TOTAL MAXIMUM DAILY LOAD (TMDL)

for

E. Coli

in the

Lower Tennessee River Watershed

(HUC 06020001)

Bledsoe, Bradley, Hamilton, Loudon, Marion, McMinn, Meigs, Rhea, Roane, and Sequatchie Counties, Tennessee

FINAL

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DEPARTMENT OF ENVIRONMENT & CONSERVATION

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LIST OF ABBREVIATIONS

ADB	Assessment Database
AFO	Animal Feeding Operation
BMP	Best Management Practices
BST	Bacteria Source Tracking
CAFO	Concentrated Animal Feeding Operation
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CFU	Colony Forming Units
DEM	Digital Elevation Model
DWPC	Division of Water Pollution Control
E. coli	Escherichia coli
EPA	Environmental Protection Agency
GIS	Geographic Information System
HSPF	Hydrological Simulation Program - Fortran
HUC	Hydrologic Unit Code
LA	Load Allocation
LDC	Load Duration Curve
MGD	Million Gallons per Day
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
MS4	Municipal Separate Storm Sewer System
MST	Microbial Source Tracking
NHD	National Hydrography Dataset
NMP	Nutrient Management Plan
NPS	Nonpoint Source
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PCR	Polymerase Chain Reaction
PDFE	Percent of Days Flow Exceeded
PFGE	Pulsed Field Gel Electrophoresis
Rf3	Reach File v.3
RM	River Mile
SSO	Sanitary Sewer Overflow
STP	Sewage Treatment Plant
SWMP	Storm Water Management Program
TDEC	Tennessee Department of Environment & Conservation
TDOT	Tennessee Department of Transportation
TMDL	Total Maximum Daily Load
TWRA	Tennessee Wildlife Resources Agency
USGS	United States Geological Survey
UCF	Unit Conversion Factor
WCS	Watershed Characterization System
WLA	Waste Load Allocation
WWTF	Wastewater Treatment Facility

SUMMARY SHEET

Total Maximum Daily Load for E. coli in Lower Tennessee River Watershed (HUC 06020001)

Impaired Waterbody Information

State: Tennessee
Counties: Hamilton and McMinn
Watershed: Lower Tennessee River (HUC 06020001)
Constituents of Concern: E. coli

Waterbodies Addressed in This Document:

Waterbody ID	Waterbody	Miles Impaired
TN06020001001T – 0200	NORTH MARKET STREET BRANCH	2.5
TN06020001007 – 0100	*FRIAR BRANCH*	*18.94*
TN06020001007 – 0200	*UNNAMED TRIB TO SOUTH CHICAMAUGA CREEK*	*1.1*
TN06020001007 – 0300	*MACKEY BRANCH*	*15.66*
TN06020001007 – 0510	*SPRING CREEK*	*9.6*
TN06020001007 – 1000	*SOUTH CHICKAMAUGA CREEK*	*17.6*
TN06020001029 – 0100	WOLFE BRANCH *	6.3
TN06020001029 – 0300	LEWIS BRANCH	1.5
TN06020001029 – 1000	LONG SAVANNAH CREEK (incl. UNNAMED TRIB TO LONG SAVANNAH CREEK)	15.0
TN06020001041 – 0320	BIVENS BRANCH	2.2
TN06020001087 – 1000	*SHOAL CREEK*	*5.4*
TN06020001109 – 0100	*SHORT CREEK*	*2.5*
TN06020001109 – 0200	STANLEY BRANCH	1.05
TN06020001109 – 0400	*BEE BRANCH*	*1.55*
TN060200011240 – 0100	UNNAMED TRIB TO CITICO CREEK	1.2
TN060200011240 – 1000	CITICO CREEK	6.1
TN060200011244 – 0100	DOBBS BRANCH	5.3
TN060200011244 – 0200	UNNAMED TRIB TO CHATTANOOGA CREEK	1.4
TN060200011244 – 0300	MCFARLAND SPRINGS BRANCH	1.2
TN060200011244 – 0400	GILLESPIE SPRINGS BRANCH	1.9
TN060200011244 – 1000	CHATTANOOGA CREEK	8.4
TN060200011244 – 2000	CHATTANOOGA CREEK	3.5

Waterbody ID	Waterbody	Miles Impaired
TN06020001426 – 0100	STRINGERS BRANCH	5.8
TN06020001426 – 1000	MOUNTAIN CREEK	3.2
TN06020001880 – 1000	*ROGERS BRANCH*	*10.4*
TN06020001889 – 0100	LITTLE WOLFTEVER CREEK *	11.9
TN06020001889 – 0200	CHESTNUT CREEK *	8.1
TN06020001889 – 0300	WILKERSON BRANCH	5.8
TN06020001889 – 0400	UNNAMED TRIB TO WOLFTEVER CREEK *	9.2
TN06020001889 – 1000	WOLFTEVER CREEK	11.1

* Analysis of monitoring data from several waterbodies that were not listed on the Final 2008 303(d) list suggested possible impairment. TMDLs were also developed for these non-listed waterbodies. Waterbodies should be included in future 303(d) list.

** Maximum water quality target is 487 CFU/100 mL for lakes, reservoirs, State Scenic Rivers, or Exceptional Tennessee Waters waterbodies and 941 CFU/100 mL for other waterbodies. Waterbodies utilizing the 487 CFU/100 mL target are italicized.

Designated Uses:

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

Water Quality Targets:

Derived from *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, 2007 Version* 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, Exceptional Tennessee Water or ONRW (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.

For further information on Tennessee's general water quality standards, see:

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

TMDL Scope:

Waterbodies identified on the Final 2008 303(d) list as impaired due to E. coli. TMDLs were developed for impaired waterbodies on a HUC-12 subwatershed or waterbody drainage area basis. This TMDL supersedes the pathogen TMDLs approved by EPA in 2006.

Several waterbodies not listed as impaired due to E. coli but located in HUC-12 subwatersheds containing waterbodies listed as impaired were also investigated. Whenever analysis of monitoring data suggested possible impairment, TMDLs were developed for these non-listed waterbodies.

Analysis/Methodology:

The TMDLs for impaired waterbodies in the Lower Tennessee River Watershed were developed using a load duration curve methodology to assure compliance with the E. coli 126 CFU/100 mL geometric mean and the 487 CFU/100 mL maximum water quality criteria for lakes, reservoirs, State Scenic Rivers, or Exceptional Tennessee Waters and 941 CFU/100 mL maximum water quality criterion for all other waterbodies. A duration curve is a cumulative frequency graph that represents the percentage of time during which the value of a given parameter is equaled or exceeded. Load duration curves are developed from flow duration curves and can illustrate existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired targets, and the region of the waterbody flow zone 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 geometric mean criterion.

Critical Conditions:

Water quality data collected over a period of up to 10 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 and the percent of samples exceeding TMDL target concentrations (percent exceedance), for each hydrologic flow zone, to meet the target (TMDL) loading for E. coli. The percent load reduction goal and/or the percent exceedance of the greatest magnitude corresponds with the critical flow zone(s).

Seasonal Variation:

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

Margin of Safety (MOS):

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

TMDLs, WLAs, & LAs for Impaired Waterbodies in the Lower Tennessee River Watershed (HUC 06020001)

HUC-12 Subwatershed (06020001__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs			LAs
					WWTFs [a]	Collection Systems	MS4s [b]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/d/ac]	[CFU/d/ac]
0102 (DA)	Bivens Branch	TN06020001041 – 0320	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.649 \times 10^{7} \times Q$
0401	Lewis Branch	TN06020001029 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.480 \times 10^{7} \times Q$	$1.480 \times 10^{7} \times Q$
	Long Savannah Creek	TN06020001029 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.102 \times 10^{6} \times Q$	$1.102 \times 10^{6} \times Q$
	Wolfe Branch	TN06020001029 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$6.880 \times 10^{6} \times Q$	$6.880 \times 10^{6} \times Q$
0402	Chestnut Creek	TN06020001889 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$5.887 \times 10^{6} \times Q$	$5.887 \times 10^{6} \times Q$
	Little Wolftever Creek	TN06020001889 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.176 \times 10^{6} \times Q$	$3.176 \times 10^{6} \times Q$
	Rogers Branch	TN060200011880 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	NA	$3.313 \times 10^{6} \times Q$	$3.313 \times 10^{6} \times Q$
	Wilkerson Branch	TN06020001889 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$9.117 \times 10^{6} \times Q$	$9.117 \times 10^{6} \times Q$
	Wolftever Creek	TN06020001889 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.404 \times 10^{5} \times Q$	$3.404 \times 10^{5} \times Q$
	Unnamed Trib to Wolftever Creek	TN06020001889 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.735 \times 10^{7} \times Q$	$2.735 \times 10^{7} \times Q$
0903	Spring Creek	TN06020001007 – 0510	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	0	$8.166 \times 10^{5} \times Q$	$8.166 \times 10^{5} \times Q$
0905	Friar Branch	TN06020001007 – 0100	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	0	$8.131 \times 10^{5} \times Q$	$8.131 \times 10^{5} \times Q$
	Mackey Branch	TN06020001007 – 0300	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	0	$1.579 \times 10^{6} \times Q$	$1.579 \times 10^{6} \times Q$
	South Chickamauga Creek	TN06020001007 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.357×10^{11}	0	$3.699 \times 10^{4} \times Q - 1.492 \times 10^{6}$	$3.699 \times 10^{4} \times Q - 5.164 \times 10^{5}$
	Unnamed Trib to S. Chickamauga Creek	TN06020001007 – 0200	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	0	$1.243 \times 10^{7} \times Q$	$1.243 \times 10^{7} \times Q$

TMDLs, WLAs, & LAs for Impaired Waterbodies in the Lower Tennessee River Watershed (HUC 06020001)

HUC-12 Subwatershed (06020001__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs			LAs
					WWTFs [a]	Collection Systems	MS4s [b]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/d/ac]	[CFU/d/ac]
1003	Dobbs Branch	TN060200011244 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$6.656 \times 10^{6} \times Q$	$6.656 \times 10^{6} \times Q$
	Gillespie Springs Branch	TN060200011244 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$3.054 \times 10^{7} \times Q$	$3.054 \times 10^{7} \times Q$
	McFarland Springs Branch	TN060200011244 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$2.524 \times 10^{7} \times Q$	$2.524 \times 10^{7} \times Q$
	Chattanooga Creek	TN060200011244 – 1000 TN060200011244 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	2.849×10^{11}	0	$6.582 \times 10^{6} \times Q$	$4.782 \times 10^{5} \times Q$
	Unnamed Trib to Chattanooga Creek	TN060200011244 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$2.514 \times 10^{7} \times Q$	$2.514 \times 10^{7} \times Q$
1202	Bee Branch	TN06020001109 – 0400	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	NA	$2.541 \times 10^{7} \times Q$	$2.541 \times 10^{7} \times Q$
	Citico Creek	TN060200011240 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$5.209 \times 10^{6} \times Q$	$5.209 \times 10^{6} \times Q$
	Unnamed Trib to Citico Creek	TN060200011240 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$2.547 \times 10^{7} \times Q$	$2.547 \times 10^{7} \times Q$
	Mountain Creek	TN060200011426 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$4.581 \times 10^{6} \times Q$	$4.581 \times 10^{6} \times Q$
	North Market Street Branch	TN06020001001T – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$4.189 \times 10^{7} \times Q$	$4.189 \times 10^{7} \times Q$
	Shoal Creek	TN06020001087 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	0	$7.068 \times 10^{6} \times Q$	$7.068 \times 10^{6} \times Q$
	Short Creek	TN06020001109 – 0100	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	NA	$2.770 \times 10^{7} \times Q$	$2.770 \times 10^{7} \times Q$
	Stanley Branch	TN06020001109 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.879 \times 10^{7} \times Q$	$3.879 \times 10^{7} \times Q$
	Stringers Branch	TN060200011426 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$5.339 \times 10^{6} \times Q$	$5.339 \times 10^{6} \times Q$

Notes: NA = Not Applicable.
Q = Mean Daily In-stream Flow (cfs).

a. WLAs for WWTFs are expressed as E. coli loads (CFU/day). All current and future WWTFs must meet water quality standards as specified in their NPDES permit.

b. Applies to any MS4 discharge loading in the subwatershed. Future MS4s will be assigned waste load allocations (WLAs) consistent with load allocations (LAs) assigned to precipitation induced nonpoint sources.

PROPOSED E. COLI TOTAL MAXIMUM DAILY LOAD (TMDL) LOWER TENNESSEE RIVER WATERSHED (HUC 06020001)

1.0 INTRODUCTION

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

2.0 SCOPE OF DOCUMENT

This document presents details of TMDL development for waterbodies in the Lower Tennessee River Watershed, identified on the Final 2008 303(d) list as not supporting designated uses due to E. coli. Portions of the Lower Tennessee River Watershed lie in 3 states: Tennessee, Alabama, and Georgia. This document addresses only impaired waterbodies in Tennessee. TMDL analyses were performed primarily on a 12-digit hydrologic unit area (HUC-12) basis. In some cases, where appropriate, TMDLs were developed for an impaired waterbody drainage area only. This TMDL supersedes the pathogen TMDLs approved by EPA in 2006.

3.0 WATERSHED DESCRIPTION

The Lower Tennessee River Watershed (HUC 06020001) is located in southeastern Tennessee (Figure 1). The Lower Tennessee River Watershed is also known as the Middle Tennessee-Chickamauga Watershed. The Lower Tennessee River Watershed lies within two Level III ecoregions (Ridge and Valley, Southwestern Appalachians) and contains eight Level IV ecoregions as shown in Figure 2 (USEPA, 1997):

- **The Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f)** form a heterogeneous region composed predominantly of limestone and cherty dolomite. Landforms are mostly low rolling ridges and valleys, and the solids vary in their productivity. Landcover includes intensive agriculture, urban and industrial, or areas of thick forest. White oak forests, bottomland oak forests, and sycamore-ash-elm riparian forests are the common forest types, and grassland barrens intermixed with cedar-pine glades also occur here.
- **The Southern Shale Valleys (67g)** consist of lowlands, rolling valleys, and slopes and hilly areas that are dominated by shale materials. The northern areas are associated with Ordovician-age calcareous shale, and the well-drained soils are often slightly acid to neutral. In the south, the shale valleys are associated with Cambrian-age shales that contain some narrow bands of limestone, but the soils tend to be strongly acid. Small farms and rural residences subdivide the land. The steeper slopes are used for pasture

or have reverted to brush and forested land, while small fields of hay, corn , tobacco, and garden crops are grown on the foot slopes and bottomland.

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

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

- **Cumberland Plateau (68a)** tablelands and open low mountains are about 1000 feet higher than the Eastern Highland Rim (71g) to the west, and receive slightly more precipitation with cooler annual temperatures than the surrounding lower-elevation ecoregions. The plateau surface is less dissected with lower relief compared to the Cumberland Mountains (69d) or the Plateau Escarpment (68c). Elevations are generally 1200-2000 feet, with the Crab Orchard Mountains reaching over 3000 feet. Pennsylvanian-age conglomerate, sandstone, siltstone, and shale is covered by well-drained, acid soils of low fertility. Bituminous coal that has been extensively surface and underground mined underlies the region. Acidification of first and second order streams is common. Stream siltation and mine spoil bedload deposits continue as long-term problems in these headwater systems. Pockets of severe acid mine drainage persist.

- **Sequatchie Valley (68b)** is structurally associated with an anticline, where erosion of broken rock to the south of the Crab Orchard Mountains scooped out the linear valley. The open, rolling, valley floor, 600-1000 feet in elevation, is generally 1000 feet below the top of the Cumberland Plateau. A low, central, cherty ridge separates the west and east valleys of Mississippian to Ordovician-age limestones, dolomites, and shales. Similar to parts of the Ridge and Valley (67f), this is an agriculturally productive region, with areas of pasture, hay, soybeans, small grain, corn, and tobacco.

- **Plateau Escarpment (68c)** is characterized by steep, forested slopes and high velocity, high gradient streams. Local relief is often 1000 feet or more. The geologic strata include Mississippian-age limestone, sandstone, shale, and siltstone, and Pennsylvanian-age shale, siltstone, sandstone, and conglomerate. Streams have cut down into the limestone, but the gorge talus slopes are composed of colluvium with huge angular, slabby blocks of sandstone. Vegetation community types in the ravines and gorges include mixed oak and chestnut oak on the upper slopes, mesic forests on

the middle and lower slopes (beech-tulip poplar, sugar maple-basswood-ash-buckeye), with hemlock along rocky streamsides and river birch along floodplain terraces.

- **The Southern Table Plateaus (68d)** include Sand Mountain and Lookout Mountain in northwest Georgia. While it has some similarities to the Cumberland Plateau (68a) in Tennessee with its Pennsylvanian-age sandstone caprock, shale layers, and coal-bearing strata, this ecoregion is lower in elevation, has a slightly warmer climate, and has more agriculture. Although the Georgia portion is mostly forested, primarily with mixed oak and oak-hickory communities, elevations decrease to the southwest in Alabama and there is more cropland and pasture. The plateau surface is less dissected with lower relief compared to the Plateau Escarpment (68c), and it is slightly cooler with more precipitation than in the nearby lower elevations of 67f.

The Lower Tennessee River Watershed, located in Bledsoe, Bradley, Hamilton, Loudon, Marion, McMinn, Meigs, Rhea, Roane, and Sequatchie Counties, Tennessee, has a drainage area of approximately 1,214 square miles (mi^2) in Tennessee. The entire watershed, including portions of Tennessee, Alabama, and Georgia, drains approximately 1,870 mi^2. Watershed land use distribution is based on the Multi-Resolution Land Characteristic (MRLC) databases derived from Landsat Thematic Mapper digital images from around 2001. Although changes in the land use of the Lower Tennessee River Watershed have occurred since 2001 as a result of rapid development, this is the most current land use data available. Land use in the Lower Tennessee River Watershed is summarized in Table 1 and shown in Figure 3. Predominant land use in the Tennessee portion of the Lower Tennessee River Watershed is forest (64.7%) followed by pasture (16.4%). Urban areas represent approximately 14.2% of the total drainage area of the watershed. Details of land use distribution of impaired subwatersheds in the Lower Tennessee River Watershed are presented in Appendix A.

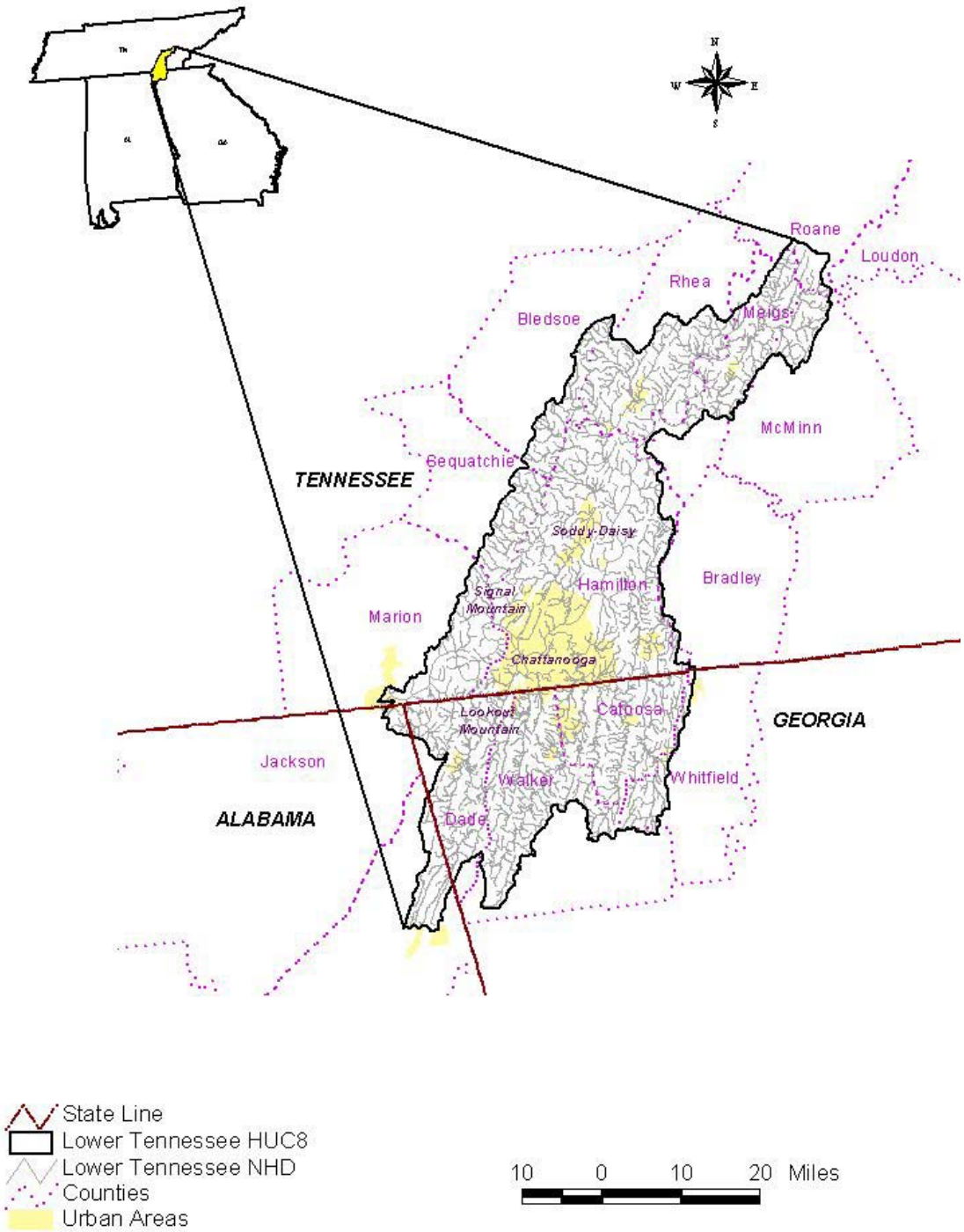

Figure 1. Location of the Lower Tennessee River Watershed.

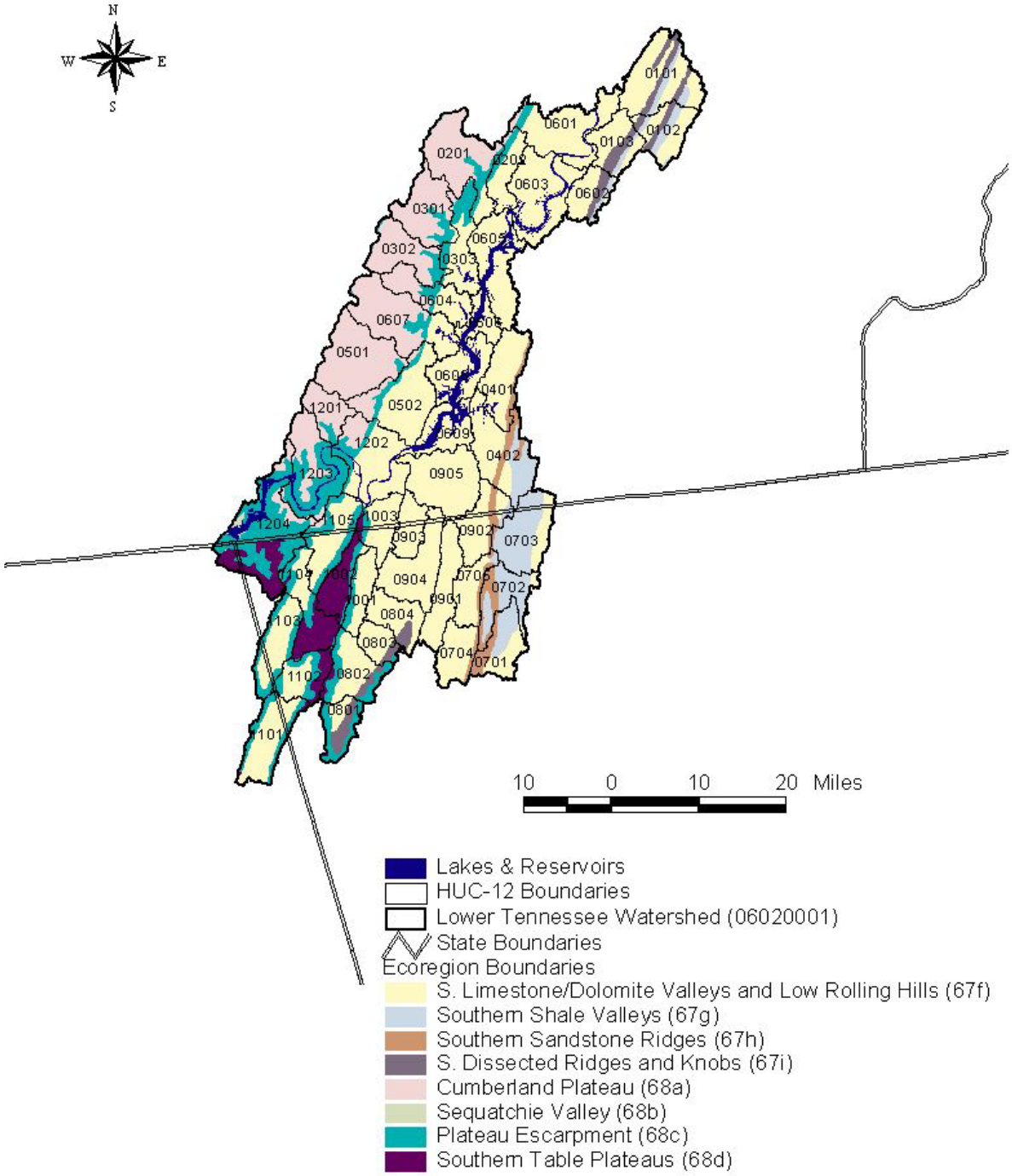

Figure 2. Level IV Ecoregions in the Lower Tennessee River Watershed.

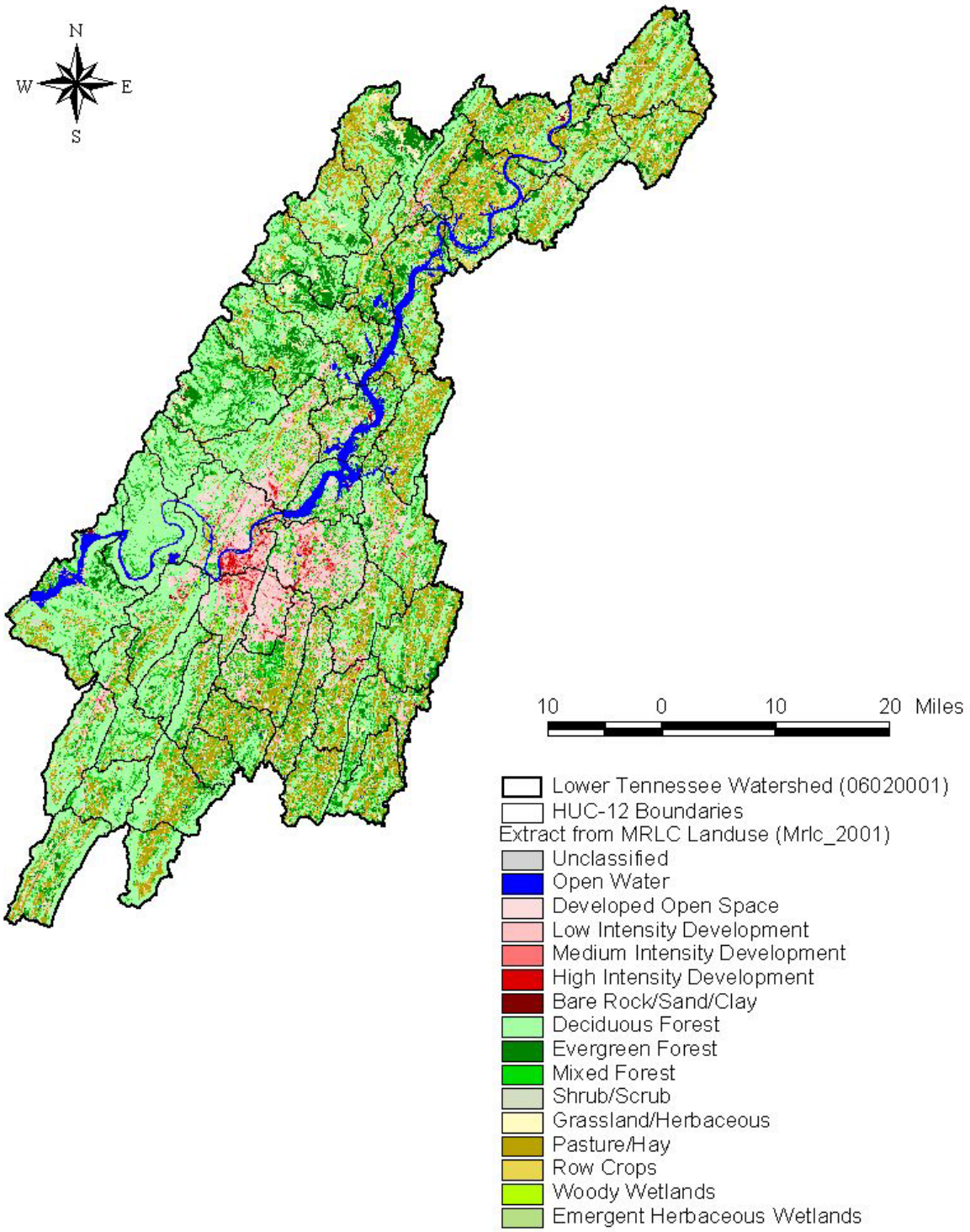

Figure 3. Land Use Characteristics of the Lower Tennessee River Watershed.

Table 1. MRLC Land Use Distribution – Lower Tennessee River Watershed (06020001)

Land use	Lower Tennessee River Watershed (TN, AL & GA)		Lower Tennessee River Watershed (TN only)	
	[acres]	[%]	[acres]	[%]
Open Water	37,704	3.2	36,418	4.7
Developed Open Space	94,800	7.9	60,101	7.7
Low Intensity Development	46,801	3.9	34,787	4.5
Medium Intensity Development	12,209	1.0	9,862	1.3
High Intensity Development	6,344	0.5	5,591	0.7
Barren Land (Rock/Sand/Clay)	2,753	0.2	2,329	0.3
Deciduous Forest	473,041	39.5	303,922	39.1
Evergreen Forest	110,360	9.2	75,320	9.7
Mixed Forest	114,550	9.6	65,459	8.4
Shrub/Scrub	39,620	3.3	25,159	3.2
Grassland/Herbaceous	32,198	2.7	23,994	3.1
Pasture/Hay	191,874	16.0	108,865	14.0
Cultivated Crops	26,573	2.2	18,636	2.4
Woody Wetlands	7,780	0.7	5,901	0.8
Emergent Herbaceous Wetlands	359	0.0	233	0.0
Total	1,199,966	100.0	776,499	100.0

4.0 PROBLEM DEFINITION

The State of Tennessee's final 2008 303(d) list (TDEC, 2008), http://state.tn.us/environment/wpc/publications/303d2008.pdf, was approved by the U.S. Environmental Protection Agency (EPA), Region IV in June of 2008. This list identified portions of 24 waterbodies in the Lower Tennessee River Watershed as not fully supporting designated use classifications due, in part, to E. coli (see Table 2 & Figure 4). The designated use classifications for these waterbodies include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. South Chickamauga Creek and Chattanooga Creek are also designated for industrial water supply.

5.0 WATER QUALITY CRITERIA & TMDL TARGET

As previously stated, the designated use classifications for the Lower Tennessee River waterbodies include fish & aquatic life, recreation, irrigation, and livestock watering & wildlife. 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, 2007 Version* (TDEC, 2007).

All of Friar Branch, Mackey Branch, Spring Creek, and Shoal Creek, and portions of South Chickamauga Creek, Unnamed Trib to South Chickamauga Creek, Short Creek, Rogers Branch, and Bee Branch have been classified as Exceptional Tennessee Waters. As of March 1, 2010, none of the other impaired waterbodies in the Lower Tennessee River Watershed have been classified as lakes, reservoirs, State Scenic Rivers, or Exceptional Tennessee Waters.

For further information concerning Tennessee's general water quality criteria and Tennessee's Antidegradation Statement, including the definition of Exceptional Tennessee Water, 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 colony forming units per 100 ml (CFU/100 ml) and the sample maximum of 487 CFU/100 ml have been selected as the appropriate numerical targets for TMDL development for Exceptional Tennessee Waters. The geometric mean standard for the E. coli group of 126 colony forming units per 100 ml (CFU/100 ml) and the sample maximum of 941 CFU/100 ml have been selected as the appropriate numerical targets for TMDL development for the other impaired waterbodies.

Table 2 Final 2008 303(d) List for E. coli Impaired Waterbodies – Lower Tennessee River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN06020001001T – 0200	NORTH MARKET STREET BRANCH	2.5	Physical Substrate Habitat Alterations Escherichia coli	Discharges from MS4 Area Collection System Failure
TN06020001007 – 0100	FRIAR BRANCH	18.94	Loss of biological integrity due to siltation Nutrients Physical Substrate Habitat Loss Escherichia coli	Land Development Discharges from MS4 Area Collection System Failure
TN06020001007 – 0200	UNNAMED TRIB TO SOUTH CHICKAMAUGA CREEK	1.1	Nutrients Escherichia coli Other Anthropogenic Habitat Losses	Collection System Failure Discharges from MS4 Area Channelization
TN06020001007 – 0300	MACKEY BRANCH	15.66	Physical Substrate Habitat Alterations Loss of biological integrity due to siltation Escherichia coli	Discharges from MS4 Area Collection System Failure
TN06020001007 – 0510	SPRING CREEK	9.6	Unknown Toxicity Excherichia coli	Discharges from MS4 Area Collection System Failure
TN06020001007 – 1000	SOUTH CHICKAMAUGA CREEK	17.6	Total Phosphorus Physical Substrate Habitat Alterations Escherichia coli Loss of biological integrity due to siltation	Land Development Discharges from MS4 Area Channelization Sources Outside of State Collection System Failure
TN06020001029 – 0300	LEWIS BRANCH	1.5	Alteration in stream-side or littoral vegetative cover Nitrate+Nitrite Total Phosphorus Low Dissolved Oxygen Escherichia coli	Confined Animal Feeding Operations (Nonpoint) Pasture Grazing
TN06020001029 – 1000	LONG SAVANNAH CREEK	15.0	Escherichia coli	Pasture Grazing
TN06020001041 – 0320	BIVENS BRANCH	2.2	Low Dissolved Oxygen Escherichia coli	Confined Animal Feeding Operations (Nonpoint)

Table 2 (cont'd) Final 2008 303(d) List for E. coli Impaired Waterbodies – Lower Tennessee River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN06020001087 – 1000	SHOAL CREEK	5.4	Escherichia coli	Discharges from MS4 Area Septic Tanks Collection System Failure
TN06020001109 – 0100	SHORT CREEK	2.5	Escherichia coli	Discharges from MS4 Area Septic Tanks
TN06020001109 – 0400	BEE BRANCH	1.55	Escherichia coli	Discharges from MS4 Area Septic Tanks
TN060200011240 – 0100	UNNAMED TRIB TO CITICO CREEK	1.2	Low Dissolved Oxygen Total Phosphorus Escherichia coli Other Anthropogenic Habitat Alterations	Collection System Failure Discharges from MS4 Area Municipal High Density Area
TN060200011240 – 1000	CITICO CREEK	6.1	Nitrate+Nitrite Low Dissolved Oxygen Escherichia coli Other Anthropogenic Habitat Alterations	Collection System Failure Discharges from MS4 Area Municipal High Density Area
TN060200011244 – 0100	DOBBS BRANCH	5.3	Unionized Ammonia Low Dissolved Oxygen Escherichia coli Other Anthropogenic Habitat Alterations	Collection System Failure Municipal High Density Area
TN060200011244 – 0200	UNNAMED TRIB TO CHATTANOOGA CREEK	1.4	Escherichia coli Other Anthropogenic Habitat Alterations	Combined Sewer Overflows Municipal High Density Area
TN060200011244 – 0300	MCFARLAND SPRINGS BRANCH	1.2	Unknown Toxicity Escherichia coli	Source in Other State
TN060200011244 – 0400	GILLESPIE SPRINGS BRANCH	1.9	Escherichia coli Other Anthropogenic Habitat Alterations	Discharges from MS4 Area Municipal High Density Area

Table 2 (cont'd) Final 2008 303(d) List for E. coli Impaired Waterbodies – Lower Tennessee River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN060200011244 – 1000	CHATTANOOGA CREEK	8.4	PCBs Dioxins Low Dissolved Oxygen Escherichia coli Other Anthropogenic Habitat Alterations Oil and Grease	Combined Sewer Overflows Dishcarges from MS4 Area Municipal High Density Area Spills Contaminated Sediment
TN060200011244 – 2000	CHATTANOOGA CREEK	3.5	Escherichia coli	Source in Other State
TN06020001426 – 0100	STRINGERS BRANCH	5.8	Escherichia coli Other Anthropogenic Habitat Alterations	Collection System Failure Discharges from MS4 Area Municipal High Density Area
TN06020001426 – 1000	MOUNTAIN CREEK	3.2	Physical Substrate Habitat Alterations Escherichia coli	Land Development Discharges from MS4 Area
TN06020001880 – 1000	ROGERS BRANCH	10.4	Escherichia coli	Discharges from MS4 Area
TN06020001889 – 0300	WILKERSON BRANCH	5.8	Escherichia coli	Discharges from MS4 Area
TN06020001889 – 1000	WOLFTEVER CREEK	11.1	Escherichia coli	Discharges from MS4 Area

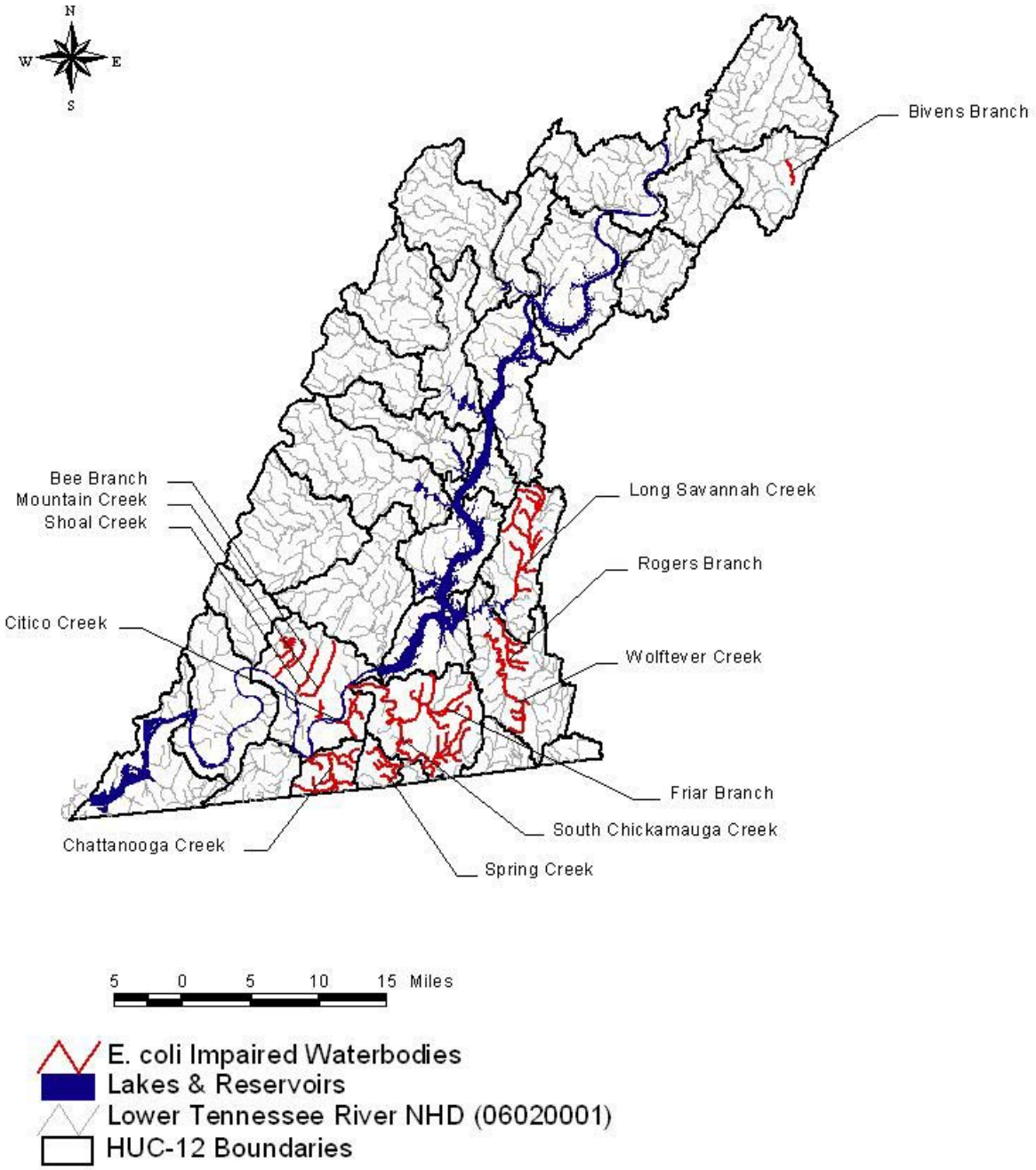

Figure 4. Waterbodies Impaired by E. Coli (as Documented on the Final 2008 303(d) List).
(Note: Only major waterbodies are labeled. For a complete listing, see Table 2.)

6.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

There are multiple water quality monitoring stations that provide data for HUC-12 containing waterbodies identified as impaired for E. coli in the Lower Tennessee River Watershed. Monitoring stations located on Exceptional Tennessee Waters have been italicized:

- HUC-12 06020001_0102:
  - BIVIN000.6MM – Bivens Branch, road crossing Mt. Verd Rd. culvert (Hwy 250) on Croft Farm
  - BIVIN000.8HM – Bivens Branch, at road crossing
  - BIVIN1T0.9MM – Trib to Bivens Branch, spring fo Bivens Branch
  - BIVIN2T0.1MM – Trib to Bivens Branch, from Farr Dairy to Bivens Branch
- HUC-12 06020001_0401:
  - LEWIS000.3HM – Lewis Branch, off Ooltewah-Georgetown Rd., near confluence with Savannah Creek
  - SAVAN005.0HM – Long Savannah Creek, at Mahan Gap Rd.
  - SAVAN1T0.4HM – Trib to Long Savannah Creek, at Snow Hill Rd.
  - WOLFE000.4HM – Wolfe Branch, at Snow Hill road crossing
- HUC-12 06020001_0402:
  - CHEST000.3HM – Chestnut Creek, at Apison Pike crossing
  - LWOLF000.5HM – Little Wolftever Creek, at Ooltewah-Ringgold Rd.
  - ROGER000.4HM – Rogers Branch, at Snow Hill Rd., off Wolftever Creek
  - ROGER000.5HM – Rogers Branch, at Creeks Bend golf course., on Hixson Pike Creek
  - WILKE000.3HM – Wilkerson Branch, at Church Rd.
  - WOLFT004.2HM – Wolftever Creek, Wolftever Embayment in Chickamauga Lake
  - WOLFT007.2HM – Wolftever Creek, at Short Tail Springs Rd.
  - WOLFT010.8HM – Wolftever Creek, near Bell Mill Rd.
  - WOLF1T0.1HM – Trib to Wolftever Creek, between Hunter Rd. and Interstate 75
- HUC-12 06020001_0903:
  - *SPRIN000.7HM – Spring Creek, on Spring Creek Rd., past K-Mart at bridge*
- HUC-12 06020001_0905:
  - *FRIAR000.8HM – Friar Branch, at Polymer Dr. next to Mayfield*
  - *FRIAR002.7HM – Friar Branch, at Hickory Valley Rd.*
  - *MACKE000.6HM – Mackey Branch, at Davidson Rd.*
  - *SCHIC000.4HM – South Chickamauga Creek, at Amnicola Hwy.*
  - *SCHIC004.9HM – South Chickamauga Creek, at Lightfoot Rd. bridge*
  - *SCHIC015.8HM – South Chickamauga Creek, at swinging foot bridge at Audobon Acres*
  - *SCHIC1T1.0HM – Trib to South Chickamauga Creek, at Airport Rd.*

- HUC-12 06020001_1003:
  - DOBBS000.3HM – Dobbs Branch, on Cannon St., at corner of Burnette St., just before Hys' Park, on other side of overpass
  - MCFAR000.2HM – McFarland Springs Branch, at Stateline Rd.
  - CHATT000.9HM – Chattanooga Creek, at railroad bridge at rendering plant
  - CHATT1T0.1HM – Trib to Chattanooga Creek, at junk yard off Hooker
- HUC-12 06020001_1202:
  - *BEE000.8HM – Bee Branch, u/s of Timberlinks Dr.*
  - CITIC000.3HM – Citico Creek, off Riverside Dr. at Tn American Water Co., above water supply intake
  - CITIC001.0HM – Citico Creek, at corner of Wilcox Blvd. and Amnicola Hwy.
  - CITIC1T0.3HM – Trib to Citico Creek, corner of North Holly and Citico Ave., at bridge, just below Carver Rec. Center
  - CITIC1T0.8HM – Trib to Citico Creek, at 3rd St. and Orchard Knob Ave., just d/s Orchard Knob Elem. School
  - CITIC1T0.9HM – Trib to Citico Creek, at corner of Willow and 5th St., just u/s Orchard Knob Elem. School
  - CITIC1T1.2HM – Trib to Citico Creek, at Parkridge Hospital back parking lot
  - CITIC2T0.0HM – Trib to Citico Creek, at McConnell and Ivy St., across from Parkridge Hospital
  - CITIC3T0.1HM – Trib to Citico Creek, at Willow and 3rd St., just u/s of Orchard Knob Elem School, d/s of Pruett's
  - CITIC3T0.7HM – Trib to Citico Creek, in Orange Grove Center Park (locked area)
  - CITIC4T0.5HM – Trib to Citico Creek, at Orange Grove and Derby St., just u/s of Orange Grove Park, d/s of Memorial Hospital
  - CITIC5T0.1HM – Trib to Citico Creek, at Cleveland and Carver, u/s of Carver Rec. Center
  - CITIC6T0.1HM – Trib to Citico Creek, at Cleveland and Orchard Knob, just above Carver Rec. Center
  - MOUNT001.5HM – Mountain Creek, u/s Signal Mountain Blvd., Kmart Rd. behind Pizza Hut
  - NMSTR000.3HM – North Market Street Branch, at Market Street bridge and Frazier Ave., on Roper property behind Suntrust Bank
  - *SHOAL001.4HM – Shoal Creek, at intersection of Green Gorge Rd. and Palisades Dr.*
  - *SHORT000.1HM – Short Branch, at next bridge on Timberlakes Dr., past Bee Branch going North*
  - STANL000.1HM – Stanley Branch, u/s of confluence with Middle Creek, on Timberlinks Dr.
  - STRIN000.6HM – Stringers Branch, behind Austin's Garden Center, on Signal Mountain Blvd., across from Baylor entrance

*There was no monitoring station for Gillespie Springs Branch.

The location of these monitoring stations is shown in Figure 5. Water quality monitoring results for these stations are tabulated in Appendix B. Examination of the data shows exceedances of the 487 CFU/100 mL maximum E. coli standard and 941 CFU/100 mL maximum E. coli standard at most monitoring stations. Water quality monitoring results for those stations with 10% or more of samples exceeding water quality maximum criteria are summarized in Table 3. Whenever a minimum of 5 samples was collected at a given monitoring station over a period of not more than 30 consecutive days, the geometric mean was calculated.

Table 3 Summary of TDEC Water Quality Monitoring Data

Monitoring Station	Date Range	E. Coli (Max WQ Target = 941 CFU/100 mL)**				
		Data Pts.	Min. [CFU/100 ml]	Avg. [CFU/100 ml]	Max. [CFU/100 ml]	No. Exceed. WQ Max. Target
BEE000.8HM	*2005 – 2009*	*16*	*90*	*983*	*2,419.6*	*11*
BIVIN000.6MM	2003 – 2009	12	100	1,815	>2,419.6	7
BIVIN000.8MM	2003 – 2004	4	630	5,758	10,540	3
CHATT000.9HM	1998 – 2009	64	45.2	863	2,419.6	20
CHATT1T0.1HM	2004 – 2009	21	100	2,430	17,260	9
CHEST000.3HM	2009	2	416	1,418	2,419.6	1
CITIC000.3HM	1999 – 2004	8	130	748	1,600	2
CITIC001.0HM	2004 – 2009	20	100	772	2,419.6	5
CITIC1T0.3HM	2000 – 2009	23	15.5	3,534	41,060	12
CITIC1T0.8HM	2000 – 2002	3	2,000	2,267	>2,400	3
CITIC1T0.9HM	2000 – 2002	3	32	1,177	>2,400	2
CITIC3T0.1HM	2000 – 2002	3	13	1,238	>2,400	2
CITIC3T0.7HM	2000 – 2002	2	130	715	1,300	1
CITIC4T0.5HM	2000 – 2002	3	170	1,013	2,000	1
CITIC5T0.1HM	2000 – 2002	3	130	1,643	>2,400	2
CITIC6T0.1HM	2000 – 2002	3	300	1,875	>2,400	3
DOBBS000.3HM	2004 – 2009	21	100	2,509	17,850	7
FRIAR000.8HM	*2004 – 2009*	*19*	*100*	*581*	*2,419.6*	*8*
FRIAR002.7HM	*2004 – 2005*	*11*	*10*	*691*	*2,750*	*4*
LEWIS000.3HM	2003 – 2009	19	410	15,615	>241,900	15
MACKE000.6HM	*2009*	*8*	*83.9*	*712*	*2,419.6*	*4*

Table 3 (cont'd) Summary of TDEC Water Quality Monitoring Data

Monitoring Station	Date Range	E. Coli (Max WQ Target = 941 CFU/100 mL)**				
		Data Pts.	Min. [CFU/100 ml]	Avg. [CFU/100 ml]	Max. [CFU/100 ml]	No. Exceed. WQ Max. Target
MCFAR000.2HM	2004 – 2009	21	62.2	710	4,570	4
MOUNT001.5HM	2004 – 2009	13	95.9	882	2,419.6	4
NMSTR000.3HM	2004 – 2009	22	100	2,246	15,150	7
ROGER000.5HM	2009	8	49.6	409	1,556.1	1
SAVAN005.0HM	2000 – 2009	15	13.4	800	>2,419.6	5
SAVAN1T0.4HM	2008 – 2009	10	135.4	2,723	17,329.0	5
SCHIC000.4HM	*1999 – 2009*	*27*	*1*	*637*	*2,419.6*	*9*
SCHIC004.9HM	*2004 – 2009*	*19*	*32.8*	*527*	*4,040*	*2*
SCHIC015.8HM	*2000 – 2009*	*26*	*1*	*263*	*1,450*	*3*
SCHIC1T1.0HM	*2009*	*4*	*488.4*	*1,524*	*2,419.6*	*4*
SHOAL001.4HM	*2005 – 2009*	*16*	*52.8*	*787*	*2,419.6*	*7*
SHORT000.1HM	*2005 – 2009*	*16*	*43.2*	*853*	*2,419.6*	*9*
SPRIN000.7HM	*2004 – 2009*	*20*	*100*	*1,074*	*5,830*	*9*
STANL000.1HM	2005 – 2009	9	7.0	488	2,490	1
STRIN000.6HM	2004 – 2009	21	76.3	553	2,500	4
WOLFE000.4HM	2008 – 2009	10	135.4	401	2,419.6	1

** Maximum water quality target is 487 CFU/100 mL for lakes, reservoirs, State Scenic Rivers, or Exceptional Tennessee Waters waterbodies and 941 CFU/100 mL for other waterbodies. Waterbodies utilizing the 487 CFU/100 mL target are italicized.

Several of the water quality monitoring stations (Table 3 and Appendix B) have at least one E. coli sample value reported as >2419. 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) 2419. Therefore, the calculated results are considered to be estimates. Future E. coli sample analyses at these sites should follow established protocol. See Section 9.4.

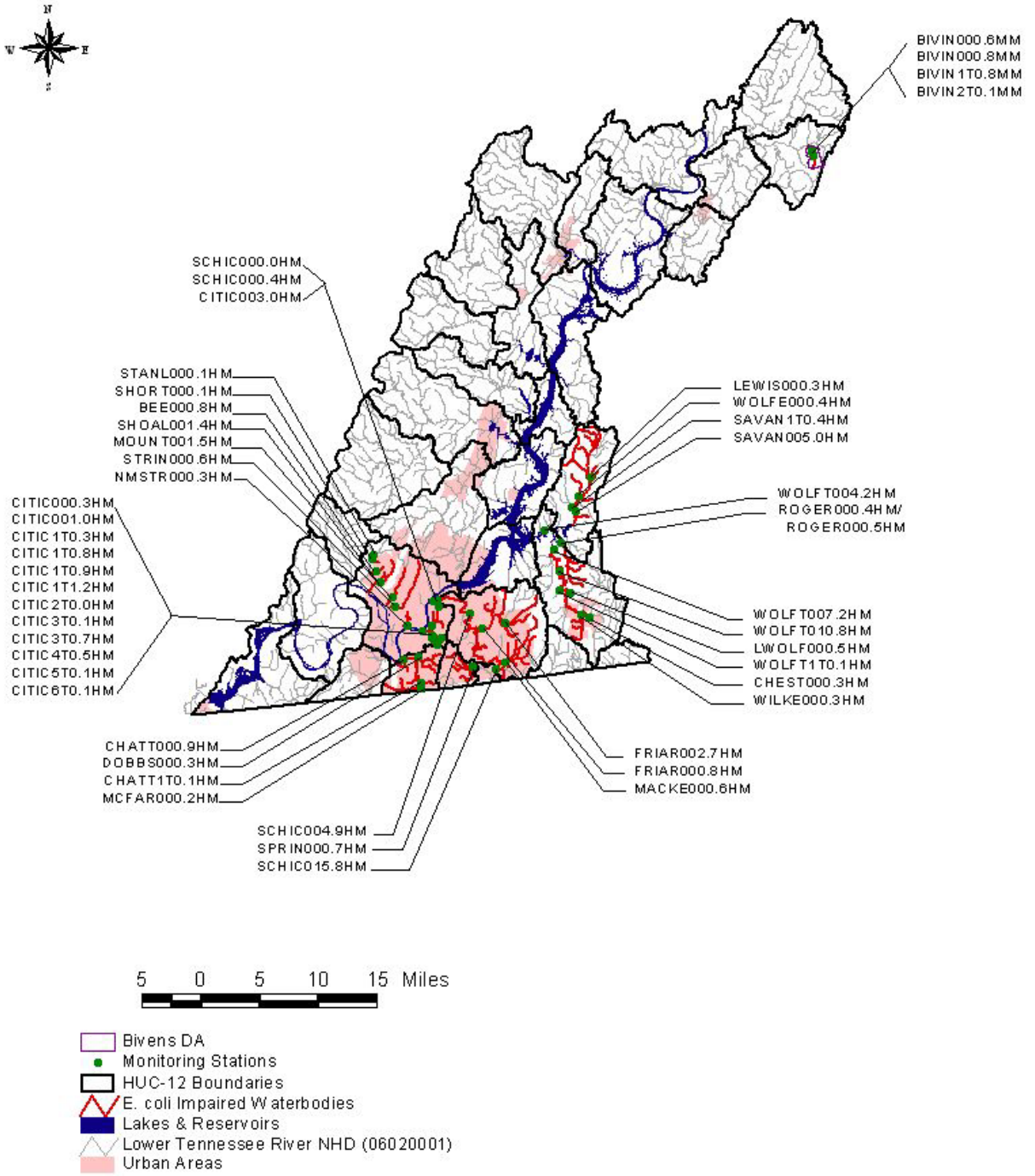

Figure 5. Water Quality Monitoring Stations in the Lower Tennessee River Watershed

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 pathogen loading and the amount of loading contributed by each of these sources.

Under the Clean Water Act, sources are classified as either point or nonpoint sources. Under 40 CFR §122.2, (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.dfm?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 Waste Load Allocations (WLAs) for all NPDES regulated point sources. Nonpoint sources are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. For the purposes of this TMDL, all sources of pollutant loading not regulated by NPDES permits are considered nonpoint sources. The TMDL must provide a Load Allocation (LA) for these sources.

7.1 Point Sources

7.1.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

Both treated and untreated sanitary wastewater contain coliform bacteria. There are 7 WWTFs in the Lower Tennessee River Watershed that have NPDES permits authorizing the discharge of treated sanitary wastewater. Three of these facilities are located in or near impaired subwatersheds or drainage areas and discharge to impaired waterbodies (see Figure 6). The permit limits for discharges from these WWTFs are in accordance with the coliform criteria specified in Tennessee Water Quality Standards for the protection of the recreation use classification.

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).

Table 4 NPDES Permitted WWTFs with Collection Systems Serving Impaired Subwatersheds or Drainage Areas

NPDES Permit No.	Facility	Design Flow [MGD]	Receiving Stream
TN0024210	Chattanooga – Moccasin Bend WWTP & Combined Sewer System	140	Tennessee River Miles 457.8, 465.2, 463.3, 464, 462.5, & 461.6, and Chattanooga Creek Miles 1.4 & 2.0
TN0027626	TDOT I-24 R.A. Marion	0.019	Tennessee River Mile 429.1
TN0064947	River Landing Condo Owners Association	0.0216	Tennessee River Mile 451.7

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, Chattanooga (TN0068063) is the only MS4 of this size in the Lower Tennessee River 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). At present, Walden (TN0077879), Signal Mountain (TN0075761), and Hamilton County Small MS4s (TN0075566) are covered under Phase II of the NPDES Storm Water Program. University of Tennessee at Chattanooga has an application pending for coverage under Phase II of the NPDES Storm Water Program.

The Tennessee Department of Transportation (TDOT) has been issued an individual MS4 permit (TNS077585) that authorizes discharges of storm water runoff from State roads 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 pathogen loading and are required to obtain an NPDES permit. Most CAFOs in Tennessee obtain coverage under TNA000000, *Class II Concentrated Animal Feeding Operation General Permit* (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.

As of March 1, 2010, there are no Class I CAFOs with an individual permit located in the Lower Tennessee River Watershed. There are five Class II CAFOs with coverage under the general NPDES permit located in the Lower Tennessee River Watershed. None of the facilities are located in impaired subwatersheds.

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 2008 303(d) List as impaired due to E. coli are attributed to nonpoint agricultural or urban sources.

7.2.1 Wildlife

Wildlife deposit coliform bacteria, with their feces, onto land surfaces where it can be transported during storm events to nearby streams. The overall deer density for Tennessee was estimated by the Tennessee Wildlife Resources Agency (TWRA) to be 23 animals per square mile.

7.2.2 Agricultural Animals

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

- Agricultural livestock grazing in pastures deposit manure containing coliform bacteria onto land surfaces. This material accumulates during periods of dry weather and is available for washoff and transport to surface waters during storm events. The number of animals in pasture and the time spent grazing are important factors in determining the loading contribution.
- Processed agricultural manure from confined feeding operations is often applied to land surfaces and can provide a significant source of coliform bacteria loading. Guidance for issues relating to manure application is available through

the University of Tennessee Agricultural Extension Service and the Natural Resources Conservation Service (NRCS).

Agricultural livestock and other unconfined animals often have direct access to waterbodies and can provide a concentrated source of coliform bacteria loading directly to a stream.

Data sources related to livestock operations include the 2007 Census of Agriculture (http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level/Tennessee/index.asp). Livestock data for counties located within the Lower Tennessee River Watershed are summarized in Table 5. 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, 2009).

Table 5 Livestock Distribution in the Lower Tennessee River Watershed

County	Livestock Population (2007 Census of Agriculture)							
	Beef Cow	Milk Cow	Poultry		Hogs	Sheep	Goats	Horse
			Layers	Broilers				
Bledsoe	16,820	589	146,380	D*	184	117	49	1,014
Bradley	15,532	2,022	220,204	5,964,354	126	329	47	1,651
Hamilton	D*	D*	D*	D*	263	407	950	1,844
Loudon	11,413	3,346	981	80	62	196	420	1,683
Marion	6,845	0	D*	1,333,486	180	D*	846	809
McMinn	17,628	4,467	D*	1,768,205	97	232	687	1,952
Meigs	7,748	412	752	D*	8	D*	242	496
Rhea	D*	D*	D*	618	310	243	470	795
Roane	7,078	341	1,932	D*	109	210	427	1,120
Sequatchie	D*	D*	578	D*	D*	60	222	500

* In keeping with the provisions of Title 7 of the United States Code, no data are published in the 2007 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, 2009).

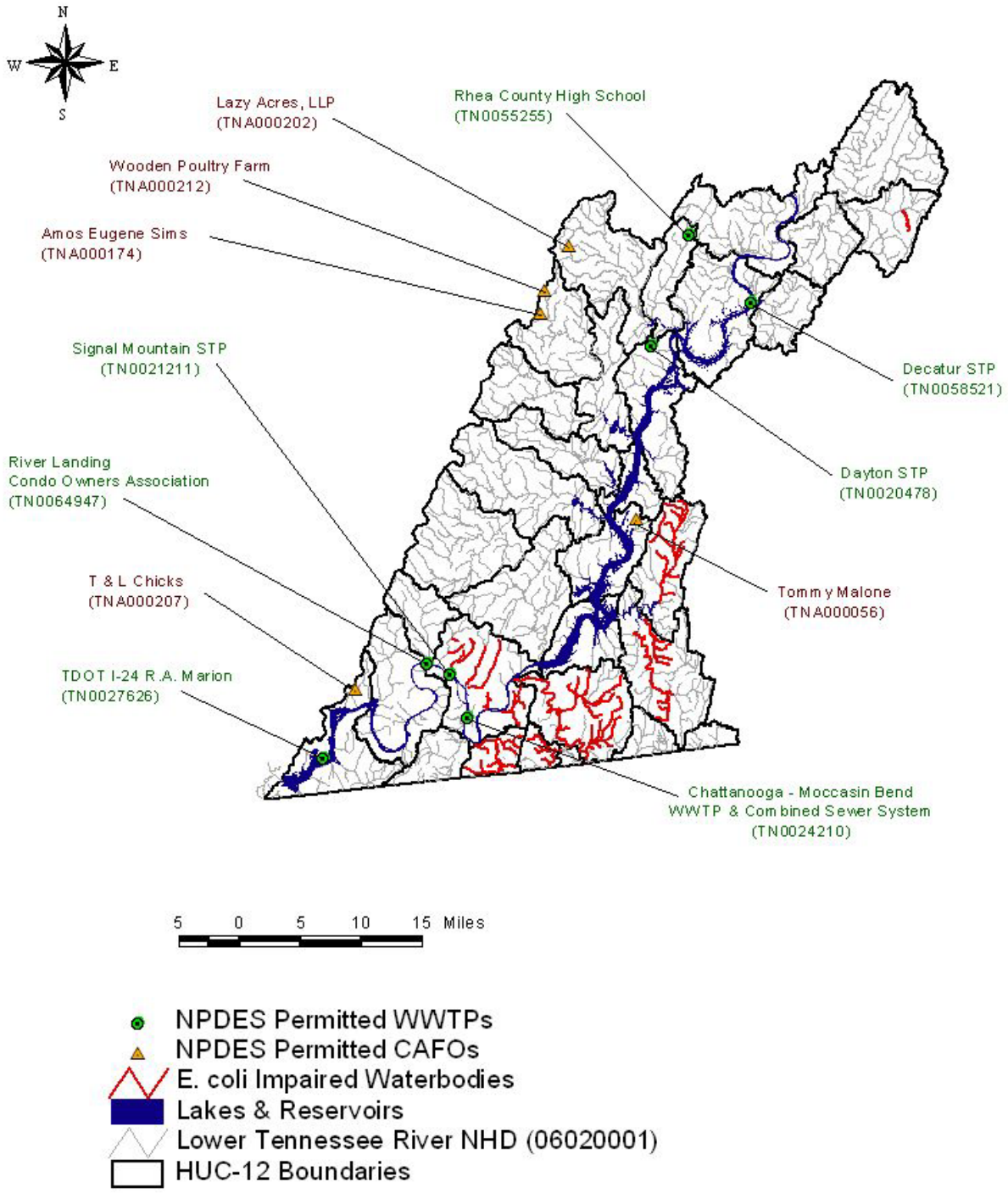

Figure 6. NPDES Regulated Point Sources in and near Impaired Subwatersheds and Drainage Areas of the Lower Tennessee River Watershed.

7.2.3 Failing Septic Systems

Some of the coliform loading in the Lower Tennessee River Watershed can be attributed to failure of septic systems and illicit discharges of raw sewage. Estimates from 1997 county census data of people in the Lower Tennessee River Watershed utilizing septic systems were compiled using the WCS and are summarized in Table 6. In middle and eastern Tennessee, it is estimated that there are approximately 2.37 people per household on septic systems, some of which can be reasonably assumed to be failing. As with livestock in streams, discharges of raw sewage provide a concentrated source of coliform bacteria directly to waterbodies.

Table 6 Estimated Population on Septic Systems in the Lower Tennessee River Watershed

County	Total Population (2000 Census)	Population on Septic Systems
Bledsoe	12,367	9,669
Bradley	87,965	73,712
Hamilton	307,896	129,964
Loudon	39,086	31,255
Marion	27,776	22,591
McMinn	49,015	42,383
Meigs	11,086	7,065
Rhea	29,400	19,965
Roane	51,910	47,227
Sequatchie	11,370	8,863

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. Urban land use area in impaired subwatersheds in the Lower Tennessee River Watershed ranges from 7% to 75%. Land use for the Lower Tennessee River impaired drainage areas is summarized in Figures 7 thru 10 and tabulated in Appendix A.

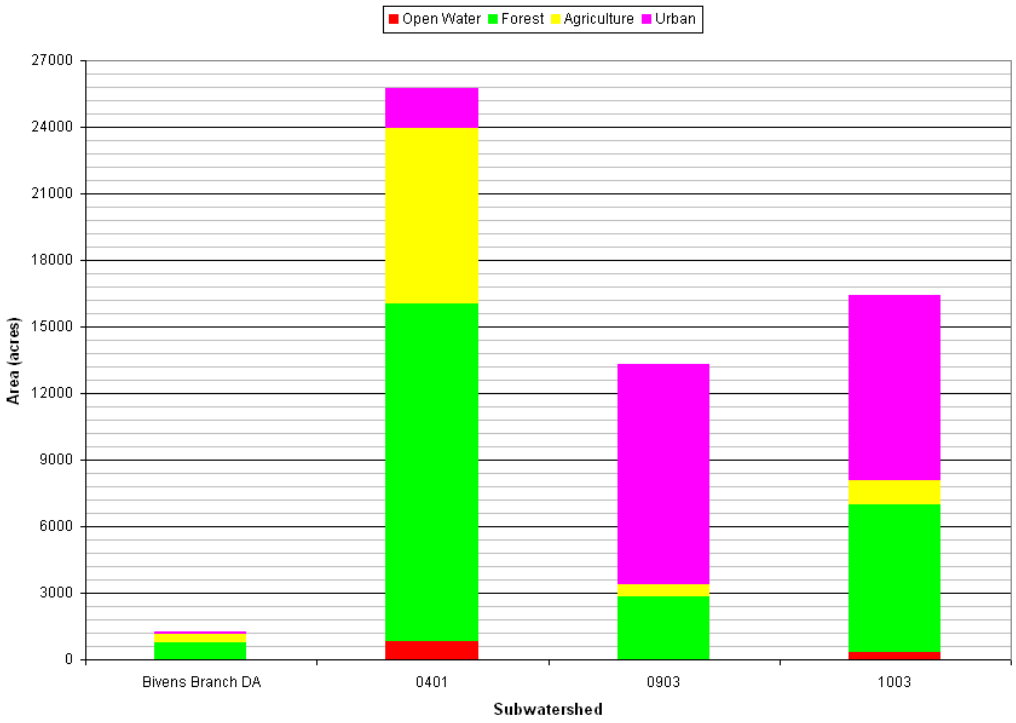

Figure 7. Land Use Area of Lower Tennessee River E. coli-Impaired Subwatersheds (less than 30,000 acres)

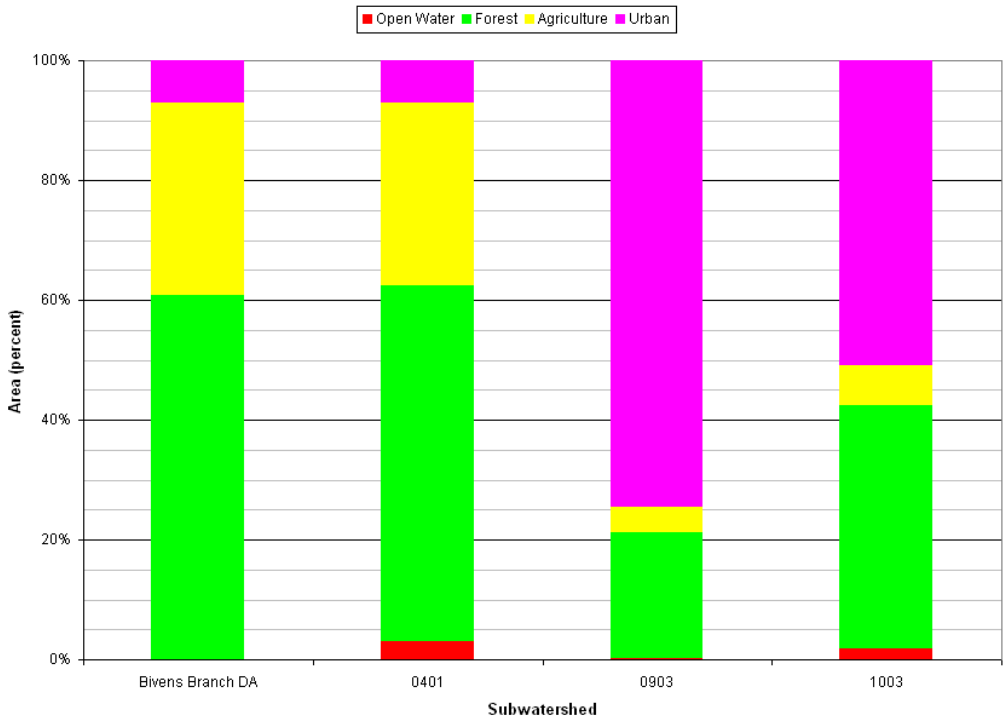

Figure 8. Land Use Percent of the Lower Tennessee River E. coli-Impaired Subwatersheds (less than 30,000 acres)

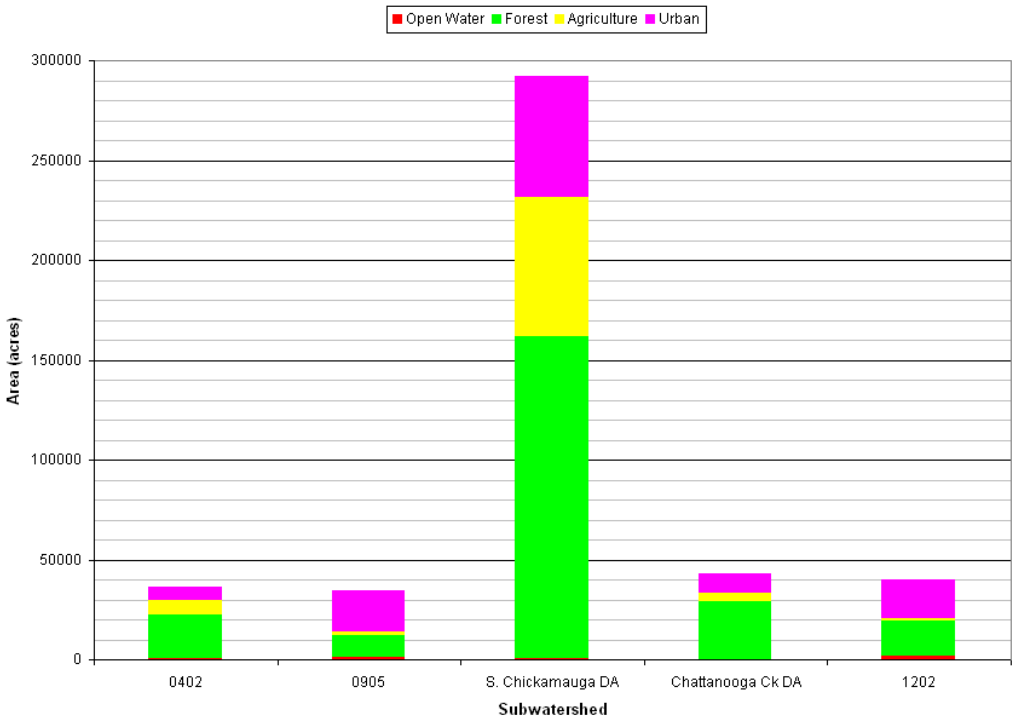

Figure 9. Land Use Area of Lower Tennessee River E. coli-Impaired Subwatersheds (greater than 30,000 acres)

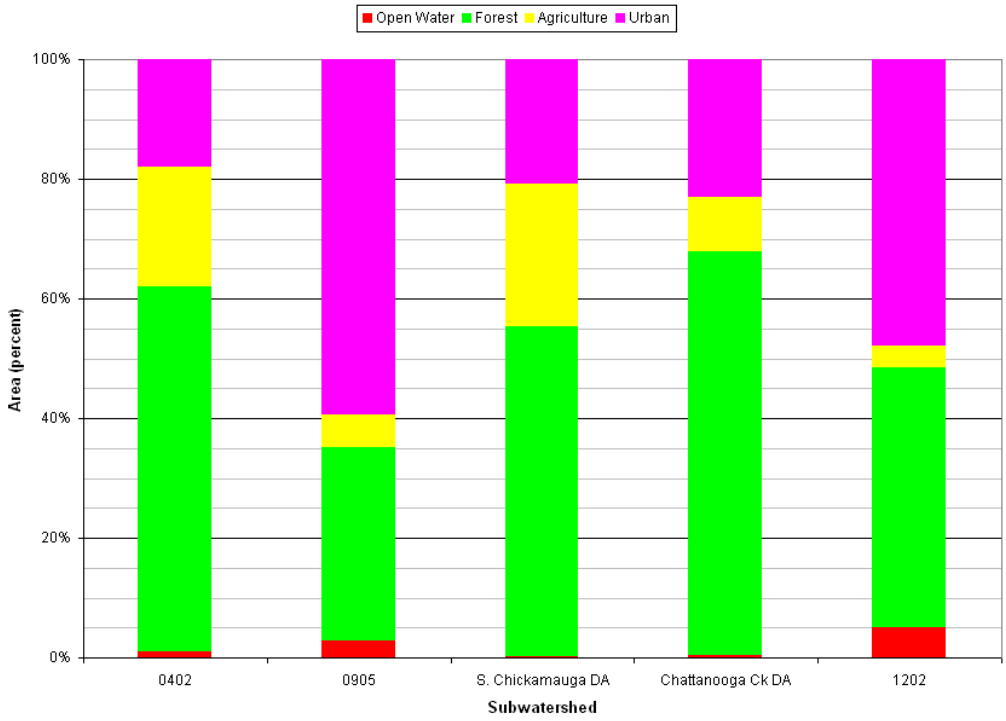

Figure 10. Land Use Percent of the Lower Tennessee River E. coli-Impaired Subwatersheds (greater than 30,000 acres)

8.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOADS

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

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

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.

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 2008 303(d) list. As part of the process of developing TMDLs, all monitoring data for the Lower Tennessee River Watershed was compiled. Several waterbodies not listed as impaired due to E. coli but located in HUC-12 subwatersheds containing waterbodies listed as impaired were also investigated. Whenever analysis of monitoring data suggested possible impairment, TMDLs were developed for these non-listed waterbodies.

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 TMDL development was the HUC-12 subwatershed containing one or more waterbodies assessed as impaired due to E. coli (as documented on the Final 2008 303(d) List). In some cases, however, TMDLs were developed for an impaired waterbody drainage area only. Determination of the appropriate area to use for analysis (see Table 7) was based on a careful consideration of a number of relevant factors, including: 1) location of impaired waterbodies in the HUC-12 subwatershed; 2) land use type and distribution; 3) water quality monitoring data; and 4) the assessment status of other waterbodies in the HUC-12 subwatershed.

Table 7 Determination of Analysis Areas for TMDL Development

HUC-12 Subwatershed (06020001____)	Impaired Waterbody	Area
0102	Bivens Branch	DA
0401	Lewis Branch	HUC-12
	Long Savannah Creek	
	Wolfe Branch	
0402	Chestnut Creek	HUC-12
	Little Wolftever Creek	
	Rogers Branch	
	Wilkerson Branch	
	Wolftever Creek	
0903	Spring Creek	HUC-12
0905	Friar Branch	HUC-12
	Mackey Branch	
	South Chickamauga Creek	
	UT South Chickamauga Ck	
1003	Chattanooga Creek	HUC-12
	UT Chattanooga Creek	
	Dobbs Branch	
	Gillespie Springs Branch	
	McFarland Springs Branch	
1202	Bee Branch	HUC-12
	Citico Creek	
	UT Citico Creek	
	Mountain Creek	
	North Market Street Branch	
	Shoal Creek	
	Short Branch	
	Stanley Branch	
	Stringers Branch	

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

8.3 TMDL Analysis Methodology

TMDLs for the Lower Tennessee River Watershed were developed using load duration curves for analysis of impaired HUC-12 subwatersheds or specific waterbody drainage areas. A load duration curve (LDC) is a cumulative frequency graph that illustrates existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired targets, and the portion of the waterbody flow zone 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.

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 twelve-year period from January 1, 1998 to December 31, 2009 was used to simulate flow. This 12-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 the Lower Tennessee River Watershed, water quality data have been collected during most flow ranges. For each Subwatershed, the critical flow zone has been identified based on the incremental levels of impairment relative to the target loads. Based on the location of the water quality exceedances on the load duration curves and the distribution of critical flow zones, no one delivery mode for E. coli appears to be dominant for waterbodies in the Lower Tennessee River Watershed (see Section 9.1.2 and 9.1.3 and Table 8).

Seasonal variation was incorporated in the load duration curves by using the entire simulation period and all water quality data collected at the monitoring stations.

8.5 Margin of Safety

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

Instantaneous Maximum (lakes, reservoirs, State Scenic Rivers, or Exceptional Tennessee Waters waterbodies):	MOS = 49 CFU/100 ml
Instantaneous Maximum (all other waterbodies):	MOS = 94 CFU/100 ml
30-Day Geometric Mean:	MOS = 13 CFU/100 ml

8.6 Determination of TMDLs

E. coli daily loading functions were calculated for impaired segments in the Lower Tennessee River Watershed using LDCs to evaluate compliance with the single maximum target concentrations according to the procedure in Appendix C. These TMDL loading functions for impaired segments and subwatersheds are shown in Table 8.

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 <u>after application of the explicit MOS</u>. WLAs for existing WWTFs are equal to [design flow multiplied by the water quality criteria]. 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 are generally small in comparison to other loading sources, further reductions were not considered to be warranted. WLAs for CAFOs and LAs for “other direct sources” (non-precipitation induced) are equal to zero. WLAs & LAs are summarized in Table 8.

Table 8. TMDLs, WLAs, & LAs for Impaired Waterbodies in the Lower Tennessee River Watershed (HUC 06020001)

HUC-12 Subwatershed (06020001__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs			LAs
					WWTFs [a]	Collection Systems	MS4s [b]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/d/ac]	[CFU/d/ac]
0102 (DA)	Bivens Branch	TN06020001041 – 0320	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.649 \times 10^{7} \times Q$
0401	Lewis Branch	TN06020001029 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.480 \times 10^{7} \times Q$	$1.480 \times 10^{7} \times Q$
	Long Savannah Creek	TN06020001029 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.102 \times 10^{6} \times Q$	$1.102 \times 10^{6} \times Q$
	Wolfe Branch	TN06020001029 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$6.880 \times 10^{6} \times Q$	$6.880 \times 10^{6} \times Q$
0402	Chestnut Creek	TN06020001889 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$5.887 \times 10^{6} \times Q$	$5.887 \times 10^{6} \times Q$
	Little Wolftever Creek	TN06020001889 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.176 \times 10^{6} \times Q$	$3.176 \times 10^{6} \times Q$
	Rogers Branch	TN060200011880 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	NA	$3.313 \times 10^{6} \times Q$	$3.313 \times 10^{6} \times Q$
	Wilkerson Branch	TN06020001889 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$9.117 \times 10^{6} \times Q$	$9.117 \times 10^{6} \times Q$
	Wolftever Creek	TN06020001889 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.404 \times 10^{5} \times Q$	$3.404 \times 10^{5} \times Q$
	Unnamed Trib to Wolftever Creek	TN06020001889 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.735 \times 10^{7} \times Q$	$2.735 \times 10^{7} \times Q$
0903	Spring Creek	TN06020001007 – 0510	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	0	$8.166 \times 10^{5} \times Q$	$8.166 \times 10^{5} \times Q$
0905	Friar Branch	TN06020001007 – 0100	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	0	$8.131 \times 10^{5} \times Q$	$8.131 \times 10^{5} \times Q$
	Mackey Branch	TN06020001007 – 0300	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	0	$1.579 \times 10^{6} \times Q$	$1.579 \times 10^{6} \times Q$
	South Chickamauga Creek	TN06020001007 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.357×10^{11}	0	$3.699 \times 10^{4} \times Q - 1.492 \times 10^{6}$	$3.699 \times 10^{4} \times Q - 1.492 \times 10^{6}$
	Unnamed Trib to S. Chickamauga Creek	TN06020001007 – 0200	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	0	$1.243 \times 10^{7} \times Q$	$1.243 \times 10^{7} \times Q$

Table 8 (cont'd). TMDLs, WLAs, & LAs for Impaired Waterbodies in the Lower Tennessee River Watershed (HUC 06020001)

HUC-12 Subwatershed (06020001__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs			LAs
					WWTFs [a]	Collection Systems	MS4s [b]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/d/ac]	[CFU/d/ac]
1003	Dobbs Branch	TN060200011244 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$6.656 \times 10^{6} \times Q$	$6.656 \times 10^{6} \times Q$
	Gillespie Springs Branch	TN060200011244 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$3.054 \times 10^{7} \times Q$	$3.054 \times 10^{7} \times Q$
	McFarland Springs Branch	TN060200011244 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$2.524 \times 10^{7} \times Q$	$2.524 \times 10^{7} \times Q$
	Chattanooga Creek	TN060200011244 – 1000 TN060200011244 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	2.849×10^{11}	0	$6.582 \times 10^{6} \times Q$	$6.582 \times 10^{6} \times Q$
	Unnamed Trib to Chattanooga Creek	TN060200011244 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$2.514 \times 10^{7} \times Q$	$2.514 \times 10^{7} \times Q$
1202	Bee Branch	TN06020001109 – 0400	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	NA	$2.541 \times 10^{7} \times Q$	$2.541 \times 10^{7} \times Q$
	Citico Creek	TN060200011240 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$5.209 \times 10^{6} \times Q$	$5.209 \times 10^{6} \times Q$
	Unnamed Trib to Citico Creek	TN060200011240 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$2.547 \times 10^{7} \times Q$	$2.547 \times 10^{7} \times Q$
	Mountain Creek	TN060200011426 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$4.581 \times 10^{6} \times Q$	$4.581 \times 10^{6} \times Q$
	North Market Street Branch	TN06020001001T – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$4.189 \times 10^{7} \times Q$	$4.189 \times 10^{7} \times Q$
	Shoal Creek	TN06020001087 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	0	$7.068 \times 10^{6} \times Q$	$7.068 \times 10^{6} \times Q$
	Short Creek	TN06020001109 – 0100	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	NA	$2.770 \times 10^{7} \times Q$	$2.770 \times 10^{7} \times Q$
	Stanley Branch	TN06020001109 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.879 \times 10^{7} \times Q$	$3.879 \times 10^{7} \times Q$
	Stringers Branch	TN060200011426 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$5.339 \times 10^{6} \times Q$	$5.339 \times 10^{6} \times Q$

Notes: NA = Not Applicable.
Q = Mean Daily In-stream Flow (cfs).

a. WLAs for WWTFs are expressed as E. coli loads (CFU/day). All current and future WWTFs must meet water quality standards as specified in their NPDES permit.

b. Applies to any MS4 discharge loading in the subwatershed. 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 Lower Tennessee River Watershed through reduction of excessive E. coli loading. Adaptive management methods, within the context of the State's rotating watershed management approach, will be used to modify TMDLs, WLAs, and LAs as required to meet water quality goals.

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. Successful implementation relies on participation at the federal, state, local and non-governmental levels.

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 (Figure 11): 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 subwatershed drainage areas less than 40 square miles, the duration curves will be divided into four zones: 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 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.

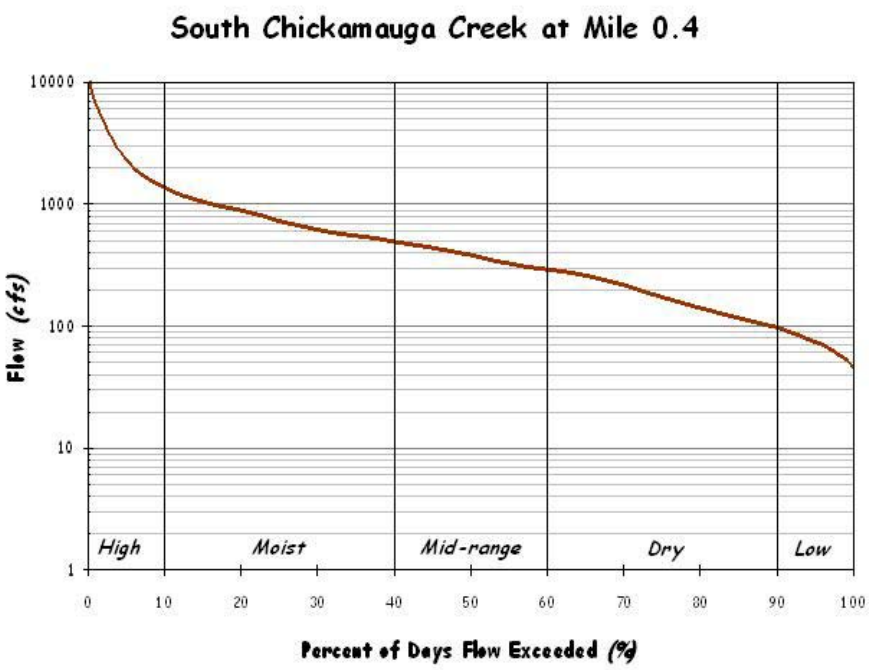

Figure 11. Five-Zone Flow Duration Curve for South Chickamauga Creek at RM 0.4

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) and/or the highest percent of samples exceeding the TMDL target 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 and/or percent exceedance, 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 and/or percent exceedance in this zone is greater than all the other zones, the zone with the second highest PLRG and/or percent exceedance will be considered 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 (which are based on water quality standards) and are expressed as average loads in CFU per day.

9.2.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

For present and future regulated discharges from municipal separate storm sewer systems (MS4s), WLAs are and will be implemented through Phase I & II MS4 permits. These permits will require the development and implementation of a Storm Water Management Program (SWMP) that will reduce the discharge of pollutants to the "maximum extent practicable" and not cause or contribute to violations of State water quality standards. 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%General%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 the 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.

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. An excellent example of stakeholder involvement is the North Chickamauga Creek Conservancy. The North Chickamauga Creek Conservancy (NCCC) is a non-profit group that provides a dedicated framework for constructive, pro-active citizen involvement and support in conserving the significant natural, historic, and cultural resources located within and near the North Chickamauga Creek watershed. NCCC often works in partnership with other organizations and governmental entities to accomplish common conservation goals. In its 17-year history, NCCC has helped to conserve over 9,000 acres within and near the North Chickamauga Creek watershed. The centerpiece of NCCC's conservation effort to date is the 3,900-acre North Chickamauga Creek Gorge Pocket Wilderness. The gorge is known for its "outstanding scenic, recreational, geologic, fish and wildlife, historic, and cultural values". The NCCC is also partnering with the U.S. Office of Surface Mining (OSM), TVA, Tennessee Division of Water Pollution Control and its Land Reclamation section, and Tennessee Department of Agriculture on a multi-year project to reduce acid mine drainage from historic abandoned underground and surface coal mines located in the headwaters of the creek.

Information regarding the accomplishments of the NCCC is available at their website:

http://www.northchick.org/.

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 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 Lower Tennessee River Watershed to reduce the amount of coliform bacteria transported to surface waters from agricultural sources. These BMPs (e.g., animal waste management systems, waste utilization, stream stabilization, fencing, heavy use area treatment, livestock exclusion, etc.) may have contributed to reductions in in-stream concentrations of coliform bacteria in one or more Lower Tennessee River Watershed E. coli-impaired subwatersheds during the TMDL evaluation period. The Natural Resources Conservation Service (NRCS) keeps a database of BMPs implemented in Tennessee. Those listed in the Lower Tennessee River Watershed are shown in Figure 12. It is recommended that additional information (e.g., livestock access to streams, manure application practices, etc.) be provided and evaluated to better identify and quantify agricultural sources of coliform bacteria loading in order to minimize uncertainty in future modeling efforts.

It is further recommended that 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.

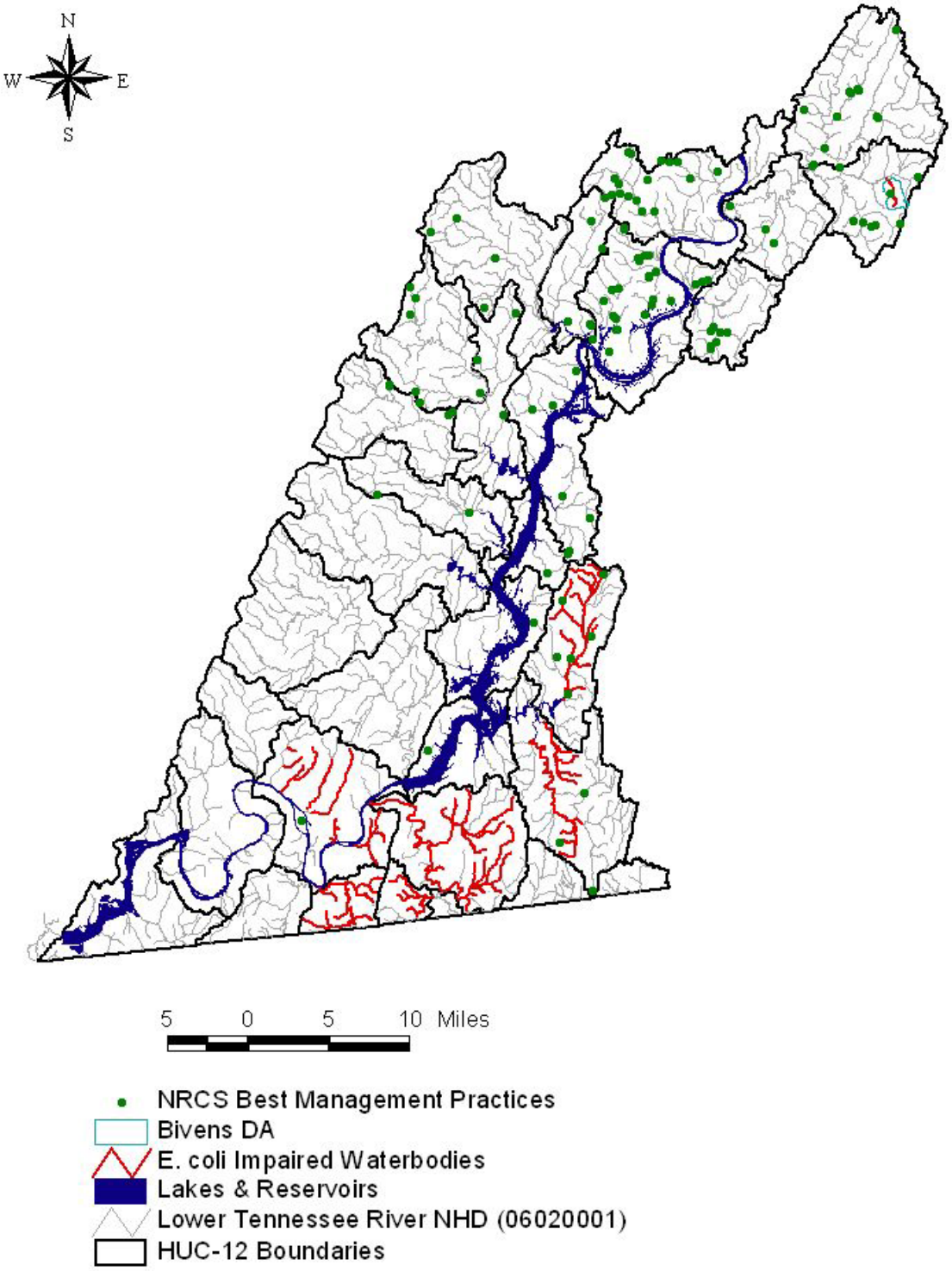

Figure 12. NRCS Best Management Practices located in the Lower Tennessee River Watershed.

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 groundwater from agriculture (EPA 841-B-03-004, July 2003).

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 Lower Tennessee River Watershed:

> Verify the assessment status of stream reaches identified on the Final 2008 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 permittees and stakeholders. Where required TMDL loading reduction has been fully achieved, adequate data to support delisting should be collected.
>
> Provide additional data to clarify status of ambiguous sites (e.g., geometric mean data) for potential listing. Analysis of available monitoring data for several waterbodies in HUC-12 0402 (Wolftever Creek and Wilkerson Branch) suggests that they are not impaired. Acquisition of geometric mean data should clarify the status of these waterbodies.

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, 2007), 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, 2004).

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

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

A multi-disciplinary group of researchers 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 .

BST technology was utilized in a study conducted in Stock Creek (Little River watershed) (Layton, 2004). Microbial source tracking using real-time PCR assays to quantify *Bacteroides* 16S rRNA genes was used to determine the percent of fecal contamination attributable to cattle. E. coli loads attributable to cattle were calculated for each of nine sampling sites in the Stock Creek subwatershed on twelve sampling dates. At the site on High Bluff Branch (tributary to Stock Creek), none of the sample dates had E. coli loads attributable to cattle above the threshold. This suggests that at this site removal of E. coli attributable to cattle would have little impact on the total E. coli loads. The E. coli load attributable to cattle made a large contribution to the total E. coli load at each of the eight remaining sampling sites. At two of the sites (STOCK005.3KN and GHOLL000.6KN), 50–75% of the E. coli attributable to cattle loads alone was above the 126 CFU/100mL threshhold. This suggests that removal of the E. coli attributable to cattle at these sites would reduce the total E. coli load to acceptable limits.

9.5 Source Area Implementation Strategy

Implementation strategies are organized according to the dominant landuse type and the sources associated with each (Table 9 and Appendix E). Each HUC-12 subwatershed 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 distributation of impaired subwatersheds. For the purpose of implementation evaluation, urban is defined as residential, commercial, and industrial landuse areas with predominant 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 predominant 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 predominant source category being wildlife.

All impaired waterbodies and corresponding HUC-12 subwatersheds or drainage areas have been classified according to their respective source area types in Table 9. 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 Lower Tennessee River Watershed are summarized in Table E-61.

Table 9. Source area types for waterbody drainage area analyses.

Waterbody NameD	Source Area Type*			
	Urban	Agricultural	Mixed	Forested
Bivens Branch		Ò		
Lewis Branch		Ò		
Long Savannah Creek		Ò		
Wolfe Branch		Ò		
Chestnut Creek			Ò	
Little Wolftever Creek			Ò	
Rogers Branch		Ò		
Wilkerson Branch			Ò	
Wolftever Creek			Ò	
Spring Creek	Ò			
Friar Branch	Ò			
Mackey Branch	Ò			
South Chickamauga Creek			Ò	
UT South Chickamauga Creek	Ò			
Chattanooga Creek			Ò	
UT Chattanooga Creek	Ò			
Dobbs Branch	Ò			
Gillespie Springs Branch	Ò			
McFarland Springs Branch	Ò			
Bee Branch	Ò			
Citico Creek	Ò			
UT Citico Creek	Ò			
Mountain Creek	Ò			
North Market Street Branch	Ò			
Shoal Creek	Ò			
Short Branch	Ò			
Stanley Branch	Ò			
Stringers Branch	Ò			

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

9.5.1 Urban Source Areas

For impaired waterbodies and corresponding HUC-12 subwatersheds or 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 10 (USEPA, 2006). Table 10 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.

Table 10. 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	

Table 10 (cont'd). Example Urban Area Management Practice/Hydrologic Flow Zone Considerations.

Management Practice	Duration Curve Zone (Flow Zone)				
	High	**Moist**	**Mid-Range**	**Dry**	**Low**
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*)					

9.5.2 Agricultural Source Areas

For impaired waterbodies and corresponding HUC-12 subwatersheds or 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 11 (USDA, 1988). Table 11 present 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.

Table 11. Example Agricultural Area Management Practice/Hydrologic Flow Zone Considerations.

Flow Condition	High	Moist	Mid-range	Dry	Low
% Time Flow Exceeded	0-10	10-40	40-60	60-90	90-100
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 11 (cont'd). Example Agricultural Area Management Practice/Hydrologic Flow Zone Considerations.

Flow Condition	High	Moist	Mid-range	Dry	Low
% Time Flow Exceeded	0-10	10-40	40-60	60-90	90-100
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**		
Potential for source area contribution under given hydrologic condition (H: High; M: Medium; L: Low)					

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

9.5.3 Forestry Source Areas

There are no impaired waterbodies with corresponding HUC-12 subwatersheds or drainage areas classified as source area type predominantly forested, with the predominant source category being wildlife, in the Lower Tennessee River Watershed.

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 13 shows best fit curve analyses (regressions) of flow (percent time exceeded) versus fecal coliform loading, for a historical (2002) TMDL analysis period versus a recent post-implementation period of sampling data (revised TMDL), for Oostanaula Creek at mile 28.4 (Hiwassee River watershed). The LDC of the single sample maximum water quality standard is also plotted to illustrate the relative degree of impairment for each period. Figure 14 shows a LDC analysis of fecal coliform loading statistics for Oostanaula Creek for the same two periods. In addition, the 90th percentiles for each flow zone are plotted for comparison. Lastly, Figure 15 shows fecal coliform concentration data statistics for recent versus historical data. The individual flow zone analyses are presented in a box and whisker plot of recent [2] versus historical [1] data. Note that Figures 13-15 present the same data, from approved TMDLs (2 cycles), each clearly illustrating improving conditions between historical and recent periods.

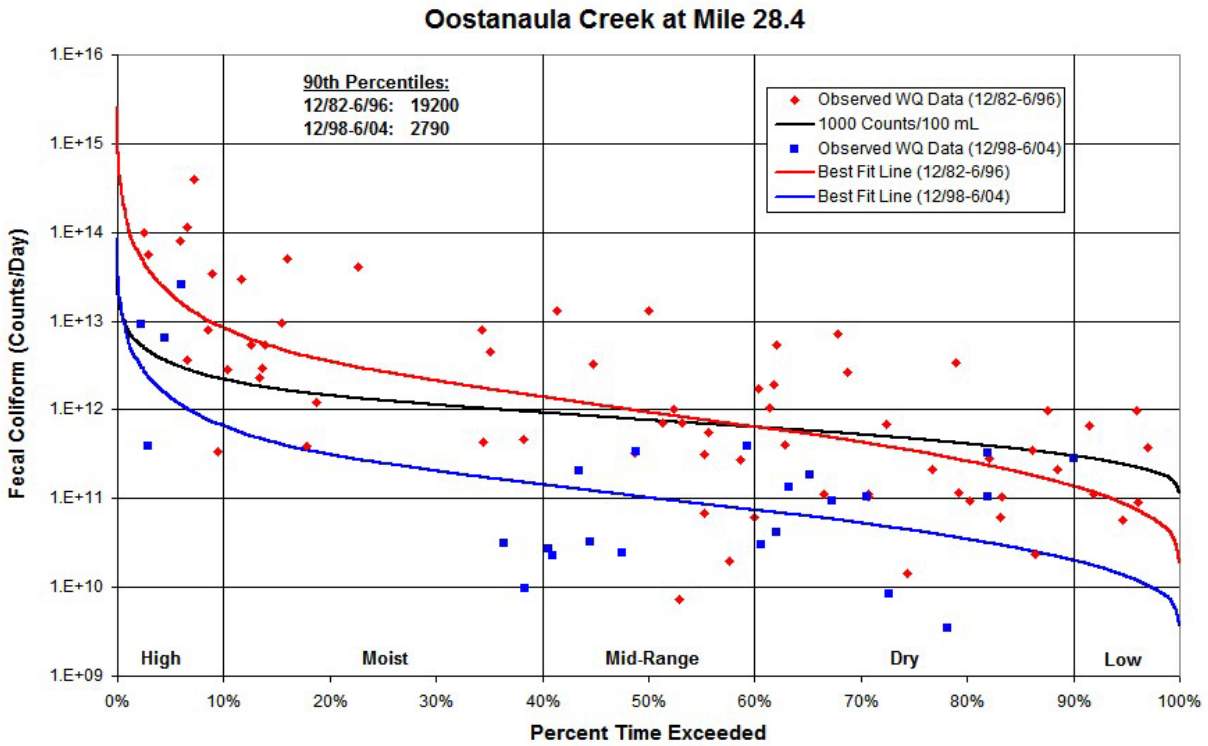

Figure 13. Oostanaula Creek TMDL implementation effectiveness (LDC regression analysis).

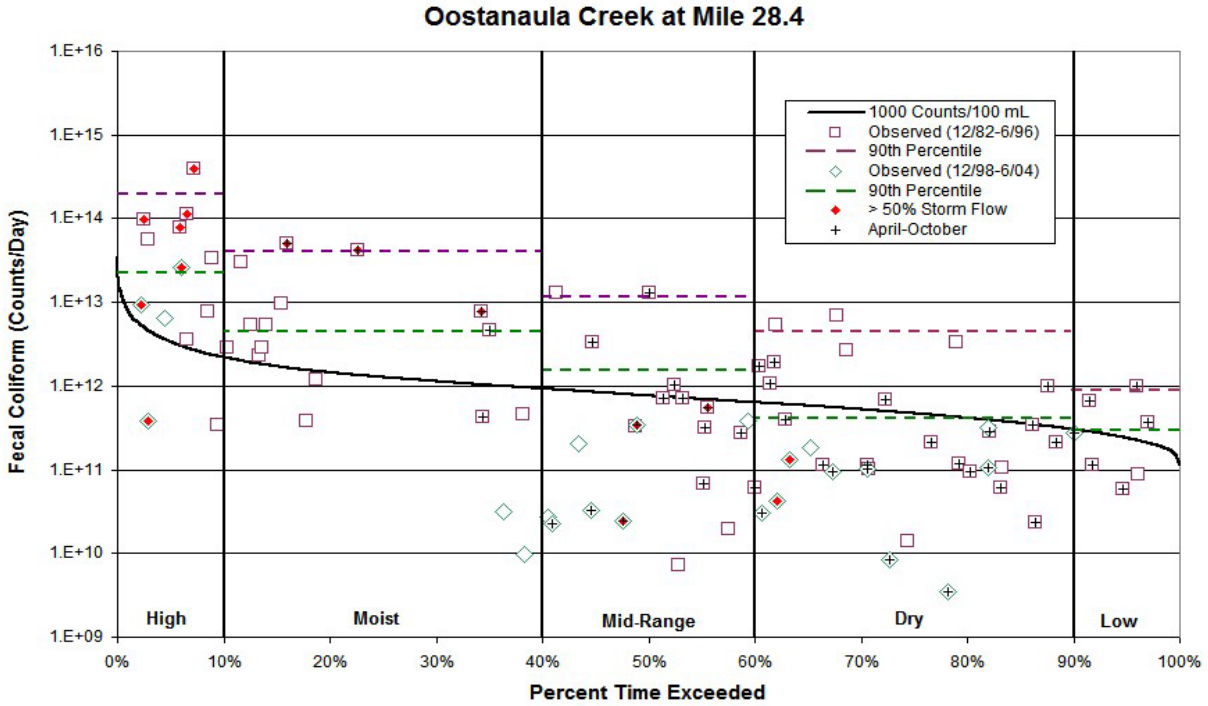

Figure 14. Oostanaula Creek TMDL implementation effectiveness (LDC analysis).

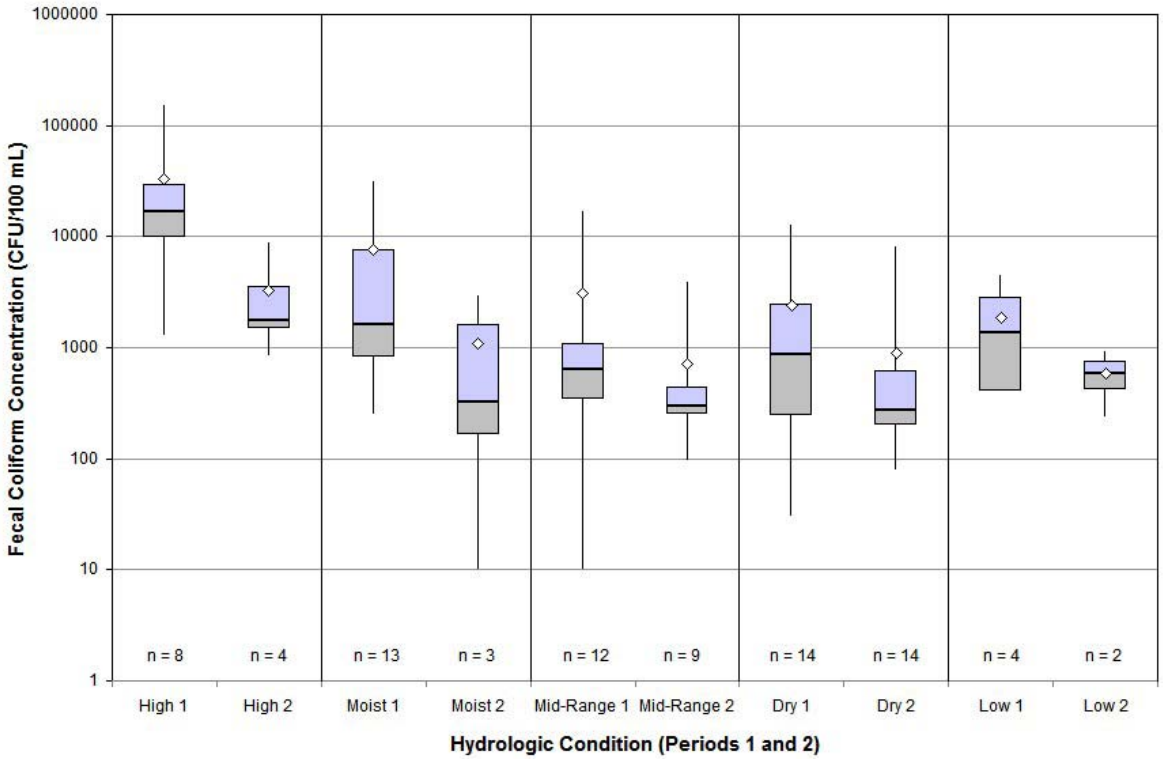

Figure 15. Oostanaula Creek TMDL implementation effectiveness (box and whisker plot).

10.0 PUBLIC PARTICIPATION

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

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

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

3) Letters were sent to WWTFs located in E. coli-impaired subwatersheds or drainage areas in the Lower Tennessee River Watershed, permitted to discharge treated effluent containing pathogens, advising them of the proposed TMDLs and their availability on the TDEC website. The letters also stated that a copy of the draft TMDL document would be provided on request. A letter was sent to the following facilities:

   Chattanooga – Moccasin Bend WWTP & Combined Sewer System (TN0024210)
   Hamilton Co. Wastewater Treatment Authority, Signal Mountain STP (TN0021211)
   River Landing Condo Owners Association (TN0064947)

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

   University of Tennessee at Chattanooga (TNS076147) pending
   Hamilton County Small MS4s (TNS075566)
   Walden (TNS077879)
   Signal Mountain (TNS075761)
   City of Chattanooga MS4 (TNS068063)
   Tennessee Dept. of Transportation (TNS077585)

5) A letter was sent to water quality partners in the Lower Tennessee River Watershed advising them of the proposed pathogen TMDLs and their availability on the TDEC website. The letter also stated that a written copy of the draft TMDL document would be provided upon request. A letter was sent to the following partners:

Natural Resources Conservation Service
Tennessee Valley Authority
Tennessee Department of Agriculture
Tennessee Wildlife Resources Agency
Georgia Dept. of Natural Resources – Environmental Protection Division
The Nature Conservancy
Southeast Tennessee RC&D Council
North Chickamauga Creek Conservancy
South Chickamauga Creek Greenway Alliance

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 Lower Tennessee River Watershed

Table A-1. 2001 MRLC Land Use Distribution of Lower Tennessee River Subwatersheds

Land Use	Impaired Subwatershed (06020001____)					
	Bivens Branch DA		0401 (incl. Long Savannah Ck)		0402 (incl. Wolftever Ck)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Open Water	0.0	0.00	795.1	3.09	380.3	1.05
Developed Open Space	85.1	6.78	1,327.8	5.16	3,944.7	10.89
Low Intensity Development	3.1	0.25	419.4	1.63	2,242.2	6.19
Medium Intensity Development	0.0	0.00	43.7	0.17	228.2	0.63
High Intensity Development	0.0	0.00	5.1	0.02	83.3	0.23
Bare Rock	0.0	0.00	82.3	0.32	50.7	0.14
Deciduous Forest	229.0	18.24	9,456.5	36.75	13,239.5	36.55
Evergreen Forest	248.8	19.82	1,389.5	5.40	2,401.6	6.63
Mixed Forest	177.3	14.12	2,562.9	9.96	4,354.0	12.02
Shrub/Scrub	97.2	7.74	983.0	3.82	1,224.3	3.38
Grassland/Herbaceous	11.3	0.90	656.2	2.55	677.4	1.87
Pasture/Hay	252.4	20.10	7,235.8	28.12	6,661.4	18.39
Row Crops	151.2	12.04	643.3	2.50	568.7	1.57
Woody Wetlands	0.0	0.00	123.5	0.48	163.0	0.45
Emergent Herbaceous Wetlands	0.0	0.00	7.7	0.03	3.6	0.01
Subtotal - Forest	763.6	60.82	15,261.6	59.31	22,114.1	61.05
Subtotal - Agriculture	403.5	32.14	7,879.1	30.62	7,230.1	19.96
Subtotal – Urban	88.3	7.03	1,796.1	6.98	6,498.4	17.94
Total	**1,255.4**	**100.00**	**25,732.0**	**100.00**	**36,223.0**	**100.0**

Table A-1 (cont'd). 2001 MRLC Land Use Distribution of Lower Tennessee River Subwatersheds

Land Use	Impaired Subwatershed (06020001____)					
	0903 (incl. Spring Creek)		0905 (part of S. Chickamauga Ck)		S. Chickamauga Creek DA (incl. 0905)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Open Water	26.6	0.20	954.9	2.76	817.5	0.28
Developed Open Space	4,419.6	33.26	8,832.6	25.53	34,948.1	11.97
Low Intensity Development	4,023.6	30.28	7,971.1	23.04	18,802.5	6.44
Medium Intensity Development	936.8	7.05	2,463.3	7.12	4,729.8	1.62
High Intensity Development	539.5	4.06	1,280.1	3.70	2,102.1	0.72
Bare Rock	1.3	0.01	20.8	0.06	379.6	0.13
Deciduous Forest	863.7	6.50	4,943.9	14.29	82,363.1	28.21
Evergreen Forest	603.3	4.54	1,397.7	4.04	25,254.9	8.65
Mixed Forest	1,090.9	8.21	3,082.6	8.91	35,327.7	12.10
Shrub/Scrub	134.2	1.01	1,041.4	3.01	10,160.4	3.48
Grassland/Herbaceous	42.5	0.32	346.0	1.00	5,751.7	1.97
Pasture/Hay	512.9	3.86	1,712.6	4.95	63,794.2	21.85
Row Crops	33.2	0.25	186.8	0.54	5,839.3	2.00
Woody Wetlands	61.1	0.46	335.6	0.97	1,605.8	0.55
Emergent Herbaceous Wetlands	0.0	0.00	24.2	0.07	58.4	0.02
Subtotal - Forest	2,797.1	21.05	11,192.1	32.35	160,901.5	55.11
Subtotal - Agriculture	546.1	4.11	1,899.4	5.49	69,633.5	23.85
Subtotal – Urban	9,919.5	74.65	20,547.2	59.39	60,582.6	20.75
Total	**13,289.3**	**100.00**	**34,593.5**	**100.00**	**291,935.1**	**100.0**

Table A-1 (cont'd). 2001 MRLC Land Use Distribution of Lower Tennessee River Subwatersheds

Land Use	Impaired Subwatershed (06020001____)					
	1003 (part of Chattanooga CK)		Chattanooga Creek DA (incl. 1003)		1202 (incl. Citico Creek)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Open Water	307.3	1.87	155.8	0.36	2,043.7	5.12
Developed Open Space	3,785.7	23.04	5,219.6	12.06	8,697.7	21.79
Low Intensity Development	2,729.2	16.61	3,129.2	7.23	6,075.2	15.22
Medium Intensity Development	1,074.6	6.54	1,021.4	2.36	2,562.6	6.42
High Intensity Development	767.3	4.67	610.3	1.41	1,776.3	4.45
Bare Rock	16.4	0.10	51.9	0.12	59.9	0.15
Deciduous Forest	3,920.4	23.86	20,220.6	46.72	12,996.6	32.56
Evergreen Forest	535.7	3.26	2,393.4	5.53	918.1	2.30
Mixed Forest	1,541.2	9.38	4,929.6	11.39	2,247.3	5.63
Shrub/Scrub	269.5	1.64	852.6	1.97	451.1	1.13
Grassland/Herbaceous	123.2	0.75	303.0	0.70	215.5	0.54
Pasture/Hay	1,013.8	6.17	3,657.2	8.45	1,293.3	3.24
Row Crops	96.9	0.59	290.0	0.67	159.7	0.40
Woody Wetlands	243.2	1.48	437.1	1.01	399.2	1.00
Emergent Herbaceous Wetlands	4.9	0.03	0.0	0.00	20.0	0.05
Subtotal - Forest	6,654.6	40.50	29,188.4	67.44	17,307.6	43.36
Subtotal - Agriculture	1,110.7	6.76	3,947.2	9.12	1,452.9	3.64
Subtotal – Urban	8,356.8	50.86	9,980.5	23.06	19,111.8	47.88
Total	**16,429.4**	**100.00**	**43,271.8**	**100.00**	**39,916.0**	**100.0**

APPENDIX B

Water Quality Monitoring Data
For Lower Tennessee River Watershed

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

Table B-1. TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
BEE000.8HM	5/12/05	770
	5/16/05	90
	5/24/05	328
	6/7/05	579
	6/8/05	461
	9/28/05	248
	7/6/09	1,732.9
	7/8/09	1,553.1
	7/16/09	1,553.1
	7/21/09	920.8
	7/27/09	>2,419.6
	8/5/09	488.4
	9/15/09	648.8
	10/5/09	1299.7
	11/3/09	214.3
	11/30/09	2419.6
BIVIN000.6MM	8/27/03	310
	10/7/03	100
	12/20/03	8,620
	1/12/04	1,210
	11/5/08	2,419.6
	12/9/08	>2,419.6
	1/7/09	>2,419.6
	8/9/09	1,732.9
	3/30/09	1,046.2
	4/21/09	547.5
	5/12/09	435.2
	6/3/09	517.2
BIVIN000.8MM	8/27/03	8,360
	10/7/03	630
	11/20/03	10,540
	1/12/04	3,500

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
BIVIN1T0.9MM	8/27/03	520
	10/7/03	100
	11/20/03	500
	1/12/04	1,210
BIVIN2T0.1MM	8/27/03	137,400
	10/7/03	1,610
	11/20/03	141,360
	1/12/04	10,810
CHATT000.9HM	11/17/98	1,414
	12/15/98	1,203
	1/12/99	260
	2/9/99	93
	3/9/99	490
	4/7/99	>2,400
	5/24/99	>2,400
	6/8/99	450
	7/15/99	>2,400
	7/28/99	280
	9/14/99	690
	10/11/99	1,000
	11/8/99	730
	12/14/99	1,400
	1/10/00	>2,400
	2/15/00	580
	3/15/00	210
	5/15/00	220
	6/19/00	>2,400
	7/19/00	490
	8/16/00	380
	9/5/00	1,400
	10/9/00	47
	11/14/00	730
	12/4/00	490
	1/16/01	>2,400
	2/6/01	120
	3/14/01	370
	4/17/01	820

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
CHATT000.9HM (cont'd)	9/11/01	65
	3/25/02	160
	9/4/02	580
	12/17/02	490
	3/26/03	140
	6/17/03	2,400
	9/8/03	2,400
	12/2/03	180
	3/9/04	250
	7/7/04	1,600
	11/29/04	310
	7/20/05	1,200
	10/31/05	920
	1/17/06	816.4
	5/22/06	686.4
	8/2/06	133.3
	12/5/06	135.4
	2/27/07	365.4
	4/24/07	98.5
	8/7/07	235.9
	10/9/07	1553.07
	2/13/08	1413.6
	4/16/08	435.2
	11/12/08	387.3
	1/28/09	45.2
	7/7/09	>2,419.6
	7/15/09	727
	7/20/09	>2,419.6
	7/22/09	307.6
	7/28/09	261.3
	8/17/09	154.1
	8/31/09	307.6
	10/12/09	2419.6
	11/16/09	172.3
	12/8/09	770.1
CHATT007.9HM	7/15/09	224.7
	7/20/09	261.3

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
CHATT007.9HM (cont'd)	7/22/09	131.4
	7/28/09	228.2
	8/3/09	387.3
	8/12/09	547.5
	10/12/09	648.8
	12/8/09	81.3
CHATT1T0.1HM	8/16/04	630
	9/13/04	100
	10/12/04	17,260
	11/8/04	520
	1/18/05	310
	2/14/05	12,910
	3/7/05	100
	3/28/05	3,270
	4/18/05	100
	5/2/05	310
	5/23/05	410
	6/6/05	730
	7/7/09	2,419.6
	7/15/09	547.5
	7/20/09	261.3
	7/22/09	>2,419.6
	7/28/09	1,203.3
	8/12/09	2419.6
	10/12/09	2419.6
	11/16/09	272.3
	12/8/09	2419.6
CHEST000.3HM	1/6/09	>2,419.6
	5/12/09	416
CITIC000.3HM	11/8/99	220
	2/15/00	770
	5/15/00	490
	8/16/00	920
	11/14/00	1,600
	2/6/01	130
	8/24/04	1,300
	11/29/04	550

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
CITIC001.0HM	8/30/04	1,480
	9/27/04	200
	10/4/04	100
	11/1/04	310
	1/10/05	740
	1/31/05	100
	2/28/05	520
	3/14/05	200
	4/11/05	310
	4/25/05	100
	5/9/05	100
	7/7/09	>2,419.6
	7/15/09	648.8
	7/20/09	2,419.6
	7/22/09	167
	7/28/09	387.3
	8/12/09	2,419.6
	10/12/09	2,419.6
	11/16/09	178.9
	12/8/09	209.8
CITIC003.0HM	5/16/06	344.1
CITIC1T0.3HM	6/14/00	>2,400
	9/18/01	580
	1/23/02	>2,400
	8/30/04	11,450
	9/27/04	970
	10/4/04	200
	11/1/04	4,500
	1/10/05	740
	1/31/05	2,990
	2/28/05	41,060
	3/14/05	860
	4/11/05	630
	4/25/05	310
	5/9/05	980

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
CITIC1T0.3HM (cont'd)	7/7/09	770.1
	7/15/09	686.7
	7/20/09	579.4
	7/22/09	1,413.6
	7/28/09	488.4
	8/12/09	2,419.6
	10/12/09	2,419.6
	11/16/09	2,419.6
	12/8/09	15.5
CITIC1T0.6HM	5/16/06	248.1
CITIC1T0.8HM	6/14/00	2,000
	9/18/01	>2,400
	1/23/02	>2,400
CITIC1T0.9HM	6/14/00	1,100
	9/18/01	32
	1/23/02	>2,400
CITIC1T1.2HM	1/23/02	2,400
CITIC2T0.0HM	1/23/02	>2,400
CITIC3T0.1HM	6/14/00	>2,400
	9/18/01	13
	1/23/02	1,300
CITIC3T0.7HM	6/14/00	130
	1/23/02	1,300
CITIC4T0.5HM	6/14/00	870
	9/18/01	170
	1/23/02	2,000
CITIC5T0.1HM	6/14/00	>2,400
	9/18/01	130
	1/23/02	>2,400
CITIC6T0.1HM	6/14/00	>2,400
	9/18/01	300
	1/23/02	>2,400
DOBBS000.3HM	8/16/04	200
	9/13/04	1,990
	10/12/04	17,850
	11/8/04	860

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
DOBBS000.3HM (cont'd)	1/18/05	100
	2/14/05	16,070
	3/7/05	100
	3/28/05	5,570
	4/18/05	100
	5/2/05	410
	5/23/05	740
	6/6/05	410
	7/7/09	1,986.3
	7/15/09	325.5
	7/20/09	209.8
	7/22/09	307.6
	7/28/09	160.7
	8/3/09	290.9
	8/12/09	2,419.6
	10/12/09	2,419.6
	12/8/09	160.7
FRIAR000.8HM	8/30/04	520
	9/27/04	200
	10/4/04	200
	11/1/04	850
	1/10/05	310
	1/31/05	100
	2/28/05	520
	3/14/05	200
	4/11/05	310
	4/25/05	630
	5/9/05	310
	7/13/09	1,299.7
	7/16/09	1,732.9
	7/21/09	344.8
	7/27/09	115.3
	8/3/09	2,419.6
	8/10/09	156.5
	11/16/09	238.2
	12/1/09	579.4

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
FRIAR002.7HM	8/30/04	740
	9/27/04	410
	10/4/04	310
	11/1/04	1,830
	1/10/05	200
	1/31/05	10
	2/28/05	740
	3/14/05	100
	4/11/05	200
	4/25/05	2,750
	5/9/05	310
LEWIS000.3HM	7/30/03	1,090
	8/18/03	740
	10/7/03	3,900
	11/20/03	1,080
	1/6/04	840
	2/11/04	410
	3/16/04	>241,900
	4/21/04	3,360
	5/25/04	740
	10/13/08	1,413.6
	10/27/08	1,203.3
	11/19/08	>2,419.6
	12/10/08	>24,196
	1/12/09	1,986.3
	2/2/09	1,732.9
	3/18/09	>2,419.6
	4/20/09	>2,419.6
	5/11/09	>2,419.6
	6/8/09	2,419.6
LEWIS001.5HM	1/12/09	22.8
LWOLF000.5HM	10/6/08	81.3
	10/22/08	146.7
	11/3/08	325.5
	12/3/08	50.4

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
LWOLF000.5HM (cont'd)	1/26/09	93.3
	2/24/09	172.3
	3/25/09	866.4
	4/6/09	178.9
	5/13/09	410.6
	6/10/09	166.4
MACKE000.6HM	7/13/09	920.8
	7/16/09	2,419.6
	7/21/09	224.7
	7/27/09	770.1
	8/3/09	365.4
	8/10/09	185
	11/16/09	83.9
	12/1/09	727
MCFAR000.2HM	8/16/04	100
	9/13/04	100
	10/12/04	1,580
	11/8/04	200
	1/18/05	200
	2/14/05	4,570
	3/7/05	100
	3/28/05	630
	4/18/05	200
	5/2/05	100
	5/23/05	630
	6/6/05	200
	7/7/09	410.6
	7/15/09	365.4
	7/20/09	186
	7/22/09	435.2
	7/28/09	191.8
	8/12/09	1,416.6
	10/12/09	2,419.6
	11/16/09	62.2
	12/8/09	816.4

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
MOUNT001.5HM	8/16/04	100
	9/13/04	100
	10/12/04	1,320
	7/6/09	>2,419.6
	7/8/09	727
	7/15/09	435.2
	7/20/09	727
	7/22/09	488.4
	8/4/09	648.8
	9/9/09	686.7
	10/7/09	1,732.9
	11/17/09	1,986.3
	12/7/09	95.9
NMSTR000.3HM	8/16/04	200
	9/13/04	100
	10/12/04	15,150
	11/8/04	850
	1/18/05	200
	2/14/05	8,160
	3/7/05	410
	3/28/05	11,530
	4/18/05	740
	5/2/05	200
	5/23/05	200
	6/6/05	630
	7/6/09	>2,419.6
	7/8/09	648.8
	7/15/09	248.1
	7/20/09	435.2
	7/22/09	1,413.6
	8/4/09	517.2
	9/9/09	727
	10/7/09	1,553.1
	11/17/09	2,419.6
	12/7/09	648.8

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
ROGER000.4HM	10/6/08	31.3
	10/22/08	35
	11/3/08	58.3
	12/3/08	58.3
	1/26/09	28.2
	2/24/09	39.5
	3/25/09	579.4
	4/6/09	228.2
	5/13/09	686.7
	6/10/09	461.1
ROGER000.5HM	7/14/09	260.3
	7/28/09	648.8
	8/3/09	60.2
	8/5/09	579.4
	8/10/09	49.6
	8/11/09	54.6
	9/16/09	1,556.1
	12/28/09	60.5
SAVAN005.0HM	2/23/00	490
	5/1/00	400
	5/2/00	1,300
	11/6/00	62
	11/7/00	180
	10/13/08	13.5
	10/27/08	23.3
	11/19/08	13.4
	12/10/08	>2,419.6
	1/12/09	461.1
	2/2/09	285.1
	3/18/09	1,299.7
	4/20/09	>2,419.6
	5/11/09	648.8
	6/3/09	1,986.3

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
SAVAN1T0.4HM	10/13/08	1,986.3
	10/27/08	727
	11/19/08	2,419.6
	12/10/08	1,7329
	1/12/09	344.8
	2/2/09	2,419.6
	3/18/09	307.6
	4/20/09	980.4
	5/11/09	135.4
	6/8/09	579.4
SCHIC000.4HM	1/12/99	1,600
	4/7/99	1,400
	7/19/99	1
	10/11/99	370
	1/10/00	>2,400
	7/19/00	2
	10/9/00	5
	1/16/01	5
	4/17/01	88
	12/1/04	>2,400
	2/23/05	>2,400
	5/11/05	260
	7/27/05	3
	11/16/05	1,400
	1/25/06	517.2
	7/25/06	140.8
	11/14/06	32.7
	3/14/07	14.5
	5/29/07	29.8
	8/14/07	13.5
	11/27/07	2419.2
	3/18/08	686.7
	5/28/08	55.6
	12/30/08	325.5
	4/22/09	387.3
	6/15/09	201.4
	8/26/09	33.6

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
SCHIC004.9HM	8/30/04	310
	9/27/04	300
	10/4/04	100
	11/1/04	4,040
	1/10/05	3,200
	1/31/05	410
	2/28/05	310
	3/14/05	100
	4/11/05	200
	4/25/05	100
	5/9/05	100
	7/13/09	145
	7/16/09	114.5
	7/21/09	32.8
	7/27/09	49.5
	8/3/09	86.2
	8/10/09	62.7
	11/16/09	129.6
	12/1/09	224.7
SCHIC015.8HM	2/22/00	68
	2/23/00	100
	5/1/00	55
	5/2/00	59
	11/6/00	170
	11/7/00	330
	8/30/04	850
	9/27/04	100
	10/4/04	100
	11/1/04	200
	1/10/05	1,450
	1/31/05	100
	2/28/05	310
	3/14/05	100
	4/11/05	310
	4/25/05	200
	5/9/05	100

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
SCHIC015.8HM (cont'd)	7/13/09	248.9
	7/16/09	387.3
	7/21/09	59.1
	7/27/09	93.3
	8/3/09	201.4
	8/10/09	112.6
	11/16/09	88.2
	12/1/09	1,046.2
	12/7/09	1
SCHIC1T1.0HM	7/13/09	>2,419.6
	7/16/09	>2,419.6
	11/16/09	488.4
	12/1/09	770.1
SHOAL001.4HM	5/12/05	121
	5/16/05	285
	5/24/05	152
	6/6/05	410
	6/7/05	396
	9/28/05	1,986
	7/6/09	2,419.6
	7/8/09	1,299.7
	7/16/09	579.4
	7/21/09	84.2
	7/27/09	547.5
	8/5/09	178.9
	9/15/09	461.1
	10/5/09	2,419.6
	11/3/09	52.8
	11/30/09	1,203.3
SHORT000.1HM	5/12/05	104
	5/16/05	344
	5/24/05	152
	6/7/05	816
	6/8/05	307
	9/28/05	770

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
SHORT000.1HM (cont'd)	7/6/09	1,986.3
	7/8/09	488.4
	7/16/09	1,732.9
	7/21/09	54.8
	7/27/09	43.2
	8/5/09	770.1
	9/15/09	920.8
	10/5/09	2,419.6
	11/3/09	325.5
	11/30/09	2,419.6
SPRIN000.7HM	8/16/04	100
	9/13/04	200
	10/12/04	2,720
	11/8/04	310
	1/18/05	100
	2/14/05	3,640
	3/7/05	100
	3/28/05	5,830
	4/18/05	100
	5/2/05	860
	5/23/05	520
	6/6/05	100
	7/7/09	1,413.6
	7/13/09	1,413.6
	7/16/09	>2,419.6
	7/21/09	261.3
	7/27/09	325.5
	8/10/09	201.4
	11/16/09	248.1
	12/1/09	613.1
STANL000.1HM	4/12/05	730
	5/12/05	47
	5/16/05	7
	5/24/05	56.3
	6/2/05	2,490

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
STANL000.1HM (cont'd)	6/7/05	73
	6/8/05	80
	10/27/09	219
	12/1/09	687
STRIN000.6HM	8/16/04	100
	9/13/04	200
	10/12/04	310
	11/8/04	100
	2/14/05	2,500
	3/7/05	410
	3/28/05	1,320
	4/18/05	100
	5/2/05	100
	5/23/05	310
	6/6/05	630
	7/6/09	1,986.3
	7/8/09	435.2
	7/15/09	160.7
	7/20/09	95.9
	7/22/09	122.3
	8/4/09	307.6
	9/9/09	325.5
	10/7/09	1,203.3
	11/17/09	819.4
	12/7/09	76.3
WILKE000.3HM	10/6/08	67
	10/22/08	111.2
	11/3/08	185
	12/3/08	93.3
	1/26/09	172.5
	2/24/09	104.6
	3/25/09	344.8
	4/6/09	178.9
	5/13/09	686.7
	6/10/09	290.9

Table B-1 (Cont.). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
WOLFE000.4HM	10/13/08	36.9
	10/27/08	32.7
	11/19/08	18.5
	12/10/08	2,419.6
	1/12/09	65
	2/2/09	224.7
	3/18/09	85.7
	4/20/09	461.1
	5/11/09	114.5
	6/8/09	547.5
WOLFT004.2HM	4/20/99	1
	5/10/99	13
	6/21/99	1
	7/6/99	1
	8/4/99	1
	9/20/99	1
WOLFT007.2HM	2/22/00	59
	2/23/00	39
	5/1/00	29
	5/2/00	39
	11/6/00	150
	11/7/00	160
WOLFT010.8HM	10/6/08	547.5
	10/22/08	101.9
	11/3/08	119.1
	12/3/08	64.5
	1/26/09	307.6
	2/24/09	93.4
	3/25/09	167
	4/6/09	172.2
	5/13/09	344.8
	6/10/09	172.5

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), nonpoint source loads (Load Allocations), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

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

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) (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 and drainage areas in the Lower Tennessee River 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 discharges of flow 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 Windows version of Hydrologic Simulation Program - Fortran (WinHSPF).

Flow duration curves for impaired waterbodies in the Lower Tennessee River Watershed were derived from WinHSPF hydrologic simulations based on parameters derived from calibrations at USGS Station Nos. 03567500 (see Appendix D for details of calibration). For example, a flow-duration curve for South Chickamauga Creek was constructed using simulated daily mean flow for the period from 1/1/98 through 12/31/09 (RM 0.4 corresponds to the location of monitoring station SCHIC000.4HM). 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 TMDLs

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

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

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

   $(\text{Target Load})_{\text{South Chickamauga Creek}}$ = (487 CFU/100 mL) x (Q) x (UCF)

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

   TMDL = (1.20×10^{10}) x (Q) CFU/day

2. Daily loads were calculated for each of the water quality samples collected at monitoring station SCHIC000.4HM (ref.: Table B-1) by multiplying the sample concentration by the daily mean flow for the sampling date and the required unit conversion factor. SCHIC000.4HM was selected for LDC analysis because it has 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 was available for some sampling dates.

   Example – 4/7/99 sampling event:
   Modelled Flow = 1,157 cfs
   Concentration = 1400 CFU/100 mL
   Daily Load = 3.96×10^{13} CFU/day

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

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

C.2 Development of WLAs & LAs

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

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

Expanding the terms:

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

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

- $[\sum WLAs]_{WWTF}$ is the allowable load associated with discharges of NPDES permitted WWTFs located in impaired subwatersheds or drainage areas. Since NPDES permits for these facilities specify that treated wastewater must meet in-stream water quality standards at the point of discharge, no additional load reduction is required. WLAs for WWTFs are calculated from the facility design flow and the Monthly Average permit limit.
- $[\sum WLAs]_{CAFO}$ is the allowable load for all CAFOs in an impaired subwatershed or drainage area. All wastewater discharges from a CAFO to waters of the state of Tennessee are prohibited, except when either chronic or catastrophic rainfall events cause an overflow of process wastewater from a facility properly designed, constructed, maintained, and operated to contain:
    - 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.
- $[\sum WLAs]_{MS4}$ 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:

- $[\sum LAs]_{DS}$ 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).
- $[\sum LAs]_{SW}$ represents the allowable E. coli loading from nonpoint sources indirectly going to surface waters from all land use areas (except areas covered by a MS4 permit) as a result of the buildup/wash-off processes associated with storm events (i.e., precipitation induced).

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

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

As stated in Section 8.4, an explicit MOS, equal to 10% of the E. coli water quality targets (ref.: Section 5.0), was utilized for determination of the percent load reductions necessary to achieve and WLAs and LAs:

Instantaneous Maximum (lake, reservoir, State Scenic River, Exceptional Tennessee Waters):

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:

$$WLA[MS4] = LA = \{TMDL - MOS - WLA[WWTFs]\} / DA$$

where: DA = waterbody drainage area (acres)

Using South Chickamauga Creek as an example:

$$TMDL_{South\ Chickamauga\ Creek} = (487\ CFU/100\ mL) \times (Q) \times (UCF)$$

$$= 1.20 \times 10^{10} \times Q$$

$MOS_{South\ Chickamauga\ Creek} = TMDL \times 0.10 = 1.20 \times 10^9 \times Q$

$MOS = (1.20 \times 10^9) \times (Q)$ CFU/day

$WLA[MS4]_{South\ Chickamauga\ Creek} = LA_{South\ Chickamauga\ Creek}$

$= \{TMDL - MOS - WLA[WWTFs]\} / DA$

$= \{(1.20 \times 10^{10} \times Q) - (1.20 \times 10^9 \times Q) - (1.508 \times 10^{11})\} / (2.92 \times 10^5)$

$WLA[MS4] = LA = [(3.699 \times 10^4 \times Q) - (5.164 \times 10^5)]$

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

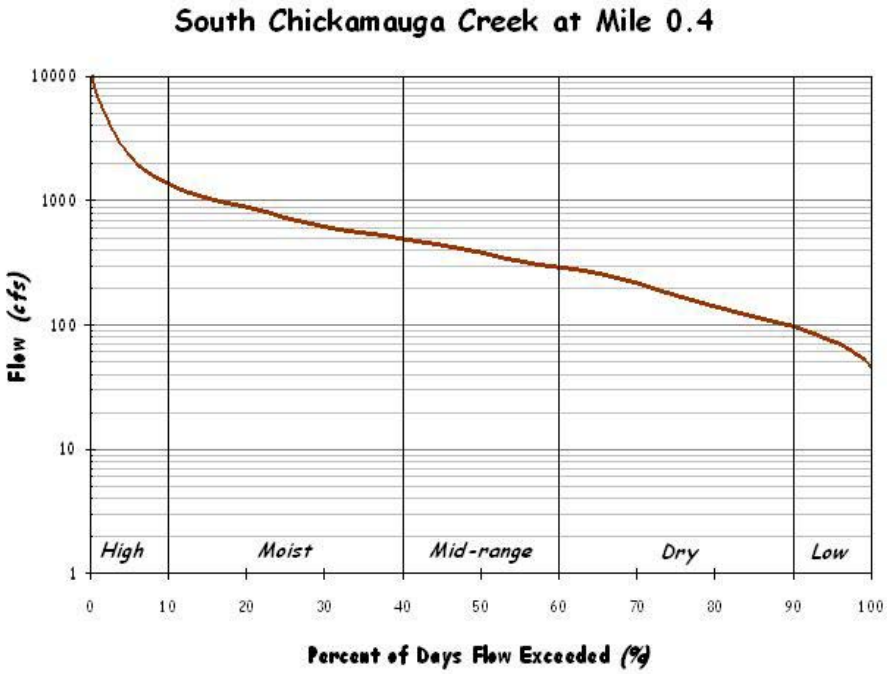

Figure C-1. Flow Duration Curve for South Chickamauga Creek at Mile 0.4

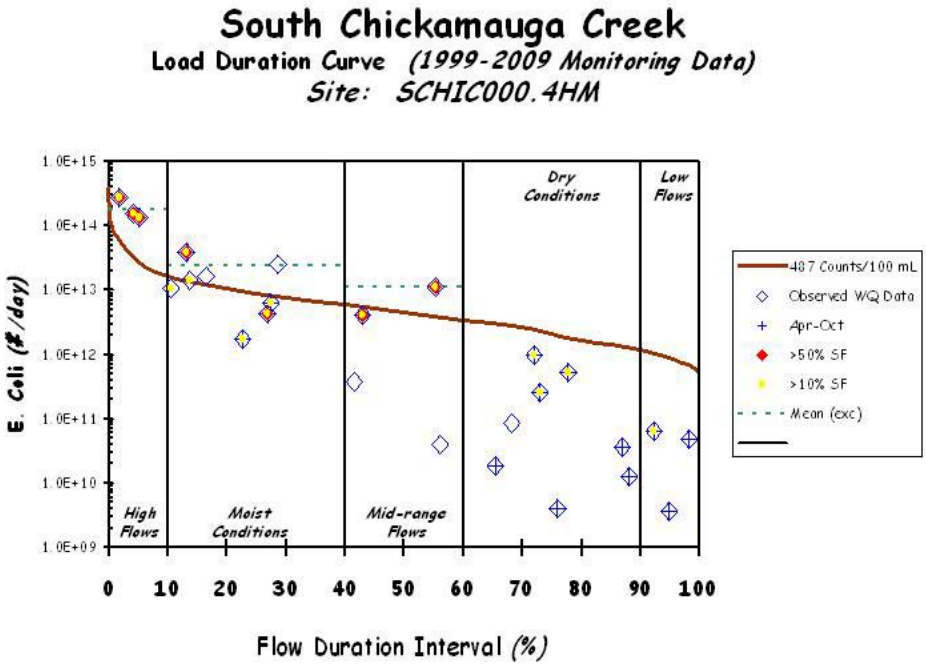

Figure C-2. E. Coli Load Duration Curve for South Chickamauga Creek at Mile 0.4

Table C-1. TMDLs, WLAs, & LAs for Impaired Waterbodies in the Lower Tennessee River Watershed (HUC 06020001)

HUC-12 Subwatershed (06020001__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs			LAs
					WWTFs [a]	Collection Systems	MS4s [b]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/d/ac]	[CFU/d/ac]
0102 (DA)	Bivens Branch	TN06020001041 – 0320	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.649 \times 10^{7} \times Q$
0401	Lewis Branch	TN06020001029 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.480 \times 10^{7} \times Q$	$1.480 \times 10^{7} \times Q$
	Long Savannah Creek	TN06020001029 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.102 \times 10^{6} \times Q$	$1.102 \times 10^{6} \times Q$
	Wolfe Branch	TN06020001029 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$6.880 \times 10^{6} \times Q$	$6.880 \times 10^{6} \times Q$
0402	Chestnut Creek	TN06020001889 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$5.887 \times 10^{6} \times Q$	$5.887 \times 10^{6} \times Q$
	Little Wolftever Creek	TN06020001889 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.176 \times 10^{6} \times Q$	$3.176 \times 10^{6} \times Q$
	Rogers Branch	TN060200011880 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	NA	$3.313 \times 10^{6} \times Q$	$3.313 \times 10^{6} \times Q$
	Wilkerson Branch	TN06020001889 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$9.117 \times 10^{6} \times Q$	$9.117 \times 10^{6} \times Q$
	Wolftever Creek	TN06020001889 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.404 \times 10^{5} \times Q$	$3.404 \times 10^{5} \times Q$
	Unnamed Trib to Wolftever Creek	TN06020001889 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.735 \times 10^{7} \times Q$	$2.735 \times 10^{7} \times Q$
0903	Spring Creek	TN06020001007 – 0510	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	0	$8.166 \times 10^{5} \times Q$	$8.166 \times 10^{5} \times Q$
0905	Friar Branch	TN06020001007 – 0100	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	0	$8.131 \times 10^{5} \times Q$	$8.131 \times 10^{5} \times Q$
	Mackey Branch	TN06020001007 – 0300	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	0	$1.579 \times 10^{6} \times Q$	$1.579 \times 10^{6} \times Q$
	South Chickamauga Creek	TN06020001007 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.357×10^{11}	0	$3.699 \times 10^{4} \times Q - 1.492 \times 10^{6}$	$3.699 \times 10^{4} \times Q - 5.164 \times 10^{5}$
	Unnamed Trib to S. Chickamauga Creek	TN06020001007 – 0200	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	0	$1.243 \times 10^{7} \times Q$	$1.243 \times 10^{7} \times Q$

Table C-1 (cont'd). TMDLs, WLAs, & LAs for Impaired Waterbodies in the Lower Tennessee River Watershed (HUC 06020001)

HUC-12 Subwatershed (06020001__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs			LAs
					WWTFs [a]	Collection Systems	MS4s [b]	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU/day]	[CFU/d/ac]	[CFU/d/ac]
1003	Dobbs Branch	TN060200011244 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$6.656 \times 10^{6} \times Q$	$6.656 \times 10^{6} \times Q$
	Gillespie Springs Branch	TN060200011244 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$3.054 \times 10^{7} \times Q$	$3.054 \times 10^{7} \times Q$
	McFarland Springs Branch	TN060200011244 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$2.524 \times 10^{7} \times Q$	$2.524 \times 10^{7} \times Q$
	Chattanooga Creek	TN060200011244 – 1000 TN060200011244 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	2.849×10^{11}	0	$6.582 \times 10^{6} \times Q$	$4.782 \times 10^{5} \times Q$
	Unnamed Trib to Chattanooga Creek	TN060200011244 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$2.514 \times 10^{7} \times Q$	$2.514 \times 10^{7} \times Q$
1202	Bee Branch	TN06020001109 – 0400	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	NA	$2.541 \times 10^{7} \times Q$	$2.541 \times 10^{7} \times Q$
	Citico Creek	TN060200011240 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$5.209 \times 10^{6} \times Q$	$5.209 \times 10^{6} \times Q$
	Unnamed Trib to Citico Creek	TN060200011240 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$2.547 \times 10^{7} \times Q$	$2.547 \times 10^{7} \times Q$
	Mountain Creek	TN060200011426 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$4.581 \times 10^{6} \times Q$	$4.581 \times 10^{6} \times Q$
	North Market Street Branch	TN06020001001T – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$4.189 \times 10^{7} \times Q$	$4.189 \times 10^{7} \times Q$
	Shoal Creek	TN06020001087 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$7.068 \times 10^{6} \times Q$	$7.068 \times 10^{6} \times Q$
	Short Creek	TN06020001109 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.770 \times 10^{7} \times Q$	$2.770 \times 10^{7} \times Q$
	Stanley Branch	TN06020001109 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.879 \times 10^{7} \times Q$	$3.879 \times 10^{7} \times Q$
	Stringers Branch	TN060200011426 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	0	$5.339 \times 10^{6} \times Q$	$5.339 \times 10^{6} \times Q$

Notes: NA = Not Applicable.
Q = Mean Daily In-stream Flow (cfs).

a. WLAs for WWTFs are expressed as E. coli loads (CFU/day). All current and future WWTFs must meet water quality standards as specified in their NPDES permit.

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

HYDRODYNAMIC MODELING METHODOLOGY

D.1 Model Selection

The Windows version of Hydrologic Simulation Program - Fortran (HSPF) was selected for flow simulation of pathogen-impaired waters in the subwatersheds of the Lower Tennessee River Watershed. HSPF is a watershed model capable of performing flow routing through stream reaches.

D.2 Model Set Up

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

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

An important factor influencing model results is the precipitation data contained in the meteorological data files used in these simulations. Weather data from multiple meteorological stations were available for the time period from January 1970 through December 2009. Meteorological data for a selected 12-year period were used for all simulations. The first year of this period was used for model stabilization with simulation data from the subsequent 11-year period (10/1/98 – 9/30/09) used for TMDL analysis.

D.3 Model Calibration

Hydrologic calibration of the watershed model involves comparison of simulated streamflow to historic streamflow data from U. S. Geological Survey (USGS) stream gaging stations for the same period of time. Two USGS continuous record stations located in the Lower Tennessee River Watershed were selected as the basis of the hydrology calibration. Station 03566420 is located on Wolftever Creek near Ooltewah, TN and has a drainage area of 18.8 square miles. Station 03567400 is located on South Chickamauga Creek near Chickamauga, TN and has a drainage area of 428 square miles.

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 Wolftever Creek near Ooltewah, USGS Station 03566420, are shown in Table D-1 and Figures D-1 and D-2. The results for South Chickamauga Creek near Chickamauga, USGS Station 03567500, are shown in Table D-2 and Figures D-3 and D-4.

Table D-1. Hydrologic Calibration Summary: Wolftever Creek at Ooltewah (USGS 03566420)

		18.7780516	
Simulation Name:	USGS03566420	**Simulation Period:**	
		Watershed Area (ac):	12021.80
Period for Flow Analysis			
Begin Date:	**10/01/79**	**Baseflow PERCENTILE:**	2.5
End Date:	**09/30/89**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**204.57**	Total Observed In-stream Flow:	**202.32**
Total of highest 10% flows:	**104.00**	Total of Observed highest 10% flows:	**111.21**
Total of lowest 50% flows:	**21.57**	Total of Observed Lowest 50% flows:	**20.42**
Simulated Summer Flow Volume (months 7-9):	**18.46**	Observed Summer Flow Volume (7-9):	**17.58**
Simulated Fall Flow Volume (months 10-12):	**49.93**	Observed Fall Flow Volume (10-12):	**45.23**
Simulated Winter Flow Volume (months 1-3):	**92.38**	Observed Winter Flow Volume (1-3):	**92.88**
Simulated Spring Flow Volume (months 4-6):	**43.79**	Observed Spring Flow Volume (4-6):	**46.63**
Total Simulated Storm Volume:	**193.36**	Total Observed Storm Volume:	**190.78**
Simulated Summer Storm Volume (7-9):	**15.68**	Observed Summer Storm Volume (7-9):	**14.70**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**1.11**	10	
Error in 50% lowest flows:	**5.66**	10	
Error in 10% highest flows:	**-6.49**	15	
Seasonal volume error - Summer:	**5.01**	30	
Seasonal volume error - Fall:	**10.40**	30	
Seasonal volume error - Winter:	**-0.54**	30	
Seasonal volume error - Spring:	**-6.08**	30	
Error in storm volumes:	**1.35**	20	
Error in summer storm volumes:	**6.70**	50	

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

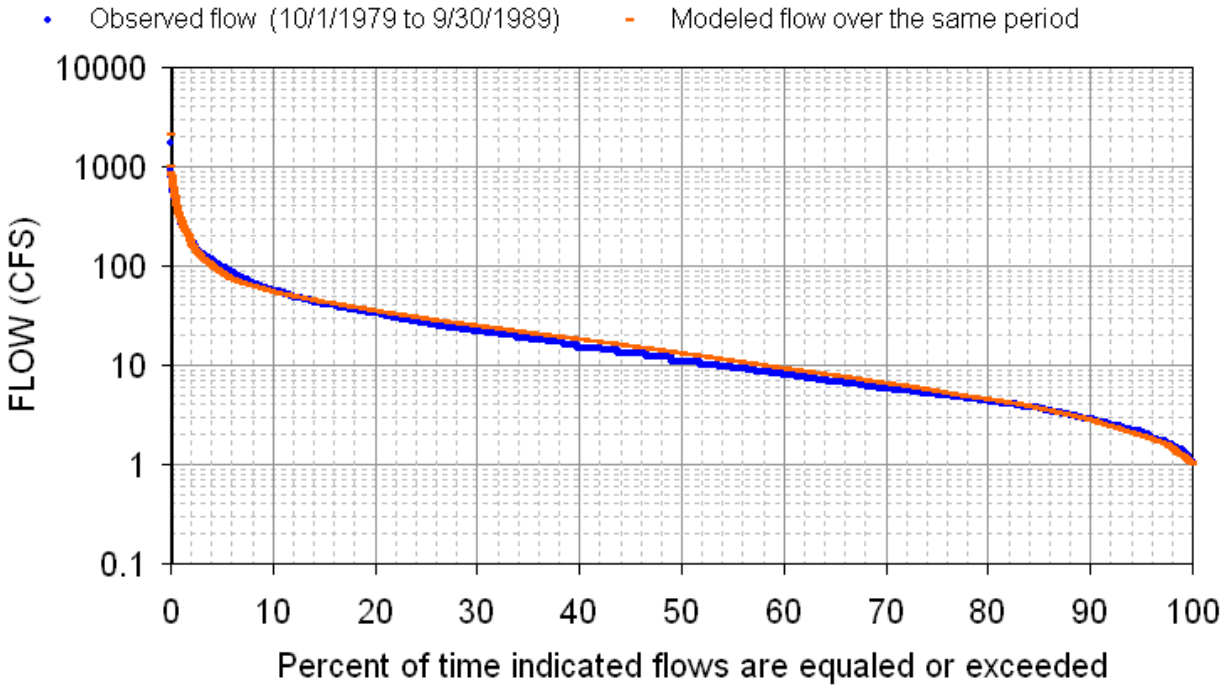

Figure D-1. Hydrologic Calibration: Wolftever Creek, USGS 03566420 (WYs1980-1989)

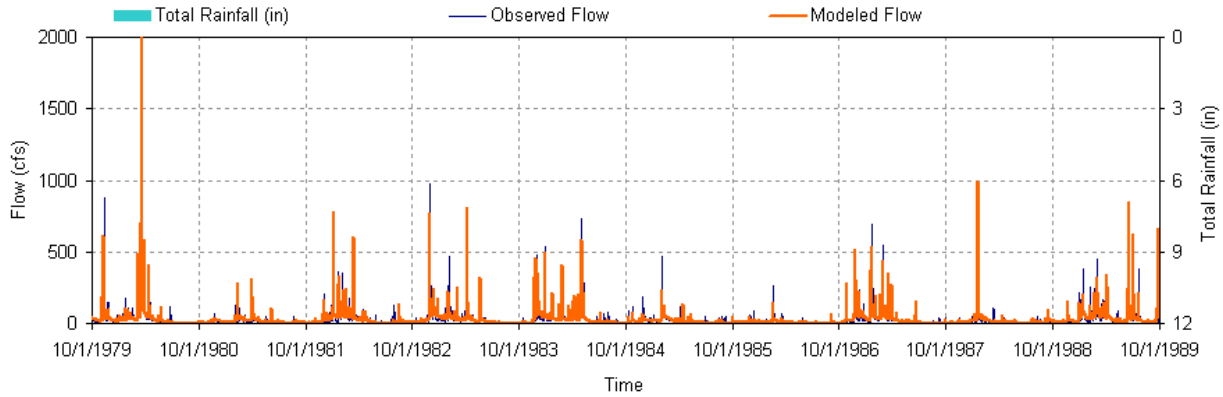

Figure D-2. 10-Year Hydrologic Comparison: Wolftever Creek, USGS 03566420

Table D-2. Hydrologic Calibration Summary: South Chickamauga Creek near Chickamauga (USGS 03567500)

		420.4430714	
Simulation Name:	USGS03567500	**Simulation Period:**	
		Watershed Area (ac):	269169.70
Period for Flow Analysis			
Begin Date:	**10/01/84**	**Baseflow PERCENTILE:**	2.5
End Date:	**09/30/94**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**237.32**	Total Observed In-stream Flow:	**224.23**
Total of highest 10% flows:	**114.54**	Total of Observed highest 10% flows:	**117.88**
Total of lowest 50% flows:	**27.52**	Total of Observed Lowest 50% flows:	**26.20**
Simulated Summer Flow Volume (months 7-9):	**27.86**	Observed Summer Flow Volume (7-9):	**22.70**
Simulated Fall Flow Volume (months 10-12):	**52.36**	Observed Fall Flow Volume (10-12):	**44.69**
Simulated Winter Flow Volume (months 1-3):	**115.10**	Observed Winter Flow Volume (1-3):	**115.36**
Simulated Spring Flow Volume (months 4-6):	**41.99**	Observed Spring Flow Volume (4-6):	**41.48**
Total Simulated Storm Volume:	**222.95**	Total Observed Storm Volume:	**199.08**
Simulated Summer Storm Volume (7-9):	**24.28**	Observed Summer Storm Volume (7-9):	**16.38**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**5.84**	10	
Error in 50% lowest flows:	**5.04**	10	
Error in 10% highest flows:	**-2.83**	15	
Seasonal volume error - Summer:	**22.77**	30	
Seasonal volume error - Fall:	**17.17**	30	
Seasonal volume error - Winter:	**-0.23**	30	
Seasonal volume error - Spring:	**1.24**	30	
Error in storm volumes:	**11.99**	20	
Error in summer storm volumes:	**48.27**	50	

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

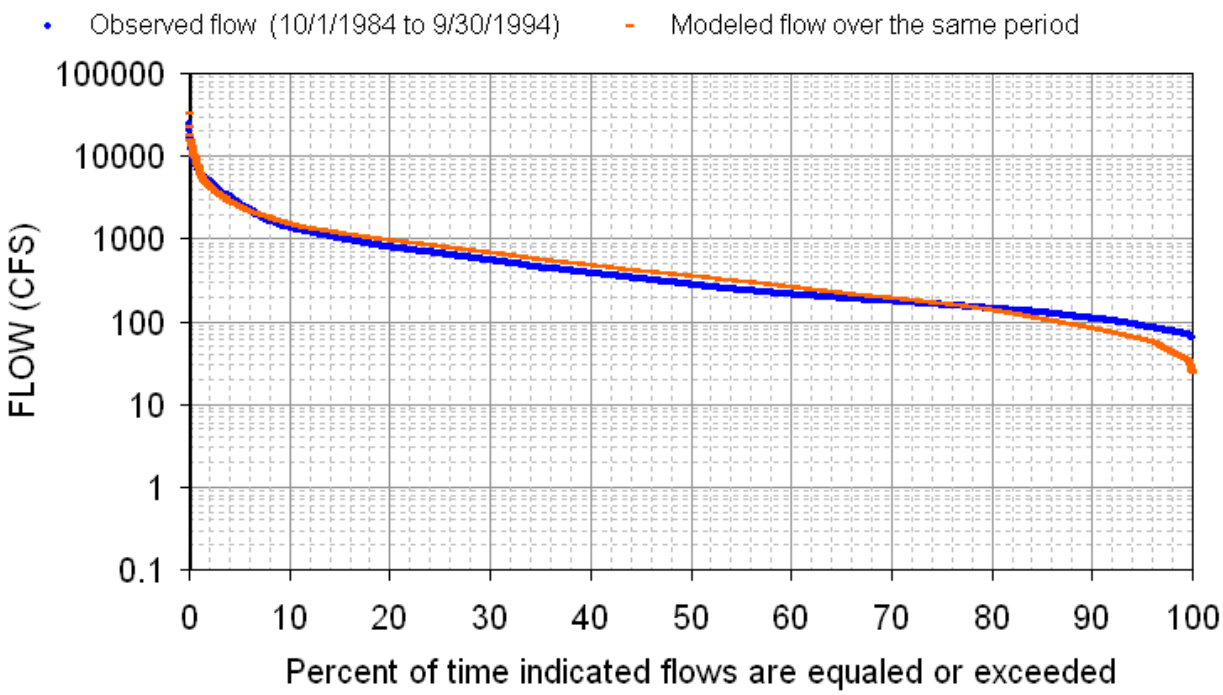

Figure D-3. Hydrologic Calibration: South Chickamauga Creek, USGS 03567500 (WYs1985-1994)

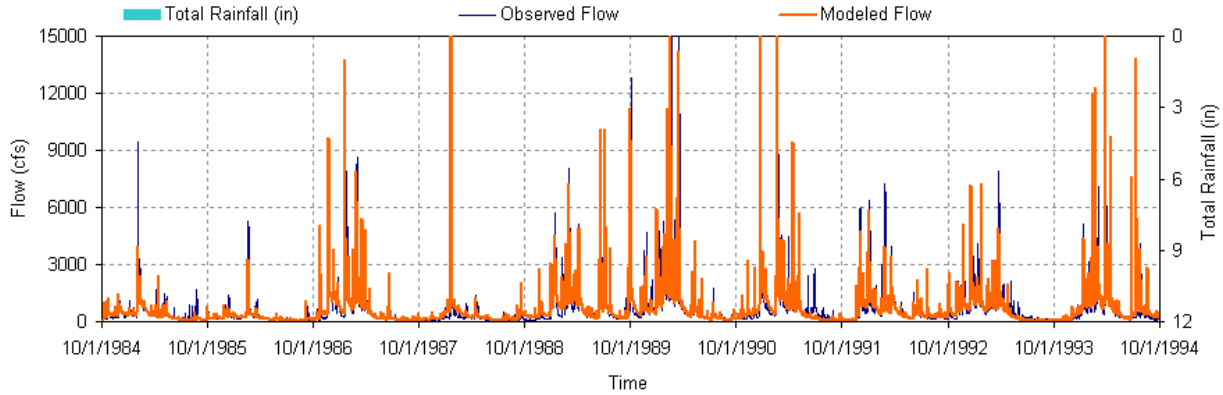

Figure D-4. 10-Year Hydrologic Comparison: South Chickamauga Creek, USGS 03567500

APPENDIX E

Source Area Implementation Strategy

All impaired waterbodies and corresponding HUC-12 subwatersheds or drainage areas have been classified according to their respective source area types in Section 9.5, Table 9. The implementation for each area will be prioritized according to the guidance provided in Section 9.5.1 and 9.5.2, with examples provided in Section 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 HUC-12 subwatersheds or drainage areas identified as predominantly urban source area types, the following example for Spring Creek provides guidance for implementation analysis:

The Spring Creek watershed, HUC-12 060200010903, lies in the southern portion of Chattanooga in the Lower Tennessee River watershed. The drainage area for Spring Creek is approximately 13,226 acres (20.67 mi^2); therefore, four flow zones were used for the duration curve analysis (see Sect. 9.1.1).

Note: The Final 2008 303(d) List includes Discharges from MS4 Areas and Collection System Failure as the Pollutant Source categories for Spring Creek; therefore, Spring Creek is listed in the Urban source area type in Section 9.5, Table 9.

The flow duration curve for Spring Creek at mile 0.7 was constructed using simulated daily mean flow for the period from 10/1/94 through 9/30/09 (mile 0.7 corresponds to the location of monitoring station SPRIN000.7HM). 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).

The E. coli LDC for Spring Creek (Figure E-2) was analyzed to determine the frequency with which observed daily water quality loads exceed the E. coli target maximum daily loading (487 CFU/100 mL x flow [cfs] x conversion factor) under four flow conditions (low, mid-range, moist, and high). Observation of the plot illustrates that exceedances occurred during all flow conditions.

The critical flow condition appears to be during moist conditions. Therefore, the implementation strategy for the Spring Creek watershed will require BMPs targeting non-point sources (dominant under high flow/runoff conditions).

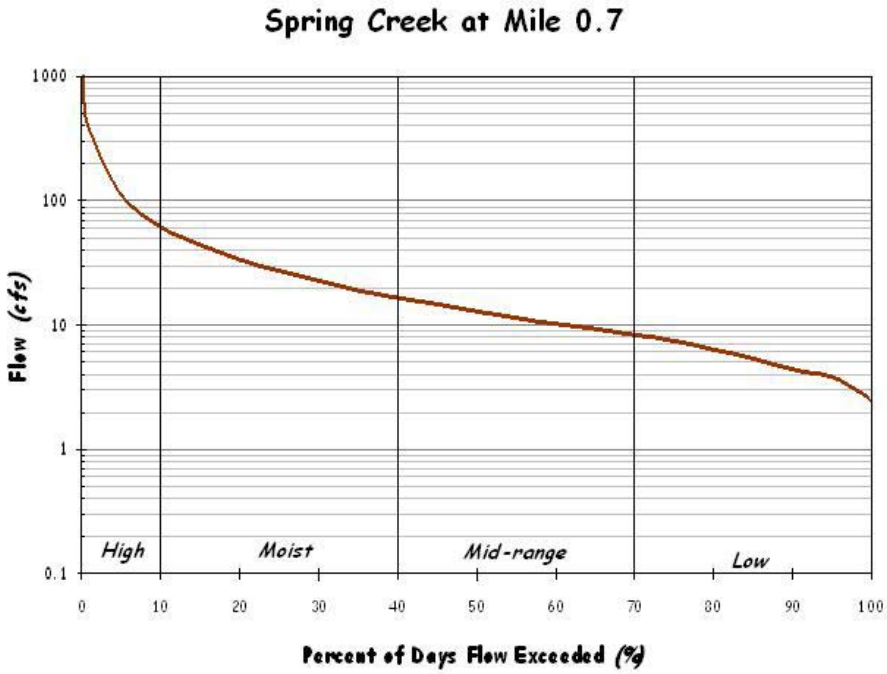

Figure E-1. Flow Duration Curve for Spring Creek at Mile 0.7

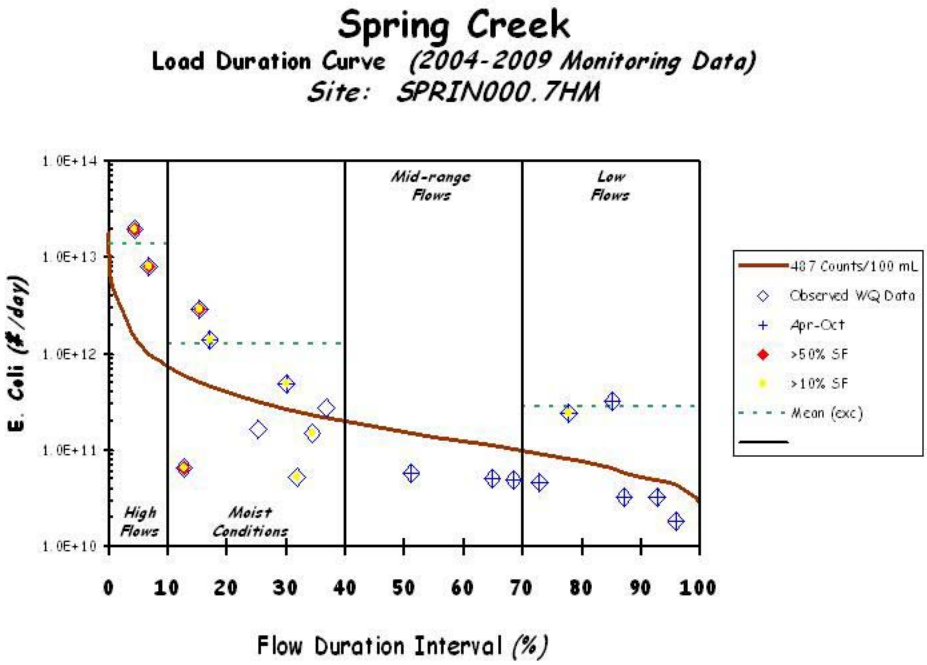

Figure E-2. E. Coli Load Duration Curve for Spring Creek at Mile 0.7

Table E-1. Load Duration Curve Summary for Implementation Strategies (Example: Spring Creek subwatershed, HUC-12 060200010903) (4 Flow Zones).

Hydrologic Condition		High	Moist	Mid-range	Low
% Time Flow Exceeded		0-10	10-40	40-70	70-100
Spring Creek (060200010903)	Number of Samples	2	8	3	6
	% > 941 CFU/100 mL[1]	100.0	50.0	0	33.3
	Load Reduction[2]	89.1%	26.4%	NR	24.2%
TMDL (CFU/day)		1.324E+12	3.239E+11	1.386E+11	6.504E+10
Margin of Safety (CFU/day)		1.324E+11	3.239E+10	1.386E+10	6.504E+09
WLA (WWTFs) (CFU/day)		NA	NA	NA	NA
WLAs (MS4s) (CFU/day/acre)[3]		9.008E+07	2.204E+07	9.431E+06	4.426E+06
LA (CFU/day/acre)[3]		9.008E+07	2.204E+07	9.431E+06	4.426E+06
Implementation Strategies[4]					
Municipal NPDES			L	M	H
Stormwater Management			H	H	
SSO Mitigation		H	M	L	
Collection System Repair			H	M	
Septic System Repair			L	M	M
Potential for source area contribution under given flow condition (H: High; M: Medium; L: Low)					

[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.

Table E-1 presents an allocation table of LDC analysis statistics for Spring Creek 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 Lower Tennessee River 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 HUC-12 subwatersheds and drainage areas identified as predominantly urban source area types can be derived from the information and results available in Tables 10 and E-61.

Table E-61 presents LDC analyses (TMDLs, WLAs, LAs, and MOS) and PLRGs for all flow zones for all E. coli impaired waterbodies in the Lower Tennessee River watershed.

E.2 Agricultural Source Areas

For impaired waterbodies and corresponding HUC-12 subwatersheds or drainage areas identified as predominantly agricultural source area types, the following example for Long Savannah Creek provides guidance for implementation analysis.

The Long Savannah Creek subwatershed, HUC-12 060200010401, lies in a non-urbanized area of Hamilton county near Chattanooga. The drainage area for Long Savannah Creek is approximately 14,494 acres (22.6 mi^2); therefore, four flow zones were used for the duration curve analysis (see Sect. 9.1.1). The landuse for Long Savannah Creek is approximately 30.6% agricultural, with most of the remainder being forested. Urban areas make up approximately 7.0% of the total area. Therefore, the predominant landuse type and sources are agricultural, although urban sources may be a contributing factor.

The flow duration curve for Long Savannah Creek was constructed using simulated daily mean flow for the period from 1/1/98 through 12/31/09. 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).

The E. coli LDC for Long Savannah Creek (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). Observation of the plot illustrates that all of the sampling events occurred during low flow conditions.

The critical flow condition appears to occur during mid-range flows. However, several exceedances also occurred during moist conditions. Therefore, the implementation strategy for the Long Savannah Creek watershed will require BMPs targeting both point 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 Long Savannah Creek 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 Lower Tennessee River 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 HUC-12 subwatersheds and drainage areas identified as predominantly agricultural source area types can be derived from the information and results available in Tables 11 and E-61.

Table E-61 presents LDC analyses (TMDLs, WLAs, LAs, and MOS) and PLRGs for all flow zones for all E. coli impaired waterbodies in the Lower Tennessee River watershed.

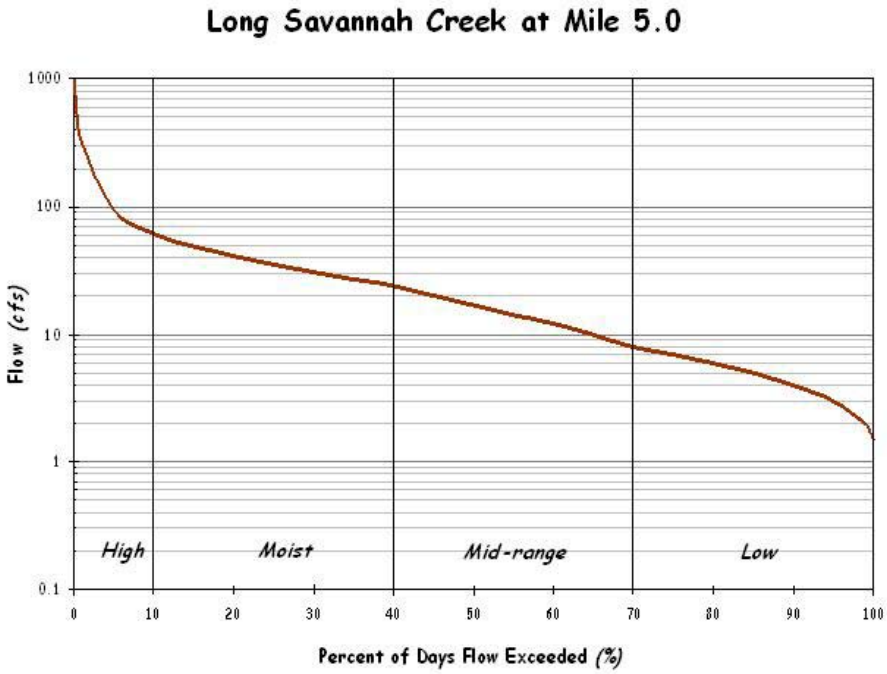

Figure E-3. Flow Duration Curve for Long Savannah Creek at Mile 5.0

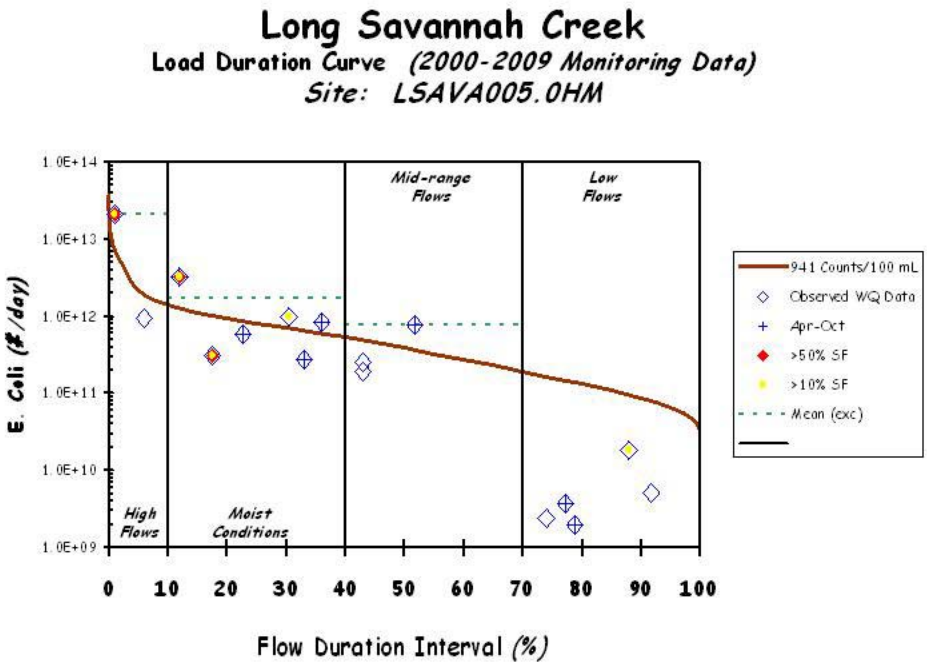

Figure E-4. E. Coli Load Duration Curve for Long Savannah Creek at Mile 5.0

Table E-2. Load Duration Curve Summary for Implementation Strategies (Example: Long Savannah Creek subwatershed, HUC-12 060200010401) (4 Flow Zones).

Hydrologic Condition		High	Moist	Mid-range	Low*
% Time Flow Exceeded		0-10	10-40	40-70	70-100
Long Savannah Creek (060200010401)	Number of Samples	2	6	2	5
	% > 941 CFU/100 mL[1]	50.0	50.0	50.0	0
	Load Reduction[2]	30.6%	19.4%	26.3%	NR
TMDL (CFU/day)		2.189E+12	8.073E+11	3.255E+11	1.102E+11
Margin of Safety (CFU/day)		2.189E+11	8.073E+10	3.255E+10	1.102E+10
WLA (WWTFs) (CFU/day)		NA	NA	NA	NA
WLAs (MS4s) (CFU/day/acre)[3]		1.126E+08	4.151E+07	1.673E+07	5.665E+06
LA (CFU/day/acre)[3]		1.126E+08	4.151E+07	1.673E+07	5.665E+06
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)					

[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 HUC-12 subwatersheds or drainage areas classified as source area type predominantly forested, with the predominant source category being wildlife, in the Lower Tennessee River 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. As a result, critical flow zones were determined and subsequently verified by secondary analyses. Therefore, the following example is from Spring Creek.

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.

Date	Sample Conc. (CFU/100 mL)	Flow (cfs)	Existing Load (CFU/Day)	Target (TMDL) Load (CFU/Day)	Percent Reduction
3/7/05	53.0	51.26	6.65E+10	6.11E+11	0(-819)
10/12/04	2,720.0	44.13	2.94E+12	5.26E+11	82.1
7/7/09	1,413.6	40.16	1.39E+12	4.78E+11	56.5
11/16/09	248.1	27.41	1.66E+11	3.27E+11	0(96)
5/2/05	860.0	23.01	4.84E+11	2.74E+11	43.4
1/18/05	100.0	21.56	5.28E+10	2.57E+11	0(-387)
11/8/04	310.00	19.99	1.52E+11	2.38E+11	0(-57)
12.1.09	613.1	18.48	2.77E+11	2.20E+11	20.6
Percent Load Reduction Goal (PLRG) for Moist Conditions (Mean)					**26.4**

2. The PLRGs calculated for each of the flow zones, not including the high flow zone (see Section. 9.1.1), were compared and the PLRG of the greatest magnitude indicates the critical flow zone for prioritizing implementation actions for Spring Creek.

Example – *High Flow Zone Percent Load Reduction Goal = 89.1*
Moist Conditions Flow Zone Percent Load Reduction Goal = 26.4
Mid-Range Flow Zone Percent Load Reduction Goal = NR
Low Flow Zone Percent Load Reduction Goal = 29.1

Therefore, the critical flow zone for prioritization of Spring Creek implementation activities is the Moist Conditions Flow Zone and subsequently actions targeting both non-point source controls.

3. Due to the frequently limited availability of sampling data and subsequent randomness of distribution of samples by flow zone, the determination of the critical flow zone by PLRG calculation often has a high degree of uncertainty. Therefore, secondary analyses were conducted to verify or supplement the determination of the critical flow zones. For each flow zone, the percent of samples that exceed the E. coli TMDL target levels was calculated. For Spring Creek:

Flow Zone	Number of Samples	Samples > 487 CFU/100 mL	% > 487 CFU/100 mL
High	2	2	100.0
Moist	***8***	***4***	***50.0***
Mid-Range	3	0	0
Low	6	2	33.3

The critical flow zone for prioritization of Spring Creek implementation activities is confirmed as the moist conditions flow zone. If a different flow zone were indicated, both zones would receive equal emphasis for implementation prioritization.

4. Lastly, emphasis (priority) should be placed on recent data versus historical data. If data from multiple watershed cycles is available, analysis of recent data (current cycle) versus the entire period of record, or previous cycles, may identify different critical areas for implementation. Chattanooga Creek is the only waterbody in the Lower Tennessee River watershed with sufficient monitoring data to allow for comparison.

Zone	Period of Record (1998-2009)			Most Recent (2002-2009)		
	# of samples	% Red.	% Exc.	# of samples	% Red.	% Exc.
High	7	17.4	28.6	3	20.4	33.3
Moist	14	8.7	14.3	7	8.7	14.3
Mid-Range	17	**19.6**	**47.1**	9	13.7	33.3
Dry	18	15.7	33.3	8	**15.3**	**25**
Low	5	0	0	3	0	0
All Zones	*61*	*14.1*	*30.4*	*30*	*12.3*	*23.3*

In this case, the critical flow zone for prioritization of implementation activities has shifted slightly from the mid-range zone to the dry condition zone. However, the mid-range and dry condition zones both have more exceedances and require higher reductions than the other three zones.

PLRGs and critical flow zones of the other impaired waterbodies were derived in a similar manner and are shown in Table E-61.

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/100 mL. If the sample geometric mean exceeded the target geometric mean concentration, the reduction required to reduce the sample geometric mean value to the target geometric mean concentration was calculated.

Example: *Monitoring Location = Spring Creek*
Sampling Period = 7/7/09 – 7/27/09
Geometric Mean Concentration = 837.2 CFU/100 mL
Target Concentration = 126 CFU/100 mL
Reduction to Target = 84.9%

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 may be utilized to supplement the results of the individual flow zone calculations.

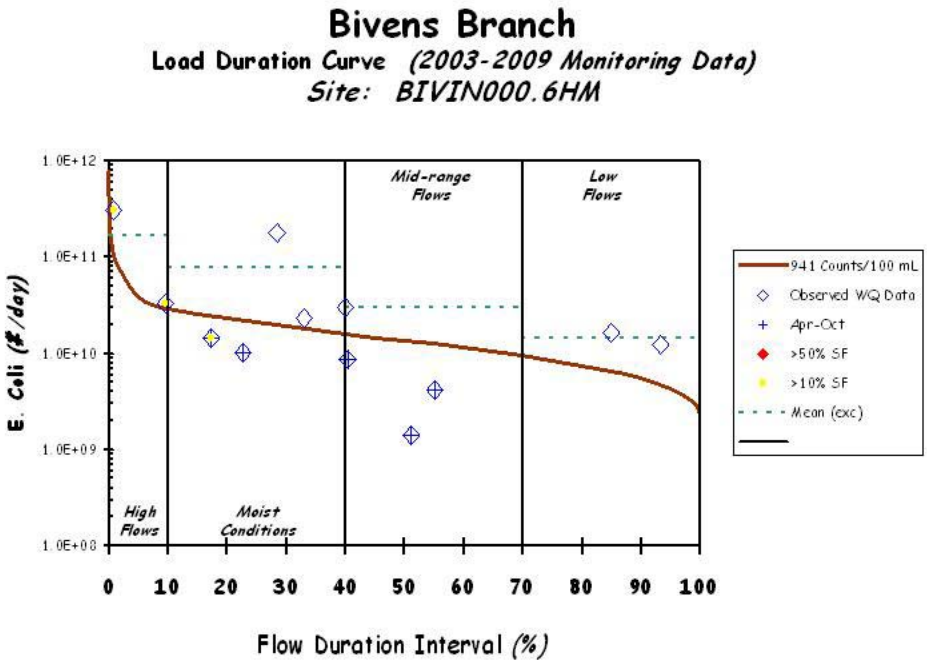

Figure E-5. E. Coli Load Duration Curve for Bivens Branch – RM0.6

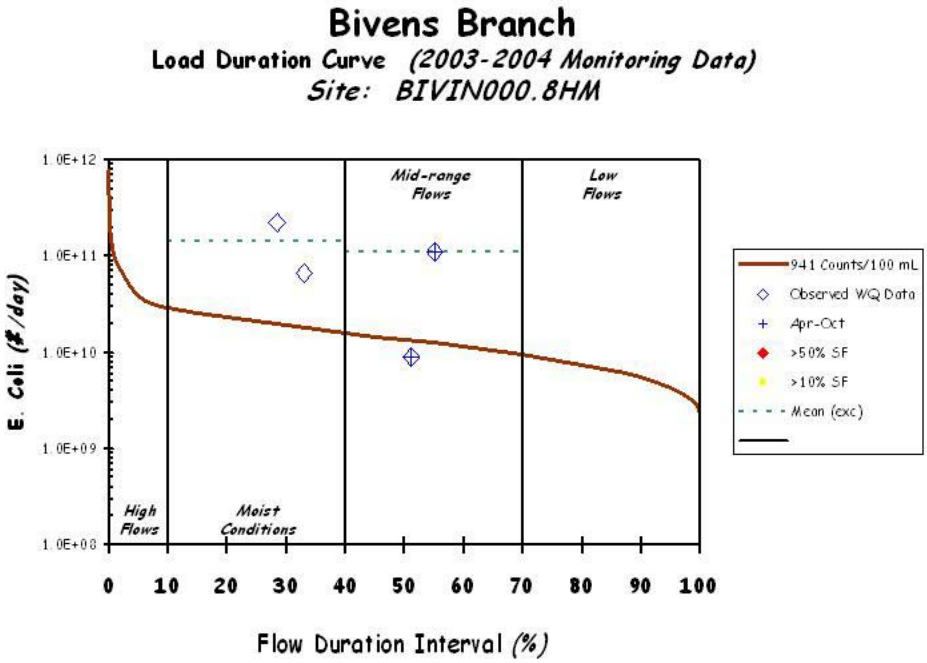

Figure E-6. E. Coli Load Duration Curve for Bivens Branch – RM0.8

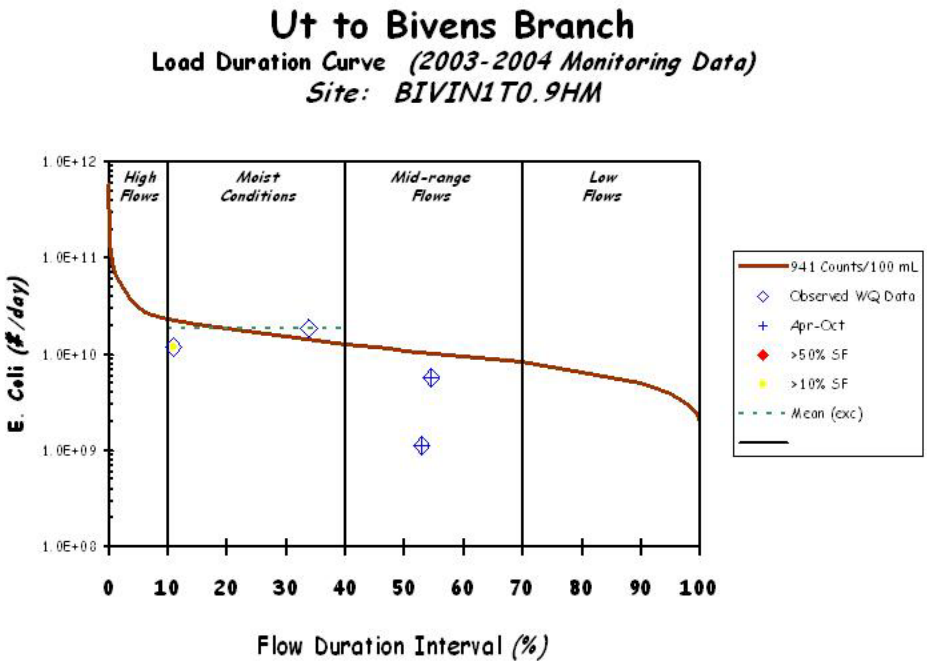

Figure E-7. E. Coli Load Duration Curve for UT to Bivens Branch – RM0.9

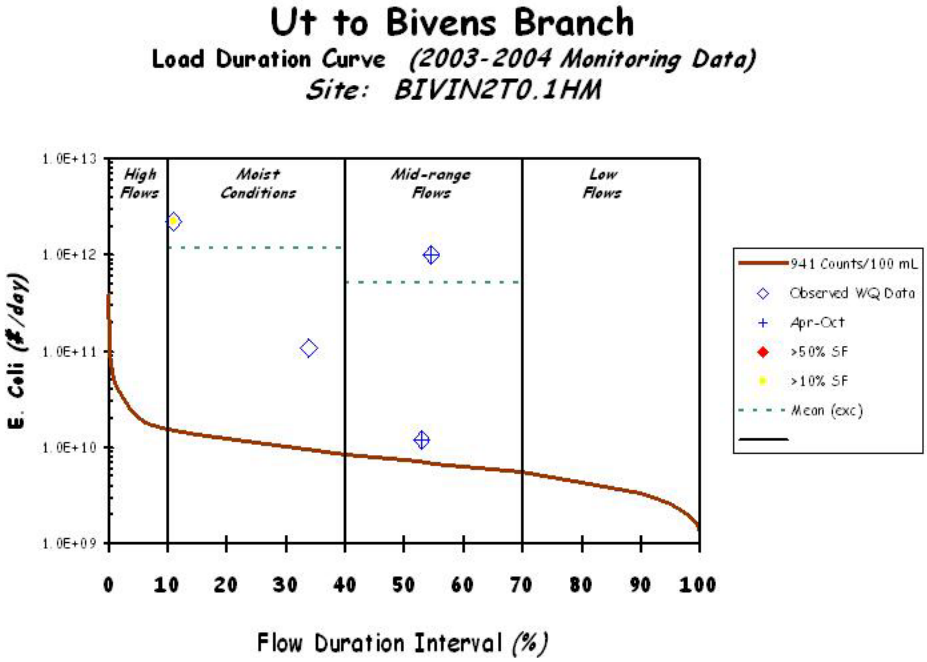

Figure E-8. E. Coli Load Duration Curve for UT to Bivens Branch – RM0.1

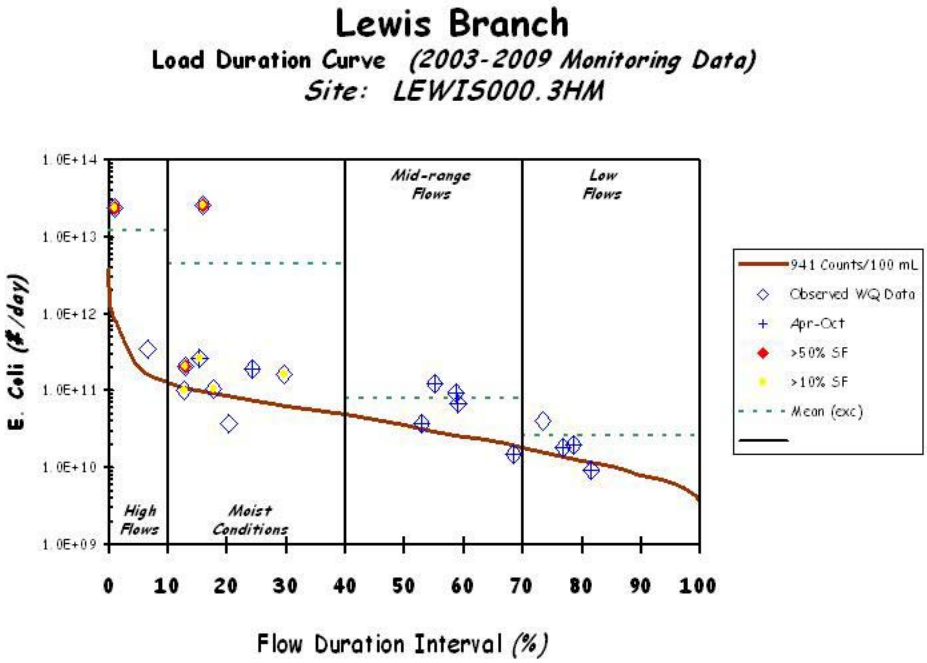

Figure E-9. E. Coli Load Duration Curve for Lewis Branch – RM0.3

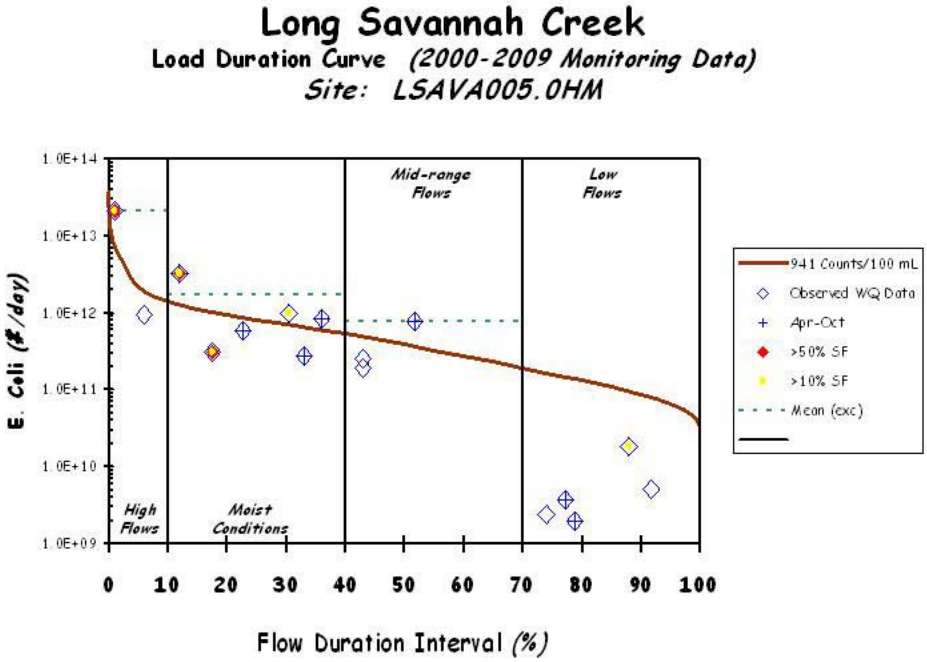

Figure E-10. E. Coli Load Duration Curve for Long Savannah Creek – RM5.0

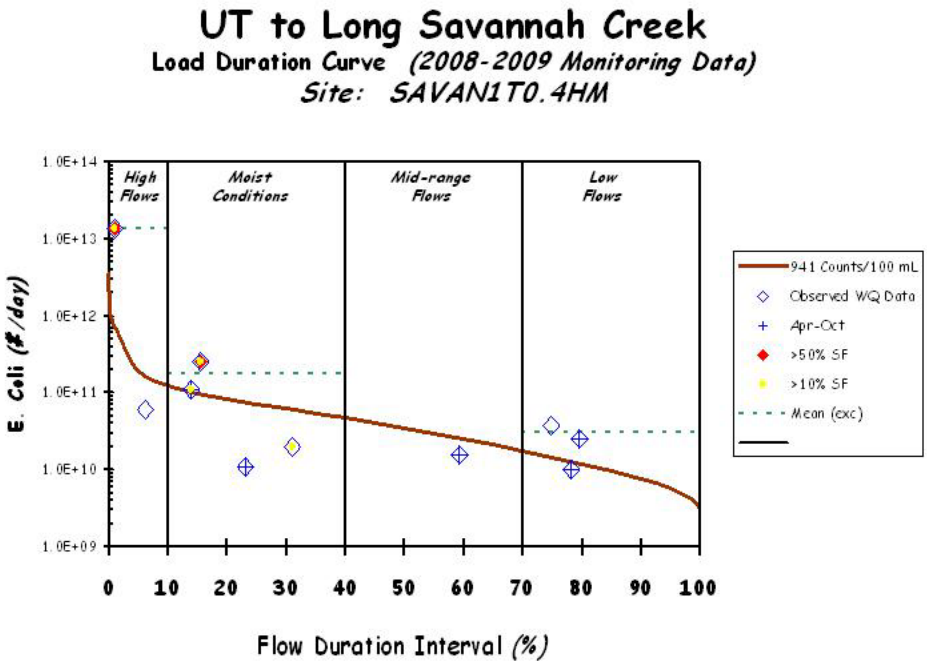

Figure E-11. E. Coli Load Duration Curve for UT to Long Savannah Creek – RM0.4

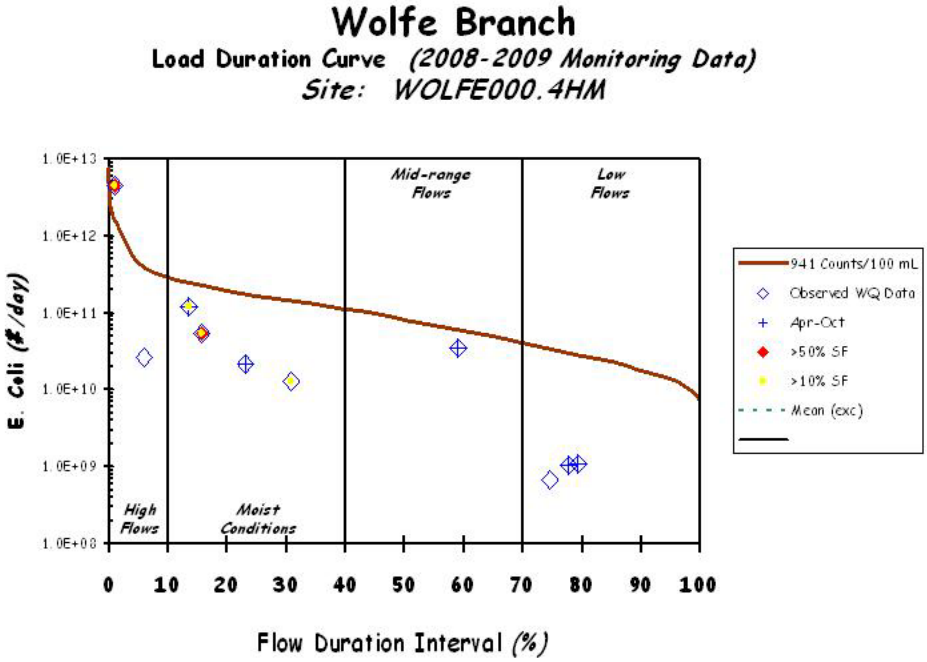

Figure E-12. E. Coli Load Duration Curve for Wolfe Branch – RM0.4

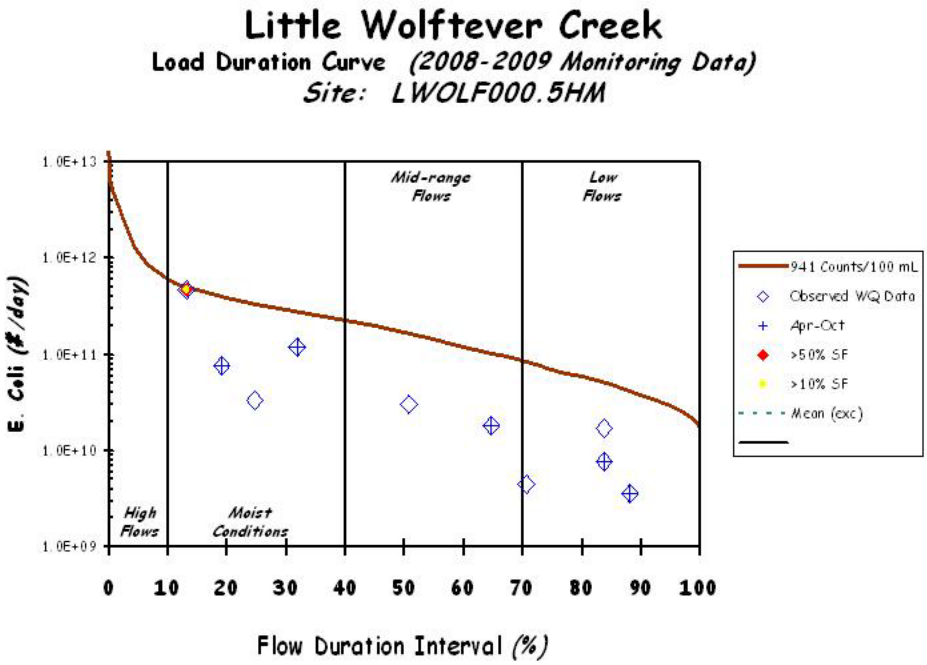

Figure E-13. E. Coli Load Duration Curve for Little Wolftever Creek – RM0.5

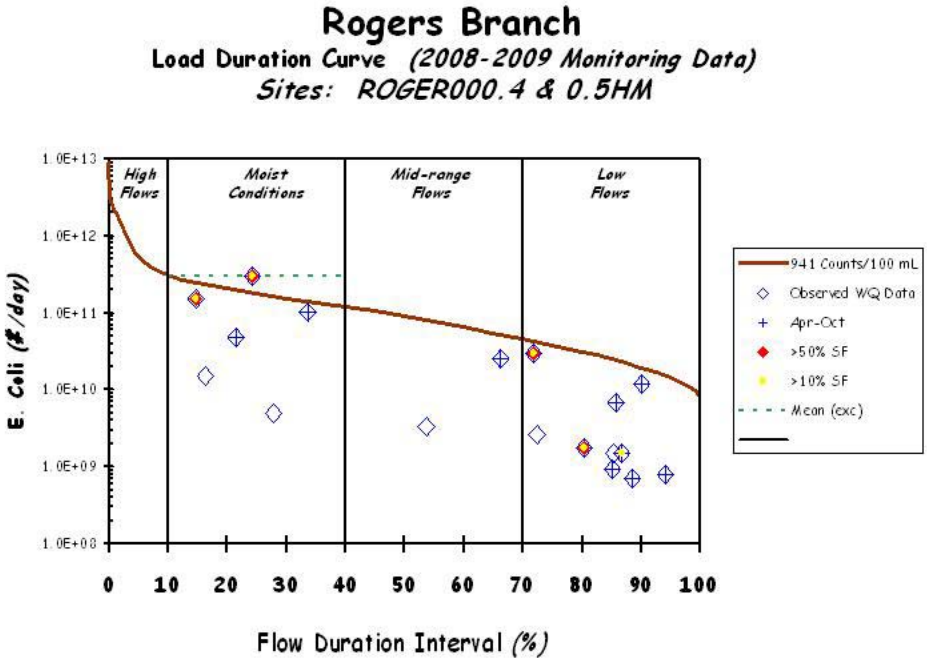

Figure E-14. E. Coli Load Duration Curve for Rogers Branch – RM0.4 & RM0.9

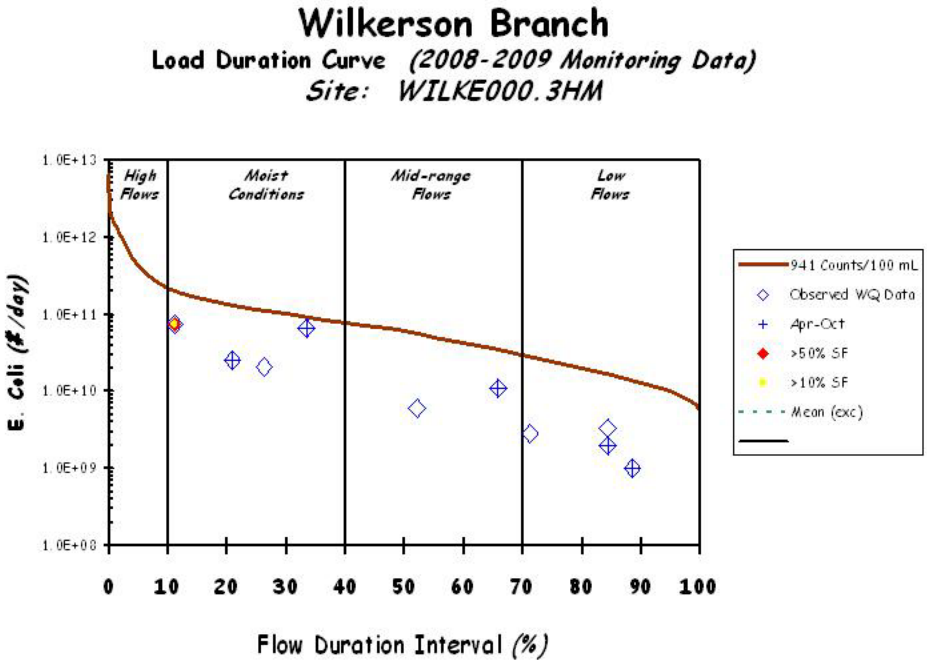

Figure E-15. E. Coli Load Duration Curve for Wilkerson Branch – RM0.3

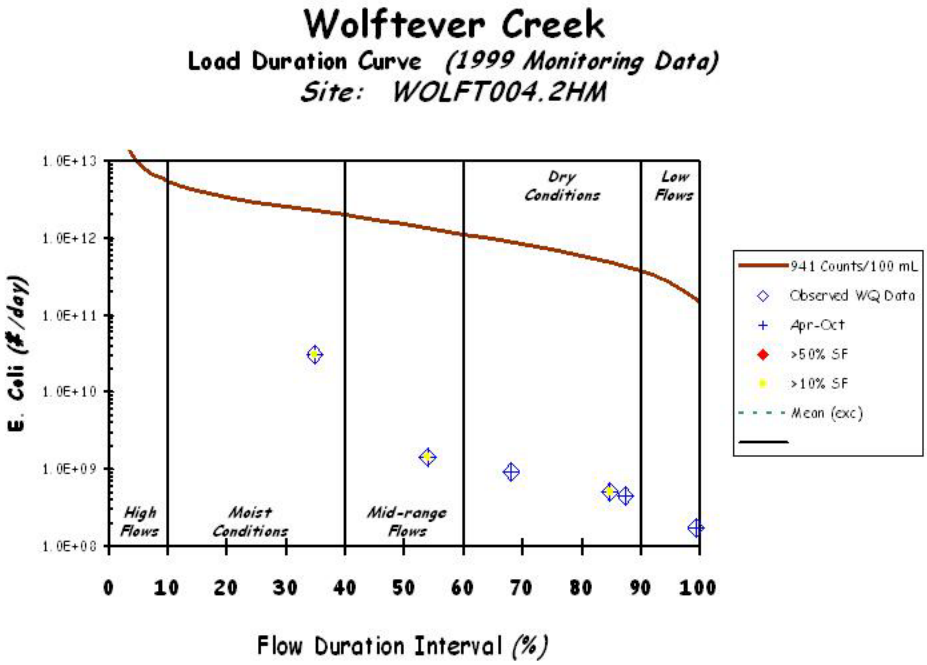

Figure E-16. E. Coli Load Duration Curve for Wolftever Creek – RM4.2

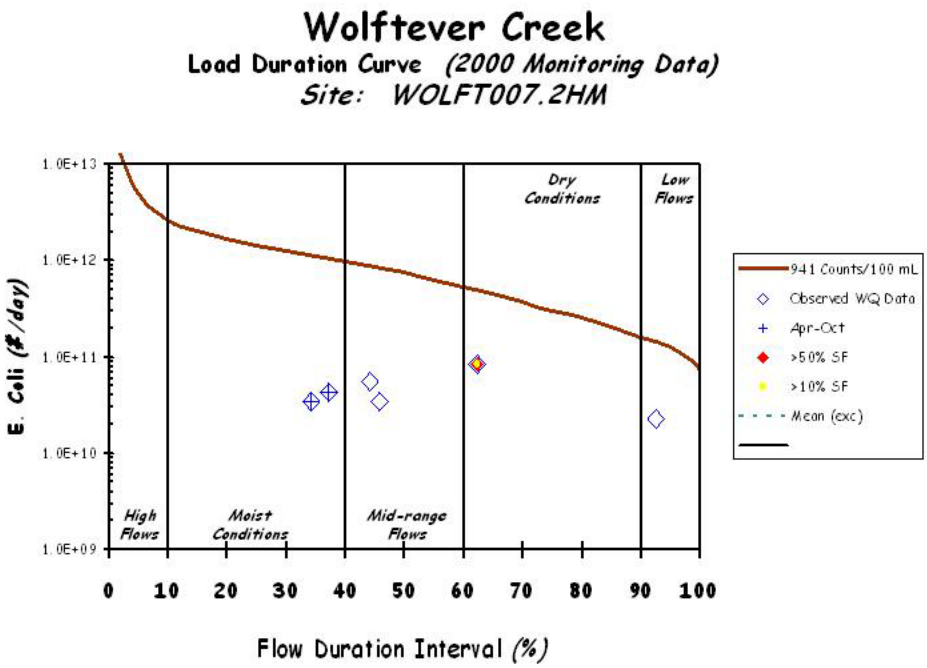

Figure E-17. E. Coli Load Duration Curve for Wolftever Creek – RM7.2

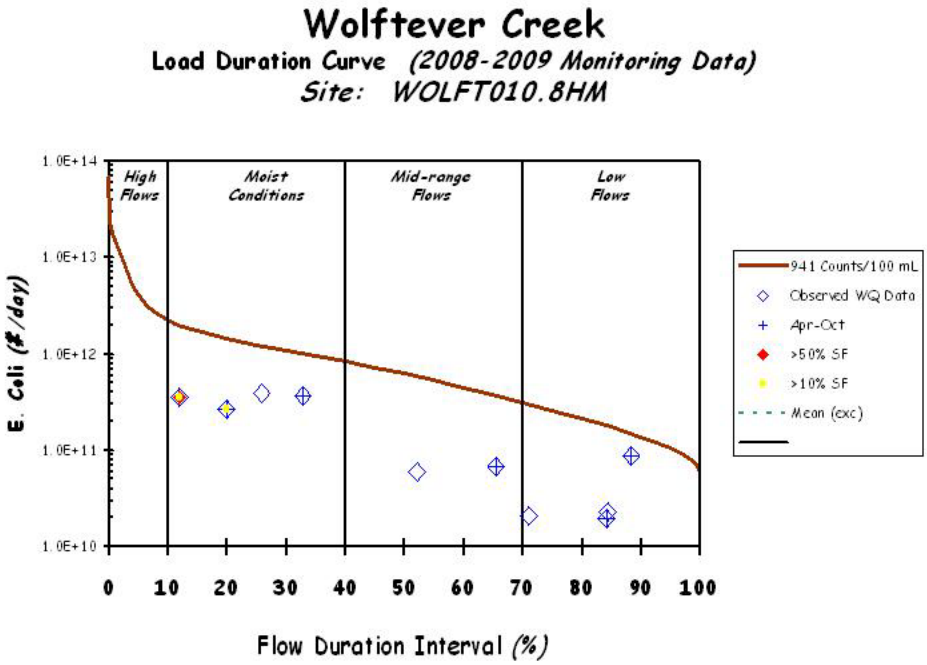

Figure E-18. E. Coli Load Duration Curve for Wolftever Creek – RM10.8

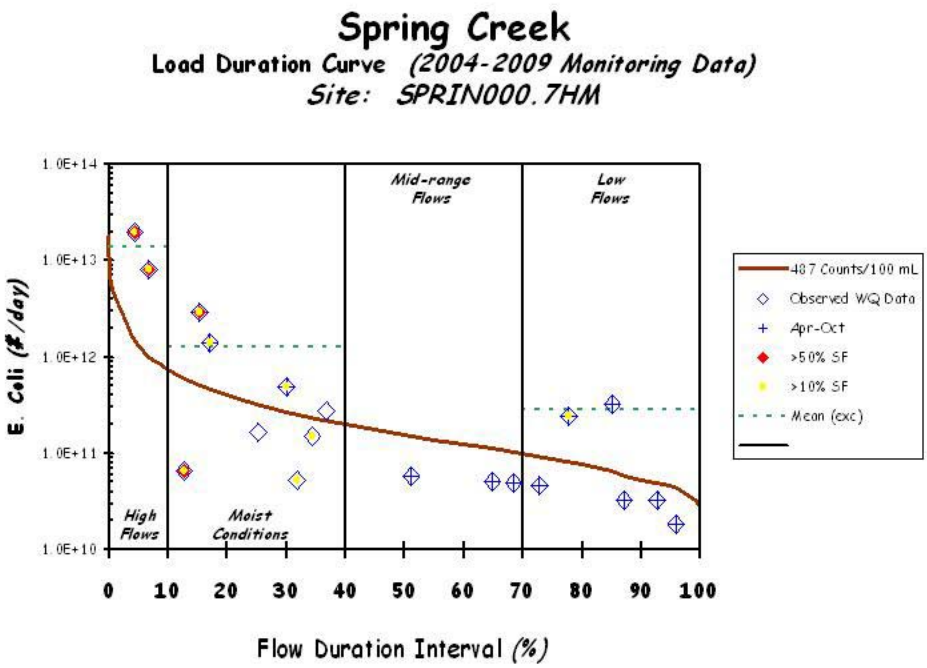

Figure E-19. E. Coli Load Duration Curve for Spring Creek – RM0.7

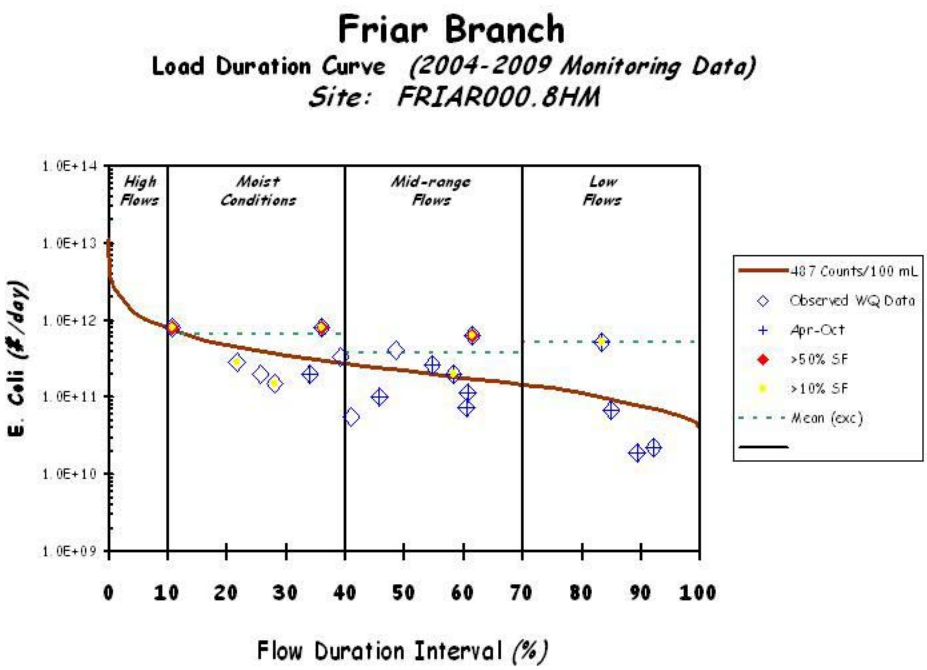

Figure E-20. E. Coli Load Duration Curve for Friar Branch – RM0.8

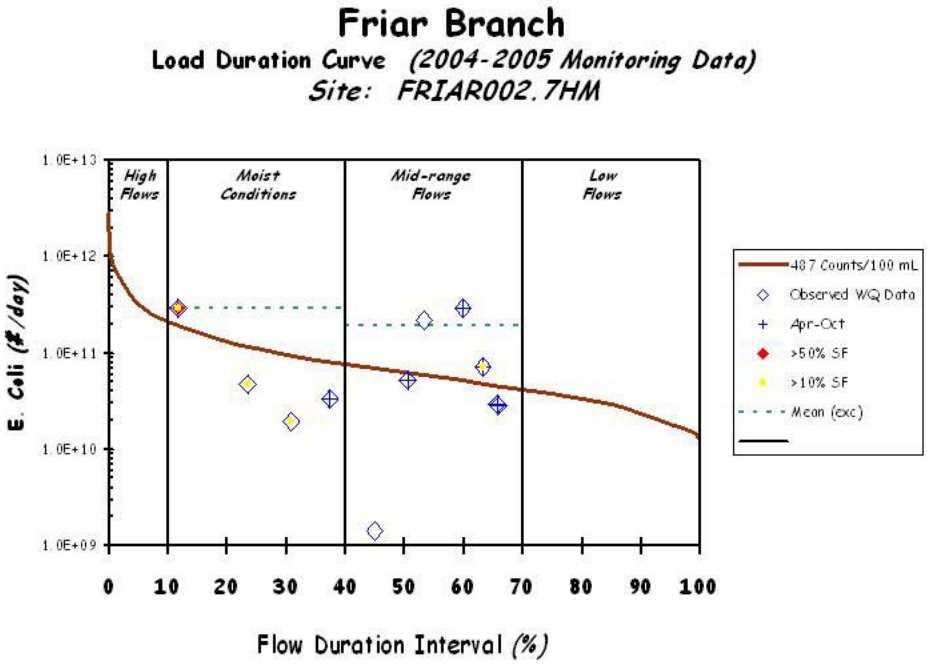

Figure E-21. E. Coli Load Duration Curve for Friar Branch – RM2.7

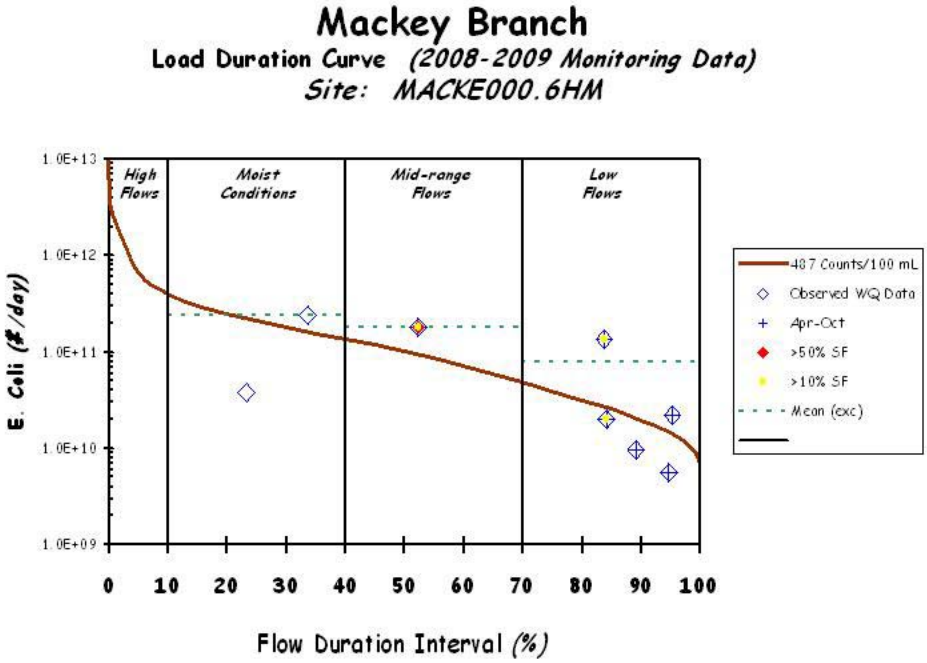

Figure E-22. E. Coli Load Duration Curve for Mackey Branch – RM0.6

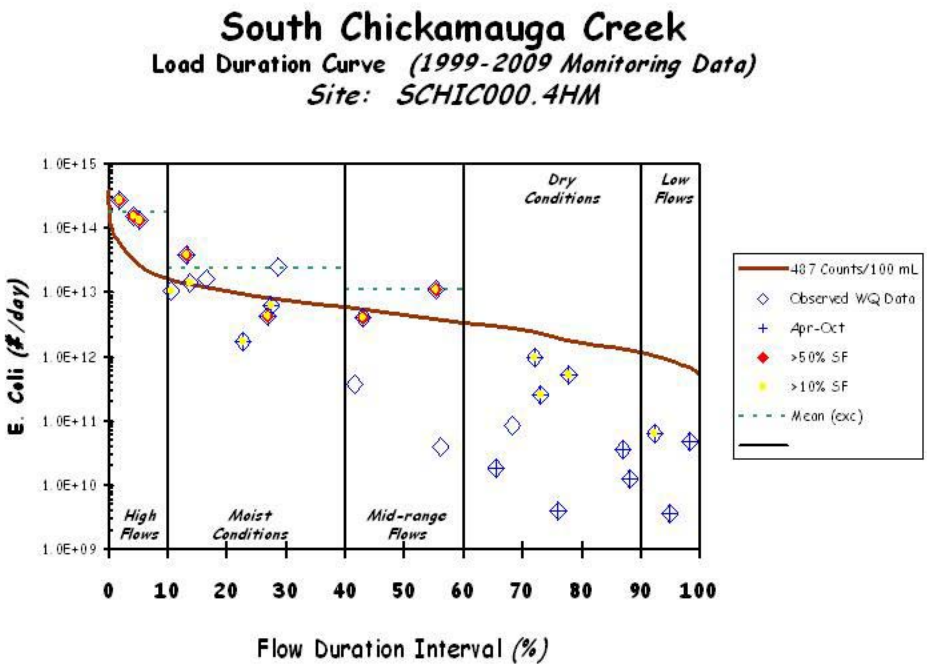

Figure E-23. E. Coli Load Duration Curve for South Chickamauga Creek – RM0.4

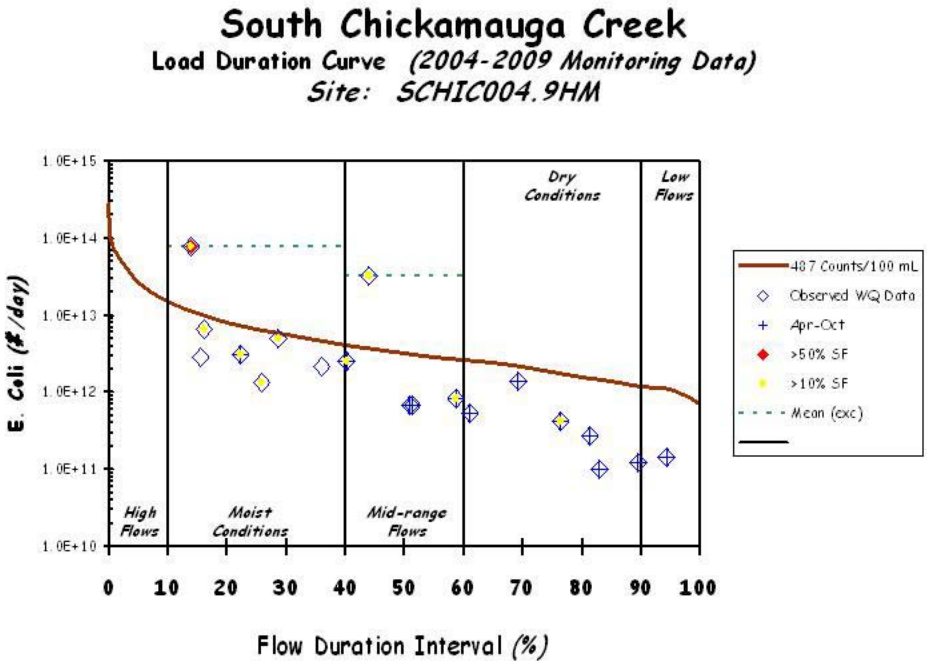

Figure E-24. E. Coli Load Duration Curve for South Chickamauga Creek – RM4.9

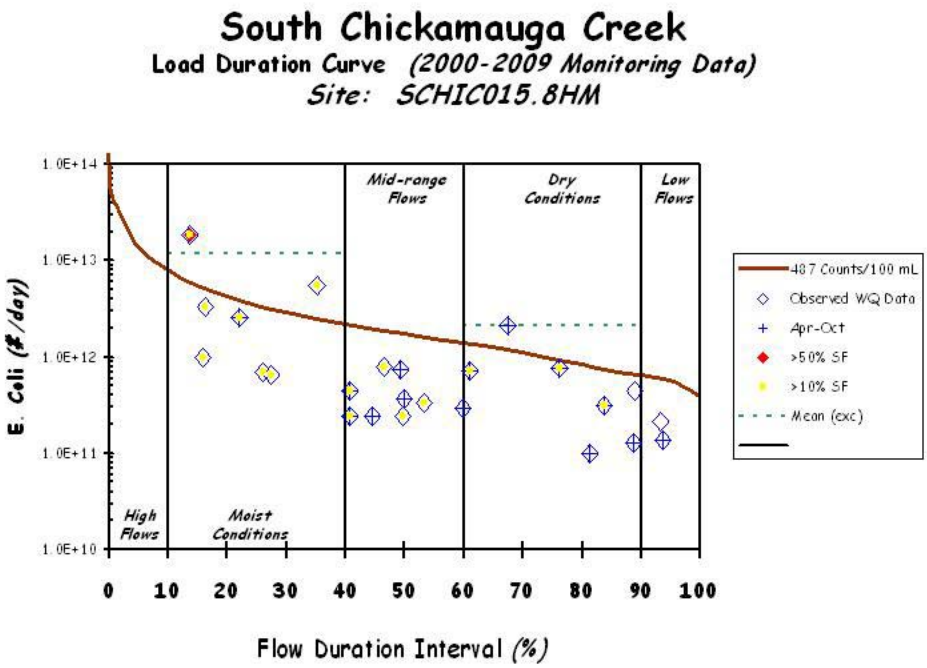

Figure E-25. E. Coli Load Duration Curve for South Chickamauga Creek – RM15.8

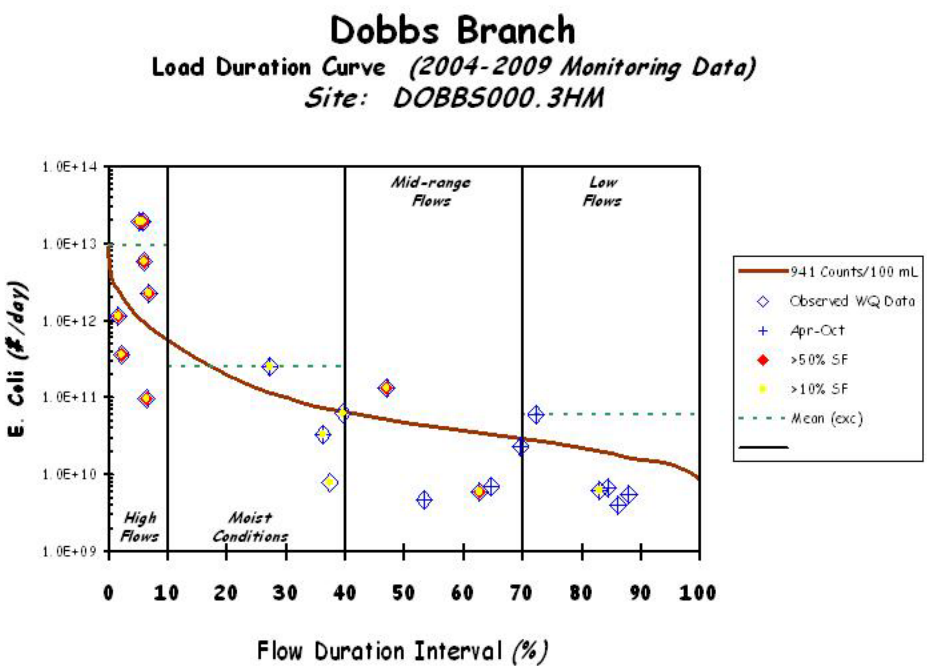

Figure E-26. E. Coli Load Duration Curve for Dobbs Branch – RM0.3

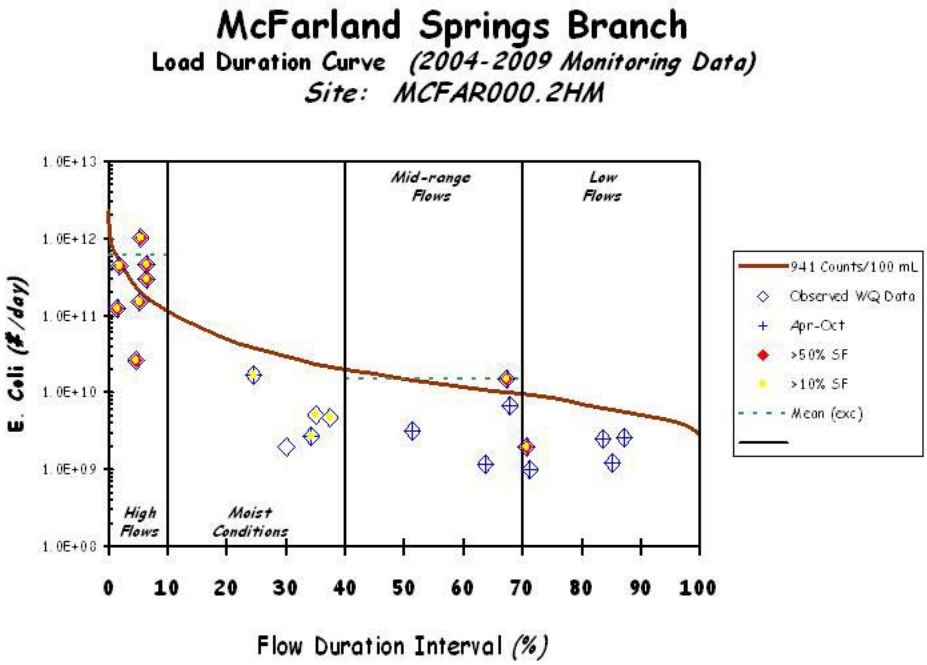

Figure E-27. E. Coli Load Duration Curve for McFarland Springs Branch – RM0.2

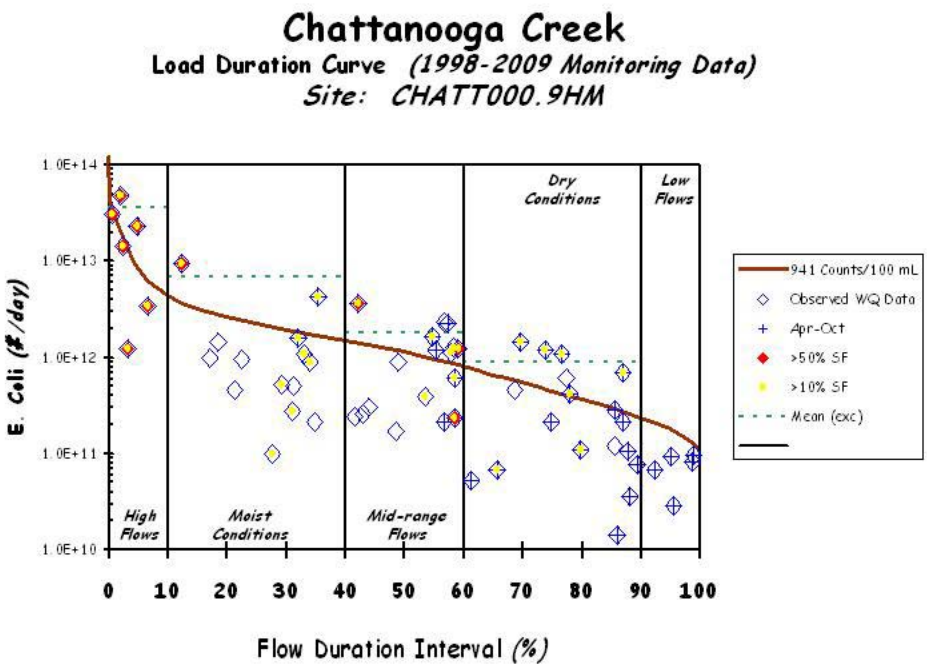

Figure E-28. E. Coli Load Duration Curve for Chattanooga Creek – RM0.9

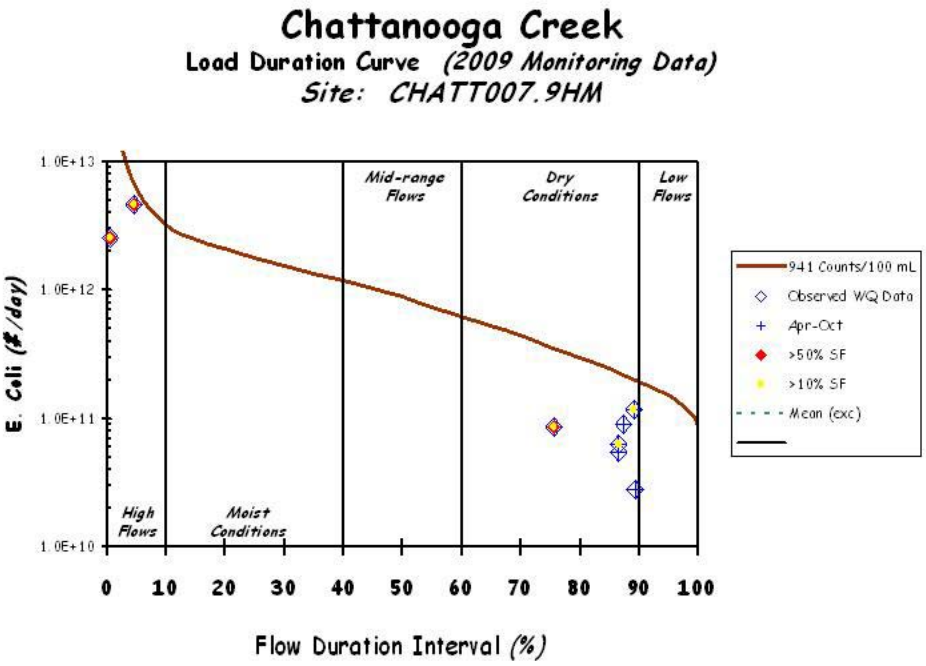

Figure E-29. E. Coli Load Duration Curve for Chattanooga Creek – RM7.9

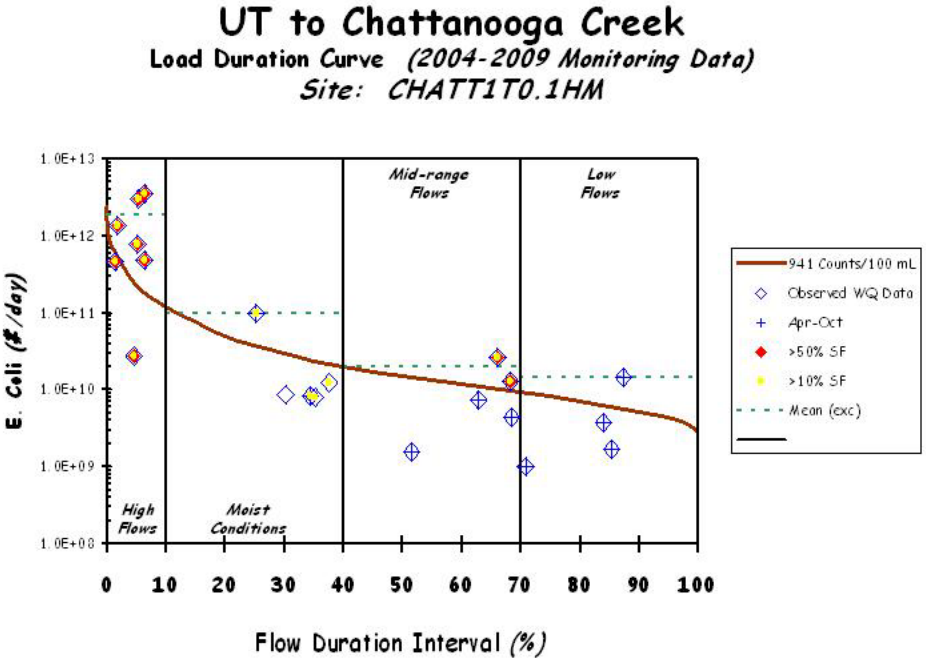

Figure E-30. E. Coli Load Duration Curve for UT to Chattanooga Creek – RM0.1

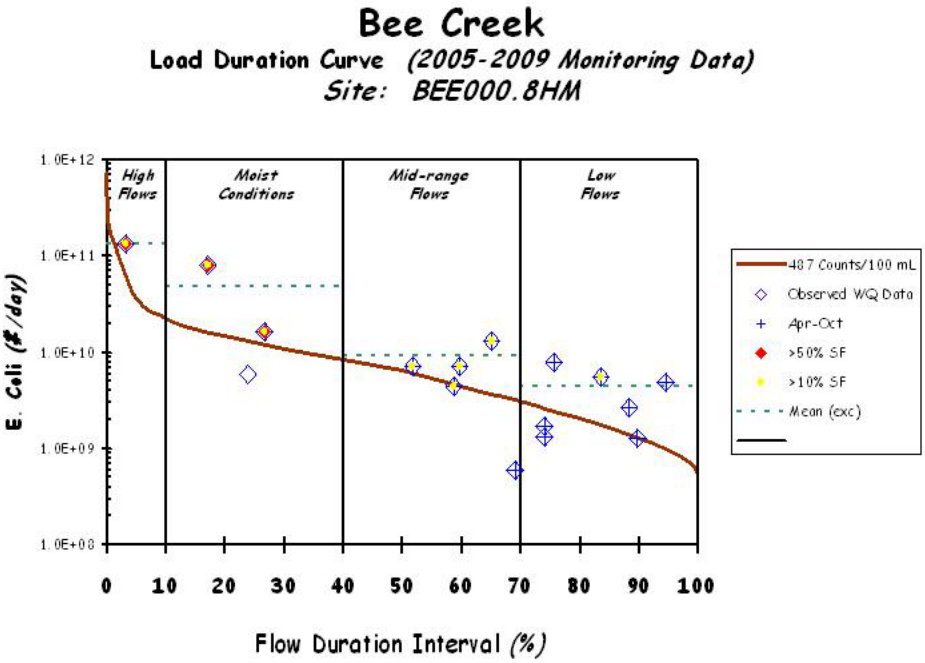

Figure E-31. E. Coli Load Duration Curve for Bee Branch – RM0.8

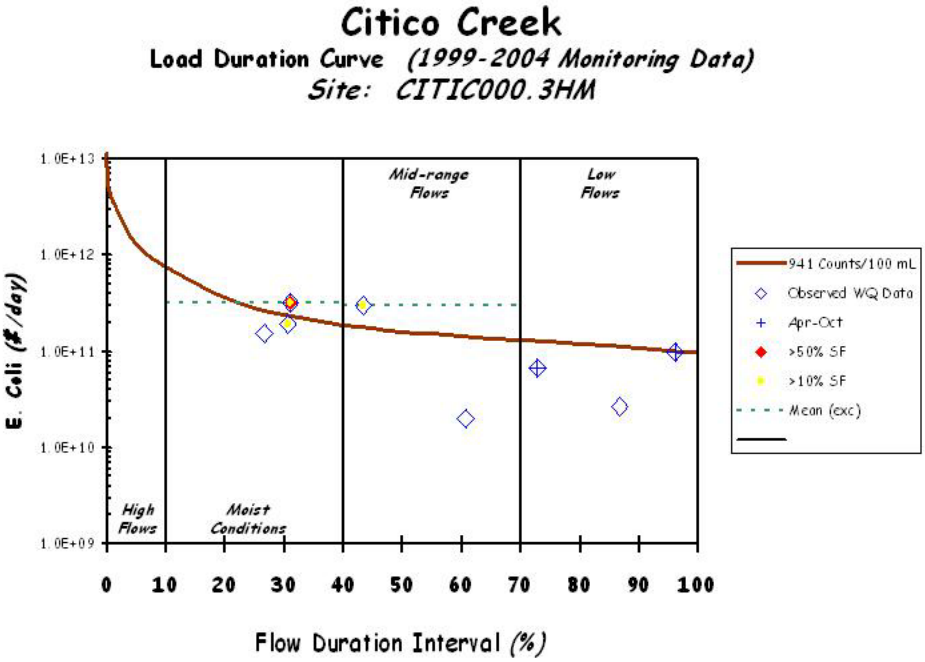

Figure E-32. E. Coli Load Duration Curve for Citico Creek – RM0.3

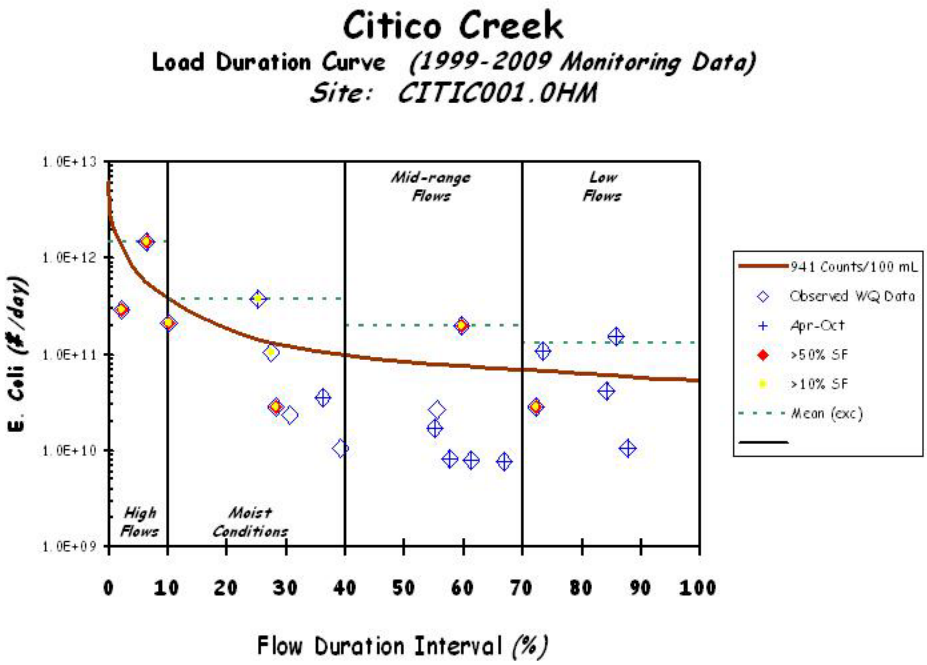

Figure E-33. E. Coli Load Duration Curve for Citico Creek – RM1.0

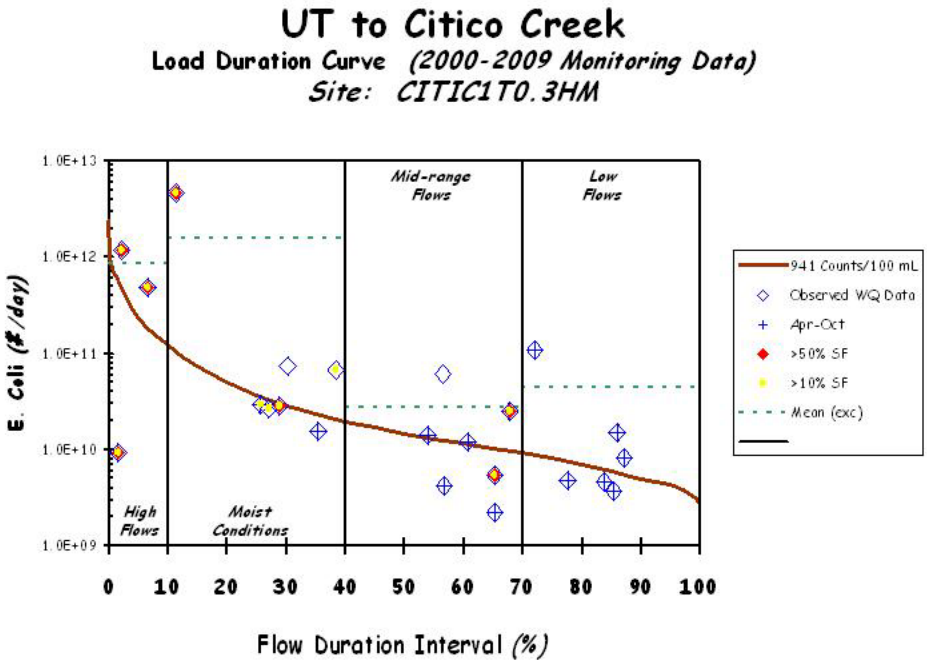

Figure E-34. E. Coli Load Duration Curve for UT to Citico Creek – RM0.3

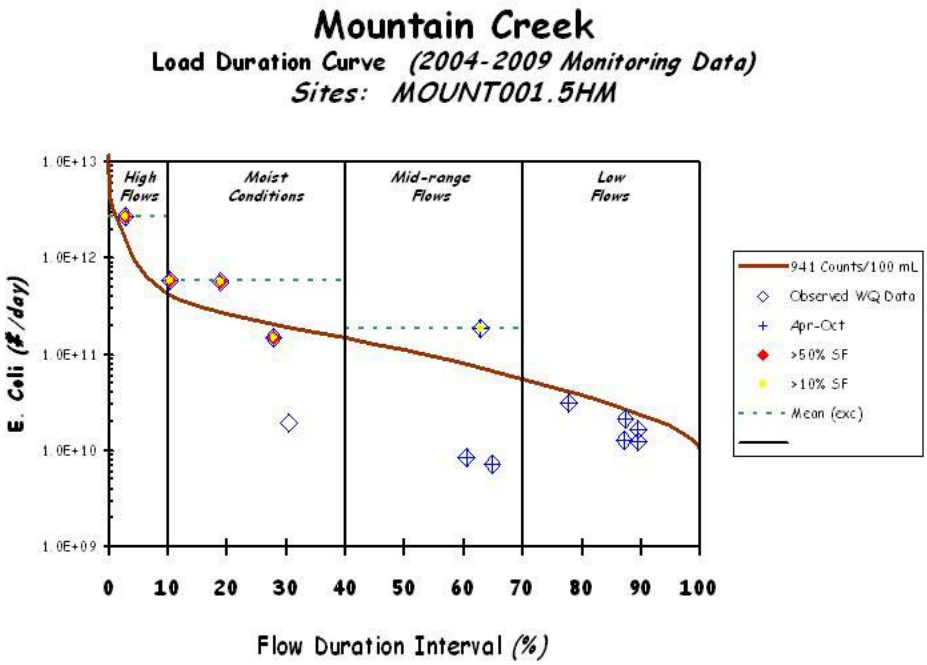

Figure E-35. E. Coli Load Duration Curve for Mountain Creek – RM1.5

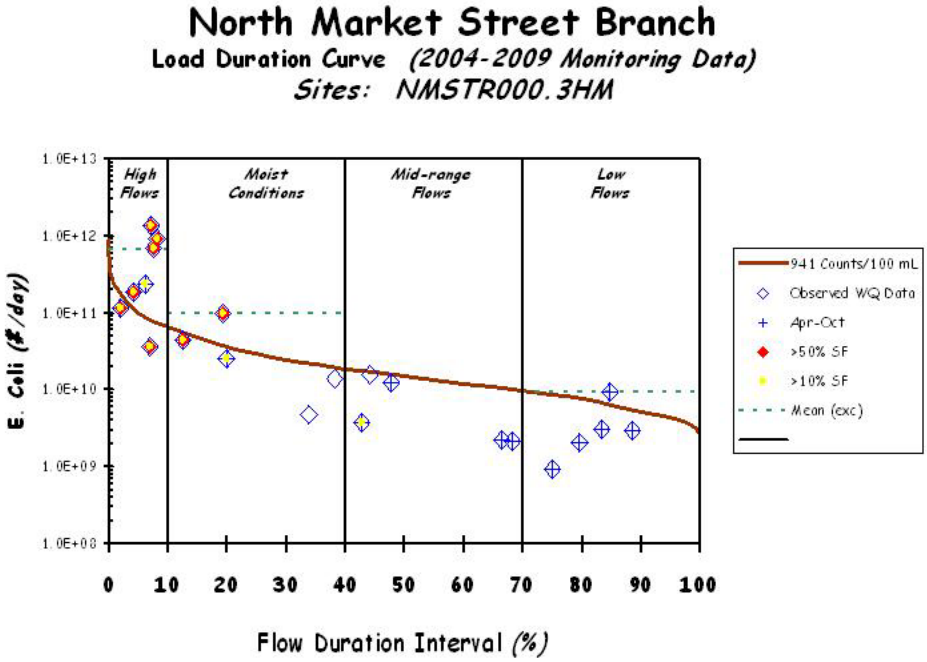

Figure E-36. E. Coli Load Duration Curve for North Market Street Branch – RM0.3

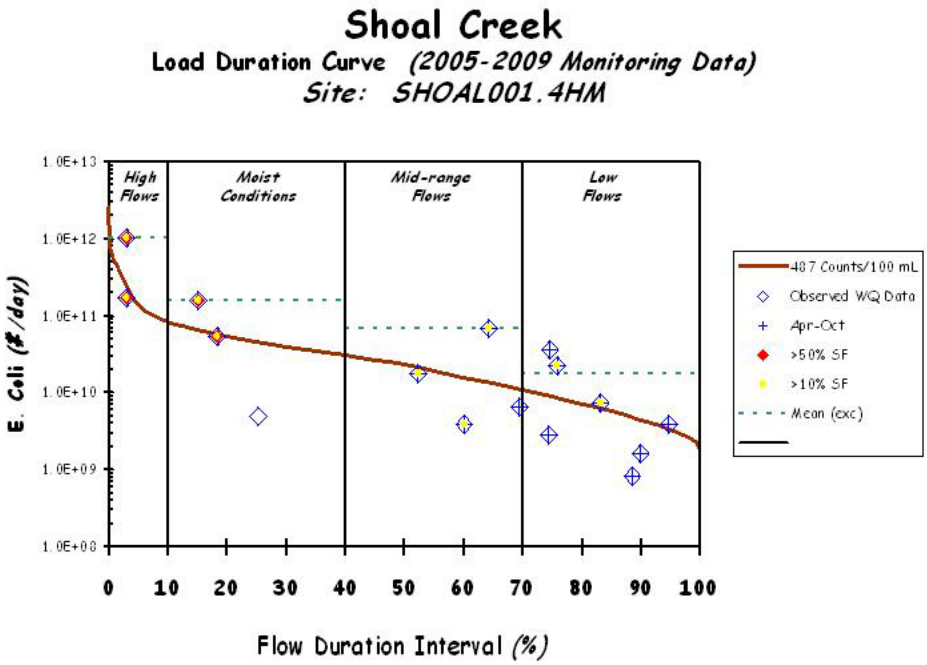

Figure E-37. E. Coli Load Duration Curve for Shoal Creek – RM1.4

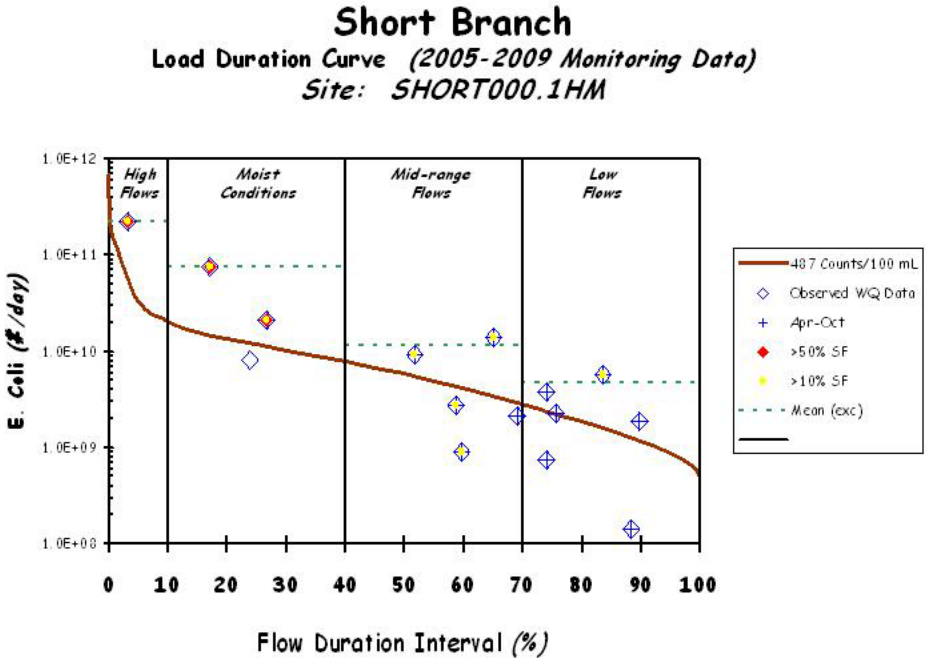

Figure E-38. E. Coli Load Duration Curve for Short Branch – RM0.1

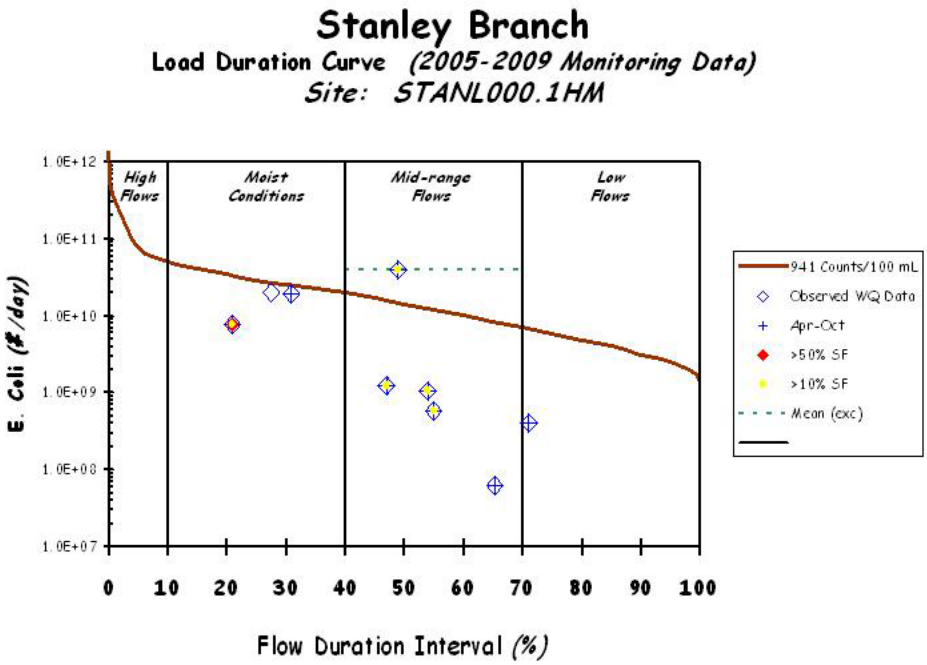

Figure E-39. E. Coli Load Duration Curve for Stanley Branch – RM0.1

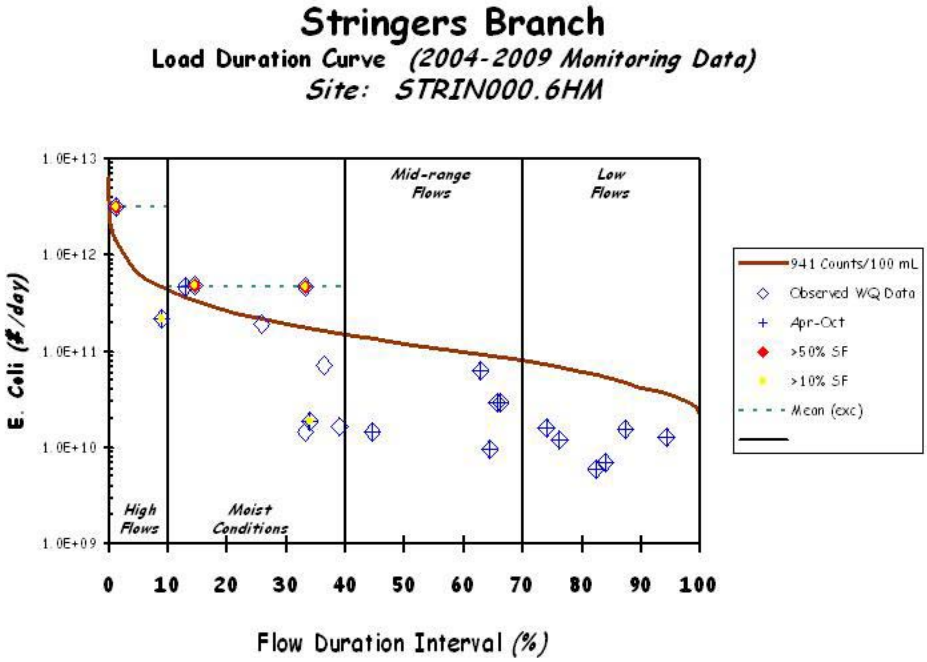

Figure E-40. E. Coli Load Duration Curve for Stringers Branch – RM0.6

Table E-3. Calculated Load Reduction Based on Daily Loading – Bivens Branch – RM0.6

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
1/7/09	High Flow Conditions	5.12	0.8%	2,419.6	3.03E+11	**61.1**		
3/30/09		1.30	9.5%	1,046.2	3.34E+10	**10.1**	**35.6**	**42.0**
4/21/09	Moist Conditions	1.06	17.3%	547.5	1.42E+10	NR		
5/12/09		0.96	22.8%	435.2	1.02E+10	NR		
12/20/03		0.86	28.4%	8,620	1.81E+11	**89.1**		
1/12/04		0.79	33.0%	1,210	2.32E+10	**22.2**		
8/9/09		0.70	40.0%	1,732.9	2.96E+10	**45.7**	**31.4**	**34.3**
6/3/09	Mid-Range Flows	0.69	40.5%	517.2	8.73E+09	NR		
10/7/03		0.58	51.1%	100	1.41E+09	NR		
8/27/03		0.55	55.1%	310	4.13E+09	NR	**NR**	**NR**
12/9/08	Low Flow Conditions	0.28	85.0%	2,419.6	1.66E+10	**61.1**		
11/5/08		0.21	93.4%	2,419.6	1.23E+10	**61.1**	**61.1**	**65.0**

Note: NR = No reduction required
NA = Not applicable

Table E-4. Calculated Load Reduction Based on Daily Loading – Bivens Branch – RM0.8

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
12/20/03	Moist Conditions	0.85	28.4%	10,540	2.20E+11	**91.1**		
1/12/04		0.78	33.6%	3,500	6.68E+10	**73.1**	**82.1**	**83.9**
10/7/03	Mid-Range Flows	0.58	52.5%	630	8.88E+09	NR		
8/27/03		0.54	57.0%	8,360	1.11E+11	**88.7**	**44.4**	**44.9**

Note: NR = No reduction required
NA = Not applicable

Table E-5. Calculated Load Reduction Based on Daily Loading – UT to Bivens Branch – BIVIN1T0.9MM

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
12/20/03	Moist Conditions	0.99	11.0%	500	1.21E+10	NR	**11.1**	**15.0**
1/12/04		0.62	33.9%	1,210	1.84E+10	**22.2**		
10/7/03	Mid-Range Flows	0.46	53.0%	100	1.12E+09	NR	**NR**	**NR**
8/27/03		0.45	54.5%	520	5.71E+09	NR		

Note: NR = No reduction required
NA = Not applicable

Table E-6. Calculated Load Reduction Based on Daily Loading – UT to Bivens Branch – BIVIN2T0.1MM

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
12/20/03	Moist Conditions	0.66	11.0%	141,360	2.27E+12	**99.3**	**95.3**	**95.8**
1/12/04		0.41	33.9%	10,810	1.10E+11	**91.3**		
10/7/03	Mid-Range Flows	0.31	53.0%	1,610	1.21E+10	**41.6**	**70.4**	**73.4**
8/27/03		0.30	54.5%	137,400	1.01E+12	**99.3**		

Note: NR = No reduction required
NA = Not applicable

Table E-7. Calculated Load Reduction Based on Daily Loading – Lewis Branch – RM0.3

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
12/10/08	High Flows	39.98	0.9%	24,196	2.37E+13	**96.1**		
1/12/09		7.28	6.6%	1,986.3	3.54E+11	**52.6**	**74.4**	**76.9**
1/6/04	Moist Conditions	4.90	12.7%	840	1.01E+11	NR		
2/2/09		4.84	13.0%	1,732.9	2.05E+11	**45.7**		
4/20/09		4.46	15.3%	2,419.6	2.64E+11	**61.1**		
3/16/04		4.36	15.9%	241,900	2.58E+13	**99.6**		
11/20/03		4.06	17.7%	1,080	1.07E+11	**12.9**		
2/11/04		3.72	20.3%	410	3.73E+10	NR		
5/11/09		3.27	24.3%	2,419.6	1.94E+11	**61.1**		
3/18/09		2.82	29.6%	2,419.6	1.67E+11	**61.1**	**42.7**	**45.9**
7/30/03	Mid-Range Flows	1.42	52.9%	1,090	3.79E+10	**13.7**		
10/7/03		1.30	55.1%	3,900	1.24E+11	**75.9**		
4/21/04		1.16	58.7%	3,360	9.54E+10	**72.0**		
6/8/09		1.15	59.1%	2,419.6	6.78E+10	**61.1**		
8/18/03		0.84	68.5%	740	1.52E+10	NR	**44.5**	**48.1**
11/19/08	Low Flows	0.69	73.6%	2,419.6	4.07E+10	**61.1**		
10/27/08		0.61	76.8%	1,203.3	1.80E+10	**21.8**		
10/13/08		0.58	78.6%	1,413.6	1.99E+10	**33.4**		
5/25/04		0.51	81.6%	740	9.29E+09	NR	**29.1**	**33.7**

Note: NR = No reduction required
NA = Not applicable

Table E-8. Calculated Load Reduction Based on Daily Loading – Long Savannah Creek – RM5.0

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
12/10/08	High Flows	351.10	0.9%	2,419.6	2.08E+13	**61.1**		
1/12/09		82.24	6.0%	461.1	9.28E+11	NR	**30.6**	**32.5**
4/20/09	Moist Conditions	55.35	12.0%	2,419.6	3.28E+12	**61.1**		
2/2/09		44.77	17.6%	285.1	3.12E+11	NR		
5/11/09		37.61	22.7%	648.8	5.97E+11	NR		
3/18/09		30.36	30.4%	1,299.7	9.65E+11	**27.6**		
5/1/00		28.37	33.1%	400	2.78E+11	NR		
5/2/00		26.41	36.1%	1,300	8.40E+11	**27.6**	**19.4**	**22.4**
2/23/00	Mid-Range Flows	21.49	43.1%	490	2.58E+11	NR		
6/3/09		16.02	51.7%	1,986.3	7.79E+11	**52.6**	**26.3**	**28.7**
11/19/08	Low Flows	7.19	74.1%	13.4	2.36E+09	NR		
10/27/08		6.44	77.3%	23.3	3.67E+09	NR		
10/13/08		6.07	78.8%	13.5	2.00E+09	NR		
11/7/00		4.15	88.0%	180	1.83E+10	NR		
11/6/00		3.41	91.9%	62	5.16E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-9. Calculated Load Reduction Based on Daily Loading – UT to Long Savannah Creek – RM0.4

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
12/10/08	High Flows	32.10	1.0%	17,329	1.36E+13	**94.6**		
1/12/09		7.14	6.1%	344.8	6.02E+10	NR	**47.3**	**47.6**
4/20/09	Moist Conditions	4.52	14.0%	980.4	1.08E+11	**4.0**		
2/2/09		4.27	15.5%	2,419.6	2.53E+11	**61.1**		
5/11/09		3.26	23.2%	135.4	1.08E+10	NR		
3/18/09		2.64	31.0%	307.6	1.98E+10	NR	**16.3**	**19.7**
6/8/09	Mid-Range Flows	1.11	59.3%	579.4	1.57E+10	NR	**NR**	**NR**
11/19/08	Low Flows	0.63	75.0%	2,419.6	3.71E+10	**61.1**		
10/27/08		0.56	78.2%	727	9.92E+09	NR		
10/13/08		0.52	79.6%	1,986.3	2.54E+10	**52.6**	**37.9**	**40.8**

Note: NR = No reduction required
NA = Not applicable

Table E-10. Calculated Load Reduction Based on Daily Loading – Wolfe Branch – RM0.4

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
12/10/08	High Flows	74.73	0.9%	2,419.6	4.42E+12	**61.1**		
1/12/09		16.86	6.0%	65	2.68E+10	NR	**30.6**	**32.5**
4/20/09	Moist Conditions	10.80	13.6%	461.1	1.22E+11	NR		
2/2/09		9.85	15.8%	224.7	5.42E+10	NR		
5/11/09		7.71	23.1%	114.5	2.16E+10	NR		
3/18/09		6.22	30.9%	85.7	1.30E+10	NR	**NR**	**NR**
6/8/09	Mid-Range Flows	2.61	59.2%	547.5	3.49E+10	NR	**NR**	**NR**
11/19/08	Low Flows	1.48	74.7%	18.5	6.70E+08	NR		
10/27/08		1.32	77.9%	32.7	1.05E+09	NR		
10/13/08		1.24	79.4%	36.9	1.11E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-11. Calculated Load Reduction Based on Daily Loading – Chestnut Creek – RM0.3

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
1/6/09	High Flows	289.70	0.1%	2419.6	1.71E+13	**61.1**	**61.1**	**65.0**
5/12/09	Moist Conditions	6.85	31.2%	416	6.97E+10	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-12. Calculated Load Reduction Based on Daily Loading – Little Wolftever Creek – RM0.5

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
3/25/09	Moist Conditions	22.00	13.2%	866.4	4.66E+11	NR	**NR**	**0.6**
4/6/09		17.46	19.1%	178.9	7.64E+10	NR		
1/26/09		14.48	24.8%	93.3	3.31E+10	NR		
5/13/09		11.94	31.9%	410.6	1.20E+11	NR		
2/24/09	Mid-Range Flows	7.15	50.7%	172.3	3.01E+10	NR	**NR**	**NR**
6/10/09		4.52	64.7%	166.4	1.84E+10	NR		
12/3/08	Low Flows	3.64	70.7%	50.4	4.49E+09	NR	**NR**	**NR**
10/22/08		2.18	83.9%	146.7	7.81E+09	NR		
11/3/08		2.17	83.9%	325.5	1.73E+10	NR		
10/6/08		1.80	88.3%	81.3	3.57E+09	NR		

Note: NR = No reduction required
NA = Not applicable

Table E-13. Calculated Load Reduction Based on Daily Loading – Rogers Branch – RM0.4 & RM0.5

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
3/25/09	Moist Conditions	10.79	14.7%	579.4	1.53E+11	NR		
12/28/09		10.21	16.3%	60.5	1.51E+10	NR		
4/6/09		8.68	21.6%	228.2	4.85E+10	NR		
9/16/09		7.97	24.3%	1,556.1	3.03E+11	**39.5**		
1/26/09		7.12	27.9%	28.2	4.91E+09	NR		
5/13/09		6.13	33.6%	686.7	1.03E+11	NR	**6.6**	**7.6**
2/24/09	Mid-Range Flows	3.51	53.8%	39.5	3.39E+09	NR		
6/10/09		2.28	66.3%	461.1	2.57E+10	NR	**NR**	**NR**
7/28/09	Low Flows	1.86	71.9%	648.8	2.96E+10	NR		
12/3/08		1.81	72.5%	58.3	2.59E+09	NR		
8/11/09		1.32	80.4%	54.6	1.76E+09	NR		
10/22/08		1.08	85.3%	35	9.24E+08	NR		
11/3/08		1.07	85.4%	58.3	1.53E+09	NR		
7/14/09		1.05	85.9%	260.3	6.71E+09	NR		
8/3/09		1.01	86.9%	60.2	1.49E+09	NR		
10/6/08		0.90	88.7%	31.3	6.92E+08	NR		
8/5/09		0.83	90.2%	579.4	1.18E+10	NR		
8/10/09		0.66	94.3%	49.6	8.02E+08	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-14. Calculated Load Reduction Based on Geomean Data – Rogers Branch – RM0.4 & RM0.5

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/14/09	1.05	85.9%	260.3			
7/28/09	1.86	71.9%	648.8			
8/3/09	1.01	86.9%	60.2			
8/5/09	0.83	90.2%	579.4			
8/10/09	0.66	94.3%	49.6	196.4	**35.8**	**42.5**
8/11/09	1.32	80.4%	54.6	143.7	**12.3**	**21.4**

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

Table E-15. Calculated Load Reduction Based on Daily Loading – Wilkerson Branch – RM0.3

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
3/25/09	Moist Conditions	8.75	11.1%	344.8	7.38E+10	NR		
4/6/09		5.86	20.9%	178.9	2.56E+10	NR		
1/26/09		4.89	26.2%	172.5	2.06E+10	NR		
5/13/09		3.99	33.5%	686.7	6.70E+10	NR	**NR**	**NR**
2/24/09	Mid-Range Flows	2.40	52.2%	104.6	6.15E+09	NR		
6/10/09		1.52	66.0%	290.9	1.08E+10	NR	**NR**	**NR**
12/3/08	Low Flows	1.23	71.3%	93.3	2.80E+09	NR		
10/22/08		0.74	84.4%	111.2	2.00E+09	NR		
11/3/08		0.74	84.5%	185	3.33E+09	NR		
10/6/08		0.61	88.6%	67	9.98E+08	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-16. Calculated Load Reduction Based on Daily Loading – Wolftever Creek – RM4.2

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
5/10/99	Moist Conditions	98.64	34.9%	13	3.14E+10	NR	**NR**	**NR**
4/20/99	Mid-Range Flows	59.55	54.0%	1	1.46E+09	NR	**NR**	**NR**
7/6/99	Dry Conditions	38.46	68.2%	1	9.41E+08	NR		
6/21/99		21.04	84.8%	1	5.15E+08	NR		
8/4/99		18.63	87.5%	1	4.56E+08	NR	**NR**	**NR**
9/20/99	Low Flows	7.04	99.5%	1	1.72E+08	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-17. Calculated Load Reduction Based on Daily Loading – Wolftever Creek – RM7.2

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
5/1/00	Moist Conditions	48.57	34.6%	29	3.45E+10	NR		
5/2/00		45.13	37.7%	39	4.31E+10	NR	**NR**	**NR**
2/22/00	Mid-Range Flows	37.71	44.9%	59	5.44E+10	NR		
2/23/00		36.17	46.6%	39	3.45E+10	NR	**NR**	**NR**
11/7/00	Dry Conditions	14.56	75.4%	160	5.70E+10	NR	**NR**	**NR**
11/6/00	Low Flows	5.66	95.4%	150	2.08E+10	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-18. Calculated Load Reduction Based on Daily Loading – Wolftever Creek – RM10.8

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
3/25/09	Moist Conditions	86.84	11.9%	167	3.55E+11	NR	**NR**	**NR**
4/6/09		62.81	20.0%	172.2	2.65E+11	NR		
1/26/09		52.10	25.8%	307.6	3.92E+11	NR		
5/13/09		42.94	32.9%	344.8	3.62E+11	NR		
2/24/09	Mid-Range Flows	25.73	52.1%	93.4	5.88E+10	NR	**NR**	**NR**
6/10/09		16.25	65.6%	172.5	6.86E+10	NR		
12/3/08	Low Flows	13.10	71.2%	64.5	2.07E+10	NR	**NR**	**NR**
10/22/08		7.81	84.3%	101.9	1.95E+10	NR		
11/3/08		7.81	84.4%	119.1	2.28E+10	NR		
10/6/08		6.45	88.5%	547.5	8.63E+10	NR		

Note: NR = No reduction required
NA = Not applicable

Table E-19. Calculated Load Reduction Based on Daily Loading – Spring Creek – RM0.7

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
3/28/05	High Flows	137.74	4.1%	5,830.0	1.96E+13	**91.6**		
2/14/05		89.33	6.5%	3,640.0	7.96E+12	**86.6**	**89.1**	**90.2**
3/7/05	Moist Conditions	51.26	12.4%	53.0	6.65E+10	NR		
10/12/04		44.13	15.0%	2,720.0	2.94E+12	**82.1**		
7/7/09		40.16	16.9%	1,413.6	1.39E+12	**56.5**		
11/16/09		27.41	25.2%	248.1	1.66E+11	NR		
5/2/05		23.01	29.5%	860.0	4.84E+11	**43.4**		
1/18/05		21.56	31.3%	100.0	5.28E+10	NR		
11/8/04		19.99	33.8%	310.0	1.52E+11	NR		
12/1/09		18.48	36.9%	613.1	2.77E+11	**20.6**	**26.4**	**25.2**
4/18/05	Mid-Range Flows	12.80	50.5%	184.0	5.76E+10	NR		
8/16/04		9.40	64.4%	219.0	5.04E+10	NR		
5/23/05		8.73	68.1%	228.0	4.87E+10	NR	**NR**	**NR**
9/13/04	Low Flows	7.91	72.4%	238.0	4.61E+10	NR		
7/13/09		6.95	77.5%	1,413.6	2.40E+11	**65.5**		
7/16/09		5.42	85.0%	2,419.6	3.21E+11	**79.9**		
7/21/09		5.05	87.0%	261.3	3.23E+10	NR		
7/27/09		4.09	92.7%	325.5	3.25E+10	NR		
8/10/09		3.68	96.1%	201.4	1.82E+10	NR	**24.2**	**25.2**

Note: NR = No reduction required
NA = Not applicable

Table E-20. Calculated Load Reduction Based on Geomean Data – Spring Creek – RM0.7

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/7/09	40.16	16.9%	1,413.6			
7/13/09	6.95	77.5%	1,413.6			
7/16/09	5.42	85.0%	2,419.6			
7/21/09	5.05	87.0%	261.3			
7/27/09	4.09	92.7%	325.5	837.2	**84.9**	**86.5**
8/10/09	3.68	96.1%	201.4	567.0	**77.8**	**80.1**

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

Table E-21. Calculated Load Reduction Based on Daily Loading – Friar Branch – RM0.8

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
2/28/05	Moist Conditions	64.27	10.5%	520	8.18E+11	**6.3**		
1/10/05		38.43	21.2%	310	2.91E+11	NR		
11/16/09		33.81	25.6%	238.2	1.97E+11	NR		
3/14/05		31.27	27.5%	200	1.53E+11	NR		
4/11/05		26.70	33.4%	310	2.02E+11	NR		
7/13/09		25.51	35.4%	1,299.7	8.11E+11	**62.5**		
12/1/09		23.73	39.3%	579.4	3.36E+11	**15.9**	**12.1**	**15.2**
1/31/05	Mid-Range Flows	22.82	40.2%	100	5.58E+10	NR		
9/27/04		20.57	45.1%	200	1.01E+11	NR		
11/1/04		19.38	47.8%	850	4.03E+11	**42.7**		
4/25/05		17.02	54.0%	630	2.62E+11	**22.7**		
8/30/04		15.76	57.6%	520	2.01E+11	**6.3**		
10/4/04		15.04	59.9%	200	7.36E+10	NR		
5/9/05		14.99	60.1%	310	1.14E+11	NR		
7/16/09		14.77	60.9%	1,732.9	6.26E+11	**71.9**	**18.0**	**21.2**
8/3/09	Low Flows	8.69	83.4%	2,419.6	5.14E+11	**79.9**		
7/21/09		8.12	84.8%	344.8	6.85E+10	NR		
7/27/09		6.74	89.3%	115.3	1.90E+10	NR		
8/10/09		5.95	92.3%	156.5	2.28E+10	NR	**20.0**	**20.5**

Note: NR = No reduction required
NA = Not applicable

Table E-22. Calculated Load Reduction Based on Geomean Data – Friar Branch – RM0.8

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/13/09	25.51	36.1%	1299.7			
7/16/09	14.77	61.6%	1732.9			
7/21/09	8.12	85.0%	344.8			
7/27/09	6.74	89.5%	115.3			
8/3/09	8.69	83.4%	2419.6	736.5	**82.9**	**84.7**
8/10/09	5.95	92.3%	156.5	482.3	**73.9**	**76.6**

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

Table E-23. Calculated Load Reduction Based on Daily Loading – Friar Branch – RM2.7

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
2/28/05	Moist Conditions	16.26	11.7%	740	2.94E+11	**34.2**		
1/10/05		9.72	23.6%	200	4.76E+10	NR		
3/14/05		7.91	30.8%	100	1.94E+10	NR		
4/11/05		6.76	37.5%	200	3.31E+10	NR	**8.5**	**10.2**
1/31/05	Mid-Range Flows	5.77	45.1%	10	1.41E+09	NR		
9/27/04		5.20	50.5%	410	5.22E+10	NR		
11/1/04		4.90	53.4%	1,830	2.20E+11	**73.4**	**24.5**	**25.4**
4/25/05	Low Flows	4.31	60.0%	2,750	2.90E+11	**82.3**		
8/30/04		3.99	63.4%	740	7.22E+10	**34.2**		
10/4/04		3.81	65.7%	310	2.89E+10	NR		
5/9/05		3.79	66.0%	310	2.88E+10	NR	**29.1**	**31.2**

Note: NR = No reduction required
NA = Not applicable

Table E-24. Calculated Load Reduction Based on Daily Loading – Mackey Branch – RM0.6

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/16/09	Moist Conditions	18.69	23.3%	83.9	3.84E+10	NR		
12/1/09		13.54	33.7%	727	2.41E+11	**33.0**	**16.5**	**19.9**
7/13/09	Mid-Range Flows	8.01	52.4%	920.8	1.80E+11	**47.1**	**47.1**	**52.4**
7/16/09	Low Flows	2.30	83.8%	2419.6	1.36E+11	**79.9**		
8/3/09		2.25	84.2%	365.4	2.02E+10	NR		
7/21/09		1.75	89.3%	224.7	9.59E+09	NR		
8/10/09		1.22	94.8%	185	5.53E+09	NR		
7/27/09		1.19	95.4%	770.1	2.23E+10	**36.8**	**23.3**	**25.0**

Note: NR = No reduction required
NA = Not applicable

Table E-25. Calculated Load Reduction Based on Geomean Data – Mackey Branch – RM0.6

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction to Target GM (126 CFU/100 ml)	Calculated Reduction to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/13/09	8.01	52.4%	920.8			
7/16/09	2.30	83.8%	2,419.6			
7/21/09	1.75	89.3%	224.7			
7/27/09	1.19	95.4%	770.1			
8/3/09	2.25	84.2%	365.4	675.7	**81.4**	**83.3**
8/10/09	1.22	94.8%	185	490.2	**74.3**	**76.9**

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

Table E-26. Calculated Load Reduction Based on Daily Loading – South Chickamauga Creek – RM0.4

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
1/10/00	High Flows	4749.00	1.7%	2,400	2.79E+14	**79.7**		
11/27/07		2658.00	4.1%	2,419.2	1.57E+14	**79.9**		
12/1/04		2605.00	4.2%	2,400	1.53E+14	**79.7**		
2/23/05		2307.00	5.1%	2,400	1.35E+14	**79.7**	**79.7**	**81.8**
12/30/08	Moist Conditions	1334.00	10.5%	325.5	1.06E+13	NR		
4/7/99		1157.00	13.1%	1,400	3.96E+13	**65.2**		
1/25/06		1105.00	13.7%	517.2	1.40E+13	**5.8**		
3/18/08		996.20	16.6%	686.7	1.67E+13	**29.1**		
4/17/01		790.20	22.7%	88	1.70E+12	NR		
5/11/05		684.00	26.9%	260	4.35E+12	NR		
4/22/09		674.10	27.4%	387.3	6.39E+12	NR		
1/12/99		652.30	28.7%	1,600	2.55E+13	**69.6**	**21.2**	**24.1**
11/14/06	Mid-Range Flows	480.50	41.7%	32.7	3.84E+11	NR		
10/11/99		462.60	43.0%	370	4.19E+12	NR		
11/16/05		323.40	55.3%	1,400	1.11E+13	**65.2**		
1/16/01		317.90	56.1%	5	3.89E+10	NR	**16.3**	**17.2**
7/27/05	Dry Conditions	256.40	65.6%	3	1.88E+10	NR		
3/14/07		239.70	68.3%	14.5	8.50E+10	NR		
6/15/09		196.50	72.2%	201.4	9.68E+11	NR		
5/28/08		187.30	73.2%	55.6	2.55E+11	NR		
7/19/99		164.70	76.1%	1	4.03E+09	NR		
7/25/06		153.70	77.9%	140.8	5.29E+11	NR		
8/14/07		108.30	87.1%	13.5	3.58E+10	NR		
10/9/00		104.00	88.3%	5	1.27E+10	NR	**NR**	**NR**

Table E-26 (cont'd). Calculated Load Reduction Based on Daily Loading – South Chickamauga Creek – RM0.4

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
5/29/07	Low Flows	87.36	92.4%	29.8	6.37E+10	NR		
7/19/00		74.72	95.1%	2	3.66E+09	NR		
8/26/09		58.81	98.5%	33.6	4.83E+10	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-27. Calculated Load Reduction Based on Daily Loading – South Chickamauga Creek – RM4.9

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
1/10/05	Moist Conditions	993.49	13.3%	3,200	7.78E+13	**84.8**		
2/28/05		862.47	15.4%	310	6.54E+12	NR		
11/16/09		893.72	15.6%	129.6	2.83E+12	NR		
4/11/05		640.51	21.5%	200	3.13E+12	NR		
3/14/05		545.01	25.1%	100	1.33E+12	NR		
1/31/05		500.20	27.8%	410	5.02E+12	NR		
12/1/09		397.31	36.0%	224.7	2.18E+12	NR		
9/27/04		350.62	39.3%	300	2.57E+12	NR	**10.6**	**10.8**
11/1/04	Mid-Range Flows	323.38	43.0%	4,040	3.20E+13	**87.9**		
5/9/05		276.56	49.9%	100	6.77E+11	NR		
4/25/05		273.53	50.2%	100	6.69E+11	NR		
7/13/09		232.48	57.8%	145	8.25E+11	NR	**22.0**	**22.3**
10/4/04	Dry Conditions	220.51	60.4%	100	5.39E+11	NR		
8/30/04		186.29	68.7%	310	1.41E+12	NR		
7/16/09		152.46	76.0%	114.5	4.27E+11	NR		
8/3/09		130.75	81.5%	86.2	2.76E+11	NR		
7/21/09		125.20	82.6%	32.8	1.00E+11	NR		
7/27/09		102.70	89.4%	49.5	1.24E+11	NR	**NR**	**NR**

Table E-27. Calculated Load Reduction Based on Daily Loading – South Chickamauga Creek – RM4.9

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
8/10/09	Low Flows	92.79	94.4%	62.7	1.42E+11	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-28. Calculated Load Reduction Based on Geomean Data – South Chickamauga Creek – RM4.9

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/13/09	232.48	57.8%	145			
7/16/09	152.46	76.0%	114.5			
7/21/09	125.20	82.6%	32.8			
7/27/09	102.70	89.4%	49.5			
8/3/09	130.75	81.5%	86.2	74.7	**NR**	**NR**
8/10/09	92.79	94.4%	62.7	63.2	**NR**	**NR**

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

Table E-29 Calculated Load Reduction Based on Daily Loading – South Chickamauga Creek – RM15.8

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
1/10/05	Moist Conditions	518.58	13.2%	1,450	1.84E+13	**66.4**		
2/28/05		440.10	15.7%	310	3.34E+12	NR		
11/16/09		453.93	15.9%	88.2	9.80E+11	NR		
4/11/05		334.68	21.4%	310	2.54E+12	NR		
12/7/09		319.98	23.1%	1	7.83E+09	NR		
3/14/05		281.48	25.3%	100	6.89E+11	NR		
1/31/05		267.96	26.6%	100	6.56E+11	NR		
12/1/09		211.56	35.2%	1,046.2	5.42E+12	**53.5**		
5/1/00		180.78	39.9%	55	2.43E+11	NR		
9/27/04		180.71	39.9%	100	4.42E+11	NR	**12.0**	**12.8**
5/2/00	Mid-Range Flows	168.17	43.5%	59	2.43E+11	NR		
11/1/04		159.65	45.5%	200	7.81E+11	NR		
4/25/05		149.18	48.4%	200	7.30E+11	NR		
2/22/00		148.03	48.7%	68	2.46E+11	NR		
5/9/05		147.36	48.9%	100	3.61E+11	NR		
2/23/00		136.28	52.3%	100	3.33E+11	NR		
10/4/04		119.58	59.0%	100	2.93E+11	NR	**NR**	**NR**
7/13/09	Dry Conditions	116.32	60.4%	248.9	7.08E+11	NR		
8/30/04		100.94	66.8%	850	2.10E+12	**42.7**		
7/16/09		79.50	75.8%	387.3	7.53E+11	NR		
7/21/09		68.24	81.1%	59.1	9.87E+10	NR		
8/3/09		63.50	83.8%	201.4	3.13E+11	NR		
7/27/09		55.67	88.6%	93.3	1.27E+11	NR		
11/7/00		55.56	88.7%	330	4.49E+11	NR	**7.1**	**8.1**

Table E-29 Calculated Load Reduction Based on Daily Loading – South Chickamauga Creek – RM15.8

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/6/00	Low Flows	50.99	93.3%	170	2.12E+11			
8/10/09		50.20	93.9%	112.6	1.38E+11	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-30. Calculated Load Reduction Based on Geomean Data – South Chickamauga Creek – RM15.8

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/13/09	232.48	57.8%	145			
7/16/09	152.46	76.0%	114.5			
7/21/09	125.20	82.6%	32.8			
7/27/09	102.70	89.4%	49.5			
8/3/09	130.75	81.5%	86.2	74.7	**NR**	**NR**
8/10/09	92.79	94.4%	62.7	63.2	**NR**	**NR**

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

Table E-31. Calculated Load Reduction Based on Daily Loading – UT to South Chickamauga Creek – RM1.0

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
7/13/09	Moist Conditions	2.29	21.4%	2,419.6	1.36E+11	**79.9**		
11/16/09		1.68	28.6%	488.4	2.01E+10	**0.3**		
12/1/09		1.23	37.5%	770.1	2.32E+10	**36.8**	**39.0**	**45.1**
7/16/09	Low Flows	0.31	74.5%	2,419.6	1.85E+10	**79.9**	**79.9**	**81.8**

Note: NR = No reduction required
NA = Not applicable

Table E-32. Calculated Load Reduction Based on Daily Loading – Dobbs Branch – RM0.3

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
6/6/05	High Flows	115.19	1.4%	410	1.16E+12	NR		
12/8/09		92.47	2.2%	160.7	3.64E+11	NR		
2/14/05		49.42	4.9%	16,070	1.94E+13	**94.1**		
10/12/04		44.54	5.7%	17,850	1.95E+13	**94.7**		
3/28/05		43.58	5.8%	5,570	5.94E+12	**83.1**		
3/7/05		40.68	6.3%	100	9.95E+10	NR		
10/12/09		38.08	6.7%	2,419.6	2.25E+12	**61.1**	**47.6**	**48.6**
7/7/09	Moist Conditions	5.13	26.8%	1,986.3	2.49E+11	**52.6**		
5/2/05		3.33	35.7%	410	3.34E+10	NR		
1/18/05		3.19	36.9%	100	7.81E+09	NR		
11/8/04		2.95	39.2%	860	6.21E+10	NR	**13.2**	**14.4**
8/12/09	Mid-Range Flows	2.30	47.0%	2,419.6	1.36E+11	**61.1**		
4/18/05		1.93	52.7%	100	4.73E+09	NR		
7/28/09		1.52	62.1%	160.7	5.99E+09	NR		
8/16/04		1.46	64.1%	200	7.15E+09	NR		
5/23/05		1.31	69.2%	740	2.37E+10	NR	**12.2**	**13.0**
9/13/04	Low Flows	1.23	71.8%	1,990	6.00E+10	**52.7**		
8/3/09		0.89	83.0%	290.9	6.30E+09	NR		
7/15/09		0.84	84.3%	325.5	6.70E+09	NR		
7/20/09		0.79	86.0%	209.8	4.08E+09	NR		
7/22/09		0.74	87.8%	307.6	5.54E+09	NR	**10.5**	**11.5**

Note: NR = No reduction required
NA = Not applicable

Table E-33. Calculated Load Reduction Based on Geomean Data – Dobbs Branch – RM0.3

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/7/09	5.13	26.8%	1,986.3			
7/15/09	0.84	84.3%	325.5			
7/20/09	0.79	86.0%	209.8			
7/22/09	0.74	87.8%	307.6			
7/28/09	1.52	62.1%	160.7	367.5	**65.7**	**69.3**
8/3/09	0.89	83.0%	290.9	250.3	**49.7**	**54.8**
8/12/09	2.30	47.0%	2,419.6	373.8	**66.3**	**69.8**

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

Table E-34. Calculated Load Reduction Based on Daily Loading – McFarland Springs Branch – RM0.2

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
6/6/05	High Flows	25.49	1.3%	200	1.25E+11	NR		
12/8/09		22.37	1.8%	816.4	4.47E+11	NR		
3/7/05		10.67	4.5%	100	2.61E+10	NR		
3/28/05		9.72	5.0%	630	1.50E+11	NR		
2/14/05		9.30	5.2%	4,570	1.04E+12	**79.4**		
10/12/04		7.88	6.3%	1,580	3.05E+11	**40.4**		
10/12/09		8.00	6.3%	2,419.6	4.74E+11	**61.1**	**25.9**	**27.6**
7/7/09	Moist Conditions	1.72	24.1%	410.6	1.73E+10	NR		
11/16/09		1.32	30.0%	62.2	2.01E+09	NR		
5/2/05		1.10	33.7%	100	2.69E+09	NR		
1/18/05		1.06	34.5%	200	5.20E+09	NR		
11/8/04		0.97	37.0%	200	4.76E+09	NR	**NR**	**NR**
4/18/05	Mid-Range Flows	0.65	50.7%	200	3.19E+09	NR		
8/16/04		0.48	63.2%	100	1.18E+09	NR		
8/12/09		0.45	67.4%	1,416.6	1.54E+10	**33.6**		
5/23/05		0.44	67.5%	630	6.79E+09	NR	**8.4**	**10.1**
7/28/09	Low Flows	0.42	70.2%	191.8	1.95E+09	NR		
9/13/04		0.41	70.8%	100	9.98E+08	NR		
7/15/09		0.28	83.5%	365.4	2.51E+09	NR		
7/20/09		0.27	85.1%	186	1.21E+09	NR		
7/22/09		0.25	87.1%	435.2	2.63E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-35. Calculated Load Reduction Based on Geomean Data – McFarland Springs Branch – RM0.2

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/7/09	1.72	24.1%	410.6			
7/15/09	0.28	83.5%	365.4			
7/20/09	0.27	85.1%	186			
7/22/09	0.25	87.1%	435.2			
7/28/09	0.42	70.2%	191.8	297.5	**57.6**	**62.0**
8/12/09	0.45	67.4%	1,416.6	381.1	**66.9**	**70.3**

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

Table E-36. Calculated Load Reduction Based on Daily Loading – Chattanooga Creek – RM0.9

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
12/8/09	High Flows	1642.00	0.5%	770.1	3.09E+13	NR		
1/10/00		817.60	1.9%	2,400	4.80E+13	**60.8**		
1/17/06		710.20	2.4%	816.4	1.42E+13	NR		
2/9/99		542.90	3.2%	93	1.24E+12	NR		
10/12/09		387.40	4.8%	2,419.6	2.29E+13	**61.1**		
3/9/99		284.50	6.5%	490	3.41E+12	NR		
3/9/99		284.50	6.5%	210	1.46E+12	NR	**17.4**	**18.6**
6/17/03	Moist Conditions	161.50	12.3%	2,400	9.48E+12	**60.8**		
11/29/04		128.80	17.1%	310	9.77E+11	NR		
12/17/02		122.10	18.5%	490	1.46E+12	NR		
11/16/09		110.20	21.3%	172.3	4.65E+11	NR		
3/14/01		105.90	22.6%	370	9.59E+11	NR		

Table E-36 (cont'd). Calculated Load Reduction Based on Daily Loading – Chattanooga Creek – RM0.9

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
1/28/09	Moist Conditions	89.54	27.7%	45.2	9.90E+10	NR		
3/9/04		85.64	29.2%	250	5.24E+11	NR		
3/26/03		80.90	31.1%	140	2.77E+11	NR		
1/12/99		80.46	31.3%	260	5.12E+11	NR		
4/17/01		79.01	32.1%	820	1.59E+12	NR		
2/15/00		76.66	33.0%	580	1.09E+12	NR		
12/4/00		75.12	34.0%	490	9.01E+11	NR		
2/6/01		73.22	34.9%	120	2.15E+11	NR		
4/7/99		72.34	35.5%	2,400	4.25E+12	**60.8**	**8.7**	**9.3**
3/25/02	Mid-Range Flows	61.87	41.70%	160	2.42E+11	NR		
9/8/03		61.11	42.20%	2,400	3.59E+12	**60.8**		
12/2/03		59.54	43.10%	180	2.62E+11	NR		
3/15/00		58.00	44.10%	210	2.98E+11	NR		
12/5/06		51.19	48.70%	135.4	1.70E+11	NR		
11/14/00		50.49	49.10%	730	9.02E+11	NR		
2/27/07		43.72	53.50%	365.4	3.91E+11	NR		
7/7/04		41.94	54.70%	1,600	1.64E+12	**41.2**		
7/20/05		41.07	55.30%	1,200	1.21E+12	**21.6**		
5/15/00		39.28	56.70%	220	2.11E+11	NR		
1/16/01		39.35	56.70%	2,400	2.31E+12	**60.8**		
5/24/99		38.42	57.40%	2,400	2.26E+12	**60.8**		
12/15/98		37.80	57.90%	1,203	1.11E+12	**21.8**		
12/14/99		36.95	58.40%	1,400	1.27E+12	**32.8**		
5/22/06		36.76	58.50%	686.4	6.17E+11	NR		
7/28/09		36.77	58.50%	261.3	2.35E+11	NR		
9/5/00		35.86	59.20%	1,400	1.23E+12	**32.8**	**19.6**	**22.4**

Table E-36 (cont'd). Calculated Load Reduction Based on Daily Loading – Chattanooga Creek – RM0.9

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
9/11/01	Dry Conditions	33.00	61.40%	65	5.25E+10	NR		
4/24/07		28.08	65.80%	98.5	6.77E+10	NR		
11/8/99		25.43	68.80%	730	4.54E+11	NR		
7/15/99		24.45	69.80%	2,400	1.44E+12	**60.8**		
6/19/00		20.45	73.90%	2,400	1.20E+12	**60.8**		
6/8/99		19.58	74.90%	450	2.16E+11	NR		
7/7/09		18.17	76.70%	2,419.6	1.08E+12	**61.1**		
11/17/98		17.64	77.50%	1,414	6.10E+11	**33.5**		
10/11/99		17.26	78.00%	1,000	4.22E+11	**5.9**		
7/28/99		16.12	79.90%	280	1.10E+11	NR		
10/31/05		12.65	85.60%	920	2.85E+11	NR		
11/12/08		12.60	85.70%	387.3	1.19E+11	NR		
10/9/00		12.54	86.00%	47	1.44E+10	NR		
7/15/09		11.85	87.00%	727	2.11E+11	NR		
7/20/09		11.82	87.10%	2,419.6	7.00E+11	**61.1**		
8/16/00		11.33	87.90%	380	1.05E+11	NR		
8/2/06		11.10	88.30%	133.3	3.62E+10	NR		
7/22/09		10.32	89.50%	307.6	7.77E+10	NR	**15.7**	**17.5**
8/31/09	Low Flows	8.87	92.5%	307.6	6.68E+10	NR		
7/19/00		7.75	95.3%	490	9.29E+10	NR		
8/17/09		7.65	95.7%	154.1	2.88E+10	NR		
9/4/02		5.73	98.8%	580	8.12E+10	NR		
9/14/99		5.69	99.0%	690	9.60E+10	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-37. Calculated Load Reduction Based on Geomean Data – Chattanooga Creek – RM0.9

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction to Target GM (126 CFU/100 ml)	Calculated Reduction to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/7/09	18.17	76.7%	2,419.6			
7/15/09	11.85	87.0%	727			
7/20/09	11.82	87.1%	2,419.6			
7/22/09	10.32	89.5%	307.6			
7/28/09	36.77	58.5%	261.3	806.9	**84.4**	**86.0**

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

Table E-38. Calculated Load Reduction Based on Daily Loading – Chattanooga Creek – RM7.9

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
12/8/09	Moist Conditions	1274.00	0.5%	81.3	2.53E+12	NR	**NR**	**NR**
10/12/09		293.10	4.6%	648.8	4.65E+12	NR		
7/28/09	Low Flows	15.41	75.6%	228.2	8.60E+10	NR	**NR**	**NR**
7/15/09		9.96	86.7%	224.7	5.48E+10	NR		
7/20/09		9.94	86.7%	261.3	6.35E+10	NR		
8/3/09		9.59	87.4%	387.3	9.09E+10	NR		
8/12/09		8.75	89.2%	547.5	1.17E+11	NR		
7/22/09		8.67	89.4%	131.4	2.79E+10	NR		

Note: NR = No reduction required
NA = Not applicable

Table E-39. Calculated Load Reduction Based on Geomean Data – Chattanooga Creek – RM7.9

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/15/09	9.96	86.7%	224.7			
7/20/09	9.94	86.7%	261.3			
7/22/09	8.67	89.4%	131.4			
7/28/09	15.41	75.6%	228.2			
8/3/09	9.59	87.4%	387.3	232.7	**45.8**	**51.4**
8/12/09	8.75	89.2%	547.5	278.0	**54.7**	**59.4**

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

Table E-40. Calculated Load Reduction Based on Daily Loading – UT to Chattanooga Creek – RM0.1

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
6/6/05	High Flows	26.43	1.3%	730	4.72E+11	NR		
12/8/09		23.41	1.8%	2,419.6	1.39E+12	**61.1**		
3/7/05		11.44	4.4%	100	2.80E+10	NR		
3/28/05		9.92	5.1%	3,270	7.94E+11	**71.2**		
2/14/05		9.69	5.2%	12,910	3.06E+12	**92.7**		
10/12/04		8.38	6.1%	17,260	3.54E+12	**94.5**		
10/12/09		8.25	6.4%	2,419.6	4.89E+11	**61.1**	**54.4**	**56.1**
7/7/09	Moist Conditions	1.63	24.9%	2,419.6	9.68E+10	**61.1**		
11/16/09		1.30	30.3%	272.3	8.65E+09	NR		
5/2/05		1.08	33.9%	310	8.19E+09	NR		
1/18/05		1.05	34.7%	310	7.93E+09	NR		
11/8/04		0.96	37.1%	520	1.22E+10	NR	**12.2**	**13.0**
4/18/05	Mid-Range Flows	0.64	50.8%	100	1.56E+09	NR		
8/16/04		0.49	62.3%	630	7.48E+09	NR		
8/12/09		0.45	66.1%	2,419.6	2.69E+10	**61.1**		
7/28/09		0.43	67.8%	1,203.3	1.28E+10	**21.8**		
5/23/05		0.43	68.0%	410	4.33E+09	NR	**16.6**	**19.0**
9/13/04	Low Flows	0.41	70.4%	100	1.00E+09	NR		
7/15/09		0.28	83.7%	547.5	3.71E+09	NR		
7/20/09		0.26	85.3%	261.3	1.68E+09	NR		
7/22/09		0.24	87.2%	2,419.6	1.44E+10	**61.1**	**15.3**	**16.3**

Note: NR = No reduction required
NA = Not applicable

Table E-41. Calculated Load Reduction Based on Geomean Data – UT to Chattanooga Creek – RM0.1

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/7/09	1.63	24.9%	2,419.6			
7/15/09	0.28	83.7%	547.5			
7/20/09	0.26	85.3%	261.3			
7/22/09	0.24	87.2%	2,419.6			
7/28/09	0.43	67.8%	1,203.3	1,001.6	**87.4**	**88.7**
8/12/09	0.45	66.1%	2,419.6	1,001.6	**87.4**	**88.7**

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

Table E-42. Calculated Load Reduction Based on Daily Loading – Bee Branch – RM0.8

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
10/5/09	High Flows	4.18	3.2%	1,299.7	1.33E+11	**62.5**	**62.5**	**66.3**
11/30/09	Moist Conditions	1.38	17.2%	2,419.6	8.18E+10	**79.9**		
11/3/09		1.11	24.0%	214.3	5.84E+09	NR		
9/15/09		1.02	26.7%	648.8	1.62E+10	**24.9**	**34.9**	**38.1**
6/7/05	Mid-Range Flows	0.51	51.7%	579	7.25E+09	**15.9**		
6/8/05		0.40	58.8%	461	4.46E+09	NR		
5/12/05		0.38	59.7%	770	7.18E+09	**36.8**		
7/6/09		0.31	65.2%	1,732.9	1.32E+10	**71.9**		
5/16/05		0.27	69.1%	90	5.99E+08	NR	**24.9**	**28.4**
5/24/05	Low Flows	0.22	74.2%	328	1.73E+09	NR		
9/28/05		0.22	74.2%	248	1.31E+09	NR		
7/8/09		0.21	75.6%	1,553.1	7.79E+09	**68.6**		
7/16/09		0.15	83.7%	1,553.1	5.55E+09	**68.6**		
7/21/09		0.12	88.4%	920.8	2.64E+09	**47.1**		
8/5/09		0.11	89.9%	488.4	1.28E+09	**0.3**		
7/27/09		0.08	94.6%	2,419.6	4.91E+09	**79.9**	**37.8**	**41.2**

Note: NR = No reduction required
NA = Not applicable

Table E-43. Calculated Load Reduction Based on Geomean Data – Bee Branch – RM0.8

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction to Target GM (126 CFU/100 ml)	Calculated Reduction to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/6/09	0.31	65.2%	1,732.9			
7/8/09	0.21	75.6%	1,553.1			
7/16/09	0.15	83.7%	1,553.1			
7/21/09	0.12	88.4%	920.8			
7/27/09	0.08	94.6%	2,419.6	1,562.5	**91.9**	**92.8**
8/5/09	0.11	89.9%	488.4	1,212.9	**89.6**	**90.7**

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

Table E-44. Calculated Load Reduction Based on Daily Loading – Citico Creek – RM0.3

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
11/29/04	Moist Conditions	11.50	26.7%	550	1.55E+11	NR		
2/15/00		10.20	30.6%	770	1.92E+11	NR		
8/24/04		10.05	31.1%	1,300	3.20E+11	**27.6**	**9.2**	**11.6**
11/14/00	Mid-Range Flows	7.68	43.5%	1,600	3.01E+11	**41.2**		
2/6/01		6.18	60.7%	130	1.97E+10	NR	**20.6**	**23.5**
5/15/00	Low Flows	5.54	73.0%	490	6.64E+10	NR		
11/8/99		4.90	86.9%	220	2.64E+10	NR		
8/16/00		4.46	96.2%	920	1.00E+11	NR	**NR**	**2.0**

Note: NR = No reduction required
NA = Not applicable

Table E-45. Calculated Load Reduction Based on Daily Loading – Citico Creek – RM1.0

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
12/8/09	High Flows	57.19	2.2%	209.8	2.94E+11	NR		
10/12/09		24.95	6.4%	2,419.6	1.48E+12	**61.1**	**30.6**	**32.5**
2/28/05	Moist Conditions	16.59	10.1%	520	2.11E+11	NR		
7/7/09		6.41	24.9%	2,419.6	3.80E+11	**61.1**		
1/10/05		5.88	27.0%	740	1.06E+11	NR		
3/14/05		5.73	27.8%	200	2.80E+10	NR		
11/16/09		5.34	30.6%	178.9	2.34E+10	NR		
4/11/05		4.63	35.8%	310	3.51E+10	NR		
1/31/05		4.36	38.7%	100	1.07E+10	NR	**8.7**	**9.3**
9/27/04	Mid-Range Flows	3.48	54.4%	200	1.70E+10	NR		
11/1/04		3.47	54.9%	310	2.63E+10	NR		
4/25/05		3.39	57.0%	100	8.29E+09	NR		
8/12/09		3.31	59.8%	2,419.6	1.96E+11	**61.1**		
5/9/05		3.26	60.7%	100	7.98E+09	NR		
10/4/04		3.12	66.3%	100	7.62E+09	NR	**10.2**	**10.8**
7/28/09	Low Flows	2.98	71.9%	387.3	2.82E+10	NR		
8/30/04		2.95	73.1%	1,480	1.07E+11	**36.4**		
7/15/09		2.66	84.0%	648.8	4.22E+10	NR		
7/20/09		2.62	85.6%	2,419.6	1.55E+11	**61.1**		
7/22/09		2.57	87.7%	167	1.05E+10	NR	**19.5**	**21.6**

Note: NR = No reduction required
NA = Not applicable

Table E-46. Calculated Load Reduction Based on Geomean Data – Citico Creek – RM1.0

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/7/09	6.41	24.9%	2,419.6			
7/15/09	2.66	84.0%	648.8			
7/20/09	2.62	85.6%	2,419.6			
7/22/09	2.57	87.7%	167			
7/28/09	2.98	71.9%	387.3	755.2	**83.3**	**85.0**
8/12/09	3.31	59.8%	2,419.6	755.2	**83.3**	**85.0**

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

Table E-47. Calculated Load Reduction Based on Daily Loading – UT to Citico Creek – RM0.3

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
12/8/09	High Flows	24.53	1.6%	15.5	9.30E+09	NR		
1/23/02		20.52	2.1%	2,400	1.20E+12	**60.8**		
10/12/09		8.24	6.5%	2,419.6	4.88E+11	**61.1**	**40.6**	**43.2**
2/28/05	Moist Conditions	4.62	11.3%	41,060	4.64E+12	**97.7**		
7/7/09		1.57	25.2%	770.1	2.96E+10	NR		
1/10/05		1.46	26.6%	740	2.65E+10	NR		
3/14/05		1.34	28.5%	860	2.82E+10	NR		
11/16/09		1.26	30.3%	2,419.6	7.48E+10	**61.1**		
4/11/05		1.00	35.0%	630	1.55E+10	NR		
1/31/05		0.91	37.9%	2,990	6.63E+10	**68.5**	**32.5**	**33.7**
9/27/04	Mid-Range Flows	0.59	53.3%	970	1.39E+10	**3.0**		
11/1/04		0.55	55.9%	4,500	6.06E+10	**79.1**		
4/25/05		0.55	56.0%	310	4.16E+09	NR		
5/9/05		0.50	60.0%	980	1.20E+10	**4.0**		
10/4/04		0.45	64.7%	200	2.20E+09	NR		
7/28/09		0.45	64.7%	488.4	5.38E+09	NR		
8/12/09		0.43	68.0%	2,419.6	2.52E+10	**61.1**	**21.0**	**22.8**
8/30/04	Low Flows	0.39	71.7%	11,450	1.09E+11	**91.8**		
9/18/01		0.33	77.3%	580	4.74E+09	NR		
7/15/09		0.27	83.7%	686.7	4.55E+09	NR		
7/20/09		0.26	85.2%	579.4	3.65E+09	NR		
6/14/00		0.25	85.7%	2,400	1.48E+10	**60.8**		
7/22/09		0.24	87.1%	1,413.6	8.25E+09	**33.4**	**31.0**	**32.9**

Note: NR = No reduction required
NA = Not applicable

Table E-48. Calculated Load Reduction Based on Geomean Data – UT to Citico Creek – RM0.3

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/7/09	1.57	25.2%	2,419.6			
7/15/09	0.27	83.7%	648.8			
7/20/09	0.26	85.2%	2,419.6			
7/22/09	0.24	87.1%	167			
7/28/09	0.45	64.7%	387.3	755.2	**83.3**	**85.0**
8/12/09	0.43	68.0%	2,419.6	755.2	**83.3**	**85.0**

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

Table E-49. Calculated Load Reduction Based on Daily Loading – Mountain Creek – RM1.5

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
10/7/09	High Flows	64.97	2.7%	1,732.9	2.75E+12	**45.7**	**45.7**	**51.1**
10/12/04	Moist Conditions	17.96	10.3%	1,320	5.80E+11	**28.7**		
11/17/09		11.85	19.0%	1,986.3	5.76E+11	**52.6**		
9/9/09		8.83	27.8%	686.7	1.48E+11	NR		
12/7/09		8.15	30.4%	95.9	1.91E+10	NR	**20.3**	**23.3**
8/16/04	Mid-Range Flows	3.41	60.5%	100	8.35E+09	NR		
7/6/09		3.13	63.0%	2,419.6	1.85E+11	**61.1**		
9/13/04		2.91	64.9%	100	7.11E+09	NR	**20.4**	**21.7**
7/8/09	Low Flows	1.75	77.9%	727	3.12E+10	NR		
7/15/09		1.21	87.2%	435.2	1.29E+10	NR		
7/20/09		1.20	87.4%	727	2.13E+10	NR		
7/22/09		1.05	89.6%	488.4	1.25E+10	NR		
8/4/09		1.05	89.7%	648.8	1.66E+10	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-50. Calculated Load Reduction Based on Geomean Data – Mountain Creek – RM1.5

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction to Target GM (126 CFU/100 ml)	Calculated Reduction to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/6/09	3.13	63.0%	2,419.6			
7/8/09	1.75	77.9%	727			
7/15/09	1.21	87.2%	435.2			
7/20/09	1.20	87.4%	727			
7/22/09	1.05	89.6%	488.4	770.6	**83.7**	**85.3**
8/4/09	1.05	89.7%	648.8	592.3	**78.7**	**80.9**

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

Table E-51. Calculated Load Reduction Based on Daily Loading – North Market Street Branch – RM0.3

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
6/6/05	High Flows	7.52	1.9%	630	1.16E+11	NR		
10/7/09		4.84	4.2%	1,553.1	1.84E+11	**39.4**		
7/6/09		3.92	6.0%	2,419.6	2.32E+11	**61.1**		
3/7/05		3.63	6.8%	410	3.64E+10	NR		
10/12/04		3.61	7.0%	15,150	1.34E+12	**93.8**		
2/14/05		3.49	7.3%	8,160	6.96E+11	**88.5**		
3/28/05		3.31	8.0%	11,530	9.33E+11	**91.8**	**53.5**	**55.3**
9/9/09	Moist Conditions	2.48	12.5%	727	4.41E+10	NR		
11/17/09		1.67	19.4%	2,419.6	9.87E+10	**61.1**		
7/8/09		1.63	19.6%	648.8	2.59E+10	NR		
1/18/05		0.97	33.4%	200	4.74E+09	NR		
12/7/09		0.87	38.3%	648.8	1.38E+10	NR	**12.2**	**13.0**
5/2/05	Mid-Range Flows	0.78	42.0%	200	3.82E+09	NR		
11/8/04		0.76	43.4%	850	1.57E+10	NR		
4/18/05		0.70	47.0%	740	1.26E+10	NR		
8/16/04		0.46	65.9%	200	2.27E+09	NR		
5/23/05		0.45	67.8%	200	2.18E+09	NR	**NR**	**NR**
9/13/04	Low Flows	0.38	74.7%	100	9.41E+08	NR		
7/15/09		0.34	79.3%	248.1	2.05E+09	NR		
7/20/09		0.29	83.1%	435.2	3.13E+09	NR		
7/22/09		0.27	84.6%	1,413.6	9.50E+09	**33.4**		
8/4/09		0.24	88.6%	517.2	3.00E+09	NR	**6.7**	**8.0**

Note: NR = No reduction required
NA = Not applicable

Table E-52. Calculated Load Reduction Based on Geomean Data – North Market Street Branch – RM0.3

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/6/09	3.92	6.0%	2,419.6			
7/8/09	1.63	19.6%	648.8			
7/15/09	0.34	79.3%	248.1			
7/20/09	0.29	83.1%	435.2			
7/22/09	0.27	84.6%	1,413.6	751.4	**83.2**	**85.0**
8/4/09	0.24	88.6%	517.2	551.9	**77.2**	**79.5**

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

Table E-53. Calculated Load Reduction Based on Daily Loading – Shoal Creek – RM1.4

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
6/6/05	High Flows	16.91	3.0%	410	1.70E+11	NR		
10/5/09		17.17	3.0%	2,419.6	1.02E+12	**79.9**	**39.9**	**40.9**
11/30/09	Moist Conditions	5.42	15.2%	1,203.3	1.59E+11	**59.5**		
9/15/09		4.87	18.4%	461.1	5.49E+10	NR		
11/3/09		3.89	25.3%	52.8	5.03E+09	NR	**19.8**	**21.2**
6/7/05	Mid-Range Flows	1.79	52.4%	396	1.74E+10	NR		
5/12/05		1.34	60.2%	121	3.96E+09	NR		
7/6/09		1.15	64.4%	2,419.6	6.78E+10	**79.9**		
5/16/05		0.96	69.5%	285	6.67E+09	NR	**20.0**	**20.5**
5/24/05	Low Flows	0.76	74.6%	152	2.81E+09	NR		
9/28/05		0.75	74.8%	1,986	3.65E+10	**75.5**		
7/8/09		0.72	75.8%	1,299.7	2.29E+10	**62.5**		
7/16/09		0.52	83.3%	579.4	7.43E+09	**15.9**		
7/21/09		0.40	88.6%	84.2	8.32E+08	NR		
8/5/09		0.37	90.0%	178.9	1.62E+09	NR		
7/27/09		0.29	94.8%	547.5	3.87E+09	**11.1**	**23.6**	**27.0**

Note: NR = No reduction required
NA = Not applicable

Table E-54. Calculated Load Reduction Based on Geomean Data – Shoal Creek – RM1.4

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
5/12/05	1.34	60.2%	121			
5/16/05	0.96	69.5%	285			
5/24/05	0.76	74.6%	152			
6/6/05	16.91	3.0%	410			
6/7/05	1.79	52.4%	396	243.2	**48.2**	**53.5**
7/6/09	1.15	64.4%	2,419.6			
7/8/09	0.72	75.8%	1,299.7			
7/16/09	0.52	83.3%	579.4			
7/21/09	0.40	88.6%	84.2			
7/27/09	0.29	94.8%	547.5	609.3	**79.3**	**81.5**
8/5/09	0.37	90.0%	178.9	361.9	**65.2**	**68.8**

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

Table E-55. Calculated Load Reduction Based on Daily Loading – Short Branch – RM0.1

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
10/5/09	High Flows	3.84	3.2%	2,419.6	2.27E+11	**79.9**	**79.9**	**81.9**
11/30/09	Moist Conditions	1.27	17.2%	2,419.6	7.50E+10	**79.9**		
11/3/09		1.02	24.0%	325.5	8.14E+09	NR		
9/15/09		0.94	26.7%	920.8	2.11E+10	**47.1**	**42.3**	**44.8**
6/7/05	Mid-Range Flows	0.47	51.7%	816	9.38E+09	**40.3**		
6/8/05		0.36	58.8%	307	2.72E+09	NR		
5/12/05		0.35	59.7%	104	8.89E+08	NR		
7/6/09		0.29	65.2%	1,986.3	1.39E+10	**75.5**		
5/16/05		0.25	69.1%	344	2.10E+09	NR	**23.2**	**24.9**
5/24/05	Low Flows	0.20	74.2%	152	7.37E+08	NR		
9/28/05		0.20	74.2%	770	3.73E+09	**36.8**		
7/8/09		0.19	75.6%	488.4	2.25E+09	**0.3**		
7/16/09		0.13	83.7%	1,732.9	5.68E+09	**71.9**		
7/21/09		0.11	88.4%	54.8	1.44E+08	NR		
8/5/09		0.10	89.9%	770.1	1.85E+09	**36.8**		
7/27/09		0.08	94.6%	43.2	8.05E+07	NR	**20.8**	**24.5**

Note: NR = No reduction required
NA = Not applicable

Table E-56. Calculated Load Reduction Based on Geomean Data – Short Branch – RM0.1

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
5/12/05	0.35	59.7%	104			
5/16/05	0.25	69.1%	344			
5/24/05	0.20	74.2%	152			
6/7/05	0.47	51.7%	816			
6/8/05	0.36	58.8%	307	267.2	**52.8**	**57.7**
7/6/09	0.29	65.2%	1,986.3			
7/8/09	0.19	75.6%	488.4			
7/16/09	0.13	83.7%	1,732.9			
7/21/09	0.11	88.4%	54.8			
7/27/09	0.08	94.6%	43.2	331.1	**61.9**	**65.9**
8/5/09	0.10	89.9%	770.1	274.0	**54.0**	**58.8**

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

Table E-57. Calculated Load Reduction Based on Daily Loading – Stanley Branch – RM0.1

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
10/27/09	Moist Conditions	1.46	20.9%	219	7.83E+09	NR		
12/1/09		1.20	27.5%	687	2.01E+10	NR		
4/12/05		1.07	31.2%	730	1.92E+10	NR	**NR**	**NR**
6/7/05	Mid-Range Flows	0.68	48.2%	73	1.22E+09	NR		
6/2/05		0.63	50.8%	2,490	3.81E+10	**62.2**		
6/8/05		0.54	55.2%	80	1.05E+09	NR		
5/12/05		0.50	57.6%	47	5.73E+08	NR		
5/16/05		0.36	68.6%	7	6.18E+07	NR	**12.4**	**13.2**
5/24/05	Low Flows	0.28	75.3%	56.3	3.91E+08	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-58. Calculated Load Reduction Based on Geomean Data – Stanley Branch – RM0.1

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction to Target GM (126 CFU/100 ml)	Calculated Reduction to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
5/12/05	0.50	57.6%	47			
5/16/05	0.36	68.6%	7			
5/24/05	0.28	75.3%	56.3			
6/2/05	0.63	50.8%	2,490			
6/7/05	0.68	48.2%	73	80.4	**NR**	**NR**
6/8/05	0.54	55.2%	80	80.4	**NR**	**NR**

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

Table E-59. Calculated Load Reduction Based on Daily Loading – Stringers Branch – RM0.6

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
6/6/05	High Flows	43.94	2.2%	630	6.77E+11	NR		
7/6/09		35.41	3.4%	1,986.3	1.72E+12	**52.6**		
3/28/05		22.56	7.5%	1,320	7.29E+11	**28.7**		
2/14/05		21.20	8.5%	2,500	1.30E+12	**62.4**		
10/12/04		19.68	9.5%	310	1.49E+11	NR	**28.7**	**31.9**
3/7/05	Moist Conditions	18.50	10.5%	410	1.86E+11	NR		
10/7/09		16.05	13.0%	1,203.3	4.73E+11	**21.8**		
7/8/09		13.62	16.0%	435.2	1.45E+11	NR		
11/17/09		9.65	25.8%	819.4	1.93E+11	NR		
12/7/09		7.72	33.3%	76.3	1.44E+10	NR		
5/2/05		6.50	40.0%	100	1.59E+10	NR	**3.6**	**4.9**
11/8/04	Mid-Range Flows	6.26	41.7%	100	1.53E+10	NR		
4/18/05		5.77	45.5%	100	1.41E+10	NR		
8/16/04		3.81	65.8%	100	9.33E+09	NR		
5/23/05		3.70	67.0%	310	2.81E+10	NR	**NR**	**NR**
9/13/04	Low Flows	3.16	74.5%	200	1.55E+10	NR		
7/15/09		2.80	79.1%	160.7	1.10E+10	NR		
7/20/09		2.44	83.0%	95.9	5.71E+09	NR		
7/22/09		2.27	84.7%	122.3	6.80E+09	NR		
8/4/09		2.06	87.4%	307.6	1.55E+10	NR		
9/9/09		1.60	94.4%	325.5	1.27E+10	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-60. Calculated Load Reduction Based on Geomean Data – Stringers Branch – RM0.6

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
7/6/09	35.41	3.4%	1,986.3			
7/8/09	13.62	16.0%	435.2			
7/15/09	2.80	79.1%	160.7			
7/20/09	2.44	83.0%	95.9			
7/22/09	2.27	84.7%	122.3	276.9	**54.5**	**59.2**
8/4/09	2.06	87.4%	307.6	190.7	**33.9**	**40.7**

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

Table E-61 Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Lower Tennessee River Watershed (HUC 06020001)

Waterbody Description (TN06020001__)	Hydrologic Condition			Flow[a]	PLR G	TMDL	MOS	WLAs			LAs
	Flow Regime	PDFE Range	Flow Range					WWTFs [c]	CS	MS4s	
		[%]	[cfs]	[cfs]	[%]	[CFU/d]	[CFU/d]	[CFU/d]		[CFU/d/ac]	[CFU/d/ac]
Bivens Branch Waterbody ID: **041 – 0320** HUC-12: 0102	High Flows	0 – 10	3.61 – 11.4	4.76	35.6	1.095×10^{11}	1.095×10^{10}	NA	NA	NA	7.848×10^{7}
	Moist	10 – 40	1.96 – 3.61	2.58	31.4	5.934×10^{10}	5.934×10^{9}				4.254×10^{7}
	Mid-Range	40 – 70	1.18 – 1.96	1.54	NR	3.542×10^{10}	3.542×10^{9}				2.539×10^{7}
	Low Flows	70 – 100	0.30 – 1.18	0.79	61.1	1.817×10^{10}	1.817×10^{9}				1.303×10^{6}
Lewis Branch Waterbody ID: **029 – 0300** HUC-12: 0401	High Flows	0 – 10	5.68 – 35.8	9.07	74.4	2.086×10^{11}	2.086×10^{10}	NA	NA	1.342×10^{8}	1.342×10^{8}
	Moist	10 – 40	2.15– 5.68	3.20	42.7	7.360×10^{10}	7.360×10^{9}			4.735×10^{7}	4.735×10^{7}
	Mid-Range	40 – 70	0.79 – 2.15	1.30	44.5	2.990×10^{10}	2.990×10^{9}			1.924×10^{7}	1.924×10^{7}
	Low Flows	70 – 100	0.16 – 0.79	0.45	29.1	1.035×10^{10}	1.035×10^{9}			6.658×10^{6}	6.658×10^{6}
Long Savannah Creek Waterbody ID: **029 – 1000** HUC-12: 0401	High Flows	0 – 10	61.20 – 318.4	95.19	30.6	2.189×10^{12}	2.189×10^{11}	NA	NA	1.126×10^{8}	1.126×10^{8}
	Moist	10 – 40	23.62 – 61.20	35.10	19.4	8.073×10^{11}	8.073×10^{10}			4.151×10^{7}	4.151×10^{7}
	Mid-Range	40 – 70	8.41 – 23.62	14.15	26.3	3.255×10^{11}	3.255×10^{10}			1.673×10^{7}	1.673×10^{7}
	Low Flows	70 – 100	1.51 – 8.41	4.79	NR	1.102×10^{11}	1.102×10^{10}			5.665×10^{6}	5.665×10^{6}
Wolfe Branch Waterbody ID: **029 – 1000** HUC-12: 0401	High Flows	0 – 10	12.60 – 68.70	19.41	30.6	4.464×10^{11}	4.464×10^{10}	NA	NA	1.335×10^{8}	1.335×10^{8}
	Moist	10 – 40	4.89 – 12.60	7.27	NR	1.672×10^{11}	1.672×10^{10}			5.002×10^{7}	5.002×10^{7}
	Mid-Range	40 – 70	1.78 – 4.89	2.98	NR	6.854×10^{10}	6.854×10^{9}			2.050×10^{7}	2.050×10^{7}
	Low Flows	70 – 100	0.32 – 1.78	1.00	NR	2.300×10^{10}	2.300×10^{9}			6.880×10^{6}	6.880×10^{6}
Chestnut Creek Waterbody ID: **889 – 0200** HUC-12: 0402	High Flows	0 – 10	14.18 – 94.4	25.89	61.1	5.955×10^{11}	5.955×10^{10}	NA	NA	1.522×10^{8}	1.522×10^{8}
	Moist	10 – 40	5.45 – 14.18	8.06	NR	1.854×10^{11}	1.854×10^{10}			4.737×10^{7}	4.737×10^{7}
	Mid-Range	40 – 70	2.43 – 5.45	3.70	NA	8.510×10^{10}	8.510×10^{9}			2.175×10^{7}	2.175×10^{7}
	Low Flows	70 – 100	0.47 – 2.43	1.44	NA	3.312×10^{10}	3.312×10^{9}			8.463×10^{6}	8.463×10^{6}
Little Wolftever Creek Waterbody ID: **889 – 0100** HUC-12: 0402	High Flows	0 – 10	26.18 – 187.9	50.45	NA	1.160×10^{12}	1.160×10^{11}	NA	NA	1.602×10^{8}	1.602×10^{8}
	Moist	10 – 40	9.77 – 26.18	14.39	NR	3.310×10^{11}	3.310×10^{10}			4.570×10^{7}	4.570×10^{7}
	Mid-Range	40 – 70	3.73 – 9.77	6.17	NR	1.419×10^{11}	1.419×10^{10}			1.959×10^{7}	1.959×10^{7}
	Low Flows	70 – 100	0.76 – 3.73	2.09	NR	4.807×10^{10}	4.807×10^{9}			6.637×10^{6}	6.637×10^{6}
Rogers Branch Waterbody ID: **1880 – 1000** HUC-12: 0402	High Flows	0 – 10	13.83 – 90.50	23.78	NR	2.854×10^{11}	2.584×10^{10}	NA	NA	7.879×10^{7}	7.879×10^{7}
	Moist	10 – 40	5.24 – 13.83	7.80	6.6	9.360×10^{10}	9.360×10^{9}			2.585×10^{7}	2.585×10^{7}
	Mid-Range	40 – 70	2.01 – 5.24	3.35	NR	4.020×10^{10}	4.020×10^{9}			1.110×10^{7}	1.110×10^{7}
	Low Flows	70 – 100	0.36 – 2.01	1.09	NR	1.308×10^{10}	1.308×10^{9}			3.612×10^{6}	3.612×10^{6}

Table E-61 (cont'd) Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Lower Tennessee River Watershed (HUC 06020001)

Waterbody Description (TN06020001__)	Hydrologic Condition			Flow[a]	PLR G	TMDL	MOS	WLAs			LAs
	Flow Regime	PDFE Range	Flow Range					WWTFs [c]	CS	MS4s	
		[%]	[cfs]	[cfs]	[%]	[CFU/d]	[CFU/d]	[CFU/d]		[CFU/d/ac]	[CFU/d/ac]
Wilkerson Branch Waterbody ID: **889 – 0300** HUC-12: 0402	High Flows	0 – 10	9.42 – 63.60	18.38	NR	4.227×10^{11}	4.227×10^{10}	NA	NA	1.676×10^{8}	1.676×10^{8}
	Moist	10 – 40	3.41 – 9.42	5.07	NR	1.166×10^{11}	1.166×10^{10}			4.622×10^{7}	4.622×10^{7}
	Mid-Range	40 – 70	1.30 – 3.41	2.17	NR	4.991×10^{10}	4.991×10^{9}			1.978×10^{7}	1.978×10^{7}
	Low Flows	70 – 100	0.25 – 1.30	0.72	NR	1.656×10^{10}	1.656×10^{9}			6.564×10^{6}	6.564×10^{6}
Wolftever Creek Waterbody ID: **089 – 1000** HUC-12: 0402	High Flows	0 – 10	250.4 –1,616.6	441.4	NR	1.015×10^{13}	1.015×10^{12}	NA	NA	1.503×10^{8}	1.503×10^{8}
	Moist	10 – 40	91.82 – 250.4	135.9	NR	3.125×10^{12}	3.125×10^{11}			4.624×10^{7}	4.624×10^{7}
	Mid-Range	40 – 60	52.30 – 91.82	71.23	NR	1.638×10^{12}	1.638×10^{11}			2.425×10^{7}	2.425×10^{7}
	Dry	60 – 90	17.48 – 52.30	32.83	NR	7.551×10^{11}	7.551×10^{10}			1.118×10^{7}	1.118×10^{7}
	Low Flows	90 – 100	6.65 – 17.48	12.52	NR	2.880×10^{11}	2.880×10^{10}			4.262×10^{6}	4.262×10^{6}
Spring Creek Waterbody ID: **007 – 0510** HUC-12: 0903	High Flows	0 – 10	62.03 – 362.1	110.3	84.9[b]	1.324×10^{12}	1.324×10^{11}	NA	0	9.008×10^{7}	9.008×10^{7}
	Moist	10 – 40	16.54 – 62.03	26.99		3.239×10^{11}	3.239×10^{10}			2.204×10^{7}	2.204×10^{7}
	Mid-Range	40 – 70	8.36 – 16.54	11.55		1.386×10^{11}	1.386×10^{10}			9.431×10^{6}	9.431×10^{6}
	Low Flows	70 – 100	2.41 – 8.36	5.42		6.504×10^{10}	6.504×10^{9}			4.426×10^{6}	4.426×10^{6}
Friar Branch Waterbody ID: **007 – 0100** HUC-12: 0905	High Flows	0 – 10	66.40 – 216.7	98.00	82.9[b]	1.176×10^{12}	1.176×10^{11}	NA	0	7.968×10^{7}	7.968×10^{7}
	Moist	10 – 40	22.92 – 66.40	33.80		4.056×10^{11}	4.056×10^{10}			2.748×10^{7}	2.748×10^{7}
	Mid-Range	40 – 70	12.33 – 22.92	16.66		1.999×10^{11}	1.999×10^{10}			1.355×10^{7}	1.355×10^{7}
	Low Flows	70 – 100	3.35 – 12.33	8.03		9.636×10^{10}	9.636×10^{9}			6.529×10^{6}	6.529×10^{6}
Mackey Branch Waterbody ID: **007 – 0300** HUC-12: 0905	High Flows	0 – 10	33.45 – 191.2	56.20	81.4[b]	6.774×10^{11}	6.774×10^{10}	NA	0	8.871×10^{7}	8.871×10^{7}
	Moist	10 – 40	11.45 – 33.45	17.54		2.105×10^{11}	2.105×10^{10}			2.769×10^{7}	2.769×10^{7}
	Mid-Range	40 – 70	4.09 – 11.45	7.26		8.712×10^{10}	8.712×10^{9}			1.146×10^{7}	1.146×10^{7}
	Low Flows	70 – 100	0.61 – 4.09	2.18		2.616×10^{10}	2.616×10^{9}			3.441×10^{6}	3.441×10^{6}
South Chickamauga Creek Waterbody ID: **007 – 1000** HUC-12: 0905	High Flows	0 – 10	1,370 –6,431	2,347	79.7	2.817×10^{13}	2.817×10^{12}	4.357×10^{11}	0	8.533×10^{7}	8.533×10^{7}
	Moist	10 – 40	498.8 – 1,370	725.9	21.2	8.710×10^{12}	8.710×10^{11}			2.536×10^{7}	2.536×10^{7}
	Mid-Range	40 – 60	288.8 – 498.8	384.5	16.3	4.614×10^{12}	4.614×10^{11}			1.273×10^{7}	1.273×10^{7}
	Dry	60 – 90	97.27 – 288.8	172.1	NR	2.065×10^{12}	2.065×10^{11}			4.874×10^{6}	4.874×10^{6}
	Low Flows	90 – 100	44.52 – 97.27	75.01	NR	9.001×10^{11}	9.001×10^{10}			1.282×10^{6}	1.282×10^{6}
UT to South Chickamauga Creek Waterbody ID: **007 – 0200** HUC-12: 0905	High Flows	0 – 10	6.71 – 35.50	13.01	NA	1.561×10^{11}	1.561×10^{10}	NA	0	1.617×10^{8}	1.617×10^{8}
	Moist	10 – 40	1.14 – 6.71	1.94	79.9	2.328×10^{10}	2.328×10^{9}			2.411×10^{7}	2.411×10^{7}
	Mid-Range	40 – 70	0.39 – 1.14	0.72	NA	8.640×10^{9}	8.640×10^{8}			8.948×10^{6}	8.948×10^{6}
	Low Flows	70 – 100	0.06 – 0.39	0.20	79.9	2.400×10^{9}	2.400×10^{8}			2.486×10^{6}	2.486×10^{6}

Table E-61 (cont'd) Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Lower Tennessee River Watershed (HUC 06020001)

Waterbody Description (TN06020001__)	Hydrologic Condition			Flow[a]	PLR G	TMDL	MOS	WLAs			LAs
	Flow Regime	PDFE Range	Flow Range					WWTFs [c]	CS	MS4s	
		[%]	[cfs]	[cfs]	[%]	[CFU/d]	[CFU/d]	[CFU/d]		[CFU/d/ac]	[CFU/d/ac]
Chattanooga Creek Waterbody ID: **1244 – 1000** HUC-12: 1003	High Flows	0 – 10	189.7 –1,246	365.1	84.4[b]	8.397×10^{12}	8.397×10^{11}	2.849×10^{11}	0	1.680×10^{8}	1.680×10^{8}
	Moist	10 – 40	34.49 – 189.7	97.61		2.245×10^{12}	2.245×10^{11}			4.009×10^{7}	4.009×10^{7}
	Mid-Range	40 – 60	34.87 – 64.49	49.32		1.134×10^{12}	1.134×10^{11}			1.700×10^{7}	1.700×10^{7}
	Dry	60 – 90	10.03 – 34.87	19.48		4.480×10^{11}	4.480×10^{10}			2.733×10^{6}	2.733×10^{6}
	Low Flows	90 – 100	4.64 – 10.03	7.83		1.801×10^{11}	1.801×10^{10}	9.474×10^{10} [d]		1.556×10^{6} [d]	1.556×10^{6} [d]
UT to Chattanooga Creek Waterbody ID: **1244 – 0200** HUC-12: 1003	High Flows	0 – 10	5.31 – 29.60	10.03	87.4[b]	2.307×10^{11}	2.307×10^{10}	NA	0	2.521×10^{8}	2.521×10^{8}
	Moist	10 – 40	0.87 – 5.31	1.62		3.726×10^{10}	3.726×10^{9}			4.072×10^{7}	4.072×10^{7}
	Mid-Range	40 – 70	0.41 – 0.87	0.58		1.334×10^{10}	1.334×10^{9}			1.458×10^{7}	1.458×10^{7}
	Low Flows	70 – 100	0.12 – 0.41	0.26		5.980×10^{9}	5.980×10^{8}			6.536×10^{6}	6.536×10^{6}
Dobbs Branch Waterbody ID: **1244 – 0100** HUC-12: 1003	High Flows	0 – 10	24.79 – 127.7	48.95	66.3[b]	1.126×10^{12}	1.126×10^{11}	NA	0	3.258×10^{8}	3.258×10^{8}
	Moist	10 – 40	2.85 – 24.79	5.83		1.341×10^{11}	1.341×10^{10}			3.880×10^{7}	3.880×10^{7}
	Mid-Range	40 – 70	1.29 – 2.85	1.82		4.186×10^{10}	4.186×10^{9}			1.211×10^{7}	1.211×10^{7}
	Low Flows	70 – 100	0.37 – 1.29	0.82		1.886×10^{10}	1.886×10^{9}			5.458×10^{6}	5.458×10^{6}
McFarland Springs Branch Waterbody ID: **1244 – 0300** HUC-12: 1003	High Flows	0 – 10	5.06 – 28.80	9.56	66.9[b]	2.199×10^{11}	2.199×10^{10}	NA	0	2.413×10^{8}	2.413×10^{8}
	Moist	10 – 40	0.88 – 5.06	1.63		3.749×10^{10}	3.749×10^{9}			4.114×10^{7}	4.114×10^{7}
	Mid-Range	40 – 70	0.42 – 0.88	0.58		1.334×10^{10}	1.334×10^{9}			1.464×10^{7}	1.464×10^{7}
	Low Flows	70 – 100	0.12 – 0.42	0.27		6.210×10^{9}	6.210×10^{8}			6.814×10^{6}	6.814×10^{6}
Bee Branch Waterbody ID: **109 – 0400** HUC-12: 1202	High Flows	0 – 10	1.89 – 12.40	3.05	91.9[b]	3.660×10^{10}	3.600×10^{10}	NA	NA	7.751×10^{7}	7.751×10^{7}
	Moist	10 – 40	0.71 – 1.89	1.08		1.296×10^{10}	1.296×10^{10}			2.744×10^{7}	2.744×10^{7}
	Mid-Range	40 – 70	0.26 – 0.71	0.48		5.400×10^{9}	5.400×10^{8}			1.144×10^{7}	1.144×10^{7}
	Low Flows	70 – 100	0.05 – 0.26	0.45		1.680×10^{9}	1.680×10^{8}			3.558×10^{6}	3.558×10^{6}
Citico Creek Waterbody ID: **1240 – 1000** HUC-12: 1202	High Flows	0 – 10	16.73 – 82.80	29.90	83.3[b]	6.877×10^{11}	6.877×10^{10}	NA	0	3.019×10^{8}	3.019×10^{8}
	Moist	10 – 40	4.26 – 16.73	6.34		1.458×10^{11}	1.458×10^{10}			6.401×10^{7}	6.401×10^{7}
	Mid-Range	40 – 70	3.02 – 4.26	3.46		7.958×10^{10}	7.958×10^{9}			3.493×10^{7}	3.493×10^{7}
	Low Flows	70 – 100	2.26 – 3.02	2.63		6.049×10^{10}	6.049×10^{9}			2.655×10^{7}	2.655×10^{7}
UT to Citico Creek Waterbody ID: **1240 – 0100** HUC-12: 1202	High Flows	0 – 10	5.35 – 29.30	10.12	83.3[b]	2.328×10^{11}	2.328×10^{10}	NA	0	2.577×10^{8}	2.577×10^{8}
	Moist	10 – 40	0.85 – 5.35	1.58		3.634×10^{10}	3.634×10^{9}			4.023×10^{7}	4.023×10^{7}
	Mid-Range	40 – 70	0.40 – 0.85	0.56		1.288×10^{10}	1.288×10^{9}			1.426×10^{7}	1.426×10^{7}
	Low Flows	70 – 100	0.12 – 0.40	0.26		5.980×10^{9}	5.980×10^{8}			6.621×10^{6}	6.621×10^{6}

Table E-61 (cont'd) Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Lower Tennessee River Watershed (HUC 06020001)

Waterbody Description (TN06020001__)	Hydrologic Condition			Flow[a]	PLRG	TMDL	MOS	WLAs			LAs
	Flow Regime	PDFE Range	Flow Range					WWTFs [c]	CS	MS4s	
		[%]	[cfs]	[cfs]	[%]	[CFU/d]	[CFU/d]	[CFU/d]		[CFU/d/ac]	[CFU/d/ac]
Mountain Creek Waterbody ID: **1426 – 1000** HUC-12: 1202	High Flows	0 – 10	18.39 – 125.5	36.04	83.7[b]	8.289×10^{11}	8.289×10^{10}	NA	0	1.753×10^{8}	1.753×10^{8}
	Moist	10 – 40	6.40 – 18.39	9.63		2.215×10^{11}	2.215×10^{10}			4.685×10^{7}	4.685×10^{7}
	Mid-Range	40 – 70	2.43 – 6.40	4.15		9.545×10^{10}	9.545×10^{9}			2.019×10^{7}	2.019×10^{7}
	Low Flows	70 – 100	0.46 – 2.43	1.32		3.036×10^{10}	3.036×10^{9}			6.422×10^{6}	6.422×10^{6}
North Market Street Branch Waterbody ID: **001T – 0200** HUC-12: 1202	High Flows	0 – 10	2.84 – 9.90	4.26	83.2[b]	9.798×10^{10}	9.798×10^{9}	NA	0	1.784×10^{8}	1.784×10^{8}
	Moist	10 – 40	0.82 – 2.84	1.28		2.944×10^{10}	2.944×10^{9}			5.361×10^{7}	5.361×10^{7}
	Mid-Range	40 – 70	0.43 – 0.82	0.58		1.334×10^{10}	1.334×10^{9}			2.429×10^{7}	2.429×10^{7}
	Low Flows	70 – 100	0.12 – 0.43	0.27		6.210×10^{9}	6.210×10^{8}			1.131×10^{7}	1.131×10^{7}
Shoal Creek Waterbody ID: **087 – 1000** HUC-12: 1202	High Flows	0 – 10	7.13 – 43.00	11.68	79.3[b]	1.402×10^{11}	1.402×10^{10}	NA	0	1.306×10^{8}	1.306×10^{8}
	Moist	10 – 40	2.56 – 7.13	3.91		4.692×10^{10}	4.692×10^{9}			4.372×10^{7}	4.372×10^{7}
	Mid-Range	40 – 70	0.94 – 2.56	1.61		1.932×10^{10}	1.932×10^{9}			1.800×10^{7}	1.800×10^{7}
	Low Flows	70 – 100	0.16 – 0.94	0.49		5.880×10^{9}	5.880×10^{8}			5.479×10^{6}	5.479×10^{6}
Short Branch Waterbody ID: **109 – 0100** HUC-12: 1202	High Flows	0 – 10	1.73 – 11.40	2.80	61.9[b]	3.360×10^{10}	3.360×10^{9}	NA	NA	7.756×10^{7}	7.756×10^{8}
	Moist	10 – 40	0.66 – 1.73	0.99		1.188×10^{10}	1.188×10^{9}			2.742×10^{7}	2.742×10^{7}
	Mid-Range	40 – 70	0.24 – 0.66	0.41		4.920×10^{9}	4.920×10^{8}			1.136×10^{7}	1.136×10^{7}
	Low Flows	70 – 100	0.04 – 0.24	0.13		1.560×10^{9}	1.560×10^{8}			3.601×10^{6}	3.601×10^{6}
Stanley Branch Waterbody ID: **109-0200** HUC-12: 1202	High Flows	0 – 10	2.24 – 13.00	3.40	NA	7.820×10^{10}	7.820×10^{9}	NA	0	1.319×10^{8}	1.319×10^{8}
	Moist	10 – 40	0.87 – 2.24	1.27	NR	2.921×10^{10}	2.921×10^{9}			4.926×10^{7}	4.926×10^{7}
	Mid-Range	40 – 70	0.34 – 0.87	0.54	12.4	1.242×10^{10}	1.242×10^{9}			2.094×10^{7}	2.094×10^{7}
	Low Flows	70 – 100	0.06 – 0.34	0.19	NR	4.370×10^{9}	4.370×10^{8}			7.369×10^{6}	7.369×10^{6}
Stringers Branch Waterbody ID: **1426 – 0100** HUC-12: 1202	High Flows	0 – 10	19.04 – 64.20	28.31	54.5[b]	6.511×10^{11}	6.511×10^{10}	NA	0	1.528×10^{8}	1.528×10^{8}
	Moist	10 – 40	6.50 – 19.04	9.73		2.238×10^{11}	2.238×10^{10}			5.253×10^{7}	5.253×10^{7}
	Mid-Range	40 – 70	3.48 – 6.50	4.72		1.086×10^{11}	1.086×10^{10}			2.548×10^{7}	2.548×10^{7}
	Low Flows	70 – 100	0.98 – 3.48	2.23		5.129×10^{10}	5.129×10^{9}			1.204×10^{7}	1.204×10^{7}

Notes: NA = Not Applicable.
NR = No Reduction Required.
PLRG = Percent Load Reduction Goal to achieve TMDL.
CS = Collection Systems
Shaded Flow Zone for each waterbody represents the critical flow zone.

a. Flow applied to TMDL, MOS, and allocation (WLA[MS4] and LA) calculations. Flows represent the midpoint value in the respective hydrologic flow regime.
b. PRG based on geomean data.
c. WLAs for WWTFs are expressed as E. coli loads (CFU/day). All current and future WWTFs must meet water quality standards as specified in their NPDES permit.
d. For this waterbody, the design flow of the CSO outfalls exceeds the flow in the waterbody, which results in a negative LA and WLA for the MS4. The average flow for the CSO outfall for the previous permit cycle is approximately one-third of the design flow. For this waterbody, the WLA and LA are based on the average flow for the CSO outfall

APPENDIX F

Public Notice Announcement

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

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR E. COLI IN LOWER TENNESSEE RIVER WATERSHED (HUC 06020001), TENNESSEE

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

A number of waterbodies in the Lower Tennessee River watershed are listed on Tennessee's Final 2008 303(d) list as not supporting designated use classifications due, in part, to pasture grazing and discharges from MS4 areas. The TMDL utilizes Tennessee's general water quality criteria, continuous flow data from a USGS discharge monitoring station located in proximity to the watershed, site specific water quality monitoring data, a calibrated hydrologic model, load duration curves, and an appropriate Margin of Safety (MOS) to establish allowable loadings of pathogens which will result in the reduced in-stream concentrations and attainment of water quality standards. The TMDL requires reductions of pathogen loading on the order of 6-92% in the listed waterbodies.

The Lower Tennessee River E. coli TMDL may be downloaded from the Department of Environment and Conservation website:

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

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

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

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

Persons wishing to comment on the proposed TMDLs are invited to submit their comments in writing no later than September 13, 2010 to:

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

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

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

APPENDIX G

Comments Received

From: "Minkara Mounir" <minkara_m@chattanooga.gov>
To: <sherry.wang@tn.gov>
Date: 9/3/2010 8:48 AM
Subject: 2010 Draft of Proposed TMDL for E. coli - Lower TN Tiver - City of Chattanooga Comments
CC: <richard.urban@tn.gov>, "McDonald, Tim" <TimM@HamiltonTN.gov>, <vicki.steed

Hello Sherry,

I appreciate the opportunity to provide comments for the 2010 draft TMDL for E. coli for Lower TN River. The following are the City of Chattanooga comments:

Pg. 9. Table 2. lists 15.68 impaired miles for Mackey Branch while the 2008 & 2010 draft 303(d) publications list 15.66.

Pg. 15. Table 3. lists monitoring station:

CHATT000.9HM as 20 dates of exceeding WQ max. while the data in Appendix B lists 18;
MACKE000.6HM as 3 exceedance dates, while Appendix B lists 4;
SCHIC000.4HM as 9 exceedance dates, while Appendix B lists 7; also lists 27 data points for this station, though 23 are in App B.

Pg. 21. Livestock data is included from 2002 Census of Agriculture. 2007 Census is available, with livestock population figures increased from 2002 figures. This update will surely impact livestock bacteria counts for the planning area.

	2002 population data	2007 pop. data
Hogs	138	263
Sheep	394	407
Goat	Not listed	950
Horse	1496	1844

Pg. 36. North Chickamauga Creek Conservancy has been in existence since 1993, resulting in a 17-year history, rather than the 13-year noted in text.

Pg. 39. The document suggests "adequate data to support delisting should be collected"; can "adequate" be further defined to provide clear guidance to the regulated sources?

Pg. 51. May want to update with your new email addresses.

Thanks

Mo

Mounir Minkara, Ph.D., P.E.

Water Quality Manager
City of Chattanooga
(423) 643-5877

APPENDIX H

Response to Comments Received

Table 2 has been corrected to list 15.66 impaired miles for Mackey Branch.

Table 3 was correct; missing data has been added to Appendix B.

Table 5 has been changed to use the 2007 Census of Agriculture. TDEC was not aware that this data was available.

Pg. 36 – correction has been made.

Pg. 36 – Waterbodies in Tennessee are periodically assessed in accordance with the State's watershed management approach. Waterbodies, previously assessed as impaired, may be recommended for "delisting" if there is sufficient evidence to demonstrate that water quality standards are being achieved. Data considered for assessment purposes must be readily available and meet minimum data quality requirements. The local environmental field office can be consulted for guidance regarding data collection in support of assessment activities.

Pg. 51 – email addresses have been corrected.