7	**77.7**	2.061E+11	2.061E+10	NA	0	NA	2.665E+07
	Moist	10–40	1.31 - 5.29	2.30	0.0		5.290E+10	5.290E+09	NA	0	NA	6.841E+06
	Mid-Range	40–70	0.382 - 1.31	0.745	8.7		1.714E+10	1.714E+09	NA	0	NA	2.216E+06
	Low Flows	70–100	0.0 - 0.382	0.117	4.6		2.691E+09	2.691E+08	NA	0	NA	3.480E+05
Little Fiery Gizzard Creek Waterbody ID: **TN06030001057–0815** HUC-12: 0202	High Flows	0–10	14.8 - 245	24.5	NA	**65.9**	5.635E+11	5.635E+10	4.276E+08	0	NA	2.544E+07
	Moist	10–40	3.49 - 14.8	6.37	0.0		1.465E+11	1.465E+10	4.276E+08	0	NA	6.453E+06
	Mid-Range	40–70	0.990 - 3.49	1.96	0.0		4.508E+10	4.508E+09	4.276E+08	0	NA	1.836E+06
	Low Flows	70–100	0.0 - 0.990	0.300	3.5		6.900E+09	6.900E+08	4.276E+08	0	NA	9.788E+04

Note: NA = Not applicable.
PDFE = Percent Days Flow Exceeded.
PLRG = Percent Load Reduction Goal.
CS = Collection Systems.
Shaded Flow Zone for each waterbody represents the critical flow zone according to daily loading results.

a. Flow applied to TMDL, MOS, and allocation (WLA [MS4] and LA) calculations. Flows represent the median value in the respective hydrologic flow zone.

b. Percent load reduction goals based on daily loading and geometric mean, respectively.

c. There are no CAFOs in impaired subwatersheds of the Guntersville Lake watershed. All future CAFOs will be assigned waste load allocations (WLAs) of zero.

d. WLAs for WWTFs expressed as E. coli loads (CFU/day). Current and future WWTFs must meet water quality standards as specified in their NPDES permits.

APPENDIX F

Public Notice of Proposed Total Maximum Daily Loads (TMDLs) for E. Coli in the Guntersville Lake Watershed (HUC 06030001)

DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR E. COLI IN THE GUNTERSVILLE LAKE WATERSHED (HUC 06030001), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed total maximum daily load (TMDL) for E. coli in the Guntersville Lake watershed, located in southern middle 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 are listed on Tennessee's Final 2006 303(d) List as not supporting designated use classifications due, in part, to discharge of E. coli from collection system failure, pasture grazing, and septic tanks. The TMDL utilizes Tennessee's general water quality criteria, recently collected site specific water quality data, continuous flow data from a USGS discharge monitoring station located in the vicinity of the watershed, a calibrated hydrologic model, and load duration curves to establish allowable loadings of E. coli which will result in reduced in-stream concentrations and attainment of water quality standards. The TMDL requires reductions of E. coli loading on the order of 26-78% for the listed waterbodies.

The proposed Guntersville Lake E. coli TMDL document can be downloaded from the following website:

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

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

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

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

Persons wishing to comment on the proposed TMDL are invited to submit their comments in writing no later than February 22, 2008 to:

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

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

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