PROPOSED
TOTAL MAXIMUM DAILY LOAD (TMDL)

for

E. Coli

in the

Loosahatchie River Watershed

(HUC 08010209)

Fayette, Hardeman, Haywood, Shelby, and Tipton 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 Loosahatchie River Watershed (HUC 08010209)

Impaired Waterbody Information

State: Tennessee
Counties: Fayette, Shelby, and Tipton
Watershed: Loosahatchie River (HUC 08010209)
Constituents of Concern: E. coli
Waterbodies Addressed in This Document:

Waterbody ID	Waterbody	Miles Impaired
TN08010209001 – 0100	TODD BRANCH	49
TN08010209001 – 1000	LOOSAHATCHIE RIVER	7.8
TN08010209002 – 0100	UNNAMED TRIB TO LOOSAHATCHIE RIVER	4.95
TN08010209002 – 0200	ROCKY BRANCH	6.62
TN08010209002 – 0300	SCOTTS CREEK	7.2
TN08010209002 – 0400	OLIVER CREEK	7.4
TN08010209002 – 0500	BUCKHEAD CREEK	14.59
TN08010209002 – 0600	HOWARD CREEK	7.21
TN08010209002 – 1000	LOOSAHATCHIE RIVER	10.3
TN08010209002 – 2000	LOOSAHATCHIE RIVER	8.2
TN08010209003 – 0200	CYPRESS CREEK	13.67
TN08010209003 – 1000	CLEAR CREEK	2.67
TN08010209004 – 0100	BLACK ANKLE CREEK	27.0
TN08010209004 – 1000	LOOSAHATCHIE RIVER	10.0
TN08010209007 – 1000	LOOSAHATCHIE RIVER	9.6
TN08010209008 – 1000	TREADVILLE BOTTOM	32.16
TN08010209010 – 1000	JONES CREEK	36.9
TN08010209014 – 1000	LAUREL CREEK	38.2
TN08010209015 – 1000	LITTLE CYPRESS CREEK	17.14
TN08010209016 – 0100	WEST BEAVER CREEK	30.95
TN08010209016 – 0210	KELLEY BRANCH	16.67
TN08010209016 – 0400	EAST BEAVER CREEK	84.5
TN08010209016 – 1000	BEAVER CREEK	30.38

Waterbody ID	Waterbody	Miles Impaired
TN08010209021 – 0100	JAKES CREEK	22.8
TN08010209021 – 0110	BEAR CREEK	14.5
TN08010209021 – 0200	ROYSTER CREEK	37.4
TN08010209021 – 0300	NORTH FORK CREEK	37.6
TN08010209021 – 0600	CROOKED CREEK CANAL	31.21
TN08010209021 – 1000	BIG CREEK	8.33
TN08010209021 – 2000	BIG CREEK	6.25
TN08010209021 – 3000	BIG CREEK	27.75
TN08010209021 – 4000	BIG CREEK	35.1

Designated Uses:

The designated use classifications for waterbodies in the Loosahatchie 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 Proposed Final 2010 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.

The E. coli TMDLs developed in this document supersede the fecal coliform TMDLs approved by EPA in 2001. Since 2001: (1) water quality standards have changed from fecal coliform to e. coli; (2) additional waterbodies have been listed; and (3) TDEC has developed an improved flow-based methodology.

Analysis/Methodology:

The TMDLs for impaired waterbodies in the Loosahatchie 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 WinHSPF model simulation period for development of load duration curve analysis included all seasons and a full range of flow and meteorological conditions.

Margin of Safety (MOS):

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

Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Loosahatchie River Watershed (HUC 08010209)

HUC-12 Subwatershed (08010209__) 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	Loosahatchie River	TN08010209011 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.211 \times 10^{6} \times Q$
0103	Jones Creek	TN08010209010 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.746 \times 10^{6} \times Q$
0104	Treadville Bottom	TN08010209008 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.516 \times 10^{6} \times Q$
0105	Loosahatchie River	TN08010209007 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	3.188×10^{10}	0	NA	$(2.827 \times 10^{5} \times Q) - (4.353 \times 10^{5})$
0201	East Beaver Creek	TN08010209016 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.156×10^{9}	0	$(5.032 \times 10^{5} \times Q) - (1.010 \times 10^{5})$	$(5.032 \times 10^{5} \times Q) - (1.010 \times 10^{5})$
0202	West Beaver Creek	TN08010209016 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.204 \times 10^{6} \times Q$	$1.204 \times 10^{6} \times Q$
0203	Beaver Creek	TN08010209016 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.156×10^{9}	0	$(2.223 \times 10^{5} \times Q) - (4.463 \times 10^{4})$	$(2.223 \times 10^{5} \times Q) - (4.463 \times 10^{4})$
	Kelley Branch	TN08010209016 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$4.346 \times 10^{6} \times Q$
0301	Big Creek	TN08010209021 – 3000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.986×10^{8}	0	$(1.027 \times 10^{6} \times Q) - (2.473 \times 10^{4})$	$(1.027 \times 10^{6} \times Q) - (2.473 \times 10^{4})$
	Big Creek	TN08010209021 – 4000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.986×10^{8}	0	$(1.632 \times 10^{6} \times Q) - (3.931 \times 10^{4})$	$(1.632 \times 10^{6} \times Q) - (3.931 \times 10^{4})$
	Crooked Creek Canal	TN08010209021 – 0500	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.603×10^{9}	0	$(1.822 \times 10^{6} \times Q) - (1.411 \times 10^{5})$	$(1.822 \times 10^{6} \times Q) - (1.411 \times 10^{5})$
0302	Big Creek	TN08010209021 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	2.092×10^{11}	0	$(3.658 \times 10^{5} \times Q) - (3.697 \times 10^{6})$	$(3.658 \times 10^{5} \times Q) - (3.697 \times 10^{6})$
	North Fork Creek	TN08010209021 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	5.164×10^{8}	0	$(1.931 \times 10^{6} \times Q) - (4.818 \times 10^{4})$	$(1.931 \times 10^{6} \times Q) - (4.818 \times 10^{4})$
	Royster Creek	TN08010209021 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.892 \times 10^{6} \times Q$	$1.892 \times 10^{6} \times Q$
0303	Big Creek	TN08010209021 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	2.094×10^{11}	0	$(2.144 \times 10^{5} \times Q) - (2.169 \times 10^{6})$	$(2.144 \times 10^{5} \times Q) - (2.169 \times 10^{6})$
	Bear Creek	TN08010209021 – 0110	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$5.027 \times 10^{6} \times Q$	$5.027 \times 10^{6} \times Q$
	Jakes Creek	TN08010209021 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.969 \times 10^{6} \times Q$	$3.969 \times 10^{6} \times Q$
0401	Laurel Creek	TN08010209014 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.744 \times 10^{6} \times Q$
0402	Little Cypress Creek	TN08010209015 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.203 \times 10^{6} \times Q$

Summary (cont'd) of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Loosahatchie River Watershed (HUC 08010209)

HUC-12 Subwatershed (08010209__) 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]
0403	Black Ankle Creek	TN08010209004 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.203 \times 10^{6} \times Q$
	Loosahatchie River	TN08010209004 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.466×10^{11}	0	$(1.256 \times 10^{5} \times Q) - (8.744 \times 10^{5})$	$(1.256 \times 10^{5} \times Q) - (8.744 \times 10^{5})$
0404	Cypress Creek	TN08010209003 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.603×10^{9}	0	$(5.454 \times 10^{5} \times Q) - (4.223 \times 10^{4})$	$(5.454 \times 10^{5} \times Q) - (4.223 \times 10^{4})$
0405	Rocky Branch	TN08010209002 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$8.179 \times 10^{6} \times Q$
	Scotts Creek	TN08010209002 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.033 \times 10^{7} \times Q$	$1.033 \times 10^{7} \times Q$
	Oliver Creek	TN08010209002 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$9.452 \times 10^{6} \times Q$	$9.452 \times 10^{6} \times Q$
	Buckhead Creek	TN08010209002 – 0500	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$5.406 \times 10^{6} \times Q$	$5.406 \times 10^{6} \times Q$
	Howard Creek	TN08010209002 – 0600	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.112 \times 10^{7} \times Q$	$1.112 \times 10^{7} \times Q$
	Loosahatchie River	TN08010209002 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.175×10^{11}	0	$(6.459 \times 10^{4} \times Q) - (1.030 \times 10^{6})$	$(6.459 \times 10^{4} \times Q) - (1.030 \times 10^{6})$
0406	Loosahatchie River	TN08010209001 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	7.071×10^{11}	0	$(4.479 \times 10^{4} \times Q) - (1.530 \times 10^{6})$	$(4.479 \times 10^{4} \times Q) - (1.530 \times 10^{6})$
	Unnamed Trib to Loosahatchie River	TN08010209002 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$2.295 \times 10^{7} \times Q$
	Loosahatchie River	TN08010209002 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.976×10^{11}	0	$(6.098 \times 10^{4} \times Q) - (1.466 \times 10^{6})$	$(6.098 \times 10^{4} \times Q) - (1.466 \times 10^{6})$
	Todd Branch	TN08010209001 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$7.983 \times 10^{6} \times Q$	$7.983 \times 10^{6} \times Q$

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) LOOSAHATCHIE RIVER WATERSHED (HUC 08010209)

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 Loosahatchie River Watershed, identified on the Proposed Final 2010 303(d) list as not supporting designated uses due to E. coli. 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.

The E. coli TMDLs developed in this document supersede the fecal coliform TMDLs approved by EPA in 2001. Since 2001: (1) water quality standards have changed from fecal coliform to e. coli; (2) additional waterbodies have been listed; and (3) TDEC has developed an improved flow-based methodology.

3.0 WATERSHED DESCRIPTION

The Loosahatchie River Watershed (HUC 08010209) is located in Western Tennessee (Figure 1). The watershed includes parts of Fayette, Hardeman, Haywood, Shelby, and Tipton counties. The Loosahatchie River Watershed lies within three Level III ecoregions (Southeastern Plains, Mississippi Alluvial Plain, and Mississippi Valley Loess Plains) and contains four Level IV subecoregions as shown in Figure 2 (USEPA, 1997):

- The **Southeastern Plains and Hills (65e)** contain several north-south trending bands of sand and clay formations. Tertiary-age sand, clay, and lignite are to the west, and Cretaceous-age fine sand, fossiliferous micaceous sand, and silty clays are to the east. With elevations reaching over 650 feet, and more rolling topography and more relief than the Loess Plains (74b) to the west, streams have increased gradient, generall sandy substrates, and distinctive faunal characteristics for west Tennessee. The natural vegetation type is oak-hickory forest, grading into oak-hickory-pine to the south.

- The **Northern Mississippi Alluvial Plain (73a)** within Tennessee is a relatively flat region of Quaternary alluvial deposits of sand, silt, clay, and gravel. It is bounded distinctly on the east by the Bluff Hills (74a), and on the west by the Mississippi River.

Average elevations are 200-300 feet with little relief. Most of the region is in cropland, with some areas of deciduous forest. Soybeans, cotton, corn, sorghum, and vegetables are the main crops. The natural vegetation consists of Southern floodplain forest (oak, tupelo, bald cypress). The two main distinctions in the Tennessee portion of the ecoregion are between areas of loamy, silty, and sandy soils with better drainage, and areas of more clayey soils of poor drainage that may contain wooded swamp-land and oxbow lakes. Waterfowl, raptors, and migratory songbirds are relatively abundant in the region.

- The **Bluff Hills (74a)** consist of sand, clay, silt, and lignite, and are capped by looess greater than 60 feet deep. The disjunct region in Tennessee encompasses those thick loess areas that are generally the steepest, most dissected, and forested. The carved loess has a mosaic of microenvironments, including dry slopes and ridges, moist slopes, ravines, bottomland areas, and small cypress swamps. While oak-hickory is the general forest type, some of the undisturbed bluff vegetation is rich in mesophytes, such as beech and sugar maple, with similarities to hardwood forests of eastern Tennessee. Smaller streams of the Bluff Hills have localized reaches of increased gradient and small areas of gravel substrate that create aquatic habitats that are distinct from those of the Loess Plains (74b) to the east. Unique, isolated fish assemblages more typical of upland habitats can be found in these stream reaches. Gravels are also exposed in places at the base of the bluffs.

- The **Loess Plains (74b)** are gently rolling, irregular plains, 250-500 feet in elevation, with loess up to 50 feet thick. The region is a productive agricultural area of soybeans, cotton, corn, milo, and sorghum crops, along with livestock and poultry. Soil erosion can be a problem on the steeper, upland Alfisol soils; bottom soils are mostly silty Entisols. Oak-hickory and southern floodplain forests are the natural vegetation types, although most of the forest cover has been removed for cropland. Some less-disturbed bottomland forest and cypress-gum swamp habitats still remain. Several large river systems with wide floodplains, the Obion, Forked Deer, Hatchie, Loosahatchie, and Wolf, cross the region. Streams are low-gradient and murky with silt and sand bottoms, and most have been channelized.

The Loosahatchie River Watershed (HUC 08010209) has approximately 1,436 miles of streams and 81 reservoir/lake acres (based on USEPA/TDEC Assessment Database (ADB)) and drains approximately 741 square miles to the Loosahatchie River, which drains to the Mississippi River. 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 Loosahatchie River watershed have occurred since 2001 as a result of rapid development, this is the most current land use data available. Land use for the Loosahatchie River Watershed is summarized in Table 1 and shown in Figure 3. Predominant land use in the Loosahatchie River Watershed is cropland (39.9%) followed by forest (34.9%). Urban areas represent approximately 11.5% of the total drainage area of the watershed. Details of land use distribution of impaired subwatersheds in the Loosahatchie River Watershed are presented in Appendix A.

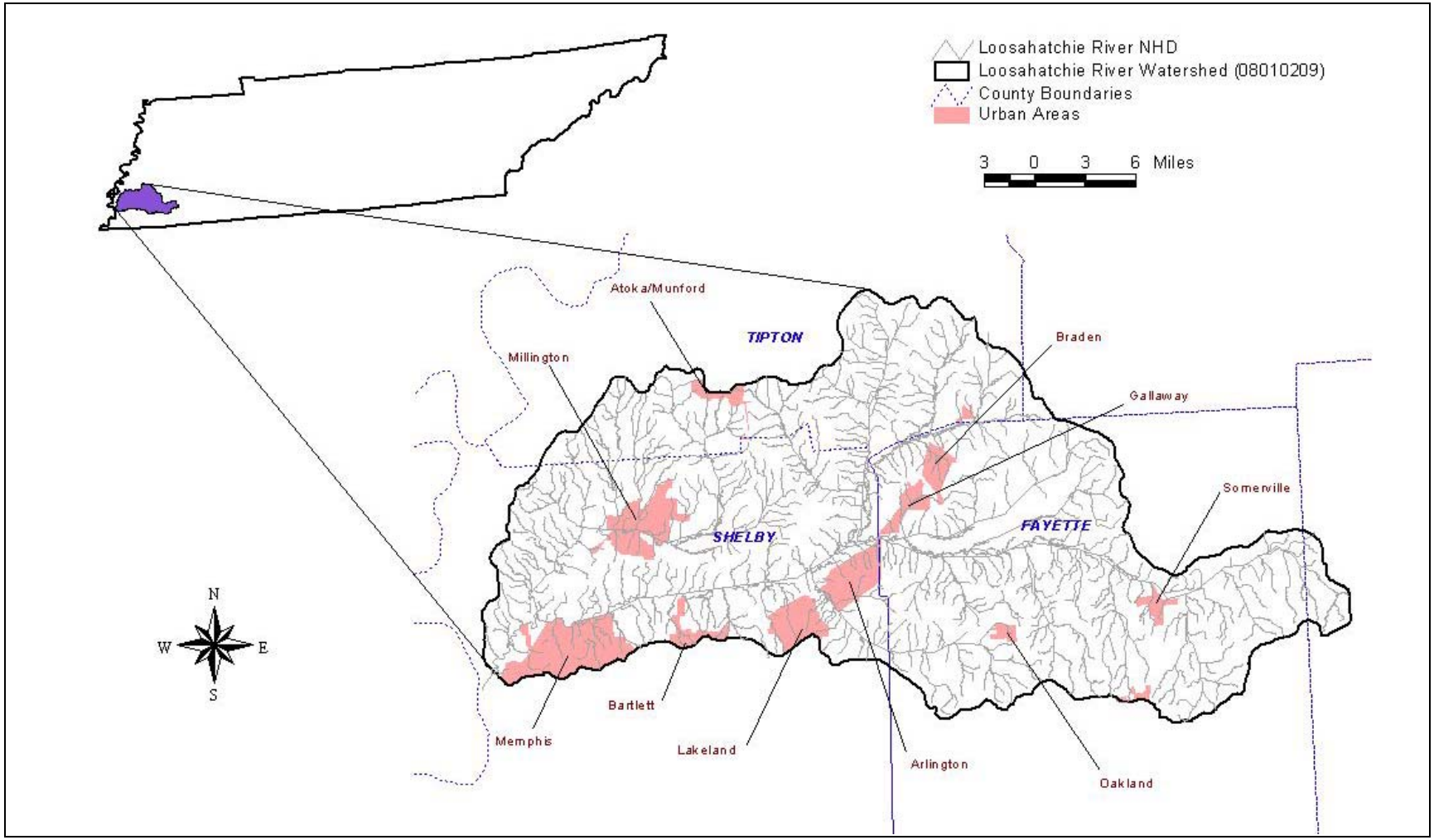

Figure 1. Location of the Loosahatchie River Watershed.

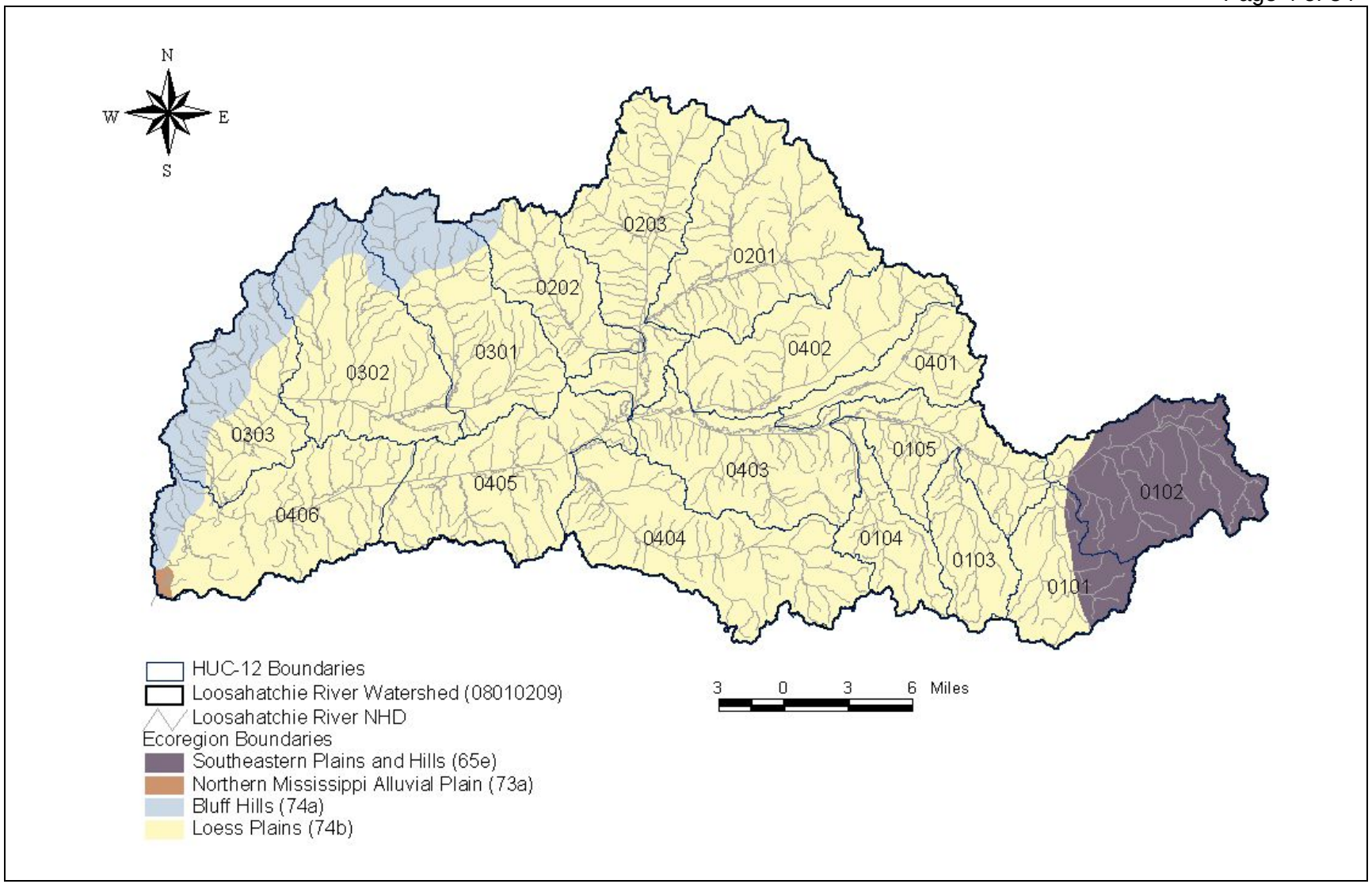

Figure 2. Level IV Ecoregions in the Loosahatchie River Watershed.

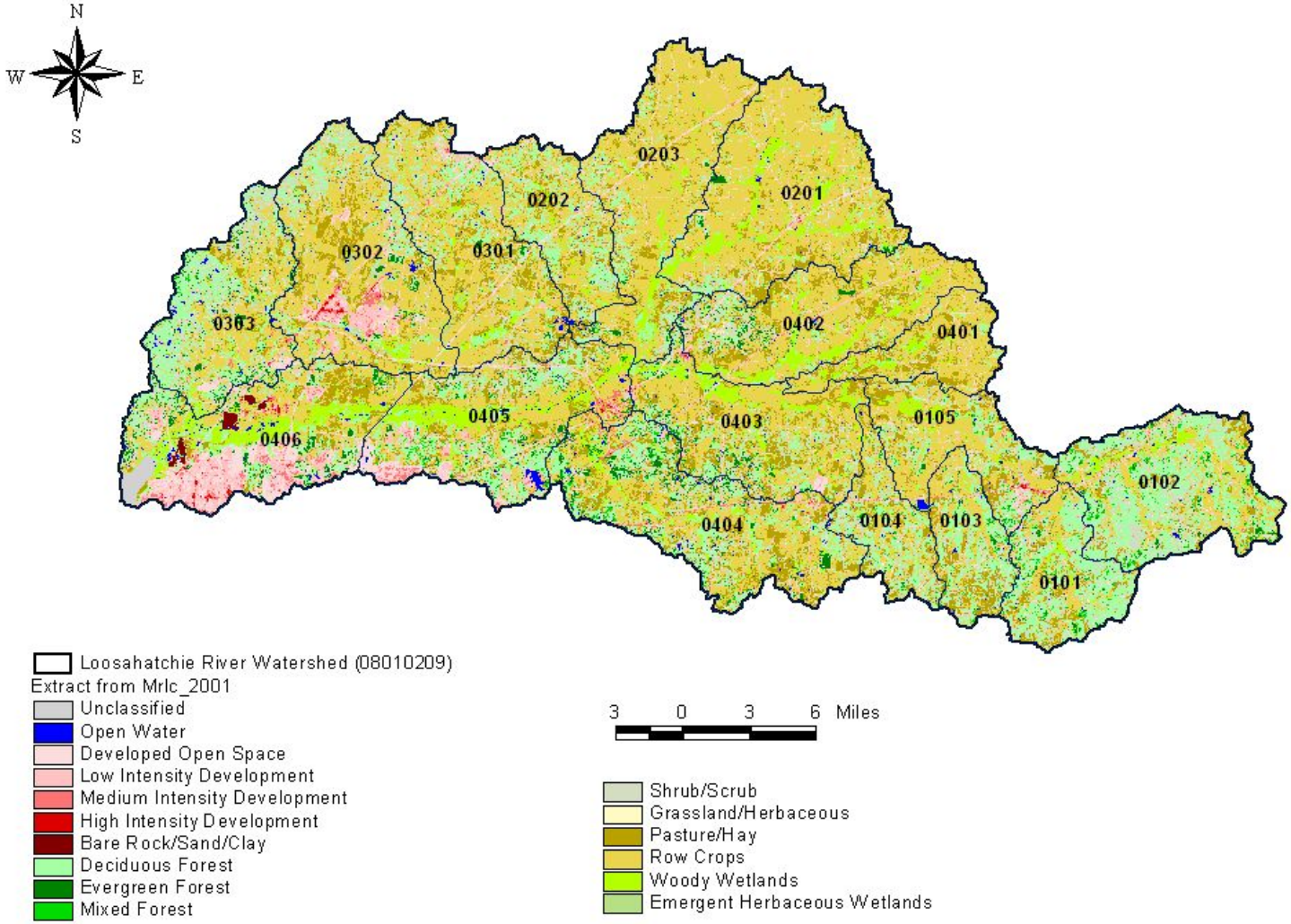

Figure 3. Land Use Characteristics of the Loosahatchie River Watershed.

Table 1 2001 MRLC Land Use Distribution – Loosahatchie River Watershed

Land Use	Area	
	[acres]	[%]
Unclassified	1,177	0.25
Open Water	3,292	0.69
Developed Open Spaces	27,491	5.79
Low Intensity Residential	17,428	3.67
Medium Intensity Residential	4,381	0.92
High Intensity Residential	626	0.13
Bare Rock/Sand/Clay	721	0.15
Deciduous Forest	71,699	15.10
Evergreen Forest	10,304	2.17
Mixed Forest	5,487	1.16
Shrub/Scrub	46,090	9.71
Grasslands/Herbaceous	676	0.14
Pasture/Hay	65,251	13.74
Row Crops	189,661	39.94
Woody Wetlands	27,377	5.77
Emergent Herbaceous Wetlands	3,163	0.67
Total	**474,825**	**100.00**

4.0 PROBLEM DEFINITION

The State of Tennessee's Proposed Final 2010 303(d) list (TDEC, 2010), http://tn.gov/environment/wpc/publications/pdf/2010proposed_final_303dlist.pdf, was submitted to the U.S. Environmental Protection Agency (EPA), Region IV in August of 2010. This list identified a number of waterbodies in the Loosahatchie 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.

5.0 WATER QUALITY CRITERIA & TMDL TARGET

As previously stated, the designated use classifications for the Loosahatchie 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).

As of June 1, 2011, none of the impaired waterbodies in the Loosahatchie 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 941 CFU/100 ml have been selected as the appropriate numerical targets for TMDL development.

Table 2 Proposed Final 2010 303(d) List for E. coli Impaired Waterbodies – Loosahatchie River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN08010209001 – 0100	TODD BRANCH	4.9	Low Dissolved Oxygen Physical Substrate Habitat Alterations Total Phosphorus Escherichia coli	Discharges from MS4 area Channelization Collection System Failure
TN08010209001 – 1000	LOOSAHATCHIE RIVER (Mississippi River to Big Creek)	7.8	Mercury PCBs Dioxins Chlordane Loss of biological integrity due to siltation Physical Substrate Habitat Alteraions Escherichia coli	Atmospheric Deposition Discharges from MS4 area Contaminated Sediment Channelization
TN08010209002 – 0100	UNNAMED TRIB TO LOOSAHATCHIE RIVER	4.95	Escherichia coli	Discharges from MS4 area
TN08010209002 – 0200	ROCKY BRANCH	6.62	Escherichia coli	Discharges from MS4 area
TN08010209002 – 0300	SCOTTS CREEK	7.2	Flow Alterations	Upstream Impoundment
TN08010209002 – 0400	OLIVER CREEK	7.4	Total Phosphorus Loss of biological integrity due to siltation Echerichia coli	Discharges from MS4 area Land Development
TN08010209002 – 0500	BUCKHEAD CREEK	14.59	Total Phosphorus Low Dissolved Oxygen Loss of biological integrity due to siltation Escherichia coli	Discharges from MS4 area Land Development
TN08010209002 – 0600	HOWARD CREEK	7.21	Total Phosphorus Escherichia coli	Discharges from MS4 area
TN08010209002 – 1000	LOOSAHATCHIE RIVER (Big Creek to Howard Creek)	10.3	Mercury Chlordane PCBs Dioxin Total Phosphorus Loss of biological integrity due to siltation Physical Substrate Habitat Alteraions Escherichia coli	Atmospheric Deposition Contaminated Sediment Discharges from MS4 area Land Development Channelization

Table 2 (cont'd) Proposed Final 2010 303(d) List for E. coli Impaired Waterbodies – Loosahatchie River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN08010209002 – 2000	LOOSAHATCHIE RIVER (Howard Creek to Clear/Cypress Creek)	8.2	Total Phosphorus Physical Substrate Habitat Alterations Loss of biological integrity due to siltation Escherichia coli	Municipal Point Source Discharges from MS4 area Land Development Channelization
TN08010209003 – 0200	CYPRESS CREEK	13.67	Total Phosphorus Physical Substrate Habitat Alterations Loss of biological integrity due to siltation Escherichia coli	Pasture Grazing Channelization
TN08010209003 – 1000	CLEAR CREEK	2.67	Total Phosphorus Physical Substrate Habitat Alterations Loss of biological integrity due to siltation Escherichia coli	Pasture Grazing Channelization
TN08010209004 – 0100	BLACK ANKLE CREEK	27.0	Low Dissolved Oxygen Total Phosphorus Loss of biological integrity due to siltation Escherichia coli	Nonirrigated Crop Production Land Development Undetermined Source
TN08010209004 – 1000	LOOSAHATCHIE RIVER (Clear/Cypress Creek to Laurel Creek)	10.0	Physical Substrate Habitat Alteraions	Channelization
TN08010209007 – 1000	LOOSAHATCHIE RIVER (Laurel Creek to Jones Creek)	9.6	Physical Substrate Habitat Alterations Escherichia coli	Channelization Undetermined Source
TN08010209008 – 1000	TREADVILLE BOTTOM	32.16	Escherichia coli	Undetermined Source
TN08010209010 – 1000	JONES CREEK	36.9	Physical Substrate Habitat Alterations Loss of biological integrity due to siltation Escherichia coli	Nonirrigated Crop Production Undetermined Source
TN08010209014 – 1000	LAUREL CREEK	38.2	Total Phosphorus Low Dissolved Oxygen Physical Substrate Habitat Alterations Loss of biological integrity due to siltation Escherichia coli	Nonirrigated Crop Production Channelization Undetermined Source

Table 2 (cont'd) Proposed Final 2010 303(d) List for E. coli Impaired Waterbodies – Loosahatchie River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN08010209015 – 1000	LITTLE CYPRESS CREEK	17.14	Total Phosphorus Low Dissolved Oxygen Physical Substrate Habitat Alterations	Nonirrigated Crop Production Channelization
TN08010209016 – 0100	WEST BEAVER CREEK	56.6	Low Dissolved Oxygen Phosphate Loss of biological integrity due to siltation Physical Substrate Habitat Alterations	Nonirrigated Cro pProduction Channelization
TN08010209016 – 0210	KELLEY BRANCH	16.67	Escherichia coli	Pasture Grazing
TN08010209016 – 0400	EAST BEAVER CREEK	84.5	Low Dissolved Oxygen Nitrate+Nitrite Total Phosphorus Loss of biological integrity due to siltation Physical Substrate Habitat Alterations	Nonirrigated Crop Production
TN08010209016 – 1000	BEAVER CREEK	30.38	Total Phosphorus Low Dissolved Oxygen Loss of biological integrity due to siltation Physical Substrate Habitat Alterations	Nonirrigated Crop Production Channelization
TN08010209021 – 0100	JAKES CREEK	22.8	Total Phosphorus Low of biological integrity due to siltation Escherichia coli	Nonirrigated Crop Production Undetermined Source
TN08010209021 – 0110	BEAR CREEK	14.5	Total Phosphorus Low Dissolved Oxygen Escherichia coli	Nonirrigated Crop Production Pasture Grazing
TN08010209021 – 0200	ROYSTER CREEK	37.4	Total Phosphorus Low Dissolved Oxygen Physical Substrate Habitat Alterations Loss of biological integrity due to siltation Escherichia coli	Nonirrigated Crop Production Channelization Pasture Grazing

Table 2 (cont'd) Proposed Final 2010 303(d) List for E. coli Impaired Waterbodies – Loosahatchie River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN08010209021 – 0300	NORTH FORK CREEK	37.6	Total Phosphorus Low Dissolved Oxygen Physical Substrate Habitat Alterations Loss of biological integrity due to siltation Escherichia coli	Nonirrigated Crop Production Channelization Discharges from MS4 Area
TN08010209021 – 0600	CROOKED CREEK CANAL	31.21	Low Dissolved Oxygen Physical Substrate Habitat Alterations Escherichia coli	Nonirrigated Crop Production Channelization Discharges from MS4 Area
TN08010209021 – 1000	BIG CREEK (Loosahatchie River to Royster Creek)	8.33	Low Dissolved Oxygen Nitrate+Nitrite Total Phosphorus Physical Substrate Habitat Alterations Loss of biological integrity due to siltation Escherichia coli	Discharges from MS4 area Municipal Point Source Channelization
TN08010209021 – 2000	BIG CREEK (Royster Creek to Crooked Creek)	6.25	Low Dissolved Oxygen Total Phosphorus Physical Substrate Habitat Alterations Loss of biological integrity due to siltation Escherichia coli	Discharges from MS4 area Channelization
TN08010209021 – 3000	BIG CREEK (Crooked Creek to Big Branch)	27.75	Total Phosphorus Low Dissolved Oxygen Physical Substrate Habitat Alterations Loss of biological integrity due to siltation Escherichia coli	Nonirrigated Crop Production Discharges from MS4 area Channelization
TN08010209021 – 4000	BIG CREEK (Big Branch to headwaters)	35.1	Escherichia coli	Undetermined Source

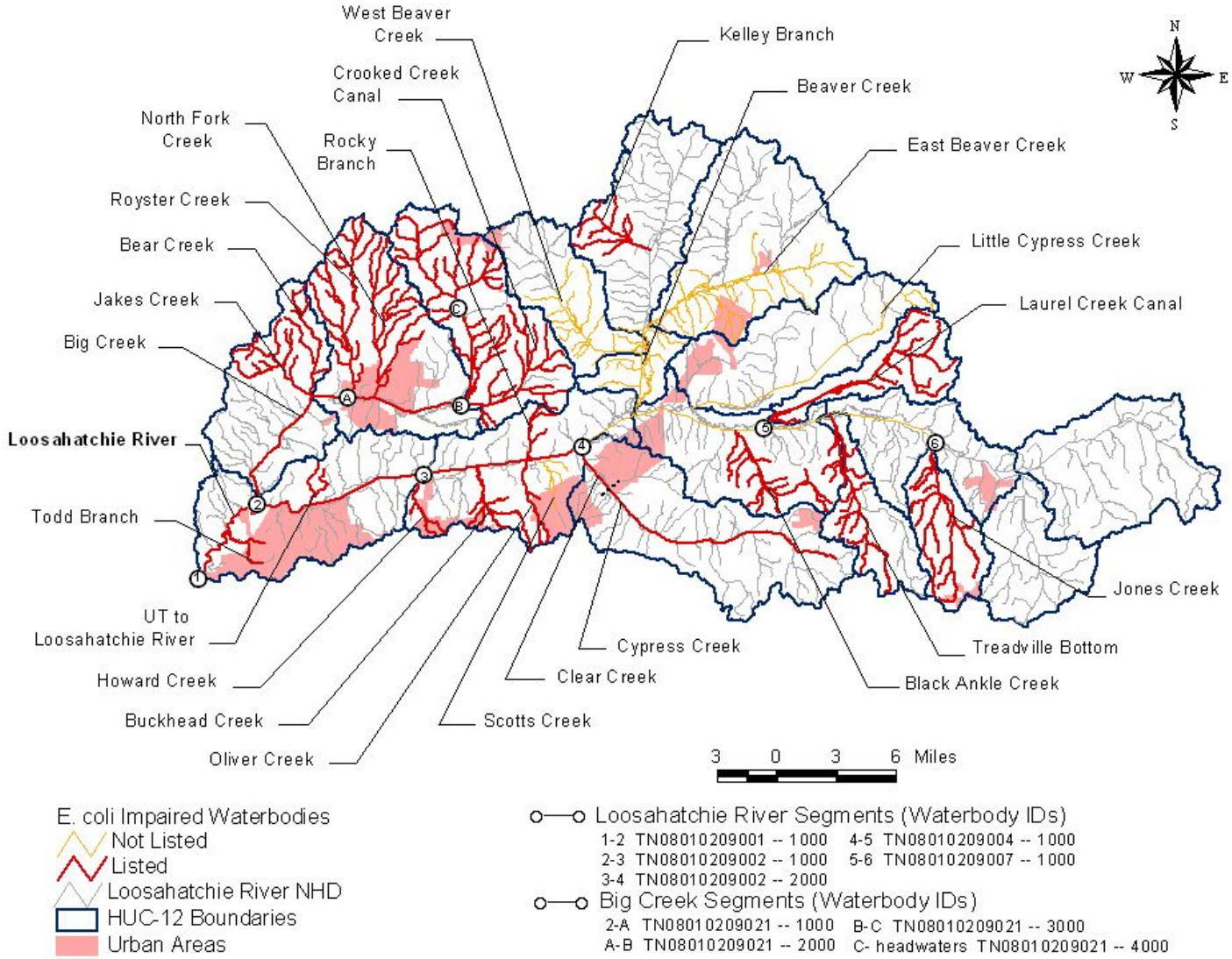

Figure 4. Waterbodies Impaired by E. Coli (as Documented on the Proposed Final 2010 303(d) List).

6.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

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

- HUC-12 08010209_0102:
  - LOOSA1C53.6FA – Loosahatchie River, at Highway 64
- HUC-12 08010209_0103:
  - JONES001.6FA – Jones Creek, at Feathers Chapel Rd. crossing
- HUC-12 08010209_0104:
  - LOOSA1T1.9FA – Treadville Bottom, at Feathers Chapel Rd. crossing
- HUC-12 08010209_0105:
  - LOOSA1C42.5FA – Loosahatchie River, at Old Salmon Mill Rd.
- HUC-12 08010209_0201:
  - EBEAV1C2.1FA – East Beaver Creek, at Beaver Creek Rd.
- HUC-12 08010209_0202:
  - WBEAV1C1.1SH – West Beaver Creek, at Collierville-Arlington Rd.
- HUC-12 08010209_0203:
  - BEAVE1C1.0SH – Beaver Creek, at Gallaway-Levee Rd.
  - KELLY001.0TI – Kelley Branch, at Mount Carmel Rd.
- HUC-12 08010209_0301:
  - BIG1C15.8SH – Big Creek, at Millington-Arlington Rd.
  - BIG1C20.8TI – Big Creek, at Meade Lake Rd./Grave Springs Rd.
  - CROOK1C1.3SH – Crooked Creek Canal, at Donnell Rd.
- HUC-12 08010209_0302:
  - BIG1C8.4SH – Big Creek, at Hwy 51 bridge crossing near Millington
  - BIG1C13.6SH – Big Creek, u/s of Millington STP, at Sledge Rd.
  - NFORK000.6SH – North Fork Creek, at Navy Rd.
  - ROYST1C0.9SH – Royster Creek, at Shelby Rd.
- HUC-12 08010209_0303:
  - BEAR001.2SH – Bear Creek, Hwy 51 north to Millington, left on Shelby Road
  - BIG1C1.0SH – Big Creek, at Fite Rd.
  - JAKES000.3SH – Jakes Creek, at Shake Rag Rd.

- HUC-12 08010209_0401:
  - LAURE003.7FA – Laurel Creek, at Lambert Rd. crossing
- HUC-12 08010209_0402:
  - LCYPR003.3FA – Little Cypress Creek, at Braden-Center Point Rd.
- HUC-12 08010209_0403:
  - BANKL001.6FA – Black Ankle Creek, at Fields Dr.
  - LOOSA1C30.2SH – Loosahatchie River, at Hwy 70 bridge
  - LOOSA1C34.0FA – Loosahatchie River, at Braden Center Point Rd.
- HUC-12 08010209_0404:
  - CLEAR001.4SH – Clear Creek, at Hwy 70
  - CYPRE010.8FA – Cypress Creek, at Chulahoma Rd.
- HUC-12 08010209_0405:
  - BUCKH002.1SH – Buckhead Creek, at Old Brownsville Road
  - BUCKH003.8SH – Buckhead Creek, at Germantown Road
  - BUCKH005.2SH – Buckhead Creek, at Brunswick Road
  - HOWAR002.1SH – Howard Creek, at Old Brownsville Rd.
  - LOOSA1C22.7SH – Loosahatchie River, at Brunswick Rd.
  - OLIVE001.3SH – Oliver Creek, at Old Brownsville Rd.
  - ROCKY000.9SH – Rocky Branch, at Stewart Rd.
  - SCOTT001.7SH – Scotts Creek, at Old Brownsville Rd.
- HUC-12 08010209_0406:
  - LOOSA005.0SH – Loosahatchie River, at Watkins Rd. crossing (first bridge)
  - LOOSA1C15.8SH – Loosahatchie River, at Singleton Pkwy /Hwy 204 crossing
  - LOOSA4T1.3SH – Unnamed Trib to Loosahatchie River, at Fite Rd.
  - TODD001.6SH – Todd Branch, at Millington Rd. bridge crossing

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 941 CFU/100 mL maximum E. coli standard at all 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.

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.

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
BANKLE001.6FA	1999 – 2008	34	1	1,077	19,860	6
BEAR001.2SH	1999 – 2008	20	16.1	614	7,270	3
BEAVE1C1.0SH	1998 – 2008	30	4.1	362	4,884	3
BIG1C1.0SH	1998 – 2008	25	7	1,626	16,000	6
BIG1C8.4SH	1999 – 2008	26	19	1,519	14,140	9
BIG1C13.6SH	1998 – 2008	34	8.6	3,392	72,419	7
BIG1C15.8SH	1999 – 2008	24	26.9	1,284	19,863	4
BIG1C20.8TI	2007 – 2008	13	10	1,820	8,164	4
BUCKH002.1SH	1999 – 2010	29	60.1	2,491	14,136	16
BUCKH003.8SH	2010	6	172	923	2,420	2
BUCKH005.2SH	2010	6	57	266	980	1
CLEAR001.4SH	2001 – 2008	24	15	3,216	24,000	9
CROOK1C1.3SH	1999 – 2008	28	4.1	1,499	12,997	8
CYPRE010.8FA	1999 – 2008	24	9.7	2,602	24,192	6
EBEAV1C2.1FA	2002 – 2008	23	2	517	6,867	2
HOWAR002.1SH	1999 – 2008	12	13	6,724	72,420	4
JAKES000.3SH	1999 – 2008	24	46.4	1,435	24,192	5
JONES001.6FA	1999 – 2008	23	5.2	1,771	24,200	6
KELLY001.0TI	1999 – 2008	16	5	483	3,654	2
LAURE003.7FA	1998 – 2008	34	3.1	1,375	14,136	8
LCYPR003.3FA	1998 – 2008	38	4.1	658	8,664	4
LOOSA005.0SH [a]	1998 – 2009	103	1.0	1,383	24,000	24
LOOSA1C15.8SH [a]	1998 – 2009	83	1.0	1,452	24,192	20
LOOSA1C22.7SH	1998 – 2008	31	2	1,950	15,531	11
LOOSA1C30.2SH	1998 – 2008	30	1	775	8,664	3
LOOSA1C34.0FA	2002 – 2008	32	2	1,548	24,200	5
LOOSA1C42.5FA	1999 – 2008	26	1	797	14,140	4
LOOSA1C53.6FA	1998 – 2009	55	1	237	3,080	3

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
LOOSA1T1.9FA	1999 – 2008	10	44	848	3,784	3
LOOSA4T1.3SH	1999 – 2008	18	1	1,042	3,900	6
NFORK000.6SH	2002 – 2008	23	63	1,628	12,033	6
OLIVE001.3SH	1999 – 2008	24	17.5	1,261	10,462	7
ROCKY000.9SH	1999 – 2008	12	63	1,977	12,033	5
ROYST1C0.9SH	1999 – 2008	24	8.4	946	11,199	6
SCOTT001.7SH	1999 – 2008	21	25.6	645	6,900	3
TODD001.6SH	1998 – 2008	30	1	3,103	24,196	14
WBEAV1C1.1SH	1999 – 2008	24	7.4	380	2,420	3

[a] Includes Memphis monitoring data for MS4 permit.

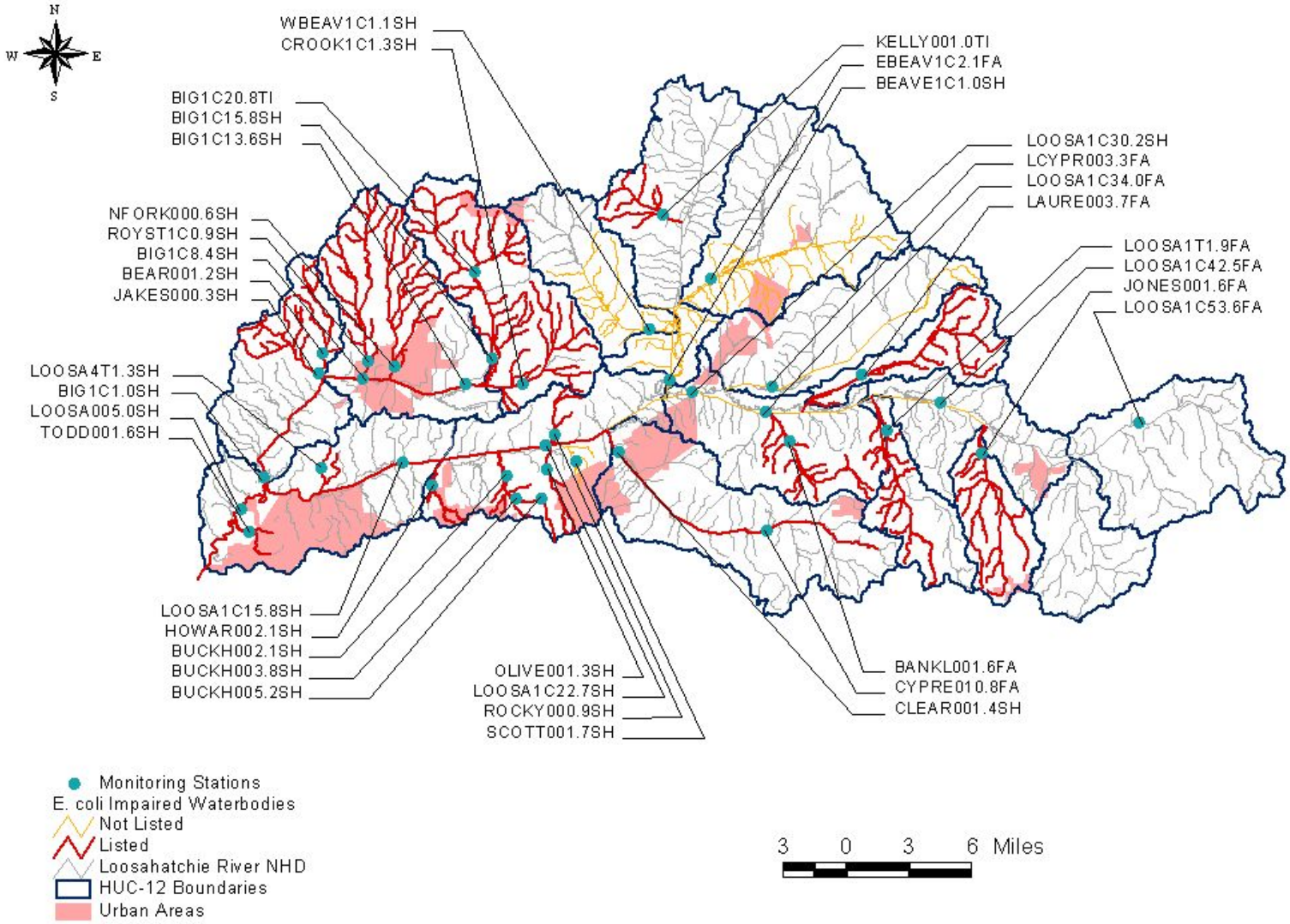

Figure 5. Water Quality Monitoring Stations in the Loosahatchie River Watershed

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 17 WWTFs in the Loosahatchie River Watershed that have NPDES permits authorizing the discharge of treated sanitary wastewater. All of these facilities are located in or near impaired subwatersheds or drainage areas. (see Figure 6 and Table 4). 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).

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

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

NPDES Permit No.	Facility	Design Flow [MGD]	Receiving Stream
TN0021067	Millington STP #2	5.8	Big Creek
TN0021652	Somerville Lagoon	0.895	Loosahatchie River @RM46.7
TN0023795	Northwest School	0.0067	Unnamed Trib to Beaver Creek @RM3.6
TN0023833	E.E. Jetter School	0.007	Unnamed Trib to Big Creek @RM2.8
TN0026361	Memphis-Chapel Hill S.D. STP	0.045	Unnamed Trib to Unnamed Trib to Crooked Creek @RM3.0
TN0026620	Mason STP	0.11	East Beaver Creek @RM6.8
TN0056863	Camelia Homes Inc.	0.014	Unnamed Trib to Big Creek @RM22.1
TN0056871	Pine Grove Mobile Home Park	0.012	Unnamed Trib to North Fork Creek @RM2.8
TN0061433	Pine Lake Cooperative	0.045	Unnamed Trib to Hall Creek @RM2.9
TN0062138	Gallaway STP	0.165	Loosahatchie River @RM34.7
TN0065277	Mallard Ridge Mobile Estates	0.0025	Unnamed Trib to North Fork Creek @RM4.7
TN0066800	Bartlett STP No. 1	2.2	Loosahatchie River @RM18.4
TN0067482	Pleasant Ridge Trailer Park	0.05	Loosahatchie River @RM20.9
TN0068543	Bartlett WWTP #2	0.5	Loosahatchie River @RM24.0
TN0077836	Oakland-Mechanical – WWTP	3.0	Loosahatchie River @RM40.5
TN0078255	City of Lakeland	4.5	Loosahatchie River @RM24.7
TN0078603	Arlington STP	2.5	Loosahatchie River @RM29.2

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, Memphis (TNS068276) is the only MS4 of this size in the Loosahatchie 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). The cities of Bartlett (TNS075698), Lakeland (TNS077526), and Millington (TNS075442), and Shelby County (TNS075663) are covered 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 June 1, 2011, there are no Class I CAFOs with individual permits or Class II CAFOs with coverage under the general NPDES permit located in the Loosahatchie River Watershed.

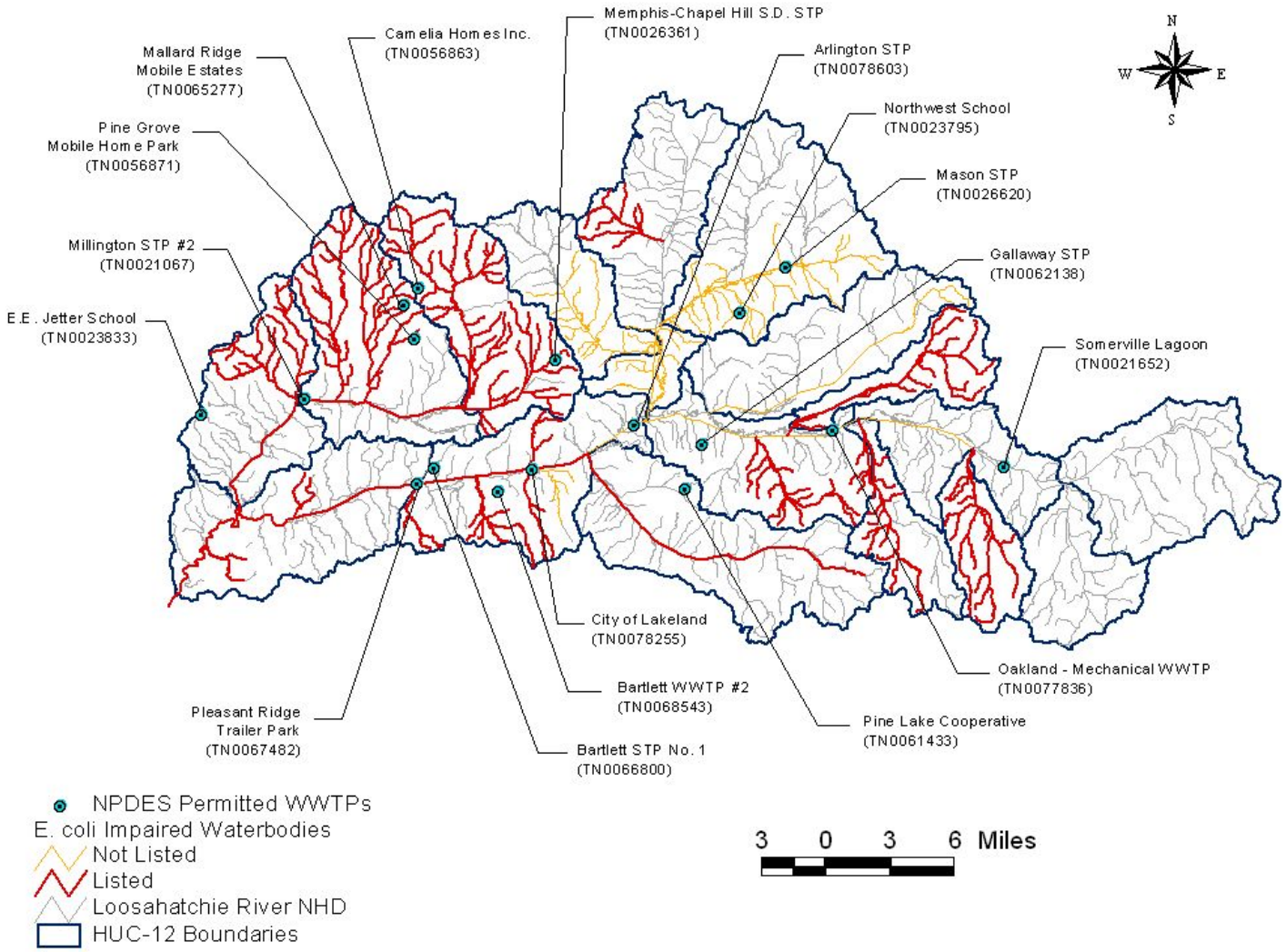

Figure 6. NPDES Regulated Point Sources in and near Impaired Subwatersheds and Drainage Areas of the Loosahatchie River Watershed.

7.2 Nonpoint Sources

Nonpoint sources of coliform bacteria are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. These sources generally, but not always, involve accumulation of coliform bacteria on land surfaces and wash off as a result of storm events. Nonpoint sources of E. coli loading are primarily associated with agricultural and urban land uses. The vast majority of waterbodies identified on the Proposed Final 2010 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 Loosahatchie 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 Loosahatchie River Watershed

County	Livestock Population (2007 Census of Agriculture)							
	Beef Cow	Milk Cow	Poultry		Hogs	Sheep	Goats	Horse
			Layers	Broilers				
Fayette	12,833	151	790	15	(D)	180	337	2,626
Shelby	(D)	(D)	606	70	42	107	649	1,975
Tipton	5,505	0	301	(D)	59	281	424	1,078

* 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).

7.2.3 Failing Septic Systems

Some of the coliform loading in the Loosahatchie 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 Loosahatchie River watershed utilizing septic systems were compiled using the WCS and are summarized in Table 6. In western Tennessee, it is estimated that there are approximately 2.51 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 Loosahatchie River Watershed

County	Total Population (2000 Census)	Total Population (1990 Census)	% of Population on Septic Systems (1990 Census)
Fayette	28,806	25,559	70.1
Shelby	897,465	826,330	0.25
Tipton	51,271	37,568	23.7

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 Loosahatchie River Watershed ranges from 5% to 30%. Land use for the Loosahatchie River impaired HUC-12s is summarized in Figures 7a, 7b, 8a, 8b, 9a, and 9b, and tabulated in Appendix A.

Figure 7a. Land Use Area of Loosahatchie River E. coli-Impaired HUC-12s 0102 thru 0105

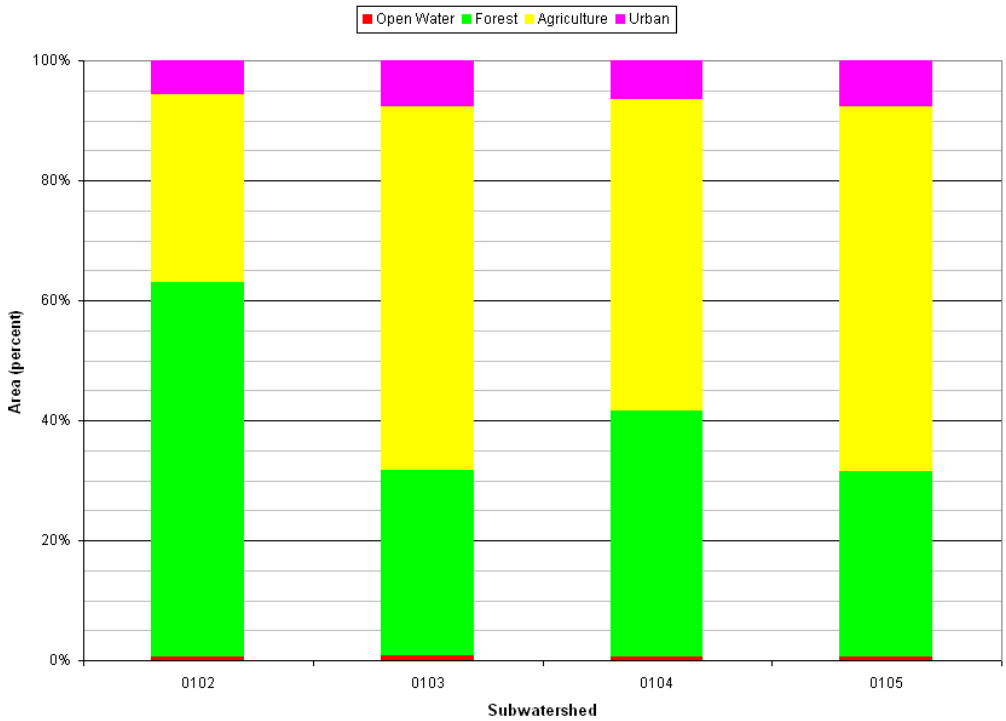

Figure 7b. Land Use Percent of the Loosahatchie River E. coli-Impaired HUC12s 0102 thru 0105

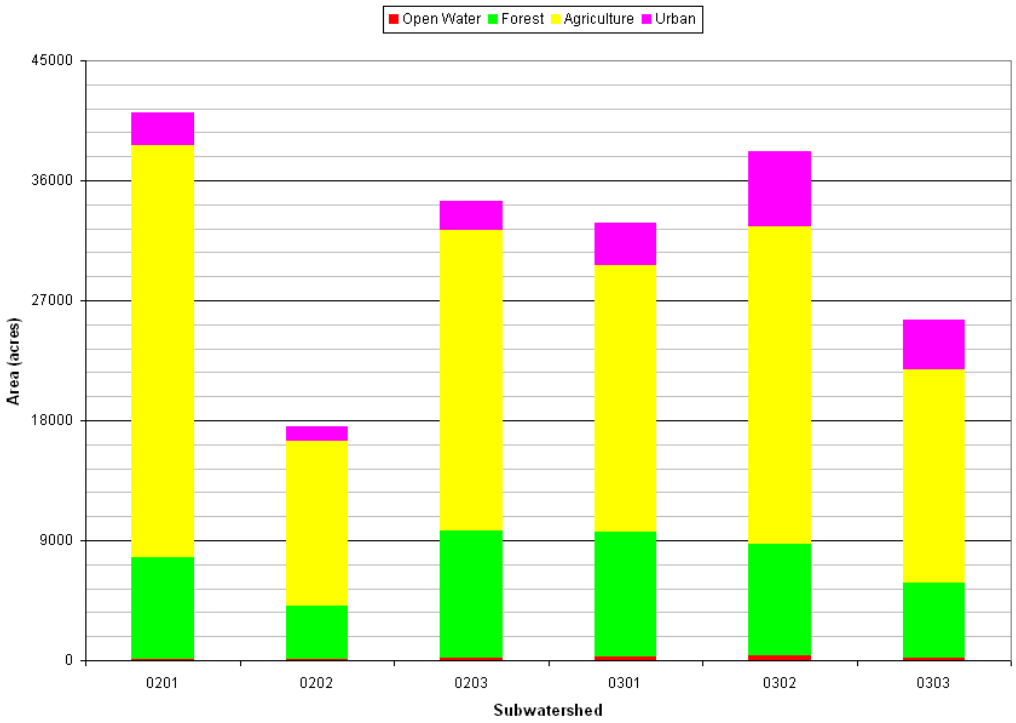

Figure 8a. Land Use Area of Loosahatchie River E. coli-Impaired HUC-12s 0201 thru 0303

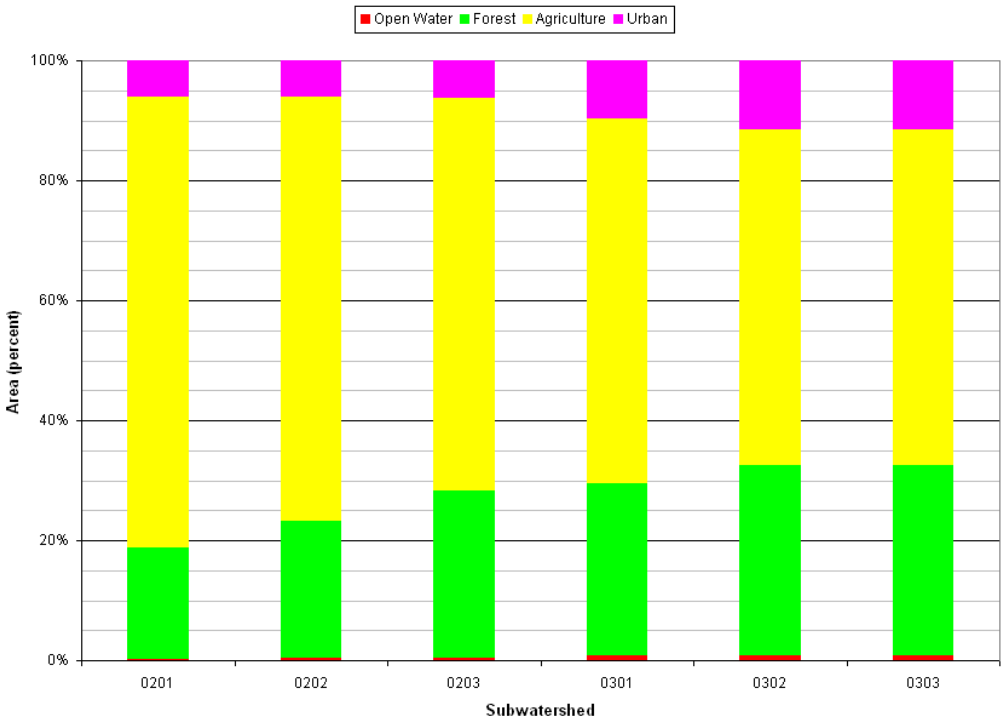

Figure 8b. Land Use Percent of the Loosahatchie River E. coli-Impaired HUC-12s 0201 thru 0303

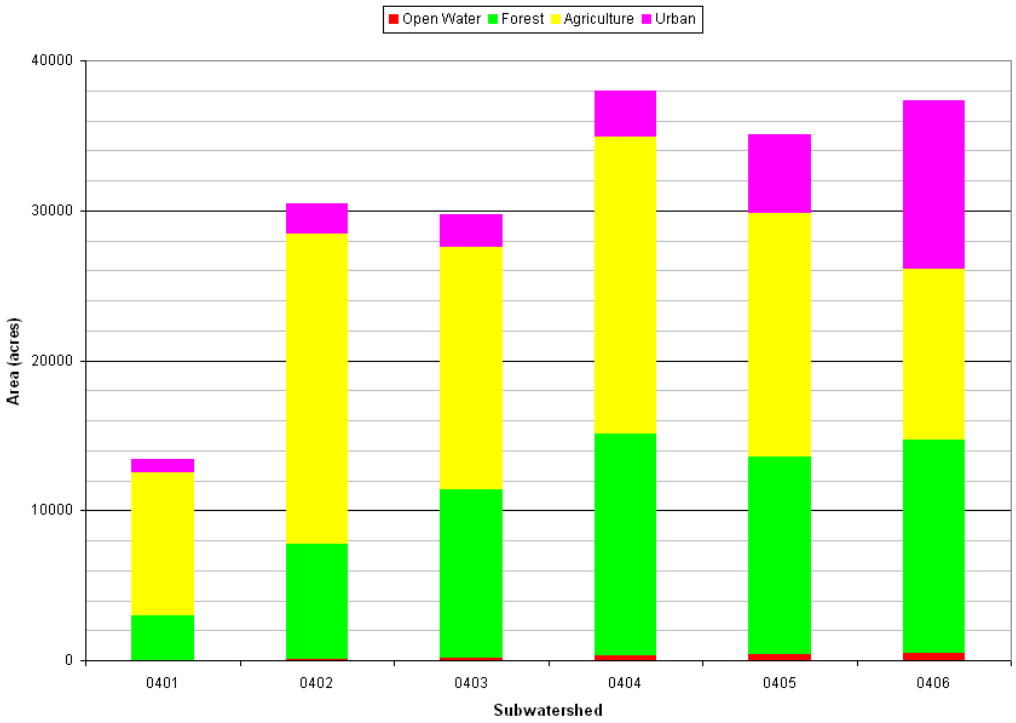

Figure 9a. Land Use Area of Loosahatchie River E. coli-Impaired HUC-12s 0401 thru 0406

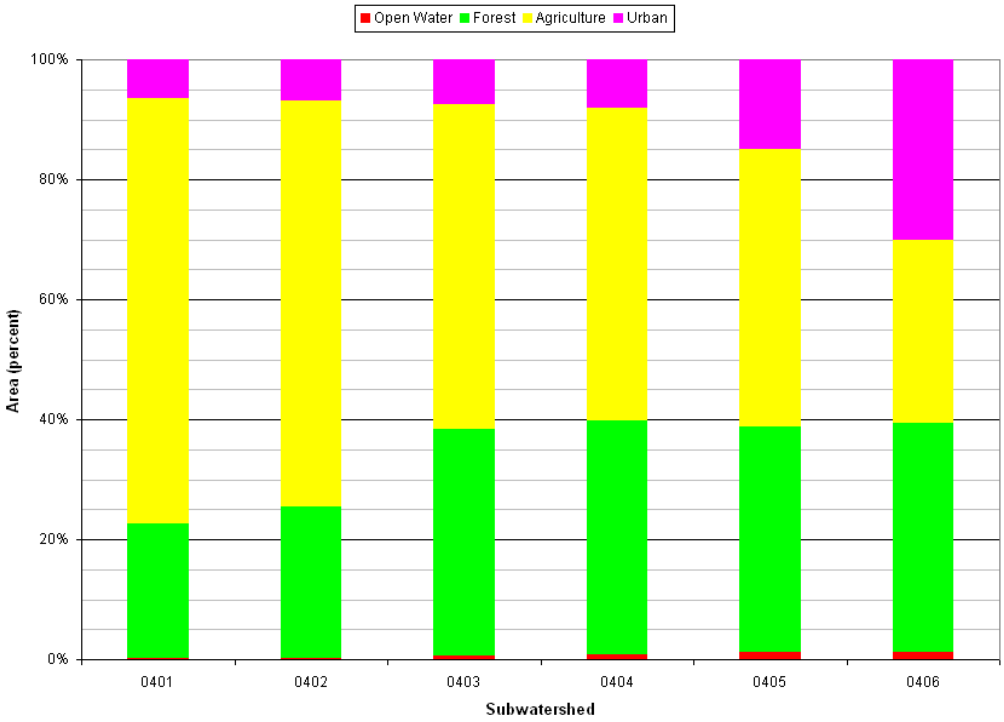

Figure 9b. Land Use Percent of the Loosahatchie River E. coli-Impaired HUC-12s 0401 thru 0406

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 Proposed Final 2010 303(d) list.

8.1 Expression of TMDLs, WLAs, & LAs

In this document, the E. coli TMDL is a daily load expressed as a function of mean daily flow (daily loading function). For implementation purposes, corresponding percent load reduction goals (PLRGs) to decrease E. coli loads to TMDL target levels, within each respective flow zone, are also expressed. WLAs & LAs for precipitation-induced loading sources are also expressed as daily loading functions in CFU/day/acre. Allocations for loading that is independent of precipitation (WLAs for WWTFs and LAs for “other direct sources”) are expressed as CFU/day.

8.2 Area Basis for TMDL Analysis

The primary area unit of analysis for TMDL development was the HUC-12 subwatershed containing one or more waterbodies assessed as impaired due to E. coli (as documented on the Proposed Final 2010 303(d) List). In some cases, however, TMDLs may be developed for an impaired waterbody drainage area only. Determination of the appropriate area to use for analysis 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. For the Loosahatchie River Watershed, all TMDLs were developed on a HUC-12 basis.

8.3 TMDL Analysis Methodology

TMDLs for the Loosahatchie 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 ten-year period from October 1, 1998 to September 30, 2008 was used to simulate for most waterbodies flow. This 10-year period contained a range of hydrologic conditions that included both low and high streamflows. Critical conditions are accounted for in the load duration curve analyses by using the entire period of flow and water quality data available for the impaired waterbodies.

In all subwatersheds, 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 Loosahatchie River watershed (see Section 9.1.2 and 9.1.3).

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

8.5 Margin of Safety

There are two methods for incorporating MOS in TMDL analysis: a) implicitly incorporate the MOS using conservative model assumptions; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. For development of pathogen TMDLs in the Loosahatchie 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 Loosahatchie 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 7.

8.7 Determination of WLAs & LAs

WLAs for MS4s and LAs for precipitation induced sources of E. coli loading were determined according to the procedures in Appendix C. These allocations represent the available loading <u>after application of the explicit MOS</u>. WLAs for existing WWTFs are equal to their existing NPDES permit limits. Since WWTF permit limits require that E. coli concentrations must comply with water quality criteria (TMDL targets) at the point of discharge (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 7.

Table 7 TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Loosahatchie River Watershed (HUC 08010209)

HUC-12 Subwatershed (08010209__) 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	Loosahatchie River	TN08010209011 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.211 \times 10^{6} \times Q$
0103	Jones Creek	TN08010209010 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.746 \times 10^{6} \times Q$
0104	Treadville Bottom	TN08010209008 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.516 \times 10^{6} \times Q$
0105	Loosahatchie River	TN08010209007 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	3.188×10^{10}	0	NA	$(2.827 \times 10^{5} \times Q) - (4.353 \times 10^{5})$
0201	East Beaver Creek	TN08010209016 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.156×10^{9}	0	$(5.032 \times 10^{5} \times Q) - (1.010 \times 10^{5})$	$(5.032 \times 10^{5} \times Q) - (1.010 \times 10^{5})$
0202	West Beaver Creek	TN08010209016 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.204 \times 10^{6} \times Q$	$1.204 \times 10^{6} \times Q$
0203	Beaver Creek	TN08010209016 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.156×10^{9}	0	$(2.223 \times 10^{5} \times Q) - (4.463 \times 10^{4})$	$(2.223 \times 10^{5} \times Q) - (4.463 \times 10^{4})$
	Kelley Branch	TN08010209016 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$4.346 \times 10^{6} \times Q$
0301	Big Creek	TN08010209021 – 3000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.986×10^{8}	0	$(1.027 \times 10^{6} \times Q) - (2.473 \times 10^{4})$	$(1.027 \times 10^{6} \times Q) - (2.473 \times 10^{4})$
	Big Creek	TN08010209021 – 4000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.986×10^{8}	0	$(1.632 \times 10^{6} \times Q) - (3.931 \times 10^{4})$	$(1.632 \times 10^{6} \times Q) - (3.931 \times 10^{4})$
	Crooked Creek Canal	TN08010209021 – 0500	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.603×10^{9}	0	$(1.822 \times 10^{6} \times Q) - (1.411 \times 10^{5})$	$(1.822 \times 10^{6} \times Q) - (1.411 \times 10^{5})$
0302	Big Creek	TN08010209021 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	2.092×10^{11}	0	$(3.658 \times 10^{5} \times Q) - (3.697 \times 10^{6})$	$(3.658 \times 10^{5} \times Q) - (3.697 \times 10^{6})$
	North Fork Creek	TN08010209021 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	5.164×10^{8}	0	$(1.931 \times 10^{6} \times Q) - (4.818 \times 10^{4})$	$(1.931 \times 10^{6} \times Q) - (4.818 \times 10^{4})$
	Royster Creek	TN08010209021 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.892 \times 10^{6} \times Q$	$1.892 \times 10^{6} \times Q$
0303	Big Creek	TN08010209021 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	2.094×10^{11}	0	$(2.144 \times 10^{5} \times Q) - (2.169 \times 10^{6})$	$(2.144 \times 10^{5} \times Q) - (2.169 \times 10^{6})$
	Bear Creek	TN08010209021 – 0110	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$5.027 \times 10^{6} \times Q$	$5.027 \times 10^{6} \times Q$
	Jakes Creek	TN08010209021 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.969 \times 10^{6} \times Q$	$3.969 \times 10^{6} \times Q$
0401	Laurel Creek	TN08010209014 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.744 \times 10^{6} \times Q$
0402	Little Cypress Creek	TN08010209015 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.203 \times 10^{6} \times Q$

Table 7 (cont'd) TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Loosahatchie River Watershed (HUC 08010209)

HUC-12 Subwatershed (08010209__) 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]
0403	Black Ankle Creek	TN08010209004 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.203 \times 10^{6} \times Q$
	Loosahatchie River	TN08010209004 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.466×10^{11}	0	$(1.256 \times 10^{5} \times Q) - (8.744 \times 10^{5})$	$(1.256 \times 10^{5} \times Q) - (8.744 \times 10^{5})$
0404	Cypress Creek	TN08010209003 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.603×10^{9}	0	$(5.454 \times 10^{5} \times Q) - (4.223 \times 10^{4})$	$(5.454 \times 10^{5} \times Q) - (4.223 \times 10^{4})$
0405	Rocky Branch	TN08010209002 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$8.179 \times 10^{6} \times Q$
	Scotts Creek	TN08010209002 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.033 \times 10^{7} \times Q$	$1.033 \times 10^{7} \times Q$
	Oliver Creek	TN08010209002 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$9.452 \times 10^{6} \times Q$	$9.452 \times 10^{6} \times Q$
	Buckhead Creek	TN08010209002 – 0500	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$5.406 \times 10^{6} \times Q$	$5.406 \times 10^{6} \times Q$
	Howard Creek	TN08010209002 – 0600	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.112 \times 10^{7} \times Q$	$1.112 \times 10^{7} \times Q$
	Loosahatchie River	TN08010209002 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.175×10^{11}	0	$(6.459 \times 10^{4} \times Q) - (1.030 \times 10^{6})$	$(6.459 \times 10^{4} \times Q) - (1.030 \times 10^{6})$
0406	Loosahatchie River	TN08010209001 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	7.071×10^{11}	0	$(4.479 \times 10^{4} \times Q) - (1.530 \times 10^{6})$	$(4.479 \times 10^{4} \times Q) - (1.530 \times 10^{6})$
	Unnamed Trib to Loosahatchie River	TN08010209002 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$2.295 \times 10^{7} \times Q$
	Loosahatchie River	TN08010209002 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.976×10^{11}	0	$(6.098 \times 10^{4} \times Q) - (1.466 \times 10^{6})$	$(6.098 \times 10^{4} \times Q) - (1.466 \times 10^{6})$
	Todd Branch	TN08010209001 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$7.983 \times 10^{6} \times Q$	$7.983 \times 10^{6} \times Q$

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 Loosahatchie 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. It relies on participation at the federal, state, local and non-governmental levels to be successful.

9.1 Application of Load Duration Curves for Implementation Planning

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

9.1.1 Flow Zone Analysis for Implementation Planning

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

For the purposes of implementation strategy development, available E. coli data are grouped according to flow zones, with the number of flow zones determined by the HUC-12 subwatershed or drainage area size, the total contributing area (for non-headwater HUC-12s), and/or the baseflow characteristics of the waterbody. In general, for drainage areas greater than 40 square miles, the duration curves will be divided into five zones (Figure 10): 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.

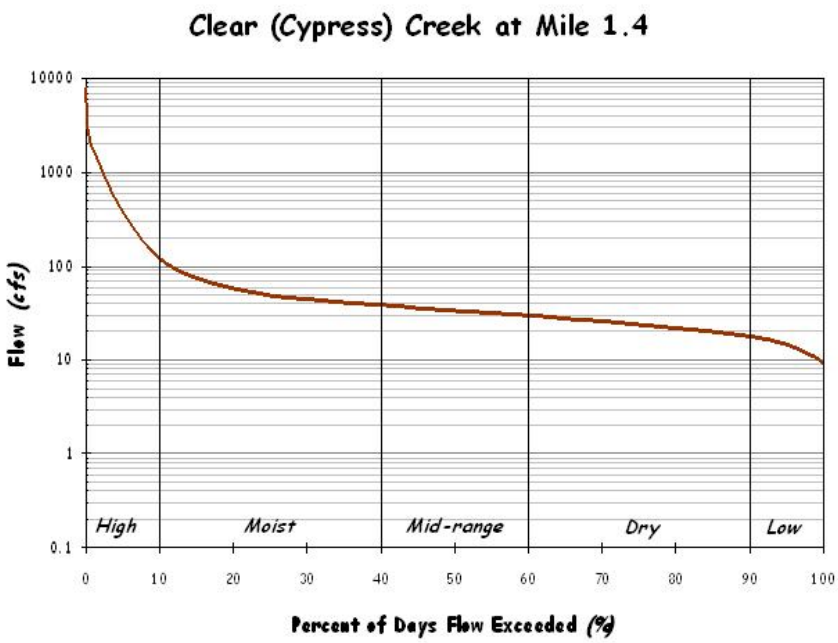

Figure 10. Five-Zone Flow Duration Curve for Clear (Cypress) Creek at RM 1.4

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 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 Cumberland River Compact. The Cumberland River Compact is a non-profit group made up of businesses, individuals, community organizations, and agencies working in the Cumberland River watershed. Members of the Compact work with educators, landowners, contractors, marinas and other interested groups to coordinate informational education programs that encourage all of us to be better stewards of our water resources. The Compact works with local, state and federal agencies and officials to promote and strengthen cooperative working relationships and encourage the development of reliable, easy-to-understand data about water quality. Members of the Compact work with local communities to develop watershed forums where citizens come together to learn more about their watershed and participate in developing a shared vision for the future. The Compact also serves as a clearing-house of available public education programs to landowner assistance. Information regarding the accomplishments of the Cumberland River Compact is available at their website:

http://www.cumberlandrivercompact.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 Loosahatchie 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 Loosahatchie 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 Loosahatchie River watershed are shown in Figure 11. 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.

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

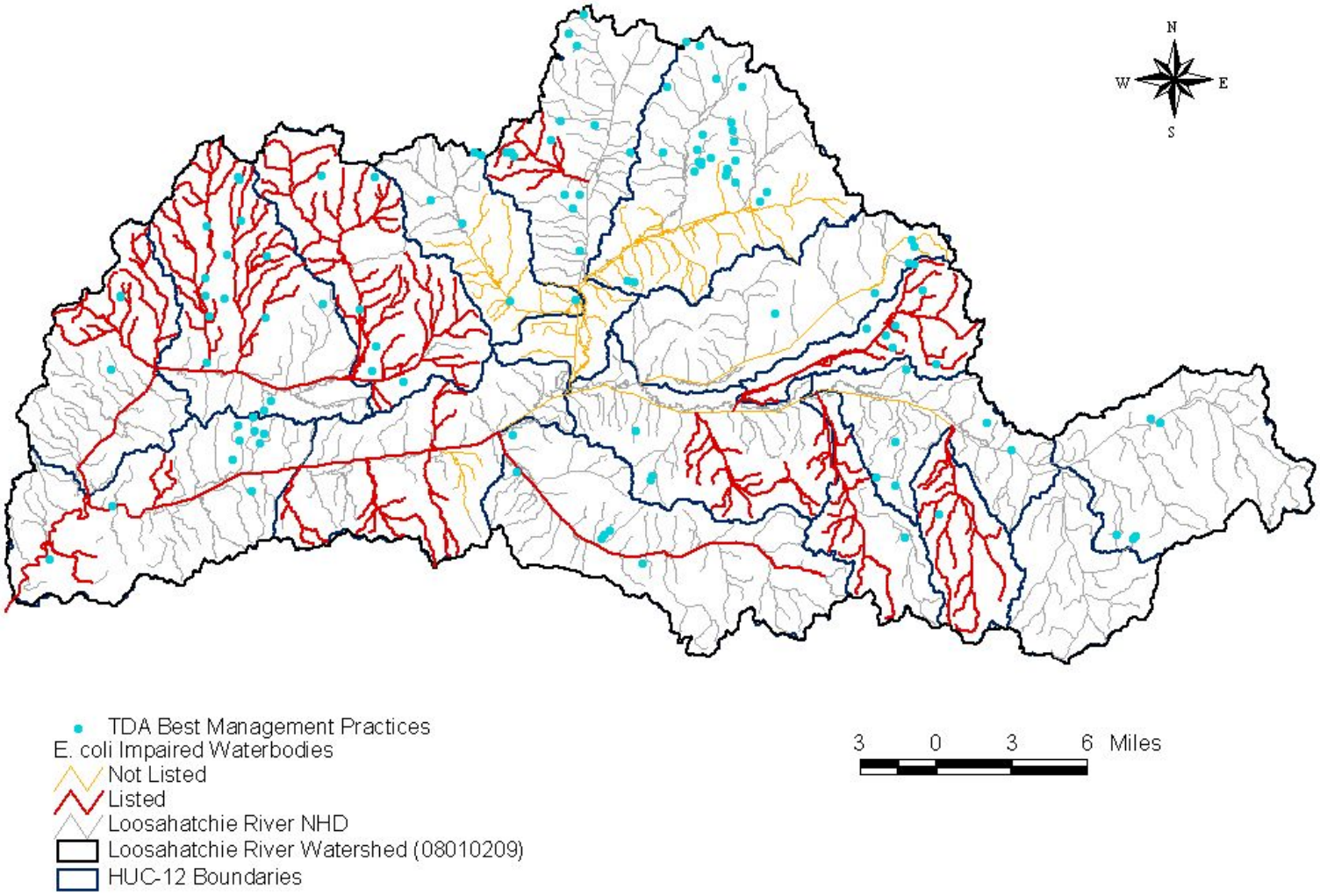

Figure 11. NRCS Best Management Practices located in the Loosahatchie River Watershed.

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 Loosahatchie River watershed:

Verify the assessment status of stream reaches identified on the Proposed Final 2010 303(d) List as impaired due to E. coli. 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. Analyses of existing data at several monitoring sites on unlisted waterbodies in the Loosahatchie River watershed suggest levels of impairment. Therefore, additional data are required for listing determination.

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

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

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

9.5 Source Area Implementation Strategy

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

Appendix E provides source area implementation examples for urban and agricultural subwatersheds, development of percent load reduction goals, and determination of critical flow zones (for implementation prioritization) for E. coli impaired waterbodies. Load duration curve analyses (TMDLs, WLAs, LAs, and MOS) and percent load reduction goals for all flow zones for all E. coli impaired waterbodies in the Loosahatchie River watershed are summarized in Table E-53.

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

Waterbody Name	Source Area Type*			
	Urban	Agricultural	Mixed	Forested
Loosahatchie Riverl (011-1000)		Ò		
Jones Creek		Ò		
Treadville Bottom		Ò		
Loosahatchie River (007-1000)		Ò		
East Beaver Creek				
West Beaver Creek		Ò		
Beaver Creek		Ò		
Kelley Branch		Ò		
Big Creek (021-3000)		Ò		
Big Creek (021-4000)		Ò		
Crooked Creek Canal		Ò		
Big Creek (021-2000)			Ò	
North Fork Creek	Ò			
Royster Creek		Ò		
Big Creek (021-1000)			Ò	
Bear Creek		Ò		
Jakes Creek		Ò		
Laurel Creek		Ò		
Little Cypress Creek		Ò		
Black Ankle Creek		Ò		
Loosahatchie River (004-1000)		Ò		
Cypress Creek		Ò		
Rocky Branch		Ò		
Scotts Creek	Ò			
Oliver Creek	Ò			
Buckhead Creek	Ò			
Howard Creek	Ò			
Loosahatchie River (002-2000)			Ò	

Table 8 (cont'd). Source area types for waterbody drainage area analyses.

Waterbody Name	Source Area Type*			
	Urban	Agricultural	Mixed	Forested
Loosahatchie River (001-1000)	Ò			
UT to Loosahatchie River	Ò			
Loosahatchie River (002-1000)	Ò			
Todd 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 9 (USEPA, 2006). Table 9 presents example urban area management practices and the corresponding potential relative effectiveness under each of the hydrologic flow zones. Each implementation strategy addresses a range of flow conditions and targets point sources, non-point sources, or a combination of each. For each waterbody, the existing loads and corresponding PLRG for each flow zone are calculated according to the method described in Section E.4. The resulting determination of the critical flow zone further focuses the types of urban management practices appropriate for development of an effective load reduction strategy for a particular waterbody.

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

Management Practice	Duration Curve Zone (Flow Zone)				
	High	Moist	Mid-Range	Dry	Low
Bacteria source reduction					
Remove illicit discharges			L	M	H
Address pet & wildlife waste		H	M	M	L
Combined sewer overflow management					
Combined sewer separation		H	M	L	
CSO prevention practices		H	M	L	
Sanitary sewer system					
Infiltration/Inflow mitigation	H	M	L	L	
Inspection, maintenance, and repair		L	M	H	H
SSO repair/abatement	H	M	L		
Illegal cross-connections					
Septic system management					
Managing private systems		L	M	H	M
Replacing failed systems		L	M	H	M
Installing public sewers		L	M	H	M

Table 9 (cont'd). Example Urban Area Management Practice/Hydrologic Flow Zone Considerations.

Management Practice	Duration Curve Zone (Flow Zone)				
	High	**Moist**	**Mid-Range**	**Dry**	**Low**
Storm water infiltration/retention					
Infiltration basin		L	M	H	
Infiltration trench		L	M	H	
Infiltration/Biofilter swale		L	M	H	
Storm Water detention					
Created wetland		H	M	L	
Low impact development					
Disconnecting impervious areas		L	M	H	
Bioretention	L	M	H	H	
Pervious pavement		L	M	H	
Green Roof		L	M	H	
Buffers		H	H	H	
New/existing on-site wastewater treatment systems					
Permitting & installation programs		L	M	H	M
Operation & maintenance programs		L	M	H	M
Other					
Point source controls		L	M	H	H
Landfill control		L	M	H	
Riparian buffers		H	H	H	
Pet waste education & ordinances		M	H	H	L
Wildlife management		M	H	H	L
Inspection & maintenance of BMPs	L	M	H	H	L
Note: Potential relative importance of management practice effectiveness under given hydrologic condition (*H: High, M: Medium, L: Low*)					

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 10 (USDA, 1988). Table 10 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 10. 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 10 (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 Loosahatchie 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 12 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 13 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 14 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 12-14 present the same data, from approved TMDLs (2 cycles), each clearly illustrating improving conditions between historical and recent periods.

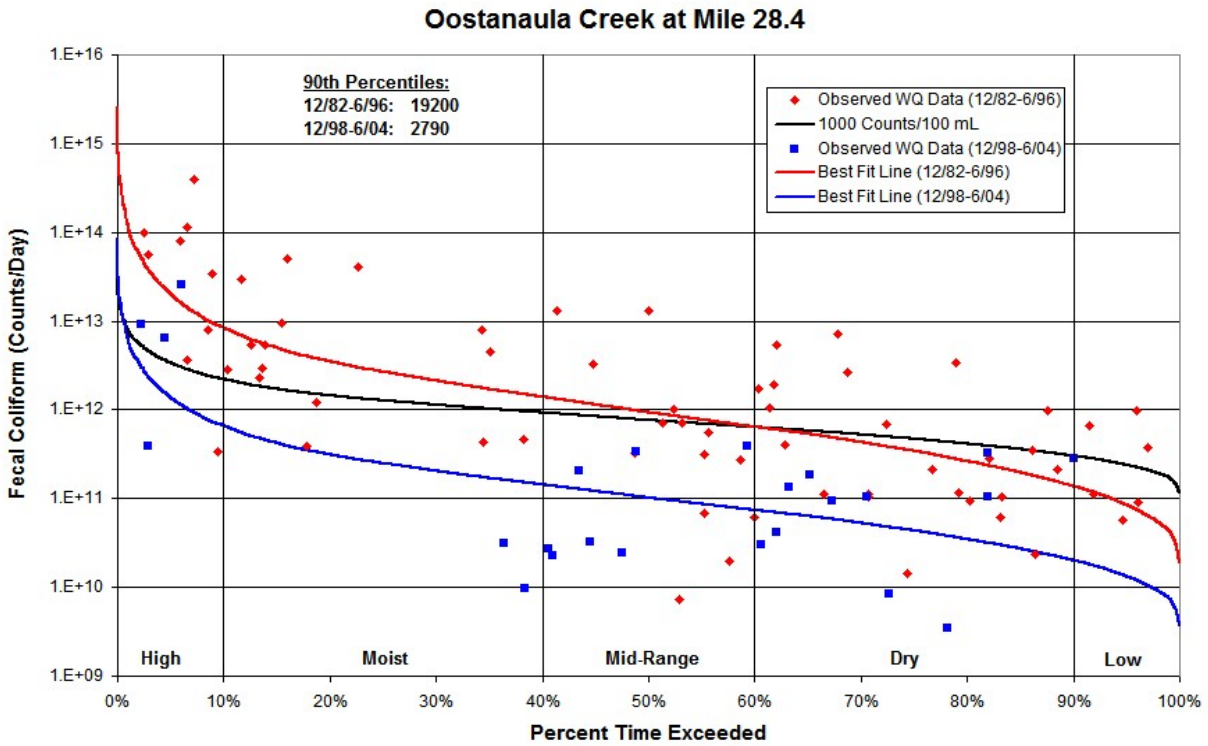

Figure 12. Oostanaula Creek TMDL implementation effectiveness (LDC regression analysis).

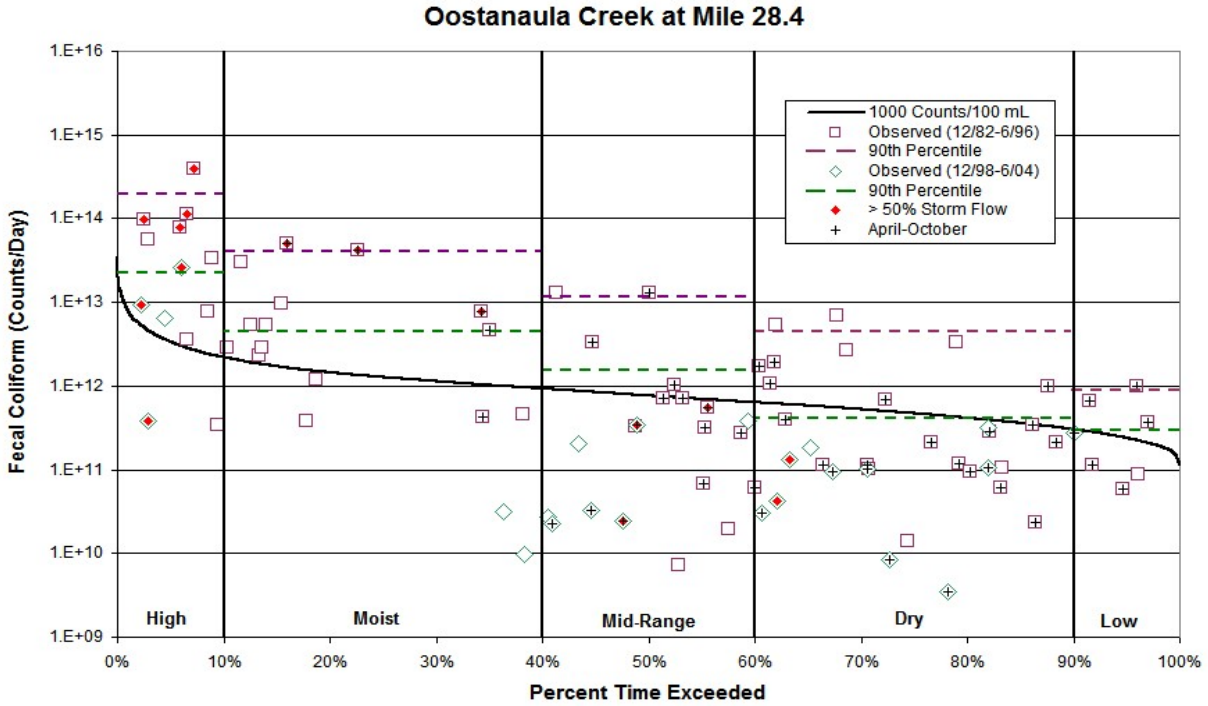

Figure 13. Oostanaula Creek TMDL implementation effectiveness (LDC analysis).

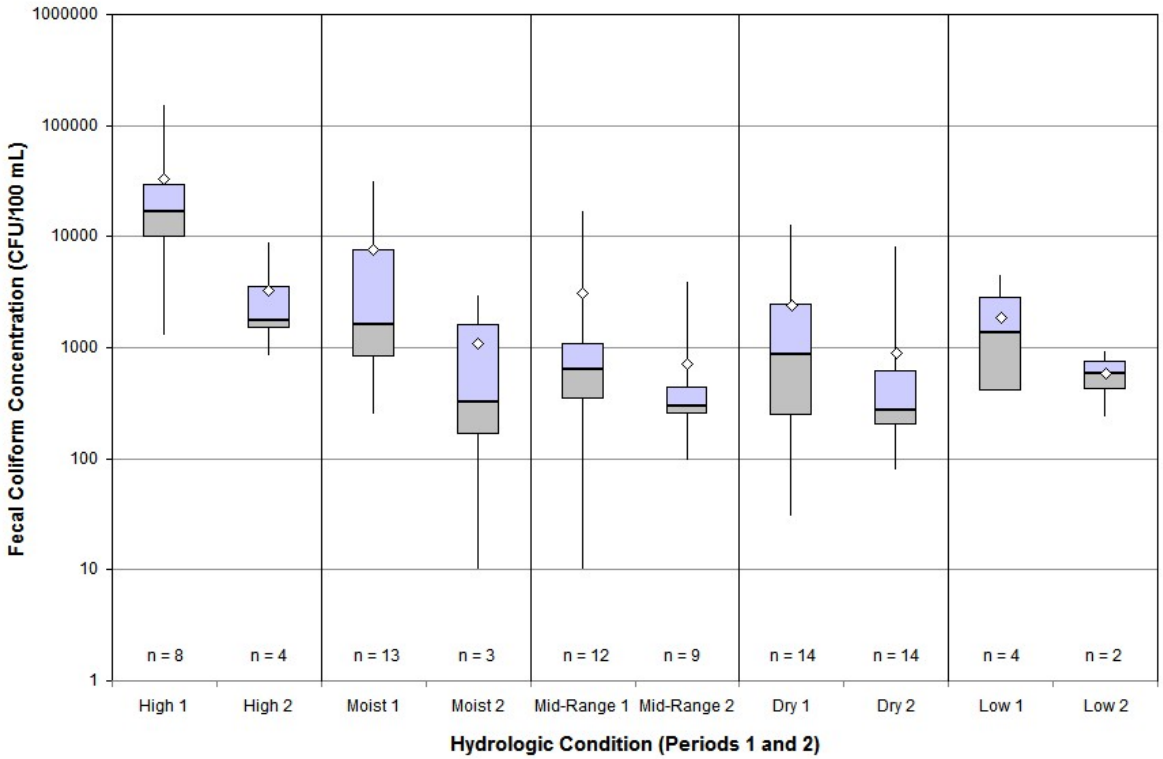

Figure 14. Oostanaula Creek TMDL implementation effectiveness (box and whisker plot).

10.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed pathogen TMDLs for the Loosahatchie 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 Loosahatchie 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:

   Millington STP #2 (TN0021067)
   Somerville Lagoon (TN0021652)
   Northwest School (TN0023795)
   E.E. Jetter School (TN0023833)
   Memphis-Chapel Hill S.D. STP (TN0026361)
   Mason STP (TN0026620)
   Camelia Homes Inc. (TN0056863)
   Pine Grove Mobile Home Park (TN0056871)
   Pine Lake Cooperative (TN0061433)
   Gallaway STP (TN0062138)
   Mallard Ridge Mobile Estates (TN0065277)
   Bartlett STP No. 1 (TN0066800)
   Pleasant Ridge Trailer Park (TN0067482)
   Bartlett WWTP #2 (TN0068543)
   Oakland-Mechanical – WWTP (TN0077836)
   City of Lakeland (TN0078255)
   Arlington STP (TN0078603)

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:

   City of Bartlett, Tennessee (TNS075698)
   City of Lakeland, Tennessee (TNS077526)
   City of Memphis, Tennessee (TNS068276)
   City of Millington, Tennessee (TNS075442)
   Shelby County, Tennessee (TNS075663)
   Tennessee Dept. of Transportation (TNS077585)

5) A letter was sent to water quality partners in the Loosahatchie 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 wouldbe provided upon request. A letter was sent to the following partners:

Natural Resources Conservation Service
Tennessee Department of Agriculture
Tennessee Wildlife Resources Agency
The Nature Conservancy

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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REFERENCES

Center for Watershed Protection, 1999. *Watershed Protection Techniques*. Vol. 3. No. 1. Center for Watershed Protection. Ellicott City, MD. April 1999.

Cleland, Bruce, 2003. *TMDL Development from the "Bottom Up" – Part III: Duration Curves and Wet-Weather Assessments*. America's Clean Water Foundation. Washington, DC. September 2003. This document can be found at TMDLs.net, a joint effort of America's Clean Water Foundation, the Association of State and Interstate Water Pollution Control Administrators, and EPA: http://www.tmdls.net/tipstools/docs/TMDLsCleland.pdf.

ENSR. 2005. *Mitigation Measures to Address Pathogen Pollution in Surface Waters: A TMDL Implementation Guidance Manual for Massachusetts*. Prepared by ENSR International for U.S. Environmental Protection Agency, Region 1. July 2005.

Hyer, Kenneth E., and Douglas L. Moyer, 2004. *Enhancing Fecal Coliform Total Maximum Daily Load Models Through Bacterial Source Tracking*. Journal of the American Water Resources Association (JAWRA) 40(6):1511-1526. Paper No. 03180.

Lane, S. L., and R. G. Fay, 1997. *National Field Manual for the Collection of Water-Quality Data, Chapter A9. Safety in Field Activities: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. 9*. October 1997. This document is available on the USGS website: http://water.usgs.gov/owq/FieldManual/Chap9/content.html.

Lawrence, Thomas B., and Samadpour, Mansour, 2003. *Microbial Source Tracking Study for South Cypress Creek (HUC TN 08010211007) Memphis, TN*. This document is available on the City of Memphis website: http://www.cityofmemphis.org/pdf_forms/MicrobialSourceTrackingStudy.pdf and http://www.cityofmemphis.org/pdf_forms/MicrobialSourceTrackingStudyFigures.pdf.

Layton, Alice, Gentry, Randy, and McKay, Larry, 2004. *Calculation of Stock Creek E. coli loads and partitioning of E. coli loads in to that attributable to bovine using Bruce Cleland's Flow Duration Curve Models*. Personal note.

Layton, Alice, McKay, Larry, Williams, Dan, Garrett, Victoria, Gentry, Randall, and Sayler, Gary, 2006. *Development of Bacteriodes 16S rRNA Gene TaqMan-Based Real-Time PCR Assays for Estimation of Total Human, and Bovine Fecal Pollution in Water*. Applied and Environmental Microbiology (AEM), June 2006, p. 4214-4224. This document is available on the UTK website: http://web.utk.edu/~hydro/JournalPapers/Layton06AEM.pdf .

Lumb, A.M., McCammon, R.B., and Kittle, J.L., Jr., 1994, Users Manual for an expert system, (HSPFEXP) for calibration of the Hydrologic Simulation Program –Fortran: U.S. Geological Survey Water-Resources Investigation Report 94-4168,102 p.

Shah, Vikas G., Hugh Dunstan, and Phillip M. Geary, 2004. *Application of Emerging Bacterial Source Tracking (BST) Methods to Detect and Distinguish Sources of Fecal Pollution in Waters.* School of Environmental and Life Sciences, The University of Newcastle, Callaghan, NSW 2308 Australia. This document is available on the University of Newcastle website: http://www.newcastle.edu.au/discipline/geology/staff_pg/pgeary/BacterialSourceTracking.pdf.

Stiles, T., and B. Cleland, 2003, Using Duration Curves in TMDL Development & Implementation Planning. ASIWPCA "States Helping States" Conference Call, July 1, 2003. This document is available on the Indiana Office of Water Quality website: http://www.state.in.us/idem/programs/water/tmdl/durationcurveshscall.pdf .

TDEC. 2003. *General Permit for Discharges from Small Municipal Separate Storm Sewer Systems.* State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control, February 2003. This document is available on the TDEC website: http://state.tn.us/environment/wpc/stormh2o/MS4II.shtml.

TDEC. 2004. *Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water.* State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control.

TDEC. 2007. *State of Tennessee Water Quality Standards, Chapter 1200-4-3 General Water Quality Criteria, 2007 Version.* State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control.

TDEC. 2010. *Proposed Final 2010 303(d) List*. State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control, August 2010.

USDA, 1988. *1-4 Effects of Conservation Practices on Water Quantity and Quality*. In *Water Quality Workshop, Integrating Water Quality and Quantity into Conservation Planning*. U.S. Department of Agriculture, Soil Conservation Service. Washington, D.C.

USDA, 2004. *2002 Census of Agricultue, Tennessee State and County Data, Volume 1, Geographic Area Series, Part 42 (AC-02-A-42)*. USDA website URL: http://www.nass.usda.gov/census/census02/volume1/tn/index2.htm . June 2004.

USEPA. 1991. *Guidance for Water Quality –based Decisions: The TMDL Process.* U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA-440/4-91-001, April 1991.

USEPA. 1997. *Ecoregions of Tennessee*. U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Corvallis, Oregon. EPA/600/R-97/022.

USEPA, 2002a. *Animal Feeding Operations Frequently Asked Questions*. USEPA website URL: http://cfpub.epa.gov/npdes/faqs.cfm?program_id=7 . September 12, 2002.

USEPA, 2002b. *Wastewater Technology Fact Sheet, Bacterial Source Tracking*. U.S. Environmental Protection Agency, Office of Water. Washington, D.C. EPA 832-F-02-010, May 2002. This document is available on the EPA website: http://www.epa.gov/owm/mtb/bacsortk.pdf.

USEPA. 2003. *National Management Measures to Control Nonpoint Source Pollution from Agriculture*. EPA 841-B-03-004. U.S. Environmental Protection Agency. Washington, DC. This document is available on the EPA website: http://www.epa.gov/owow/nps/agmm/index.html.

USEPA. 2004. *The Use of Best Management Practices (BMPs) in Urban Watersheds*. U.S. Environmental Protection Agency, Office of Research and Development. Washington, D.C. EPA/600/R-04/184, September 2004.

USEPA. 2005a. *National Management Measures to Control Nonpoint Source Pollution from Urban Areas*. U.S. Environmental Protection Agency, Office of Water. Washington, D.C. EPA 841-B-05-004, November 2005. This document is available on the EPA website: http://www.epa.gov/owow/nps/urbanmm/index.html.

USEPA. 2005b. *National Management Measures to Control Nonpoint Source Pollution from Forestry*. U.S. Environmental Protection Agency, Office of Water. Washington, D.C. EPA 841-B-05-001, May 2005. This document is available on the EPA website: http://www.epa.gov/owow/nps/forestrymgmt/.

USEPA, 2006. *An Approach for Using Load Duration Curves in Developing TMDLs.* U.S. Environmental Protection Agency, Office of Wetlands, Oceans, & Watersheds. Washington, D.C. Draft, December 2006.

APPENDIX A

Land Use Distribution in the Loosahatchie River Watershed

Table A-1 2001 MRLC Land Use Distribution of Impaired Subwatersheds

Land Use	Impaired Subwatershed (08010209____)							
	0102		0103 (Jones Creek)		0104 (Treadville Bottom)		0105	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Unclassified	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Open Water	188.5	0.60	96.8	0.73	70.9	0.54	150.2	0.73
Developed Open Space	1,363.5	4.34	584.7	4.41	516.0	3.93	907.5	4.41
Low Intensity Development	380.1	1.21	323.5	2.44	277.0	2.11	502.1	2.44
Medium Intensity Development	50.3	0.16	94.1	0.71	39.4	0.30	146.1	0.71
High Intensity Development	0.0	0.00	21.2	0.16	5.3	0.04	32.9	0.16
Bare Rock	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Deciduous Forest	10,816.5	34.43	1,835.0	13.84	2,442.0	18.60	2,848.1	13.84
Evergreen Forest	559.2	1.78	123.3	0.93	227.1	1.73	191.4	0.93
Mixed Forest	1,008.5	3.21	242.6	1.83	235.0	1.79	376.6	1.83
Shrub/Scrub	5,636.0	17.94	1,259.6	9.50	1,601.7	12.20	1,955.0	9.50
Grassland/Herbaceous	81.7	0.26	29.2	0.22	39.4	0.30	45.3	0.22
Pasture/Hay	2,733.2	8.70	2,181.1	16.45	2,075.7	15.81	3,385.2	16.45
Row Crops	7,093.7	22.58	5,849.9	44.12	4,747.4	36.16	9,079.5	44.12
Woody Wetlands	1,347.7	4.29	575.4	4.34	786.4	5.99	893.1	4.34
Emergent Herbaceous Wetland	160.2	0.51	42.4	0.32	65.6	0.50	65.9	0.32
Subtotal – Urban	1,793.9	5.71	1,023.6	7.72	837.6	6.38	1,588.7	7.72
Subtotal - Agriculture	9,826.9	31.28	8,031.0	60.57	6,823.1	51.97	12,464.7	60.57
Subtotal – Forest	19,609.9	62.42	4,107.6	30.98	5,397.3	41.11	6,375.4	30.98
Total	**31,419**	**100.00**	**13,259**	**100.00**	**13,129**	**100.00**	**20,579**	**100.00**

Table A-1 (cont'd) 2001 MRLC Land Use Distribution of Impaired Subwatersheds

Land Use	Impaired Subwatershed (08010209____)							
	0201 (East Beaver Creek)		0202 (West Beaver Creek)		0203		0301	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Unclassified	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Open Water	102.8	0.25	61.4	0.35	161.6	0.47	246.16	0.75
Developed Open Space	1,843.0	4.48	842.7	4.80	1,783.7	5.18	1,824.30	5.57
Low Intensity Development	571.8	1.39	215.9	1.23	357.5	1.04	1,070.87	3.27
Medium Intensity Development	41.1	0.10	15.8	0.09	26.9	0.08	234.04	0.71
High Intensity Development	4.1	0.01	1.8	0.01	3.4	0.01	45.10	0.14
Bare Rock	0.0	0.00	0.0	0.00	0.0	0.00	0.00	0.00
Deciduous Forest	2,246.2	5.46	1,783.7	10.16	5,430.5	15.78	4,157.75	12.69
Evergreen Forest	230.4	0.56	96.6	0.55	185.2	0.54	542.78	1.66
Mixed Forest	65.8	0.16	36.9	0.21	92.8	0.27	139.66	0.43
Shrub/Scrub	1,254.8	3.05	849.7	4.84	2,402.3	6.98	3,216.70	9.81
Grassland/Herbaceous	37.0	0.09	12.3	0.07	15.9	0.05	9.70	0.03
Pasture/Hay	4,081.0	9.92	2,082.2	11.86	4,880.2	14.18	4,794.79	14.63
Row Crops	26,855.9	65.28	10,330.1	58.84	17,602.6	51.14	15,168.97	46.28
Woody Wetlands	3,488.6	8.48	1,118.3	6.37	1,324.4	3.85	934.61	2.85
Emergent Herbaceous Wetland	312.7	0.76	108.8	0.62	155.8	0.45	390.11	1.19
Subtotal – Urban	2,460.1	5.98	1,076.2	6.13	2,171.6	6.31	3,174.3	9.68
Subtotal - Agriculture	30,936.9	75.20	12,412.2	70.70	22,482.8	65.31	19,963.8	60.91
Subtotal – Forest	7,635.5	18.56	4,006.3	22.82	9,606.9	27.91	9,391.3	28.65
Total	**41,135**	**100.0**	**17,556**	**100.0**	**34,423**	**100.0**	**32,776**	**100.00**

Table A-1 (cont'd) 2001 MRLC Land Use Distribution of Impaired Subwatersheds

Land Use	Impaired Subwatershed (08010209____)							
	0302		0303		0401 (Laurel Creek Canel)		0402 (Little Cypress)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Unclassified	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Open Water	332.40	0.81	222.47	0.81	34.9	0.26	82.3	0.27
Developed Open Space	1,975.30	6.01	1,322.02	6.01	525.6	3.92	1,122.1	3.68
Low Intensity Development	2,529.29	4.20	1,692.80	4.20	337.9	2.52	878.1	2.88
Medium Intensity Development	1,008.66	1.04	675.07	1.04	9.4	0.07	67.1	0.22
High Intensity Development	145.19	0.20	97.17	0.20	1.3	0.01	6.1	0.02
Bare Rock	0.00	0.00	0.00	0.00	0.0	0.00	6.1	0.02
Deciduous Forest	2,911.36	14.78	1,948.51	14.78	750.8	5.60	1,832.5	6.01
Evergreen Forest	718.29	1.93	480.73	1.93	63.0	0.47	463.5	1.52
Mixed Forest	87.88	0.44	58.81	0.44	24.1	0.18	79.3	0.26
Shrub/Scrub	3,797.76	11.25	2,541.76	11.25	602.0	4.49	2,021.6	6.63
Grassland/Herbaceous	0.00	0.04	0.00	0.04	22.8	0.17	85.4	0.28
Pasture/Hay	5,872.40	12.13	3,930.26	12.13	2,603.6	19.42	5,476.2	17.96
Row Crops	17,980.15	43.87	12,033.71	43.87	6,903.3	51.49	15,163.2	49.73
Woody Wetlands	91.70	2.29	61.37	2.29	1,418.5	10.58	2,972.9	9.75
Emergent Herbaceous Wetland	752.68	1.01	503.75	1.01	111.3	0.83	231.7	0.76
Subtotal – Urban	5,658.4	11.45	3,787.1	11.45	874.1	6.52	2,073.4	6.80
Subtotal - Agriculture	23,852.6	56.00	15,964.0	56.00	9,506.9	70.91	20,639.4	67.69
Subtotal – Forest	8,359.7	31.74	5,594.9	31.74	2,992.4	22.32	7,692.9	25.23
Total	**38,203**	**100.00**	**25,568**	**100.0**	**13,408**	**100.0**	**30,488**	**100.0**

Table A-1 (cont'd) 2001 MRLC Land Use Distribution of Impaired Subwatersheds

Land Use	Impaired Subwatershed (08010209____)							
	0403		0404 (Cypress Creek)		0405		0406	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Unclassified	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Open Water	157.6	0.53	292.3	0.77	413.8	1.18	452.2	1.21
Developed Open Space	1,052.9	3.54	1,465.1	3.86	2,640.5	7.53	5,530.7	14.80
Low Intensity Development	957.8	3.22	1,210.8	3.19	1,862.0	5.31	4,159.2	11.13
Medium Intensity Development	169.5	0.57	364.4	0.96	655.7	1.87	1,345.3	3.60
High Intensity Development	14.9	0.05	34.2	0.09	52.6	0.15	213.0	0.57
Bare Rock	0.0	0.00	0.0	0.00	0.0	0.00	512.0	1.37
Deciduous Forest	3,358.1	11.29	6,004.5	15.82	4,842.6	13.81	5,605.4	15.00
Evergreen Forest	1,177.9	3.96	1,913.0	5.04	1,146.7	3.27	1,569.5	4.20
Mixed Forest	324.2	1.09	717.4	1.89	789.0	2.25	220.5	0.59
Shrub/Scrub	3,176.7	10.68	4,664.7	12.29	2,861.4	8.16	2,578.5	6.90
Grassland/Herbaceous	47.6	0.16	30.4	0.08	10.5	0.03	26.2	0.07
Pasture/Hay	5,291.5	17.79	7,150.8	18.84	4,926.8	14.05	3,142.8	8.41
Row Crops	10,832.8	36.42	12,605.0	33.21	11,319.3	32.28	8,262.4	22.11
Woody Wetlands	2,953.6	9.93	1,366.4	3.60	3,148.9	8.98	3,505.3	9.38
Emergent Herbaceous Wetland	226.1	0.76	140.4	0.37	396.2	1.13	239.2	0.64
Subtotal – Urban	2,195.1	7.38	3,074.4	8.10	5,210.8	14.86	11,248.2	30.10
Subtotal - Agriculture	16,124.2	54.21	19,755.8	52.05	16,246.1	46.33	11,405.2	30.52
Subtotal – Forest	11,264.1	37.87	14,836.8	39.09	13,195.3	37.63	14,256.5	38.15
Total	**29,741**	**100.00**	**37,959**	**100.00**	**35,066**	**100.00**	**37,362**	**100.0**

APPENDIX B

Water Quality Monitoring Data
For Loosahatchie River Watershed

There are a number of water quality monitoring stations that provide data for waterbodies identified as impaired for pathogens in the Loosahatchie 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. Monitoring data reported by Memphis as part of their MS4 permit are tabulated in Table B-2.

Table B-1. TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
BANKL001.6FA	7/1/99	27.2
	7/31/02	111.8
	8/28/02	186.0
	9/30/02	488.4
	10/30/02	816.4
	11/20/02	190.4
	1/8/03	26.5
	1/28/03	22.8
	3/3/03	101.4
	3/26/03	>2,419.2
	4/23/03	301.0
	5/28/03	49.6
	6/25/03	23.1
	7/31/07	62.0
	8/6/07	35.0
	8/14/07	28.0
	8/21/07	9.0
	8/28/07	1.0
	8/29/07	4.0
	9/4/07	2.0
	10/2/07	148.0
	10/30/07	74.0
	11/27/07	411.0
	1/3/08	60.0
	1/30/08	1,112.0
	2/27/08	91.0
	3/4/08	4,106.0
	3/11/08	218.0
	3/19/08	2,613.0
	3/25/08	323.0
	3/26/08	179.0

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

Monitoring Station	Date	E. Coli [cts./100 mL]
BANKL001.6FA (cont'd)	4/29/08	2,420.0
	5/27/08	19,860.0
	6/24/08	99.0
BEAR001.2SH	7/7/99	21.8
	7/17/02	16.1
	8/14/02	135.4
	10/16/02	119.8
	11/13/02	104.3
	12/11/02	72.8
	1/15/03	32.7
	2/12/03	107.6
	3/12/03	123.6
	4/7/03	160.7
	5/14/03	461.1
	6/11/03	30.9
	7/11/07	980.0
	9/12/07	192.0
	10/17/07	1,300.0
	2/13/08	7,270.0
	3/12/08	471.0
	4/22/08	57.0
	5/13/08	548.0
	6/10/08	76.3
BEAVE1C1.0SH	8/20/98	103.4
	9/30/98	43.2
	10/21/98	248.1
	11/18/98	25.9
	12/15/98	37.7
	2/3/99	79.4
	4/4/00	980.1
	7/24/02	4,884.0
	8/21/02	97.0
	9/12/02	8.6
	10/23/02	49.5
	11/18/02	168.9
	12/16/02	133.6

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
BEAVA1C1.0SH (cont'd)	1/27/03	4.1
	2/19/03	82.0
	3/25/03	104.6
	4/16/03	66.3
	5/21/03	248.1
	6/18/03	328.2
	2/20/06	153.0
	11/20/06	135.0
	7/18/07	47.0
	8/22/07	1,986.0
	9/19/07	27.0
	12/18/07	285.0
	1/24/08	82.0
	3/18/08	144.0
	4/16/08	99.0
	5/22/08	82.0
	6/17/08	115.3
BIG1C1.0SH	8/20/98	117.8
	9/30/98	48.1
	10/21/98	145.0
	11/18/98	62.4
	12/15/98	1,299.7
	1/20/99	62.7
	3/3/99	93.4
	7/10/02	365.4
	8/7/02	209.0
	9/4/02	178.9
	10/9/02	461.1
	4/2/03	126.7
	5/12/03	2,613.0
	6/27/07	120.0
	8/8/07	7.0
	9/5/07	31.0
	10/10/07	1,733.0
	11/7/07	116.0
	12/5/07	68.0

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
BIG1C1.0SH (cont'd)	1/9/08	16,000.0
	2/6/08	12,590.0
	3/5/08	3,654.0
	4/2/08	305.0
	5/6/08	160.0
	6/3/08	86.0
BIG1C13.6SH	8/20/98	75.4
	9/30/98	172.3
	10/21/98	260.2
	11/18/98	40.4
	12/15/98	344.1
	3/2/99	231.0
	6/2/99	57.3
	9/1/99	58.3
	12/1/99	25.6
	3/22/00	152.9
	2/7/01	8.6
	7/17/02	20.3
	8/14/02	186.0
	9/11/02	9.8
	10/16/02	1,203.3
	11/13/02	84.0
	12/11/02	161.6
	1/15/03	25.9
	2/12/03	95.8
	3/12/03	57.6
	4/7/03	8,664.0
	5/14/03	171.0
	6/11/03	28.5
	7/11/07	166.0
	9/12/07	387.0
	10/17/07	2,420.0
	11/14/07	24,196.0
	12/12/07	1,153.0

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
BIG1C13.6SH (cont'd)	1/16/08	210.0
	2/13/08	1,782.0
	3/12/08	132.0
	4/22/08	100.0
	5/13/08	214.0
	6/10/08	72,419.6
BIG1C15.8SH	7/7/99	101.4
	7/17/02	52.6
	8/14/02	2,419.2
	9/11/02	39.3
	10/16/02	71.1
	11/13/02	740.0
	12/11/02	209.8
	1/15/03	26.9
	2/12/03	278.0
	3/12/03	111.9
	4/7/03	216.0
	5/14/03	185.0
	6/11/03	86.5
	7/11/07	179.0
	9/12/07	41.0
	10/17/07	1,553.0
	11/14/07	19,863.0
	12/12/07	617.0
	1/16/08	150.0
	2/13/08	2,909.0
	3/12/08	145.0
	4/22/08	53.0
	5/13/08	299.0
	6/10/08	461.1
BIG1C20.8TI	8/6/07	210.0
	8/14/07	17.0
	8/21/07	116.0
	8/28/07	10.0
	9/4/07	26.0
	11/14/07	6,131.0

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
BIG1C20.8TI (cont'd)	2/13/08	2,700.0
	3/4/08	5,475.0
	3/11/08	473.0
	3/12/08	174.0
	3/19/08	8,164.0
	3/25/08	31.0
	5/22/08	135.0
BIG1C8.4SH	3/3/99	298.7
	10/21/99	>2,419.2
	4/18/00	42.5
	7/17/02	410.6
	8/14/02	>2,419.2
	9/11/02	82.0
	10/16/02	118.7
	11/13/02	305.0
	12/11/02	248.1
	1/15/03	19.0
	2/12/03	920.0
	3/12/03	24.6
	4/7/03	5,974.0
	5/14/03	1,106.0
	6/11/03	47.2
	7/11/07	921.0
	9/12/07	548.0
	10/17/07	1,986.0
	11/14/07	14,140.0
	12/12/07	3,654.0
	1/16/08	41.0
	2/13/08	1,725.0
	3/12/08	187.0
	4/22/08	139.0
	5/13/08	299.0
	6/10/08	1,413.6

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
BUCKH002.1SH	7/7/99	>2,419.2
	7/10/02	81.3
	8/7/02	266.0
	9/4/02	113.7
	10/9/02	1,553.1
	11/6/02	14,136.0
	12/9/02	214.2
	1/14/03	60.1
	2/5/03	1,565.0
	3/4/03	88.2
	4/2/03	83.2
	5/12/03	3,873.0
	6/4/03	>2,419.2
	6/27/07	1,565.0
	10/10/07	>2,420.0
	11/7/07	1,414.0
	12/5/07	1,872.0
	1/9/08	10,000.0
	2/6/08	7,270.0
	3/5/08	14,136.0
	4/2/08	1,039.0
	5/6/08	190.0
	6/3/08	1,046.0
	4/13/10	111
	4/28/10	613
	5/6/10	101
	5/12/10	816
	5/25/10	2,420
	5/26/10	365
BUCKH003.8SH	4/13/10	2,420
	4/28/10	261
	5/6/10	172
	5/12/10	435
	5/25/10	1,986
	5/26/10	261

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
BUCKH005.2SH	4/13/10	67
	4/28/10	184
	5/6/10	57
	5/12/10	225
	5/25/10	980
	5/26/10	86
CLEAR001.4SH	2/7/01	59.8
	7/10/02	240.0
	8/7/02	17,329.0
	9/4/02	435.2
	10/9/02	727.0
	11/6/02	6,488.0
	12/9/02	410.6
	1/14/03	25.9
	2/5/03	248.9
	3/4/03	31.8
	4/2/03	110.6
	6/4/03	1,203.3
	6/27/07	38.0
	8/8/07	15.0
	9/5/07	75.0
	10/10/07	20.0
	11/7/07	9,606.0
	12/5/07	1,860.0
	1/9/08	>24,000.0
	2/6/08	10,462.0
	3/5/08	1,616.0
	4/2/08	959.0
	5/6/08	300.0
	6/3/08	921.0
CROOK1C1.3SH	7/7/99	304.4
	7/17/02	50.4
	9/11/02	4.1
	10/16/02	579.4
	11/13/02	120.0
	12/11/02	133.3

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
CROOK1C1.3SH (cont'd)	1/15/03	86.0
	2/12/03	325.5
	3/12/03	88.6
	4/7/03	12,033.0
	5/14/03	920.8
	6/11/03	42.8
	7/11/07	102.0
	8/21/07	>2,420.0
	9/12/07	222.0
	10/17/07	1,203.0
	11/14/07	12,997.0
	12/12/07	609.0
	1/16/08	120.0
	2/13/08	1,211.0
	3/4/08	1,785.0
	3/11/08	199.0
	3/12/08	211.0
	3/19/08	3,255.0
	3/25/08	256.0
	4/22/08	53.0
	5/13/08	219.0
	6/10/08	2,419.8
	3/19/08	3,255.0
	3/25/08	256.0
	4/22/08	53.0
	5/13/08	219.0
	6/10/08	2,419.8
CYPRE010.8FA	1/27/99	214.2
	5/23/00	686.7
	7/17/02	410.6
	8/14/02	>24,192.0
	9/11/02	218.0
	10/16/02	158.5
	11/13/02	591.0
	12/11/02	416.0

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
CYPRE010.8FA (cont'd)	1/15/03	9.7
	2/12/03	27.5
	3/12/03	141.4
	4/7/03	>24,192.0
	5/14/03	1,986.3
	6/14/03	111.9
	7/11/07	2,420.0
	10/17/07	>2,420.0
	11/27/07	1,300.0
	1/3/08	210.0
	1/30/08	839.0
	2/27/08	260.0
	3/26/08	276.0
	4/29/08	866.0
	5/27/08	435.0
	6/24/08	66.0
EBEAV1C2.1FA	7/24/02	6867.0
	8/21/02	54.4
	9/12/02	18.3
	10/23/02	214.3
	11/19/02	101.7
	12/16/02	160.7
	1/27/03	38.8
	2/19/03	178.5
	3/25/03	93.4
	4/16/03	21.6
	5/21/03	2419.2
	6/18/03	272.3
	7/18/07	25
	8/22/07	23
	9/19/07	2
	11/20/07	52
	12/18/07	107

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
EBEAV1C2.1FA (cont'd)	1/24/08	93
	2/20/08	328
	3/18/08	101
	4/16/08	435
	5/22/08	58
	6/17/08	218.7
HOWAR002.1SH	7/7/99	13.4
	7/11/07	276
	9/5/07	1986
	10/17/07	144
	11/14/07	921
	12/12/07	>2420
	1/16/08	280
	2/13/08	649
	3/12/08	53
	4/22/08	1414
	5/13/08	113
	6/10/08	72419.6
JAKES000.3SH	7/7/99	63.7
	7/17/02	46.4
	8/14/02	24,192.0
	9/11/02	178.9
	10/16/02	435.2
	11/13/02	1,565.0
	12/11/02	116.9
	1/15/03	178.2
	2/12/03	65.0
	3/12/03	52.1
	4/7/03	166.9
	5/14/03	387.3
	6/11/03	53.7
	7/11/07	93.0
	9/12/07	125.0
	10/17/07	>2,420.0
	11/14/07	1,178.0
	12/12/07	563.0

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
JAKES000.3SH (cont'd)	1/16/08	250.0
	2/13/08	1,300.0
	3/12/08	110.0
	4/22/08	196.0
	5/13/08	613.0
	6/10/08	82.6
JONES001.6FA	5/27/99	98.8
	4/25/00	>2,419.2
	7/31/02	6,488.0
	8/28/02	145.0
	9/30/02	107.1
	10/30/02	275.5
	11/20/02	98.3
	1/8/03	16.1
	1/28/03	5.2
	3/3/03	9.7
	3/26/03	>2,419.2
	4/23/03	2,014.0
	5/28/03	31.7
	6/25/03	248.1
	10/30/07	33.0
	11/27/07	57.0
	1/3/08	40.0
	1/20/08	1,222.0
	2/27/08	18.0
	3/26/08	29.0
	4/29/08	727.0
	5/27/08	24,200.0
	6/24/08	20.0
KELLY001.0TI	6/23/99	224.4
	7/18/07	99.0
	8/6/07	199.0
	8/14/07	74.0
	8/22/07	5.0
	8/28/07	308.0
	9/4/07	236.0
	11/20/07	48.0

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
KELLY001.0TI (cont'd)	1/24/08	179.0
	3/4/08	1,935.0
	3/11/08	193.0
	3/18/08	236.0
	3/19/08	3,654.0
	3/25/08	86.0
	4/16/08	173.0
	5/22/08	73.0
LAURE003.7FA	8/20/98	47.1
	10/21/98	21.3
	12/15/98	866.4
	2/3/99	161.6
	4/4/00	1,732.9
	1/31/02	547.5
	8/28/02	197.0
	9/30/02	113.0
	10/30/02	88.4
	11/20/02	88.4
	1/8/03	24.3
	1/28/03	3.1
	3/3/03	42.8
	3/26/03	>2,419.2
	4/23/03	226.0
	5/28/03	90.6
	6/25/03	26.9
	7/31/07	60.0
	8/6/07	12.0
	8/14/07	86.0
	10/2/07	17.0
	10/30/07	140.0
	11/27/07	88.0
	1/3/08	50.0
	1/30/08	2,851.0
	2/27/08	242.0

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
LAURE003.7FA (cont'd)	3/4/08	14,136.0
	3/11/08	282.0
	3/19/08	8,164.0
	3/25/08	571.0
	3/26/08	162.0
	4/29/08	2,420.0
	5/27/08	9,210.0
	6/24/08	1,553.0
LCYPR003.3FA	8/20/98	114.5
	10/21/98	112.6
	12/15/98	21.1
	2/3/99	88.4
	4/4/00	816.4
	7/31/02	261.3
	8/28/02	172.5
	9/30/02	39.0
	10/30/02	214.3
	11/20/02	85.7
	1/8/03	56.9
	1/28/03	4.1
	3/3/03	101.4
	3/26/03	>2,419.2
	4/23/03	109.0
	5/28/03	209.8
	6/25/03	32.7
	7/31/07	51.0
	8/6/07	84.0
	8/14/07	488.0
	8/21/07	32.0
	8/28/07	32.0
	8/29/07	19.0
	9/4/07	11.0
	10/2/07	32.0
	10/30/07	50.0
	11/27/07	201.0

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
LCYPR003.3FA (cont'd)	1/3/08	61.0
	1/30/08	836.0
	2/27/08	142.0
	3/4/08	7,270.0
	3/11/08	107.0
	3/19/08	8,664.0
	3/25/08	98.0
	3/26/08	111.0
	4/29/08	687.0
	5/27/08	1,070.0
	6/24/08	108.0
LOOSA005.0SH	8/20/98	55.2
	9/30/98	70.3
	10/21/98	88.8
	11/18/98	24.3
	12/15/98	1,203.3
	3/3/99	114.5
	6/2/99	29.8
	9/1/99	14.3
	12/1/99	26.5
	3/22/00	579.4
	2/7/01	12.0
	5/8/01	>2,419.2
	8/14/01	2,690.0
	11/20/01	410.0
	2/20/02	1,553.1
	5/22/02	7.4
	7/10/02	88.6
	8/7/02	1,086.0
	9/4/02	122.3
	10/9/02	920.8
	11/6/02	12,033.0
	12/9/02	218.8
	1/14/03	20.1
	2/5/03	55.4
	3/4/03	51.2

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
LOOSA005.0SH (cont'd)	4/2/03	57.6
	5/12/03	3,873.0
	6/4/03	101.7
	8/25/03	866.4
	12/8/03	132.0
	2/24/04	18.7
	6/8/04	17.3
	10/25/04	272.3
	2/8/05	595.0
	6/29/05	613.1
	9/21/05	70.3
	1/31/06	610.0
	5/24/06	14.0
	10/10/06	31.0
	1/17/07	870.0
	4/11/07	51.0
	8/8/07	22.0
	11/7/07	15,531.0
	2/6/08	17,250.0
	3/5/08	3,640.0
	4/2/08	4,200.0
	5/6/08	100.0
	6/3/08	216.0
	9/30/08	41.0
	12/17/08	77.0
	3/31/09	157.0
	6/30/09	8.0
	9/23/09	186.0
	12/15/09	488.0
LOOSA1C15.8SH	8/20/98	51.2
	9/30/98	307.6
	10/21/98	93.3
	11/18/98	20.9
	12/15/98	1,046.2
	3/3/99	1,553.1

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
LOOSA1C15.8SH (cont'd)	3/22/00	275.5
	7/10/02	88.2
	8/7/02	24,192.0
	9/4/02	67.9
	10/9/02	1,046.2
	11/6/02	14,136.0
	12/9/02	248.1
	1/14/03	39.3
	2/5/03	48.0
	4/2/03	24.4
	5/12/03	4,106.0
	6/4/03	816.4
	8/8/07	23.0
	11/7/07	12,997.0
	2/6/08	9,880.0
	4/2/08	2,247.0
	5/6/08	310.0
	6/3/08	517.0
LOOSA1C22.7SH	8/20/98	64.7
	9/30/98	365.4
	10/21/98	228.2
	11/18/98	29.2
	12/15/98	727.0
	3/31/99	>2,419.2
	5/2/00	26.0
	7/10/02	210.5
	8/7/02	15,531.0
	9/4/02	204.6
	10/9/02	613.1
	11/6/02	8,164.0
	12/9/02	82.6
	1/14/03	34.1
	2/5/03	29.8
	3/4/03	14.3
	4/2/03	41.1
	5/12/03	1,597.0
	6/4/03	1,110.0

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
LOOSA1C22.7SH (cont'd)	6/27/07	613.0
	8/8/07	2.0
	9/5/07	161.0
	10/10/07	411.0
	11/7/07	1,733.0
	12/5/07	387.0
	1/9/08	14,000.0
	2/6/08	5,794.0
	3/5/08	2,755.0
	4/2/08	1,607.0
	5/6/08	960.0
	6/3/08	546.0
LOOSA1C30.2SH	8/20/98	45.1
	9/30/98	17.4
	10/21/98	39.1
	11/18/98	72.8
	12/15/98	275.6
	2/3/99	103.4
	4/4/00	1,986.2
	7/24/02	8,664.0
	8/21/02	8,664.0
	9/12/02	135.4
	10/23/02	66.3
	11/18/02	106.3
	12/16/02	143.9
	1/27/03	21.1
	2/19/03	48.9
	3/25/03	93.3
	4/16/03	42.2
	5/21/03	435.2
	6/18/03	770.1
	7/8/07	128.0
	8/22/07	<1.0
	9/19/07	31.0
	11/20/07	285.0
	12/18/07	416.0

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
LOOSA1C30.2SH (cont'd)	1/24/08	72.0
	2/20/08	141.0
	3/18/08	143.0
	4/16/08	124.0
	5/22/08	29.0
	6/17/08	147.0
LOOSA1C34.0FA	7/31/02	249.5
	8/28/02	203.5
	9/30/02	176.6
	10/30/02	686.7
	11/20/02	53.0
	1/8/03	90.7
	1/28/03	63.1
	3/3/03	62.4
	3/26/03	>2,419.2
	4/23/03	383.0
	5/28/03	107.1
	6/25/03	79.4
	8/6/07	281.0
	8/14/07	35.0
	8/21/07	2.0
	8/28/07	9.0
	8/29/07	3.0
	9/4/07	31.0
	10/2/07	11.0
	10/30/07	78.0
	11/27/07	154.0
	1/3/08	24.0
	1/30/08	2,613.0
	2/27/08	35.0
	3/11/08	82.0
	3/18/08	122.0
	3/19/08	15,290.0
	3/25/08	310.0
	3/26/08	36.0

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
LOOSA1C34.0FA (cont'd)	4/29/08	1,553.0
	5/27/08	24,200.0
	6/24/08	88.0
LOOSA1C42.5FA	5/27/99	28.1
	4/25/00	68.1
	7/31/02	410.6
	8/28/02	93.3
	9/30/02	112.4
	10/30/02	260.2
	11/20/02	63.1
	1/8/03	8.5
	1/28/03	3.1
	3/3/03	35.9
	3/26/03	>2,419.2
	4/23/03	86.0
	5/28/03	68.9
	6/25/03	38.8
	11/27/05	52.0
	7/31/07	57.0
	8/29/07	1.0
	10/2/07	1.0
	10/30/07	80.0
	1/3/08	14.0
	1/30/08	1,274.0
	2/27/08	33.0
	3/26/08	26.0
	4/29/08	1,300.0
	5/27/08	14,140.0
	6/24/08	39.0
LOOSA1C53.6FA	8/20/98	32.8
	9/30/98	98.4
	10/21/98	46.5
	11/18/98	28.1
	12/15/98	172.5
	1/27/99	95.9

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
LOOSA1C53.6FA (cont'd)	2/7/01	2.0
	5/8/01	21.1
	8/14/01	95.8
	11/20/01	18.1
	2/20/02	727.0
	5/22/02	201.4
	7/31/02	37.7
	8/28/02	83.9
	9/30/02	260.2
	10/30/02	116.2
	11/20/02	31.3
	1/8/03	63.8
	1/28/03	8.4
	3/3/03	68.3
	3/26/03	2,419.2
	4/23/03	175.0
	5/28/03	86.0
	6/25/03	60.9
	8/25/03	121.0
	12/8/03	2.0
	2/24/04	193.5
	6/8/04	83.6
	10/25/04	410.6
	2/8/05	172.5
	6/29/05	25.9
	9/21/05	66.3
	1/31/06	19.0
	5/24/06	24.0
	10/10/06	24.0
	1/17/07	110.0
	4/11/07	550.0
	7/31/07	67.0
	8/29/07	1.0
	10/2/07	23.0
	10/30/07	75.0
	11/27/07	15.0

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
LOOSA1C53.6FA (cont'd)	1/3/08	6.0
	1/30/08	537.0
	2/27/08	15.0
	3/26/08	110.0
	4/29/08	133.0
	5/27/08	3,080.0
	6/24/08	135.0
	9/30/08	488.0
	12/17/08	20.0
	3/31/09	51.0
	6/30/09	291.0
	9/23/09	1,046.0
	12/15/09	210.0
LOOSA1T1.9FA	5/27/99	77.6
	8/4/99	162.4
	4/25/00	2,419.2
	8/6/07	613.0
	11/27/07	44.0
	2/27/08	96.0
	3/4/08	1,098.0
	3/11/08	59.0
	3/19/08	3,784.0
	3/25/08	130.0
LOOSA4T1.3SH	3/31/99	1413.6
	5/2/00	>2419.2
	6/27/07	58.0
	8/6/07	<2420.0
	8/8/07	211.0
	8/14/07	29.0
	8/21/07	120.0
	10/10/07	548.0
	12/5/07	670.0
	1/9/08	3900.0
	3/4/08	0.0
	3/5/08	3873.0
	3/11/08	195.0

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
LOOSA4T1.3SH (cont'd)	3/19/08	1733.0
	3/25/08	613.0
	4/2/08	185.0
	5/6/08	276.0
	6/3/08	88.0
NFORK000.6SH	7/17/02	135.4
	8/14/02	7,270.0
	9/11/02	90.7
	10/16/02	60.9
	11/13/02	122.0
	12/11/02	98.4
	1/15/03	6.3
	2/12/03	26.5
	3/12/03	58.3
	4/7/03	178.2
	5/14/03	201.0
	6/11/03	28.5
	7/11/07	488.0
	9/12/07	135.0
	10/17/07	1,046.0
	11/14/07	12,033.0
	12/12/07	11,199.0
	1/16/08	74.0
	2/13/08	1,211.0
	3/12/08	160.0
	4/22/08	261.0
	5/13/08	144.0
	6/10/08	2,419.8
OLIVE001.3SH	6/9/99	172.2
	7/10/02	178.5
	8/7/02	10,462.0
	9/4/02	107.9
	10/9/02	488.4
	11/6/02	1,565.0
	12/9/02	90.9

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
OLIVE001.3SH (cont'd)	1/14/03	83.0
	2/5/03	121.1
	3/4/03	17.5
	4/2/03	59.4
	5/12/03	820.0
	6/4/03	980.4
	6/27/07	4,611.0
	8/8/07	23.0
	10/10/07	613.0
	11/7/07	2,420.0
	12/5/07	305.0
	1/9/08	4,600.0
	2/6/08	1,396.0
	3/5/08	327.0
	4/2/08	71.0
	5/6/08	291.0
	6/3/08	461.0
ROCKY000.9SH	6/23/99	816.4
	6/27/07	63.0
	12/5/07	435.0
	1/9/08	>2,400
	3/4/08	2,420.0
	3/5/08	1,585.0
	3/11/08	379.0
	3/19/08	12,033.0
	3/28/08	323.0
	4/2/08	2,359.0
	5/6/08	430.0
	6/3/08	479.0
ROYST1C0.9SH	7/7/99	95.9
	7/17/02	71.7
	8/14/02	1,986.3
	9/11/02	8.4
	10/16/02	75.4
	11/13/02	37.4
	12/11/02	112.4

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
ROYST1C0.9SH (cont'd)	1/15/03	85.7
	2/12/03	107.1
	3/12/03	56.5
	4/7/03	364.0
	5/14/03	689.0
	6/11/03	24.0
	7/11/07	70.0
	9/12/07	185.0
	10/17/07	1,414.0
	11/14/07	11,199.0
	12/12/07	1,296.0
	1/16/08	400.0
	2/13/08	1,789.0
	3/12/08	148.0
	4/22/08	55.0
	5/13/08	22.0
	6/10/08	2,419.6
SCOTT001.7SH	6/23/99	86.0
	7/10/02	1,732.9
	9/4/02	86.2
	10/9/02	209.8
	11/6/02	1,723.0
	12/9/02	82.0
	1/14/03	198.9
	2/5/03	66.9
	3/4/03	25.6
	4/2/03	387.3
	5/12/03	98.5
	6/4/03	178.5
	10/10/07	326.0
	11/7/07	157.0
	12/5/07	276.0
	1/9/08	6,900.0
	2/6/08	387.0

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
SCOTT001.7SH (cont'd)	3/5/08	40.0
	4/2/08	97.0
	5/6/08	228.0
	6/3/08	260.0
TODD001.6SH	8/20/98	770.1
	9/30/98	204.0
	10/21/98	686.7
	11/18/98	517.2
	12/15/98	980.4
	7/10/02	>2,419.2
	8/7/02	770.1
	9/4/02	239.0
	10/9/02	178.5
	11/6/02	1,299.7
	12/9/02	8,164.0
	1/14/03	29.4
	2/5/03	>2,419.2
	3/4/03	30.7
	4/2/03	1,986.3
	5/12/03	>2,419.2
	6/4/03	1,413.6
	6/27/07	<1.0
	8/8/07	111.0
	9/5/07	148.0
	10/10/07	>2,420.0
	11/7/07	97.0
	12/5/07	345.0
	1/9/08	>2,400.0
	2/6/08	>24,196.0
	3/5/08	>2,420.0
	4/2/08	11,199.0
	5/6/08	840.0
	6/3/08	>24,196.0

Table B-1 (cont'd). TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
WBEAV1C1.1SH	6/23/99	29.9
	7/24/02	52.0
	8/21/02	59.4
	9/12/02	7.4
	10/23/02	44.8
	11/18/02	218.7
	12/16/02	613.1
	1/27/03	17.1
	2/19/03	101.2
	3/25/03	95.9
	4/16/03	67.0
	5/21/03	261.3
	6/18/03	178.2
	7/18/07	93.0
	8/22/07	>2,420.0
	9/19/07	91.0
	11/20/07	148.0
	12/18/07	1,414.0
	1/24/08	115.0
	2/20/08	115.0
	3/18/08	199.0
	4/16/08	111.0
	5/22/08	>2,420.0
	6/17/08	248.9

Table B-2. Memphis MS4 Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
01L (LOOSA1C15.8SH)	07/01/04	900
	08/19/04	<2
	09/28/04	148
	10/12/04	1,600
	11/02/04	1,500
	11/17/04	44
	12/08/04	1,800
	01/05/05	2,600
	03/13/05	14,000
	04/18/05	3,500
	04/21/05	700
	05/16/05	800
	06/06/05	400
	07/12/05	500
	08/03/05	<2
	08/22/05	80
	09/19/05	530
	10/03/05	90
	11/07/05	20
	12/07/05	40
	01/09/06	40
	02/01/06	190
	03/14/06	190
	04/11/06	270
	05/03/06	140
	06/06/06	1,000
	07/12/06	30
	08/08/06	80
	09/21/06	420
	10/11/06	7
	11/20/06	140
	12/11/06	10
	01/10/07	223
	02/07/07	110
	03/12/07	340
	04/17/07	930
	05/22/07	30

Table B-2 (cont'd). Memphis MS4 Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
01L (LOOSA1C15.8SH)	06/07/07	360
	07/17/07	<10
	08/08/07	80
	09/18/07	50
	10/10/07	340
	11/07/07	4,800
	12/18/07	1,320
	01/15/08	3,600
	02/11/08	90
	03/05/08	2,500
	04/22/08	<10
	05/06/08	150
	06/11/08	1,600
	07/14/08	110
	08/14/08	90
	09/24/08	70
	10/21/08	620
	11/17/08	30
	12/02/08	190
	01/13/09	290
	02/23/09	60
	03/04/09	380
	04/21/09	920
	05/19/09	200
	06/02/09	110
05L (LOOSA005.0SH)	07/01/04	84
	08/19/04	<2
	09/28/04	<2
	10/12/04	5,900
	11/02/04	2,400
	11/17/04	104
	12/08/04	1,700
	01/05/05	4,100
	03/13/05	24,000
	04/18/05	2,800
	04/21/05	1,700
	05/16/05	300
	06/06/05	400

Table B-2 (cont'd). Memphis MS4 Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
05L (LOOSA005.0SH)	07/12/05	1,300
	08/03/05	<2
	08/22/05	21
	09/19/05	23
	10/03/05	90
	11/07/05	10
	12/07/05	40
	01/09/06	20
	02/01/06	310
	03/14/06	150
	04/11/06	270
	05/03/06	60
	06/06/06	120
	07/12/06	30
	08/08/06	<10
	09/21/06	260
	10/11/06	20
	12/11/06	30
	01/10/07	1,030
	02/07/07	90
	04/17/07	320
	05/22/07	20
	06/07/07	20
	07/17/07	20
	08/08/07	20
	09/18/07	20
	10/10/07	810
	11/07/07	8,800
	11/07/07	4,400
	12/18/07	1,080
	01/15/08	7,600
	03/05/08	1,800
	08/14/08	<10
	10/21/08	220
	11/17/08	10
	12/02/08	10
	03/04/09	360

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 Loosahatchie 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 Loosahatchie River Watershed were derived from WinHSPF hydrologic simulations based on parameters derived from calibrations at USGS Station No. 07030240 (see Appendix D for details of calibration). For example, a flow-duration curve for Clear (Cypress) Creek was constructed using simulated daily mean flow for the period from 10/1/98 through 9/30/08 (RM 1.4 corresponds to the location of monitoring station CLEAR001.4SH). 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 Loosahatchie 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 (Clear [Cypress] Creek is shown as an example):

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

   $(\text{Target Load})_{\text{Clear Creek}}$ = (941 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 = (2.30×10^{10}) x (Q) CFU/day

2. Daily loads were calculated for each of the water quality samples collected at monitoring station CLEAR001.4SH (ref.: Table B-1) by multiplying the sample concentration by the daily mean flow for the sampling date and the required unit conversion factor. CLEAR001.4SH 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 – 3/5/08 sampling event:
   Modelled Flow = 71.6 cfs
   Concentration = 1,616 CFU/100 mL
   Daily Load = 2.83×10^{12} 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 Clear Creek as an example:

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

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

$MOS_{Clear\ Creek}$ = TMDL x 0.10 = $2.30x10^9$ x Q

MOS = ($2.30x10^9$) x (Q) CFU/day

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

= {TMDL – MOS – WLA[WWTFs]} / DA

= {($2.30x10^{10}$ x Q) – ($2.30x10^9$ x Q) – ($1.603x10^9$)} / ($3.80x10^4$)

WLA[MS4] = LA = [$5.454x10^5$ x Q] – [$4.223x10^4$]

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

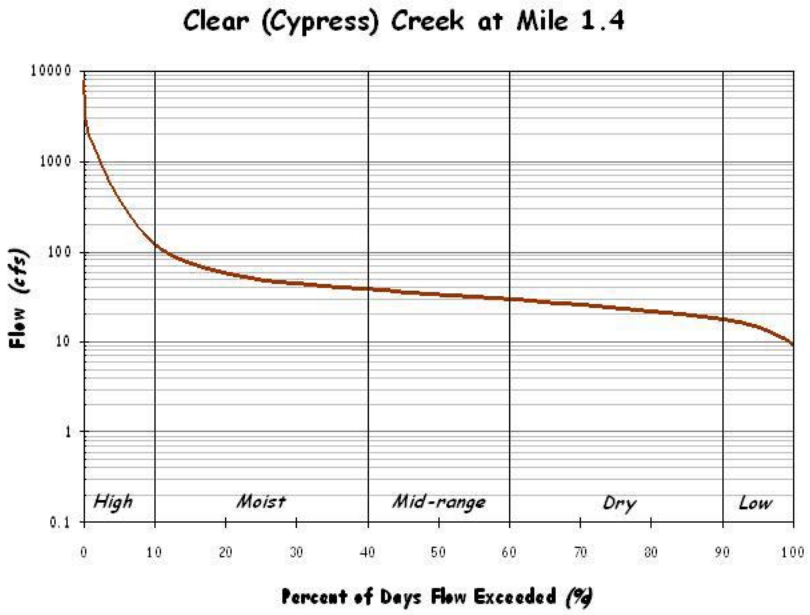

Figure C-1. Flow Duration Curve for Clear (Cypress) Creek at Mile 1.4

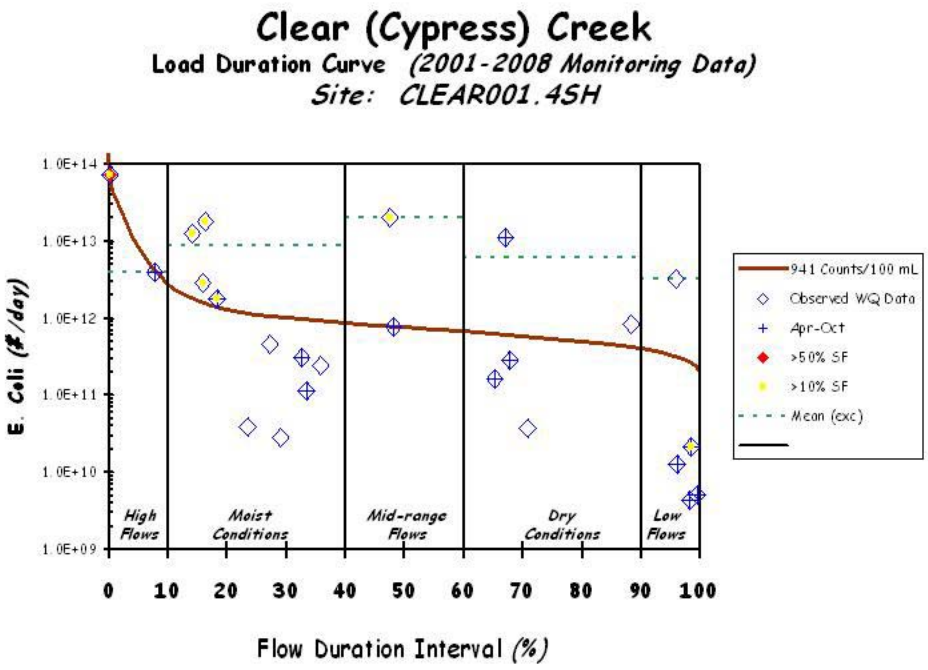

Figure C-2. E. Coli Load Duration Curve for Clear (Cypress) Creek at Mile 1.4

Table C-1. TMDLs, WLAs, & LAs for Impaired Waterbodies in the Loosahatchie River Watershed (HUC 08010209)

HUC-12 Subwatershed (08010209__) 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	Loosahatchie River	TN08010209011 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.211 \times 10^{6} \times Q$
0103	Jones Creek	TN08010209010 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.746 \times 10^{6} \times Q$
0104	Treadville Bottom	TN08010209008 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.516 \times 10^{6} \times Q$
0105	Loosahatchie River	TN08010209007 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	3.188×10^{10}	0	NA	$(2.827 \times 10^{5} \times Q) - (4.353 \times 10^{5})$
0201	East Beaver Creek	TN08010209016 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.156×10^{9}	0	$(5.032 \times 10^{5} \times Q) - (1.010 \times 10^{5})$	$(5.032 \times 10^{5} \times Q) - (1.010 \times 10^{5})$
0202	West Beaver Creek	TN08010209016 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.204 \times 10^{6} \times Q$	$1.204 \times 10^{6} \times Q$
0203	Beaver Creek	TN08010209016 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.156×10^{9}	0	$(2.223 \times 10^{5} \times Q) - (4.463 \times 10^{4})$	$(2.223 \times 10^{5} \times Q) - (4.463 \times 10^{4})$
	Kelley Branch	TN08010209016 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$4.346 \times 10^{6} \times Q$
0301	Big Creek	TN08010209021 – 3000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.986×10^{8}	0	$(1.027 \times 10^{6} \times Q) - (2.473 \times 10^{4})$	$(1.027 \times 10^{6} \times Q) - (2.473 \times 10^{4})$
	Big Creek	TN08010209021 – 4000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.986×10^{8}	0	$(1.632 \times 10^{6} \times Q) - (3.931 \times 10^{4})$	$(1.632 \times 10^{6} \times Q) - (3.931 \times 10^{4})$
	Crooked Creek Canal	TN08010209021 – 0500	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.603×10^{9}	0	$(1.822 \times 10^{6} \times Q) - (1.411 \times 10^{5})$	$(1.822 \times 10^{6} \times Q) - (1.411 \times 10^{5})$
0302	Big Creek	TN08010209021 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	2.092×10^{11}	0	$(3.658 \times 10^{5} \times Q) - (3.697 \times 10^{6})$	$(3.658 \times 10^{5} \times Q) - (3.697 \times 10^{6})$
	North Fork Creek	TN08010209021 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	5.164×10^{8}	0	$(1.931 \times 10^{6} \times Q) - (4.818 \times 10^{4})$	$(1.931 \times 10^{6} \times Q) - (4.818 \times 10^{4})$
	Royster Creek	TN08010209021 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.892 \times 10^{6} \times Q$	$1.892 \times 10^{6} \times Q$
0303	Big Creek	TN08010209021 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	2.094×10^{11}	0	$(2.144 \times 10^{5} \times Q) - (2.169 \times 10^{6})$	$(2.144 \times 10^{5} \times Q) - (2.169 \times 10^{6})$
	Bear Creek	TN08010209021 – 0110	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$5.027 \times 10^{6} \times Q$	$5.027 \times 10^{6} \times Q$
	Jakes Creek	TN08010209021 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.969 \times 10^{6} \times Q$	$3.969 \times 10^{6} \times Q$
0401	Laurel Creek	TN08010209014 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.744 \times 10^{6} \times Q$
0402	Little Cypress Creek	TN08010209015 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.203 \times 10^{6} \times Q$

Table C-1 (cont'd). TMDLs, WLAs, & LAs for Impaired Waterbodies in the Loosahatchie River Watershed (HUC 08010209)

HUC-12 Subwatershed (08010209__) 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]
0403	Black Ankle Creek	TN08010209004 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$1.203 \times 10^{6} \times Q$
	Loosahatchie River	TN08010209004 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.466×10^{11}	0	$(1.256 \times 10^{5} \times Q) - (8.744 \times 10^{5})$	$(1.256 \times 10^{5} \times Q) - (8.744 \times 10^{5})$
0404	Cypress Creek	TN08010209003 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.603×10^{9}	0	$(5.454 \times 10^{5} \times Q) - (4.223 \times 10^{4})$	$(5.454 \times 10^{5} \times Q) - (4.223 \times 10^{4})$
0405	Rocky Branch	TN08010209002 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$8.179 \times 10^{6} \times Q$
	Scotts Creek	TN08010209002 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.033 \times 10^{7} \times Q$	$1.033 \times 10^{7} \times Q$
	Oliver Creek	TN08010209002 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$9.452 \times 10^{6} \times Q$	$9.452 \times 10^{6} \times Q$
	Buckhead Creek	TN08010209002 – 0500	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$5.406 \times 10^{6} \times Q$	$5.406 \times 10^{6} \times Q$
	Howard Creek	TN08010209002 – 0600	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.112 \times 10^{7} \times Q$	$1.112 \times 10^{7} \times Q$
	Loosahatchie River	TN08010209002 – 2000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.175×10^{11}	0	$(6.459 \times 10^{4} \times Q) - (1.030 \times 10^{6})$	$(6.459 \times 10^{4} \times Q) - (1.030 \times 10^{6})$
0406	Loosahatchie River	TN08010209001 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	7.071×10^{11}	0	$(4.479 \times 10^{4} \times Q) - (1.530 \times 10^{6})$	$(4.479 \times 10^{4} \times Q) - (1.530 \times 10^{6})$
	Unnamed Trib to Loosahatchie River	TN08010209002 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$2.295 \times 10^{7} \times Q$
	Loosahatchie River	TN08010209002 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.976×10^{11}	0	$(6.098 \times 10^{4} \times Q) - (1.466 \times 10^{6})$	$(6.098 \times 10^{4} \times Q) - (1.466 \times 10^{6})$
	Todd Branch	TN08010209001 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$7.983 \times 10^{6} \times Q$	$7.983 \times 10^{6} \times Q$

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 Loosahatchie River Watershed. HSPF is a watershed model capable of performing flow routing through stream reaches.

D.2 Model Set Up

The Loosahatchie 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 used for the simulation. Weather data from multiple meteorological stations were available for the time period from January 1970 through September 2008. Meteorological data for a selected 11-year period were used for all simulations. The first year of this period was used for model stabilization with simulation data from the subsequent 10-year period (10/1/98 – 9/30/08) used for TMDL analysis. Meteorological data from the station at Mason, Tennessee was used for hydrologic calibration.

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. The USGS continuous record station located near Arlington, Tennessee (USGS 07030240) was selected as the basis of the hydrology calibration. This station is located in the Loosahatchie River Watershed within Level IV ecoregion 74B and with a drainage area of 262 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 Loosahatchie River near Arlington, USGS Station 07030240, are shown in Table D-1 and Figure D-1 and D-2.

Table D-1. Hydrologic Calibration Summary: Loosahatchie River near Arlington (USGS 07030240)

Simulation Name:	USGS07030240	**Simulation Period:**	
		Watershed Area (ac):	166666.00
Period for Flow Analysis			
Begin Date:	**10/01/97**	**Baseflow PERCENTILE:**	2.5
End Date:	**09/30/07**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**196.82**	Total Observed In-stream Flow:	**195.52**
Total of highest 10% flows:	**120.20**	Total of Observed highest 10% flows:	**123.79**
Total of lowest 50% flows:	**28.30**	Total of Observed Lowest 50% flows:	**27.32**
Simulated Summer Flow Volume (months 7-9):	**27.84**	Observed Summer Flow Volume (7-9):	**24.97**
Simulated Fall Flow Volume (months 10-12):	**55.73**	Observed Fall Flow Volume (10-12):	**51.12**
Simulated Winter Flow Volume (months 1-3):	**68.59**	Observed Winter Flow Volume (1-3):	**73.82**
Simulated Spring Flow Volume (months 4-6):	**44.66**	Observed Spring Flow Volume (4-6):	**45.61**
Total Simulated Storm Volume:	**164.19**	Total Observed Storm Volume:	**153.33**
Simulated Summer Storm Volume (7-9):	**19.72**	Observed Summer Storm Volume (7-9):	**14.38**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**0.67**	10	
Error in 50% lowest flows:	**3.59**	10	
Error in 10% highest flows:	**-2.90**	15	
Seasonal volume error - Summer:	**11.51**	30	
Seasonal volume error - Fall:	**9.03**	30	
Seasonal volume error - Winter:	**-7.09**	30	
Seasonal volume error - Spring:	**-2.10**	30	
Error in storm volumes:	**7.08**	20	
Error in summer storm volumes:	**37.09**	50	

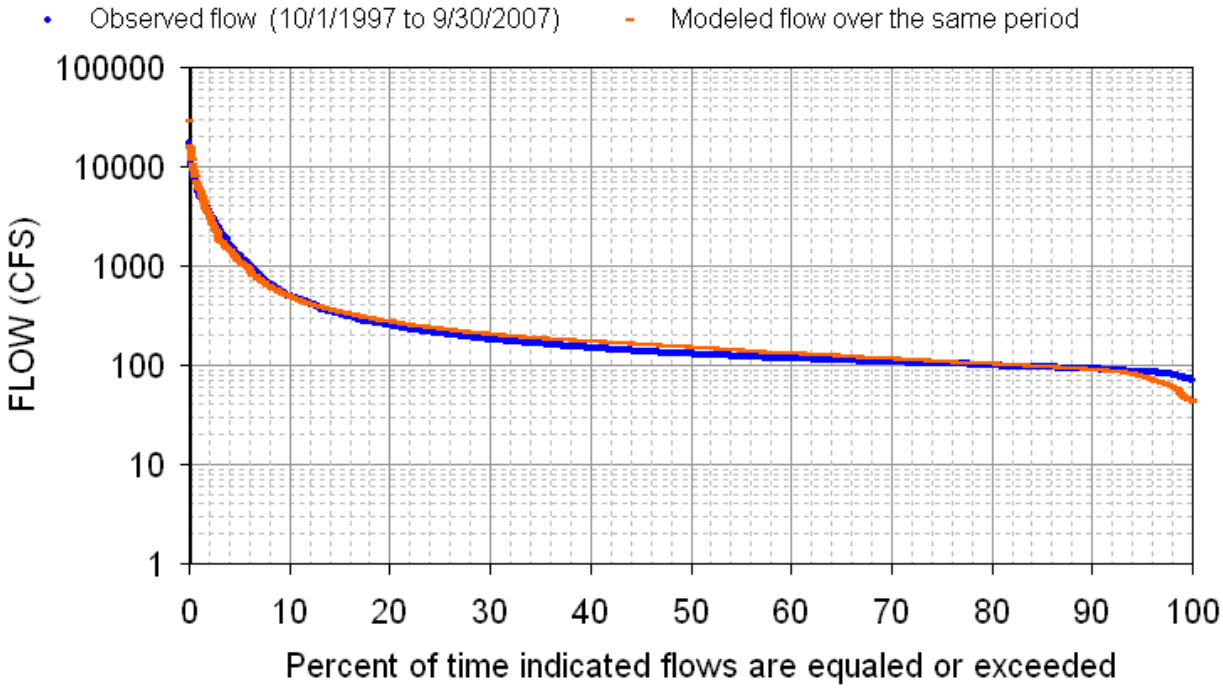

Figure D-1. Hydrologic Calibration: Loosahatchie River, USGS 07030240 (WYs1998-2007)

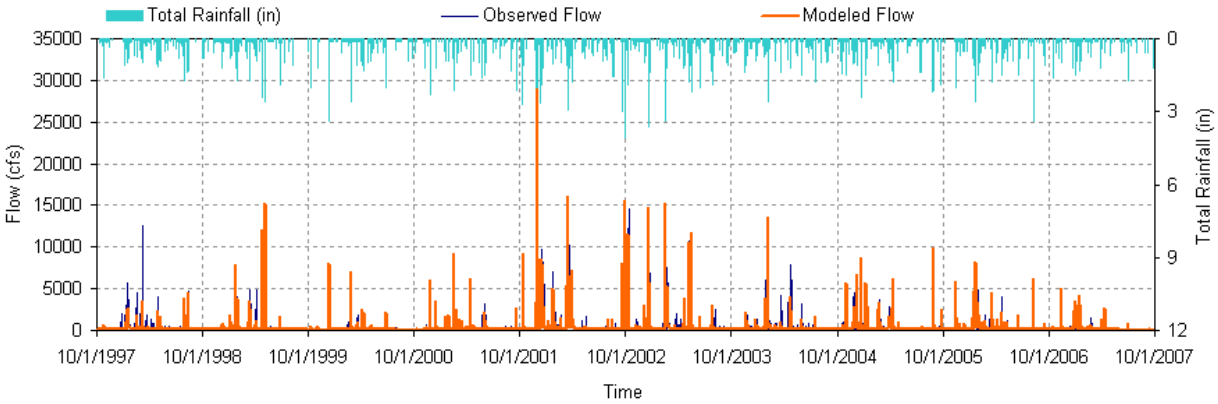

Figure D-2. 10-Year Hydrologic Comparison: Loosahatchie River, USGS 07030240

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 8. 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 Oliver Creek provides guidance for implementation analysis:

The Oliver Creek watershed, HUC-12 080102090204, lies near Lakeland. The drainage area for Oliver Creek is approximately 2,190 acres (3.4 mi^2); therefore, four flow zones were used for the duration curve analysis (see Sect. 9.1.1).

The flow duration curve for Oliver Creek at mile 1.3 was constructed using simulated daily mean flow for the period from 10/1/98 through 9/30/08 (mile 1.3 corresponds to the location of monitoring station OLIVE001.3SH). 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 Oliver 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 (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 the exceedances occured across most flow regimes indicating the Oliver Creek watershed may be impacted by multiple sources.

Critical conditions for the Oliver Creek watershed (HUC-12 080102090204) occur during mid-range flow conditions, typically indicative of both point source and non-point source contributions (see Table E-3, Section E.4). According to hydrograph separation analysis, only some of the exceedances occured during stormflow events.

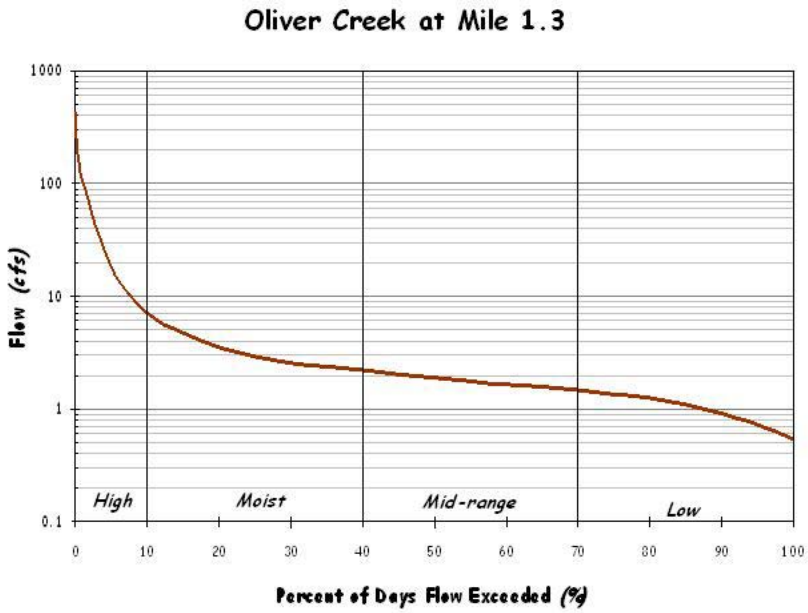

Figure E-1. Flow Duration Curve for Oliver Creek at Mile 1.3

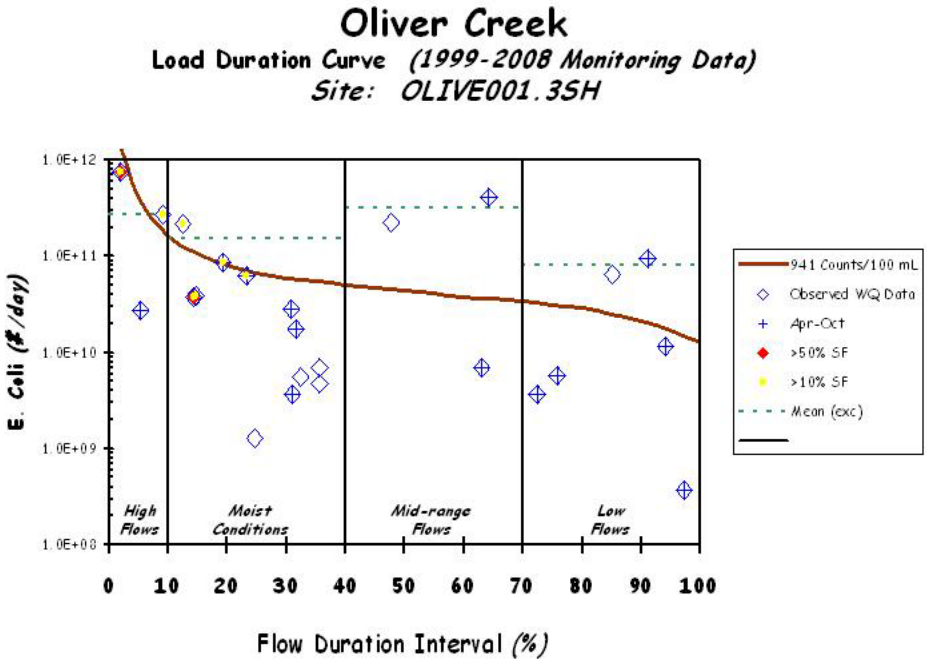

Figure E-2. E. Coli Load Duration Curve for Oliver Creek

Table E-1. Load Duration Curve Summary for Implementation Strategies (Example: Oliver Creek subwatershed, HUC-12 080102090204) (4 Flow Zones).

Hydrologic Condition		High	Moist	Mid-range	Low*
% Time Flow Exceeded		0-10	10-40	40-70	70-100
Oliver Creek (080102090204)	Number of Samples	3	12	3	6
	% > 941 CFU/100 mL[1]	33.3	8.3	66.7	33.3
	Load Reduction[2]	10.9	0.4	56.8	23.5
TMDL (CFU/day)		4.094E+11	6.716E+11	4.094E+10	2.507E+10
Margin of Safety (CFU/day)		4.094E+10	6.716E+10	4.094E+09	2.507E+09
WLA (WWTFs) (CFU/day)		NA	NA	NA	NA
WLAs (MS4s) (CFU/day/acre)[3]		1.682E+08	2.760E+07	1.682E+07	1.030E+07
LA (CFU/day/acre)[3]		1.682E+08	2.760E+07	1.682E+07	1.030E+07
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)					

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

Results indicate the implementation strategy for the Oliver Creek watershed will require BMPs targeting point sources (dominant under low flow/baseflow conditions) and non-point sources (dominant under high flow/runoff conditions). Table E-1 presents an allocation table of LDC analysis statistics for Oliver 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 Loosahatchie 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 9 and E-53.

Table E-53 presents LDC analyses (TMDLs, WLAs, LAs, and MOS) and PLRGs for all flow zones for all E. coli impaired waterbodies in the Loosahatchie 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 Black Ankle Creek provides guidance for implementation analysis.

The Black Ankle Creek subwatershed, HUC-12 080102090201, lies in a non-urbanized area of Fayette county. The drainage area for Black Ankle Creek is approximately 17,200 acres (26.9 mi^2); therefore, four flow zones were used for the duration curve analysis (see Sect. 9.1.1). The landuse for Black Ankle Creek is approximately 54.6% agricultural, with most of the remainder being forested. Urban areas make up approximately 8.0% 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 Black Ankle Creek was constructed using simulated daily mean flow for the period from 10/1/98 through 9/30/08. 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 Black Ankle 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 exceedances occur under the high flow and moist conditions zones indicating that the Black Ankle Creek watershed is impacted by non-point-type sources. LDCs for other impaired waterbodies were developed using a similar procedure (Appendix C) and are shown in Figures E-5 through E-41.

Critical conditions for the Black Ankle Creek watershed occur during moist conditions, typically indicative of non-point source contributions (see Table E-3, Section E.4). Exceedances of the E. coli water quality standard occur mainly under the higher flow conditions. According to hydrograph separation analysis, exceedances occur during both storm (runoff) and non-storm (baseflow) periods. These factors indicate that non-point sources are significant contributors to impairment in the Black Ankle Creek watershed. However, it is possible that both point and non-point type sources contribute to exceedances of the E. coli standard in Black Ankle Creek.

Results indicate the implementation strategy for the Black Ankle Creek watershed will require BMPs targeting non-point sources (dominant under high flow/runoff conditions). Table E-2 presents an allocation table of Load Duration Curve analysis statistics for Black Ankle 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 Loosahatchie 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 10 and E-53.

Table E-53 presents LDC analyses (TMDLs, WLAs, LAs, and MOS) and PLRGs for all flow zones for all E. coli impaired waterbodies in the Loosahatchie River watershed.

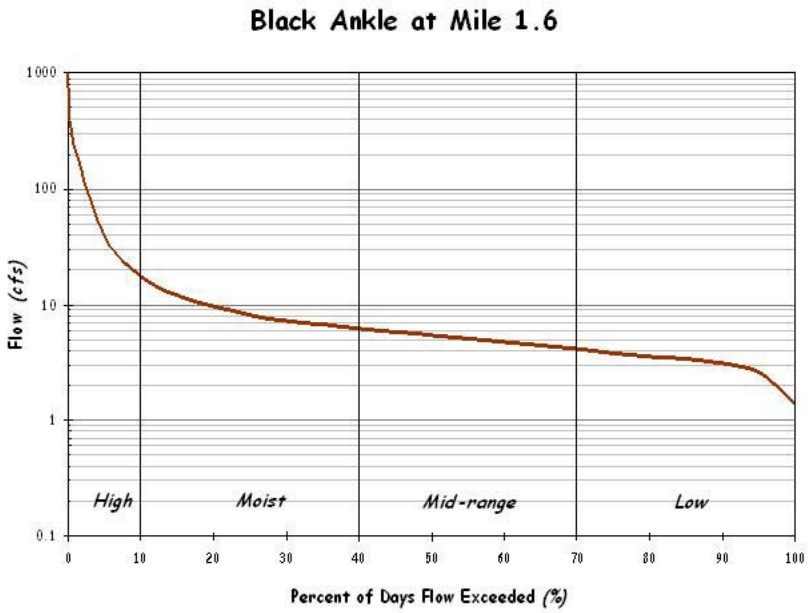

Figure E-3. Flow Duration Curve for Black Ankle Creek at Mile 1.6

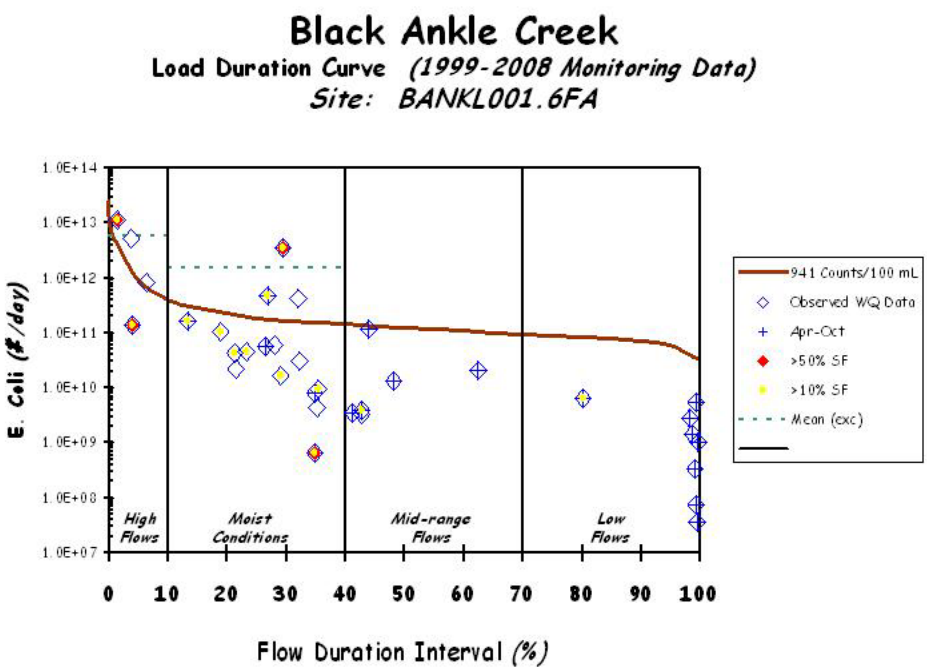

Figure E-4. E. Coli Load Duration Curve for Black Ankle Creek

Table E-2. Load Duration Curve Summary for Implementation Strategies (Example: Black Ankle Creek subwatershed, HUC-12 080102090201) (4 Flow Zones).

Hydrologic Condition		High	Moist	Mid-range	Low*
% Time Flow Exceeded		0-10	10-40	40-70	70-100
Black Ankle Creek (080102090201)	Number of Samples	4	16	6	8
	% > 941 CFU/100 mL[1]	75.0	18.8	0.0	0.0
	Load Reduction[2]	39.1	13.6	NR	NR
TMDL (CFU/day)		9.067E+11	1.879E+11	1.178E+11	7.774E+10
Margin of Safety (CFU/day)		9.067E+10	1.879E+10	1.178E+10	7.774E+09
WLA (WWTFs) (CFU/day)		NA	NA	NA	NA
WLAs (MS4s) (CFU/day/acre)[3]		NA	NA	NA	NA
LA (CFU/day/acre)[3]		1.687E+08	2.875E+07	1.802E+07	1.189E+07
Implementation Strategies[4]					
Pasture and Hayland Management		H	H	M	L
Livestock Exclusion				M	H
Fencing				M	H
Manure Management		H	H	M	L
Riparian Buffers		L	M	H	M
Potential for source area contribution under given flow condition (H: High; M: Medium; L: Low)					

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

E.3 Forestry Source Areas

There are no impaired waterbodies with corresponding HUC-12 subwatersheds or drainage areas classified as source area type predominantly forested, with the predominant source category being wildlife, in the Loosahatchie 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. The following example is from Oliver 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
1/9/08	4,600.0	1.96	2.21E+11	4.51E+10	79.5
7/10/02	178.5	1.60	6.99E+09	3.68E+10	0(-427)
8/7/02	10,462.0	1.58	4.04E+11	3.64E+10	91.0
Percent Load Reduction Goal (PLRG) for Mid-Range Conditions (Mean)					**56.8**

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 Oliver Creek.

   Example – *High Flow Zone Percent Load Reduction Goal = 10.9*
   Moist Conditions Flow Zone Percent Load Reduction Goal = 0.4
   Mid-Range Flow Zone Percent Load Reduction Goal = 56.8
   Low Flow Zone Percent Load Reduction Goal = 23.5

Therefore, the critical flow zone for prioritization of Oliver implementation activities is the Mid-Range Flow Zone and subsequently actions targeting both point source and 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 Oliver Creek:

Flow Zone	Number of Samples	Samples > 941 CFU/100 mL	% > 941 CFU/100 mL
High	3	1	33.3
Moist	12	1	8.3
Mid-Range	***3***	***2***	***66.7***
Low	6	2	33.3

The critical flow zone for prioritization of Oliver Creek implementation activities is confirmed as the mid-range 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. Due to the limited period of record for Oliver Creek and other Loosahatchie River watershed waterbodies (six years or less), the following example is from Beaver Creek, Holston River watershed.

Zone	Period of Record (1988-2001)			Most Recent (1997-2001)		
	# of samples	% Red.	% Exc.	# of samples	% Red.	% Exc.
High	3	50.3	66.7	0	NA	NA
Moist	8	**57.1**	**75**	1	**88.5**	**100**
Mid-Range	8	12.1	12.5	2	48.3	50
Dry	19	8	15.8	6	13.1	16.7
Low	4	0	0	2	0	0

The critical flow zone for prioritization of implementation activities, as with the Oliver Creek example above, is confirmed as the same zone (moist flow zone for Beaver Creek) as initial analyses indicted. However, if a different flow zone, or zones, were identified, the flow zone(s) from analysis of recent data would have emphasis for implementation prioritization.

PLRGs and critical flow zones of the other impaired waterbodies were derived in a similar manner and are shown in Table E-53.

Table E-3. Summary of Critical Conditions for Impaired Waterbodies in the Loosahatchie River Watershed.

Waterbody ID	Moist	Mid-range	Dry	Low
Loosahatchie River (011-1000)[a]	Ò			
Jones Creek[b]	Ò			
Treadville Bottom[b]	Ò			
Loosahatchie River (007-1000)[a]	Ò			
East Beaver Creek[a]		Ò		
West Beaver Creek[a]				Ò
Beaver Creek[a]				Ò
Kelley Branch[b]				
Big Creek (021-3000)[a]			Ò	
Big Creek (021-4000)[b]	Ò			
Crooked Creek Canal[b]				Ò
Big Creek (021-2000)[a]			Ò	
North Fork Creek[b]				Ò
Royster Creek[b]				Ò
Big Creek (021-1000)[a]		Ò		
Bear Creek[b]	Ò			
Jakes Creek[b]	Ò			
Laurel Creek [b]	Ò			
Little Cypress Creek[b]	Ò			
Black Ankle Creek[b]	Ò			
Loosahatchie River (004-1000)[a]	Ò			
Cypress Creek[ab]		Ò		
Rocky Branch[b]	Ò			
Scotts Creek[b]	Ò			
Oliver Creek[b]		Ò		
Buckhead Creek[b]				Ò
Howard Creek[b]				Ò
Loosahatchie River (002-2000)[a]	Ò			

Table E-3 (cont'd). Summary of Critical Conditions for Impaired Waterbodies in the Loosahatchie River Watershed.

Waterbody ID	Moist	Mid-range	Dry	Low
Loosahatchie River (001-1000)[a]	Ò			
UT to Loosahatchie River[b]		Ò		
Loosahatchie River (002-1000)[a]	Ò			
Todd Branch[b]	Ò			

[a] Waterbody(ies) with 5 flow zones.
[b] Waterbody(ies) with 4 flow zones.

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 = Black Ankle Creek*
Sampling Period = 3/4/08 – 3/26/08
Geometric Mean Concentration = 670.2 CFU/100 mL
Target Concentration = 126 CFU/100 mL
Reduction to Target = 81.2%

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.

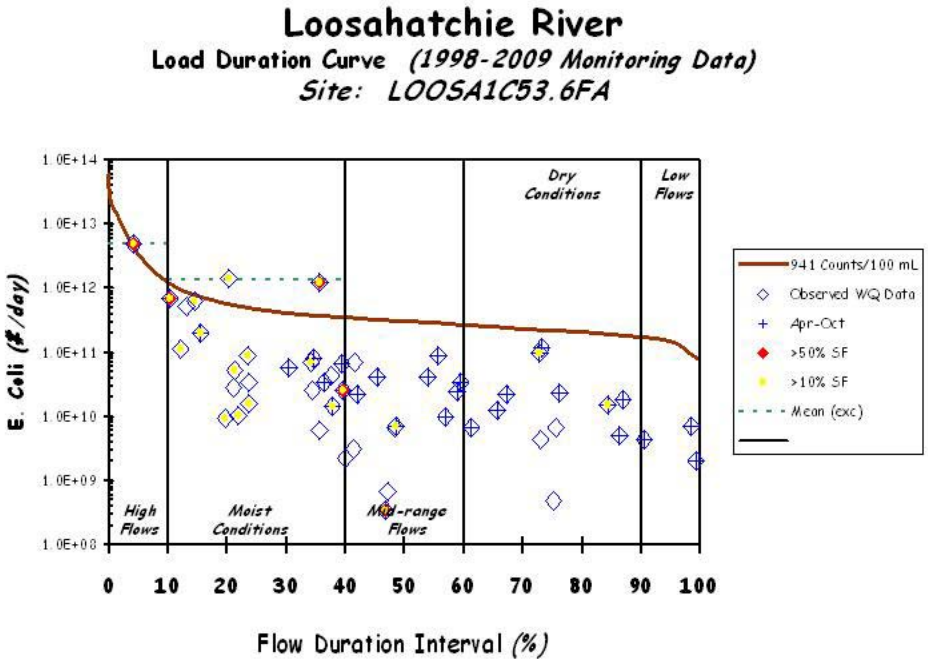

Figure E-5. E. Coli Load Duration Curve for Loosahatchie River – RM53.6

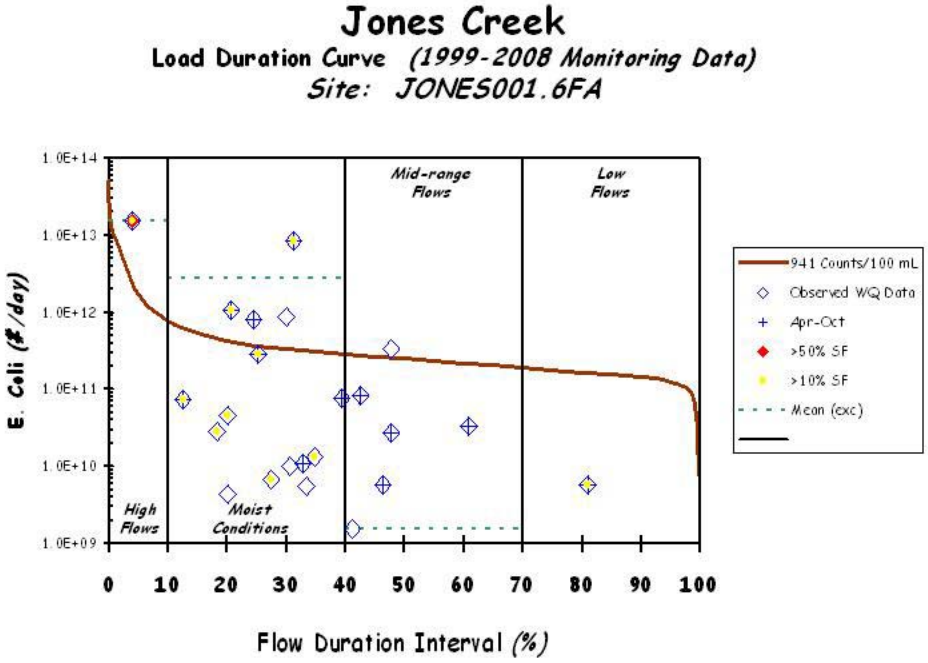

Figure E-6. E. Coli Load Duration Curve for Jones Creek

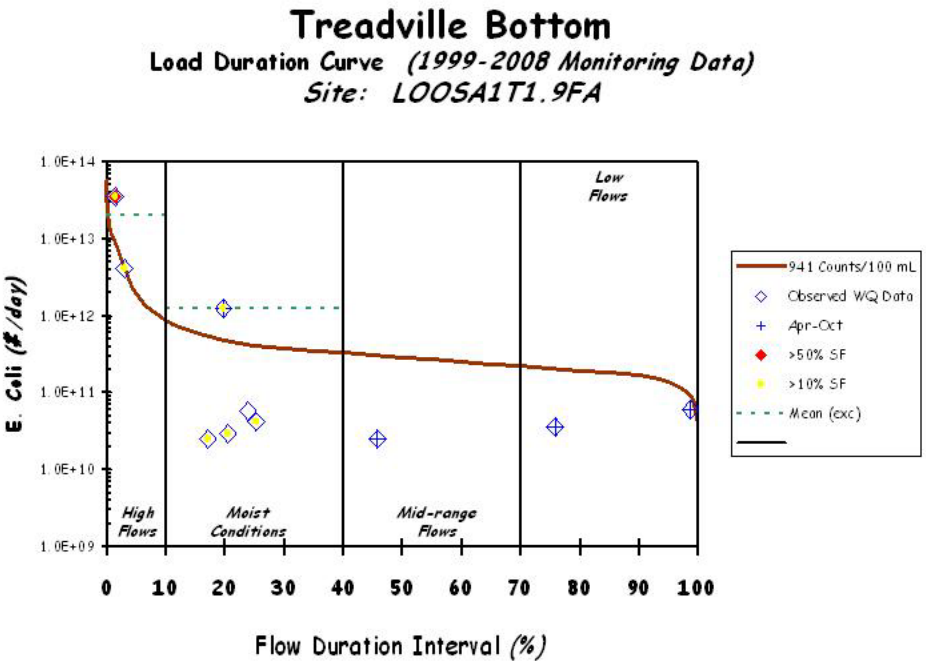

Figure E-7. E. Coli Load Duration Curve for Treadville Bottom

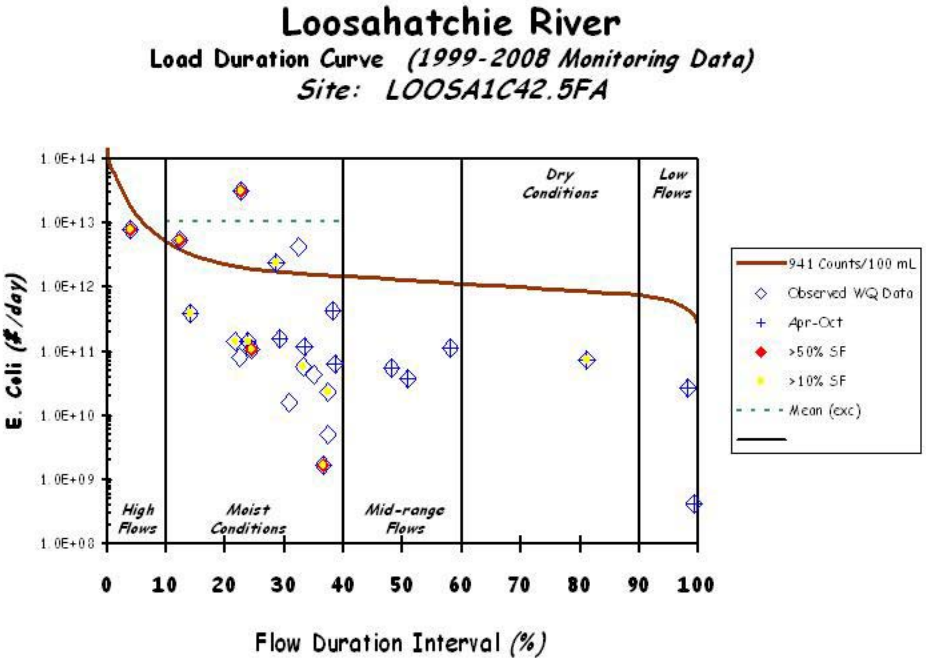

Figure E-8. E. Coli Load Duration Curve for Loosahatchie River – RM42.5

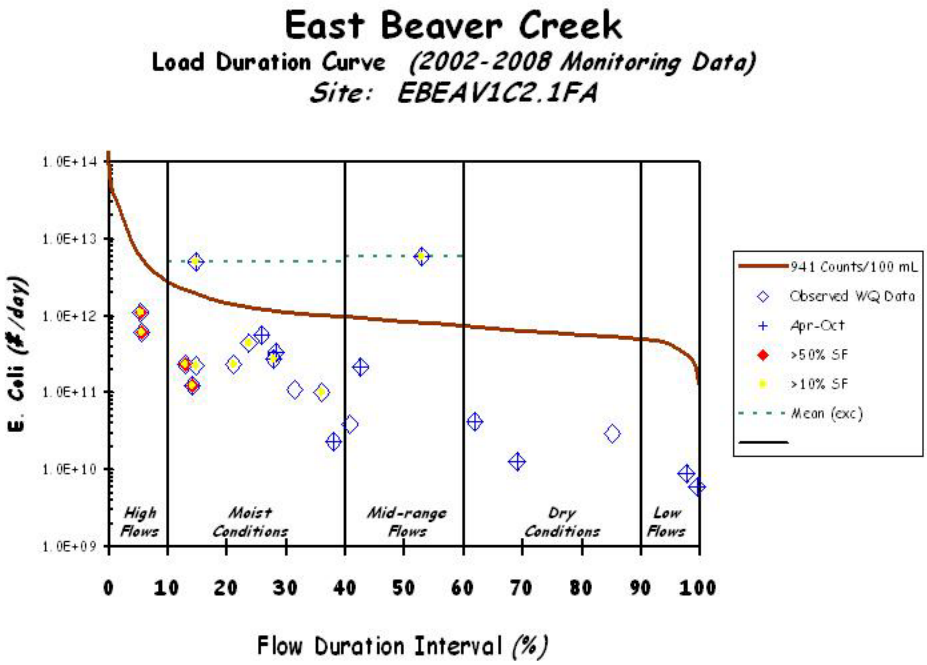

Figure E-9. E. Coli Load Duration Curve for East Beaver Creek – RM2.1

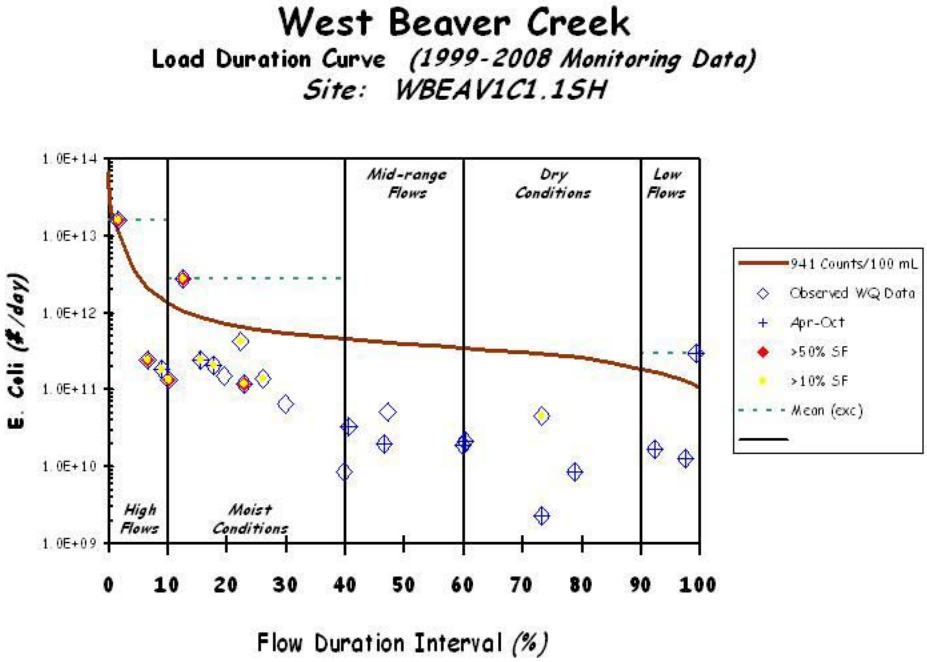

Figure E-10. E. Coli Load Duration Curve for West Beaver Creek – RM1.1

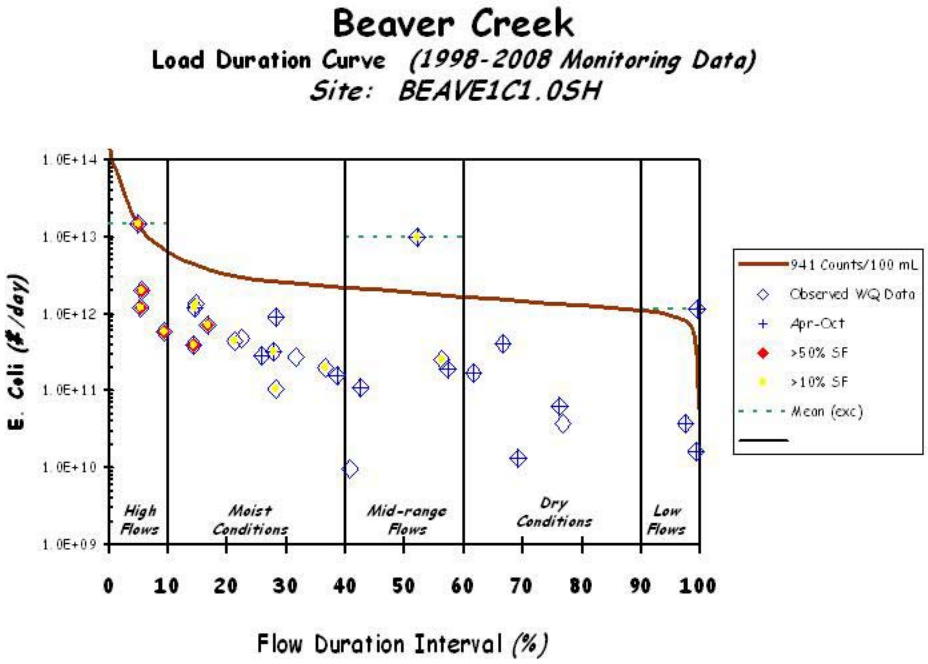

Figure E-11. E. Coli Load Duration Curve for Beaver Creek – RM1.0

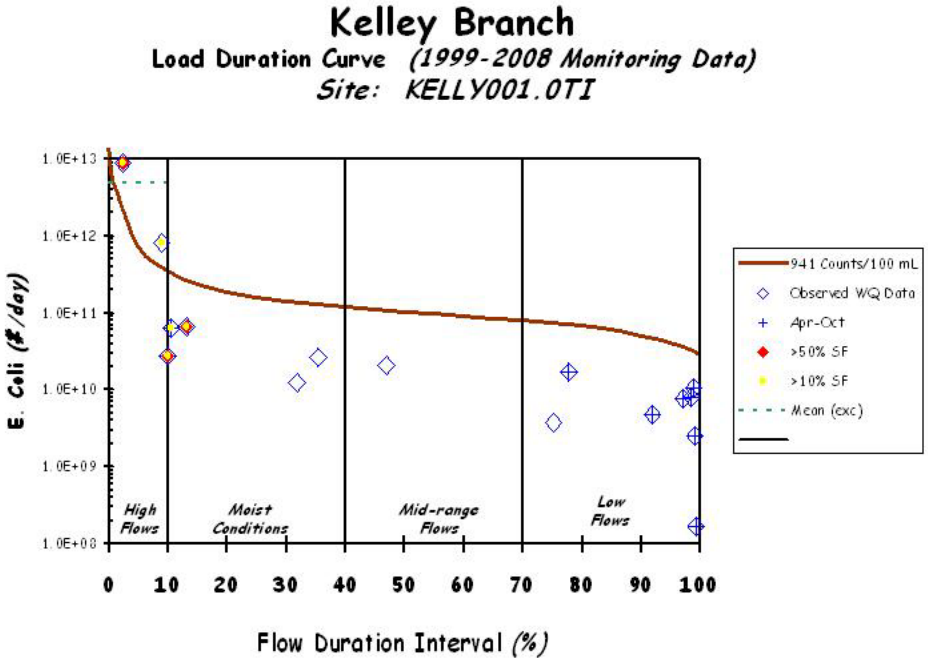

Figure E-12. E. Coli Load Duration Curve for Kelley Branch

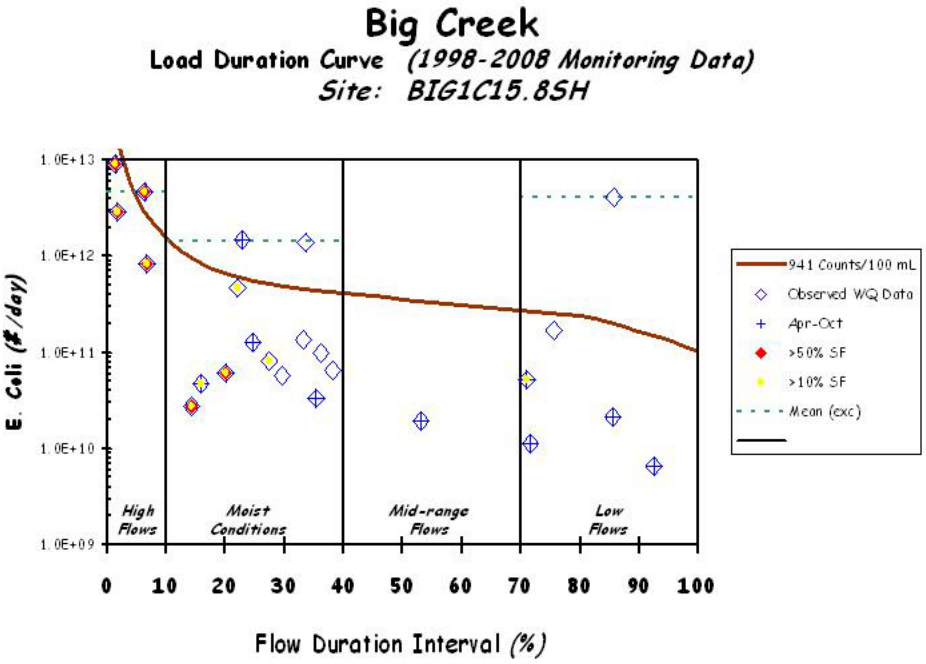

Figure E-13. E. Coli Load Duration Curve for Big Creek – RM15.8

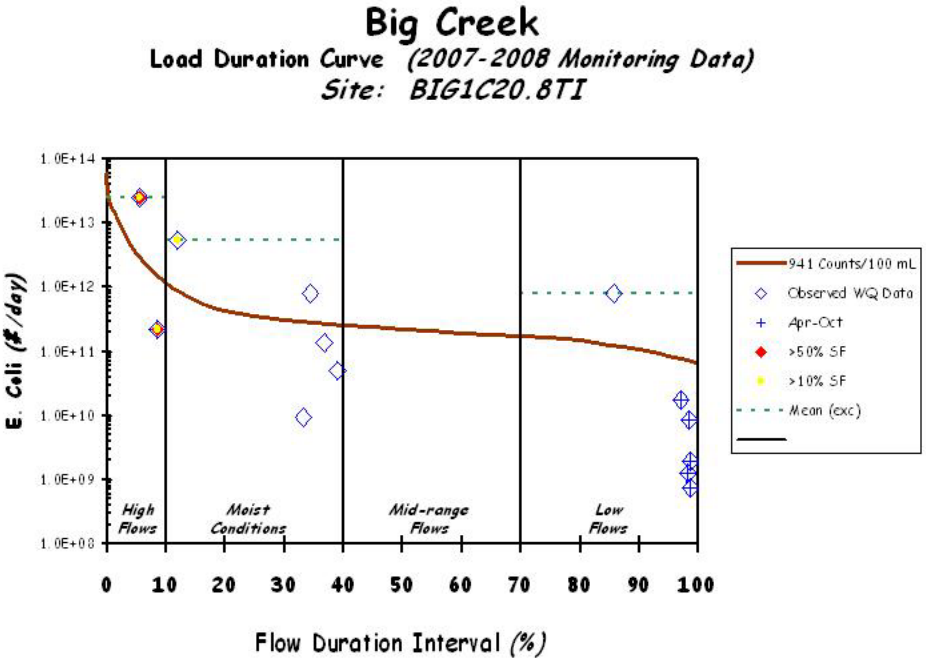

Figure E-14. E. Coli Load Duration Curve for Big Creek – RM20.8

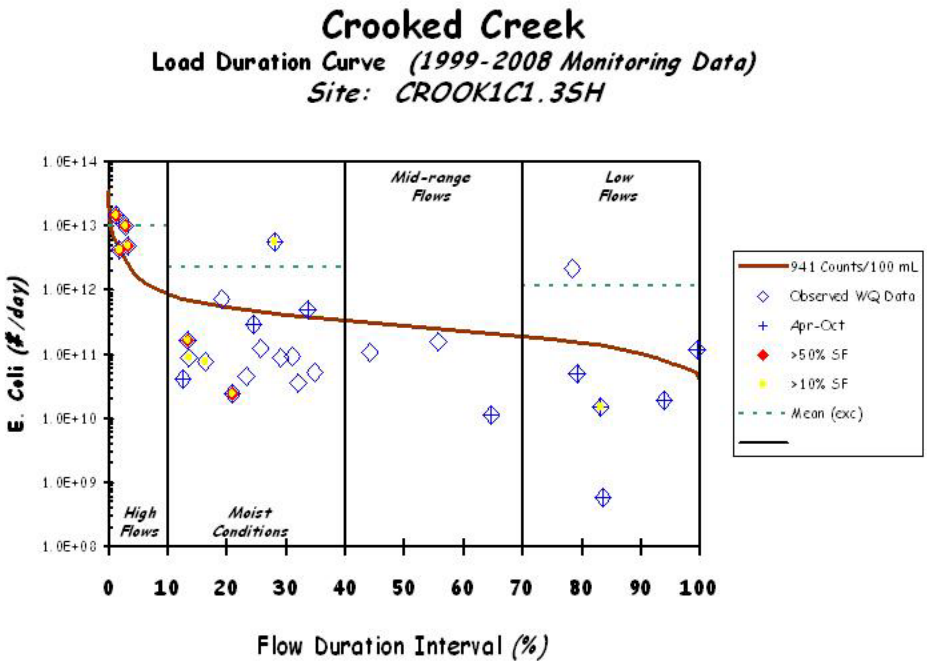

Figure E-15. E. Coli Load Duration Curve for Crooked Creek Canal

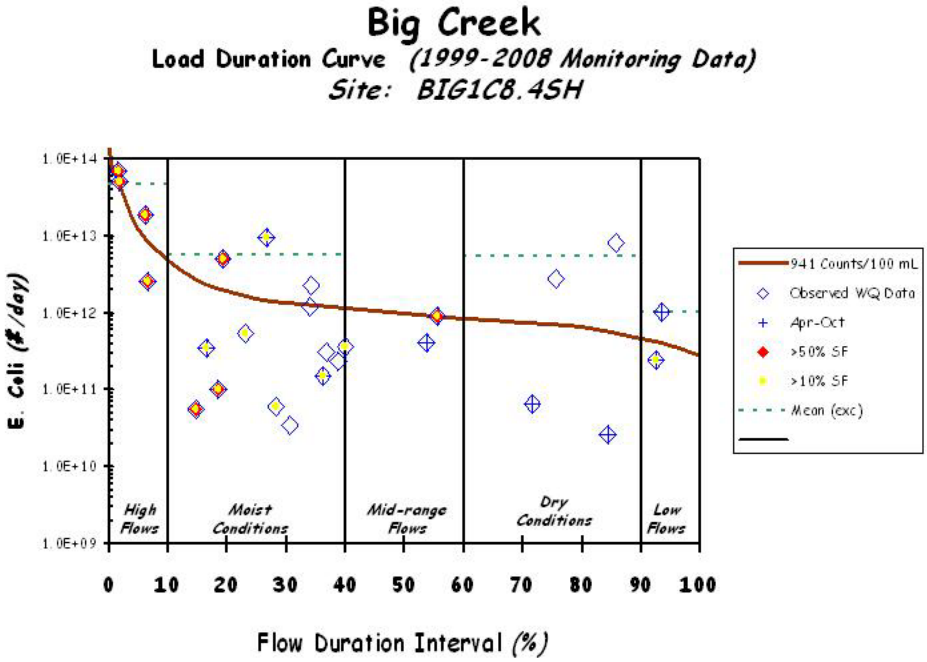

Figure E-16. E. Coli Load Duration Curve for Big Creek – RM8.4

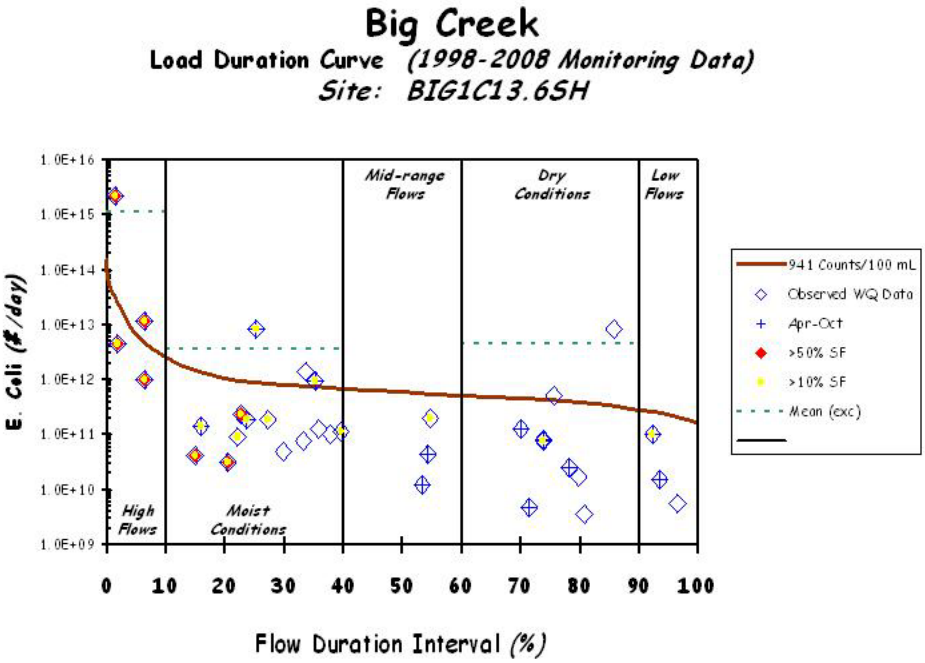

Figure E-17. E. Coli Load Duration Curve for Big Creek – RM13.6

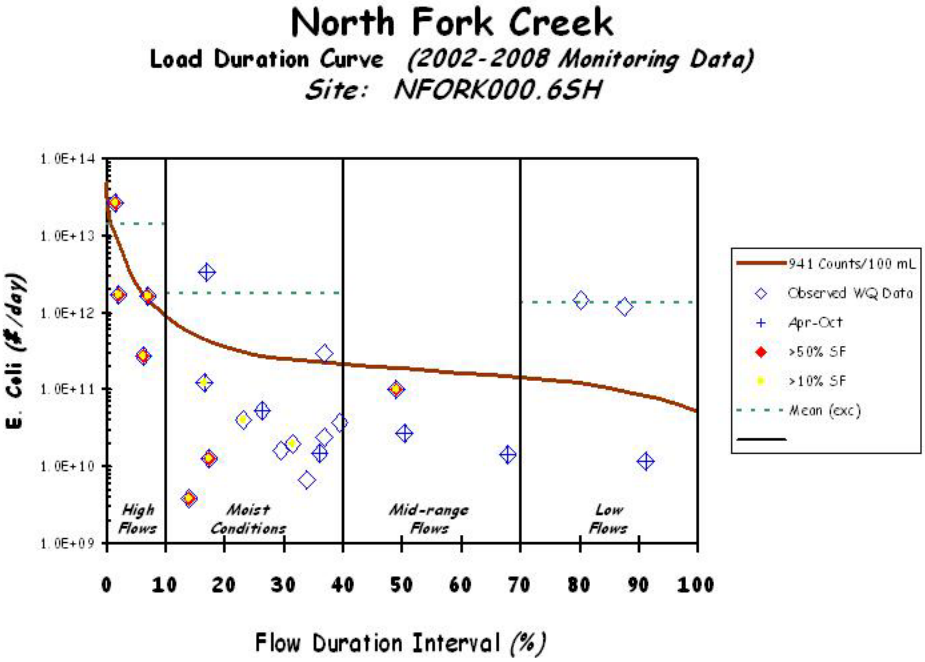

Figure E-18. E. Coli Load Duration Curve for North Fork Creek

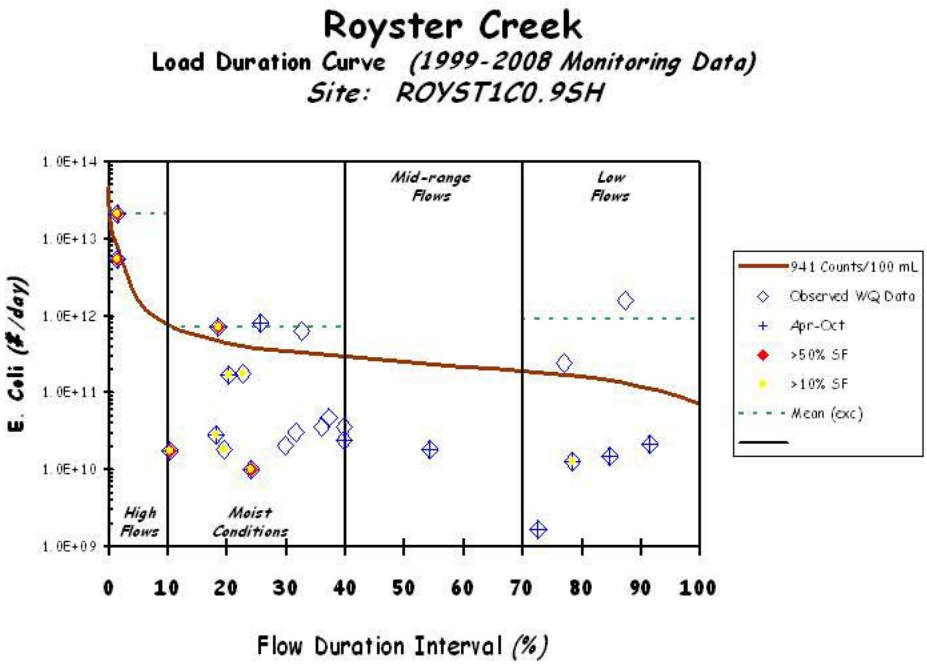

Figure E-19. E. Coli Load Duration Curve for Royster Creek

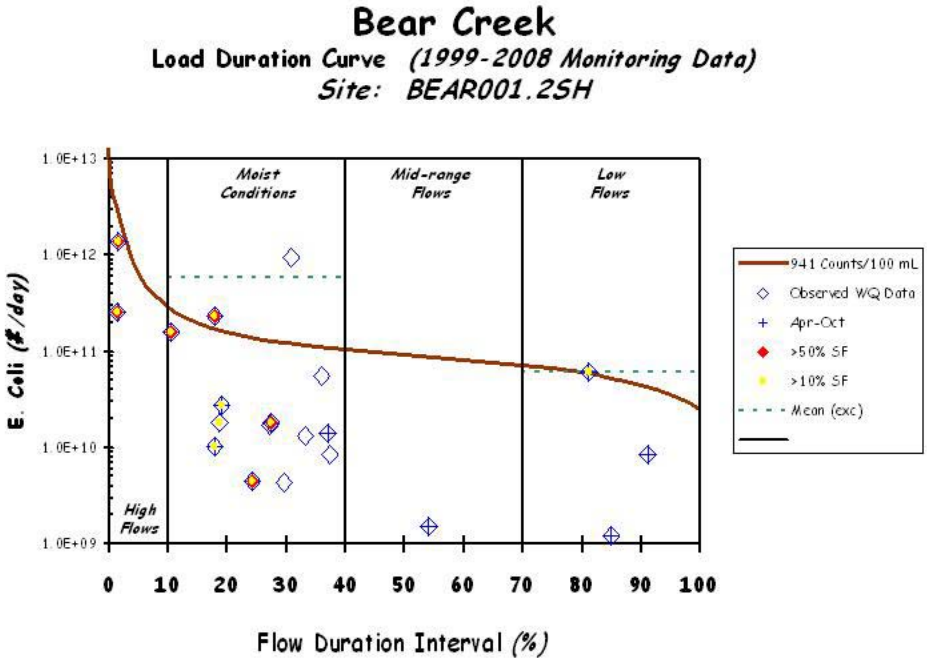

Figure E-20. E. Coli Load Duration Curve for Bear Creek

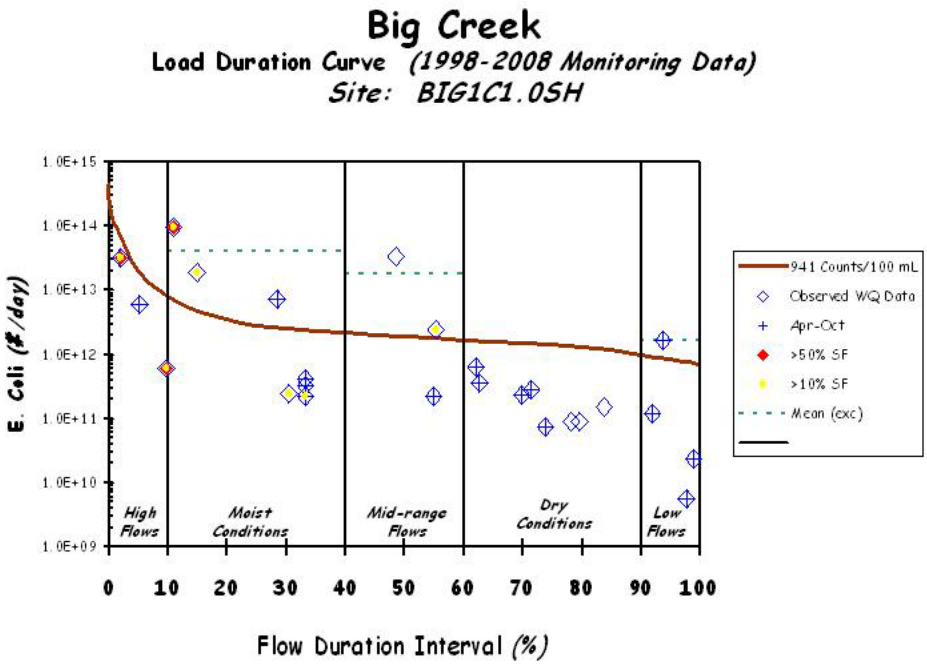

Figure E-21. E. Coli Load Duration Curve for Big Creek – RM1.0

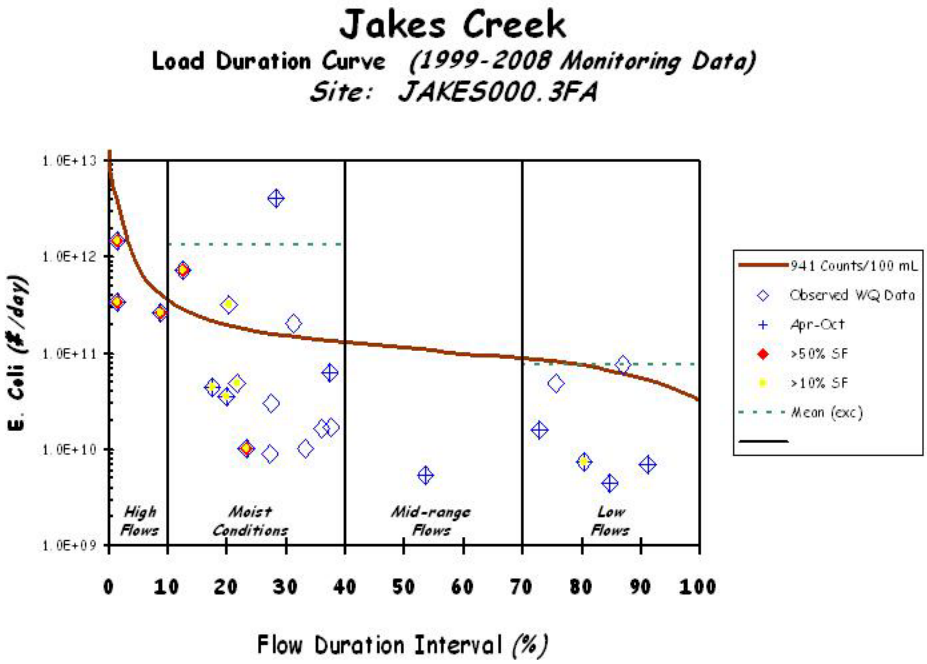

Figure E-22. E. Coli Load Duration Curve for Jakes Creek

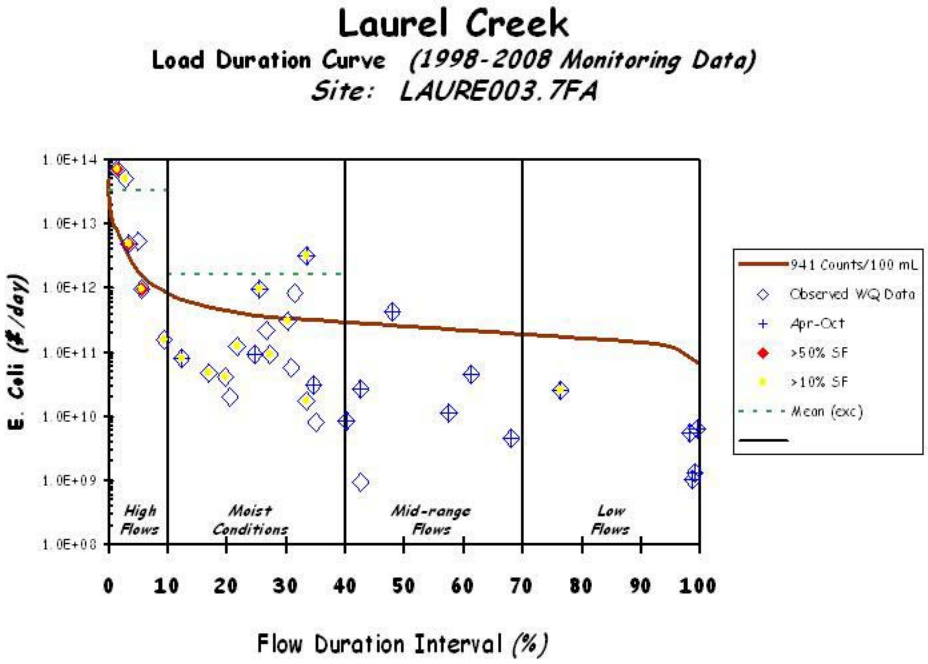

Figure E-23. E. Coli Load Duration Curve for Laurel Creek

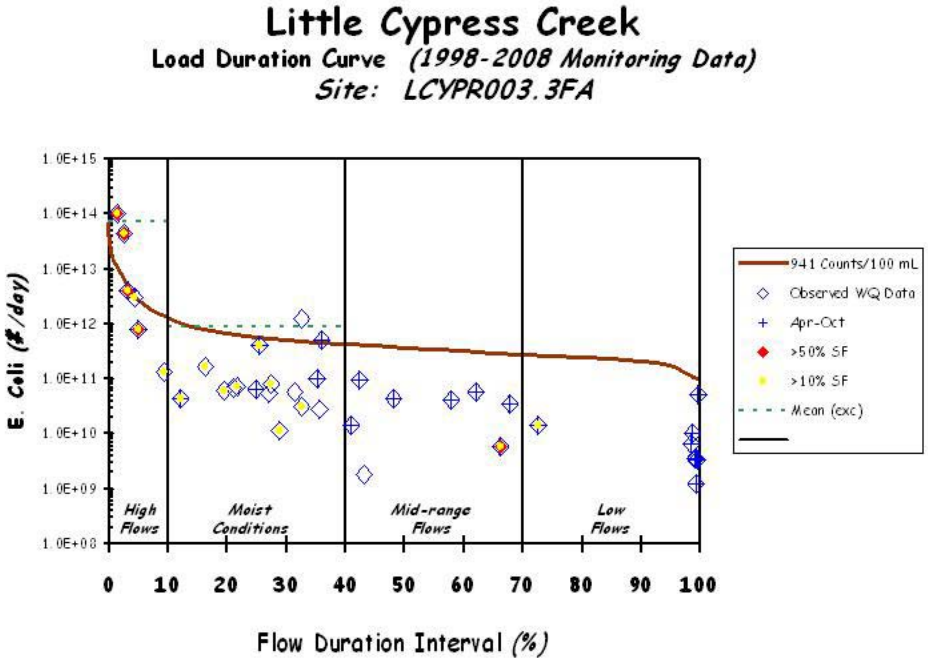

Figure E-24. E. Coli Load Duration Curve for Little Cypress Creek

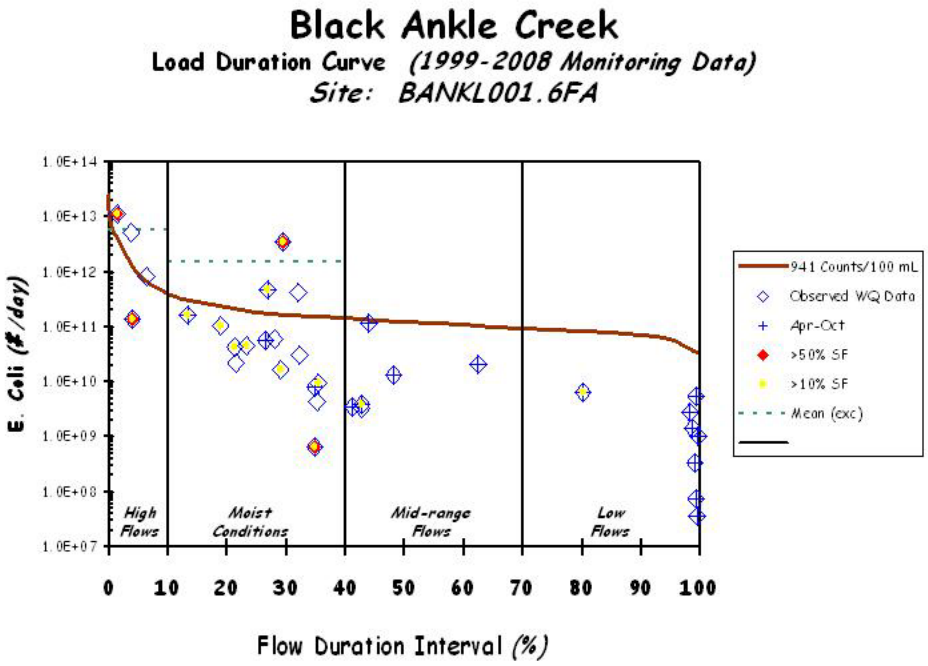

Figure E-25. E. Coli Load Duration Curve for Black Ankle Creek

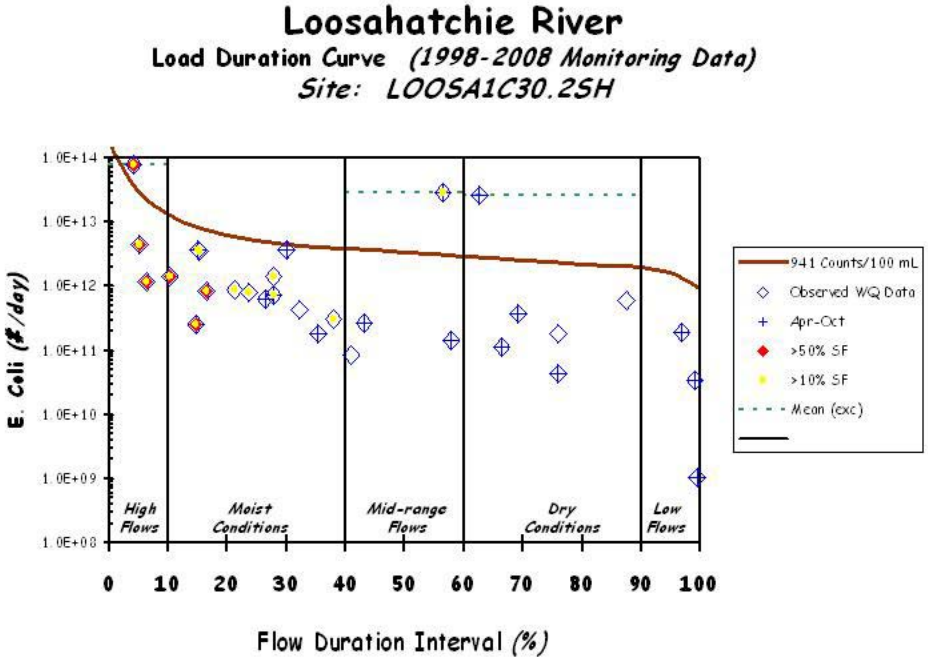

Figure E-26. E. Coli Load Duration Curve for Loosahatchie River – RM30.2

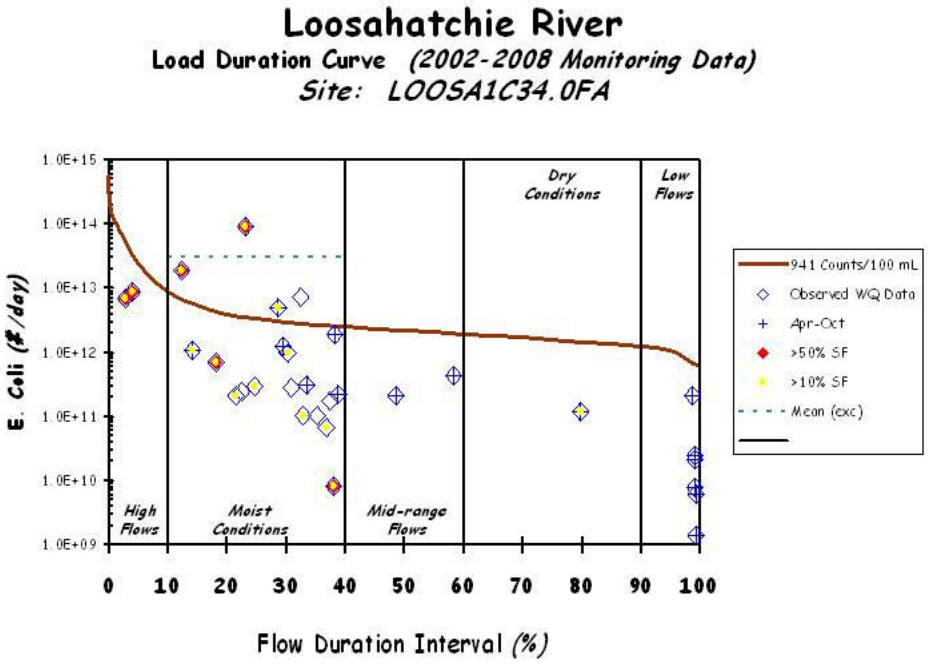

Figure E-27. E. Coli Load Duration Curve for Loosahatchie River – RM34.0

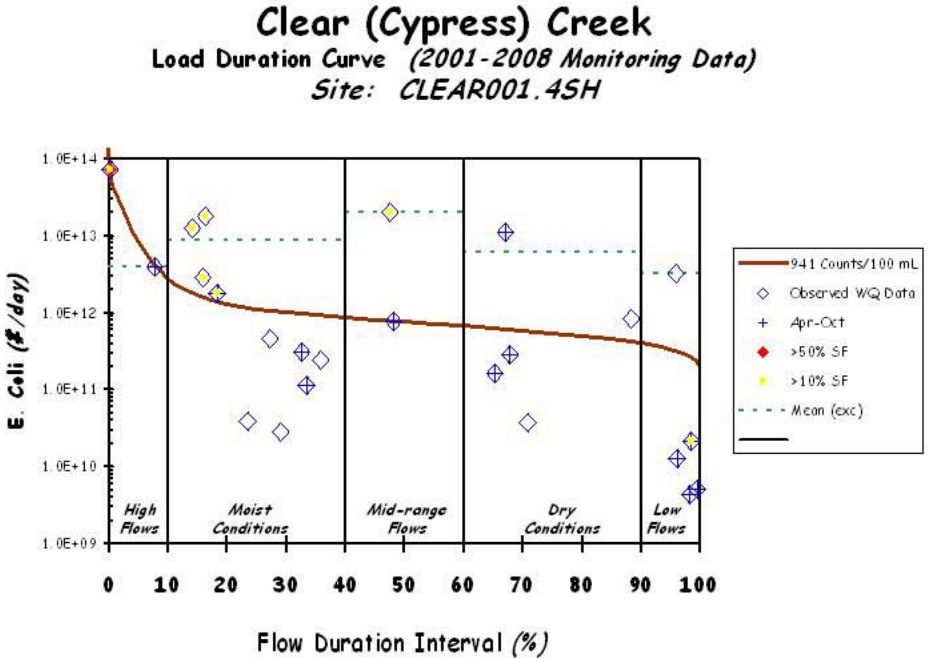

Figure E-28. E. Coli Load Duration Curve for Clear Creek – RM1.4

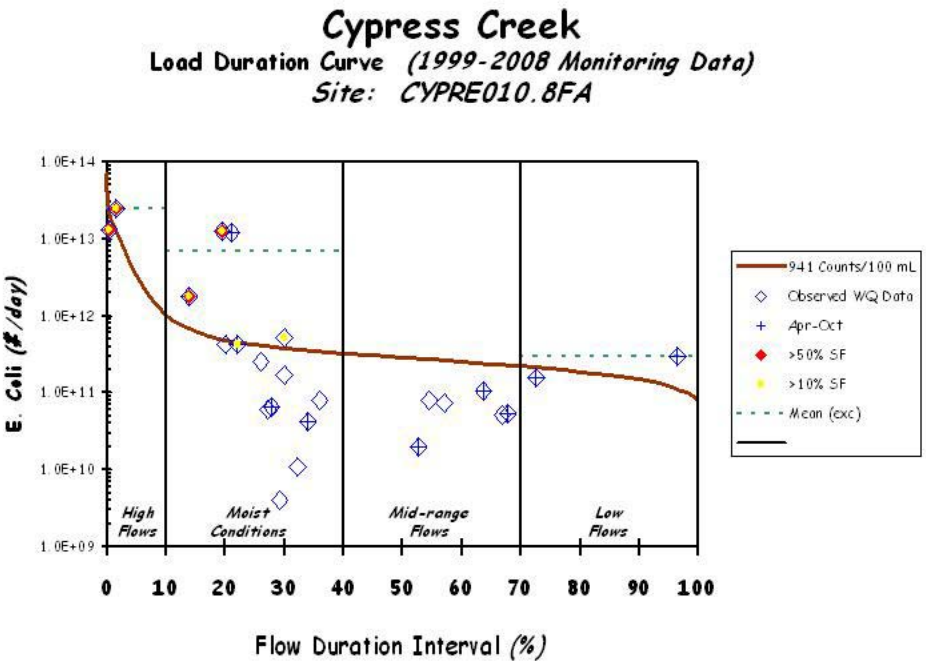

Figure E-29. E. Coli Load Duration Curve for Cypress Creek – RM10.8

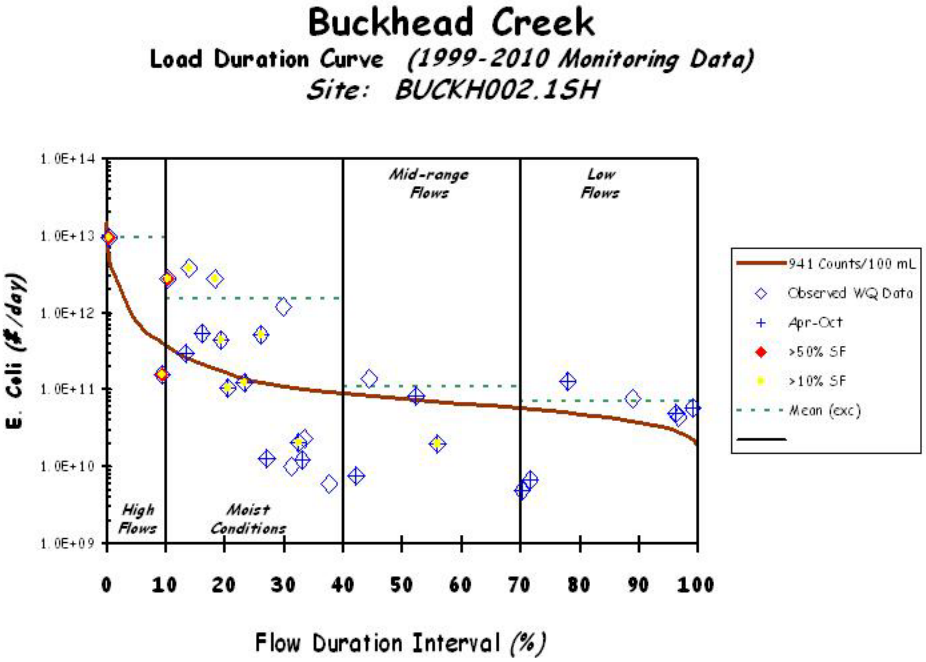

Figure E-30. E. Coli Load Duration Curve for Buckhead Creek – RM2.1

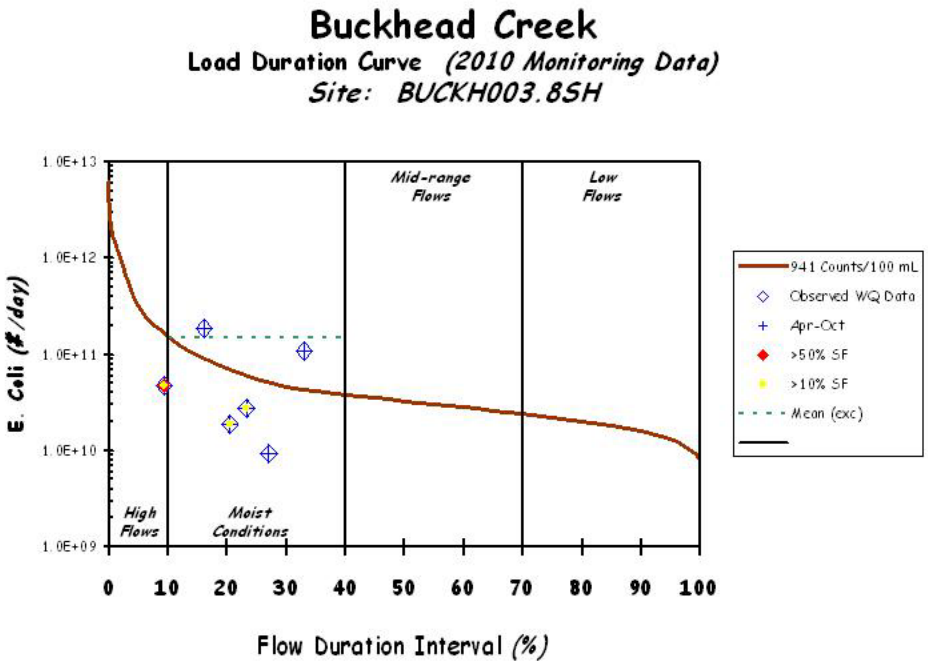

Figure E-31. E. Coli Load Duration Curve for Buckhead Creek – RM3.8

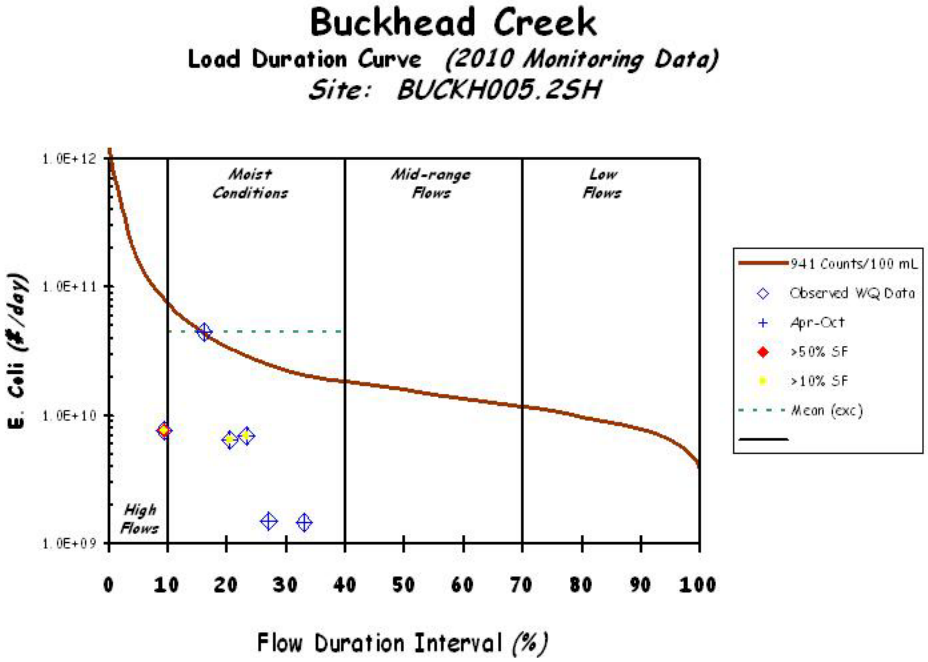

Figure E-32. E. Coli Load Duration Curve for Buckhead Creek – RM5.2

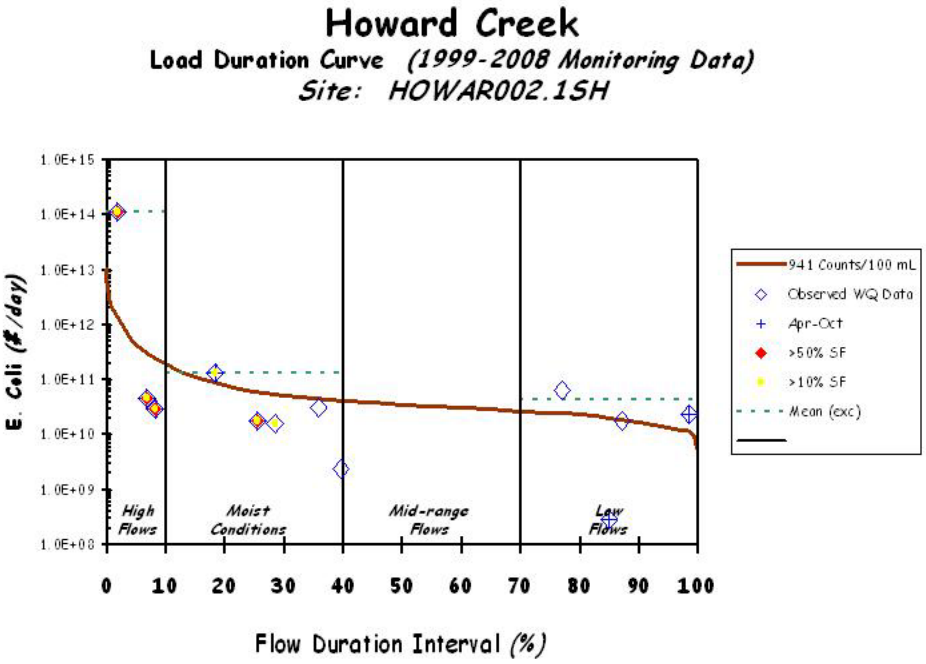

Figure E-33. E. Coli Load Duration Curve for Howard Creek

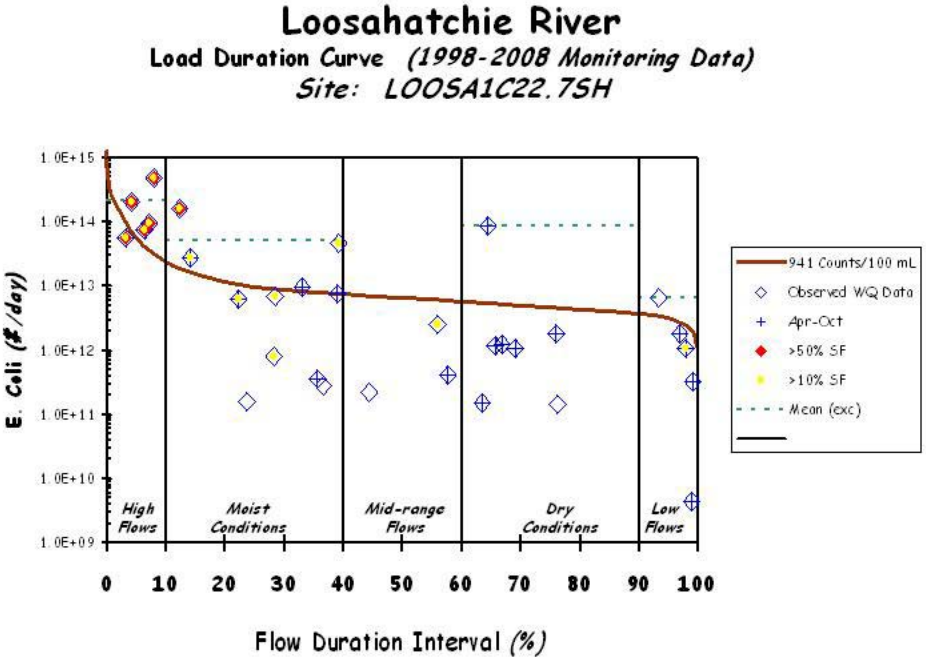

Figure E-34. E. Coli Load Duration Curve for Loosahatchie River – RM22.7

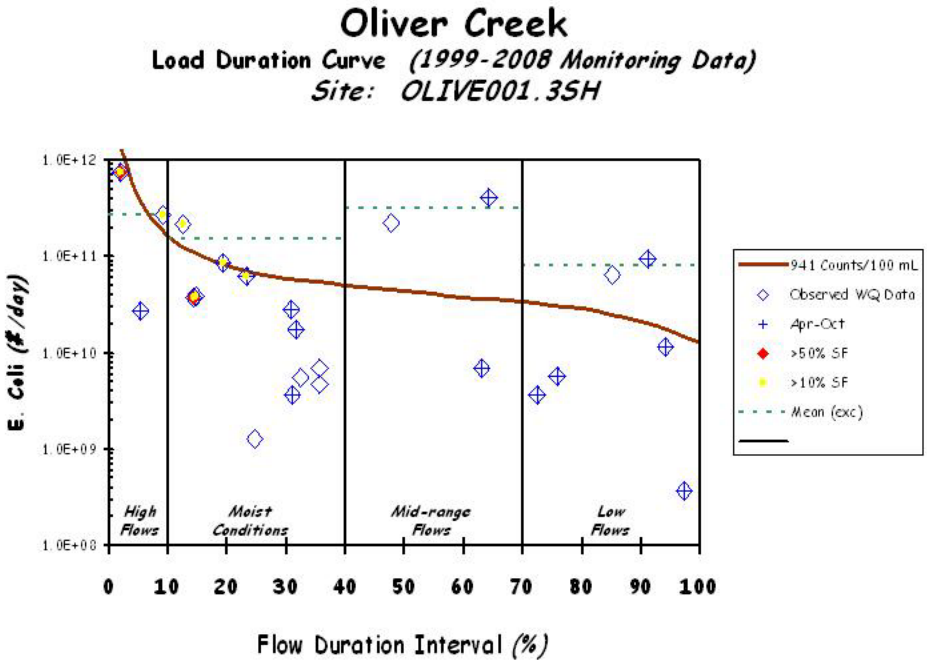

Figure E-35. E. Coli Load Duration Curve for Oliver Creek

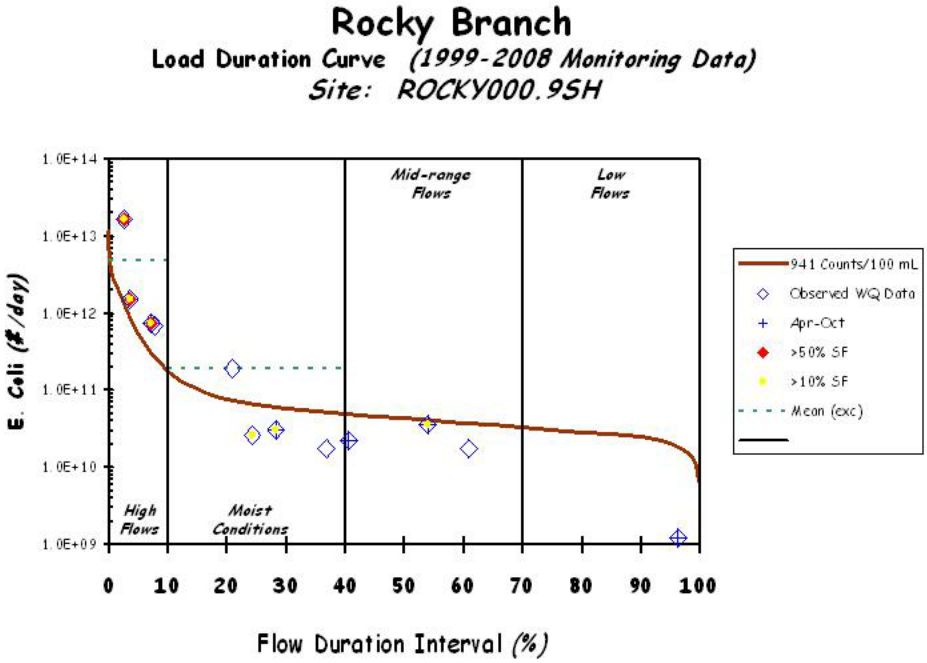

Figure E-36. E. Coli Load Duration Curve for Rocky Branch

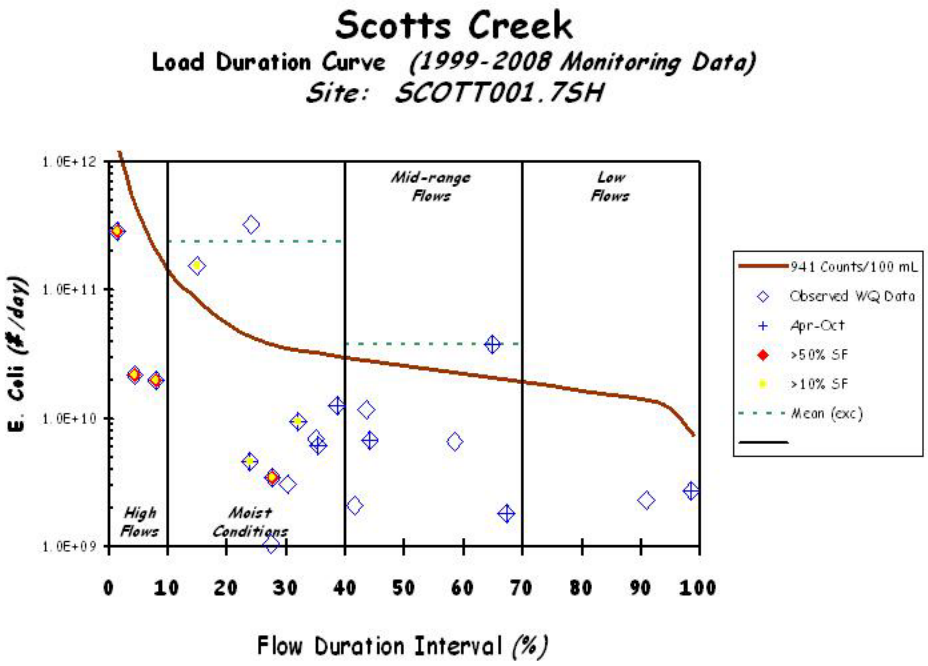

Figure E-37. E. Coli Load Duration Curve for Scotts Creek

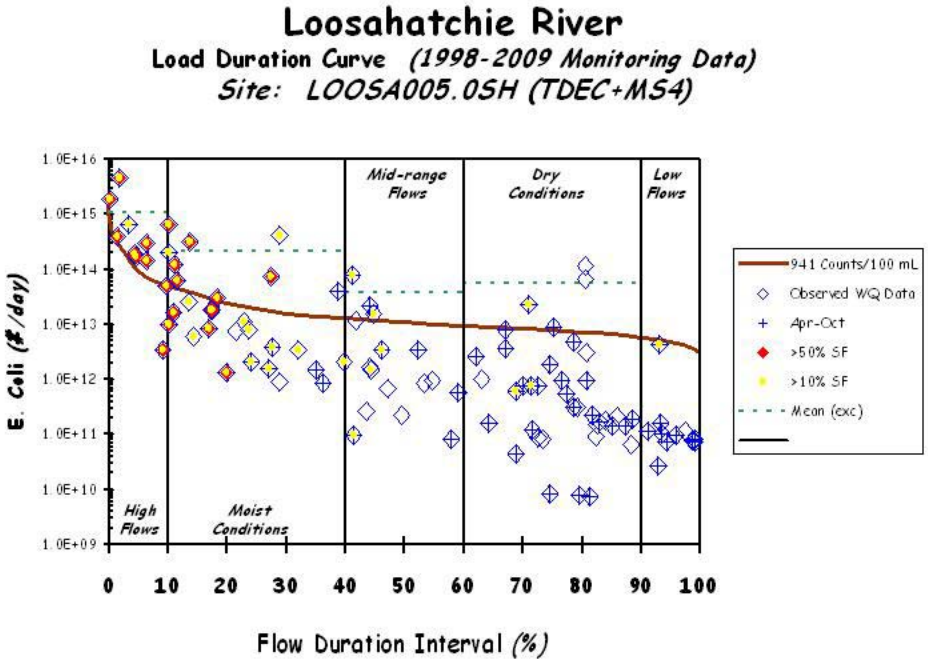

Figure E-38. E. Coli Load Duration Curve for Loosahatchie River – RM5.0

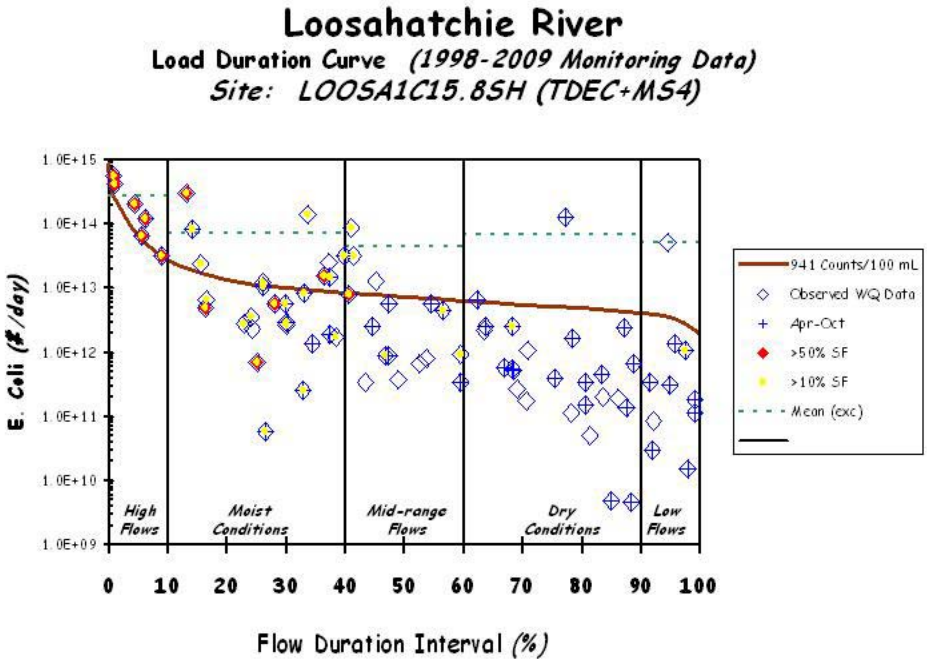

Figure E-39. E. Coli Load Duration Curve for Loosahatchie River – RM15.8

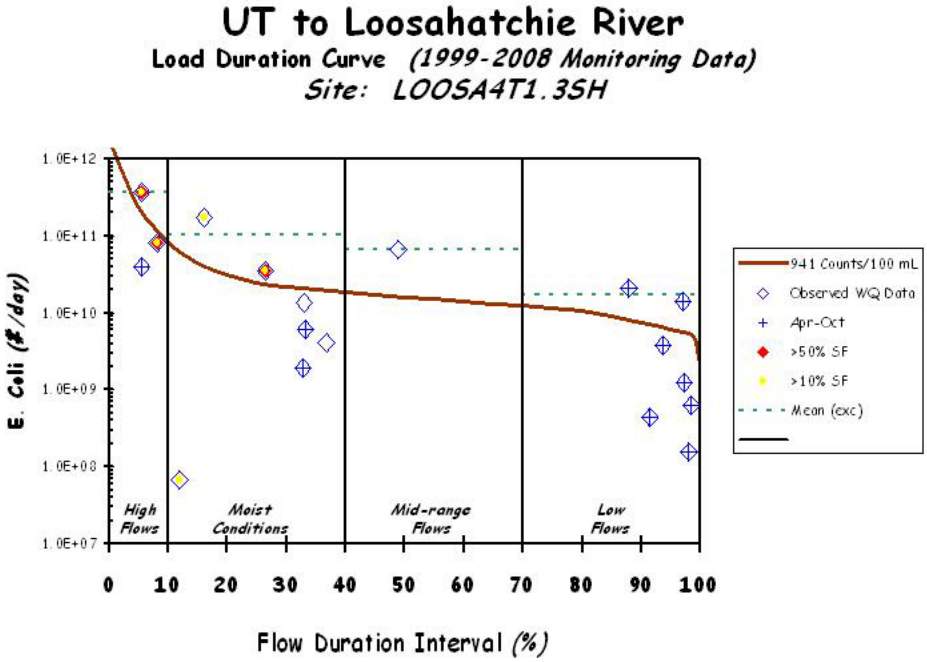

Figure E-40. E. Coli Load Duration Curve for UT to Loosahatchie River – RM1.3

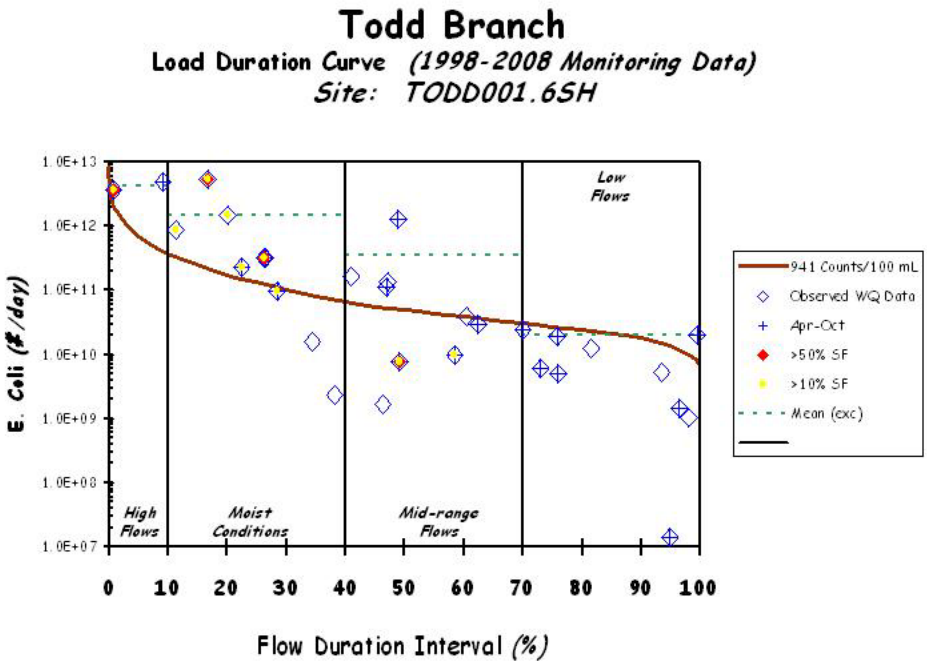

Figure E-41. E. Coli Load Duration Curve for Todd Branch

Table E-4. Calculated Load Reduction Based on Daily Loading – Loosahatchie River – RM53.6

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]	[%]	[%]	[%]
9/23/09	High Flows	194.70	4.1%	1,046.0	4.98E+12	**10.0**	**10.0**	**19.0**
4/11/07	Moist Conditions	51.60	10.4%	550.0	6.94E+11	NR		
1/17/07		42.84	12.2%	110.0	1.15E+11	NR		
1/30/08		39.32	13.1%	537.0	5.17E+11	NR		
2/20/02		34.81	14.5%	727.0	6.19E+11	NR		
9/30/02		31.44	15.6%	260.2	2.00E+11	NR		
11/27/07		24.98	19.8%	15.0	9.17E+09	NR		
3/26/03		24.06	20.4%	2,419.2	1.42E+12	**61.1**		
3/31/09		23.07	21.2%	51.0	2.88E+10	NR		
1/27/99		22.90	21.4%	95.9	5.37E+10	NR		
12/15/09		22.75	21.6%	210.0	1.17E+11	NR		
1/31/06		22.50	21.9%	19.0	1.05E+10	NR		
2/8/05		21.19	23.5%	172.5	8.94E+10	NR		
11/20/02		20.85	23.8%	31.3	1.60E+10	NR		
3/3/03		20.86	23.8%	68.3	3.49E+10	NR		
4/29/08		17.79	30.4%	133.0	5.79E+10	NR		
12/15/98		16.65	34.3%	172.5	7.03E+10	NR		
1/8/03		16.60	34.5%	63.8	2.59E+10	NR		
5/22/02		16.59	34.6%	201.4	8.17E+10	NR		
2/27/08		16.37	35.6%	15.0	6.01E+09	NR		
5/27/08		16.33	35.7%	3,080.0	1.23E+12	**69.4**		
5/28/03		16.16	36.5%	86.0	3.40E+10	NR		
3/26/08		15.82	37.6%	110.0	4.26E+10	NR		
7/31/02		15.78	37.8%	37.7	1.46E+10	NR		
4/23/03		15.47	39.4%	175.0	6.62E+10	NR		
9/21/05		15.40	39.7%	66.3	2.50E+10	NR	**5.2**	**5.5**

Table E-4 (cont'd). Calculated Load Reduction Based on Daily Loading – Loosahatchie River – RM53.6

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]	[%]	[%]	[%]
1/3/08	Mid-Range Flows	15.32	40.0%	6.0	2.25E+09	NR		
1/28/03		15.01	41.4%	8.4	3.08E+09	NR		
2/24/04		14.94	41.7%	193.5	7.07E+10	NR		
6/25/03		14.86	42.0%	60.9	2.21E+10	NR		
10/30/02		14.22	45.5%	116.2	4.04E+10	NR		
8/29/07		13.90	46.9%	1.0	3.40E+08	NR		
12/8/03		13.84	47.3%	2.0	6.77E+08	NR		
12/17/08		13.61	48.5%	20.0	6.66E+09	NR		
5/8/01		13.59	48.6%	21.1	7.02E+09	NR		
6/24/08		12.72	53.9%	135.0	4.20E+10	NR		
6/30/09		12.39	55.8%	291.0	8.82E+10	NR		
8/20/98		12.16	57.0%	32.8	9.76E+09	NR		
6/8/04		11.80	59.0%	83.6	2.41E+10	NR		
8/25/03		11.73	59.5%	121.0	3.47E+10	NR	**NR**	**NR**
5/24/06	Dry Conditions	11.47	61.3%	24.0	6.73E+09	NR		
10/21/98		10.85	65.8%	46.5	1.23E+10	NR		
8/28/02		10.61	67.4%	83.9	2.18E+10	NR		
10/25/04		9.93	72.9%	410.6	9.97E+10	NR		
11/20/01		9.90	73.2%	18.1	4.38E+09	NR		
9/30/08		9.89	73.4%	488.0	1.18E+11	NR		
2/7/01		9.70	75.2%	2.0	4.74E+08	NR		
11/18/98		9.62	75.7%	28.1	6.61E+09	NR		
9/30/98		9.52	76.3%	98.4	2.29E+10	NR		
10/30/07		8.36	84.4%	75.0	1.53E+10	NR		
6/29/05		8.06	86.4%	25.9	5.11E+09	NR		
8/14/01		7.96	87.1%	95.8	1.87E+10	NR	**NR**	**NR**

Table E-4 (cont'd). Calculated Load Reduction Based on Daily Loading – Loosahatchie River – RM53.6

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]	[%]	[%]	[%]
10/10/06	Low Flows	7.44	90.7%	24.0	4.37E+09	NR		
7/31/07		4.22	98.6%	67.0	6.92E+09	NR		
10/2/07		3.65	99.5%	23.0	2.05E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-5. Calculated Load Reduction Based on Daily Loading – Jones Creek – RM1.6

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]	[%]	[%]	[%]
7/31/02	High Flows	97.40	4.0%	6,488.0	1.55E+13	**85.5**	**42.7**	**43.5**
9/30/02	Moist Conditions	27.90	12.5%	107.1	7.31E+10	NR		
11/27/07		20.10	18.3%	57.0	2.80E+10	NR		
11/20/02		18.70	20.2%	98.3	4.50E+10	NR		
3/3/03		18.70	20.2%	9.7	4.44E+09	NR		
4/25/00		18.20	20.8%	2,419.2	1.08E+12	**61.1**		
4/23/03		16.20	24.5%	2,014.0	7.98E+11	53.3		
4/29/08		15.90	25.3%	727.0	2.83E+11	NR		
2/27/08		15.20	27.5%	18.0	6.69E+09	NR		
3/26/03		14.50	30.1%	2,419.2	8.58E+11	**61.1**		
3/26/08		14.40	30.6%	29.0	1.02E+10	NR		
5/27/08		14.20	31.2%	24,200.0	8.41E+12	**96.1**		
5/28/03		13.90	32.9%	31.7	1.08E+10	NR		
1/8/03		13.80	33.4%	16.1	5.44E+09	NR		
1/3/08		13.60	34.9%	40.0	1.33E+10	NR		
6/25/03		12.70	39.5%	248.1	7.71E+10	NR	**18.1**	**19.0**

Table E-5 (cont'd). Calculated Load Reduction Based on Daily Loading – Jones Creek – RM1.6

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]	[%]	[%]	[%]
1/28/03	Mid-Range Flows	12.40	41.2%	5.2	1.58E+09	NR		
10/30/02		12.20	42.6%	275.5	8.22E+10	NR		
6/24/08		11.60	46.4%	20.0	5.68E+09	NR		
5/27/99		11.40	47.9%	98.8	2.76E+10	NR		
1/20/08		11.40	47.9%	1,222.0	3.41E+11	**23.0**		
8/28/02		9.47	61.0%	145.0	3.36E+10	NR	**3.8**	**5.1**
10/30/07	Low Flows	7.19	81.0%	33.0	5.81E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-6. Calculated Load Reduction Based on Daily Loading – Treadville Bottom – RM1.9

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]	[%]	[%]	[%]
3/19/08	High Flows	388.00	1.3%	3,784.0	3.59E+13	**75.1**		
3/4/08		154.90	2.9%	1,098.0	4.16E+12	**14.3**	**44.7**	**50.2**
11/27/07	Moist Conditions	23.48	17.2%	44.0	2.53E+10	NR		
4/25/00		21.21	19.8%	2,419.2	1.26E+12	**61.1**		
3/11/08		20.68	20.5%	59.0	2.99E+10	NR		
3/25/08		18.43	24.0%	130.0	5.86E+10	NR		
2/27/08		17.96	25.3%	96.0	4.22E+10	NR	**12.2**	**13.0**
5/27/99	Mid-Range Flows	13.35	45.9%	77.6	2.53E+10	NR	**NR**	**NR**
8/4/99	Low Flows	8.95	75.9%	162.4	3.56E+10	NR		
8/6/07		4.09	98.8%	613.0	6.14E+10	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-7. Calculated Load Reduction Based on Geomean Data – Treadville Bottom – RM1.9

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]	[%]	[%]
2/27/08	17.96	25.3%	96.0			
3/4/08	154.90	2.9%	1,098.0			
3/11/08	20.68	20.5%	59.0			
3/19/08	388.00	1.3%	3,784.0			
3/25/08	18.43	24.0%	130.0	**314.1**	**59.9**	**64.0**

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

Table E-8. Calculated Load Reduction Based on Daily Loading – Loosahatchie River – RM42.5

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]	[%]	[%]	[%]
7/31/02	High Flows	791.00	4.0%	410.6	7.95E+12	NR	**NR**	**NR**
1/30/08	Moist Conditions	171.00	12.3%	1,274.0	5.33E+12	**26.1**		
9/30/02		143.00	14.2%	112.4	3.93E+11	NR		
11/20/02		94.50	21.7%	63.1	1.46E+11	NR		
3/3/03		91.50	22.5%	35.9	8.04E+10	NR		
5/27/08		90.50	22.8%	14,140.0	3.13E+13	**93.3**		
4/25/00		86.60	24.0%	68.1	1.44E+11	NR		
11/27/05		84.80	24.6%	52.0	1.08E+11	NR		
4/29/08		76.90	28.7%	1,300.0	2.45E+12	**27.6**		
4/23/03		76.10	29.3%	86.0	1.60E+11	NR		
1/8/03		74.30	30.9%	8.5	1.55E+10	NR		
3/26/03		72.60	32.4%	2,419.2	4.30E+12	**61.1**		
2/27/08	Moist Conditions (con'td)	71.60	33.2%	33.0	5.78E+10	NR		
5/28/03		71.20	33.5%	68.9	1.20E+11	NR		
3/26/08		69.30	35.0%	26.0	4.41E+10	NR		
8/29/07		67.80	36.7%	1.0	1.66E+09	NR		
1/28/03		67.10	37.5%	3.1	5.09E+09	NR		
1/3/08		67.00	37.5%	14.0	2.29E+10	NR		
10/30/02		66.10	38.2%	260.2	4.21E+11	NR		
6/25/03		65.70	38.7%	38.8	6.24E+10	NR	**11.0**	**12.0**
6/24/08	Mid-Range Flows	57.70	48.3%	39.0	5.51E+10	NR		
5/27/99		55.80	51.0%	28.1	3.84E+10	NR		
8/28/02		50.50	58.2%	93.3	1.15E+11	NR	**NR**	**NR**
10/30/07	Dry Conditions	37.20	81.3%	80.0	7.28E+10	NR	**NR**	**NR**
7/31/07	Low Flows	19.70	98.5%	57.0	2.75E+10	NR		
10/2/07		17.30	99.4%	1.0	4.23E+08	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-9. Calculated Load Reduction Based on Daily Loading – East Beaver Creek – RM2.1

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]	[%]	[%]	[%]
2/19/03	High Flows	255.20	5.4%	178.5	1.11E+12	NR		
3/18/08		244.70	5.6%	101.0	6.05E+11	NR	**NR**	**NR**
11/19/02	Moist Conditions	96.08	13.0%	101.7	2.39E+11	NR		
5/22/08		89.13	14.2%	58.0	1.26E+11	NR		
5/21/03		86.42	14.8%	2,419.2	5.12E+12	61.1		
12/18/07		85.99	14.8%	107.0	2.25E+11	NR		
12/16/02		60.72	21.1%	160.7	2.39E+11	NR		
2/20/08		55.63	23.8%	328.0	4.46E+11	NR		
4/16/08		52.68	25.9%	435.0	5.61E+11	NR		
6/17/08		50.50	27.8%	218.7	2.70E+11	NR		
6/18/03		49.95	28.3%	272.3	3.33E+11	NR		
3/25/03		47.54	31.5%	93.4	1.09E+11	NR		
1/24/08		44.71	36.0%	93.0	1.02E+11	NR		
4/16/03		43.43	38.1%	21.6	2.30E+10	NR	**5.1**	**5.4**
1/27/03	Mid-Range Flows	41.84	40.9%	38.8	3.97E+10	NR		
10/23/02		40.91	42.7%	214.3	2.14E+11	NR		
7/24/02		35.60	53.0%	6,867.0	5.98E+12	86.3	**28.8**	**29.2**
8/21/02	Low Flows	31.43	61.9%	54.4	4.18E+10	NR		
9/12/02		28.40	69.2%	18.3	1.27E+10	NR		
11/20/07		23.13	85.2%	52.0	2.94E+10	NR		
7/18/07		14.61	97.8%	25.0	8.94E+09	NR		
9/19/07		10.76	99.4%	2.0	5.27E+08	NR		
8/22/07		10.56	99.6%	23.0	5.94E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-10. Calculated Load Reduction Based on Daily Loading – West Beaver Creek – RM1.1

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]	[%]	[%]	[%]
12/18/07	High Flows	465.00	1.5%	1,414.0	1.61E+13	**33.5**		
2/19/03		99.30	6.5%	101.2	2.46E+11	NR		
4/16/08		68.30	8.9%	111.0	1.85E+11	NR	**11.2**	**13.4**
3/25/03	Moist Conditions	57.30	10.2%	95.9	1.34E+11	NR		
5/22/08		46.20	12.6%	2,420.0	2.74E+12	**61.1**		
5/21/03		38.60	15.6%	261.3	2.47E+11	NR		
6/17/08		34.10	17.8%	248.9	2.08E+11	NR		
3/18/08		31.60	19.6%	199.0	1.54E+11	NR		
12/16/02		28.40	22.3%	613.1	4.26E+11	NR		
6/18/03		27.80	22.9%	178.2	1.21E+11	NR		
11/18/02		25.60	26.1%	218.7	1.37E+11	NR		
2/20/08		23.70	29.9%	115.0	6.67E+10	NR		
1/27/03		20.20	39.9%	17.1	8.45E+09	NR	**6.1**	**6.5**
4/16/03	Mid-Range Flows	20.00	40.6%	67.0	3.28E+10	NR		
10/23/02		18.30	46.6%	44.8	2.01E+10	NR		
1/24/08		18.10	47.2%	115.0	5.09E+10	NR		
7/24/02		15.10	60.0%	52.0	1.92E+10	NR		
8/21/02		15.00	60.4%	59.4	2.18E+10	NR	**NR**	**NR**
9/12/02	Low Flows	12.70	73.3%	7.4	2.30E+09	NR		
11/20/07		12.70	73.3%	148.0	4.60E+10	NR		
6/23/99		11.70	78.8%	29.9	8.56E+09	NR		
7/18/07		7.31	92.5%	93.0	1.66E+10	NR		
9/19/07		5.72	97.6%	91.0	1.27E+10	NR		
8/22/07		4.98	99.4%	2,420.0	2.95E+11	**61.1**	**10.2**	**10.8**

Note: NR = No reduction required
NA = Not applicable

Table E-11. Calculated Load Reduction Based on Daily Loading – Beaver 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]	[%]	[%]	[%]
4/4/00	High Flows	621.00	5.0%	980.1	1.49E+13	**4.0**		
2/19/03		589.00	5.3%	82.0	1.18E+12	NR		
3/18/08		570.00	5.5%	144.0	2.01E+12	NR		
2/3/99		299.00	9.4%	79.4	5.81E+11	NR	**1.0**	**3.4**
5/22/08	Moist Conditions	200.00	14.4%	82.0	4.01E+11	NR		
5/21/03		198.00	14.6%	248.1	1.20E+12	NR		
12/18/07		196.00	14.7%	285.0	1.37E+12	NR		
11/18/02		170.00	16.7%	168.9	7.02E+11	NR		
12/16/02		137.00	21.4%	133.6	4.48E+11	NR		
2/20/06		131.00	22.6%	153.0	4.90E+11	NR		
4/16/08		120.00	25.9%	99.0	2.91E+11	NR		
6/17/08		115.00	27.8%	115.3	3.24E+11	NR		
12/15/98		114.00	28.3%	37.7	1.05E+11	NR		
6/18/03		114.00	28.3%	328.2	9.15E+11	NR		
3/25/03		108.00	31.6%	104.6	2.76E+11	NR		
1/24/08		100.00	36.7%	82.0	2.01E+11	NR		
4/16/03		97.40	38.6%	66.3	1.58E+11	NR	**NR**	**NR**
1/27/03	Mid-Range Flows	94.70	40.8%	4.1	9.50E+09	NR		
10/23/02		92.40	42.6%	49.5	1.12E+11	NR		
7/24/02		81.60	52.2%	4,884.0	9.75E+12	**80.7**		
11/20/06		76.70	56.3%	135.0	2.53E+11	NR		
8/20/98		75.60	57.4%	103.4	1.91E+11	NR	**16.1**	**16.5**

Table E-11 (cont'd). Calculated Load Reduction Based on Daily Loading – Beaver 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]	[%]	[%]	[%]
8/21/02	Dry Conditions	71.40	61.7%	97.0	1.69E+11	NR	**NR**	**NR**
10/21/98		66.50	66.8%	248.1	4.04E+11	NR		
9/12/02		64.20	69.4%	8.6	1.35E+10	NR		
9/30/98		58.50	76.2%	43.2	6.18E+10	NR		
11/18/98		58.00	76.8%	25.9	3.68E+10	NR		
7/18/07	Low Flows	33.00	97.7%	47.0	3.79E+10	NR	**17.5**	**19.1**
9/19/07		24.30	99.4%	27.0	1.61E+10	NR		
8/22/07		23.80	99.7%	1,986.0	1.16E+12	**52.6**		

Note: NR = No reduction required
NA = Not applicable

Table E-12. Calculated Load Reduction Based on Daily Loading – Kelley Branch – 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]	[%]	[%]	[%]
3/19/08	High Flows	101.00	2.3%	3,654.0	9.03E+12	**74.2**		
3/4/08		17.10	8.9%	1,935.0	8.10E+11	**51.4**	**62.8**	**66.5**
5/22/08	Moist Conditions	15.40	10.0%	73.0	2.75E+10	NR		
4/16/08		14.80	10.5%	173.0	6.26E+10	NR		
3/18/08		11.60	13.1%	236.0	6.70E+10	NR		
3/25/08		5.90	31.8%	86.0	1.24E+10	NR		
3/11/08		5.58	35.5%	193.0	2.63E+10	NR	**NR**	**NR**
1/24/08	Mid-Range	4.74	47.1%	179.0	2.08E+10	NR	**NR**	**NR**
11/20/07	Low Flows	3.24	75.3%	48.0	3.80E+09	NR		
6/23/99		3.12	77.8%	224.4	1.71E+10	NR		
7/18/07		1.97	92.1%	99.0	4.77E+09	NR		
8/6/07		1.56	97.2%	199.0	7.60E+09	NR		
9/4/07		1.41	98.7%	236.0	8.14E+09	NR		
8/28/07		1.39	99.1%	308.0	1.05E+10	NR		
8/14/07		1.38	99.2%	74.0	2.50E+09	NR		
8/22/07		1.36	99.4%	5.0	1.66E+08	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-13. Calculated Load Reduction Based on Geomean Data – Kelley 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]	[%]	[%]
8/6/07	1.56	97.2%	199.0			
8/14/07	1.38	99.2%	74.0			
8/22/07	1.36	99.4%	5.0			
8/28/07	1.39	99.1%	308.0			
9/4/07	1.41	98.7%	236.0	88.2	NR	NR
3/4/08	17.10	8.9%	1,935.0			
3/11/08	5.58	35.5%	193.0			
3/18/08	11.60	13.1%	236.0			
3/19/08	101.00	2.3%	3,654.0			
3/25/08	5.90	31.8%	86.0	488.1	**74.2**	**76.8**

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

Table E-14. Calculated Load Reduction Based on Daily Loading – Big 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]	[%]	[%]	[%]
6/10/08	High Flows	751.70	1.3%	461.1	8.98E+12	NR		
5/14/03		512.90	2.0%	185.0	2.93E+12	NR		
10/17/07		109.10	7.1%	1,553.0	4.67E+12	**39.4**		
5/13/08		87.26	8.9%	299.0	8.41E+11	NR	**9.9**	**11.4**
1/15/03	Moist Conditions	52.91	15.4%	26.9	2.73E+10	NR		
4/22/08		49.15	17.2%	53.0	4.66E+10	NR		
6/11/03		44.72	19.3%	86.5	6.03E+10	NR		
11/13/02		43.50	20.2%	740.0	4.69E+11	NR		
8/14/02		41.73	21.4%	2,419.2	1.50E+12	**61.1**		
4/7/03				216.0	1.27E+11	NR		
1/16/08				150.0	8.15E+10	NR		
3/12/03		39.96	22.9%	111.9	5.78E+10	NR		
2/12/03		37.91	24.5%	278.0	1.35E+11	NR		
2/13/08		35.93	26.7%	2,909.0	1.40E+12	**67.7**		
10/16/02		30.77	33.5%	71.1	3.34E+10	NR		
12/11/02		30.70	33.6%	209.8	9.75E+10	NR		
3/12/08		30.56	33.9%	145.0	6.53E+10	NR	**9.9**	**10.5**
7/17/02	Mid-Range Flows	25.30	43.5%	52.6	1.92E+10	NR	**NR**	**NR**
7/11/07	Low Flows	17.34	62.5%	179.0	5.17E+10	NR		
9/11/02		12.74	78.7%	39.3	1.12E+10	NR		
12/12/07		12.48	79.7%	617.0	1.68E+11	NR		
7/7/99		12.23	80.5%	101.4	2.12E+10	NR		
11/14/07		11.24	83.4%	19,863.0	4.13E+12	**95.3**		
9/12/07		6.14	94.6%	41.0	6.59E+09	NR	**15.9**	**16.0**

Note: NR = No reduction required
NA = Not applicable

Table E-15. Calculated Load Reduction Based on Daily Loading – Big Creek – RM20.8

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]	[%]	[%]	[%]
3/19/08	High Flows	123.00	5.6%	8,164.0	2.46E+13	**88.5**		
5/22/08		66.00	8.6%	135.0	2.18E+11	NR		
3/4/08		39.70	11.9%	5,475.0	5.32E+12	**82.8**	**57.1**	**58.1**
3/25/08	Moist Conditions	12.50	33.3%	31.0	9.48E+09	NR		
2/13/08		12.30	34.5%	2,700.0	8.13E+11	**65.1**		
3/11/08		11.90	36.9%	473.0	1.38E+11	NR		
3/12/08		11.50	39.1%	174.0	4.90E+10	NR	**16.3**	**17.2**
11/14/07	Low Flows	5.30	85.9%	6,131.0	7.95E+11	**84.7**		
8/6/07		3.36	97.2%	210.0	1.73E+10	NR		
8/14/07		3.10	98.4%	17.0	1.29E+09	NR		
8/21/07		3.06	98.7%	116.0	8.68E+09	NR		
8/28/07		3.02	98.8%	10.0	7.39E+08	NR		
9/4/07		3.03	98.8%	26.0	1.93E+09	NR	**14.1**	**14.4**

Note: NR = No reduction required
NA = Not applicable

Table E-16. Calculated Load Reduction Based on Daily Loading – Crooked Creek – RM1.3

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]	[%]	[%]	[%]
6/10/08	High Flows	249.00	1.2%	2,419.8	1.47E+13	**61.1**		
5/14/03		185.00	1.7%	920.8	4.17E+12	NR		
3/19/08		127.00	2.7%	3,255.0	1.01E+13	**71.1**		
3/4/08		114.00	3.1%	1,785.0	4.98E+12	**47.3**	**44.9**	**49.9**

Table E-16 (cont'd). Calculated Load Reduction Based on Daily Loading – Crooked Creek – RM1.3

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]	[%]	[%]	[%]
4/22/08	Moist Conditions	31.30	12.5%	53.0	4.06E+10	NR		
5/13/08		30.20	13.3%	219.0	1.62E+11	NR		
11/13/02		29.60	13.6%	120.0	8.69E+10	NR		
1/16/08		26.60	16.4%	120.0	7.81E+10	NR		
2/13/08		24.20	19.2%	1,211.0	7.17E+11	**22.3**		
6/11/03		22.90	21.0%	42.8	2.40E+10	NR		
3/12/03		21.30	23.3%	88.6	4.62E+10	NR		
10/16/02		20.70	24.5%	579.4	2.93E+11	NR		
3/25/08		20.10	25.7%	256.0	1.26E+11	NR		
4/7/03		19.00	28.0%	12,033.0	5.59E+12	**92.2**		
3/11/08		18.60	29.0%	199.0	9.06E+10	NR		
3/12/08		17.70	31.0%	211.0	9.14E+10	NR		
1/15/03		17.30	32.1%	86.0	3.64E+10	NR		
10/17/07		16.80	33.7%	1,203.0	4.94E+11	**21.8**		
12/11/02		16.40	34.8%	133.3	5.35E+10	NR	**9.1**	**10.2**
2/12/03	Mid-Range Flows	13.50	44.2%	325.5	1.08E+11	NR		
12/12/07		10.70	55.7%	609.0	1.59E+11	NR		
7/17/02		9.09	64.8%	50.4	1.12E+10	NR	**NR**	**NR**
11/14/07	Low Flows	6.91	78.5%	12,997.0	2.20E+12	**92.8**		
7/7/99		6.79	79.2%	304.4	5.06E+10	NR		
7/11/07		6.02	83.2%	102.0	1.50E+10	NR		
9/11/02		5.90	83.7%	4.1	5.92E+08	NR		
9/12/07		3.54	94.1%	222.0	1.92E+10	NR		
8/21/07		2.00	99.6%	2,420.0	1.18E+11	**61.1**	**25.6**	**26.4**

Note: NR = No reduction required
NA = Not applicable

Table E-17. Calculated Load Reduction Based on Geomean Data – Crooked Creek – RM1.3

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]	[%]	[%]
3/4/08	113.90	3.1%	1,785.0			
3/11/08	18.55	29.0%	199.0			
3/12/08	17.69	31.0%	211.0			
3/19/08	127.10	2.7%	3,255.0			
3/25/08	20.10	25.6%	256.0	574.6	**78.1**	**80.3**

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

Table E-18. Calculated Load Reduction Based on Daily Loading – Big Creek – RM8.4

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]	[%]	[%]	[%]
6/10/08	High Flows	2030.00	1.5%	1,413.6	7.02E+13	**33.4**		
5/14/03		1860.00	1.7%	1,106.0	5.03E+13	**14.9**		
10/17/07		380.00	6.2%	1,986.0	1.85E+13	**52.6**		
5/13/08		352.00	6.6%	299.0	2.57E+12	NR	**25.2**	**30.2**
1/15/03	Moist Conditions	119.00	14.8%	19.0	5.53E+10	NR		
4/22/08		103.00	16.6%	139.0	3.50E+11	NR		
6/11/03		89.60	18.6%	47.2	1.03E+11	NR		
8/14/02		86.10	19.4%	2,419.2	5.10E+12	**61.1**		
11/13/02		71.30	23.2%	305.0	5.32E+11	NR		
4/7/03		64.00	26.6%	5,974.0	9.35E+12	**84.2**		
1/16/08		61.10	28.2%	41.0	6.13E+10	NR		
3/12/03		57.60	30.7%	24.6	3.47E+10	NR		
2/12/03		54.30	34.0%	920.0	1.22E+12	NR		
2/13/08		54.10	34.3%	1,725.0	2.28E+12	**45.4**		

Table E-18 (cont'd). Calculated Load Reduction Based on Daily Loading – Big Creek – RM8.4

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]	[%]	[%]	[%]
10/16/02	Moist Conditions (cont'd)	52.70	36.2%	118.7	1.53E+11	NR		
12/11/02		52.10	36.8%	248.1	3.16E+11	NR		
3/12/08		50.50	38.8%	187.0	2.31E+11	NR	**14.7**	**16.1**
3/3/99	Mid-Range Flows	49.50	40.1%	298.7	3.62E+11	NR		
7/17/02		40.70	53.8%	410.6	4.09E+11	NR		
7/11/07		39.70	55.5%	921.0	8.95E+11	NR	**NR**	**NR**
9/11/02	Dry Conditions	32.10	71.7%	82.0	6.44E+10	NR		
12/12/07		30.50	75.7%	3,654.0	2.73E+12	**74.2**		
4/18/00		24.80	84.4%	42.5	2.58E+10	NR		
11/14/07		23.40	85.8%	14,140.0	8.10E+12	**93.3**	**41.9**	**42.7**
9/12/07	Low Flows	18.10	92.6%	548.0	2.43E+11	NR		
10/21/99		17.40	93.6%	2,419.2	1.03E+12	**61.1**	**30.6**	**32.5**

Note: NR = No reduction required
NA = Not applicable

Table E-19. Calculated Load Reduction Based on Daily Loading – Big Creek – RM13.6

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]	[%]	[%]	[%]
6/10/08	High Flows	1260.00	1.4%	72,419.6	2.23E+15	**98.7**		
5/14/03		1070.00	1.8%	171.0	4.48E+12	NR		
10/17/07		203.00	6.3%	2,420.0	1.20E+13	**61.1**		
5/13/08		196.00	6.4%	214.0	1.03E+12	NR	**40.0**	**41.0**
1/15/03	Moist Conditions	65.10	15.0%	25.9	4.13E+10	NR		
4/22/08		59.70	16.0%	100.0	1.46E+11	NR		
6/11/03		46.50	20.6%	28.5	3.24E+10	NR		
11/13/02		43.50	22.2%	84.0	8.94E+10	NR		
3/2/99		42.90	22.7%	231.0	2.42E+11	NR		

Table E-19 (cont'd). Calculated Load Reduction Based on Daily Loading – Big Creek – RM13.6

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]	[%]	[%]	[%]
8/14/02	Moist Conditions (cont'd)	40.90	23.8%	186.0	1.86E+11	NR		
4/7/03		39.50	25.2%	8,664.0	8.37E+12	**89.1**		
1/16/08		37.30	27.2%	210.0	1.92E+11	NR		
3/12/03		35.20	29.8%	57.6	4.96E+10	NR		
2/12/03		33.20	33.3%	95.8	7.78E+10	NR		
2/13/08		33.00	33.7%	1,782.0	1.44E+12	**47.2**		
10/16/02		32.20	35.2%	1,203.3	9.48E+11	**21.8**		
12/11/02		31.90	35.8%	161.6	1.26E+11	NR		
3/12/08		30.90	37.9%	132.0	9.98E+10	NR		
3/22/00		30.10	39.6%	152.9	1.13E+11	NR	**10.5**	**11.5**
7/17/02	Mid-Range Flows	24.90	53.3%	20.3	1.24E+10	NR		
8/20/98		24.50	54.4%	75.4	4.52E+10	NR		
12/15/98		24.40	54.7%	344.1	2.05E+11	NR	**NR**	**NR**
10/21/98	Dry Conditions	20.00	70.1%	260.2	1.27E+11	NR		
9/11/02		19.60	71.6%	9.8	4.70E+09	NR		
9/30/98		19.10	73.9%	172.3	8.05E+10	NR		
7/11/07		19.10	73.9%	166.0	7.76E+10	NR		
12/12/07		18.60	75.7%	1,153.0	5.25E+11	**18.4**		
6/2/99		18.00	78.2%	57.3	2.52E+10	NR		
11/18/98		17.40	79.9%	40.4	1.72E+10	NR		
2/7/01		17.10	80.8%	8.6	3.60E+09	NR		
11/14/07		14.30	85.8%	24,196.0	8.47E+12	**96.1**	**11.4**	**12.3**
9/12/07	Low Flows	11.10	92.5%	387.0	1.05E+11	NR		
9/1/99		10.60	93.7%	58.3	1.51E+10	NR		
12/1/99		9.18	96.7%	25.6	5.75E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-20. Calculated Load Reduction Based on Daily Loading – North Fork Creek – 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]	[%]	[%]	[%]
6/10/08	High Flows	454.00	1.3%	2,419.8	2.69E+13	**61.1**		
5/14/03		352.00	1.9%	201.0	1.73E+12	NR		
5/13/08		77.20	6.2%	144.0	2.72E+11	NR		
10/17/07		65.40	7.0%	1,046.0	1.67E+12	**10.0**	**17.8**	**21.0**
1/15/03	Moist Conditions	25.00	14.0%	6.3	3.85E+09	NR		
4/22/08		19.50	16.6%	261.0	1.25E+11	NR		
8/14/02		18.80	17.0%	7,270.0	3.34E+12	**87.1**		
6/11/03		18.20	17.4%	28.5	1.27E+10	NR		
11/13/02		13.50	23.2%	122.0	4.03E+10	NR		
4/7/03		12.30	26.2%	178.2	5.36E+10	NR		
3/12/03		11.40	29.4%	58.3	1.63E+10	NR		
1/16/08		11.00	31.4%	74.0	1.99E+10	NR		
2/12/03		10.50	33.9%	26.5	6.81E+09	NR		
10/16/02		10.20	36.1%	60.9	1.52E+10	NR		
12/11/02		10.10	36.8%	98.4	2.43E+10	NR		
2/13/08		10.10	36.8%	1,211.0	2.99E+11	**22.3**		
3/12/08		9.65	39.4%	160.0	3.78E+10	NR	**8.4**	**9.1**
7/11/07	Mid-Range Flows	8.38	49.1%	488.0	1.00E+11	NR		
7/17/02		8.25	50.4%	135.4	2.73E+10	NR		
9/11/02		6.49	67.9%	90.7	1.44E+10	NR	**NR**	**NR**
12/12/07	Low Flows	5.35	80.3%	11,199.0	1.47E+12	**91.6**		
11/14/07		4.07	87.7%	12,033.0	1.20E+12	**92.2**		
9/12/07		3.54	91.2%	135.0	1.17E+10	NR	**36.8**	**37.1**

NA = Not applicable

Table E-21. Calculated Load Reduction Based on Daily Loading – Royster 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]	[%]	[%]	[%]
6/10/08	High Flows	298.60	1.2%	2,419.6	2.13E+13	**61.1**		
5/14/03		217.90	1.8%	689.0	5.39E+12	NR	**30.6**	**32.5**
5/13/08	Moist Conditions	36.07	12.5%	22.0	1.78E+10	NR		
4/22/08		34.98	13.0%	55.0	2.80E+10	NR		
10/17/07		33.90	13.7%	1,414.0	7.13E+11	**33.5**		
11/13/02		30.44	16.5%	37.4	1.82E+10	NR		
4/7/03				364.0	1.72E+11	NR		
1/16/08				400.0	1.74E+11	NR		
6/11/03		27.82	19.2%	24.0	1.01E+10	NR		
8/14/02		26.43	21.1%	1,986.3	8.02E+11	**52.6**		
3/12/03		24.64	23.2%	56.5	2.09E+10	NR		
1/15/03		23.83	24.7%	85.7	3.06E+10	NR		
2/13/08		21.95	28.0%	1,789.0	6.30E+11	**47.4**		
2/12/03		20.31	31.5%	107.1	3.56E+10	NR		
3/12/08		19.90	32.5%	148.0	4.85E+10	NR		
10/16/02		18.91	35.2%	75.4	2.38E+10	NR		
12/11/02		18.44	36.5%	112.4	3.55E+10	NR	**8.9**	**10.0**
7/17/02	Mid-Range Flows	15.55	45.3%	71.7	1.82E+10	NR	**NR**	**NR**
9/11/02	Low Flows	7.77	79.0%	8.4	1.66E+09	NR		
12/12/07		7.72	79.2%	1,296.0	2.41E+11	**27.4**		
7/11/07		6.87	82.9%	70.0	1.27E+10	NR		
7/7/99				95.9	1.48E+10	NR		
11/14/07		6.73	83.4%	11,199.0	1.56E+12	**91.6**		
9/12/07		3.92	94.2%	185.0	2.18E+10	NR	**19.8**	**21.2**

Note: NR = No reduction required
NA = Not applicable

Table E-22. Calculated Load Reduction Based on Daily Loading – Bear Creek – RM1.2

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]	[%]	[%]	[%]
6/10/08	High Flows	138.00	1.3%	76.3	2.58E+11	NR		
5/14/03		121.00	1.5%	461.1	1.37E+12	NR	**NR**	**NR**
5/13/08	Moist Conditions	12.00	10.5%	548.0	1.61E+11	NR		
4/22/08		7.46	17.9%	57.0	1.04E+10	NR		
10/17/07		7.41	18.0%	1,300.0	2.36E+11	**27.6**		
11/13/02		7.11	18.8%	104.3	1.81E+10	NR		
4/7/03		7.04	19.1%	160.7	2.77E+10	NR		
6/11/03		5.97	24.3%	30.9	4.51E+09	NR		
3/12/03		5.59	27.2%	123.6	1.69E+10	NR		
8/14/02		5.56	27.5%	135.4	1.84E+10	NR		
1/15/03		5.36	29.7%	32.7	4.29E+09	NR		
2/13/08		5.26	30.9%	7,270.0	9.36E+11	**87.1**		
2/12/03		5.07	33.2%	107.6	1.33E+10	NR		
3/12/08		4.86	36.0%	471.0	5.60E+10	NR		
10/16/02		4.79	37.0%	119.8	1.40E+10	NR		
12/11/02		4.76	37.4%	72.8	8.48E+09	NR	**8.2**	**8.8**
7/17/02	Mid-Range Flows	3.82	54.1%	16.1	1.50E+09	NR	**NR**	**NR**
7/11/07	Low Flows	2.54	81.3%	980.0	6.09E+10	**4.0**		
7/7/99		2.29	85.1%	21.8	1.22E+09	NR		
9/12/07		1.78	91.2%	192.0	8.36E+09	NR	**1.3**	**4.5**

Note: NR = No reduction required
NA = Not applicable

Table E-23. Calculated Load Reduction Based on Daily Loading – Big 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]	[%]	[%]	[%]
10/9/02	High Flows	2780.00	1.9%	461.1	3.14E+13	NR		
4/2/08		813.00	5.2%	305.0	6.07E+12	NR		
12/5/07		363.00	9.7%	68.0	6.04E+11	NR	**NR**	**NR**
2/6/08	Moist Conditions	316.00	10.9%	12,590.0	9.73E+13	**92.5**		
3/5/08		207.00	15.0%	3,654.0	1.85E+13	**74.2**		
5/12/03		113.00	28.4%	2,613.0	7.22E+12	**64.0**		
3/3/99		109.00	30.4%	93.4	2.49E+11	NR		
4/2/03		104.00	33.2%	126.7	3.22E+11	NR		
5/6/08		104.00	33.2%	160.0	4.07E+11	NR		
6/3/08		104.00	33.2%	86.0	2.19E+11	NR	**33.0**	**34.0**
1/9/08	Mid-Range Flows	84.20	48.6%	16,000.0	3.30E+13	**94.1**		
8/20/98		77.90	55.0%	117.8	2.25E+11	NR		
12/15/98		77.60	55.3%	1,299.7	2.47E+12	**27.6**	**40.6**	**43.2**
7/10/02	Dry Conditions	71.50	62.1%	365.4	6.39E+11	NR		
8/7/02		71.10	62.7%	209.0	3.64E+11	NR		
10/21/98		65.40	69.9%	145.0	2.32E+11	NR		
9/4/02		64.20	71.6%	178.9	2.81E+11	NR		
9/30/98		62.70	73.9%	48.1	7.38E+10	NR		
1/20/99		59.50	78.3%	62.7	9.13E+10	NR		
11/18/98		58.10	79.6%	62.4	8.87E+10	NR		
11/7/07		53.00	83.9%	116.0	1.50E+11	NR	**NR**	**NR**
6/27/07	Low Flows	40.50	92.1%	120.0	1.19E+11	NR		
10/10/07		38.50	93.9%	1,733.0	1.63E+12	**45.7**		
8/8/07		33.20	97.8%	7.0	5.69E+09	NR		
9/5/07		31.20	99.0%	31.0	2.37E+10	NR	**11.4**	**12.8**

Note: NR = No reduction required
NA = Not applicable

Table E-24. Calculated Load Reduction Based on Daily Loading – Jakes 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]	[%]	[%]	[%]
6/10/08	High Flows	169.00	1.3%	82.6	3.42E+11	NR		
5/14/03		155.00	1.4%	387.3	1.47E+12	NR		
5/13/08		17.70	8.8%	613.0	2.65E+11	NR	**NR**	**NR**
10/17/07	Moist Conditions	12.40	12.6%	2,420.0	7.34E+11	**61.1**		
4/22/08		9.37	17.5%	196.0	4.49E+10	NR		
4/7/03		8.56	20.0%	166.9	3.50E+10	NR		
11/13/02		8.48	20.3%	1,565.0	3.25E+11	**39.9**		
1/16/08		8.09	21.8%	250.0	4.95E+10	NR		
6/11/03		7.74	23.4%	53.7	1.02E+10	NR		
3/12/03		6.99	27.3%	52.1	8.91E+09	NR		
1/15/03		6.96	27.4%	178.2	3.03E+10	NR		
8/14/02		6.84	28.3%	24,192.0	4.05E+12	**96.1**		
2/13/08		6.54	31.2%	1,300.0	2.08E+11	**27.6**		
2/12/03		6.32	33.3%	65.0	1.01E+10	NR		
3/12/08		6.07	36.0%	110.0	1.63E+10	NR		
10/16/02		5.95	37.5%	435.2	6.34E+10	NR		
12/11/02		5.94	37.6%	116.9	1.70E+10	NR	**16.1**	**17.3**
7/17/02	Mid-Range Flows	4.77	53.6%	46.4	5.41E+09	NR	**NR**	**NR**
9/11/02	Low Flows	3.71	73.0%	178.9	1.62E+10	NR		
12/12/07		3.57	75.7%	563.0	4.92E+10	NR		
7/11/07		3.27	80.4%	93.0	7.44E+09	NR		
7/7/99		2.89	84.9%	63.7	4.50E+09	NR		
11/14/07		2.66	87.0%	1,178.0	7.67E+10	**20.1**		
9/12/07		2.25	91.2%	125.0	6.88E+09	NR	**3.4**	**4.7**

Note: NR = No reduction required
NA = Not applicable

Table E-25. Calculated Load Reduction Based on Daily Loading – Laurel Creek – RM3.7

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]	[%]	[%]	[%]
3/19/08	High Flows	353.00	1.3%	8,164.0	7.05E+13	**88.5**		
3/4/08		147.00	2.8%	14,136.0	5.08E+13	**93.3**		
4/4/00		118.00	3.4%	1,732.9	5.00E+12	**45.7**		
1/30/08		78.20	5.0%	2,851.0	5.45E+12	**67.0**		
1/31/02		70.60	5.6%	547.5	9.46E+11	NR		
2/3/99		40.10	9.3%	161.6	1.59E+11	NR	**49.1**	**50.8**
9/30/02	Moist Conditions	29.40	12.3%	113.0	8.13E+10	NR		
11/27/07		21.80	17.0%	88.0	4.69E+10	NR		
11/20/02		19.50	19.8%	88.4	4.22E+10	NR		
3/3/03		18.90	20.5%	42.8	1.98E+10	NR		
3/11/08		18.20	21.7%	282.0	1.26E+11	NR		
4/23/03		16.50	24.8%	226.0	9.12E+10	NR		
4/29/08		16.20	25.5%	2,420.0	9.59E+11	**61.1**		
3/25/08		15.80	26.7%	571.0	2.21E+11	NR		
2/27/08		15.60	27.3%	242.0	9.24E+10	NR		
12/15/98		14.70	30.2%	866.4	3.12E+11	NR		
3/26/08		14.50	30.8%	162.0	5.75E+10	NR		
3/26/03		14.40	31.4%	2,419.2	8.52E+11	**61.1**		
1/3/08		14.00	33.5%	50.0	1.71E+10	NR		
5/27/08		14.00	33.5%	9,210.0	3.15E+12	**89.8**		
5/28/03		13.80	34.6%	90.6	3.06E+10	NR		
1/8/03		13.70	35.1%	24.3	8.14E+09	NR		
6/25/03		12.70	40.3%	26.9	8.36E+09	NR	**12.5**	**13.0**

Table E-25 (cont'd). Calculated Load Reduction Based on Daily Loading – Laurel Creek – RM3.7

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]	[%]	[%]	[%]
10/30/02	Mid-Range Flows	12.30	42.6%	88.4	2.66E+10	NR		
1/28/03		12.30	42.6%	3.1	9.33E+08	NR		
6/24/08		11.50	48.0%	1,553.0	4.37E+11	**39.4**		
8/20/98		10.00	57.6%	47.1	1.15E+10	NR		
8/28/02		9.45	61.4%	197.0	4.55E+10	NR		
10/21/98		8.62	68.1%	21.3	4.49E+09	NR	**6.6**	**7.6**
10/30/07	Low Flows	7.64	76.5%	140.0	2.62E+10	NR		
7/31/07		3.74	98.5%	60.0	5.49E+09	NR		
8/6/07		3.47	98.8%	12.0	1.02E+09	NR		
10/2/07		3.20	99.3%	17.0	1.33E+09	NR		
8/14/07		3.05	99.7%	86.0	6.42E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-26. Calculated Load Reduction Based on Geomean Data – Laurel Creek – RM3.7

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]	[%]	[%]
2/27/08	15.60	27.3%	242.0			
3/4/08	147.00	2.8%	14,136.0			
3/11/08	18.20	21.7%	282.0			
3/19/08	353.00	1.3%	8,164.0			
3/25/08	15.80	26.7%	571.0	1350.8	**90.7**	**91.6**
3/26/08	14.50	30.8%	162.0	1246.6	**89.9**	**90.9**

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

Table E-27. Calculated Load Reduction Based on Daily Loading – Little Cypress Creek – RM3.3

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]	[%]	[%]	[%]
3/19/08	High Flows	487.00	1.3%	8,664.0	1.03E+14	**89.1**		
3/4/08		254.00	2.5%	7,270.0	4.52E+13	**87.1**		
4/4/00		202.00	3.1%	816.4	4.03E+12	NR		
1/30/08		144.00	4.3%	836.0	2.95E+12	NR		
7/31/02		123.00	4.9%	261.3	7.86E+11	NR		
2/3/99		61.50	9.3%	88.4	1.33E+11	NR	**29.4**	**29.8**
9/30/02	Moist Conditions	44.90	12.1%	39.0	4.28E+10	NR		
11/27/07		33.70	16.4%	201.0	1.66E+11	NR		
11/20/02		29.30	19.5%	85.7	6.14E+10	NR		
3/3/03		27.50	21.2%	101.4	6.82E+10	NR		
3/11/08		27.10	21.7%	107.0	7.09E+10	NR		
4/23/03		24.30	25.0%	109.0	6.48E+10	NR		
4/29/08		24.00	25.4%	687.0	4.03E+11	NR		
3/25/08		23.10	27.0%	98.0	5.54E+10	NR		
2/27/08		22.90	27.4%	142.0	7.96E+10	NR		
12/15/98		22.10	28.9%	21.1	1.14E+10	NR		
3/26/08		21.00	31.5%	111.0	5.70E+10	NR		
3/26/03		20.70	32.7%	2,419.2	1.23E+12	**61.1**		
1/3/08		20.70	32.7%	61.0	3.09E+10	NR		
5/28/03		19.90	35.3%	209.8	1.02E+11	NR		
1/8/03		19.80	35.6%	56.9	2.76E+10	NR		
5/27/08		19.60	36.1%	1,070.0	5.13E+11	**12.1**	**4.6**	**5.4**

Table E-27 (cont'd). Calculated Load Reduction Based on Daily Loading – Little Cypress Creek – RM3.3

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]	[%]	[%]	[%]
6/25/03	Mid-Range Flows	18.30	41.0%	32.7	1.46E+10	NR		
10/30/02		18.00	42.4%	214.3	9.44E+10	NR		
1/28/03		17.80	43.2%	4.1	1.79E+09	NR		
6/24/08		16.60	48.2%	108.0	4.39E+10	NR		
8/20/98		14.40	58.0%	114.5	4.03E+10	NR		
8/28/02		13.60	62.1%	172.5	5.74E+10	NR		
8/29/07		12.80	66.4%	19.0	5.95E+09	NR		
10/21/98		12.50	68.0%	112.6	3.44E+10	NR	**NR**	**NR**
10/30/07	Low Flows	11.70	72.8%	50.0	1.43E+10	NR		
7/31/07		5.32	98.6%	51.0	6.64E+09	NR		
8/6/07		4.94	98.9%	84.0	1.02E+10	NR		
10/2/07		4.60	99.2%	32.0	3.60E+09	NR		
8/21/07		4.51	99.4%	32.0	3.53E+09	NR		
9/4/07		4.49	99.4%	11.0	1.21E+09	NR		
8/28/07		4.37	99.6%	32.0	3.42E+09	NR		
8/14/07		4.30	99.8%	488.0	5.13E+10	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-28. Calculated Load Reduction Based on Geomean Data – Little Cypress Creek – RM3.3

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]	[%]	[%]
7/31/07	5.32	98.6%	51.0			
8/6/07	4.94	98.9%	84.0			
8/14/07	4.30	99.8%	488.0			
8/21/07	4.51	99.4%	32.0			
8/28/07	4.37	99.6%	32.0	73.5	NR	NR
8/29/07	12.80	66.4%	19.0	60.3	NR	NR
2/27/08	22.90	27.4%	142.0			
3/4/08	254.00	2.5%	7,270.0			
3/11/08	27.10	21.7%	107.0			
3/19/08	487.00	1.3%	8,664.0			
3/25/08	23.10	27.0%	98.0	622.9	**79.8**	**81.9**
3/26/08	21.00	31.5%	111.0	593.0	**78.8**	**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-29. Calculated Load Reduction Based on Daily Loading – Black Ankle Creek – RM1.6

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]	[%]	[%]	[%]
3/19/08	High Flows	181.00	1.3%	2,613.0	1.16E+13	**64.0**		
3/4/08		51.50	3.8%	4,106.0	5.17E+12	77.1		
7/31/02		50.40	3.9%	111.8	1.38E+11	NR		
1/30/08		30.10	6.4%	1,112.0	8.19E+11	15.4	**39.1**	**42.7**
9/30/02	Moist Conditions	13.70	13.3%	488.4	1.64E+11	NR		
11/27/07		10.20	19.0%	411.0	1.03E+11	NR		
11/20/02		9.18	21.3%	190.4	4.28E+10	NR		
3/3/03		9.11	21.6%	101.4	2.26E+10	NR		
3/11/08		8.65	23.4%	218.0	4.61E+10	NR		
4/23/03		7.89	26.4%	301.0	5.81E+10	NR		
4/29/08		7.77	26.9%	2,420.0	4.60E+11	**61.1**		
3/25/08		7.62	28.0%	323.0	6.02E+10	NR		
2/27/08		7.45	29.0%	91.0	1.66E+10	NR		
5/27/08		7.37	29.4%	19,860.0	3.58E+12	**95.3**		
3/26/03		7.02	32.0%	2,419.2	4.15E+11	**61.1**		
3/26/08		6.99	32.3%	179.0	3.06E+10	NR		
5/28/03		6.73	34.9%	49.6	8.17E+09	NR		
8/29/07		6.73	34.9%	4.0	6.59E+08	NR		
1/8/03		6.68	35.3%	26.5	4.33E+09	NR		
1/3/08		6.67	35.4%	60.0	9.79E+09	NR	**13.6**	**14.1**
6/25/03	Mid-Range Flows	8.11	43.7%	99.0	1.97E+10	NR		
7/1/99		6.85	52.4%	27.2	4.56E+09	NR		
1/28/03		6.59	54.2%	22.8	3.68E+09	NR		
10/30/02		6.10	57.8%	186.0	2.77E+10	NR		
6/24/08		5.84	59.7%	4.0	5.71E+08	NR		
8/28/02		5.07	65.6%	74.0	9.18E+09	NR	**NR**	**NR**

Table E-29 (cont'd). Calculated Load Reduction Based on Daily Loading – Black Ankle Creek – RM1.6

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]	[%]	[%]	[%]
10/30/07	Low Flows	3.59	80.2%	74.0	6.50E+09	NR		
7/31/07		1.82	98.5%	62.0	2.76E+09	NR		
8/6/07		1.69	98.8%	35.0	1.45E+09	NR		
8/21/07		1.56	99.2%	9.0	3.44E+08	NR		
9/4/07		1.53	99.4%	2.0	7.49E+07	NR		
10/2/07		1.55	99.4%	148.0	5.61E+09	NR		
8/28/07		1.50	99.6%	1.0	3.67E+07	NR		
8/14/07		1.48	99.8%	28.0	1.01E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-30. Calculated Load Reduction Based on Geomean Data – Black Ankle Creek at Mile 1.6

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]	[%]	[%]
7/31/07	1.82	98.5%	62.0			
8/6/07	1.69	98.8%	35.0			
8/14/07	1.48	99.8%	28.0			
8/21/07	1.56	99.2%	9.0			
8/28/07	1.50	99.6%	1.0	14.0	NR	NR
8/29/07	6.73	34.9%	4.0	8.1	NR	NR
9/4/07	1.53	99.4%	2.0	4.6	NR	NR
2/27/08	7.45	29.0%	91.0			
3/4/08	51.50	3.8%	4,106.0			
3/11/08	8.65	23.4%	218.0			
3/19/08	181.00	1.3%	2,613.0			
3/25/08	7.62	28.0%	323.0	**585.4**	**78.5**	**80.7**
3/26/08	6.99	32.3%	179.0	**670.2**	**81.2**	**83.1**

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

Table E-31. Calculated Load Reduction Based on Daily Loading – Loosahatchie River – RM30.2

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]	[%]	[%]	[%]
4/4/00	High Flows	1641.00	4.1%	1,986.2	7.97E+13	**52.6**		
3/18/08		1301.00	5.2%	143.0	4.55E+12	NR		
2/19/03		1003.00	6.4%	48.9	1.20E+12	NR	**17.5**	**19.1**
2/3/99	Moist Conditions	560.30	10.3%	103.4	1.42E+12	NR		
5/22/08		362.00	14.7%	29.0	2.57E+11	NR		
5/21/03		354.00	15.2%	435.2	3.77E+12	NR		
12/18/07		352.00	15.3%	416.0	3.58E+12	NR		
11/18/02		322.40	16.5%	106.3	8.38E+11	NR		
12/16/02		250.70	21.4%	143.9	8.83E+11	NR		
2/20/08		227.80	23.8%	141.0	7.86E+11	NR		
4/16/08		211.80	26.5%	124.0	6.43E+11	NR		
12/15/98		205.70	27.8%	275.6	1.39E+12	NR		
6/17/08		205.40	27.8%	147.0	7.39E+11	NR		
6/18/03		195.70	30.0%	770.1	3.69E+12	NR		
3/25/03		189.00	32.3%	93.3	4.31E+11	NR		
4/16/03		179.40	35.5%	42.2	1.85E+11	NR		
1/24/08		173.60	38.1%	72.0	3.06E+11	NR	**NR**	**NR**
1/27/03	Mid-Range Flows	166.80	41.1%	21.1	8.61E+10	NR		
10/23/02		162.00	43.3%	66.3	2.63E+11	NR		
7/24/02		134.70	56.6%	8,664.0	2.86E+13	**89.1**		
8/20/98		131.90	57.9%	45.1	1.46E+11	NR	**22.3**	**22.6**
8/21/02	Dry Conditions	123.70	62.8%	8,664.0	2.62E+13	**89.1**		
10/21/98		117.10	66.6%	39.1	1.12E+11	NR		
9/12/02		112.90	69.3%	135.4	3.74E+11	NR		
9/30/98		102.50	76.0%	17.4	4.36E+10	NR		
11/18/98		102.30	76.1%	72.8	1.82E+11	NR		
11/20/07		87.60	87.6%	285.0	6.11E+11	NR	**14.9**	**15.0**

Table E-31 (cont'd). Calculated Load Reduction Based on Daily Loading – Loosahatchie River – RM30.2

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]	[%]	[%]	[%]
7/8/07	Low Flows	61.40	97.1%	128.0	1.92E+11	NR		
9/19/07		44.04	99.3%	31.0	3.34E+10	NR		
8/22/07		41.53	99.7%	1.0	1.02E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-32. Calculated Load Reduction Based on Daily Loading – Loosahatchie River – RM34.0

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]	[%]	[%]	[%]
3/19/08	High Flows	2883.00	2.1%	15,290.0	1.08E+15	**93.8**		
3/18/08		2301.00	2.7%	122.0	6.87E+12	NR		
7/31/02		1410.00	4.0%	249.5	8.61E+12	NR	**31.3**	**31.5**
1/30/08	Moist Conditions	293.50	12.4%	2,613.0	1.88E+13	**64.0**		
9/30/02		247.20	14.2%	176.6	1.07E+12	NR		
11/27/07		189.80	18.2%	154.0	7.15E+11	NR		
11/20/02		163.80	21.5%	53.0	2.12E+11	NR		
3/3/03		156.40	22.6%	62.4	2.39E+11	NR		
5/27/08		154.00	23.2%	24,200.0	9.12E+13	**96.1**		
3/11/08		145.66	24.8%	82.0	2.92E+11	NR		
4/29/08		131.76	28.7%	1,553.0	5.01E+12	**39.4**		
4/23/03		129.67	29.5%	383.0	1.22E+12	NR		
3/25/08		128.53	30.2%	310.0	9.75E+11	NR		
1/8/03		126.48	30.8%	90.7	2.81E+11	NR		
3/26/03		123.27	32.5%	2,419.2	7.30E+12	**61.1**		
2/27/08		123.14	32.9%	35.0	1.05E+11	NR		
5/28/03		121.15	33.5%	107.1	3.17E+11	NR		

Table E-32 (cont'd). Calculated Load Reduction Based on Daily Loading – Loosahatchie River – RM34.0

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]	[%]	[%]	[%]
3/26/08	Moist Conditions (cont'd)	117.89	35.2%	36.0	1.04E+11	NR		
1/3/08		115.63	36.9%	24.0	6.79E+10	NR		
1/28/03		114.62	37.4%	63.1	1.77E+11	NR		
8/29/07		113.20	38.1%	3.0	8.31E+09	NR		
10/30/02		112.53	38.2%	686.7	1.89E+12	NR		
6/25/03		111.52	38.9%	79.4	2.17E+11	NR	**13.0**	**13.7**
6/24/08	Mid-Range Flows	97.98	48.6%	88.0	2.11E+11	NR		
8/28/02		85.52	58.4%	203.5	4.26E+11	NR	**NR**	**NR**
10/30/07	Dry Conditions	63.81	79.8%	78.0	1.22E+11	NR	**NR**	**NR**
8/6/07	Low Flows	30.96	98.8%	281.0	2.13E+11	NR		
8/14/07		28.60	99.2%	35.0	2.45E+10	NR		
10/2/07		28.58	99.2%	31.0	2.17E+10	NR		
8/21/07		28.46	99.3%	11.0	7.66E+09	NR		
8/28/07		28.38	99.4%	2.0	1.39E+09	NR		
9/4/07		28.27	99.5%	9.0	6.22E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-33. Calculated Load Reduction Based on Geomean Data – Loosahatchie River – RM34.0

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]	[%]	[%]
8/6/07	30.96	98.8%	281.0			
8/14/07	28.60	99.2%	35.0			
8/21/07	28.38	99.4%	2.0			
8/28/07	28.27	99.5%	9.0			
8/29/07	113.20	38.1%	3.0	14.0	NR	NR
9/4/07	28.58	99.2%	31.0	9.0	NR	NR
2/27/08	123.14	32.9%	35.0			
3/11/08	145.66	24.8%	82.0			
3/18/08	2301.00	2.7%	122.0			
3/19/08	2883.00	2.1%	15,290.0			
3/25/08	128.53	30.2%	310.0	278.0	**54.7**	**59.3**
3/26/08	117.89	35.2%	36.0	279.5	**54.9**	**59.6**

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

Table E-34. Calculated Load Reduction Based on Daily Loading – Clear (Cypress) 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]	[%]	[%]	[%]
10/9/02	High Flows	4090.00	0.1%	727.0	7.27E+13	NR		
4/2/08		172.00	7.7%	959.0	4.04E+12	**1.9**	**0.9**	**5.8**
11/6/02	Moist Conditions	80.50	14.1%	6,488.0	1.28E+13	**85.5**		
3/5/08		71.60	16.0%	1,616.0	2.83E+12	**41.8**		
2/6/08		69.50	16.4%	10,462.0	1.78E+13	**91.0**		
6/4/03		61.80	18.3%	1,203.3	1.82E+12	**21.8**		
3/4/03		50.70	23.6%	31.8	3.94E+10	NR		
12/9/02		46.20	27.3%	410.6	4.64E+11	NR		
1/14/03		44.80	29.1%	25.9	2.84E+10	NR		
5/6/08		42.50	32.7%	300.0	3.12E+11	NR		
4/2/03		42.00	33.5%	110.6	1.14E+11	NR		
2/5/03		40.70	35.8%	248.9	2.48E+11	NR	**24.0**	**25.6**
1/9/08	Mid-Range Flows	34.30	47.7%	24,000.0	2.01E+13	**96.1**		
6/3/08		34.10	48.2%	921.0	7.68E+11	NR	**24.0**	**24.1**
7/10/02	Dry Conditions	27.40	65.4%	240.0	1.61E+11	NR		
8/7/02		26.70	67.2%	17,329.0	1.13E+13	**94.6**		
9/4/02		26.50	68.0%	435.2	2.82E+11	NR		
2/7/01		25.40	70.9%	59.8	3.72E+10	NR		
12/5/07		18.60	88.4%	1,860.0	8.46E+11	**49.4**	**28.8**	**29.9**
11/7/07	Low Flows	13.80	96.1%	9,606.0	3.24E+12	**90.2**		
6/27/07		13.70	96.3%	38.0	1.27E+10	NR		
8/8/07		11.90	98.4%	15.0	4.37E+09	NR		
9/5/07		11.70	98.6%	75.0	2.15E+10	NR		
10/10/07		10.30	99.7%	20.0	5.04E+09	NR	**18.0**	**18.2**

Note: NR = No reduction required
NA = Not applicable

Table E-35. Calculated Load Reduction Based on Daily Loading – Cypress 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]	[%]	[%]	[%]
5/27/08	High Flows	1230.00	0.3%	435.0	1.31E+13	NR		
5/14/03		502.00	1.6%	1,986.3	2.44E+13	**52.6**	**26.3**	**28.7**
10/17/07	Moist Conditions	30.40	13.9%	2,420.0	1.80E+12	**61.1**		
8/14/02		21.70	19.6%	24,192.0	1.28E+13	**96.1**		
1/30/08		21.10	20.2%	839.0	4.33E+11	NR		
4/7/03		20.40	21.1%	24,192.0	1.21E+13	**96.1**		
4/29/08		19.80	22.2%	866.0	4.20E+11	NR		
11/13/02		17.70	26.1%	591.0	2.56E+11	NR		
3/12/03		17.40	27.2%	141.4	6.02E+10	NR		
10/16/02		17.20	27.8%	158.5	6.67E+10	NR		
1/15/03		16.70	29.3%	9.7	3.96E+09	NR		
12/11/02		16.50	30.0%	416.0	1.68E+11	NR		
11/27/07		16.50	30.0%	1,300.0	5.25E+11	**27.6**		
2/12/03		16.00	32.2%	27.5	1.08E+10	NR		
6/14/03		15.60	34.1%	111.9	4.27E+10	NR		
1/27/99		15.20	36.1%	214.2	7.97E+10	NR	**20.1**	**20.9**
6/24/08	Mid-Range Flows	12.10	52.8%	66.0	1.95E+10	NR		
3/26/08		11.90	54.5%	276.0	8.04E+10	NR		
2/27/08		11.60	57.1%	260.0	7.38E+10	NR		
7/17/02		10.50	63.8%	410.6	1.05E+11	NR		
1/3/08		10.00	66.9%	210.0	5.14E+10	NR		
9/11/02		9.90	68.0%	218.0	5.28E+10	NR	**NR**	**NR**
5/23/00	Low Flows	9.22	72.8%	686.7	1.55E+11	NR		
7/11/07		4.99	96.7%	2,420.0	2.95E+11	**61.1**	**30.6**	**32.5**

Note: NR = No reduction required
NA = Not applicable

Table E-36. Calculated Load Reduction Based on Daily Loading – Buckhead Creek – RM2.1

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]	[%]	[%]	[%]
10/9/02	High Flows	246.93	0.4%	1,553.1	9.38E+12	**39.4**		
5/26/10		17.76	9.3%	365.0	1.59E+11	NR	**19.7**	**22.7**
2/6/08	Moist Conditions	15.39	10.4%	7,270.0	2.74E+12	**87.1**		
4/2/08		11.61	13.3%	1,039.0	2.95E+11	**9.4**		
11/6/02		11.24	13.9%	14,136.0	3.89E+12	**93.3**		
5/25/10		9.26	16.2%	2,420.0	5.48E+11	**61.1**		
3/5/08		7.95	18.4%	14,136.0	2.75E+12	**93.3**		
6/4/03		7.53	19.4%	2,419.2	4.46E+11	**61.1**		
4/28/10		7.10	20.6%	613.0	1.07E+11	NR		
5/12/10		6.12	23.4%	816.0	1.22E+11	NR		
5/12/03		5.52	26.0%	3,873.0	5.23E+11	**75.7**		
5/6/10		5.28	27.0%	101.0	1.30E+10	NR		
1/9/08		4.83	29.8%	10,000.0	1.18E+12	**90.6**		
3/4/03		4.64	31.2%	88.2	1.00E+10	NR		
5/6/08		4.51	32.5%	190.0	2.10E+10	NR		
4/13/10		4.44	33.1%	111.0	1.21E+10	NR		
12/9/02		4.40	33.4%	214.2	2.31E+10	NR		
1/14/03		4.05	37.6%	60.1	5.96E+09	NR	**35.7**	**37.2**
4/2/03	Mid-Range Flows	3.78	42.3%	83.2	7.70E+09	NR		
2/5/03		3.68	44.5%	1,565.0	1.41E+11	**39.9**		
6/3/08		3.27	52.3%	1,046.0	8.36E+10	**10.0**		
8/7/02		3.08	55.9%	266.0	2.01E+10	NR		
7/10/02		2.47	70.3%	81.3	4.92E+09	NR		
9/4/02		2.42	71.8%	113.7	6.73E+09	NR		
7/7/99		2.17	78.0%	2,419.2	1.29E+11	**61.1**	**15.9**	**18.6**

Table E-36 (cont'd). Calculated Load Reduction Based on Daily Loading – Buckhead Creek – RM2.1

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]	[%]	[%]	[%]
12/5/07	Low Flows	1.70	89.0%	1,872.0	7.77E+10	**49.7**		
6/27/07		1.28	96.5%	1,565.0	4.89E+10	**39.9**		
11/7/07		1.25	96.8%	1,414.0	4.34E+10	**33.5**		
10/10/07		1.00	99.2%	2,420.0	5.91E+10	**61.1**	**46.0**	**51.4**

Note: NR = No reduction required
NA = Not applicable

Table E-37. Calculated Load Reduction Based on Geomean Data – Buckhead Creek – RM2.1

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]	[%]	[%]
4/28/10	7.10	20.6%	613			
5/6/10	5.28	27.0%	101			
5/12/10	6.12	23.4%	816			
5/25/10	9.26	16.2%	2,420			
5/26/10	17.76	9.3%	365	**536.9**	**76.5%**	**79.0%**

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 – Buckhead Creek – RM3.8

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]	[%]	[%]	[%]
5/26/10	High Flows	7.46	9.3%	261	4.76E+10	NR	**NR**	**NR**
5/25/10	Moist Conditions	3.89	16.2%	1,986	1.89E+11	**52.6**		
4/28/10		2.98	20.6%	261	1.90E+10	NR		
5/12/10		2.57	23.4%	435	2.73E+10	NR		
5/6/10		2.22	27.0%	172	9.33E+09	NR	**13.2**	**14.3**
4/13/10	Mid-Range Flows	1.86	33.1%	2,420	1.10E+11	**61.1**	**61.1**	**65.0**

Note: NR = No reduction required
NA = Not applicable

Table E-39. Calculated Load Reduction Based on Geomean Data – Buckhead Creek – RM3.8

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]	[%]	[%]
4/28/10	2.98	20.6%	261			
5/6/10	2.22	27.0%	172			
5/12/10	2.57	23.4%	435			
5/25/10	3.89	16.2%	1,986			
5/26/10	7.46	9.3%	261	**399.1**	**68.4%**	**71.7%**

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

Table E-40. Calculated Load Reduction Based on Daily Loading – Buckhead Creek – RM5.2

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]	[%]	[%]	[%]
5/26/10	High Flows	3.62	9.3%	86	7.61E+09	NR	**NR**	**NR**
5/25/10	Moist Conditions	1.88	16.2%	980	4.52E+10	**52.6**		
4/28/10		1.45	20.6%	184	6.51E+09	NR		
5/12/10		1.25	23.4%	225	6.86E+09	NR		
5/6/10		1.07	27.0%	57	1.50E+09	NR	**1.0**	**3.4**
4/13/10	Mid-Range Flows	0.90	33.1%	67	1.48E+09	**61.1**	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-41. Calculated Load Reduction Based on Geomean Data – Buckhead Creek – RM5.2

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]	[%]	[%]
4/28/10	1.45	20.6%	184			
5/6/10	1.07	27.0%	57			
5/12/10	1.25	23.4%	225			
5/25/10	1.88	16.2%	980			
5/26/10	3.62	9.3%	86	**181.9**	**30.7%**	**37.9%**

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

Table E-42. Calculated Load Reduction Based on Daily Loading – Howard Creek – RM2.1

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]	[%]	[%]	[%]
6/10/08	High Flows	64.57	1.7%	72,419.6	1.14E+14	**98.7**		
10/17/07		13.20	6.8%	144.0	4.65E+10	NR		
5/13/08		10.86	8.1%	113.0	3.00E+10	NR	**32.9**	**32.9**
4/22/08	Moist Conditions	3.79	18.3%	1,414.0	1.31E+11	**33.5**		
7/11/07		2.59	25.5%	276.0	1.75E+10	NR		
1/16/08		2.36	28.4%	280.0	1.62E+10	NR		
2/13/08		1.95	35.9%	649.0	3.09E+10	NR		
3/12/08		1.81	39.6%	53.0	2.35E+09	NR	**6.7**	**8.0**
12/12/07	Low Flows	1.06	77.1%	2,420.0	6.29E+10	**61.1**		
7/7/99		0.88	85.0%	13.4	2.89E+08	NR		
11/14/07		0.80	87.3%	921.0	1.80E+10	NR		
9/5/07		0.48	98.7%	1,986.0	2.34E+10	**52.6**	**28.4**	**32.6**

Note: NR = No reduction required
NA = Not applicable

Table E-43. Calculated Load Reduction Based on Daily Loading – Loosahatchie River – RM22.7

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]	[%]	[%]	[%]
10/9/02	High Flows	3810.00	3.1%	613.1	5.72E+13	NR		
3/5/08		3080.00	4.2%	2,755.0	2.08E+14	**65.8**		
4/2/08		1930.00	6.3%	1,607.0	7.59E+13	**41.4**		
3/31/99		1600.00	7.2%	2,419.2	9.47E+13	**61.1**		
1/9/08		1420.00	7.9%	14,000.0	4.86E+14	**93.3**	**52.3**	**55.1**

Table E-43 (cont'd). Calculated Load Reduction Based on Daily Loading – Loosahatchie River – RM22.7

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]	[%]	[%]	[%]
11/6/02	Moist Conditions	818.00	12.3%	8,164.0	1.63E+14	**88.5**		
5/12/03		704.00	14.2%	1,597.0	2.75E+13	**41.1**		
6/3/08		462.00	22.4%	546.0	6.17E+12	NR		
3/4/03		442.00	23.8%	14.3	1.55E+11	NR		
12/9/02		393.00	28.2%	82.6	7.94E+11	NR		
12/15/98		391.00	28.4%	727.0	6.95E+12	NR		
6/4/03		361.00	33.0%	1,110.0	9.80E+12	**15.2**		
4/2/03		348.00	35.7%	41.1	3.50E+11	NR		
1/14/03		343.00	36.6%	34.1	2.86E+11	NR		
5/6/08		332.00	39.0%	960.0	7.80E+12	NR		
2/6/08		331.00	39.3%	5,794.0	4.69E+13	**83.8**	**21.0**	**15.3**
2/5/03	Mid-Range Flows	310.00	44.5%	29.8	2.26E+11	NR		
12/5/07		265.00	55.9%	387.0	2.51E+12	NR		
8/20/98		257.00	57.7%	64.7	4.07E+11	NR	**NR**	**NR**
5/2/00	Dry Conditions	238.00	63.6%	26.0	1.51E+11	NR		
8/7/02		235.00	64.5%	15,531.0	8.93E+13	**93.9**		
7/10/02		231.00	65.7%	210.5	1.19E+12	NR		
10/21/98		227.00	66.9%	228.2	1.27E+12	NR		
9/4/02		220.00	69.2%	204.6	1.10E+12	NR		
9/30/98		200.00	76.0%	365.4	1.79E+12	NR		
11/18/98		199.00	76.3%	29.2	1.42E+11	NR	**13.4**	**13.5**
11/7/07	Low Flows	153.00	93.4%	1,733.0	6.49E+12	**45.7**		
6/27/07		121.00	97.0%	613.0	1.81E+12	NR		
10/10/07		108.00	98.1%	411.0	1.09E+12	NR		
8/8/07		90.50	99.0%	2.0	4.43E+09	NR		
9/5/07		84.50	99.3%	161.0	3.33E+11	NR	**9.1**	**10.2**

Note: NR = No reduction required
NA = Not applicable

Table E-44. Calculated Load Reduction Based on Daily Loading – Oliver Creek – RM1.3

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]	[%]	[%]	[%]
10/9/02	High Flows	61.90	1.9%	488.4	7.40E+11	NR		
4/2/08		15.70	5.3%	71.0	2.73E+10	NR		
2/6/08		8.02	9.1%	1,396.0	2.74E+11	**32.6**	**10.9**	**13.3**
11/6/02	Moist Conditions	5.75	12.5%	1,565.0	2.20E+11	**39.9**		
12/5/07		4.96	14.3%	305.0	3.70E+10	NR		
3/5/08		4.77	14.8%	327.0	3.82E+10	NR		
6/4/03		3.64	19.4%	980.4	8.73E+10	NR		
5/12/03		3.08	23.4%	820.0	6.18E+10	NR		
3/4/03		2.96	24.7%	17.5	1.27E+09	NR		
6/3/08		2.53	30.9%	461.0	2.85E+10	NR		
4/2/03		2.52	31.1%	59.4	3.66E+09	NR		
5/6/08		2.49	31.6%	291.0	1.77E+10	NR		
12/9/02		2.46	32.5%	90.9	5.47E+09	NR		
1/14/03		2.36	35.6%	83.0	4.79E+09	NR		
2/5/03		2.36	35.6%	121.1	6.99E+09	NR	**0.4**	**1.2**
1/9/08	Mid-Range Flows	1.96	47.9%	4,600.0	2.21E+11	**79.5**		
7/10/02		1.60	63.1%	178.5	6.99E+09	NR		
8/7/02		1.58	64.3%	10,462.0	4.04E+11	**91.0**	**56.8**	**57.8**
9/4/02	Low Flows	1.41	72.5%	107.9	3.72E+09	NR		
6/9/99		1.35	75.8%	172.2	5.69E+09	NR		
11/7/07		1.09	85.2%	2,420.0	6.45E+10	**61.1**		
6/27/07		0.85	91.3%	4,611.0	9.53E+10	**79.6**		
10/10/07		0.76	94.2%	613.0	1.14E+10	NR		
8/8/07		0.65	97.4%	23.0	3.64E+08	NR	**23.5**	**24.4**

Note: NR = No reduction required
NA = Not applicable

Table E-45. Calculated Load Reduction Based on Daily Loading – Rocky Branch – 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]	[%]	[%]	[%]
3/19/08	High Flows	55.95	2.6%	12,033.0	1.65E+13	**92.2**		
3/5/08		39.72	3.5%	1,585.0	1.54E+12	**40.6**		
4/2/08		13.04	7.1%	2,359.0	7.53E+11	**60.1**		
3/4/08		11.61	7.7%	2,420.0	6.87E+11	**61.1**	**63.5**	**67.2**
1/9/08	Moist Conditions	3.28	20.9%	2,400.0	1.93E+11	**60.8**		
3/11/08		2.86	24.4%	379.0	2.65E+10	NR		
6/3/08		2.61	28.2%	479.0	3.06E+10	NR		
3/28/08		2.27	36.9%	323.0	1.79E+10	NR	**15.2**	**16.2**
5/6/08	Mid-Range Flows	2.15	40.7%	430.0	2.27E+10	NR		
6/23/99		1.80	53.9%	816.4	3.60E+10	NR		
12/5/07		1.64	61.0%	435.0	1.75E+10	NR	**NR**	**NR**
6/27/07	Low Flows	0.80	96.4%	63.0	1.23E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-46. Calculated Load Reduction Based on Geomean Data – Rocky Branch – 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]	[%]	[%]
3/4/08	2.76	12.0%	1.0			
3/5/08	1.80	16.1%	3,873.0			
3/11/08	0.85	36.9%	195.0			
3/19/08	8.76	5.6%	1,733.0			
3/25/08	0.90	33.0%	613.0	**240.4**	**47.6**	**53.0**
4/2/08	8.85	5.5%	185.0	**682.8**	**81.5**	**83.5**

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

Table E-47. Calculated Load Reduction Based on Daily Loading – Scotts Creek – RM1.7

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]	[%]	[%]	[%]
10/9/02	High Flows	56.70	1.4%	209.8	2.91E+11	NR		
3/5/08		22.10	4.3%	40.0	2.16E+10	NR		
4/2/08		8.38	7.9%	97.0	1.99E+10	NR	**NR**	**NR**
11/6/02	Moist Conditions	3.70	14.9%	1,723.0	1.56E+11	**45.4**		
5/12/03		1.92	24.0%	98.5	4.63E+09	NR		
1/9/08		1.91	24.1%	6,900.0	3.22E+11	**86.4**		
3/4/03		1.67	27.4%	25.6	1.05E+09	NR		
6/23/99		1.66	27.6%	86.0	3.49E+09	NR		
12/9/02		1.54	30.2%	82.0	3.09E+09	NR		
6/3/08		1.49	32.0%	260.0	9.48E+09	NR		
1/14/03		1.41	35.1%	198.9	6.86E+09	NR		
6/4/03		1.40	35.5%	178.5	6.11E+09	NR		
4/2/03		1.33	38.6%	387.3	1.26E+10	NR	**13.2**	**13.9**
2/5/03	Mid-Range Flows	1.27	41.6%	66.9	2.08E+09	NR		
2/6/08		1.23	43.7%	387.0	1.16E+10	NR		
5/6/08		1.22	44.3%	228.0	6.81E+09	NR		
12/5/07		0.98	58.5%	276.0	6.60E+09	NR		
7/10/02		0.90	65.0%	1,732.9	3.81E+10	**45.7**		
9/4/02		0.87	67.4%	86.2	1.83E+09	NR	**7.6**	**8.5**
11/7/07	Low Flows	0.60	91.0%	157.0	2.32E+09	NR		
10/10/07		0.34	98.7%	326.0	2.72E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-48. Calculated Load Reduction Based on Daily Loading – Loosahatchie River – 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]	[%]	[%]	[%]
11/2/04	High Flows	32,330	0.2%	2,400.0	1.90E+15	**60.8**		
12/18/07		15,060	1.3%	1,080.0	3.98E+14	**12.9**		
2/6/08		11,000	1.7%	17,250.0	4.64E+15	**94.5**		
4/2/08		6,180	3.3%	4,200.0	6.35E+14	**77.6**		
2/20/02		4,370	4.2%	1,553.1	1.66E+14	**39.4**		
12/8/04		4,593	4.4%	1,700.0	1.91E+14	**44.6**		
3/5/08		3,295	6.4%	1,800.0	1.45E+14	**47.7**		
3/5/08		2,810	6.9%	3,640.0	2.50E+14	**74.1**		
10/9/02		2,270	8.9%	920.8	5.11E+13	NR		
5/3/06		2,399	9.1%	60.0	3.52E+12	NR		
11/6/02		2,220	9.2%	12,033.0	6.54E+14	**92.2**	**49.4**	**52.7**
5/8/01	Moist Conditions	2,060	10.1%	2,419.2	1.22E+14	**61.1**		
9/23/09		2,201	10.2%	186.0	1.00E+13	NR		
4/17/07		2,093	10.9%	320.0	1.64E+13	NR		
7/12/05		2,014	11.6%	1,300.0	6.41E+13	**27.6**		
6/4/03		1,840	11.8%	101.7	4.58E+12	NR		
1/31/06		1,750	12.3%	610.0	2.61E+13	NR		
1/15/08		1,702	13.8%	7,600.0	3.16E+14	**87.6**		
3/31/09		1,599	14.3%	157.0	6.14E+12	NR		
2/8/05		1,270	15.7%	595.0	1.85E+13	NR		
9/21/06		1,316	16.9%	260.0	8.37E+12	NR		
3/22/00		1,130	17.5%	579.4	1.60E+13	NR		
5/12/03		1,100	18.1%	3,873.0	1.04E+14	**75.7**		
4/11/07		1,080	18.2%	51.0	1.35E+12	NR		
1/10/07		1,195	18.3%	1,030.0	3.01E+13	**8.6**		
2/1/06		971.9	21.6%	310.0	7.37E+12	NR		
12/15/09		910.4	22.9%	488.0	1.09E+13	NR		

Table E-48 (cont'd). Calculated Load Reduction Based on Daily Loading – Loosahatchie River – 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]	[%]	[%]	[%]
3/4/09	Moist Conditions (cont'd)	878.6	23.7%	360.0	7.74E+12	NR		
6/3/08		772.0	24.9%	216.0	4.08E+12	NR		
3/4/03		714.0	27.0%	51.2	8.94E+11	NR		
7/1/04		765.6	27.1%	84.0	1.57E+12	NR		
1/5/05		753.4	27.5%	4,100.0	7.56E+13	**77.0**		
3/13/05		716.6	28.8%	24,000.0	4.21E+14	**96.1**		
12/9/02		665.0	29.3%	218.8	3.56E+12	NR		
4/2/03		598.0	33.7%	57.6	8.43E+11	NR		
5/6/08		564.0	37.0%	100.0	1.38E+12	NR		
4/18/05		569.6	38.9%	2,800.0	3.90E+13	**66.4**		
1/17/07		545.0	39.1%	870.0	1.16E+13	NR		
5/22/02		544.0	39.2%	7.4	9.85E+10	NR		
3/14/06		561.3	39.8%	150.0	2.06E+12	NR	**17.2**	**18.3**
1/14/03	Mid-Range Flows	532.0	40.4%	20.1	2.62E+11	NR		
10/12/04		550.8	41.2%	5,900.0	7.95E+13	**84.1**		
3/3/99		517.0	41.9%	114.5	1.45E+12	NR		
12/8/03		514.0	42.5%	132.0	1.66E+12	NR		
12/15/98		506.0	43.4%	1,203.3	1.49E+13	**21.8**		
10/25/04		506.0	43.4%	272.3	3.37E+12	NR		
4/21/05		523.5	44.3%	1,700.0	2.18E+13	**44.6**		
2/5/03		496.0	44.5%	55.4	6.72E+11	NR		
2/24/04		476.0	47.4%	18.7	2.18E+11	NR		
5/16/05		461.7	52.4%	300.0	3.39E+12	NR		
12/17/08		456.3	53.3%	77.0	8.60E+11	NR		
2/7/07		444.3	54.8%	90.0	9.78E+11	NR		
8/20/98		413.0	57.0%	55.2	5.58E+11	NR		
6/30/09		425.5	58.0%	8.0	8.33E+10	NR	**10.7**	**11.8**

Table E-48 (cont'd). Calculated Load Reduction Based on Daily Loading – Loosahatchie River – 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]	[%]	[%]	[%]
6/8/04	Dry Conditions	383.0	61.6%	17.3	1.62E+11	NR		
4/11/06		402.3	62.1%	270.0	2.66E+12	NR		
11/17/04		393.3	63.2%	104.0	1.00E+12	NR		
9/21/05		364.0	65.7%	70.3	6.26E+11	NR		
8/25/03		360.0	66.8%	866.4	7.63E+12	NR		
7/10/02		359.0	67.0%	88.6	7.78E+11	NR		
6/6/05		373.4	67.2%	400.0	3.65E+12	NR		
10/21/98		356.0	67.6%	88.8	7.73E+11	NR		
5/24/06		352.0	68.6%	14.0	1.21E+11	NR		
8/14/08		363.5	69.0%	5.0	4.45E+10	NR		
8/7/02		348.0	69.4%	1,086.0	9.25E+12	**13.4**		
8/14/01		342.0	70.5%	2,690.0	2.25E+13	**65.0**		
10/3/05		352.5	71.6%	90.0	7.76E+11	NR		
11/17/08		347.0	72.7%	10.0	8.49E+10	NR		
12/2/08		342.9	73.6%	10.0	8.39E+10	NR		
9/30/98		321.0	74.6%	70.3	5.52E+11	NR		
8/19/04		337.8	74.7%	1.0	8.26E+09	NR		
10/21/08		337.4	74.8%	220.0	1.82E+12	NR		
9/4/02		320.0	75.0%	122.3	9.57E+11	NR		
6/29/05		320.0	75.0%	613.1	4.80E+12	NR		
6/6/06		328.7	76.6%	120.0	9.65E+11	NR		
11/20/01		306.0	78.2%	410.0	3.07E+12	NR		
6/2/99		305.0	78.4%	29.8	2.22E+11	NR		
12/7/05		317.9	79.3%	40.0	3.11E+11	NR		
8/3/05		316.0	79.6%	1.0	7.73E+09	NR		
11/18/98		293.0	80.5%	24.3	1.74E+11	NR		
11/7/07		311.5	80.6%	8,800.0	6.71E+13	**89.3**		
2/7/01		291.0	80.9%	12.0	8.54E+10	NR		

Table E-48 (cont'd). Calculated Load Reduction Based on Daily Loading – Loosahatchie River – 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]	[%]	[%]	[%]
9/28/04	Dry Conditions (cont'd)	307.9	81.4%	1.0	7.53E+09	NR		
1/9/06		301.9	82.7%	20.0	1.48E+11	NR		
9/19/05		300.0	83.0%	23.0	1.69E+11	NR		
5/22/07		288.2	85.3%	20.0	1.41E+11	NR		
12/11/06		281.0	86.1%	30.0	2.06E+11	NR		
11/7/07		254.0	86.2%	15,531.0	9.65E+13	**93.9**		
8/22/05		271.8	87.5%	21.0	1.40E+11	NR		
11/7/05		263.3	88.4%	10.0	6.44E+10	NR		
7/12/06		261.1	88.6%	30.0	1.92E+11	NR	**7.1**	**7.4**
10/10/06	Low Flows	215.0	90.5%	31.0	1.63E+11	NR		
6/7/07		231.7	91.2%	20.0	1.13E+11	NR		
8/8/06		218.6	93.0%	5.0	2.67E+10	NR		
9/1/99		191.0	93.1%	14.3	6.68E+10	NR		
10/10/07		217.0	93.3%	810.0	4.30E+12	NR		
10/11/06		213.9	93.6%	20.0	1.05E+11	NR		
7/17/07		193.6	96.0%	20.0	9.47E+10	NR		
12/1/99		157.0	97.5%	26.5	1.02E+11	NR		
8/8/07		150.0	98.1%	22.0	8.07E+10	NR		
9/18/07		161.7	98.8%	20.0	7.91E+10	NR		
8/8/07		149.6	99.3%	20.0	7.32E+10	NR		
9/30/08		0.0	100.0%	41.0	0.00E+00	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-49. Calculated Load Reduction Based on Daily Loading – Loosahatchie River – 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]	[%]	[%]	[%]
12/8/04	High Flows	12,990	0.7%	1,800.0	5.72E+14	**47.7**		
11/2/04		11,330	1.0%	1,500.0	4.16E+14	**37.3**		
3/5/08		3,338	4.3%	2,500.0	2.04E+14	**62.4**		
10/9/02		2,505	5.6%	1,046.2	6.41E+13	**10.1**		
4/2/08		2,241	6.1%	2,247.0	1.23E+14	**58.1**		
4/21/09		1,414	8.9%	920.0	3.18E+13	NR	**35.9**	**42.0**
11/6/02	Moist Conditions	873.9	13.2%	14,136.0	3.02E+14	**93.3**		
5/12/03		809.5	14.2%	4,106.0	8.13E+13	**77.1**		
12/18/07		759.4	15.5%	1,320.0	2.45E+13	**28.7**		
3/22/00		724.1	16.3%	275.5	4.88E+12	NR		
3/4/09		713.5	16.6%	380.0	6.63E+12	NR		
1/10/07		513.9	22.9%	223.0	2.80E+12	NR		
1/13/09		494.6	24.2%	290.0	3.51E+12	NR		
2/1/06		494.0	24.3%	190.0	2.30E+12	NR		
2/23/09		484.6	25.1%	60.0	7.11E+11	NR		
12/15/98		475.6	26.0%	1,046.2	1.22E+13	**10.1**		
4/17/07		475.8	26.0%	930.0	1.08E+13	NR		
4/22/08		470.5	26.5%	5.0	5.76E+10	NR		
7/12/05		457.2	28.0%	500.0	5.59E+12	NR		
6/3/08		442.7	29.8%	517.0	5.60E+12	NR		
12/9/02		440.7	30.0%	248.1	2.68E+12	NR		
4/11/06		439.6	30.1%	270.0	2.90E+12	NR		
4/2/03		419.1	32.9%	24.4	2.50E+11	NR		
6/4/03		418.2	33.1%	816.4	8.35E+12	NR		
3/13/05		414.2	33.6%	14,000.0	1.42E+14	**93.3**		
5/3/06		407.0	34.5%	140.0	1.39E+12	NR		
10/12/04		394.2	36.4%	1,600.0	1.54E+13	**41.2**		
1/5/05		389.0	37.2%	2600.0	2.47E+13	**63.8**		

Table E-49 (contd). Calculated Load Reduction Based on Daily Loading – Loosahatchie River – 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]	[%]	[%]	[%]
5/19/09	Moist Conditions (cont'd)	386.5	37.4%	200.0	1.89E+12	NR		
6/11/08		386.4	37.5%	1600.0	1.51E+13	**41.2**		
3/14/06		380.2	38.5%	190.0	1.77E+12	NR		
4/18/05		371.2	39.9%	3500.0	3.18E+13	**73.1**	**20.1**	**21.9**
7/1/04	Mid-Range Flows	367.2	40.7%	900.0	8.09E+12	NR		
2/6/08		364.0	41.1%	9,880.0	8.80E+13	**90.5**		
1/15/08		361.3	41.5%	3,600.0	3.18E+13	**73.9**		
1/14/03		351.7	43.4%	39.3	3.38E+11	NR		
5/6/08		343.4	44.7%	310.0	2.60E+12	NR		
3/3/99		340.7	45.2%	1,553.1	1.29E+13	**39.4**		
7/14/08		331.8	46.9%	110.0	8.93E+11	NR		
4/21/05		329.2	47.4%	700.0	5.64E+12	NR		
6/2/09		328.9	47.5%	110.0	8.85E+11	NR		
2/5/03		321.7	49.0%	48.0	3.78E+11	NR		
2/11/08		306.8	52.6%	90.0	6.76E+11	NR		
2/7/07		302.0	53.7%	110.0	8.13E+11	NR		
5/16/05		298.1	54.5%	800.0	5.83E+12	NR		
10/21/08		290.4	56.6%	620.0	4.41E+12	NR		
8/20/98		278.5	59.5%	51.2	3.49E+11	NR		
11/20/06		278.3	59.5%	140.0	9.53E+11	NR	**12.7**	**13.7**
6/6/06	Dry Conditions	267.1	62.4%	1,000.0	6.53E+12	**96.1**		
3/12/07		262.4	63.6%	340.0	2.18E+12	NR		
6/6/05		262.3	63.7%	400.0	2.57E+12	NR		
10/21/98		252.3	67.0%	93.3	5.76E+11	NR		
8/14/08		248.6	68.3%	90.0	5.47E+11	NR		
9/21/06		248.0	68.4%	420.0	2.55E+12	NR		
7/10/02		247.3	68.5%	88.2	5.34E+11	NR		
11/17/04		245.0	69.2%	44.0	2.64E+11	NR		

Table E-49 (contd). Calculated Load Reduction Based on Daily Loading – Loosahatchie River – 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]	[%]	[%]	[%]
11/17/08	Dry Conditions (cont'd)	238.5	70.8%	30.0	1.75E+11	NR		
12/2/08		237.6	71.0%	190.0	1.10E+12	NR		
9/24/08		226.1	75.5%	70.0	3.87E+11	NR		
8/7/02		221.3	77.3%	24,192.0	1.31E+14	**96.1**		
11/18/98		217.8	78.2%	20.9	1.11E+11	NR		
9/30/98		217.2	78.4%	307.6	1.63E+12	NR		
7/12/06		209.7	80.6%	30.0	1.54E+11	NR		
9/4/02		209.5	80.7%	67.9	3.48E+11	NR		
12/11/06		207.0	81.5%	10.0	5.06E+10	NR		
10/3/05		201.8	83.5%	90.0	4.44E+11	NR		
12/7/05		201.4	83.6%	40.0	1.97E+11	NR		
8/19/04		197.3	85.1%	1.0	4.83E+09	NR		
1/9/06		193.4	86.2%	40.0	1.89E+11	NR		
9/19/05		190.5	87.2%	530.0	2.47E+12	NR		
5/22/07		189.3	87.6%	30.0	1.39E+11	NR		
8/3/05		186.8	88.4%	1.0	4.57E+09	NR		
9/28/04		184.5	88.9%	148.0	6.68E+11	NR	**4.1**	**4.5**
8/8/06	Low Flows	175.0	91.7%	80.0	3.43E+11	NR		
10/11/06		174.1	92.0%	7.0	2.98E+10	NR		
11/7/05		172.8	92.3%	20.0	8.46E+10	NR		
11/7/07		160.3	94.7%	12,997.0	5.10E+13	**92.8**		
8/22/05		156.9	95.1%	80.0	3.07E+11	NR		
6/7/07		151.6	95.8%	360.0	1.34E+12	NR		
10/10/07		128.0	97.6%	340.0	1.06E+12	NR		
7/17/07		121.9	98.1%	5.0	1.49E+10	NR		
8/8/07		95.46	99.2%	80.0	1.87E+11	NR		
9/18/07		93.35	99.3%	50.0	1.14E+11	NR	**9.3**	**9.3**

Note: NR = No reduction required
NA = Not applicable

Table E-50. Calculated Load Reduction Based on Daily Loading – UT to Loosahatchie River – RM1.3

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]	[%]	[%]	[%]
4/2/08	High Flows	8.85	5.5%	185.0	4.01E+10	NR		
3/19/08		8.76	5.6%	1,733.0	3.72E+11	45.7		
12/5/07		4.96	8.2%	670.0	8.13E+10	NR	**15.2**	**17.0**
3/4/08	Moist Conditions	2.76	12.0%	1.0	6.75E+07	NR		
3/5/08		1.80	16.1%	3,873.0	1.70E+11	75.7		
3/31/99		1.03	26.4%	1,413.6	3.57E+10	**33.4**		
6/3/08		0.90	32.9%	88.0	1.93E+09	NR		
3/25/08		0.90	33.0%	613.0	1.34E+10	NR		
5/6/08		0.89	33.2%	276.0	6.03E+09	NR		
3/11/08		0.85	36.9%	195.0	4.04E+09	NR	**15.6**	**16.9**
1/9/08	Mid-Range Flows	0.71	49.1%	3,900.0	6.74E+10	75.9	**75.9**	**7833**
5/2/00	Low Flows	0.35	88.0%	2,419.2	2.07E+10	61.1		
6/27/07		0.30	91.6%	58.0	4.32E+08	NR		
10/10/07		0.28	93.9%	548.0	3.76E+09	NR		
8/6/07		0.24	97.2%	2,420.0	1.42E+10	61.1		
8/8/07		0.24	97.4%	211.0	1.22E+09	NR		
8/14/07		0.22	98.3%	29.0	1.58E+08	NR		
8/21/07		0.22	98.6%	120.0	6.42E+08	NR	**17.5**	**18.3**

Note: NR = No reduction required
NA = Not applicable

Table E-51. Calculated Load Reduction Based on Geomean Data – UT to Loosahatchie River – RM1.3

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]	[%]	[%]
3/4/08	2.76	12.0%	1.0			
3/5/08	1.80	16.1%	3,873.0			
3/11/08	0.85	36.9%	195.0			
3/19/08	8.76	5.6%	1,733.0			
3/25/08	0.90	33.0%	613.0	**240.4**	**47.6**	**53.0**
4/2/08	8.85	5.5%	185.0	**682.8**	**81.5**	**83.5**

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

Table E-52. Calculated Load Reduction Based on Daily Loading – Todd Branch – RM1.6

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]	[%]	[%]	[%]
10/9/02	High Flows	117.76	0.7%	1,299.7	3.74E+12	**27.6**		
4/2/08		17.48	9.2%	11,199.0	4.79E+12	**91.6**	**59.6**	**63.6**
3/5/08	Moist Conditions	14.42	11.4%	2,420.0	8.54E+11	**61.1**		
2/6/08		9.29	16.8%	24,196.0	5.50E+12	**96.1**		
11/6/02		7.51	20.2%	8,164.0	1.50E+12	**88.5**		
6/4/03		6.49	22.6%	1,413.6	2.24E+11	**33.4**		
3/3/99		5.38	26.3%	2,419.2	3.19E+11	**61.1**		
5/12/03		5.32	26.5%	2,419.2	3.15E+11	**61.1**		
5/6/08		4.80	28.5%	840.0	9.86E+10	NR		
12/9/02		3.57	34.4%	185.0	1.61E+10	NR		
3/4/03		3.08	38.2%	30.7	2.31E+09	NR	**44.6**	**46.8**

Table E-52 (cont'd). Calculated Load Reduction Based on Daily Loading – Todd Branch – RM1.6

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]	[%]	[%]	[%]
1/9/08	Mid-Range Flows	2.74	41.1%	2,400.0	1.61E+11	**61.1**		
1/14/03		2.33	46.4%	29.4	1.68E+09	NR		
4/2/03		2.29	47.1%	1,986.3	1.11E+11	**52.6**		
2/5/03		2.29	47.2%	2,419.2	1.35E+11	**61.1**		
6/3/08		2.18	49.1%	24,196.0	1.29E+12	**96.1**		
9/5/07		2.17	49.3%	148.0	7.86E+09	NR		
8/7/02		1.71	58.6%	239.0	1.00E+10	NR		
12/15/98		1.64	60.6%	980.4	3.93E+10	**4.0**		
8/20/98		1.58	62.6%	770.1	2.97E+10	NR	**26.7**	**29.1**
7/10/02	Low Flows	1.31	70.1%	770.1	2.48E+10	NR		
9/30/98		1.23	73.1%	204.0	6.16E+09	NR		
10/21/98		1.16	75.8%	686.7	1.95E+10	NR		
9/4/02		1.15	76.0%	178.5	5.03E+09	NR		
11/18/98		1.00	81.7%	517.2	1.27E+10	NR		
12/5/07		0.63	93.7%	345.0	5.31E+09	NR		
6/27/07		0.58	95.1%	1.0	1.43E+07	NR		
8/8/07		0.53	96.7%	111.0	1.44E+09	NR		
11/7/07		0.44	98.2%	97.0	1.03E+09	NR		
10/10/07		0.34	99.7%	2,420.0	2.01E+10	**61.1**	**6.1**	**6.5**

Note: NR = No reduction required
NA = Not applicable

Table E-53 Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Loosahatchie River Watershed (HUC 08010209)

Waterbody Description (TN08010209__)	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]
Loosahatchie River Waterbody ID: **011 – 2000** HUC-12: 0102	High Flows	0 – 10	54.4 – 1,107	146.1	10.0	3.360×10^{12}	3.360×10^{11}	NA	NA	NA	1.770×10^{8}
	Moist	10 – 40	15.3 – 54.4	20.1	5.2	4.630×10^{11}	4.630×10^{10}				2.438×10^{7}
	Mid-Range	40 – 60	11.7 – 15.3	13.3	NR	3.068×10^{11}	3.068×10^{10}				1.616×10^{7}
	Dry	60 – 90	7.54 – 11.7	9.71	NR	2.233×10^{11}	2.233×10^{10}				1.176×10^{7}
	Low Flows	90 – 100	3.36 – 7.54	6.47	NR	1.488×10^{11}	1.488×10^{10}				7.837×10^{6}
Jones Creek Waterbody ID: **010 – 1000** HUC-12: 0103	High Flows	0 – 10	34.2 – 414.5	73.9	42.7	1.699×10^{12}	1.699×10^{11}	NA	NA	NA	1.290×10^{8}
	Moist	10 – 40	12.6 – 34.2	16.0	18.1	3.680×10^{11}	3.680×10^{10}				2.793×10^{7}
	Mid-Range	40 – 70	8.33 – 12.6	10.2	3.8	2.348×10^{11}	2.348×10^{10}				1.782×10^{7}
	Low Flows	70 – 100	3.30 – 8.33	6.82	NA	1.569×10^{11}	1.569×10^{10}				1.191×10^{7}
Treadville Bottom Waterbody ID: **008 – 1000** HUC-12: 0104	High Flows	0 – 10	38.6 – 828.7	83.5	59.9[b]	1.921×10^{12}	1.921×10^{11}	NA	NA	NA	1.266×10^{8}
	Moist	10 – 40	14.4 – 38.6	18.1		4.152×10^{11}	4.152×10^{10}				2.736×10^{7}
	Mid-Range	40 – 70	9.64 – 14.4	11.9		2.726×10^{11}	2.726×10^{10}				1.796×10^{7}
	Low Flows	70 – 100	0.00 – 9.64	7.97		1.833×10^{11}	1.833×10^{10}				1.208×10^{7}
Loosahatchie River Waterbody ID: **007 – 1000** HUC-12: 0105	High Flows	0 – 10	222.0 – 2,798	593.2	NR	1.364×10^{13}	1.364×10^{12}	3.188×10^{10}	0	NA	1.672×10^{8}
	Moist	10 – 40	64.5 – 222.0	83.9	11.0	1.929×10^{12}	1.929×10^{11}				2.327×10^{7}
	Mid-Range	40 – 60	49.2 – 64.5	56.4	NR	1.297×10^{12}	1.885×10^{11}				1.551×10^{7}
	Dry	60 – 90	32.6 – 49.2	40.2	NR	9.246×10^{11}	9.246×10^{10}				1.093×10^{7}
	Low Flows	90 – 100	17.6 – 32.6	27.7	NR	6.366×10^{11}	6.366×10^{10}				7.389×10^{6}
East Beaver Creek Waterbody ID: **016 – 0400** HUC-12: 0201	High Flows	0 – 10	121.7 – 2,590	276.4	NR	6.357×10^{12}	6.357×10^{11}	4.156×10^{9}	0	1.390×10^{8}	1.390×10^{8}
	Moist	10 – 40	42.4 – 121.7	53.7	5.1	1.234×10^{12}	1.234×10^{11}			2.690×10^{7}	2.690×10^{7}
	Mid-Range	40 – 60	32.2 – 42.4	37.1	28.8	8.533×10^{11}	8.533×10^{10}			1.857×10^{7}	1.857×10^{7}
	Dry	60 – 90	21.5 – 32.2	26.3	NA	6.042×10^{11}	6.042×10^{10}			1.312×10^{7}	1.312×10^{7}
	Low Flows	90 – 100	0.00 – 21.5	18.4	NR	4.225×10^{11}	4.225×10^{10}			9.142×10^{6}	9.142×10^{6}
West Beaver Creek Waterbody ID: **016 – 0100** HUC-12: 0202	High Flows	0 – 10	58.7 – 633	130.2	11.2	2.993×10^{12}	2.993×10^{11}	NA	NA	1.566×10^{8}	1.566×10^{8}
	Moist	10 – 40	20.1 – 58.7	26.2	6.1	6.026×10^{11}	6.026×10^{10}			3.153×10^{7}	3.153×10^{7}
	Mid-Range	40 – 60	15.1 – 20.1	17.4	NR	4.002×10^{11}	4.002×10^{10}			2.094×10^{7}	2.094×10^{7}
	Dry	60 – 90	8.11 – 15.1	12.4	NA	2.852×10^{11}	2.852×10^{10}			1.492×10^{7}	1.492×10^{7}
	Low Flows	90 – 100	4.55 – 8.11	6.63	10.2	1.525×10^{11}	1.525×10^{10}			7.980×10^{6}	7.980×10^{6}
Beaver Creek Waterbody ID: **016 – 1000** HUC-12: 0203	High Flows	0 – 10	275.0 – 3,513	619.1	1.0	1.424×10^{13}	1.424×10^{12}	4.156×10^{9}	0	1.376×10^{8}	1.376×10^{8}
	Moist	10 – 40	95.5 – 275.0	121.5	NR	2.795×10^{12}	2.792×10^{11}			2.697×10^{7}	2.697×10^{7}
	Mid-Range	40 – 60	73.0 – 95.5	84.0	16.1	1.932×10^{12}	1.932×10^{11}			1.863×10^{7}	1.863×10^{7}
	Dry	60 – 90	48.5 – 73.0	59.7	NR	1.372×10^{12}	1.372×10^{11}			1.322×10^{7}	1.322×10^{7}
	Low Flows	90 – 100	25.0 – 48.5	41.5	17.5	9.540×10^{11}	9.540×10^{10}			9.177×10^{6}	9.177×10^{6}

Table E-53 (cont'd) Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Loosahatchie River Watershed (HUC 08010209)

Waterbody Description (TN08010209__)	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]
Kelley Branch Waterbody ID: **016 – 0200** HUC-12: 0203	High Flows	0 – 10	15.3 – 190.0	31.6	74.2[b]	7.277×10^{11}	7.277×10^{10}	NA	NA	NA	1.375×10^{8}
	Moist	10 – 40	5.23 – 15.3	6.92		1.592×10^{11}	1.592×10^{10}				3.007×10^{7}
	Mid-Range	40 – 70	3.47 – 5.23	4.22		9.706×10^{11}	9.706×10^{10}				1.834×10^{7}
	Low Flows	70 – 100	1.27 – 3.47	2.61		6.003×10^{10}	6.003×10^{9}				1.134×10^{7}
Big Creek Waterbody ID: **021 – 3000** HUC-12: 0301	High Flows	0 – 10	68.6 – 1,036	176	9.9	4.042×10^{12}	4.042×10^{11}	4.986×10^{8}	0	1.804×10^{8}	1.804×10^{8}
	Moist	10 – 40	17.9 – 68.6	23.8	9.9	5.469×10^{11}	5.469×10^{10}			2.439×10^{7}	2.439×10^{7}
	Mid-Range	40 – 70	11.9 – 17.9	14.5	NR	3.335×10^{11}	3.335×10^{10}			1.486×10^{7}	1.486×10^{7}
	Low Flows	70 – 100	4.39 – 11.9	8.78	15.9	2.019×10^{11}	2.019×10^{10}			8.990×10^{6}	8.990×10^{6}
Big Creek Waterbody ID: **021 – 4000** HUC-12: 0301	High Flows	0 – 10	51.9 – 718.2	143	57.1	3.296×10^{12}	3.296×10^{11}	4.986×10^{8}	0	2.338×10^{8}	2.338×10^{8}
	Moist	10 – 40	11.3 – 51.9	15.1	16.3	3.473×10^{11}	3.473×10^{10}			2.460×10^{7}	2.460×10^{7}
	Mid-Range	40 – 70	7.48 – 11.3	9.12	NA	2.098×10^{11}	2.098×10^{10}			1.484×10^{7}	1.484×10^{7}
	Low Flows	70 – 100	2.77 – 7.48	5.50	14.1	1.265×10^{11}	1.265×10^{10}			8.936×10^{6}	8.936×10^{6}
Crooked Creek Waterbody ID: **021 – 0500** HUC-12: 0301	High Flows	0 – 10	37.8 – 276.1	67.7	78.1[b]	1.556×10^{12}	1.556×10^{11}	1.603×10^{9}	0	1.232×10^{8}	1.232×10^{8}
	Moist	10 – 40	14.7 – 37.8	20.4		4.692×10^{11}	4.692×10^{10}			3.702×10^{7}	3.702×10^{7}
	Mid-Range	40 – 70	8.26 – 14.7	10.8		2.484×10^{11}	2.484×10^{10}			1.953×10^{7}	1.953×10^{7}
	Low Flows	70 – 100	1.81 – 8.26	3.25		7.475×10^{10}	7.475×10^{9}			5.779×10^{6}	5.779×10^{6}
Big Creek Waterbody ID: **021 – 2000** HUC-12: 0302	High Flows	0 – 10	209.6 – 2,755	535.5	25.2	1.232×10^{13}	1.232×10^{12}	2.618×10^{9}	0	1.958×10^{8}	1.958×10^{8}
	Moist	10 – 40	49.5 – 209.6	66.8	14.7	1.536×10^{12}	1.536×10^{11}			2.438×10^{7}	2.438×10^{7}
	Mid-Range	40 – 60	36.9 – 49.5	42.7	NR	9.821×10^{11}	9.821×10^{10}			1.557×10^{7}	1.557×10^{7}
	Dry	60 – 90	19.9 – 36.9	30.7	41.9	7.061×10^{11}	7.061×10^{10}			1.118×10^{7}	1.118×10^{7}
	Low Flows	90 – 100	12.1 – 19.9	16.3	30.6	3.747×10^{11}	3.747×10^{10}			5.912×10^{6}	5.912×10^{6}
North Fork Creek Waterbody ID: **021 – 0300** HUC-12: 0302	High Flows	0 – 10	39.8 – 549.0	104.2	17.8	2.395×10^{12}	2.395×10^{11}	5.164×10^{8}	0	2.011×10^{8}	2.011×10^{8}
	Moist	10 – 40	9.55 – 39.8	12.6	8.4	2.898×10^{11}	2.898×10^{10}			2.429×10^{7}	2.429×10^{7}
	Mid-Range	40 – 70	6.00 – 9.55	7.70	NR	1.771×10^{11}	1.771×10^{10}			1.482×10^{7}	1.482×10^{7}
	Low Flows	70 – 100	2.24 – 6.00	4.50	36.8	1.035×10^{11}	1.035×10^{10}			8.643×10^{6}	8.643×10^{6}
Royster Creek Waterbody ID: **021 – 0200** HUC-12: 0302	High Flows	0 – 10	34.2 – 406.3	69.5	30.6	1.559×10^{12}	1.559×10^{11}	NA	NA	1.316×10^{8}	1.316×10^{8}
	Moist	10 – 40	12.8 – 34.2	16.7	8.9	3.848×10^{11}	3.848×10^{10}			3.166×10^{7}	3.166×10^{7}
	Mid-Range	40 – 70	8.40 – 12.8	10.2	NR	2.346×10^{11}	2.346×10^{10}			1.930×10^{7}	1.930×10^{7}
	Low Flows	70 – 100	3.07 – 8.40	6.26	19.8	1.440×10^{11}	1.440×10^{10}			1.185×10^{7}	1.185×10^{7}
Bear Creek Waterbody ID: **021 – 0110** HUC-12: 0303	High Flows	0 – 10	12.6 – 157.0	28.2	NR	6.491×10^{11}	6.491×10^{10}	NA	NA	1.419×10^{8}	1.419×10^{8}
	Moist	10 – 40	4.61 – 12.6	5.85	8.2	1.346×10^{11}	1.346×10^{10}			2.941×10^{7}	2.941×10^{7}
	Mid-Range	40 – 70	3.08 – 4.61	3.76	NR	8.648×10^{10}	8.648×10^{9}			1.890×10^{7}	1.890×10^{7}
	Low Flows	70 – 100	1.09 – 3.08	2.29	1.3	5.267×10^{10}	5.267×10^{9}			1.151×10^{7}	1.151×10^{7}

Table E-53 (cont'd) Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Loosahatchie River Watershed (HUC 08010209)

Waterbody Description (TN08010209__)	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]
Big Creek Waterbody ID: **021 – 1000** HUC-12: 0303	High Flows	0 – 10	349.0 – 4,636	874.6	NR	2.012×10^{13}	2.012×10^{12}	2.094×10^{11}	0	1.853×10^{8}	1.853×10^{8}
	Moist	10 – 40	94.2 – 349.0	123.8	33.0	2.846×10^{12}	2.846×10^{11}			2.436×10^{7}	2.436×10^{7}
	Mid-Range	40 – 60	72.7 – 94.2	82.6	40.6	1.899×10^{12}	1.899×10^{11}			1.553×10^{7}	1.553×10^{7}
	Dry	60 – 90	43.1 – 72.7	61.9	NR	1.424×10^{12}	1.424×10^{11}			1.110×10^{7}	1.110×10^{7}
	Low Flows	90 – 100	29.7 – 43.1	37.0	11.4	8.510×10^{11}	8.510×10^{10}			1.135×10^{6}	1.135×10^{6}
Jakes Creek Waterbody ID: **021 – 0100** HUC-12: 0303	High Flows	0 – 10	15.6 – 201.8	33.8	NR	7.783×10^{11}	7.783×10^{10}	NA	NA	1.343×10^{8}	1.343×10^{8}
	Moist	10 – 40	5.74 – 15.6	7.36	16.1	1.693×10^{11}	1.693×10^{10}			2.921×10^{7}	2.921×10^{7}
	Mid-Range	40 – 70	3.84 – 5.74	4.66	NR	1.072×10^{11}	1.072×10^{10}			1.850×10^{7}	1.850×10^{7}
	Low Flows	70 – 100	1.40 – 3.84	2.86	3.4	6.578×10^{10}	6.578×10^{9}			1.135×10^{7}	1.135×10^{7}
Laurel Creek Waterbody ID: **014 – 1000** HUC-12: 0401	High Flows	0 – 10	36.5 – 407.3	78.1	90.7[b]	1.797×10^{12}	1.797×10^{11}	NA	NA		1.363×10^{8}
	Moist	10 – 40	12.7 – 36.5	16.3		3.749×10^{11}	3.749×10^{10}				2.843×10^{7}
	Mid-Range	40 – 70	8.39 – 12.7	10.3		2.369×10^{11}	2.369×10^{10}				1.796×10^{7}
	Low Flows	70 – 100	2.89 – 8.39	6.84		1.573×10^{11}	1.573×10^{10}				1.193×10^{7}
Little Cypress Creek Waterbody ID: **015 – 0100** HUC-12: 0402	High Flows	0 – 10	56.8 – 547.5	118	79.8[b]	2.717×10^{12}	2.717×10^{11}	NA	NA	NA	1.421×10^{8}
	Moist	10 – 40	18.5 – 56.8	24.2		5.566×10^{11}	5.566×10^{10}				2.910×10^{7}
	Mid-Range	40 – 70	12.1 – 18.5	15.0		3.450×10^{11}	3.450×10^{10}				1.804×10^{7}
	Low Flows	70 – 100	4.10 – 12.1	9.87		2.270×10^{10}	2.270×10^{9}				1.187×10^{7}
Black Ankle Creek Waterbody ID: **004 – 0100** HUC-12: 0403	High Flows	0 – 10	17.7 – 213.0	39.4	81.2[b]	9.067×10^{11}	9.037×10^{10}	NA	NA	NA	1.387×10^{8}
	Moist	10 – 40	6.25 – 17.7	8.17		1.879×10^{11}	1.879×10^{10}				2.875×10^{7}
	Mid-Range	40 – 70	4.13 – 6.25	5.12		1.178×10^{11}	1.178×10^{10}				1.802×10^{7}
	Low Flows	70 – 100	1.40 – 4.13	3.38		7.774×10^{10}	7.774×10^{9}				1.189×10^{7}
Loosahatchie River Waterbody ID: **004 – 1000** HUC-12: 0403	High Flows	0 – 10	388.3 – 4,827	1,035	54.9[b]	2.381×10^{13}	2.381×10^{12}	1.446×10^{11}	0	1.686×10^{8}	1.686×10^{8}
	Moist	10 – 40	110.3 – 388.3	144		3.326×10^{12}	3.326×10^{11}			2.258×10^{7}	2.258×10^{7}
	Mid-Range	40 – 60	83.8 – 110.3	96.0		2.209×10^{12}	2.209×10^{11}			1.461×10^{7}	1.461×10^{7}
	Dry	60 – 90	54.9 – 83.7	68.2		1.570×10^{12}	1.570×10^{11}			1.005×10^{7}	1.005×10^{7}
	Low Flows	90 – 100	26.2 – 54.9	46.6		1.071×10^{12}	1.071×10^{11}			6.496×10^{6}	6.496×10^{6}
Clear (Cypress) Creek Waterbody ID: **003 – 1000** HUC-12: 0404	High Flows	0 – 10	121.3 – 1,678	373	0.9	8.582×10^{12}	8.582×10^{11}	1.603×10^{9}	0	2.036×10^{8}	2.036×10^{8}
	Moist	10 – 40	38.3 – 121.3	48.6	24.0	1.118×10^{12}	1.118×10^{11}			2.646×10^{7}	2.646×10^{7}
	Mid-Range	40 – 60	29.6 – 38.3	33.3	24.0	7.659×10^{11}	7.659×10^{10}			1.812×10^{7}	1.812×10^{7}
	Dry	60 – 90	17.7 – 29.6	23.7	28.8	5.451×10^{11}	5.451×10^{11}			1.288×10^{7}	1.288×10^{7}
	Low Flows	90 – 100	9.11 – 17.7	14.7	18.0	3.381×10^{11}	3.381×10^{11}			7.975×10^{6}	7.975×10^{6}

Table E-53 (cont'd) Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Loosahatchie River Watershed (HUC 08010209)

Waterbody Description (TN08010209__)	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]
Rocky Branch Waterbody ID: **002 – 0200** HUC-12: 0405	High Flows	0 – 10	7.81 – 189.4	23.3	81.5[b]	5.350×10^{11}	5.350×10^{10}	NA	NA	NA	1.902×10^{8}
	Moist	10 – 40	2.16 – 7.81	2.81		6.463×10^{10}	6.463×10^{9}				2.298×10^{7}
	Mid-Range	40 – 70	1.45 – 2.16	1.77		4.071×10^{10}	4.071×10^{9}				1.448×10^{7}
	Low Flows	70 – 100	0.00 – 1.45	1.18		2.714×10^{10}	2.714×10^{9}				9.651×10^{6}
Scotts Creek Waterbody ID: **002 – 0300** HUC-12: 0405	High Flows	0 – 10	6.28 – 7.71	17.6	NR	4.055×10^{11}	4.055×10^{10}	NA	NA	2.292×10^{8}	2.292×10^{8}
	Moist	10 – 40	1.29 – 6.28	1.81	13.2	4.163×10^{10}	4.163×10^{9}			2.353×10^{7}	2.353×10^{7}
	Mid-Range	40 – 70	0.84 – 1.29	1.04	7.6	2.392×10^{10}	2.392×10^{9}			1.352×10^{7}	1.352×10^{7}
	Low Flows	70 – 100	0.32 – 0.84	0.67	NR	1.541×10^{10}	1.541×10^{9}			8.712×10^{6}	8.712×10^{6}
Oliver Creek Waterbody ID: **002 – 0400** HUC-12: 0405	High Flows	0 – 10	7.14 – 100.0	17.8	10.9	4.094×10^{11}	4.094×10^{10}	NA	NA	1.682×10^{8}	1.682×10^{8}
	Moist	10 – 40	2.20 – 7.14	2.92	0.4	6.716×10^{10}	6.719×10^{9}			2.760×10^{7}	2.760×10^{7}
	Mid-Range	40 – 70	1.46 – 2.20	1.78	56.8	4.094×10^{10}	4.094×10^{9}			1.682×10^{7}	1.682×10^{7}
	Low Flows	70 – 100	0.54 – 1.46	1.09	23.5	2.507×10^{10}	2.507×10^{9}			1.030×10^{7}	1.030×10^{7}
Buckhead Creek Waterbody ID: **002 – 0500** HUC-12: 0405	High Flows	0 – 10	16.1 – 152.0	33.5	76.5[b]	7.705×10^{11}	7.705×10^{10}	NA	NA	2.235×10^{8}	2.235×10^{8}
	Moist	10 – 40	3.91 – 16.1	5.71		1.313×10^{11}	1.313×10^{10}			3.809×10^{7}	3.809×10^{7}
	Mid-Range	40 – 70	2.48 – 3.91	3.12		7.176×10^{10}	7.176×10^{9}			2.081×10^{7}	2.081×10^{7}
	Low Flows	70 – 100	0.84 – 2.48	1.88		4.324×10^{10}	4.324×10^{9}			1.254×10^{7}	1.254×10^{7}
Howard Creek Waterbody ID: **002 – 0600** HUC-12: 0405	High Flows	0 – 10	8.58 – 171.6	18.4	32.9	4.230×10^{11}	4.230×10^{10}	NA	NA	2.045×10^{8}	2.045×10^{8}
	Moist	10 – 40	1.80 – 8.58	2.63	6.7	6.049×10^{10}	6.049×10^{9}			2.925×10^{7}	2.925×10^{7}
	Mid-Range	40 – 70	1.18 – 1.80	1.45	NA	3.335×10^{10}	3.335×10^{9}			1.613×10^{7}	1.613×10^{7}
	Low Flows	70 – 100	0.00 – 1.18	0.88	28.4	2.024×10^{10}	2.24×10^{9}			9.787×10^{6}	9.787×10^{6}
Loosahatchie River Waterbody ID: **002 – 2000** HUC-12: 0405	High Flows	0 – 10	1,060 – 10,564	2,440	52.3	5.612×10^{13}	5.612×10^{12}	4.175×10^{11}	0	1.563×10^{8}	1.563×10^{8}
	Moist	10 – 40	328.0 – 1,060	423.5	21.0	9.741×10^{12}	9.741×10^{11}			2.605×10^{7}	2.605×10^{7}
	Mid-Range	40 – 60	248.0 – 328.0	287.0	NR	6.601×10^{12}	6.601×10^{11}			1.723×10^{7}	1.723×10^{7}
	Dry	60 – 90	165.0 – 248.0	202.0	13.4	4.646×10^{12}	4.646×10^{11}			1.174×10^{7}	1.174×10^{7}
	Low Flows	90 – 100	90.3 – 165.0	141.9	9.1	3.264×10^{12}	3.264×10^{11}			7.862×10^{6}	7.862×10^{6}
Loosahatchie River Waterbody ID: **001 – 1000** HUC-12: 0406	High Flows	0 – 10	2,216 – 29,265	4,009	49.4	8.582×10^{13}	8.582×10^{12}	7.071×10^{11}	0	1.780×10^{8}	1.780×10^{8}
	Moist	10 – 40	559.2 – 2,216	827.7	17.2	1.771×10^{13}	1.771×10^{12}			3.554×10^{7}	3.554×10^{7}
	Mid-Range	40 – 60	414.1 – 559.2	478.2	10.7	1.053×10^{13}	1.053×10^{12}			1.989×10^{7}	1.989×10^{7}
	Dry	60 – 90	244.8 – 414.1	335.8	7.1	7.337×10^{12}	7.337×10^{11}			1.351×10^{7}	1.351×10^{7}
	Low Flows	90 – 100	133.5 – 244.8	203.5	NR	4.114×10^{12}	4.114×10^{11}			7.583×10^{6}	7.583×10^{6}

Table E-53 (cont'd) Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Loosahatchie River Watershed (HUC 08010209)

Waterbody Description (TN08010209__)	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]
UT to Loosahatchie River Waterbody ID: **002 – 0100** HUC-12: 0406	High Flows	0 – 10	3.64 – 92.2	10.3	47.6[b]	2.367×10^{11}	2.367×10^{10}	NA	NA	NA	2.362×10^{8}
	Moist	10 – 40	0.80 – 3.64	1.08		2.484×10^{10}	2.484×10^{9}				4.479×10^{7}
	Mid-Range	40 – 70	0.53 – 0.80	0.65		1.495×10^{10}	1.495×10^{9}				1.492×10^{7}
	Low Flows	70 – 100	0.00 – 0.53	0.39		8.970×10^{9}	8.970×10^{8}				8.951×10^{6}
Loosahatchie River Waterbody ID: **002 – 1000** HUC-12: 0406	High Flows	0 – 10	1,140 – 10,200	2,641	35.9	6.074×10^{13}	6.074×10^{12}	4.976×10^{11}	0	1.596×10^{8}	1.596×10^{8}
	Moist	10 – 40	355.8 – 1,140	470.0	20.1	1.081×10^{13}	1.081×10^{12}			2.719×10^{7}	2.719×10^{7}
	Mid-Range	40 – 60	264.0 – 355.8	307.0	12.7	7.061×10^{12}	7.061×10^{11}			1.725×10^{7}	1.725×10^{7}
	Dry	60 – 90	173.8 – 264.0	215.0	4.1	4.945×10^{12}	4.945×10^{11}			1.164×10^{7}	1.164×10^{7}
	Low Flows	90 – 100	96.3 – 173.8	150.0	9.3	3.450×10^{12}	3.450×10^{11}			7.681×10^{6}	7.681×10^{6}
Todd Branch Waterbody ID: **001 – 0100** HUC-12: 0406	High Flows	0 – 10	16.3 – 81.5	29.7	59.6	6.826×10^{11}	6.826×10^{10}	NA	NA	2.369×10^{8}	2.369×10^{8}
	Moist	10 – 40	2.85 – 16.3	5.76	44.6	1.325×10^{11}	1.325×10^{10}			4.598×10^{7}	4.598×10^{7}
	Mid-Range	40 – 70	1.32 – 2.85	1.88	26.7	4.324×10^{10}	4.324×10^{9}			1.501×10^{7}	1.501×10^{7}
	Low Flows	70 – 100	0.30 – 1.32	0.91	NA	2.093×10^{10}	2.093×10^{9}			7.265×10^{6}	7.265×10^{6}

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.

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 LOOSAHATCHIE RIVER WATERSHED (HUC 08010209), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed Total Maximum Daily Load (TMDL) for E. coli in the Loosahatchie River watershed, located in western 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 Loosahatchie watershed are listed on Tennessee's Proposed Final 2010 303(d) list as not supporting designated use classifications due, in part, to discharges from MS4 areas and pasture grazing. 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 5.2-90.7% in the listed waterbodies.

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

http://www.tennesse.gov/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 July 11, 2011 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

City of Memphis
TENNESSEE

A C WHARTON, JR. - Mayor
GEORGE M. LITTLE - Chief Administrative Officer
DIVISION OF PUBLIC WORKS
DWAN L. GILLIOM - Director
Storm Water Program

July 6, 2011

Dr. Sherry H. Wang
Tennessee Department of Environment and Conservation
Division of Water Pollution Control
401 Church Street
L&C Annex, Seventh Floor
Nashville, Tennessee 37243

RE: Comments to Draft of Proposed Total Maximum Daily Load for E. coli
Loosahatchie River Watershed, Tennessee

Dr. Wang:

The City of Memphis respectively submits the attached comments to the referenced document for your review and comment.

Sincerely,

Bobby D. Allen, P.E.
Storm Water Program Manager
City of Memphis

2714 Union Avenue Extended, Suite 625 • Memphis, Tennessee 38112 • (901) 636-4349

Comments on Draft Proposed Total Maximum Daily Load for E. Coli for Loosahatchie River Watershed, Tennessee

Section 2.0 Scope of Document

Comment:
While improving water quality conditions on a watershed basis may be preferable, it is not always feasible to accomplish. The Loosahatchie watershed encompasses more than one jurisdiction including both rural and urban communities. The jurisdictions are under different permitting requirements and often have different agendas. Also, rural areas (specifically agricultural areas) are governed under different agencies and by different regulations when compared to MS4 areas. Significant time and money could be spent by a MS4 to comply with the TMDL requirements. However, all of their work could be rendered insignificant by the constant discharge of neighboring entities. How does TDEC propose that the local MS4 address the contributions of E. coli for areas outside of their jurisdiction?

Section 6.0 Water Quality Assessment and Deviation From Target, Paragraph 2
The second paragraph (page 14 of 50) states that: "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."

Comment:
Please identify which sample results listed in Appendix B represent a geometric mean calculation.

Section 9.3.1 Urban Nonpoint Sources
The sixth paragraph of this section states that "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 humane inducements for congregation. In addition, in some instances population control measures may be appropriate."

Comment:
It would be economically and technically unfeasible to reduce the proximity of animals to the waterbodies. Also, to remove the drinking source from wildlife would be considered inhumane and not socially acceptable. Reducing the population by harvesting would not be socially acceptable and a capture and release program would be cost prohibitive.

Section 9.3.2 Agricultural Nonpoint Sources. Paragraph 1
The first paragraph of this section states that existing BMPs "…may have contributed to reductions in in-stream concentrations of coliform bacteria in one or more Loosahatchie River Wastershed…"

Comment:
How long have these BMPs been under evaluation? Please clarify if the existing data does or does not support a reduction in in-stream concentrations of coliform bacteria from these BMPs.

Section 9.3.2 Agricultural Nonpoint Sources. Paragraph 2
This paragraph states that: "Demonstration sites for various types of BMPs should be established and maintained, and their performance (in source reductions) evaluated over a period of at least two years prior to recommendations for utilization for subsequent implementation."

Comment:
Is TDEC proposing that the MS4 conduct pilot studies for various types of BMPs for a minimum of two years prior to recommending BMPs for subsequent implementation? This would prove extremely costly and unmanageable with current staff loads.

Has TDEC determined if there are economically feasible BMP technologies currently available that can improve water quality conditions as required by the TMDL?

Table B-1 TDEC Water Quality Monitoring Data

Comment:
Some of the data in this table were collected as far back as 1998 and as such do not realistically represent the current status of the watershed. The majority of the sampling sites do not have current sampling data. Please explain how this data could be considered valid for determining current TMDL values.

Table B-2 TDEC Water Quality Monitoring Data

Comment:
Some of the data in this table were collected as far back as 2004 and as such do not realistically represent the current status of the watershed. The majority of the sampling sites do not have current sampling data. Please explain how this data could be considered valid for determining current TMDL values.

Section C.1.1 Development of Flow Duration Curves, Paragraph 2
This paragraph states that the flow duration curves were derived from a simulation program based on "parameters derived from calibrations at USGS Station Nos. 07030240".

Comment:
How much actual data, from individual watershed areas, was available and used to develop flow duration curves? How is this station representative of the entire watershed?

Section C.1.2 Development of Load Duration Curves and TMDLs, Second Paragraph
This paragraph states that: "E. coli load duration curves for impaired waterbodies in the Loosahatchie 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."

Comment:
The LDCs were developed using non-current data (see comments to Table B-1 and B-2) and computer simulated FDCs (see comment to Section C.1.2). Development of a TMDL without the use of valid and adequate data can result in overly conservative results. Compliance with such TMDL protocols will place unjustified and extensive financial and manpower burdens on the MS4 which is already operating under difficult economic conditions.

s/pw/sw/tmdl/loosahatchie/ecoli/commentsdrafttmdlforecolimay2011

APPENDIX H

Response to Comments Received

Section 2.0 Scope of Document

TDEC recognizes that portions of the Loosahatchie River watershed fall under the jurisdiction of different entities. Each local MS4 is responsible only for contributions of E. coli within their own boundaries.

Section 6.0 Water Quality Assessment and Deviation From Target

The sample results listed in Table 3 are the minimum, average, and maximum of the monitoring data and do not include any geometric mean calculations. Geomean calculations are presented in Appendix E. Sufficient data was available to perform geomean calculations for the following waterbodies: Treadville Bottom (Table E-7), Kelley Branch (Table E-13), Crooked Creek (Table E-17), Laurel Creek (Table E-26), Little Cypress Creek (Table E-28), Black Ankle Creek (Table E-30), Loosahatchie River at RM34.0 (Table E-33), Buckhead Creek (Tables E-37 , E-39, and E-41), Rocky Branch (Table E-46), and Unnamed Trib to Loosahatchie River (Table E-51).

Section 9.3.1 Urban Nonpoint Sources

Comment noted.

Section 9.3.2 Agricultural Nonpoint Sources

As of July 2010, there were 141 BMPs reported by NRCS in the Loosahatchie River watershed. Some of them have been under evaluation since 2002, while others were implemented as recently as 2009. Since agricultural areas do not generally lie within the boundaries of a local MS4, BMPs related to agricultural activity would not be the responsibility of the local MS4.

Table B-1 TDEC Water Quality Monitoring Data and

Table B-2 Memphis MS4 Water Quality Monitoring Data

A TMDL document is developed using the water quality data currently available. TDEC agrees that the existing data may not be representative of current conditions. As stated in Section 9.4 of the TMDL, additional monitoring and assessment activities are recommended for all impaired waterbodies in the Loosahatchie River watershed. Once additional monitoring representing all seasons and a full range of flow and meteorological conditions has been obtained, the required load reductions may be revised.

However, TMDLs, LAs and WLAs are a function of the water quality standard, the daily mean in-stream flow, any point source discharges, and an appropriate margin of safety. Additional monitoring data will not change the TMDL for a given waterbody.

Figures H-1 and H-2 present load duration curves at mile 5.0 of the Loosahatchie River. Figure H-1 compares the mean of the exceedances for two 5-year time periods. The figure shows mixed results depending on the flow regime. Figure H-2 compares the best-fit line for all monitoring data for the two 5-year time periods. The two lines are barely distinguishable. Therefore, the results suggest no measurable change for the watershed as a whole.

Figures similar to H-1 and H-2 were constructed for several other waterbodies. Results for Big Creek and Todd Branch suggest deterioration. Results for most other monitoring stations in the Loosahatchie River watershed suggest either no change or deterioration.

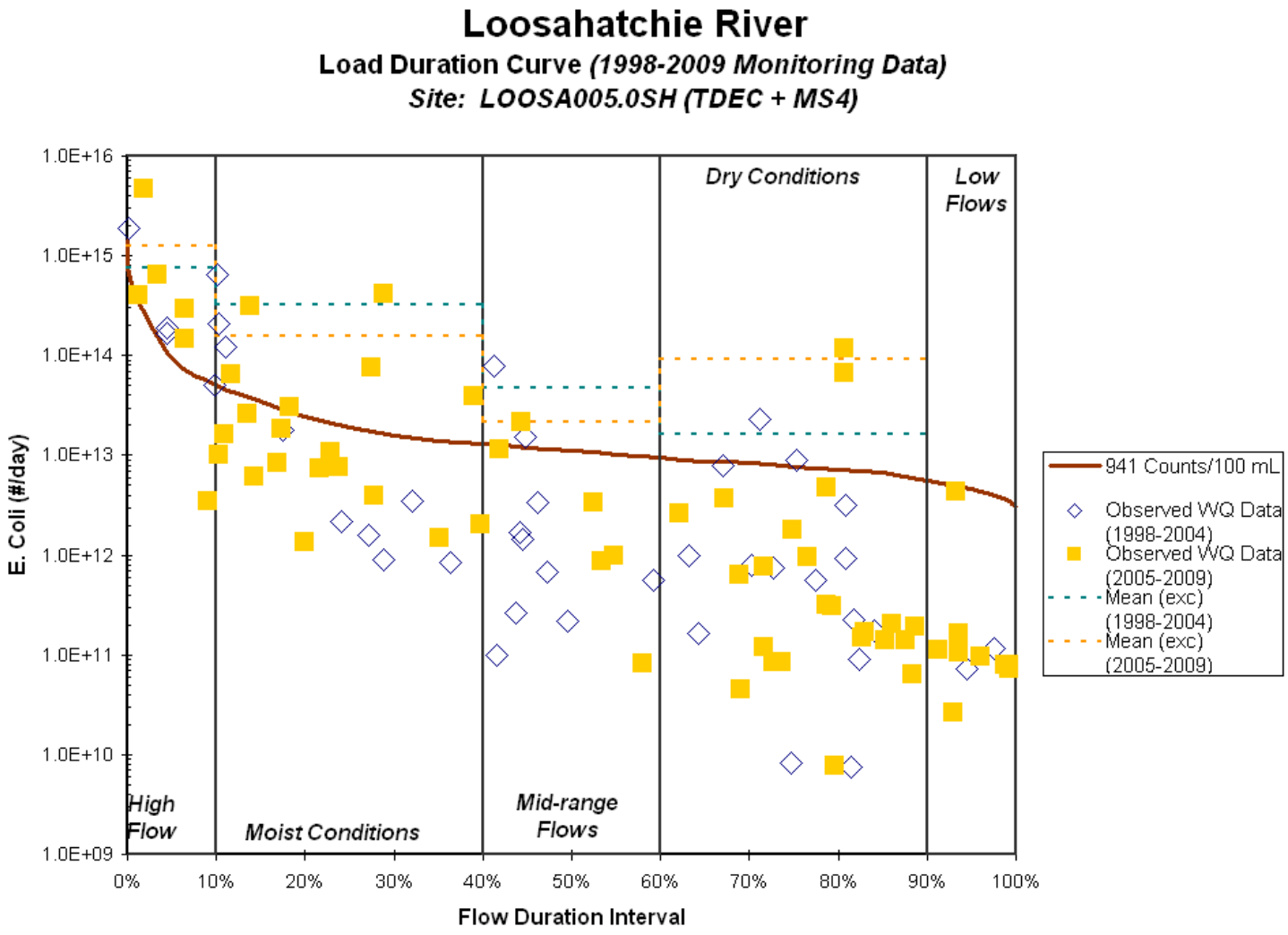

Figure H-1. E. Coli Load Duration Curve for Loosahatchie River – RM5.0
Two Date Ranges – Comparison of Mean Exceedances

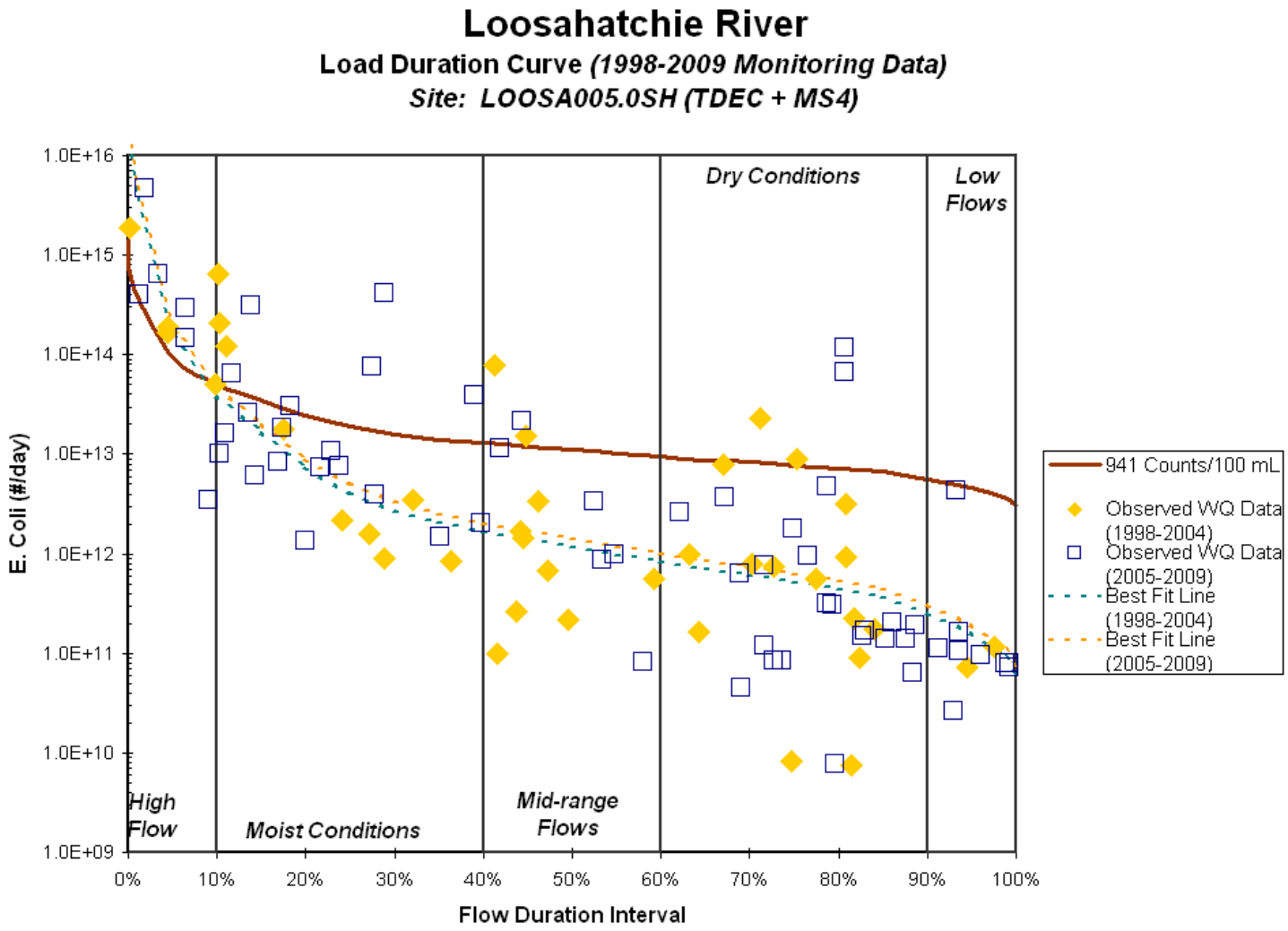

Figure H-2. E. Coli Load Duration Curve for Loosahatchie River – RM5.0
Two Date Ranges – Comparison of Best Fit Lines

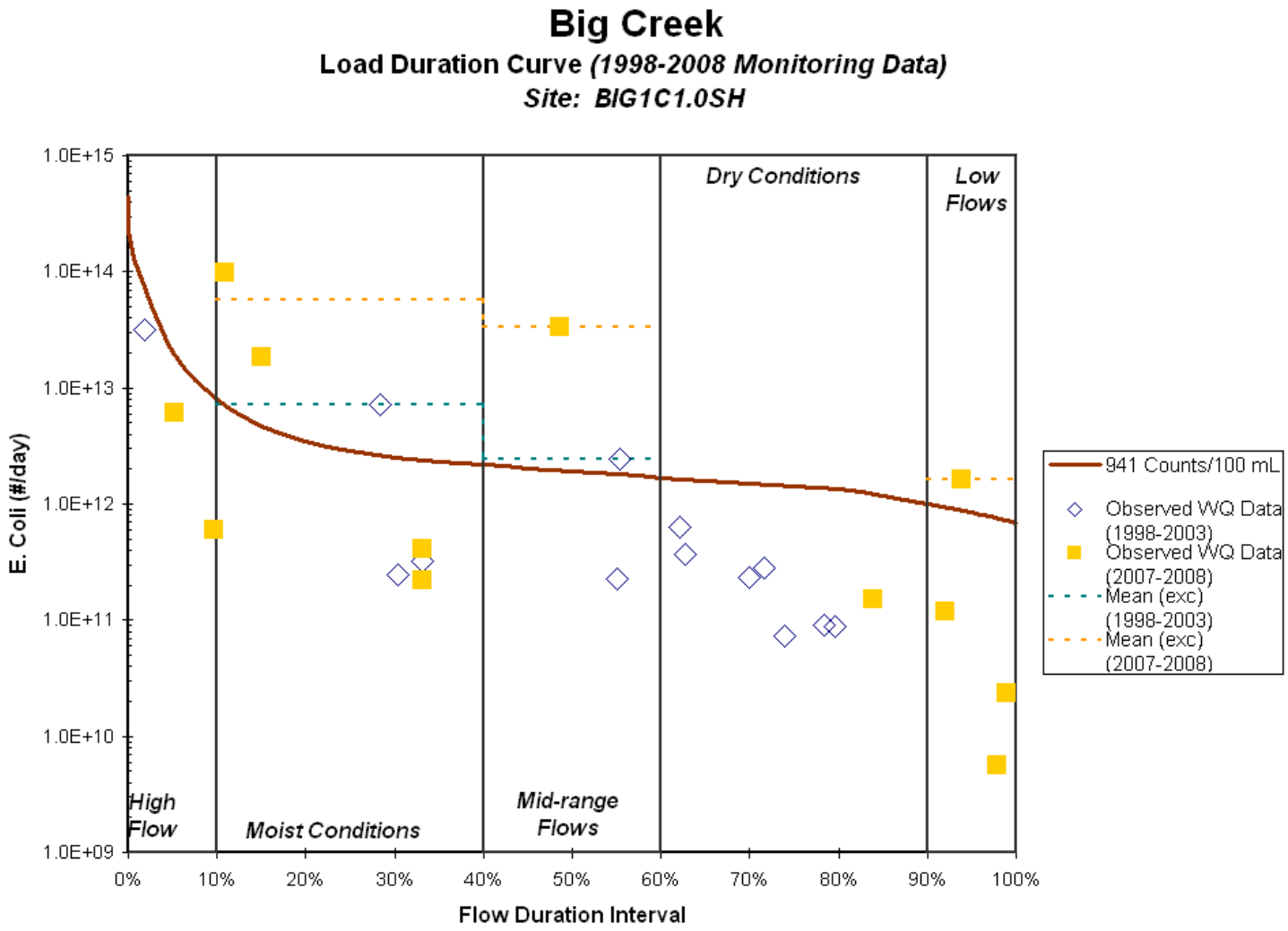

Figure H-3. E. Coli Load Duration Curve for Big Creek – RM1.0
Two Date Ranges – Comparison of Mean Exceedances

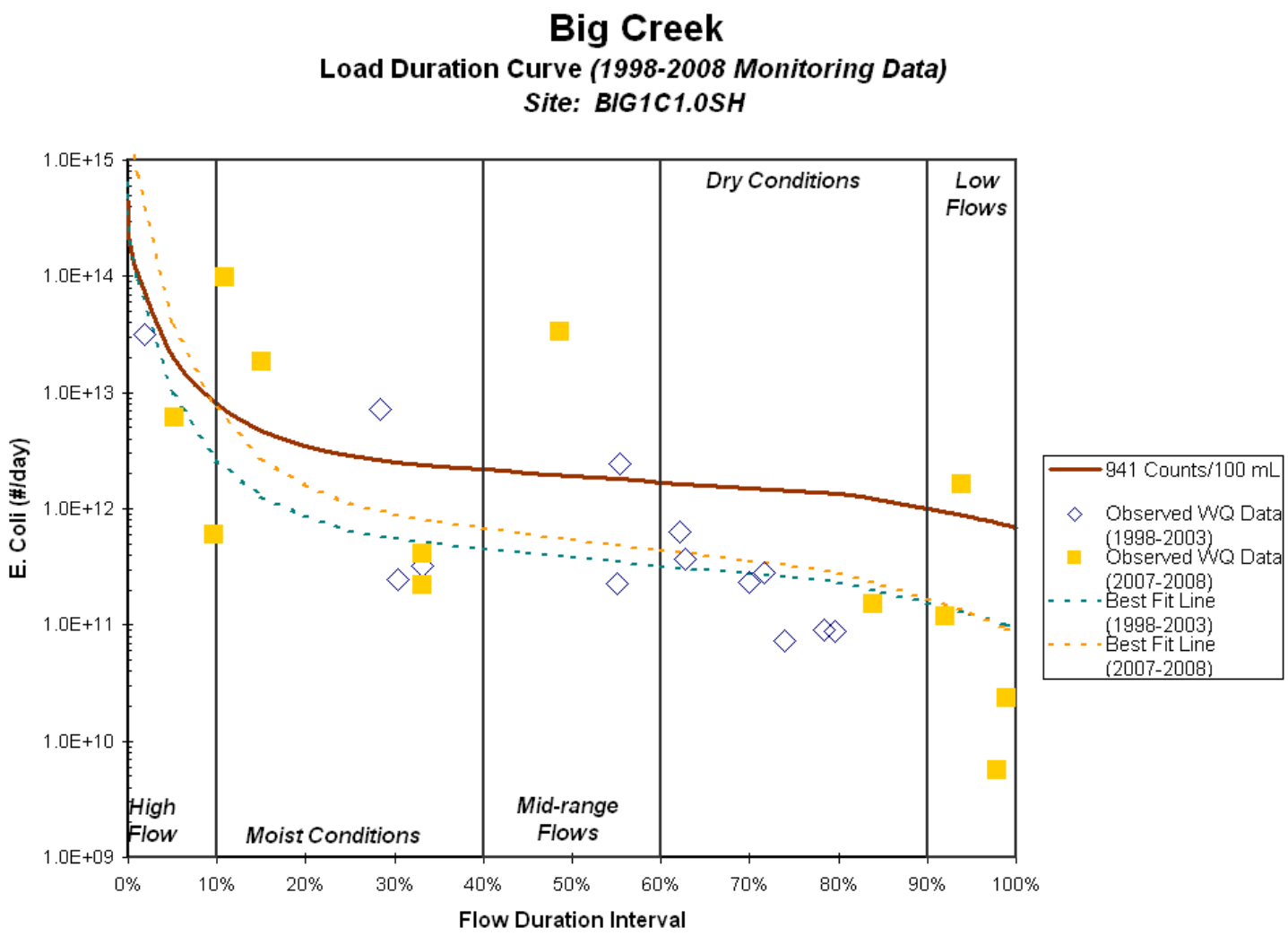

Figure H-4. E. Coli Load Duration Curve for Big Creek – RM1.0
Two Date Ranges – Comparison of Best Fit Lines

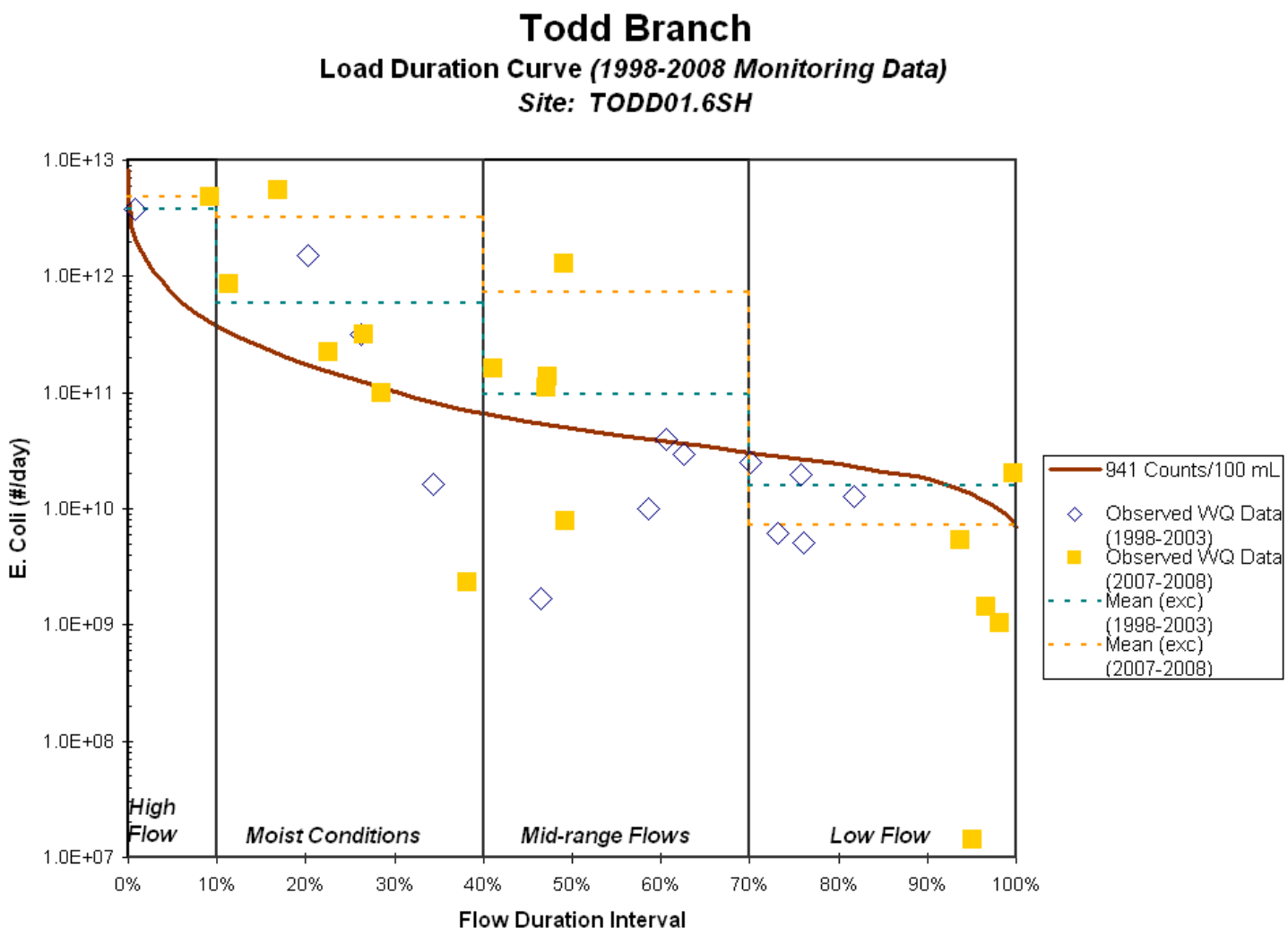

Figure H-5. E. Coli Load Duration Curve for Todd Branch – RM1.6
Two Date Ranges – Comparison of Mean Exceedances

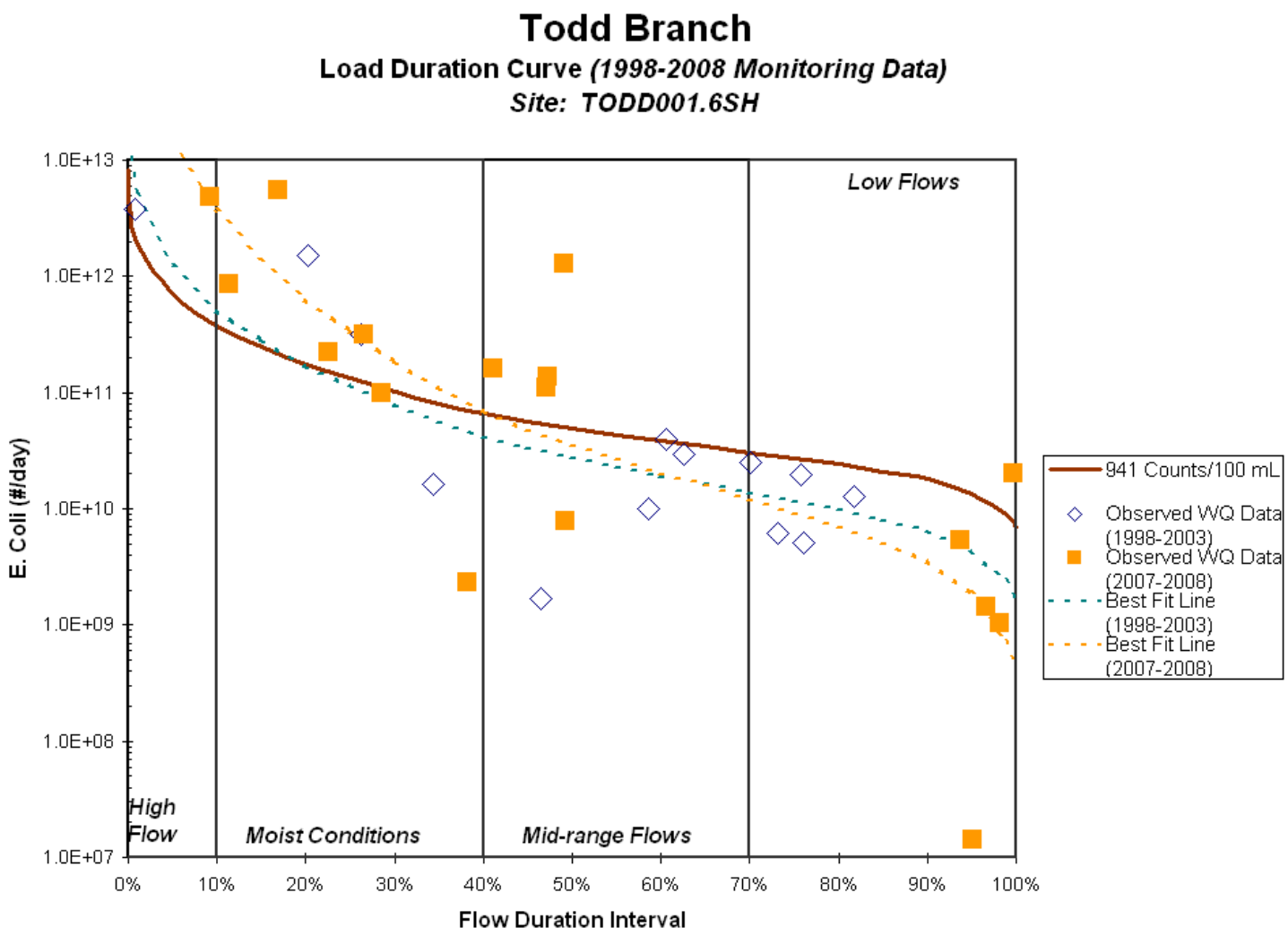

Figure H-6. E. Coli Load Duration Curve for Todd Branch – RM1.6
Two Date Ranges – Comparison of Best Fit Lines

Section C.1.1 Development of Flow Duration Curves

A flow duration curve can only be developed based on actual historic flow data when such data is available. As stated in the TMDL document, for ungaged streams, alternative methods must be used to estimate daily mean flow. For the Loosahatchie River watershed, daily mean flow was simulated using WinHSPF.

USGS Station No. 07030240 is located on the Loosahatchie River near Arlington, TN. This gaging station was selected based on a number of factors including: location, Level IV ecoregion, landuse, similarity of drainage area, length of record, and topography. An explanation to this effect has been added to section D.3.

Section C.1.2 Development of Load Duration Curves and TMDLs

As stated in the TMDL document, the target load for a given waterbody is equal to the TMDL and the TMDL is a function of the water quality standard and the daily mean in-stream flow. Calculation of the TMDL does not take into account monitoring results. However, the required load reduction is based on monitoring results. The purpose of the load reduction (PLRG) is to facilitate implementation. Waterbodies with a higher PLRG can be given a higher priority for allocation of resources. For each waterbody, the flow zone of the load duration curve with the highest PLRG can be targeted and management practices suggested in Table 9 can be examined. Use of the resources contained in the TMDL document can enable the MS4 to target their resources more effectively and reduce unjustified and unnecessary financial and manpower burdens.