PROPOSED
TOTAL MAXIMUM DAILY LOAD (TMDL)

for

E. Coli

in the

South Fork Forked Deer River Watershed

(HUC 08010205)

Chester, Crockett, Dyer, Haywood, Henderson, Lauderdale, McNairy, and Madison Counties, Tennessee

FINAL

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Submitted December 6, 2011
Approved by EPA Region 4 – December 15, 2011

TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF FIGURES (cont'd)

LIST OF TABLES

LIST OF TABLES (cont'd)

LIST OF TABLES (cont'd)

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
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
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 South Fork Forked Deer River Watershed (HUC 08010205)

Impaired Waterbody Information

State: Tennessee
Counties: Crockett, Dyer, Haywood, Lauderdale, and Madison
Watershed: South Fork Forked Deer River (HUC 08010205)
Constituents of Concern: E. coli
Waterbodies Addressed in This Document:

Waterbody ID	Waterbody	Miles Impaired
TN08010205001 – 0200	MILL CREEK	27.2
TN08010205001 – 1000	SOUTH FORK FORKED DEER RIVER	15.6
TN08010205003 – 1000	SOUTH FORK FORKED DEER RIVER	6.8
TN08010205005 – 0100	LITTLE NIXON CREEK	15.3
TN08010205005 – 0200	MERIDIAN CREEK	36.29
TN08010205005 – 1000	NIXON CREEK	20.4
TN08010205010 – 0100	KAIL CREEK	27.4
TN08010205010 – 0200	JACOBS CREEK	25.9
TN08010205010 – 1000	SOUTH FORK FORKED DEER RIVER	13.2
TN08010205011 – 1000	MUD CREEK	42.9
TN08010205012 – 0400	SANDY CREEK	4.3
TN08010205012 – 0500	CENTRAL CREEK	2.0
TN08010205012 – 0600	ANDERSON BRANCH	5.2
TN08010205012 – 0700	BOND CREEK	9.7
TN08010205012 – 0900	HICKS CREEK	28.5
TN08010205012 – 1000	SOUTH FORK FORKED DEER RIVER	21.6
TN08010205012 – 1200	CUB CREEK	2.07
TN08010205012 – 1400	PANTHER CREEK	21.1
TN08010205018 – 1000	SOUTH FORK FORKED DEER RIVER	19.8
TN08010205018 – 1200	UNNAMED TRIB TO SOUTH FORK FORKED DEER RIVER	2.99
TN08010205028 – 0300	BEAR CREEK	9.7
TN08010205028 – 1000	NORTH FORK OF SOUTH FORK FORKED DEER RIVER	24.4

Waterbody ID	Waterbody	Miles Impaired
TN08010205031 – 1000	BLACK CREEK	12.9
TN08010205036 – 0110	UNNAMED TRIB TO TISDALE CREEK	2.89
TN08010205036 – 1000	HALLS CREEK	15.77

Designated Uses:

The designated use classifications for waterbodies in the South Fork Forked Deer River Watershed include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. Some waterbodies are also designated for navigation.

Water Quality Targets:

Derived from *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, 2007 Version* for recreation use classification (most stringent):

> The concentration of the E. coli group shall not exceed 126 colony forming units per 100 mL, as a geometric mean based on a minimum of 5 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purposes of determining the geometric mean, individual samples having an E. coli concentration of less than 1 per 100 mL shall be considered as having a concentration of 1 per 100 mL.
>
> Additionally, the concentration of the E. coli group in any individual sample taken from a lake, reservoir, State Scenic River, Exceptional Tennessee Water or ONRW (1200-4-3-.06) shall not exceed 487 colony forming units per 100 mL. The concentration of the E. coli group in any individual sample taken from any other waterbody shall not exceed 941 colony forming units per 100 mL.

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

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

TMDL Scope:

Waterbodies identified on the Final 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 E. coli TMDLs approved by EPA in 2006. Since 2006: (1) additional waterbodies have been listed; and (2) TDEC has developed an improved flow-based methodology.

Analysis/Methodology:

The TMDLs for impaired waterbodies in the South Fork Forked Deer 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 South Fork Forked Deer River Watershed (HUC 08010205)

HUC-12 Subwatershed (08010205__) 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]
0105	South Fork Forked Deer River	TN08010205018 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.666×10^{10}	0	$(7.129 \times 10^{4} \times Q) - (3.080 \times 10^{5})$	$(7.129 \times 10^{4} \times Q) - (3.080 \times 10^{5})$
0106	South Fork Forked Deer River	TN08010205018 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.666×10^{10}	0	$(7.129 \times 10^{4} \times Q) - (3.080 \times 10^{5})$	$(7.129 \times 10^{4} \times Q) - (3.080 \times 10^{5})$
	UT to South Fork Forked Deer River	TN08010205018 – 1200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.044 \times 10^{7} \times Q$	$3.044 \times 10^{7} \times Q$
0203	Bear Creek	TN08010205028 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$4.661 \times 10^{6} \times Q$	$4.661 \times 10^{6} \times Q$
	North Fork of South Fork Forked Deer River	TN08010205028 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.781×10^{8}	0	$(1.992 \times 10^{5} \times Q) - (1.713 \times 10^{3})$	$(1.992 \times 10^{5} \times Q) - (1.713 \times 10^{3})$
0204	North Fork of South Fork Forked Deer River	TN08010205028 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.781×10^{8}	0	$(1.992 \times 10^{5} \times Q) - (1.713 \times 10^{3})$	$(1.992 \times 10^{5} \times Q) - (1.713 \times 10^{3})$
0302	Sandy Creek	TN08010205012 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$8.208 \times 10^{6} \times Q$	$8.208 \times 10^{6} \times Q$
	Central Creek	TN08010205012 – 0500	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.490 \times 10^{7} \times Q$	$2.490 \times 10^{7} \times Q$
	Anderson Branch	TN08010205012 – 0600	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	NA	$5.032 \times 10^{6} \times Q$	$5.032 \times 10^{6} \times Q$
	Bond Creek	TN08010205002 – 0700	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$6.499 \times 10^{6} \times Q$	$6.499 \times 10^{6} \times Q$
	Hicks Creek	TN08010205012 – 0900	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$4.032 \times 10^{6} \times Q$	$4.032 \times 10^{6} \times Q$
	South Fork Forked Deer River	TN08010205012 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.684×10^{10}	0	$(3.326 \times 10^{4} \times Q) - (1.442 \times 10^{5})$	$(3.326 \times 10^{4} \times Q) - (1.442 \times 10^{5})$
0305	Cub Creek	TN08010205012 – 1200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	5.699×10^{8}	0	$(3.605 \times 10^{6} \times Q) - (9.923 \times 10^{4})$	$(3.605 \times 10^{6} \times Q) - (9.923 \times 10^{4})$
	South Fork Forked Deer River	TN08010205012 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.684×10^{10}	0	$(3.326 \times 10^{4} \times Q) - (1.442 \times 10^{5})$	$(3.326 \times 10^{4} \times Q) - (1.442 \times 10^{5})$
0306	Panther Creek	TN08010205012 – 1400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.211×10^{9}	0	$(2.298 \times 10^{6} \times Q) - (1.344 \times 10^{5})$	$(2.298 \times 10^{6} \times Q) - (1.344 \times 10^{5})$
	South Fork Forked Deer River	TN08010205012 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.684×10^{10}	0	$(2.707 \times 10^{4} \times Q) - (1.178 \times 10^{5})$	$(2.707 \times 10^{4} \times Q) - (1.178 \times 10^{5})$

Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the South Fork Forked Deer River Watershed (HUC 08010205) (cont'd)

HUC-12 Subwatershed (08010205__) 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]
0401	Little Nixon Creek	TN08010205005 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.593 \times 10^{6} \times Q$	$2.593 \times 10^{6} \times Q$
	Nixon Creek	TN08010205005 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.727 \times 10^{5} \times Q$	$2.727 \times 10^{5} \times Q$
0402	Meridian Creek	TN08010205005 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$5.416 \times 10^{6} \times Q$
0403	Nixon Creek	TN08010205005 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.727 \times 10^{5} \times Q$	$2.727 \times 10^{5} \times Q$
0501	Mud Creek	TN08010205011 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.089×10^{8}	0	$(1.350 \times 10^{6} \times Q) - (2.666 \times 10^{4})$	$(1.350 \times 10^{6} \times Q) - (2.666 \times 10^{4})$
0502	Kail Creek	TN08010205010 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.757 \times 10^{6} \times Q$	$1.757 \times 10^{6} \times Q$
0503	Jacobs Creek	TN08010205010 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.248 \times 10^{6} \times Q$	$2.248 \times 10^{6} \times Q$
	South Fork Forked Deer River	TN08010205010 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	7.672×10^{11}	0	$(2.203 \times 10^{4} \times Q) - (1.565 \times 10^{6})$	$(2.203 \times 10^{4} \times Q) - (1.565 \times 10^{6})$
0504	Black Creek	TN08010205031 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.113 \times 10^{6} \times Q$	$1.113 \times 10^{6} \times Q$
0505	UT to Tisdale Creek	TN08010205036 – 0110	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.986 \times 10^{7} \times Q$	$3.986 \times 10^{7} \times Q$
	Halls Creek	TN08010205036 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.223 \times 10^{6} \times Q$	$1.223 \times 10^{6} \times Q$
0506	Mill Creek	TN08010205001 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.817 \times 10^{6} \times Q$	$1.817 \times 10^{6} \times Q$
0507	South Fork Forked Deer River	TN08010205001 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	8.893×10^{11}	0	$(1.663 \times 10^{4} \times Q) - (1.370 \times 10^{6})$	$(1.663 \times 10^{4} \times Q) - (1.370 \times 10^{6})$
	South Fork Forked Deer River	TN08010205003 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	8.573×10^{11}	0	$(3.492 \times 10^{4} \times Q) - (1.440 \times 10^{6})$	$(3.492 \times 10^{4} \times Q) - (1.440 \times 10^{6})$

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)
SOUTH FORK FORKED DEER RIVER WATERSHED (HUC 08010205)

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 South Fork Forked Deer River Watershed, identified on the 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 E. coli TMDLs approved by EPA in 2006. Since 2006: (1) additional waterbodies have been listed; and (2) TDEC has developed an improved flow-based methodology.

3.0 WATERSHED DESCRIPTION

The South Fork Forked Deer River Watershed (HUC 08010205) is located in Western Tennessee (Figure 1). The watershed includes parts of Chester, Crockett, Dyer, Lauderdale, Haywood, Henderson, McNairy, and Madison counties. The South Fork Forked Deer 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 **Northern Hilly Gulf Coastal Plain (65e)** contains 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 Pleistocene Valley Trains (73b)** ecoregion is composed of scattered small remnants of late-Wisconsin glacial outwash deposits and terraces from the Mississippi and Ohio rivers. Surface features reflect braided stream depositional regimes. Ecoregion 73b is generally higher than the neighboring Northern Holocene Meander Belts (73a) and Northern Backswamps (73d). Ecoregions 73a and 73d are limited and fragmented because the Pleistocene valley trains have been largely eroded away by lateral channel migration or buried by deep sediments during Holocene times. Cropland is extensive; soybeans are the meain crops along with areas of cotton. Evidence from the limited remaining forests indicates that original vegetation was primarily species typical of higher bottomlands such as Nuttall oak, willow oak, swamp chestnut oak, sugarberry, and green ash.

- 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 South Fork Forked Deer River Watershed (HUC 08010205) has approximately 1,829 miles of streams (based on USEPA/TDEC Assessment Database (ADB)) and drains approximately 1,062 square miles to the South Fork Forked Deer River, which ultimately 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 South Fork Forked Deer 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 South Fork Forked Deer River Watershed is summarized in Table 1 and shown in Figure 3. Predominant land use in the South Fork Forked Deer River Watershed is almost evenly split between cropland (40.7%) and forest (40.9%). Urban areas represent approximately 7.7% of the total drainage area of the watershed. Details of land use distribution of impaired subwatersheds in the South Fork Forked Deer River Watershed are presented in Appendix A.

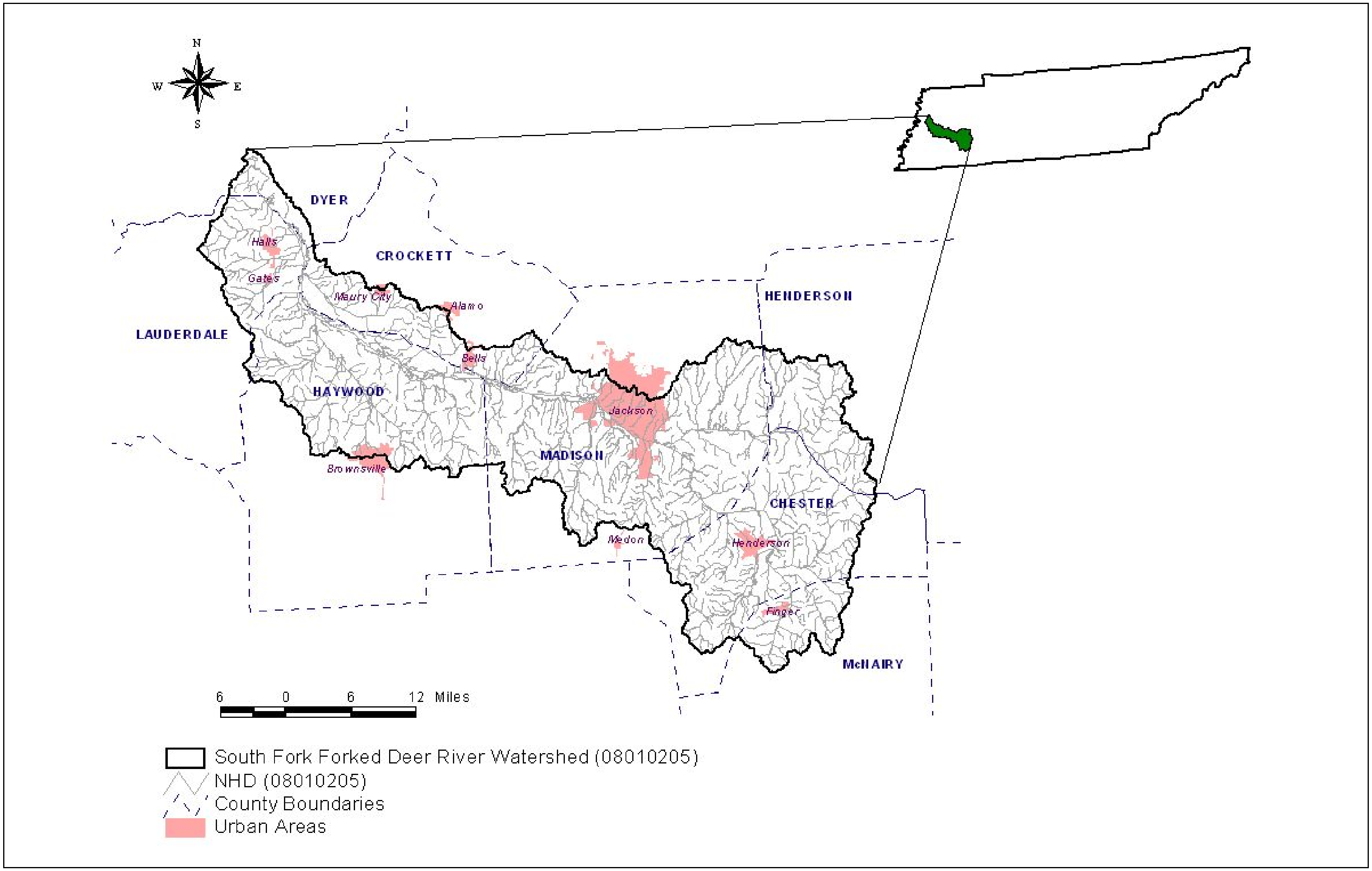

Figure 1. Location of the South Fork Forked Deer River Watershed.

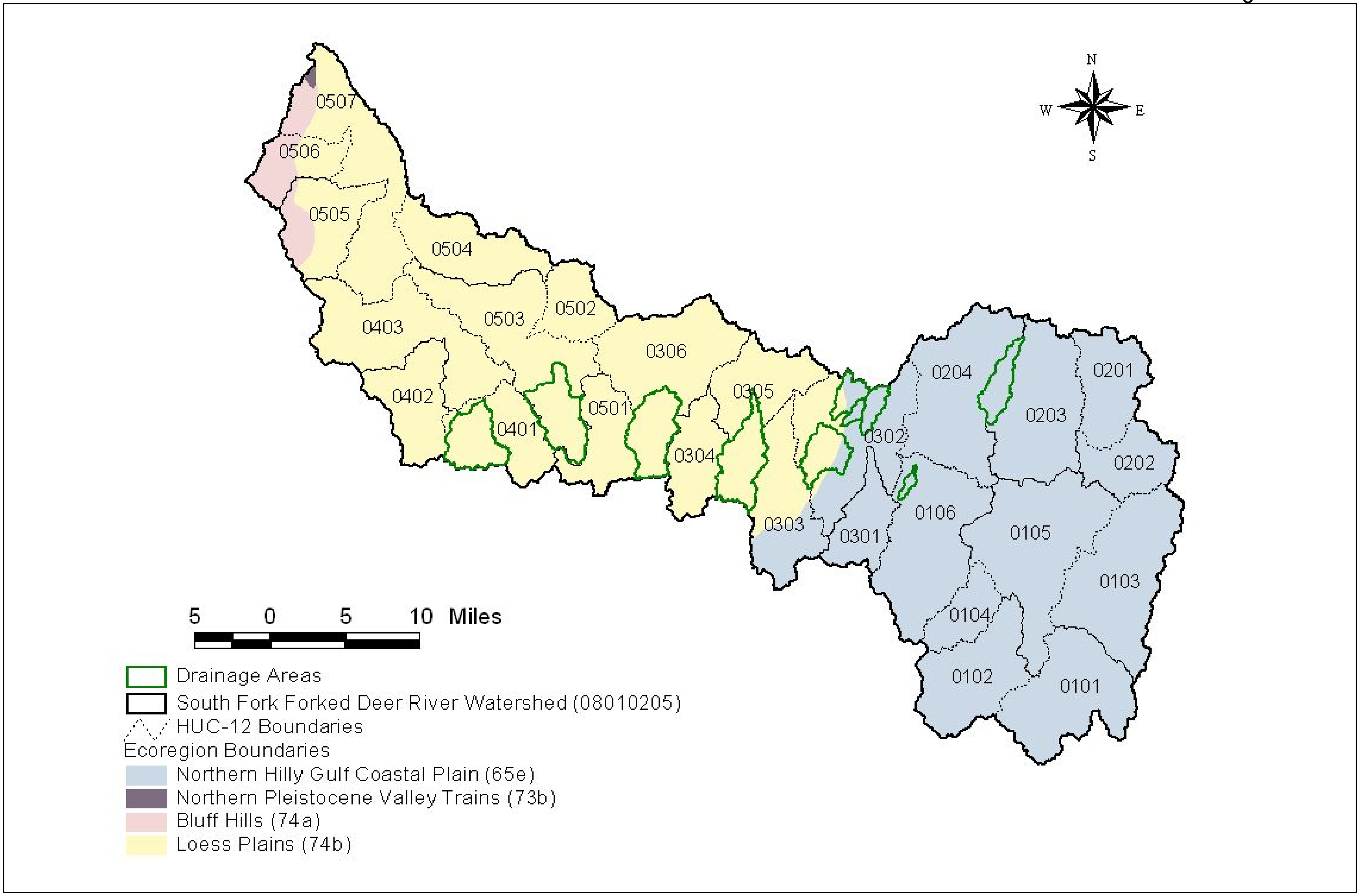

Figure 2. Level IV Ecoregions in the South Fork Forked Deer River Watershed.

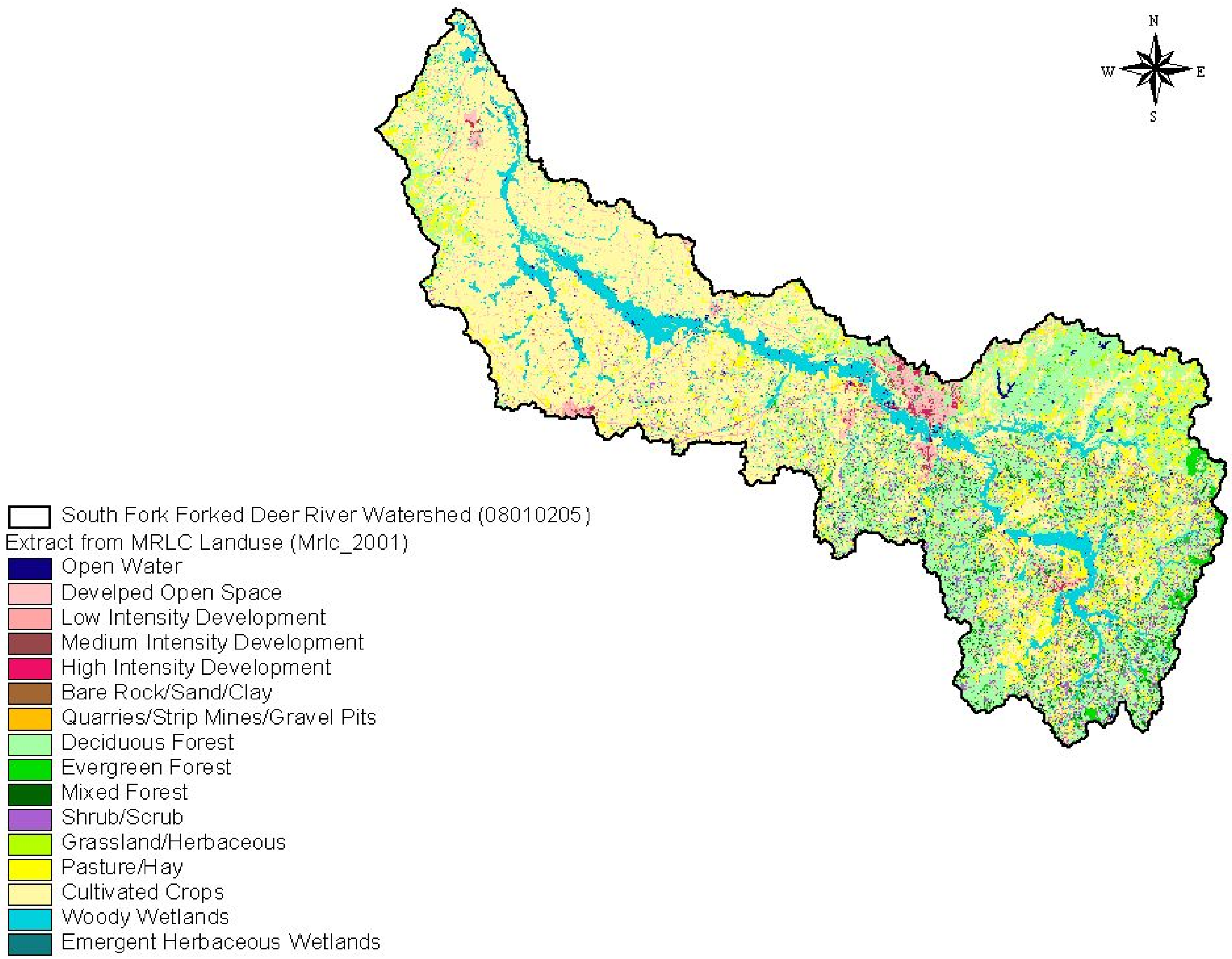

Figure 3. Land Use Characteristics of the South Fork Forked Deer River Watershed.

Table 1 2001 MRLC Land Use Distribution – South Fork Forked Deer River Watershed

Land Use	Area	
	[acres]	[%]
Unclassified	0	0.0
Open Water	4,346	0.6
Developed Open Spaces	37,824	5.6
Low Intensity Residential	9,914	1.5
Medium Intensity Residential	1,426	0.2
High Intensity Residential	3,260	0.5
Bare Rock/Sand/Clay	0	0.0
Deciduous Forest	156,051	23.0
Evergreen Forest	14,396	2.1
Mixed Forest	11,816	1.7
Shrub/Scrub	32,324	4.8
Grasslands/Herbaceous	1,969	0.3
Pasture/Hay	67,772	10.0
Row Crops	276,655	40.7
Woody Wetlands	59,826	8.8
Emergent Herbaceous Wetlands	1,426	0.2
Total	**679,074**	**100.00**

4.0 PROBLEM DEFINITION

The State of Tennessee's Final 2010 303(d) list (TDEC, 2011), http://tn.gov/environment/wpc/publications/pdf/2010_303d_final.pdf, was approved by the U.S. Environmental Protection Agency (EPA), Region IV in October of 2011. This list identified a number of waterbodies in the South Fork Forked Deer 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. Some waterbodies are also classified for navigation.

5.0 WATER QUALITY CRITERIA & TMDL TARGET

As previously stated, the designated use classifications for the South Fork Forked Deer River waterbodies include fish & aquatic life, recreation, irrigation, livestock watering & wildlife, and navigation. 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).

A portion of Anderson Branch has been classified as an Exceptional Tennessee Water because it passes through the Colonel Forrest V. Durand Wetland Area. Portions of South Fork Forked Deer River have been classified as Exceptional Tennessee Waters because it passes through Colonel Forrest V. Durand Wetland Area, Lake Lauderdale Wildlife Refuge, South Fork Waterforwl Refuge, and FMHA Privett Wetland Area. As of June 1, 2010, none of the other impaired waterbodies in the South Fork Forked Deer River Watershed have been classified as lakes, reservoirs, State Scenic Rivers, or Exceptional Tennessee Waters.

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

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

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

Table 2 Final 2010 303(d) List for E. coli Impaired Waterbodies – South Fork Forked Deer River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN08010205001 – 0200	MILL CREEK	27.2	Habitat loss due to alteration in stream-side or littoral vegetative cover Escherichia coli	Nonirrigated Crop Production Channelization Undetermined Pathogen Source
TN08010205001 – 1000	SOUTH FORK FORKED DEER RIVER (Forked Deer River to Sumrow Creek)	15.6	Loss of biological integrity due to siltation Physical Substrate Habitat Alteraions Escherichia coli	Nonirrigated Crop Production Channelization Undetermined Pathogen Source
TN08010205003 – 1000	SOUTH FORK FORKED DEER RIVER (Sumrow Creek to Nixon Creek)	6.8	Loss of biological integrity due to siltation Physical Substrate Habitat Alteraions Escherichia coli	Nonirrigated Crop Production Channelization Undetermined Pathogen Source
TN08010205005 – 0100	LITTLE NIXON CREEK	15.3	Loss of biological integrity due to siltation Physical Substrate Habitat Alteraions Escherichia coli	Channelization Discharges from MS4 area
TN08010205005 – 0200	MERIDIAN CREEK	36.29	Low Dissolved Oxygen Loss of biological integrity due to siltation Physical Substrate Habitat Alteraions **Escherichia coli (delisted)**	Nonirrigated Crop Production Channelization
TN08010205005 – 1000	NIXON CREEK	20.4	Loss of biological integrity due to siltation Phosphorus Physical Substrate Habitat Alteraions Escherichia coli	Nonirrigated Crop Production Channelization Discharges from MS4 area
TN08010205010 – 0100	KAIL CREEK	27.4	Physical Substrate Habitat Alterations Escherichia coli	Channelization Undetermined Pathogen Source
TN08010205010 – 0200	JACOBS CREEK	25.9	Physical Substrate Habitat Alterations	Nonirrigated Crop Production Channelization
TN08010205010 – 1000	SOUTH FORK FORKED DEER RIVER (Nixon Creek to Mud Creek)	13.2	Loss of biological integrity due to siltation Physical Substrate Habitat Alteraions Escherichia coli	Nonirrigated Crop Production Channelization Undetermined Pathogen Source
TN08010205011 – 1000	MUD CREEK	42.9	Physical Substrate Habitat Alterations	Channelization

Table 2 (cont'd) Final 2010 303(d) List for E. coli Impaired Waterbodies – South Fork Forked Deer River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN08010205012 – 0400	SANDY CREEK	4.3	Loss of biological integrity due to siltation Physical Substrate Habitat Alteraions Escherichia coli	Discharges from MS4 area Channelization
TN08010205012 – 0500	CENTRAL CREEK	2.0	Physical Substrate Habitat Alteraions Escherichia coli	Discharges from MS4 area Channelization
TN08010205012 – 0600	ANDERSON BRANCH	5.2	Habitat loss due to alteration in stream-side or littoral vegetative cover Escherichia coli	Collection System Failure Discharges from MS4 area
TN08010205012 – 0700	BOND CREEK	9.7	Habitat loss due to alteration in stream-side or littoral vegetative cover Escherichia coli	Discharges from MS4 area Streambank Modifications
TN08010205012 – 0900	HICKS CREEK	28.5	Loss of biological integrity due to siltation	Sand/Rock/Gravel Mining
TN08010205012 – 1000	SOUTH FORK FORKED DEER RIVER (Mud Creek to Meridian Creek)	21.6	Phosphorus Loss of biological integrity due to siltation Physical Substrate Habitat Alteraions Escherichia coli	Discharges from MS4 area Nonirrigated Crop Production Dredge Mining Sand/Rock/Gravel Mining Land Development Channelization
TN08010205012 – 1200	CUB CREEK	2.07	Habitat loss due to alteration in stream-side or littoral vegetative cover Loss of biological integrity due to siltation Escherichia coli	Animal Feeding Operations (NPS) Pasture Grazing Channelization
TN08010205012 – 1400	PANTHER CREEK	21.1	Escherichia coli	Package Plant Pasture Grazing
TN08010205031 – 1000	BLACK CREEK	12.9	Nutrient Biological Indicators Low Dissolved Oxygen Physical Substrate Habitat Alterations Loss of biological integrity due to siltation Escherichia coli	Pasture Grazing Nonirrigated Crop Production Channelization

Table 2 (cont'd) Final 2010 303(d) List for E. coli Impaired Waterbodies – South Fork Forked Deer River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN08010205036 – 0110	UNNAMED TRIB TO TISDALE CREEK	2.89	Habitat loss due to alteration in stream-side or littoral vegetative cover Loss of biological integrity due to siltation Physical Substrate Habitat Alterations Escherichia coli	Nonirrigated Crop Production Channelization Undetermined Pathogen Source
TN08010205036 – 1000	HALLS CREEK	15.77	Phosphorus Habitat loss due to alteration in stream-side or littoral vegetative cover Physical Substrate Habitat Alterations Excherichia coli	Nonirrigated Crop Production Channelization Undetermined Pathogen Source

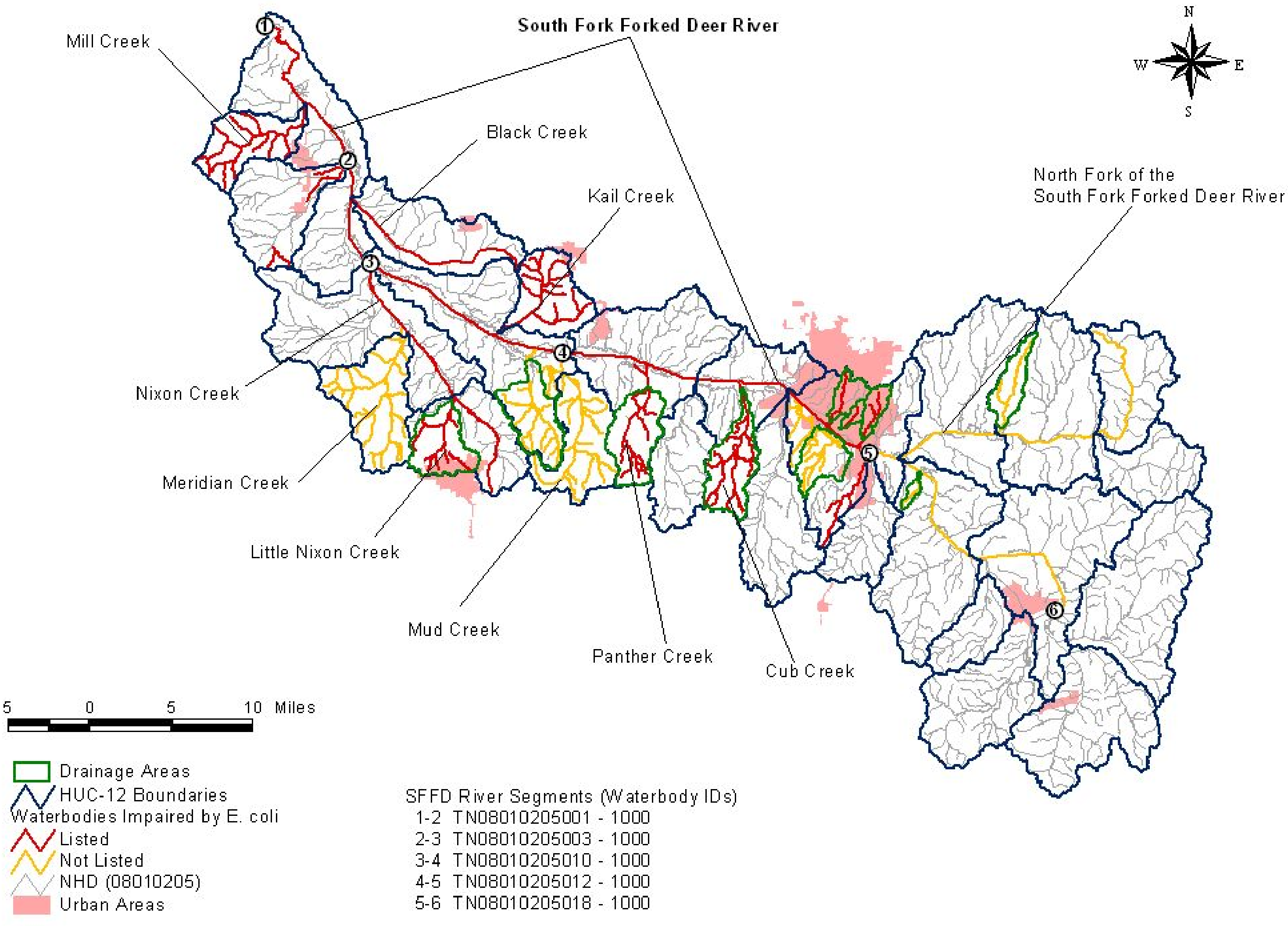

Figure 4. Waterbodies Impaired by E. Coli (as Documented on the Final 2010 303(d) List).

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 South Fork Forked Deer River Watershed:

- HUC-12 08010205_0106:
  - *SFFDE065.6MN – South Fork Forked Deer River, at Ozier Rd. (Hwy 197) in Pinson*
  - SFFDE1T0.7MN – Unnamed Trib to South Fork Forked Deer River, u/s of Perry Switch Road
- HUC-12 08010205_0203:
  - BEAR005.7MN – Bear Creek, unnamed road off Fowler Rd.
- HUC-12 08010205_0204:
  - NFSFF001.4MN – North Fork of the South Fork Forked Deer River, at Miflin Rd.
- HUC-12 08010205_0302:
  - *ANDER000.5MN – Anderson Branch, at Jackson Fairgrounds*
  - BOND001.0MN – Bond Creek, at Perry Switch Road
  - CENTR000.4MN – Central Creek, at State Street
  - HICKS000.9MN – Hicks Creek, u/s of Westover Rd.
  - SANDY000.5MN – Sandy Creek, at Airways Blvd. (Hwy 70)
  - *SFFDE052.7MN – South Fork Forked Deer River, at Westover Road*
- HUC-12 08010205_0305:
  - CUB001.6MN – Cub Creek, at Lower Brownsville Road
- HUC-12 08010205_0306:
  - PANTH001.9MN – Panther Creek, at Lower Brownsville Road
  - *SFFDE036.7HY – South Fork Forked Deer River, at Hwy 79*
  - *SFFDE043.2MN – South Fork Forked Deer River, at Roberts Station Road*
- HUC-12 08010205_0401:
  - LNIXO002.9HY – Little Nixon Creek, at Allen King Road
- HUC-12 08010205_0402:
  - MERID001.7HY – Meridian Creek, at Thomas Road
- HUC-12 08010205_0403:
  - NIXON002.2HY – Nixon Creek, at Rudolph Road
- HUC-12 08010205_0501:
  - MUD001.3HY – Mud Creek, at Hwy 79

- HUC-12 08010205_0502:
  - KAIL001.9HY – Kail Creek, at Cherryville Rd.
- HUC-12 08010205_0503:
  - JACOB004.1HY – Jacobs Creek, at Hwy 79
  - *SFFDE030.4HY/030.6HY – South Fork Forked Deer River, at Hwy 54*
- HUC-12 08010205_0504:
  - BLACK001.6CK – Black Creek, at Spence Road
- HUC-12 08010205_0505:
  - HALLS001.2LE – Halls Creek, at Espy Park Road
  - TISDA1T1.2LE – Unnamed Trib to Tisdale Creek, off John White Rd., 300 yds d/s of Curve-Concord Rd.
- HUC-12 08010205_0506:
  - MILL001.5LE – Mill Creek, at Poplar Grove Rd
- HUC-12 08010205_0507:
  - *SFFDE011.2DY – South Fork Forked Deer River, at Hwy 210*
  - SFFDE019.1LE – South Fork Forked Deer River, Hwy 88 bridge crossing, about 3.5 mi S-SW of Chestnut Bluff, TN

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.

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
ANDER000.5MN	*2001 – 2007*	*16*	*9.7*	*754*	*7,701*	*3*
BEAR005.7MN	2005 – 2006	4	25.3	373	1,000	1
BLACK001.6CK	2001 – 2007	14	32.7	1,097	4,106	6
BOND001.0MN	2001 – 2007	20	48.8	964	4,611	8
CENTR000.4MN	2001 – 2007	14	11	797	2,419.2	4
CUB001.6MN	2001 – 2007	17	9.7	1,542	64,880	3
HALLS001.2LE	2001 – 2007	20	7.3	1,288	17,329	4

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

Monitoring Station	Date Range	E. Coli (Max WQ Target = 941 CFU/100 mL)**				
		Data Pts.	Min. [CFU/100 ml]	Avg. [CFU/100 ml]	Max. [CFU/100 ml]	No. Exceed. WQ Max. Target
HICKS000.9MN	2006 – 2007	4	22	6,778	24,000	2
JACOB004.1HY	2001 – 2007	31	1	674	14,000	3
KAIL001.9HY	2006 – 2007	26	11	749	8,700	5
LNIXO002.9HY	2001 – 2007	15	5.2	1,954	19,863	4
MERID001.7HY	2001 – 2007	38	1	656	19,863	3
MILL001.5LE	2006 – 2007	26	21	1,280	24,000	3
MUD001.3HY	2001 – 2007	16	13.2	480	2,419.2	2
NFSFF001.4MN	2001 – 2007	27	48	229	2,400	1
NIXON002.2HY	2001 – 2007	14	19.3	647	3,654	3
PANTH001.9MN	2001 – 2007	29	4.1	560	4,600	4
SANDY000.5MN	2001 – 2007	11	1	924	6,867	2
SFFDE011.2DY	*2001 – 2007*	*13*	*19.9*	*434*	*1,700*	*3*
SFFDE019.1LE	2006 – 2007	3	39	508	1,400	1
SFFDE030.4HY	*2000 – 2001*	*11*	*31.7*	*212*	*980*	*1*
SFFDE030.6HY	*2001 – 2009*	*45*	*9.7*	*688*	*8,164*	*12*
SFFDE036.7HY	*2001 – 2002*	*12*	*23.8*	*334*	*2,419.2*	*1*
SFFDE043.2MN	*2001 – 2007*	*16*	*52.1*	*336*	*1,000*	*4*
SFFDE052.7MN	*2001 – 2002*	*12*	*34.1*	*483*	*2,419.2*	*2*
SFFDE065.6MN	*2001 – 2007*	*16*	*0*	*263*	*2,400*	*2*
SFFDE1T0.7MN	2007	5	28	390	1,413	1
TISDA1T1.2LE	2007	5	556	5,115	12,997	4

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

Several of the water quality monitoring stations (Table 3 and Appendix B) have at least one E. coli sample value reported as >2419. For the purpose of calculating summary data statistics, TMDLs, Waste Load Allocations (WLAs), and Load Allocations (LAs), these data values are treated as (equal to) 2419. Therefore, the calculated results are considered to be estimates. Future E. coli sample analyses at these sites should follow established protocol. See Section 9.4.

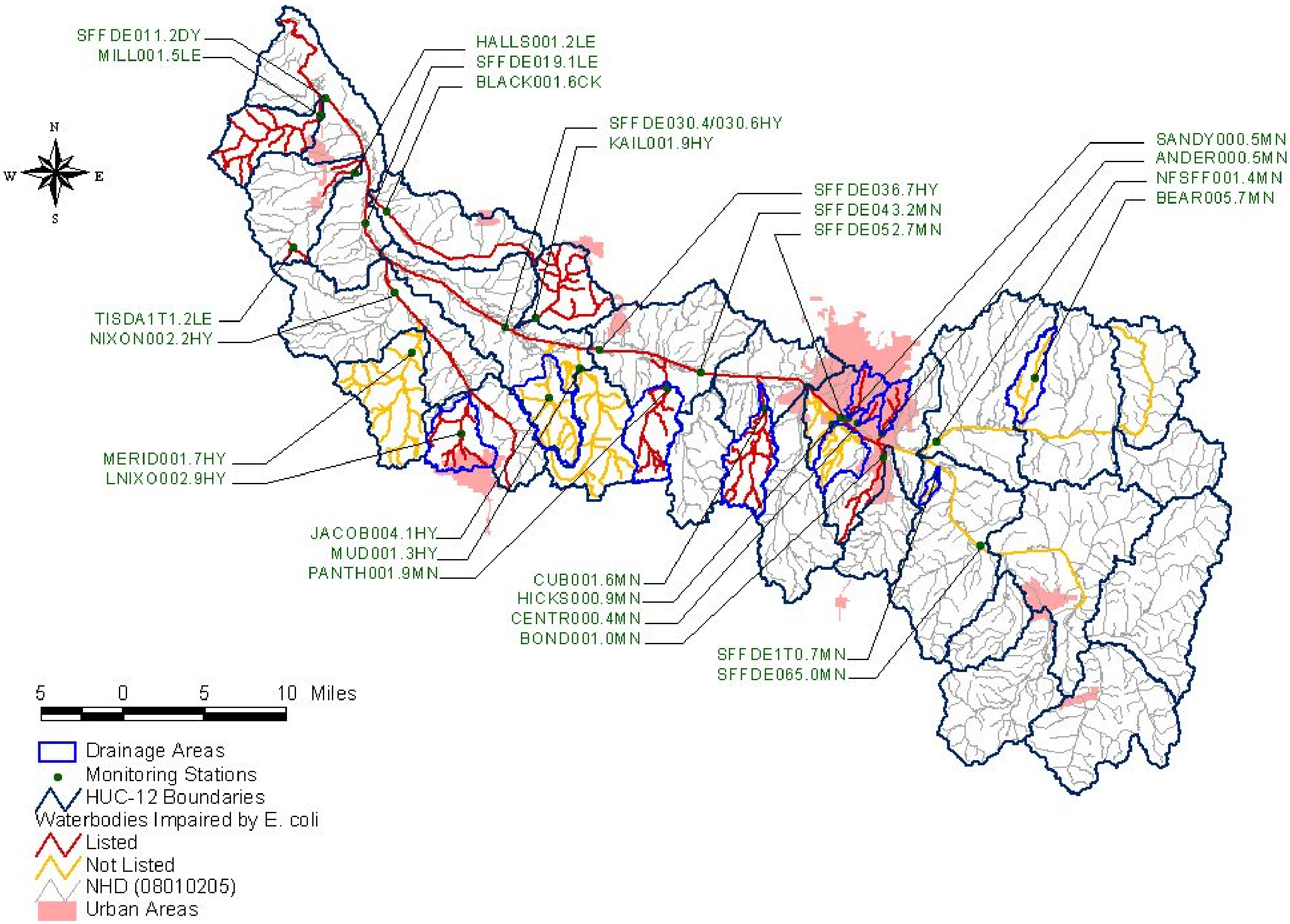

Figure 5. Water Quality Monitoring Stations in the South Fork Forked Deer River Watershed

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 South Fork Forked Deer River Watershed that have NPDES permits authorizing the discharge of treated sanitary wastewater. Fifteen of these facilities are located in or near impaired subwatersheds or drainage areas. (see Figure 6 and Table 4). Four of the facilities are sewage treatment plants (STPs) serving municipalities and are major facilities with design capacities equal to or greater than 1.0 million gallons per day (MGD). 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
TN0022519	Denmark TravelCenter	0.014	Panther Creek @RM6.9
TN0023230	Old South Inn	0.02	Unnamed Trib to Panther Creek @RM6.9
TN0023311	West Middle High School	0.0125	Unnamed Trib to Johnson Creek @RM5.3
TN0023272	Beech Bluff Elementary School	0.005	Unnamed Trib to North Fork of SFFD @RM8.1
TN0024813	Jackson Energy Authority – Miller Avenue STP	17.4	SFFD River @RM50.8 & RM51.1
TN0026026	Henderson STP – East Lagoon	0.2	SFFD River @RM73.2
TN0026247	Bells Lagoon	2.75	Old Channel SFFD River to SFFD River @RM36
TN0056472	Denmark School	0.016	Cub Creek @RM7.8
TN0057291	Halls Lagoon	1.0	SFFD River @RM10.8
TN0060151	Bells Truck Stop	0.01148	Wet weather conveyance to Cane Creek @RM2.2
TN0064220	Henderson STP – North Lagoon	0.47	SFFD River @RM67.3
TN0064238	Henderson STP – South Lagoon	0.6	SFFD River @RM74.9
TN0065218	Maury City Wastewater Lagoon	0.15	SFFD River @RM27.1
TN0067083	Pinson Lagoon – Jackson Energy Authority	0.04	SFFD River @RM65.7
TN0075078	Brownsville Energy Authority Lagoon	2.28	SFFD River @RM30.6

7.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

Municipal Separate Storm Sewer Systems (MS4s) are considered to be point sources of E. coli. Discharges from MS4s occur in response to storm events through road drainage systems, curb and gutter systems, ditches, and storm drains. Phase I of the EPA storm water program (http://cfpub.epa.gov/npdes/stormwater/swphases.cfm#phase1) requires large and medium MS4s to obtain NPDES storm water permits. Large and medium MS4s are those located in incorporated places or counties serving populations greater than 100,000 people. At present, there are no MS4s of this size in the South Fork Forked Deer 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 Jackson and Brownsville, and Madison County 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. The TDOT MS4 will not be considered a potential source because: (1) The area covered by the permit is less than 0.1% of the total drainage area of the watershed; (2) Sampling of stormwater runoff from state highways indicates negligible contribution of E. coli; and (3) An extensive study conducted by California Dept. of Transportation (Caltrans) concluded that highway facilities, including maintenance stations, do not appear to be a significant source of pathogens in urban drainage. (For more detail, see Appendix G.)

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 a permit. Most CAFOs in Tennessee obtain coverage under SOPC00000 or SOPCD0000, *General State Operating Permit for Concentrated Animal Feeding Operations* (http://tn.gov/environment/wpc/pdf/sopc00000pmt.pdf or http://tn.gov/environment/wpc/pdf/sopcd0000pmt.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 CAFOs with coverage under the general SOP permit located in the South Fork Forked Deer River Watershed.

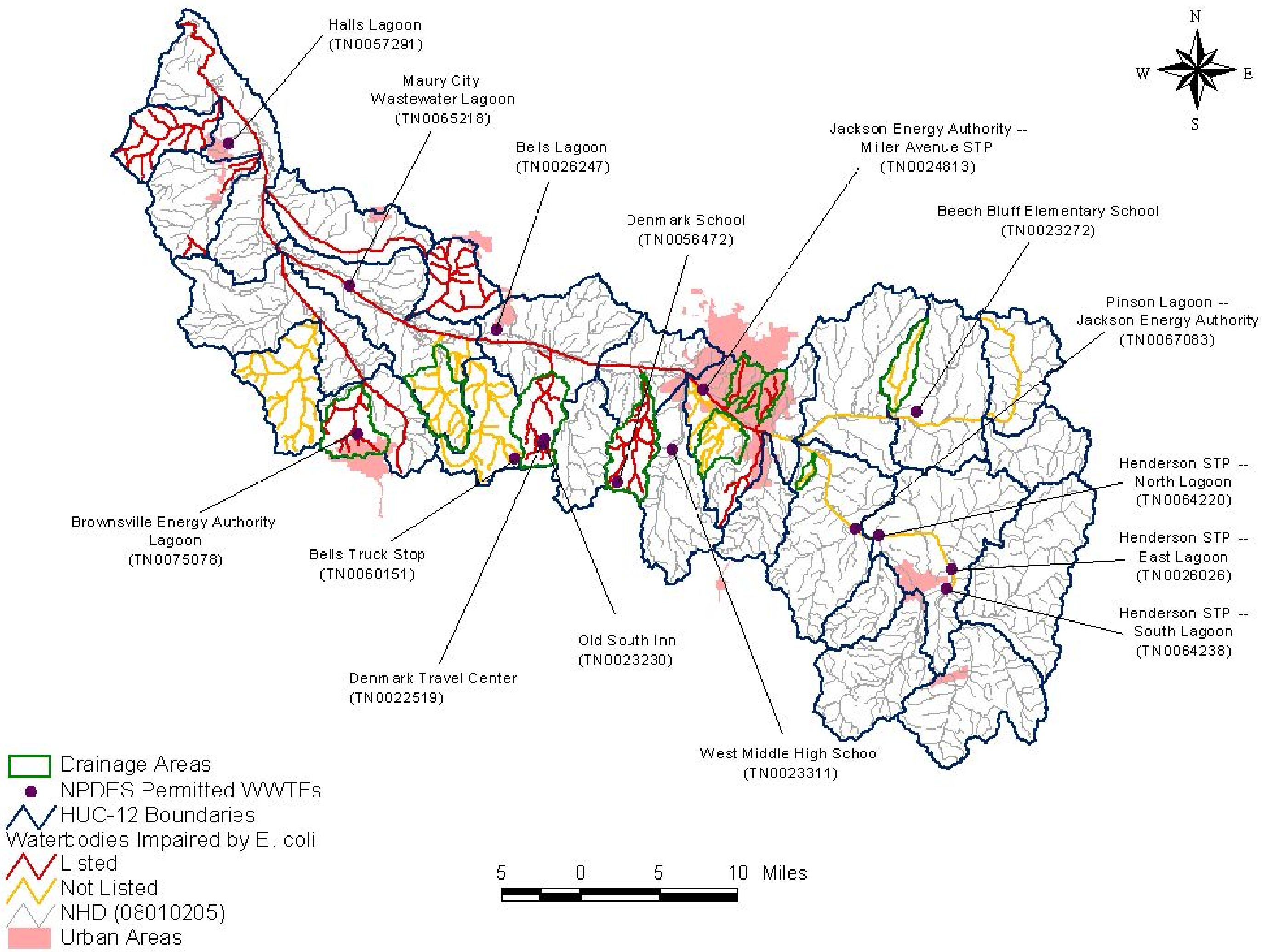

Figure 6. NPDES Regulated Point Sources in and near Impaired Subwatersheds and Drainage Areas of the South Fork Forked Deer River Watershed.

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 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 South Fork Forked Deer 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).

7.2.3 Failing Septic Systems

Some of the coliform loading in the South Fork Forked Deer 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 South Fork Forked Deer 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 5 Livestock Distribution in the South Fork Forked Deer River Watershed

County	Livestock Population (2007 Census of Agriculture)							
	Beef Cow	Milk Cow	Poultry		Hogs	Sheep	Goats	Horse
			Layers	Broilers				
Crockett	4,044	0	182	0	(D)	227	871	610
Dyer	5,947	0	881	200	484	180	374	853
Haywood	3,045	0	1,146	0	424	(D)	139	606
Lauderdale	(D)	(D)	239	0	93	122	513	758
Madison	(D)	(D)	259	0	(D)	19	643	1,076

* 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).

Table 6 Estimated Population on Septic Systems in the South Fork Forked Deer River Watershed

County	Total Population (2000 Census)	Total Population (1990 Census)	% of Population on Septic Systems (1990 Census)
Crockett	14,532	13,378	26.2
Dyer	37,279	34,854	35.1
Haywood	19,797	19,437	41.7
Lauderdale	27,101	23,491	25.5
Madison	91,837	77,982	26.8

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 South Fork Forked Deer River Watershed ranges from 2% to 95%. Land use for the South Fork Forked Deer River drainage areas is summarized in Figures 7a, 7b, 8a, 8b, 9a, and 9b, and tabulated in Appendix A.

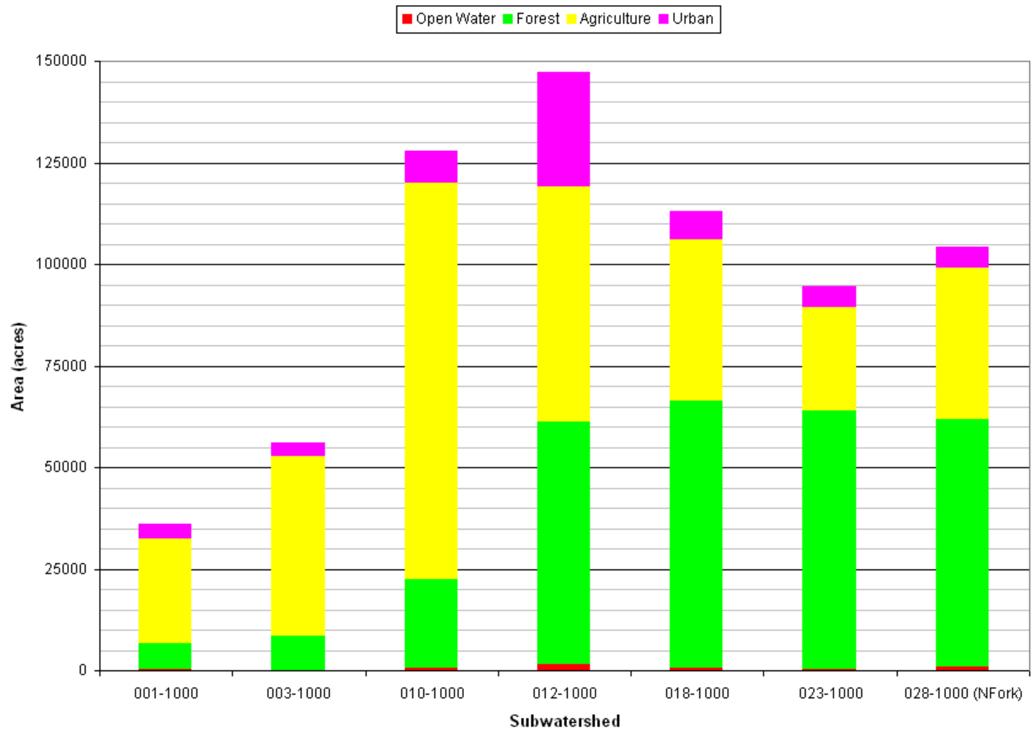

Figure 7a. Land Use Area of South Fork Forked Deer River Segments

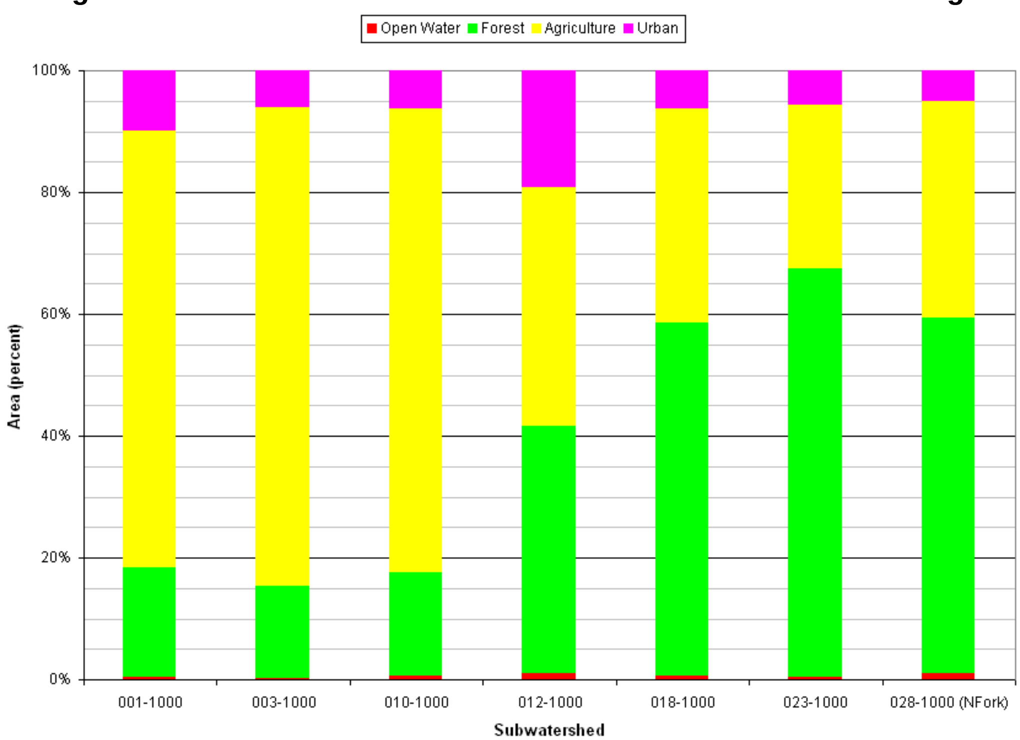

Figure 7b. Land Use Percent of the South Fork Forked Deer River Segments

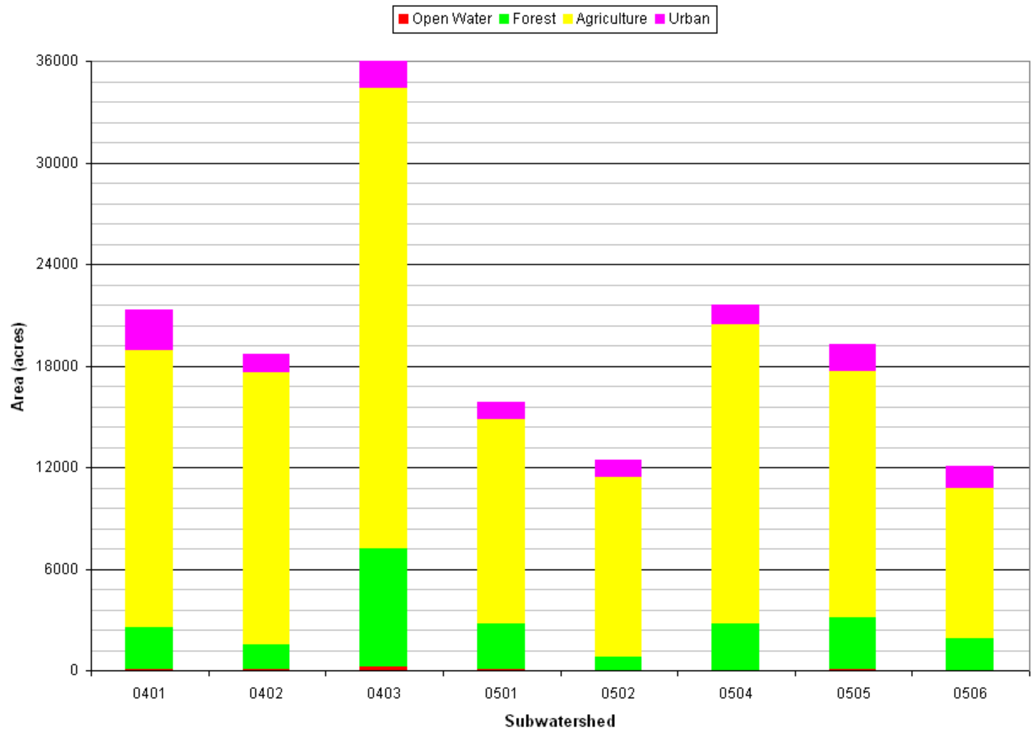

Figure 8a. Land Use Area of South Fork Forked Deer River E. coli-Impaired HUC-12s

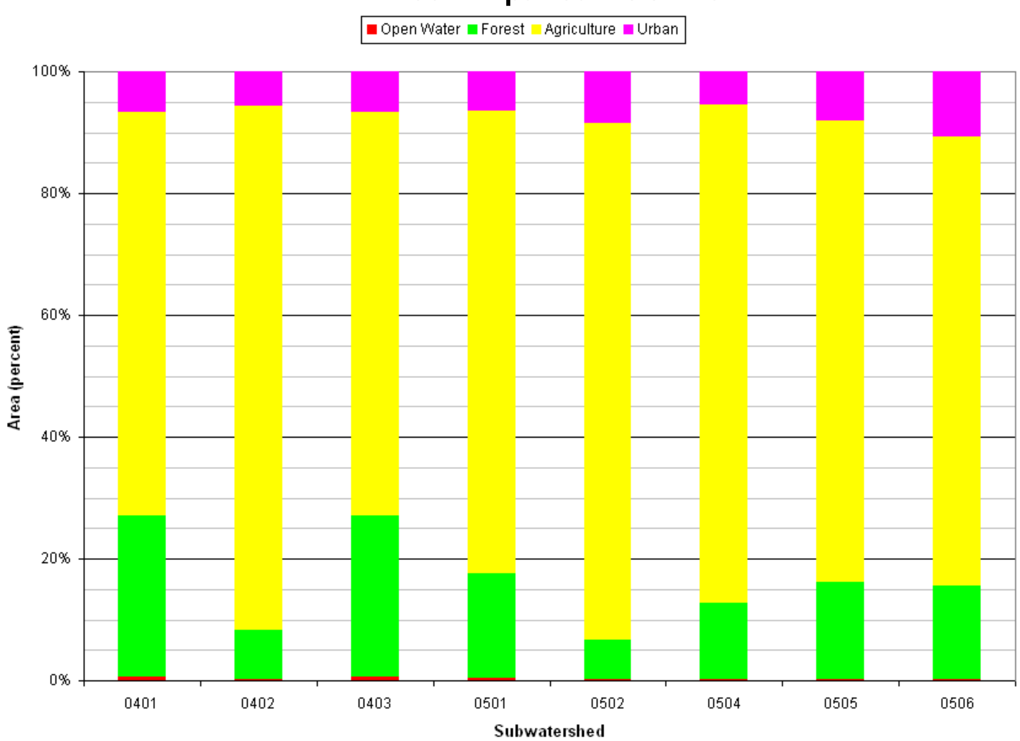

Figure 8b. Land Use Percent of the South Fork Forked Deer River E. coli-Impaired HUC-12s

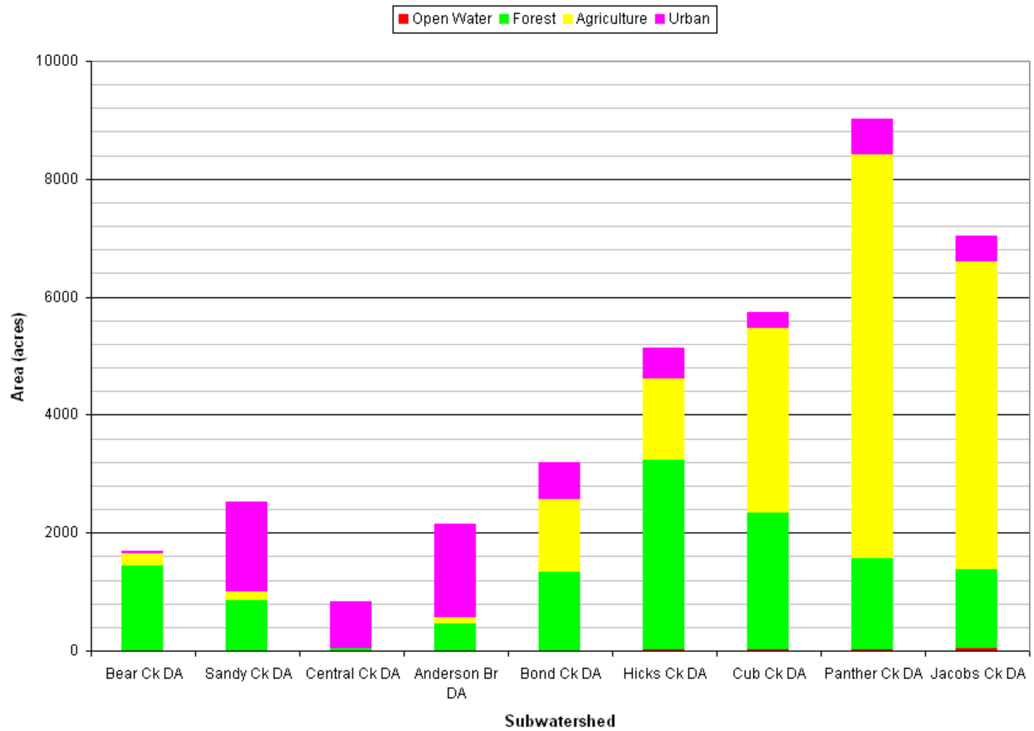

Figure 9a. Land Use Area of South Fork Forked Deer River E. coli-Impaired Drainage Areas

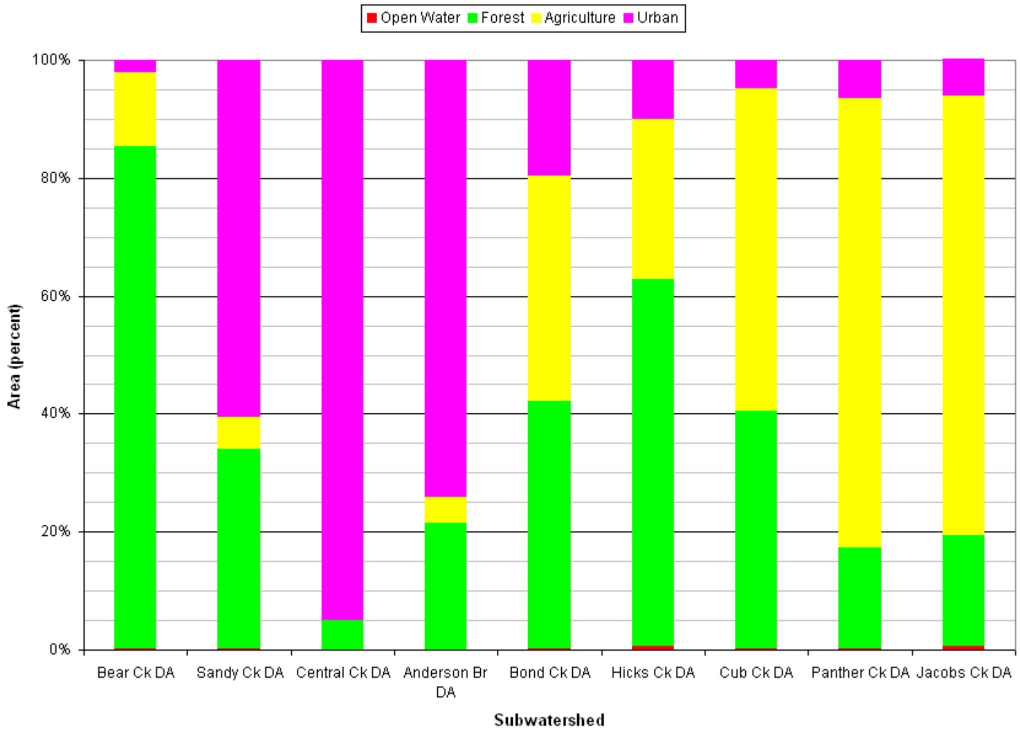

Figure 9b. Land Use Percent of the South Fork Forked Deer River E. coli-Impaired Drainage Areas

8.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOADS

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

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

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

This document describes TMDL, Waste Load Allocation (WLA), Load Allocation (LA), and Margin of Safety (MOS) development for waterbodies identified as impaired due to E. coli on the Final 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 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 South Fork Forked Deer River Watershed, most TMDLs were developed on a HUC-12 basis.

8.3 TMDL Analysis Methodology

TMDLs for the South Fork Forked Deer 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 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 South Fork Forked Deer 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 South Fork Forked Deer 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 South Fork Forked Deer 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 South Fork Forked Deer River Watershed (HUC 08010205)

HUC-12 Subwatershed (08010205__) 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]
0105	South Fork Forked Deer River	TN08010205018 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.666×10^{10}	0	$(7.129 \times 10^{4} \times Q) - (3.080 \times 10^{5})$	$(7.129 \times 10^{4} \times Q) - (3.080 \times 10^{5})$
0106	South Fork Forked Deer River	TN08010205018 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.666×10^{10}	0	$(7.129 \times 10^{4} \times Q) - (3.080 \times 10^{5})$	$(7.129 \times 10^{4} \times Q) - (3.080 \times 10^{5})$
	UT to South Fork Forked Deer River	TN08010205018 – 1200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.044 \times 10^{7} \times Q$	$3.044 \times 10^{7} \times Q$
0203	Bear Creek	TN08010205028 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$4.661 \times 10^{6} \times Q$	$4.661 \times 10^{6} \times Q$
	North Fork of South Fork Forked Deer River	TN08010205028 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.781×10^{8}	0	$(1.992 \times 10^{5} \times Q) - (1.713 \times 10^{3})$	$(1.992 \times 10^{5} \times Q) - (1.713 \times 10^{3})$
0204	North Fork of South Fork Forked Deer River	TN08010205028 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.781×10^{8}	0	$(1.992 \times 10^{5} \times Q) - (1.713 \times 10^{3})$	$(1.992 \times 10^{5} \times Q) - (1.713 \times 10^{3})$
0302	Sandy Creek	TN08010205012 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$8.208 \times 10^{6} \times Q$	$8.208 \times 10^{6} \times Q$
	Central Creek	TN08010205012 – 0500	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.490 \times 10^{7} \times Q$	$2.490 \times 10^{7} \times Q$
	Anderson Branch	TN08010205012 – 0600	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	NA	$5.032 \times 10^{6} \times Q$	$5.032 \times 10^{6} \times Q$
	Bond Creek	TN08010205002 – 0700	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$6.499 \times 10^{6} \times Q$	$6.499 \times 10^{6} \times Q$
	Hicks Creek	TN08010205012 – 0900	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$4.032 \times 10^{6} \times Q$	$4.032 \times 10^{6} \times Q$
	South Fork Forked Deer River	TN08010205012 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.684×10^{10}	0	$(3.326 \times 10^{4} \times Q) - (1.442 \times 10^{5})$	$(3.326 \times 10^{4} \times Q) - (1.442 \times 10^{5})$
0305	Cub Creek	TN08010205012 – 1200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	5.699×10^{8}	0	$(3.605 \times 10^{6} \times Q) - (9.923 \times 10^{4})$	$(3.605 \times 10^{6} \times Q) - (9.923 \times 10^{4})$
	South Fork Forked Deer River	TN08010205012 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.684×10^{10}	0	$(3.326 \times 10^{4} \times Q) - (1.442 \times 10^{5})$	$(3.326 \times 10^{4} \times Q) - (1.442 \times 10^{5})$
0306	Panther Creek	TN08010205012 – 1400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.211×10^{9}	0	$(2.298 \times 10^{6} \times Q) - (1.344 \times 10^{5})$	$(2.298 \times 10^{6} \times Q) - (1.344 \times 10^{5})$
	South Fork Forked Deer River	TN08010205012 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.684×10^{10}	0	$(2.707 \times 10^{4} \times Q) - (1.178 \times 10^{5})$	$(2.707 \times 10^{4} \times Q) - (1.178 \times 10^{5})$

Table 7 (cont'd). TMDLs, WLAs, & LAs for Impaired Waterbodies in the South Fork Forked Deer River Watershed (HUC 08010205)

HUC-12 Subwatershed (08010205__) 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]
0401	Little Nixon Creek	TN08010205005 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.593 \times 10^{6} \times Q$	$2.593 \times 10^{6} \times Q$
	Nixon Creek	TN08010205005 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.727 \times 10^{5} \times Q$	$2.727 \times 10^{5} \times Q$
0402	Meridian Creek	TN08010205005 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$5.416 \times 10^{6} \times Q$
0403	Nixon Creek	TN08010205005 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.727 \times 10^{5} \times Q$	$2.727 \times 10^{5} \times Q$
0501	Mud Creek	TN08010205011 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.089×10^{8}	0	$(1.350 \times 10^{6} \times Q) - (2.666 \times 10^{4})$	$(1.350 \times 10^{6} \times Q) - (2.666 \times 10^{4})$
0502	Kail Creek	TN08010205010 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.757 \times 10^{6} \times Q$	$1.757 \times 10^{6} \times Q$
0503	Jacobs Creek	TN08010205010 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.248 \times 10^{6} \times Q$	$2.248 \times 10^{6} \times Q$
	South Fork Forked Deer River	TN08010205010 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	7.672×10^{11}	0	$(2.203 \times 10^{4} \times Q) - (1.565 \times 10^{6})$	$(2.203 \times 10^{4} \times Q) - (1.565 \times 10^{6})$
0504	Black Creek	TN08010205031 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.113 \times 10^{6} \times Q$	$1.113 \times 10^{6} \times Q$
0505	UT to Tisdale Creek	TN08010205036 – 0110	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.986 \times 10^{7} \times Q$	$3.986 \times 10^{7} \times Q$
	Halls Creek	TN08010205036 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.223 \times 10^{6} \times Q$	$1.223 \times 10^{6} \times Q$
0506	Mill Creek	TN08010205001 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.817 \times 10^{6} \times Q$	$1.817 \times 10^{6} \times Q$
0507	South Fork Forked Deer River	TN08010205001 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	8.893×10^{11}	0	$(1.663 \times 10^{4} \times Q) - (1.370 \times 10^{6})$	$(1.663 \times 10^{4} \times Q) - (1.370 \times 10^{6})$
	South Fork Forked Deer River	TN08010205003 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	8.573×10^{11}	0	$(3.492 \times 10^{4} \times Q) - (1.440 \times 10^{6})$	$(3.492 \times 10^{4} \times Q) - (1.440 \times 10^{6})$

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 South Fork Forked Deer 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.

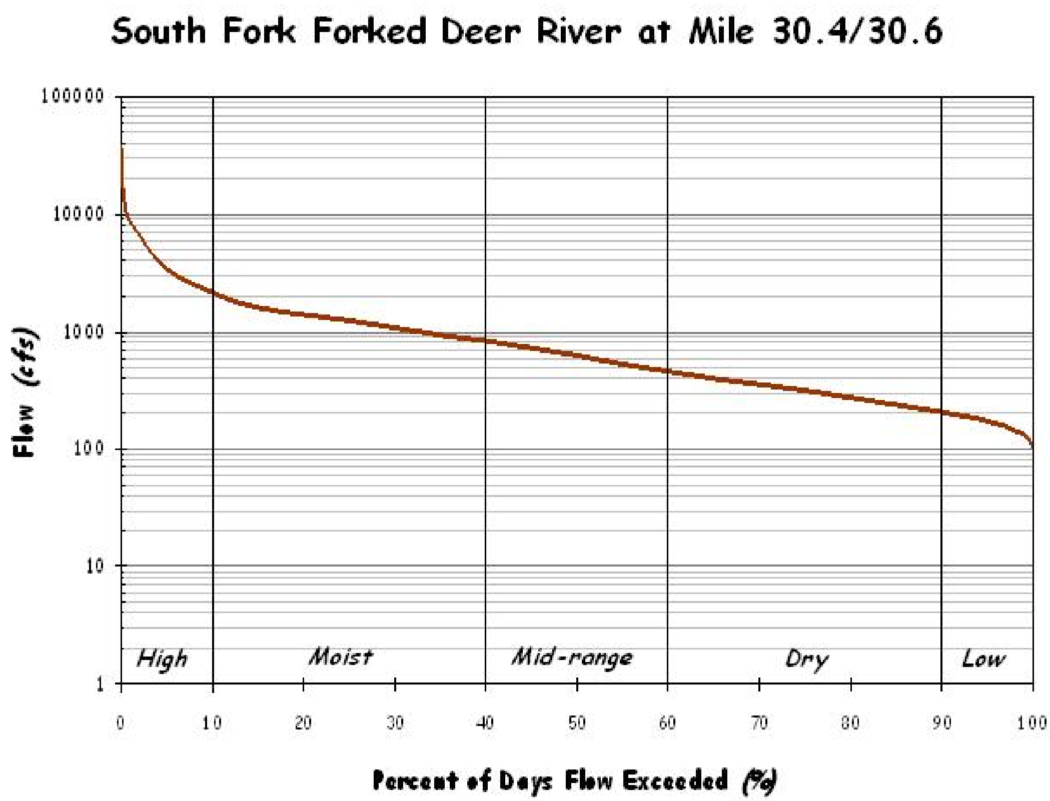

Figure 10. Five-Zone Flow Duration Curve for South Fork Forked Deer River at RM 30.4/30.6

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 Permit No. SOPC00000 or SOPCD0000, General State Operating Permit for *Concentrated Animal Feeding Operations* or the facility's individual permit. Provisions of the state operating 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 South Fork Forked Deer 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 South Fork Forked Deer 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 South Fork Forked Deer 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.

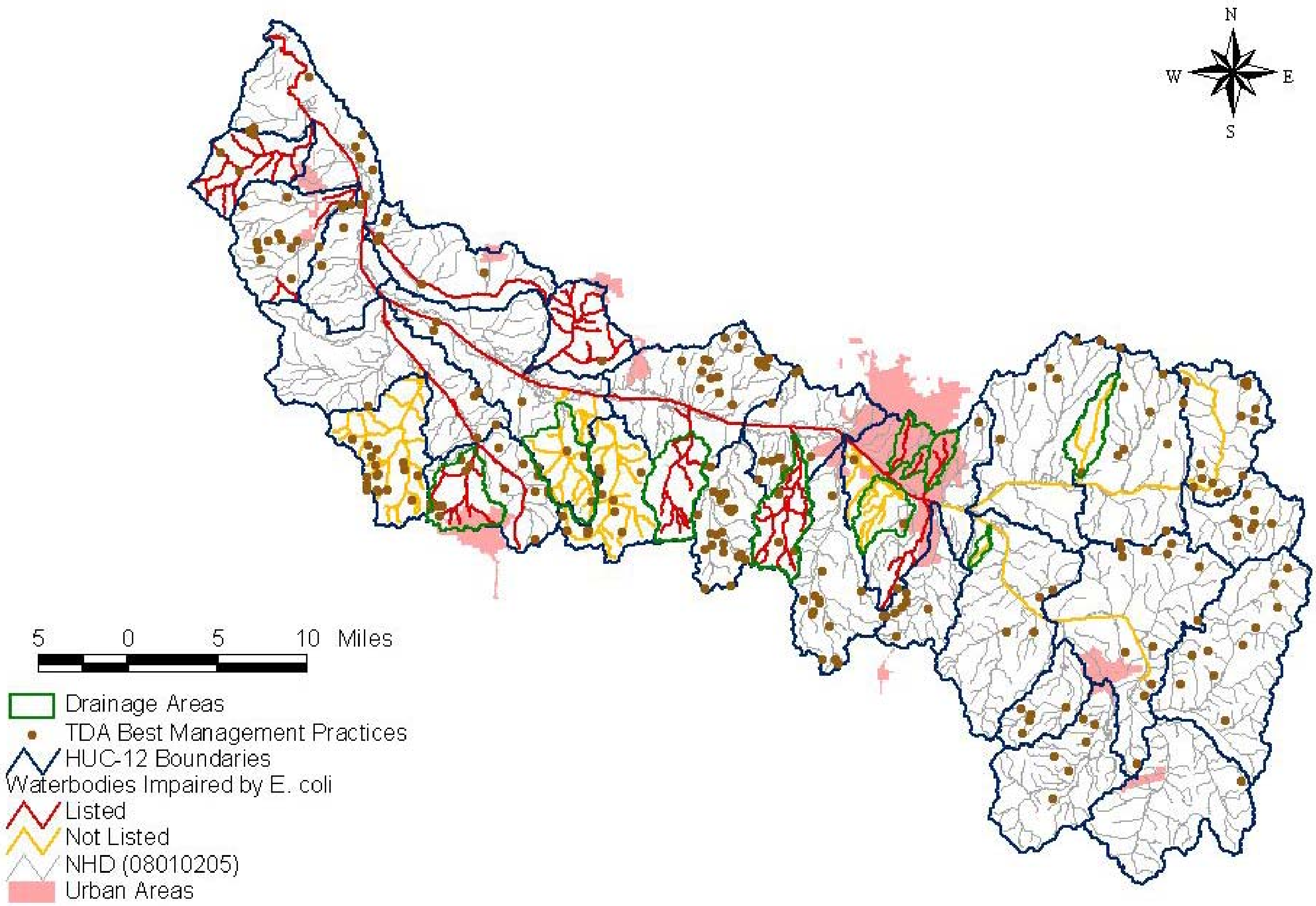

Figure 11. NRCS Best Management Practices located in the South Fork Forked Deer River Watershed.

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

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 South Fork Forked Deer River Watershed:

Verify the assessment status of stream reaches identified on the 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 South Fork Forked Deer 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, 2007), is encouraged. Finally, for individual monitoring locations, where historical E. coli data are greater than 1000 colonies/100 mL (or future samples are anticipated to be), a 1:100 dilution should be performed as described in Protocol A of the *Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2004).

9.4.2 Source Identification

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

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

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

A multi-disciplinary group of researchers at the University of Tennessee, Knoxville (UTK) has developed and tested a series of different microbial assay methods based on real-time PCR to detect fecal bacterial concentrations and host sources in water samples (Layton, 2006). The assays have been used in a study of fecal contamination and have proven useful in identification of areas where cattle represent a significant fecal input and in development of BMPs. It is expected that these types of assays could have broad applications in monitoring fecal impacts from Animal Feeding Operations, as well as from wildlife and human sources. Additional information can be found on the following UTK website: http://web.utk.edu/~hydro/JournalPapers/Layton06AEM.pdf .

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

9.5 Source Area Implementation Strategy

Implementation strategies are organized according to the dominant landuse type and the sources associated with each (Table 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 South Fork Forked Deer River Watershed are summarized in Table E-41.

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

HUC-12 / Waterbody Name	Source Area Type*			
	Urban	Agricultural	Mixed	Forested
South Fork Forked Deer River (018-1000)		Ò		
UT to South Fork Forked Deer River			Ò	
Bear Creek			Ò	
0200s (North Fork of South Fork Forked Deer River)		Ò		
Sandy Creek	Ò			
Central Creek	Ò			
Anderson Branch	Ò			
Bond Creek			Ò	
Hicks Creek			Ò	
South Fork Forked Deer River (012-1000)			Ò	
Cub Creek		Ò		
Panther Creek		Ò		
0401 (Little Nixon Creek)		Ò		
0402 (Meridian Creek)		Ò		
Nixon Creek		Ò		
0501 (Mud Creek)		Ò		
0502 (Kail Creek)		Ò		
Jacobs Creek		Ò		
South Fork Forked Deer River (010-1000)		Ò		
0504 (Black Creek)		Ò		
UT to Tisdale Creek		Ò		
0505 (Halls Creek)		Ò		
0506 (Mill Creek)		Ò		
South Fork Forked Deer River (001-1000)		Ò		
South Fork Forked Deer River (003-1000)		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
Storm water infiltration/retention					
Infiltration basin		L	M	H	
Infiltration trench		L	M	H	
Infiltration/Biofilter swale		L	M	H	
Storm Water detention					
Created wetland		H	M	L	

Table 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**
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 South Fork Forked Deer 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.

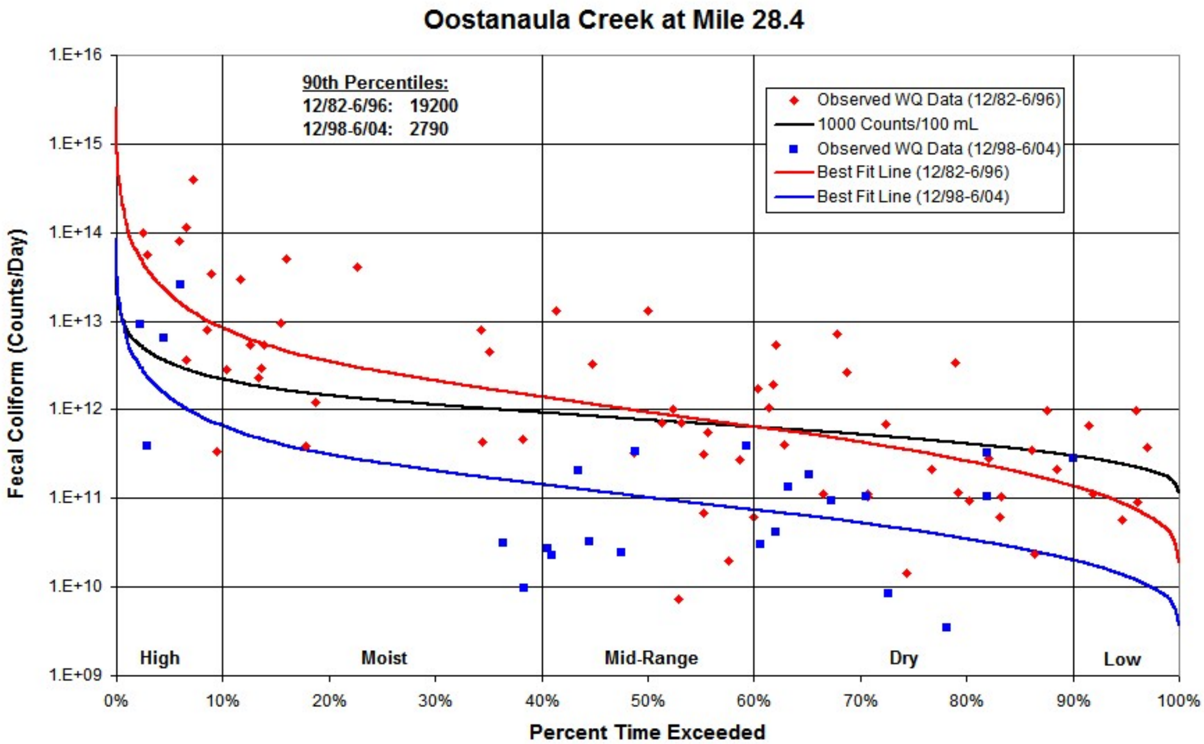

Figure 12. Oostanaula Creek TMDL implementation effectiveness (LDC regression analysis).

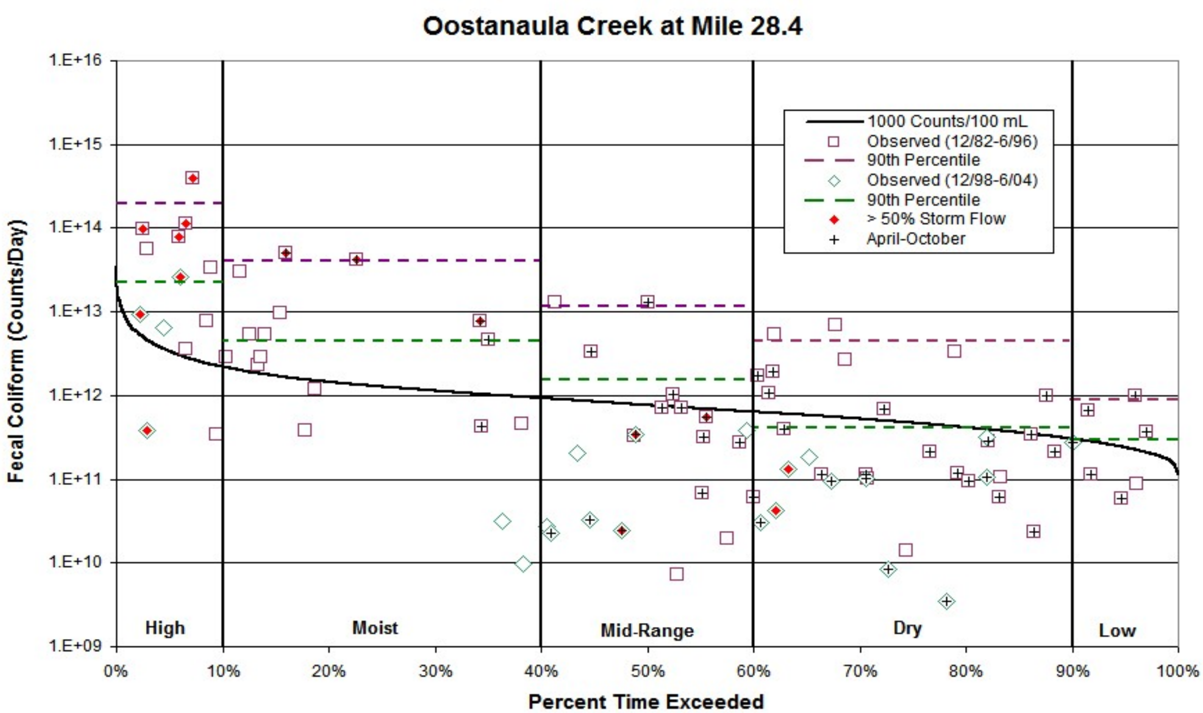

Figure 13. Oostanaula Creek TMDL implementation effectiveness (LDC analysis).

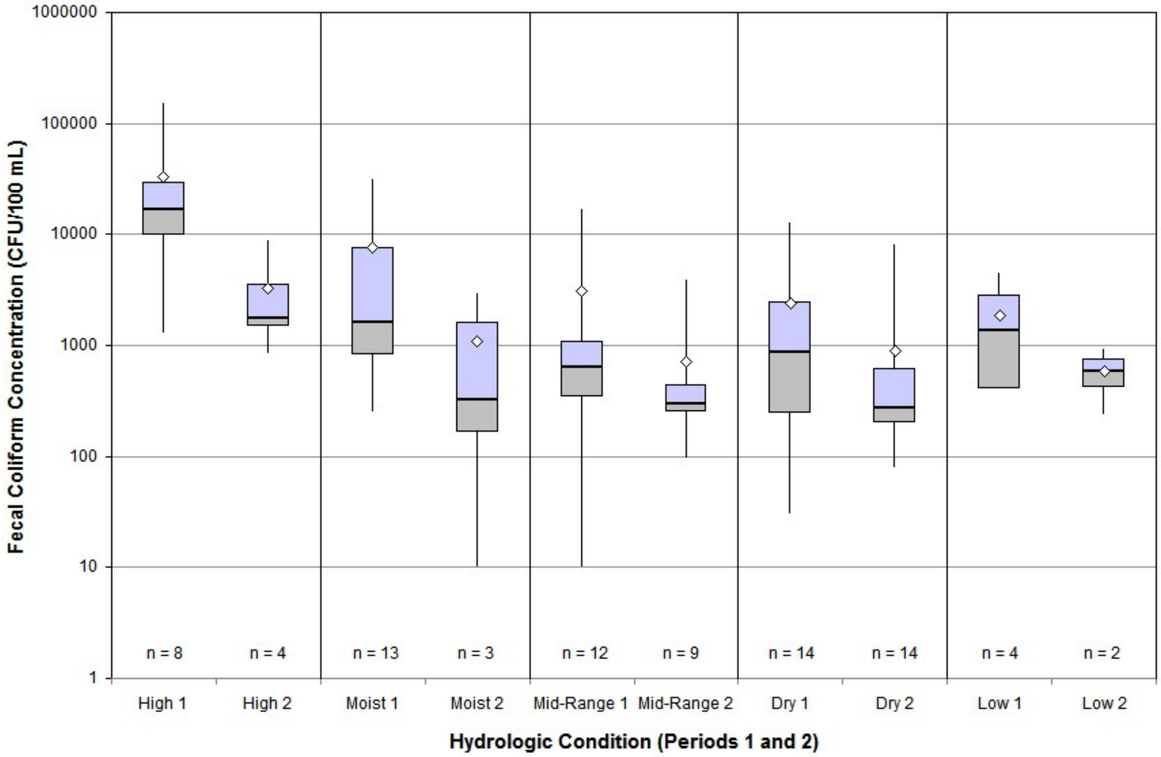

Figure 14. Oostanaula Creek TMDL implementation effectiveness (box and whisker plot).

10.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed pathogen TMDLs for the South Fork Forked Deer River Watershed will be placed on Public Notice for a 35-day period and comments solicited. Steps that will be 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 South Fork Forked Deer 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:

   Denmark Travel Center (TN0022519)
   Old South Inn (TN0023230)
   West Middle High School (TN0023311)
   Beech Bluff Elementary School (TN0023272)
   JEA – Miller Avenue STP (TN0024813)
   Henderson STP – East Lagoon (TN0026026)
   Bells Lagoon (TN0026247)
   Denmark School (TN0056472)
   Halls Lagoon (TN0057291)
   Bells Truck Stop (TN0060151)
   Henderson STP – North Lagoon (TN0064220)
   Henderson STP – South Lagoon (TN0064238)
   Maury City Wastewater Lagoon (TN0065218)
   JEA – Pinson Lagoon (TN0067083)
   Brownsville Energy Authority Lagoon (TN0075078)

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 Brownsville, Tennessee (TNS075191)
   City of Jackson, Tennessee (TNS075361)
   Madison County, Tennessee (TNS075604)
   Tennessee Dept. of Transportation (TNS077585)

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

Natural Resources Conservation Service
Tennessee 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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Sherry H. Wang, Ph.D., Watershed Management Section
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APPENDIX A

Land Use Distribution in the South Fork Forked Deer River Watershed

Table A-1 2001 MRLC Land Use Distribution of Segments of South Fork Forked Deer River

Land Use	Waterbody ID (08010205____)							
	001-1000 (Forked Deer River to Sumrow Creek)		003-1000 (Sumrow Creek to Nixon Creek)		010-1000 (Nixon Creek to Mud Creek)		012-1000 (Mud Creek to Meridian Creek)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Unclassified	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Open Water	179.4	0.50	95.2	0.17	686.9	0.54	1373.6	0.93
Developed Open Space	2828.2	7.83	3056.6	5.44	5828.2	4.56	14685.1	9.98
Low Intensity Development	450.3	1.25	292.9	0.52	2063.3	1.61	8074.7	5.49
Medium Intensity Development	126.4	0.35	6.3	0.01	98.7	0.08	1907.6	1.30
High Intensity Development	192.6	0.53	0.0	0.00	0.0	0.00	3515.1	2.39
Bare Rock	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Deciduous Forest	2292.2	6.35	5459.3	9.72	5291.2	4.14	31621.2	21.49
Evergreen Forest	74.6	0.21	137.9	0.25	99.7	0.08	2033.1	1.38
Mixed Forest	0.0	0.00	0.0	0.00	61.9	0.05	2163.8	1.47
Shrub/Scrub	25.3	0.07	19.5	0.03	1112.2	0.87	8044.7	5.47
Grassland/Herbaceous	6.0	0.02	14.7	0.03	28.1	0.02	114.3	0.08
Pasture/Hay	1416.8	3.92	3972.3	7.07	4827.7	3.78	10598.0	7.20
Row Crops	24441.9	67.66	40235.6	71.62	92581.3	72.41	47069.0	31.99
Woody Wetlands	4033.9	11.17	2871.6	5.11	14638.5	11.45	15423.2	10.48
Emergent Herbaceous Wetland	54.2	0.15	18.3	0.03	542.9	0.42	501.9	0.34
Subtotal – Urban	3,597.6	9.96	3,355.9	5.97	7,990.1	6.25	28,182.5	19.16
Subtotal - Agriculture	25,858.7	71.59	44,207.9	78.69	97,409.0	76.18	57,667.0	39.20
Subtotal – Forest	6,486.2	17.96	8,521.3	15.17	21,774.6	17.03	59,902.2	40.72
Total	**36,122**	**100.00**	**56,180**	**100.00**	**127,861**	**100.00**	**147,125**	**100.00**

Table A-1 (cont'd) 2001 MRLC Land Use Distribution of Segments of South Fork Forked Deer River

Land Use	Waterbody ID (08010205____)					
	018-1000 (Meridian Creek to Sugar Creek)		023-1000 (Sugar Creek to headwaters)		028-1000 (North Fork of SFFD)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Unclassified	0.0	0.00	0.0	0.00	0.0	0.00
Open Water	631.6	0.56	403.0	0.43	970.7	0.93
Developed Open Space	5277.1	4.67	4640.0	4.90	4791.0	4.59
Low Intensity Development	1095.7	0.97	472.9	0.50	354.9	0.34
Medium Intensity Development	148.5	0.13	30.0	0.03	20.9	0.02
High Intensity Development	475.5	0.42	167.8	0.18	52.2	0.05
Bare Rock	0.0	0.00	0.0	0.00	0.0	0.00
Deciduous Forest	38605.0	34.17	35358.2	37.37	43932.7	42.09
Evergreen Forest	2924.0	2.59	5957.9	6.30	3653.2	3.50
Mixed Forest	4203.4	3.72	5049.0	5.34	1398.7	1.34
Shrub/Scrub	10324.2	9.14	10811.4	11.43	4989.3	4.78
Grassland/Herbaceous	69.8	0.06	112.2	0.12	1398.7	1.34
Pasture/Hay	16907.0	14.97	12617.5	13.34	17827.8	17.08
Row Crops	22789.3	20.17	12759.8	13.49	19424.7	18.61
Woody Wetlands	9355.5	8.28	6119.1	6.47	5448.5	5.22
Emergent Herbaceous Wetland	169.5	0.15	112.1	0.12	114.8	0.11
Subtotal – Urban	6,996.7	6.19	5,310.6	5.61	5,218.9	5.00
Subtotal - Agriculture	39,696.3	35.14	25,377.4	26.82	37,252.5	35.69
Subtotal – Forest	65,651.6	58.11	63,520.0	67.14	60,935.9	58.38
Total	**112,976**	**100.00**	**94,611**	**100.00**	**104,378**	**100.00**

*Note: Acreage and land use for each segment does not include upstream segments.

Table A-2 2001 MRLC Land Use Distribution of Impaired HUC-12s & Drainage Areas

Land Use	Impaired Subwatershed (08010205____)							
	Bear Creek (in 0203)		Sandy Creek (in 0302)		Central Creek (in 0302)		Anderson Branch (in 0302)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Unclassified	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Open Water	2.0	0.12	3.0	0.12	0.0	0.00	0.2	0.01
Developed Open Space	35.1	2.08	881.2	34.94	346.2	41.65	839.0	39.09
Low Intensity Development	0.0	0.00	415.6	16.48	296.0	35.61	563.9	26.27
Medium Intensity Development	0.0	0.00	87.0	3.45	54.0	6.49	46.6	2.17
High Intensity Development	0.0	0.00	140.2	5.56	93.0	11.19	140.8	6.56
Bare Rock	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Deciduous Forest	1287.4	76.22	655.5	25.99	30.7	3.69	389.1	18.13
Evergreen Forest	6.2	0.37	125.6	4.98	4.4	0.53	43.4	2.02
Mixed Forest	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Shrub/Scrub	19.6	1.16	52.7	2.09	4.9	0.59	12.7	0.59
Grassland/Herbaceous	125.3	7.42	5.3	0.21	0.0	0.00	0.0	0.00
Pasture/Hay	82.3	4.87	52.0	2.06	0.0	0.00	29.0	1.35
Row Crops	130.2	7.71	88.0	3.49	0.0	0.00	67.0	3.12
Woody Wetlands	0.8	0.05	8.6	0.34	2.0	0.24	15.0	0.70
Emergent Herbaceous Wetland	0.0	0.00	6.8	0.27	0.0	0.00	0.0	0.00
Subtotal – Urban	35.1	2.08	1,524.0	60.43	789.2	94.94	1,590.3	74.09
Subtotal - Agriculture	212.5	12.58	140.0	5.55	0.0	0.00	95.9	4.47
Subtotal – Forest	1,439.5	85.22	854.5	33.88	42.0	5.05	460.2	21.44
Total	**1,689**	**100.00**	**2,521**	**100.0**	**831**	**100.00**	**2,147**	**100.0**

Table A-2 (cont'd) 2001 MRLC Land Use Distribution of Impaired HUC-12s & Drainage Areas

Land Use	Impaired Subwatershed (08010205____)							
	Bond Creek (in 0302)		Hicks Creek (in 0302)		Cub Creek (in 0305)		Panther Creek (in 0306)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Unclassified	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Open Water	9.2	0.29	29.3	0.57	14.9	0.26	19.8	0.22
Developed Open Space	271.7	8.53	234.6	4.57	184.9	3.22	326.1	3.62
Low Intensity Development	152.9	4.80	117.6	2.29	85.6	1.49	221.6	2.46
Medium Intensity Development	83.4	2.62	62.1	1.21	0.0	0.00	3.6	0.04
High Intensity Development	116.6	3.66	100.1	1.95	5.2	0.09	37.8	0.42
Bare Rock	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Deciduous Forest	861.5	27.05	1356.5	26.42	1660.8	28.92	971.2	10.78
Evergreen Forest	29.9	0.94	63.7	1.24	32.2	0.56	0.9	0.01
Mixed Forest	67.5	2.12	138.1	2.69	88.4	1.54	9.9	0.11
Shrub/Scrub	344.0	10.80	367.6	7.16	418.6	7.29	357.7	3.97
Grassland/Herbaceous	0.0	0.00	7.2	0.14	0.6	0.01	0.9	0.01
Pasture/Hay	352.6	11.07	390.2	7.60	654.1	11.39	758.6	8.42
Row Crops	861.5	27.05	1001.7	19.51	2480.8	43.20	6093.8	67.64
Woody Wetlands	34.1	1.07	1242.0	24.19	108.5	1.89	200.0	2.22
Emergent Herbaceous Wetland	0.0	0.00	23.6	0.46	7.5	0.13	7.2	0.08
Subtotal – Urban	624.6	19.61	514.4	10.02	275.6	4.80	589.2	6.54
Subtotal - Agriculture	1,214.1	38.12	1,391.9	27.11	3,134.9	54.59	6,852.3	76.06
Subtotal – Forest	1,337.1	41.98	3,198.6	62.30	2,316.6	40.34	1,547.8	17.18
Total	**3,185**	**100.00**	**5,134**	**100.0**	**5,742**	**100.00**	**9,009**	**100.0**

Table A-2 (cont'd) 2001 MRLC Land Use Distribution of Impaired HUC-12s & Drainage Areas

Land Use	Impaired Subwatershed (08010205____)							
	0401 (incl Little Nixon Ck)		Little Nixon Creek (in 0401)		0402 (Meridian Ck)		0403 (d/s portion of Nixon Ck)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Unclassified	0.00	0.00	0.00	0.00	0.0	0.00	0.0	0.00
Open Water	87.22	0.59	32.73	0.41	42.9	0.23	212.3	0.59
Developed Open Space	1272.13	4.81	477.37	5.98	636.5	3.41	1172.8	4.81
Low Intensity Development	842.41	1.54	316.11	3.96	377.1	2.02	367.0	1.54
Medium Intensity Development	53.18	0.05	19.96	0.25	0.0	0.00	0.0	0.05
High Intensity Development	174.44	0.29	65.46	0.82	37.3	0.20	50.4	0.29
Bare Rock	0.00	0.00	0.00	0.00	0.0	0.00	0.0	0.00
Deciduous Forest	959.41	11.96	360.02	4.51	395.7	2.12	1788.0	11.96
Evergreen Forest	4.25	0.50	1.60	0.02	1.9	0.01	32.4	0.50
Mixed Forest	29.78	0.35	11.18	0.14	3.7	0.02	7.2	0.35
Shrub/Scrub	444.61	2.91	166.84	2.09	95.2	0.51	172.7	2.91
Grassland/Herbaceous	2.13	0.05	0.80	0.01	1.9	0.01	7.2	0.05
Pasture/Hay	1304.03	7.75	489.34	6.13	731.7	3.92	1503.8	7.75
Row Crops	15078.30	58.40	5658.14	70.88	15336.0	82.16	25647.3	58.40
Woody Wetlands	923.25	10.55	346.45	4.34	931.4	4.99	4795.6	10.55
Emergent Herbaceous Wetland	97.86	0.25	36.72	0.46	72.8	0.39	219.5	0.25
Subtotal – Urban	2,342.2	6.69	878.9	11.01	1,050.9	5.63	1,590.1	6.69
Subtotal - Agriculture	16,382.3	66.15	6,147.5	77.01	16,067.7	86.08	27,151.1	66.15
Subtotal – Forest	2,461.3	26.57	923.6	11.57	1,502.6	8.05	7,022.5	26.57
Total	**21,273**	**100.00**	**7,982.7**	**100.00**	**18,664**	**100.0**	**35,976**	**100.00**

Table A-2 (cont'd) 2001 MRLC Land Use Distribution of Impaired HUC-12s & Drainage Areas

Land Use	Impaired Subwatershed (08010205____)							
	Nixon Creek (incl 0401-0403)		0501 (Mud Ck)		0502 (Kail Ck)		Jacobs Creek (in 0503)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Unclassified	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Open Water	425.1	0.56	66.7	0.42	18.7	0.15	38.0	0.54
Developed Open Space	3188.4	4.20	728.8	4.59	938.1	7.54	329.8	4.69
Low Intensity Development	1351.3	1.78	277.9	1.75	78.4	0.63	94.2	1.34
Medium Intensity Development	53.1	0.07	1.6	0.01	13.7	0.11	0.0	0.00
High Intensity Development	212.6	0.28	31.8	0.20	22.4	0.18	14.1	0.20
Bare Rock	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Deciduous Forest	3408.6	4.49	1324.2	8.34	288.7	2.32	715.9	10.18
Evergreen Forest	53.1	0.07	31.8	0.20	18.7	0.15	24.6	0.35
Mixed Forest	38.0	0.05	41.3	0.26	0.0	0.00	9.8	0.14
Shrub/Scrub	675.6	0.89	768.5	4.84	6.2	0.05	395.2	5.62
Grassland/Herbaceous	15.2	0.02	4.8	0.03	5.0	0.04	3.5	0.05
Pasture/Hay	3325.1	4.38	1100.3	6.93	191.6	1.54	400.9	5.70
Row Crops	54043.9	71.19	10938.4	68.89	10375.4	83.39	4834.9	68.75
Woody Wetlands	8775.8	11.56	535.1	3.37	479.0	3.85	171.6	2.44
Emergent Herbaceous Wetland	341.6	0.45	27.0	0.17	10.0	0.08	11.3	0.16
Subtotal – Urban	4,805.4	6.33	1,040.0	6.55	1,052.6	8.46	438.1	6.23
Subtotal - Agriculture	57,369.0	75.57	12,038.7	75.82	10,567.0	84.93	5,235.8	74.45
Subtotal – Forest	13,307.9	17.53	2,732.6	17.21	807.5	6.49	1,332.0	18.94
Total	**75,907.4**	**100.0**	**15,878**	**100.0**	**12,446**	**100.00**	**7,044**	**100.00**

Table A-2 (cont'd) 2001 MRLC Land Use Distribution of Impaired HUC-12s & Drainage Areas

Land Use	Impaired Subwatershed (08010205____)					
	0504 (Black Ck)		0505 (Halls Ck)		0506 (Mill CK)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Unclassified	0.0	0.00	0.0	0.00	0.0	0.00
Open Water	28.1	0.13	50.0	0.26	34.9	0.29
Developed Open Space	1099.5	5.09	1304.6	6.78	1017.0	8.45
Low Intensity Development	60.5	0.28	188.6	0.98	170.9	1.42
Medium Intensity Development	6.5	0.03	15.4	0.08	51.8	0.43
High Intensity Development	6.5	0.03	30.8	0.16	57.8	0.48
Bare Rock	0.0	0.00	0.0	0.00	0.0	0.00
Deciduous Forest	987.2	4.57	2189.7	11.38	1196.4	9.94
Evergreen Forest	28.1	0.13	48.1	0.25	45.7	0.38
Mixed Forest	0.0	0.00	0.0	0.00	0.0	0.00
Shrub/Scrub	2.2	0.01	5.8	0.03	13.2	0.11
Grassland/Herbaceous	0.0	0.00	7.7	0.04	1.2	0.01
Pasture/Hay	114.5	0.53	1849.2	9.61	1103.7	9.17
Row Crops	17572.4	81.35	12728.6	66.15	7760.8	64.48
Woody Wetlands	1687.0	7.81	810.1	4.21	572.9	4.76
Emergent Herbaceous Wetland	8.6	0.04	9.6	0.05	10.8	0.09
Subtotal – Urban	1,172.9	5.43	1,539.4	8.00	1,297.5	10.78
Subtotal - Agriculture	17,686.9	81.88	14,577.7	75.76	8,864.5	73.65
Subtotal – Forest	2,713.1	12.56	3,071.0	15.96	1,840.3	15.29
Total	**21,601**	**100.0**	**19,238**	**100.00**	**12,037**	**100.0**

APPENDIX B

Water Quality Monitoring Data
For South Fork Forked Deer River Watershed

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

Table B-1. TDEC Water Quality Monitoring Data

Monitoring Station	Date	E. Coli [cts./100 mL]
ANDER000.5MN	4/3/01	101.4
	5/8/01	248.1
	6/5/01	7701
	7/10/01	461.1
	8/7/01	648.8
	9/11/01	65.7
	10/2/01	152.9
	11/6/01	12
	12/4/01	228.2
	1/8/02	9.7
	2/5/02	31.8
	3/5/02	387.3
	7/13/06	180
	10/11/06	520
	1/11/07	120
	4/12/07	1200
BEAR005.7MN	8/10/05	325.5
	10/6/05	1000
	1/26/06	25.3
	4/12/06	140
BLACK001.6CK	4/5/01	2419.2
	5/10/01	798
	6/7/01	2723
	7/12/01	4106
	8/9/01	298
	9/13/01	185
	10/4/01	32.7
	11/6/01	83.9
	1/10/02	235.9
	2/20/02	1533.1
	3/7/02	47.1

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

Monitoring Station	Date	E. Coli [cts./100 mL]
BLACK001.6CK (cont'd)	7/11/06	700
	1/9/07	1200
	4/10/07	1000
BOND001.0MN	4/3/01	166.4
	5/29/01	1299.7
	5/30/01	517.2
	5/31/01	2419.2
	6/4/01	1553.1
	6/5/01	4611
	6/6/01	1413.6
	6/7/01	1413.6
	7/10/01	461.1
	8/7/01	275.5
	9/11/01	648.8
	10/2/01	161.6
	11/6/01	218.7
	12/4/01	770.1
	1/8/02	48.8
	2/5/02	160.7
	3/5/02	410.6
	7/13/06	1200
	1/11/07	1300
	4/12/07	230
CENTR000.4MN	6/5/01	2419.2
	7/10/01	275.5
	8/7/01	2419.2
	9/11/01	214.3
	10/2/01	157.6
	11/6/01	38.2
	12/4/01	225.4
	1/8/02	1119.9
	2/5/02	461.2
	3/5/02	613.1

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

Monitoring Station	Date	E. Coli [cts./100 mL]
CENTR000.4MN (cont'd)	7/13/06	2000
	10/11/06	11
	1/11/07	290
	4/12/07	920
CUB001.6MN	4/4/01	68.9
	5/9/01	2419.2
	5/14/01	64880
	6/6/01	231.8
	7/11/01	1413.6
	8/8/01	307.6
	9/12/01	298.7
	10/3/01	70.8
	11/7/01	12.1
	12/5/01	209.8
	1/9/02	62.4
	2/20/02	816.4
	3/6/02	12.1
	7/13/06	150
	10/11/06	230
	1/11/07	420
	4/12/07	60
HALLS001.2LE	4/5/01	2419.2
	5/10/01	1203.3
	6/7/01	17329
	7/12/01	100
	8/9/01	359
	9/13/01	121
	10/4/01	7.3
	11/6/01	14.6
	12/6/01	44.1
	1/10/02	579.4
	2/21/02	1553.1
	3/7/02	45.5

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

Monitoring Station	Date	E. Coli [cts./100 mL]
HALLS001.2LE (cont'd)	7/11/06	52
	1/9/07	870
	4/10/07	100
	7/2/07	816
	7/9/07	59
	7/10/07	17
	7/11/07	31
	7/12/07	47
HICKS000.9MN	7/13/06	22
	10/11/06	690
	1/11/07	2400
	4/12/07	24000
JACOB004.1HY	6/7/01	866.4
	10/4/01	8.5
	12/6/01	248.1
	1/10/02	71.7
	2/21/02	1553.1
	3/7/02	5.2
	7/12/06	42
	8/1/06	330
	9/5/06	29
	9/13/06	2400
	9/18/06	14000
	9/20/06	400
	9/25/06	93
	11/14/06	76
	12/7/06	12
	1/10/07	170
	2/6/07	1
	3/5/07	6.3
	3/8/07	2
	3/13/07	5
	3/15/07	13
	3/20/07	10
	3/22/07	7.4

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

Monitoring Station	Date	E. Coli [cts./100 mL]
JACOB004.1HY (cont'd)	4/11/07	15
	5/1/07	70
	6/5/07	79
	6/11/07	84
	6/13/07	119
	6/18/07	35
	6/20/07	63
	6/26/07	88
KAIL001.9HY	7/12/06	57
	8/1/06	170
	9/5/06	58
	9/13/06	1300
	9/18/06	8700
	9/20/06	540
	9/25/06	74
	10/12/06	120
	11/14/06	870
	12/7/06	16
	1/10/07	390
	2/6/07	11
	3/5/07	72
	3/8/07	99
	3/13/07	68
	3/15/07	76
	3/20/07	250
	3/22/07	44
	4/11/07	2400
	5/1/07	98
	6/5/07	91
	6/11/07	148
	6/13/07	22
	6/18/07	2420
	6/20/07	344
	6/26/07	1046

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

Monitoring Station	Date	E. Coli [cts./100 mL]
LNIXO002.9HY	4/5/01	1986.3
	5/10/01	19863
	6/7/01	4160
	7/12/01	59
	8/9/01	100
	9/13/01	5.2
	10/4/01	17.1
	11/6/01	313
	12/6/01	104.6
	1/10/02	727
	2/21/02	12.1
	3/7/02	39
	7/11/06	170
	1/8/07	25
	4/10/07	1986.3
MERID001.7HY	4/5/01	24.3
	5/10/01	408.3
	6/7/01	1299.7
	7/12/01	307.6
	8/9/01	392
	9/13/01	41
	10/4/01	2
	11/6/01	28
	12/6/01	66.3
	1/10/02	145
	2/21/02	686.7
	3/7/02	8.6
	7/12/06	26
	8/1/06	2
	9/5/06	4
	9/13/06	30
	9/18/06	17000
	9/20/06	330
	9/25/06	120

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

Monitoring Station	Date	E. Coli [cts./100 mL]
MERID001.7HY (cont'd)	11/14/06	210
	12/7/06	40
	12/12/06	16
	1/10/07	96
	2/6/07	76
	3/5/07	21
	3/8/07	45
	3/13/07	28
	3/15/07	28
	3/20/07	17
	3/22/07	15
	4/11/07	3200
	5/1/07	20
	6/5/07	23
	6/11/07	21
	6/13/07	4
	6/18/07	1
	6/20/07	1
	6/26/07	134
MILL001.5LE	7/12/06	610
	8/1/06	110
	9/5/06	78
	9/13/06	880
	9/18/06	24000
	9/20/06	310
	9/25/06	230
	10/12/06	34
	11/14/06	260
	12/7/06	110
	1/10/07	260
	2/6/07	21
	3/5/07	120
	3/8/07	120

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

Monitoring Station	Date	E. Coli [cts./100 mL]
MILL001.5LE (cont'd)	3/13/07	100
	3/15/07	130
	3/20/07	210
	3/22/07	89
	4/11/07	2400
	5/1/07	388
	6/5/07	1414
	6/11/07	147
	6/13/07	345
	6/18/07	613
	6/20/07	157
	6/26/07	155
MUD001.3HY	4/4/01	456.9
	5/9/01	289.4
	6/6/01	461.1
	7/11/01	201.4
	8/8/01	461.1
	9/12/01	133.4
	10/3/01	42.8
	11/7/01	13.2
	12/5/01	344.8
	1/9/02	1203
	2/20/02	2419.2
	3/6/02	26
	7/12/06	670
	10/12/06	44
	1/10/07	370
	4/11/07	550
NFSFF001.4MN	4/3/01	103.9
	5/8/01	100.6
	6/5/01	235.9
	7/10/01	139.6
	8/7/01	142.1
	9/11/01	461.1
	10/2/01	86.5

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

Monitoring Station	Date	E. Coli [cts./100 mL]
NFSFF001.4MN (cont'd)	11/6/01	67.7
	12/4/01	201.4
	1/8/02	83.6
	2/5/02	126.7
	3/5/02	90.9
	9/7/06	370
	9/12/06	390
	9/14/06	170
	9/19/06	2400
	9/21/06	200
	3/7/07	97
	3/12/07	74
	3/14/07	89
	3/19/07	52
	3/21/07	48
	6/7/07	84
	6/12/07	114
	6/14/07	67
	6/19/07	108
	6/21/07	89
NIXON002.2HY	4/5/01	1732.9
	5/10/01	104.6
	6/7/01	3654
	7/12/01	1281
	8/9/01	624
	9/13/01	30
	10/4/01	49.5
	11/6/01	19.3
	1/10/02	57.1
	2/21/02	435.2
	3/7/02	166.4
	7/11/06	110
	1/9/07	340
	4/10/07	460

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

Monitoring Station	Date	E. Coli [cts./100 mL]
PANTH001.9MN	6/6/01	816.4
	7/11/01	686.7
	8/8/01	26.9
	9/12/01	17.5
	12/5/01	461.1
	1/9/02	365.4
	2/20/02	2419.2
	3/6/02	33.6
	9/5/06	33
	9/13/06	81
	9/18/06	4600
	9/20/06	19
	9/25/06	100
	10/12/06	120
	11/14/06	410
	12/7/06	82
	1/10/07	22
	3/8/07	4.1
	3/13/07	210
	3/15/07	1200
	3/22/07	37
	4/11/07	1600
	5/1/07	365
	6/5/07	36
	6/11/07	517
	6/13/07	816
	6/18/07	345
	6/20/07	770
	6/26/07	58
SANDY000.5MN	6/5/01	6867
	12/4/01	325.5
	2/5/02	488.4

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

Monitoring Station	Date	E. Coli [cts./100 mL]
SANDY000.5MN (cont'd)	1/16/07	1600
	3/6/07	100
	3/7/07	12
	3/12/07	74
	3/14/07	2
	3/19/07	1
	3/21/07	6.3
	4/17/07	690
SFFDE011.2DY	5/10/01	181.9
	6/7/01	302.6
	7/12/01	1483
	8/9/01	171
	9/13/01	175
	10/4/01	43.5
	11/6/01	31.8
	1/10/02	80.9
	2/21/02	1299.7
	3/7/02	19.9
	7/11/06	50
	1/9/07	1700
	4/10/07	100
SFFDE019.1LE	7/11/06	39
	1/9/07	1400
	4/10/07	86
SFFDE030.4HY	9/28/98	128.1
	12/16/98	31.7
	3/24/99	461.1
	6/9/99	72.3
	9/28/99	184.2
	12/1/99	160.7
	3/29/00	74.8
	6/20/00	166.9
	9/6/00	37.7
	12/14/00	980.4
	6/27/01	39.9

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

Monitoring Station	Date	E. Coli [cts./100 mL]
SFFDE030.6HY	4/5/01	1553.1
	5/10/01	38.6
	6/7/01	3430
	7/12/01	400
	8/9/01	657
	9/12/01	30.3
	9/13/01	97
	10/4/01	71.4
	11/6/01	77.6
	12/6/01	387.3
	12/17/01	1732.9
	1/10/02	95.9
	2/21/02	1732.9
	3/7/02	19.9
	3/12/02	8164
	6/18/02	25.6
	9/24/02	536
	12/16/02	66.9
	3/25/03	118.7
	6/19/03	1203.3
	9/16/03	72.7
	12/11/03	1413.6
	3/18/04	90.7
	6/8/04	156.5
	9/27/04	9.7
	12/15/04	58.1
	3/16/05	31.3
	6/15/05	579.4
	9/14/05	51.2
	12/14/05	120
	3/23/06	2000
	6/20/06	410
	9/26/06	690

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

Monitoring Station	Date	E. Coli [cts./100 mL]
SFFDE030.6HY (cont'd)	1/18/07	290
	3/21/07	70
	6/7/07	67
	9/19/07	129
	12/17/07	2420
	3/25/08	31
	6/4/08	142.1
	9/9/08	162
	12/8/08	68
	3/4/09	980
	6/23/09	105
	9/29/09	365
SFFDE036.7HY	4/4/01	118.2
	5/9/01	93.3
	6/6/01	331
	7/11/01	328.2
	8/8/01	261.3
	9/12/01	23.8
	10/3/01	153.9
	11/7/01	58.1
	12/5/01	66.2
	1/9/02	120.1
	2/20/02	2419.2
	3/6/02	31.4
SFFDE043.2MN	4/4/01	81.3
	5/9/01	97.8
	6/6/01	387.3
	7/11/01	980.4
	8/8/01	686.7
	9/12/01	272.3
	10/3/01	155.3
	11/7/01	93.3
	12/5/01	57.3

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

Monitoring Station	Date	E. Coli [cts./100 mL]
SFFDE043.2MN	1/9/02	65
	2/20/02	920.8
	3/6/02	52.1
	7/13/06	93
	10/11/06	180
	1/11/07	250
	4/12/07	1000
SFFDE052.7MN	4/4/01	105.6
	5/9/01	44.3
	6/6/01	478.6
	7/11/01	2419.2
	8/8/01	344.8
	9/12/01	261.3
	10/3/01	122.3
	11/7/01	49.7
	12/5/01	146.7
	1/9/02	51.2
	2/20/02	1732.9
	3/6/02	34.1
SFFDE065.6MN	4/3/01	0
	5/8/01	90.9
	6/5/01	579.4
	7/10/01	143.9
	8/7/01	156.5
	9/11/01	198.9
	10/2/01	98.5
	11/6/01	86.5
	12/4/01	59.1
	1/8/02	83.6
	2/5/02	75.4
	3/5/02	36.4
	7/18/06	36
	10/10/06	160
	1/16/07	2400
	4/17/07	6

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

Monitoring Station	Date	E. Coli [cts./100 mL]
SFFDE1T0.7MN	8/15/07	43
	8/16/07	1413
	8/20/07	140
	8/21/07	326
	8/22/07	28
TISDA1T1.2LE	7/2/07	7701
	7/5/07	2755
	7/9/07	12997
	7/10/07	556
	7/11/07	1565

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 South Fork Forked Deer 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 South Fork Forked Deer River Watershed were derived from WinHSPF hydrologic simulations based on parameters derived from calibrations at several USGS gaging stations (see Appendix D for details of calibration). For example, a flow-duration curve for South Fork Forked Deer River was constructed using simulated daily mean flow for the period from 10/1/98 through 9/30/09 (RM 30.4/30.6 corresponds to the location of monitoring stations SFFDE030.4HY and SFFDE030.6HY). 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 South Fork Forked Deer River Watershed were developed from the flow duration curves developed in Section C.1.1, E. coli target concentrations, and available water quality monitoring data. Load duration curves and required load reductions were developed using the following procedure (South Fork Forked Deer River at RM30.4 & RM30.6 is shown as an example):

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

   $(\text{Target Load})_{\text{SFFD River}}$ = (487 CFU/100 mL) x (Q) x (UCF)

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

   TMDL = (1.20x10^{10}) x (Q) CFU/day

2. Daily loads were calculated for each of the water quality samples collected at monitoring stations SFFDE030.4HY and SFFDE030.6HY (ref.: Table B-1) by multiplying the sample concentration by the daily mean flow for the sampling date and the required unit conversion factor. SFFDE030.4HY and SFFDE030.6HY were selected for LDC analysis because they have a longer period of record and multiple exceedances of the target concentration.

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

   Example – 2/21/02 sampling event:
   Modelled Flow = 1,987 cfs
   Concentration = 1,732.9 CFU/100 mL
   Daily Load = 8.42x10^{13} CFU/day

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

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

C.2 Development of WLAs & LAs

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

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

Expanding the terms:

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

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

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

  Therefore, a WLA of zero has been assigned to this class of facilities.
- $[\sum \text{WLAs}]_{\text{MS4}}$ 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:

- $[\sum \text{LAs}]_{\text{DS}}$ 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:

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

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

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

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

Target – MOS = 438 CFU/100 ml

Instantaneous Maximum (other):

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

Target – MOS = 847 CFU/100 ml

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

Target – MOS = 113 CFU/100 ml

C.2.1 Daily Load Calculation

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

WLA[MS4] = LA = {TMDL – MOS – WLA[WWTFs]} / DA

where: DA = waterbody drainage area (acres)

Using South Fork Forked Deer River as an example:

$$\text{TMDL}_{\text{SFFD River}} = (487 \text{ CFU/100 mL}) \times (Q) \times (UCF)$$

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

$MOS_{SFFD\ River}$ = TMDL x 0.10 = 1.20×10^{9} x Q

MOS = (1.20×10^{9}) x (Q) CFU/day

$WLA[MS4]_{SFFD\ River}$ = $LA_{SFFD\ River}$

= {TMDL – MOS – WLA[WWTFs]} / DA

= {(1.20×10^{10} x Q) – (1.20×10^{9} x Q) – (7.672×10^{11})} / (4.902×10^{5})

WLA[MS4] = LA = [2.203×10^{4} x Q] – [1.565×10^{6}]

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

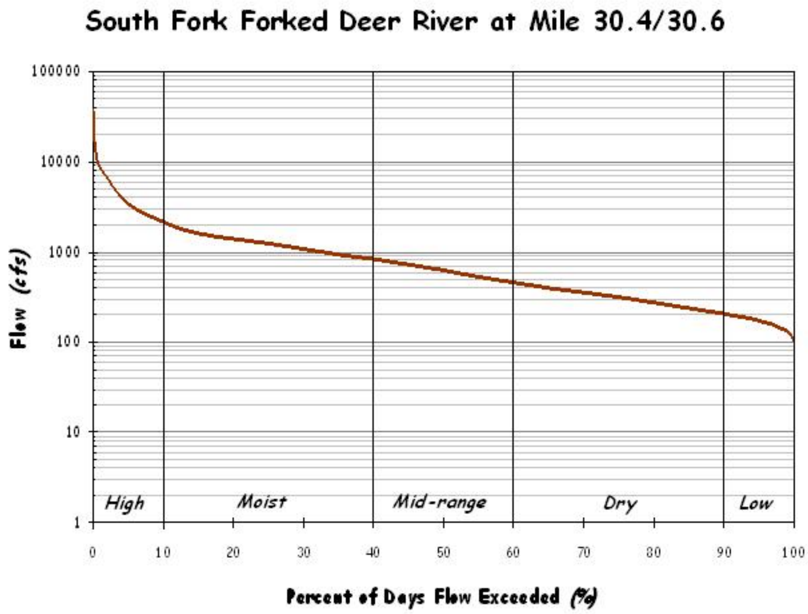

Figure C-1. Flow Duration Curve for South Fork Forked Deer River at Mile 30.4/30.6

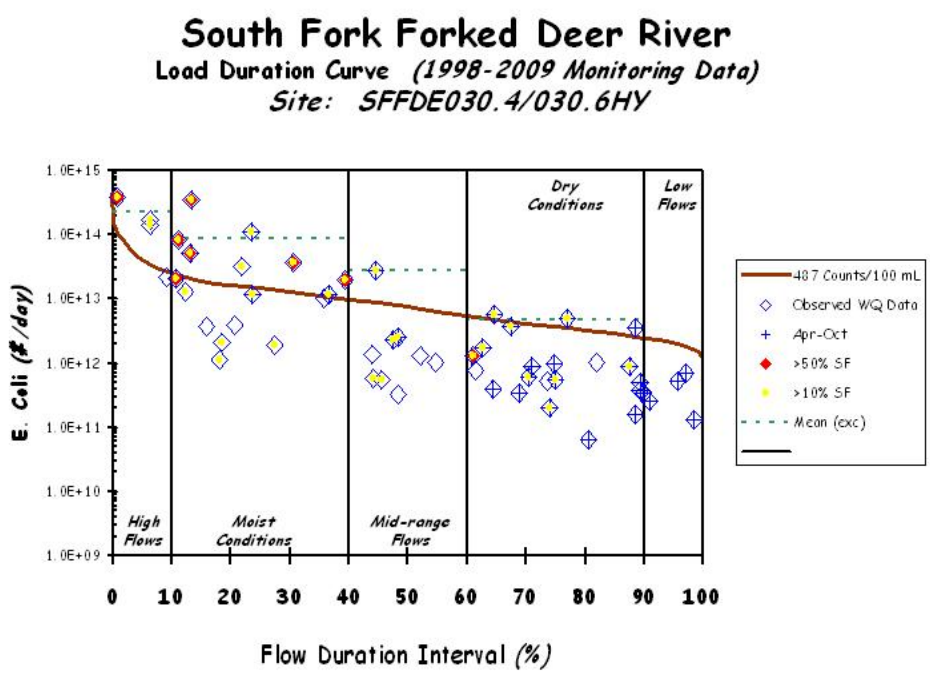

Figure C-2. E. Coli Load Duration Curve for South Fork Forked Deer River at Mile 30.4/30.6

Table C-1. TMDLs, WLAs, & LAs for Impaired Waterbodies in the South Fork Forked Deer River Watershed (HUC 08010205)

HUC-12 Subwatershed (08010205__) 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]
0105	South Fork Forked Deer River	TN08010205018 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.666×10^{10}	0	$(7.129 \times 10^{4} \times Q) - (3.080 \times 10^{5})$	$(7.129 \times 10^{4} \times Q) - (3.080 \times 10^{5})$
0106	South Fork Forked Deer River	TN08010205018 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.666×10^{10}	0	$(7.129 \times 10^{4} \times Q) - (3.080 \times 10^{5})$	$(7.129 \times 10^{4} \times Q) - (3.080 \times 10^{5})$
	UT to South Fork Forked Deer River	TN08010205018 – 1200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.044 \times 10^{7} \times Q$	$3.044 \times 10^{7} \times Q$
0203	Bear Creek	TN08010205028 – 0300	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$4.661 \times 10^{6} \times Q$	$4.661 \times 10^{6} \times Q$
	North Fork of South Fork Forked Deer River	TN08010205028 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.781×10^{8}	0	$(1.992 \times 10^{5} \times Q) - (1.713 \times 10^{3})$	$(1.992 \times 10^{5} \times Q) - (1.713 \times 10^{3})$
0204	North Fork of South Fork Forked Deer River	TN08010205028 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.781×10^{8}	0	$(1.992 \times 10^{5} \times Q) - (1.713 \times 10^{3})$	$(1.992 \times 10^{5} \times Q) - (1.713 \times 10^{3})$
0302	Sandy Creek	TN08010205012 – 0400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$8.208 \times 10^{6} \times Q$	$8.208 \times 10^{6} \times Q$
	Central Creek	TN08010205012 – 0500	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.490 \times 10^{7} \times Q$	$2.490 \times 10^{7} \times Q$
	Anderson Branch	TN08010205012 – 0600	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	NA	NA	$5.032 \times 10^{6} \times Q$	$5.032 \times 10^{6} \times Q$
	Bond Creek	TN08010205002 – 0700	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$6.499 \times 10^{6} \times Q$	$6.499 \times 10^{6} \times Q$
	Hicks Creek	TN08010205012 – 0900	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$4.032 \times 10^{6} \times Q$	$4.032 \times 10^{6} \times Q$
	South Fork Forked Deer River	TN08010205012 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.684×10^{10}	0	$(3.326 \times 10^{4} \times Q) - (1.442 \times 10^{5})$	$(3.326 \times 10^{4} \times Q) - (1.442 \times 10^{5})$
0305	Cub Creek	TN08010205012 – 1200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	5.699×10^{8}	0	$(3.605 \times 10^{6} \times Q) - (9.923 \times 10^{4})$	$(3.605 \times 10^{6} \times Q) - (9.923 \times 10^{4})$
	South Fork Forked Deer River	TN08010205012 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.684×10^{10}	0	$(3.326 \times 10^{4} \times Q) - (1.442 \times 10^{5})$	$(3.326 \times 10^{4} \times Q) - (1.442 \times 10^{5})$
0306	Panther Creek	TN08010205012 – 1400	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	1.211×10^{9}	0	$(2.298 \times 10^{6} \times Q) - (1.344 \times 10^{5})$	$(2.298 \times 10^{6} \times Q) - (1.344 \times 10^{5})$
	South Fork Forked Deer River	TN08010205012 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	4.684×10^{10}	0	$(2.707 \times 10^{4} \times Q) - (1.178 \times 10^{5})$	$(2.707 \times 10^{4} \times Q) - (1.178 \times 10^{5})$

Table C-1 (cont'd). TMDLs, WLAs, & LAs for Impaired Waterbodies in the South Fork Forked Deer River Watershed (HUC 08010205)

HUC-12 Subwatershed (08010205__) 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]
0401	Little Nixon Creek	TN08010205005 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.593 \times 10^{6} \times Q$	$2.593 \times 10^{6} \times Q$
	Nixon Creek	TN08010205005 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.727 \times 10^{5} \times Q$	$2.727 \times 10^{5} \times Q$
0402	Meridian Creek	TN08010205005 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	NA	$5.416 \times 10^{6} \times Q$
0403	Nixon Creek	TN08010205005 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.727 \times 10^{5} \times Q$	$2.727 \times 10^{5} \times Q$
0501	Mud Creek	TN08010205011 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	4.089×10^{8}	0	$(1.350 \times 10^{6} \times Q) - (2.666 \times 10^{4})$	$(1.350 \times 10^{6} \times Q) - (2.666 \times 10^{4})$
0502	Kail Creek	TN08010205010 – 0100	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.757 \times 10^{6} \times Q$	$1.757 \times 10^{6} \times Q$
0503	Jacobs Creek	TN08010205010 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$2.248 \times 10^{6} \times Q$	$2.248 \times 10^{6} \times Q$
	South Fork Forked Deer River	TN08010205010 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	7.672×10^{11}	0	$(2.203 \times 10^{4} \times Q) - (1.565 \times 10^{6})$	$(2.203 \times 10^{4} \times Q) - (1.565 \times 10^{6})$
0504	Black Creek	TN08010205031 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.113 \times 10^{6} \times Q$	$1.113 \times 10^{6} \times Q$
0505	UT to Tisdale Creek	TN08010205036 – 0110	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$3.986 \times 10^{7} \times Q$	$3.986 \times 10^{7} \times Q$
	Halls Creek	TN08010205036 – 1000	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.223 \times 10^{6} \times Q$	$1.223 \times 10^{6} \times Q$
0506	Mill Creek	TN08010205001 – 0200	$2.30 \times 10^{10} \times Q$	$2.30 \times 10^{9} \times Q$	NA	NA	$1.817 \times 10^{6} \times Q$	$1.817 \times 10^{6} \times Q$
0507	South Fork Forked Deer River	TN08010205001 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	8.893×10^{11}	0	$(1.663 \times 10^{4} \times Q) - (1.370 \times 10^{6})$	$(1.663 \times 10^{4} \times Q) - (1.370 \times 10^{6})$
	South Fork Forked Deer River	TN08010205003 – 1000	$1.20 \times 10^{10} \times Q$	$1.20 \times 10^{9} \times Q$	8.573×10^{11}	0	$(3.492 \times 10^{4} \times Q) - (1.440 \times 10^{6})$	$(3.492 \times 10^{4} \times Q) - (1.440 \times 10^{6})$

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 South Fork Forked Deer River Watershed. HSPF is a watershed model capable of performing flow routing through stream reaches.

D.2 Model Set Up

The South Fork Forked Deer 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 December 2009. 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 (10/1/99 – 9/30/09) used for TMDL analysis. Meteorological data from the stations at Brownsville and Jackson, 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. Three USGS continuous record stations located in and near the South Fork Forked Deer River watershed were selected as the basis of the hydrology calibration. Station 07027500 is located in the South Fork Forked Deer watershed at Jackson, TN, within Level IV ecoregion 65E and has a drainage area of 495 square miles. Calibration parameters determined for station 07027500 were used for impaired waterbodies lying in ecoregion 65E. Station 07027720 is located in the South Fork Forked Deer watershed near Owl City, TN, within Level IV ecoregion 74B, but also including portions in ecoregion 65E, and has a drainage area of 718 square miles. Calibration parameters determined for station 07027720 were used for portions of South Fork Forked Deer River including portions of ecoregions 65E and 74B. Station 07030240 is located in the Loosahatchie River watershed near Arlington, TN, within Level IV ecoregion 74B and has a drainage area of 262 square miles. Calibration parameters determined for station 07030240 were used for impaired waterbodies lying in ecoregion 74B.

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 South Fork Forked Deer River at Jackson, USGS Station 07027500, are shown in Table D-1 and Figure D-1 and D-2. The results of the hydrologic calibration for South Fork Forked Deer River near Owl City, USGS Station 07027720, are shown in Table D-2 and Figure D-3 and D-4. The results of the hydrologic calibration for Loosahatchie River near Arlington, USGS Station 07030240, are shown in Table D-3 and Figure D-5 and D-6.

Table D-1. Hydrologic Calibration Summary: South Fork Forked Deer at Jackson (USGS 07027500)

			488.638117
Simulation Name:	USGS07027500	**Simulation Period:**	
		Watershed Area (ac):	312828.50
Period for Flow Analysis			
Begin Date:	**05/01/88**	**Baseflow PERCENTILE:**	2.5
End Date:	**05/01/91**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**88.98**	Total Observed In-stream Flow:	**84.05**
Total of highest 10% flows:	**44.74**	Total of Observed highest 10% flows:	**41.46**
Total of lowest 50% flows:	**9.96**	Total of Observed Lowest 50% flows:	**9.25**
Simulated Summer Flow Volume (months 7-9):	**8.15**	Observed Summer Flow Volume (7-9):	**7.30**
Simulated Fall Flow Volume (months 10-12):	**21.03**	Observed Fall Flow Volume (10-12):	**19.59**
Simulated Winter Flow Volume (months 1-3):	**42.75**	Observed Winter Flow Volume (1-3):	**40.63**
Simulated Spring Flow Volume (months 4-6):	**17.05**	Observed Spring Flow Volume (4-6):	**16.54**
Total Simulated Storm Volume:	**81.65**	Total Observed Storm Volume:	**75.04**
Simulated Summer Storm Volume (7-9):	**6.31**	Observed Summer Storm Volume (7-9):	**5.03**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**5.86**	10	
Error in 50% lowest flows:	**7.65**	10	
Error in 10% highest flows:	**7.91**	15	
Seasonal volume error - Summer:	**11.67**	30	
Seasonal volume error - Fall:	**7.39**	30	
Seasonal volume error - Winter:	**5.21**	30	
Seasonal volume error - Spring:	**3.09**	30	
Error in storm volumes:	**8.82**	20	
Error in summer storm volumes:	**25.51**	50	

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

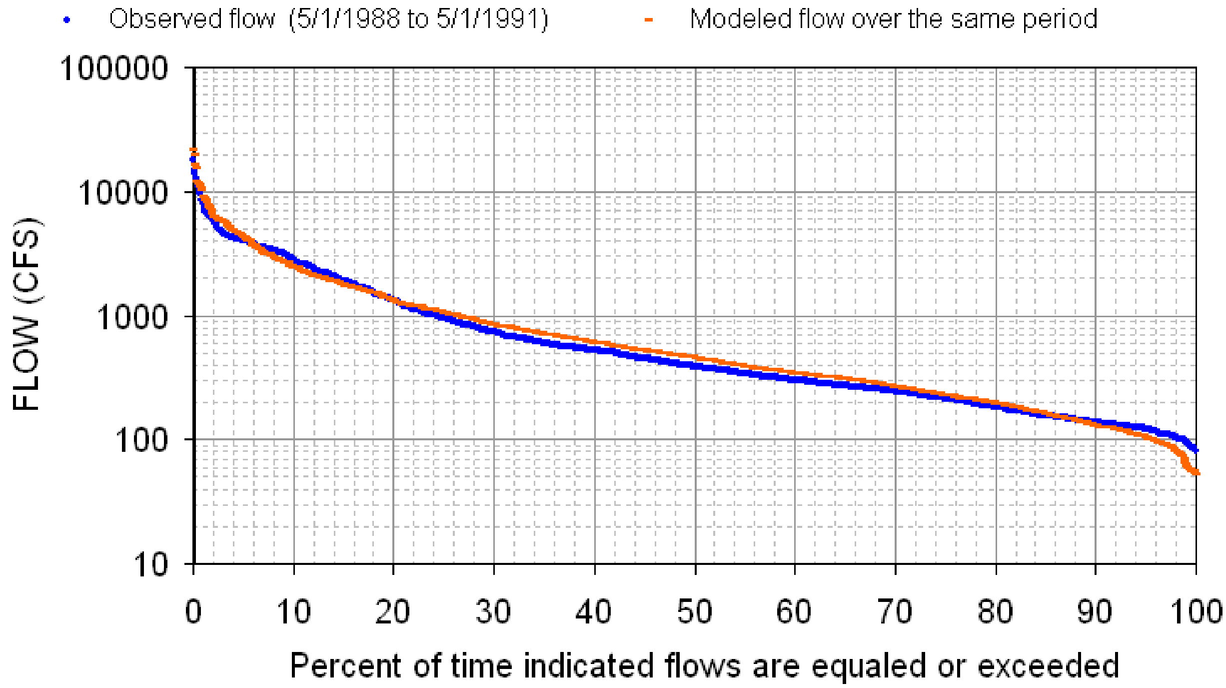

Figure D-1. Hydrologic Calibration: South Fork Forked Deer, USGS 07027500 (1988-1991)

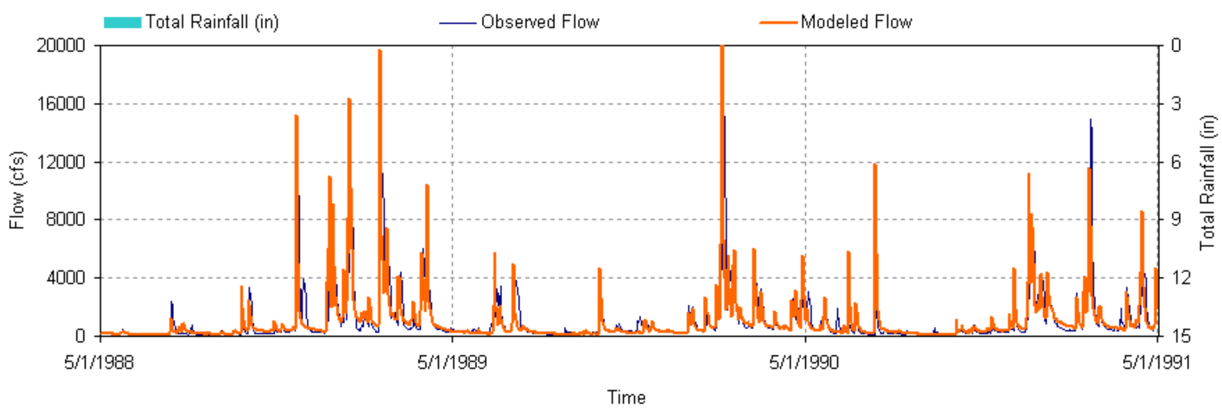

Figure D-2. 3-Year Hydrologic Comparison: South Fork Forked Deer River, USGS 07027500

Table D-2. Hydrologic Calibration Summary: South Fork Forked Deer near Owl City (USGS 07027720)

			765.7108316
Simulation Name:	USGS07027720	**Simulation Period:**	
		Watershed Area (ac):	490211.80
Period for Flow Analysis			
Begin Date:	**10/01/01**	**Baseflow PERCENTILE:**	2.5
End Date:	**10/01/09**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**166.37**	Total Observed In-stream Flow:	**158.73**
Total of highest 10% flows:	**71.39**	Total of Observed highest 10% flows:	**69.73**
Total of lowest 50% flows:	**24.92**	Total of Observed Lowest 50% flows:	**23.83**
Simulated Summer Flow Volume (months 7-9):	**16.94**	Observed Summer Flow Volume (7-9):	**15.92**
Simulated Fall Flow Volume (months 10-12):	**45.97**	Observed Fall Flow Volume (10-12):	**46.46**
Simulated Winter Flow Volume (months 1-3):	**63.28**	Observed Winter Flow Volume (1-3):	**54.67**
Simulated Spring Flow Volume (months 4-6):	**40.17**	Observed Spring Flow Volume (4-6):	**41.68**
Total Simulated Storm Volume:	**144.24**	Total Observed Storm Volume:	**130.43**
Simulated Summer Storm Volume (7-9):	**11.44**	Observed Summer Storm Volume (7-9):	**8.85**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**4.82**	10	
Error in 50% lowest flows:	**4.57**	10	
Error in 10% highest flows:	**2.37**	15	
Seasonal volume error - Summer:	**6.41**	30	
Seasonal volume error - Fall:	**-1.05**	30	
Seasonal volume error - Winter:	**15.76**	30	
Seasonal volume error - Spring:	**-3.62**	30	
Error in storm volumes:	**10.59**	20	
Error in summer storm volumes:	**29.17**	50	

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

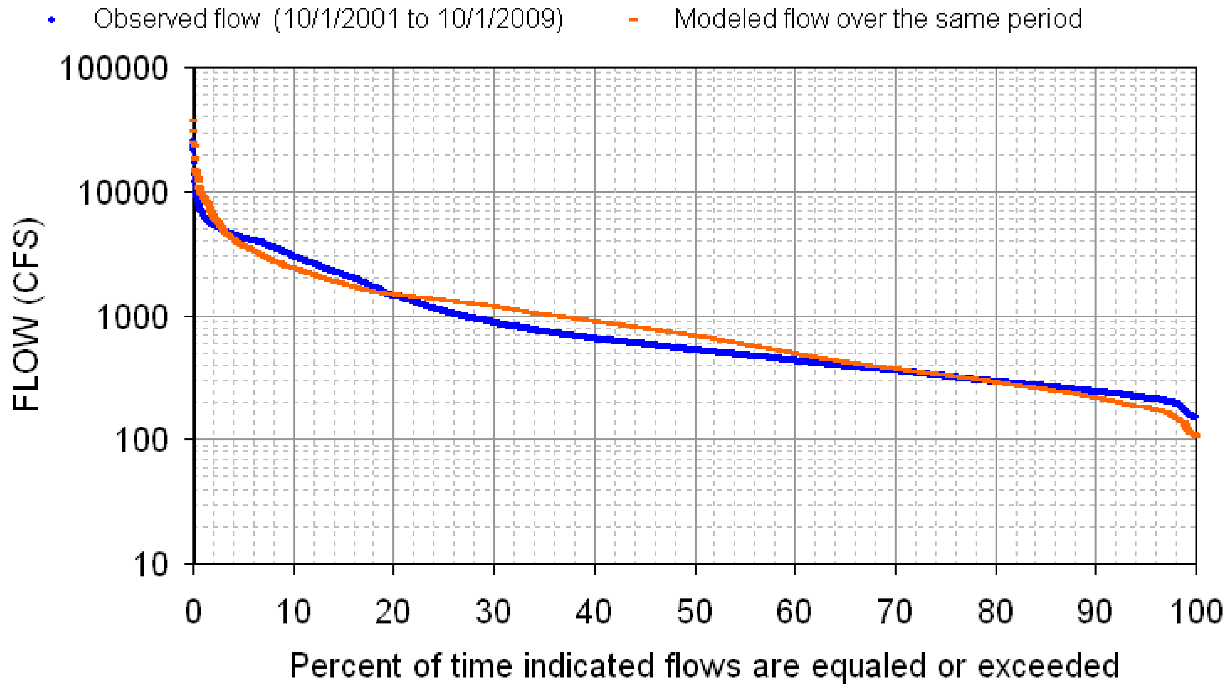

Figure D-3. Hydrologic Calibration: South Fork Forked Deer, USGS 07027720 (WYs2002-2009)

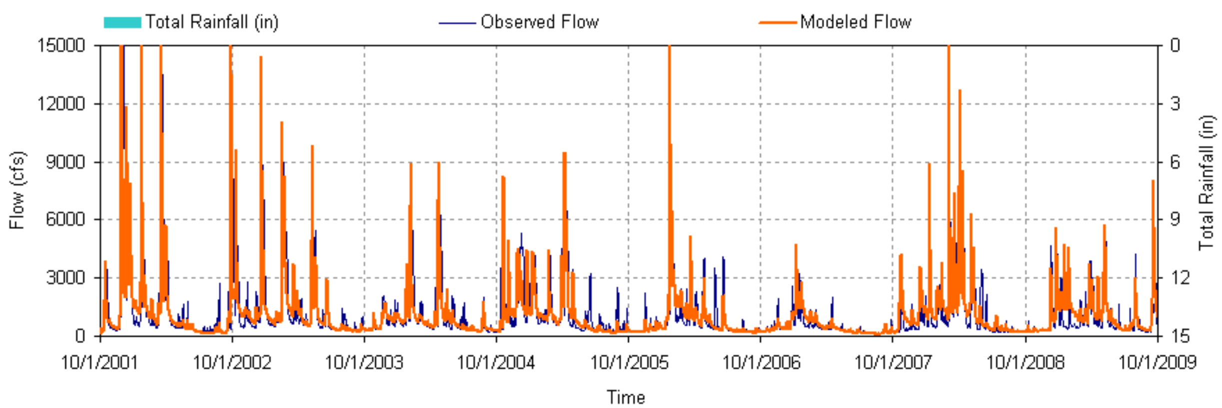

Figure D-4. 8-Year Hydrologic Comparison: South Fork Forked Deer River, USGS 07027720

Table D-3. Hydrologic Calibration Summary: Loosahatchie 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	

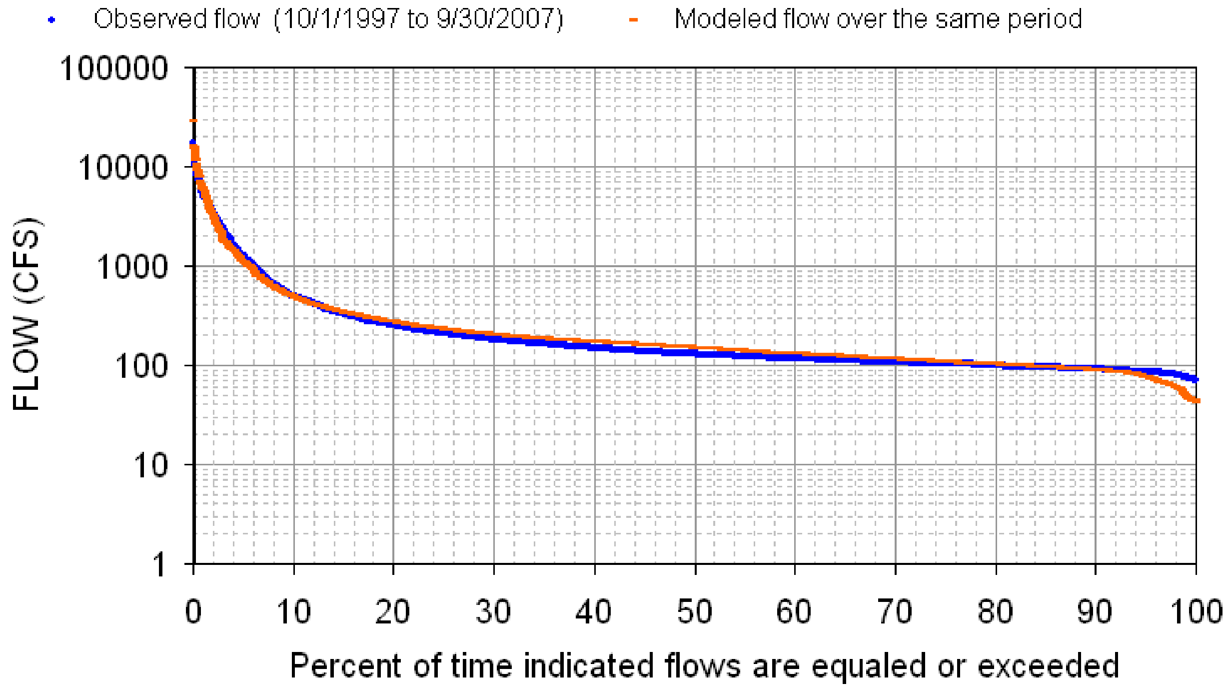

Figure D-5. Hydrologic Calibration: Loosahatchie River, USGS 07030240 (WYs1998-2007)

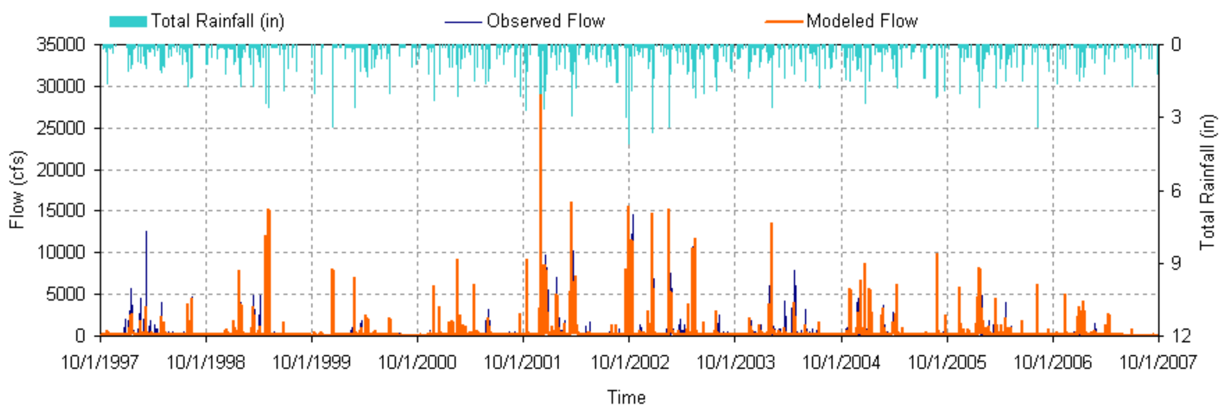

Figure D-6. 10-Year Hydrologic Comparison: Loosahatchie River, USGS 07030240

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 Anderson Branch provides guidance for implementation analysis:

The Anderson Branch watershed, HUC-12 080102050302, lies near Jackson. The drainage area for Anderson Branch is approximately 2,147 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 Anderson Branch at mile 0.5 was constructed using simulated daily mean flow for the period from 10/1/98 through 9/30/08 (mile 0.5 corresponds to the location of monitoring station ANDER000.5MN). 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 Anderson Branch (Figure E-2) was analyzed to determine the frequency with which observed daily water quality loads exceed the E. coli target maximum daily loading (487 CFU/100 mL x flow [cfs] x conversion factor) under four flow conditions (low, mid-range, moist, and high). Observation of the plot illustrates that the exceedances occured across several flow regimes indicating the Anderson Branch watershed may be impacted by multiple sources.

Critical conditions for the Anderson Branch watershed (HUC-12 080102050302) 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.

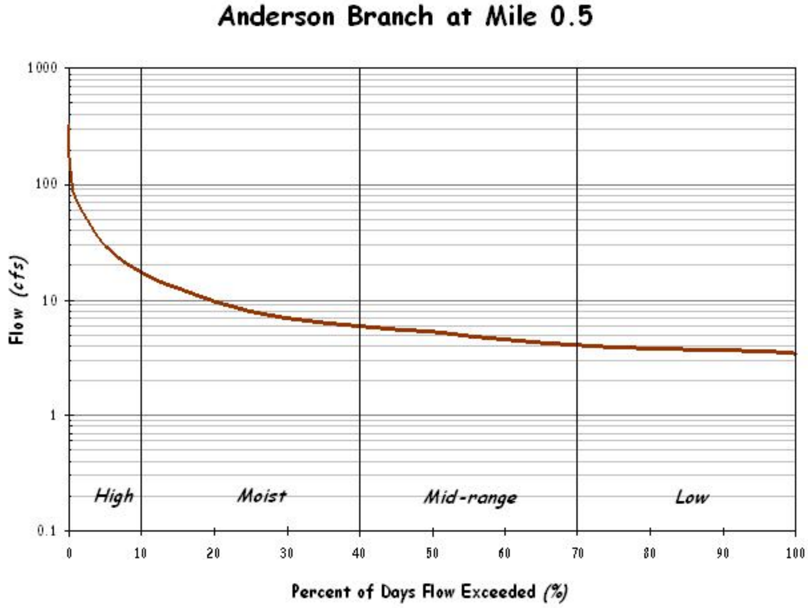

Figure E-1. Flow Duration Curve for Anderson Branch at Mile 0.5

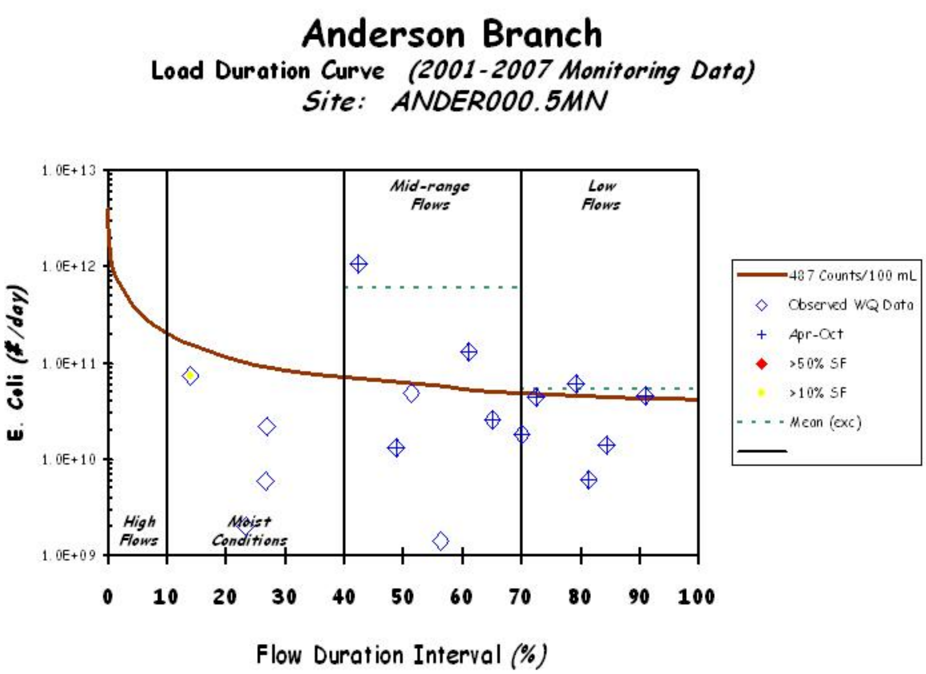

Figure E-2. E. Coli Load Duration Curve for Anderson Branch

Table E-1. Load Duration Curve Summary for Implementation Strategies (Example: Anderson Branch subwatershed, HUC-12 080102050302) (4 Flow Zones).

Hydrologic Condition		High	Moist	Mid-range	Low*
% Time Flow Exceeded		0-10	10-40	40-70	70-100
Anderson Branch (080102050302)	Number of Samples	0	4	6	6
	% > 487 CFU/100 mL[1]	NA	0.0	33.3	33.3
	Load Reduction[2]	NA	NR	25.5	5.2
TMDL (CFU/day)		3.548E+11	9.468E+10	5.892E+10	4.476E+10
Margin of Safety (CFU/day)		3.548E+10	9.468E+09	5.892E+09	4.476E+09
WLA (WWTFs) (CFU/day)		NA	NA	NA	NA
WLAs (MS4s) (CFU/day/acre)[3]		1.488E+08	3.970E+07	2.471E+07	1.877E+07
LA (CFU/day/acre)[3]		1.488E+08	3.970E+07	2.471E+07	1.877E+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 Anderson Branch subwatershed.
1 Tennessee Maximum daily water quality criterion for E. coli.
2 Reductions (percent) based on mean of observed percent load reductions in range.
3 LAs and MS4s are expressed as daily load per unit area in order to provide for future changes in the distribution of LAs and MS4s (WLAs).
4 Watershed-specific Best Management Practices for Urban Source reduction. Actual BMPs applied may vary and should not be limited according to this grouping.

Results indicate the implementation strategy for the Anderson Branch 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 Anderson Branch E. coli and implementation strategies for each source category covering the entire range of flow (Stiles, 2003). The implementation strategies listed in Table E-1 are a subset of the categories of BMPs and implementation strategies available for application to the South Fork Forked Deer 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-41.

Table E-41 presents LDC analyses (TMDLs, WLAs, LAs, and MOS) and PLRGs for all flow zones for all E. coli impaired waterbodies in the South Fork Forked Deer 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 Halls Creek provides guidance for implementation analysis.

The Halls Creek subwatershed, HUC-12 080102050505, lies in a non-urbanized area of Lauderdale county. The drainage area for Halls Creek is approximately 19,238 acres (30.1 mi^2); therefore, five flow zones were used for the duration curve analysis (see Sect. 9.1.1). The landuse for Halls Creek is approximately 75.8% 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 Halls 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-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 (see Appendix C).

The E. coli LDC for Halls 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 exceedances occur in multiple flow zones indicating that the Halls Creek watershed may be impacted by both point-type and 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-31.

Critical conditions for the Halls 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 under a variety of 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 Halls Creek watershed. However, it is possible that both point and non-point type sources contribute to exceedances of the E. coli standard in Halls Creek.

Results indicate the implementation strategy for the Halls 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 Halls 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 South Fork Forked Deer 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-41.

Table E-41 presents LDC analyses (TMDLs, WLAs, LAs, and MOS) and PLRGs for all flow zones for all E. coli impaired waterbodies in the South Fork Forked Deer River watershed.

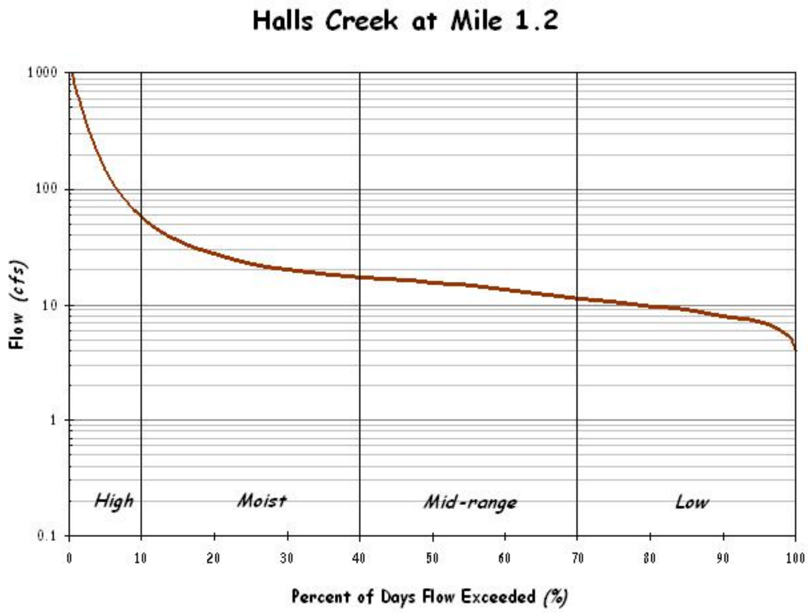

Figure E-3. Flow Duration Curve for Halls Creek at Mile 1.2

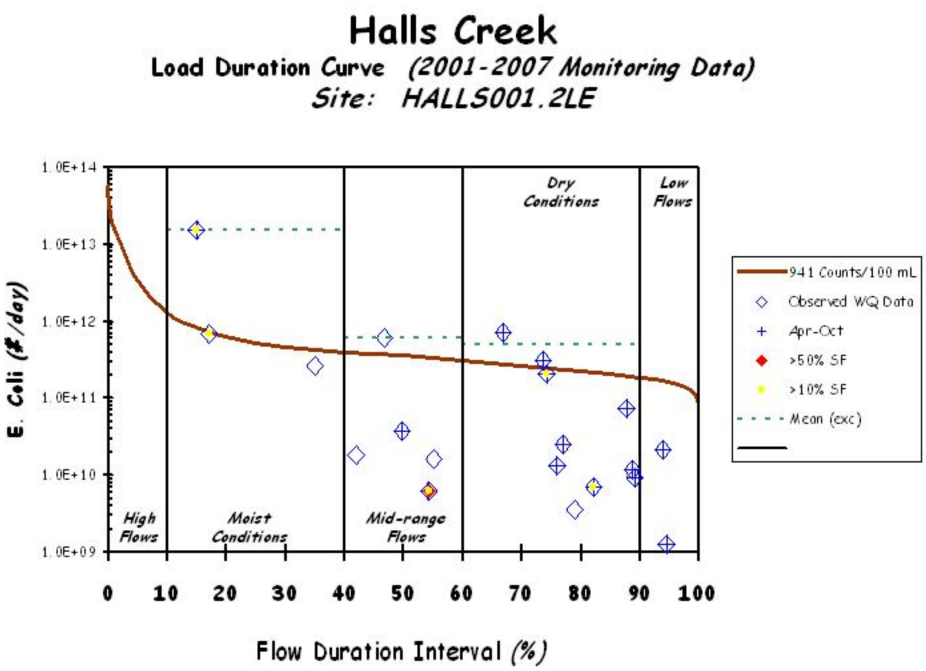

Figure E-4. E. Coli Load Duration Curve for Halls Creek

Table E-2. Load Duration Curve Summary for Implementation Strategies (Example: Halls Creek subwatershed, HUC-12 080102050505) (5 Flow Zones).

Hydrologic Condition		High	Moist	Mid-range	Dry*	Low
% Time Flow Exceeded		0-10	10-40	40-60	60-90	90-100
Halls Creek (080102050505)	Number of Samples	0	3	5	10	2
	% > 941 CFU/100 mL[1]	NA	33.3	20.0	20.0	0.0
	Load Reduction[2]	NA	31.5%	7.9%	8.3%	NR
TMDL (CFU/day)		1.755E+12	2.719E+11	1.866E+11	1.260E+11	8.484E+10
Margin of Safety (CFU/day)		1.755E+11	2.719E+10	1.866E+10	1.260E+10	8.484E+09
WLA (WWTFs) (CFU/day)		NA	NA	NA	NA	NA
WLAs (MS4s) (CFU/day/acre)[3]		9.333E+07	1.446E+07	9.922E+06	6.700E+06	4.511E+05
LA (CFU/day/acre)[3]		9.333E+07	1.446E+07	9.922E+06	6.700E+06	4.511E+05
Implementation Strategies[4]						
Municipal NPDES			L	M	H	H
Stormwater Management			H	H		
SSO Mitigation		H	M	L		
Collection System Repair			H	M	L	
Septic System Repair			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 Halls 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 South Fork Forked Deer 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 Anderson Branch.

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
6/5/01	7,701	5.80	1.09E+12	6.90E+10	93.7
4/3/01	101.4	5.39	1.34E+10	6.42E+10	0 (-380)
3/5/02	387.3	5.21	4.93E+10	6.20E+10	0 (-25.7)
11/6/01	12	4.82	1.41E+09	5.74E+10	0 (-3,958)
4/12/07	1,200	4.49	1.32E+11	5.35E+10	59.4
5/8/01	248.1	4.29	2.60E+10	5.11E+10	0 (-96.3)
Percent Load Reduction Goal (PLRG) for Mid-Range Conditions (Mean)					**25.5**

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 Anderson Branch.

Example – *High Flow Zone Percent Load Reduction Goal = NA*
Moist Conditions Flow Zone Percent Load Reduction Goal = NR
Mid-Range Flow Zone Percent Load Reduction Goal = 25.5
Low Flow Zone Percent Load Reduction Goal = 5.2

Therefore, the critical flow zone for prioritization of Anderson Branch 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 Anderson Branch:

Flow Zone	Number of Samples	Samples > 487 CFU/100 mL	% > 487 CFU/100 mL
High	0	NA	NA
Moist	4	0	0.0
Mid-Range	***6***	***2***	***33.3***
Low	6	2	33.3

The critical flow zone for prioritization of Anderson Branch 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. The following example is from South Fork Forked Deer River at RM30.6.

Zone	Period of Record (2001-2009)			Most Recent (2003-2009)		
	# of samples	% Red.	% Exc.	# of samples	% Red.	% Exc.
High	4	58.7	75	2	80.0	100
Moist	15	**30.9**	**40**	9	**20.9**	**33.3**
Mid-Range	7	10.3	14.3	4	NR	0
Dry	16	5.9	18.8	9	6.8	22.2
Low	3	NR	0	3	NR	0

The critical flow zone for prioritization of implementation activities, as with the Anderson Branch example above, is confirmed as the same zone (moist flow zone for SFFD RM30.6) 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-41.

Table E-3. Summary of Critical Conditions for Impaired Waterbodies in the South Fork Forked Deer River Watershed.

Waterbody ID	Moist	Mid-range	Dry	Low
South Fork Forked Deer River (018-1000) [a]	ò			
UT to South Fork Forked Deer River [b]				ò
Bear Creek [b]				ò
0200s (North Fork of South Fork Forked Deer River) [a]			ò	
Sandy Creek [b]	ò			
Central Creek [b]				ò
Anderson Branch [b]		ò		
Bond Creek [b]	ò			
Hicks Creek [b]	ò			
South Fork Forked Deer River (012-1000) [a]		ò		
Cub Creek [b]				ò
Panther Creek [b]	ò			
0401 (Little Nixon Creek) [b]				ò
0402 (Meridian Creek) [b]	ò			
Nixon Creek [a]		ò		
0501 (Mud Creek) [b]	ò			
0502 (Kail Creek) [b]	ò			
Jacobs Creek [b]	ò			
South Fork Forked Deer River (010-1000) [a]	ò			
0504 (Black Creek) [a]		ò		
UT to Tisdale Creek [b]				ò
0505 (Halls Creek) [a]	ò			
0506 (Mill Creek) [b]				ò
South Fork Forked Deer River (001-1000) [a]	ò			
South Fork Forked Deer River (003-1000) [a]				

[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 = Mill Creek*
Sampling Period = 9/5/06 – 9/25/09
Geometric Mean Concentration = 651.6 CFU/100 mL
Target Concentration = 126 CFU/100 mL
Reduction to Target = 80.7%

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.

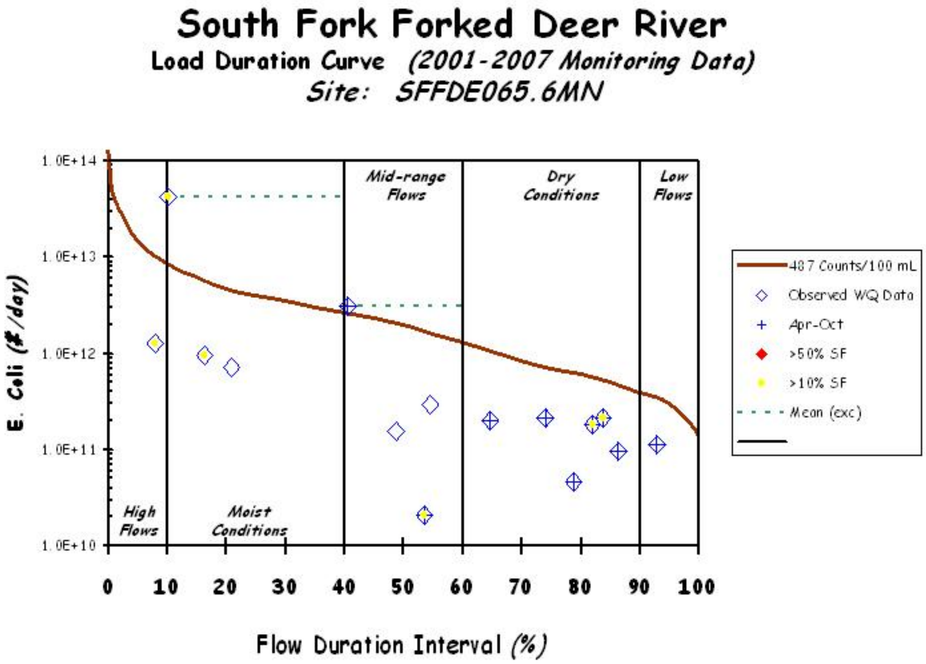

Figure E-5. E. Coli Load Duration Curve for South Fork Forked Deer River – RM65.6

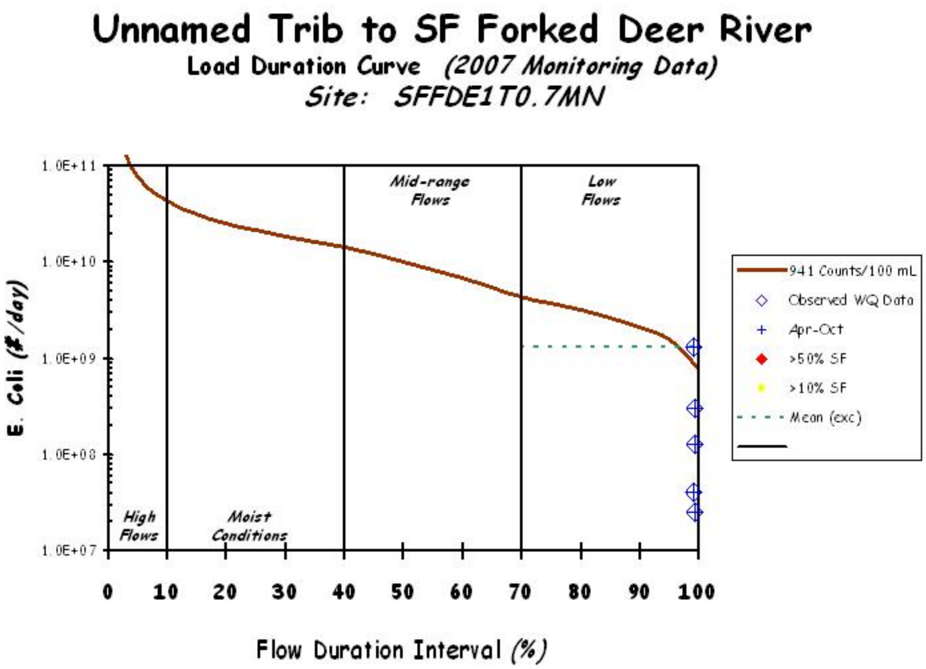

Figure E-6. E. Coli Load Duration Curve for Unnamed Tributary to South Fork Forked Deer River – RM0.7

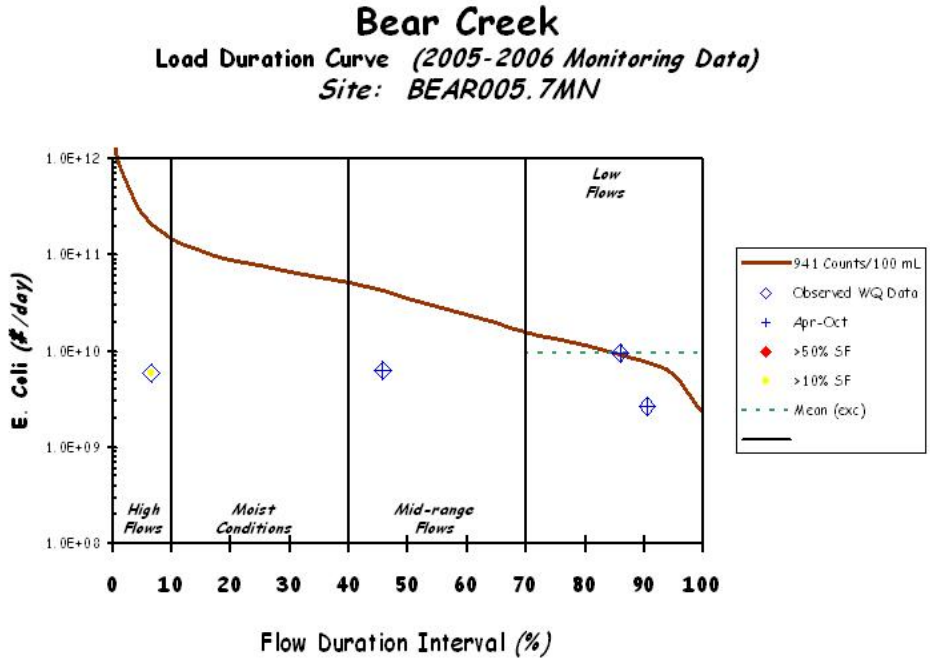

Figure E-7. E. Coli Load Duration Curve for Bear Creek – RM5.7

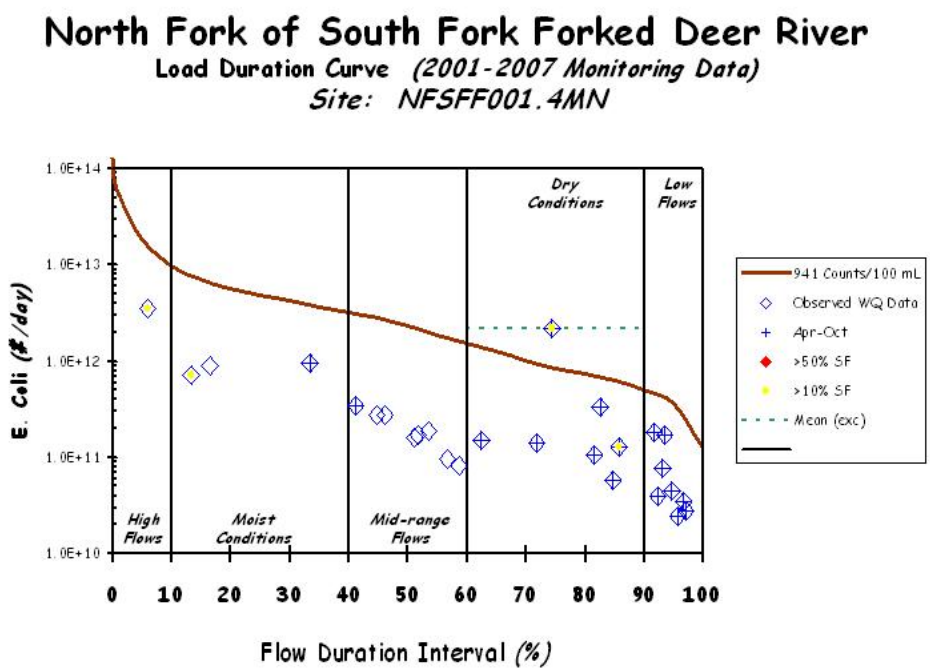

Figure E-8. E. Coli Load Duration Curve for North Fork of the South Fork Forked Deer River – RM1.4

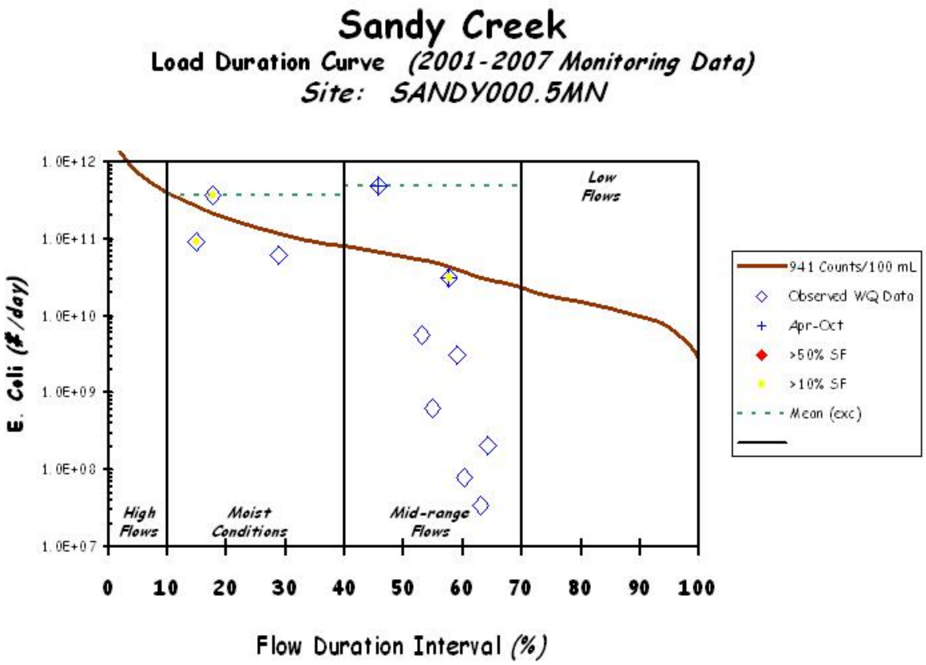

Figure E-9. E. Coli Load Duration Curve for Sandy Creek

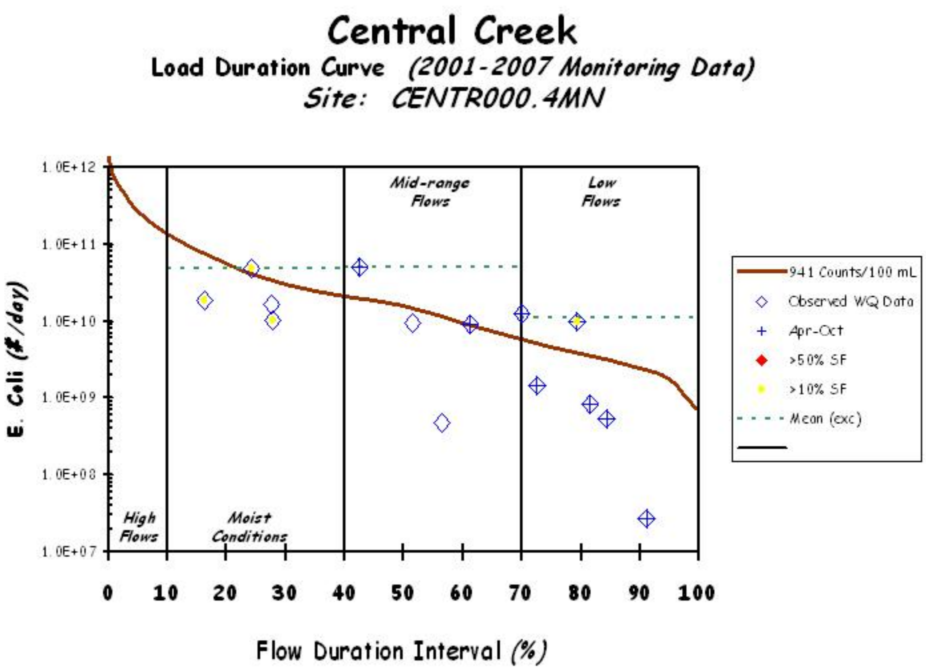

Figure E-10. E. Coli Load Duration Curve for Central Creek

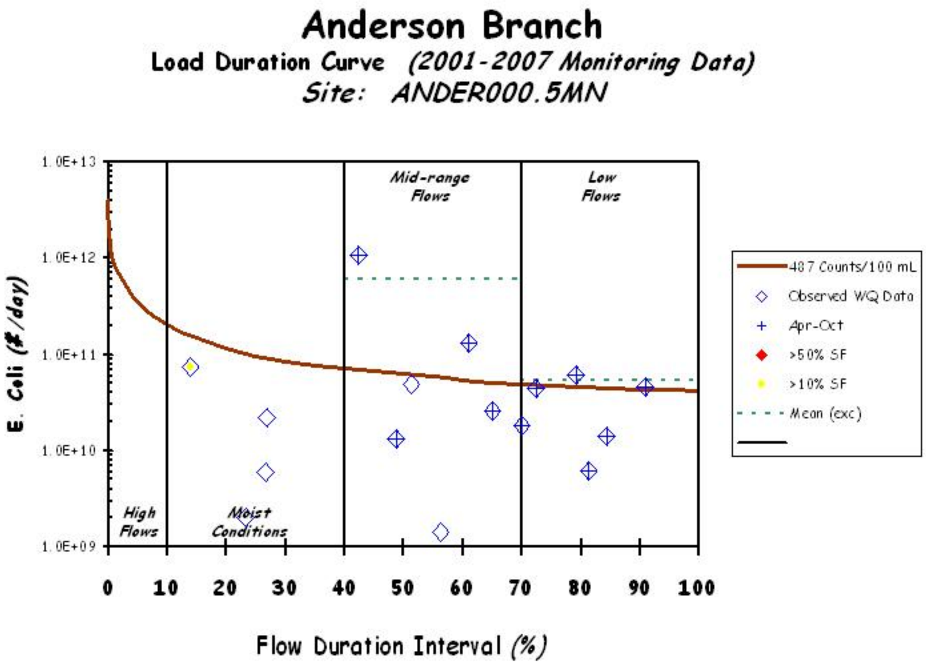

Figure E-11. E. Coli Load Duration Curve for Anderson Branch

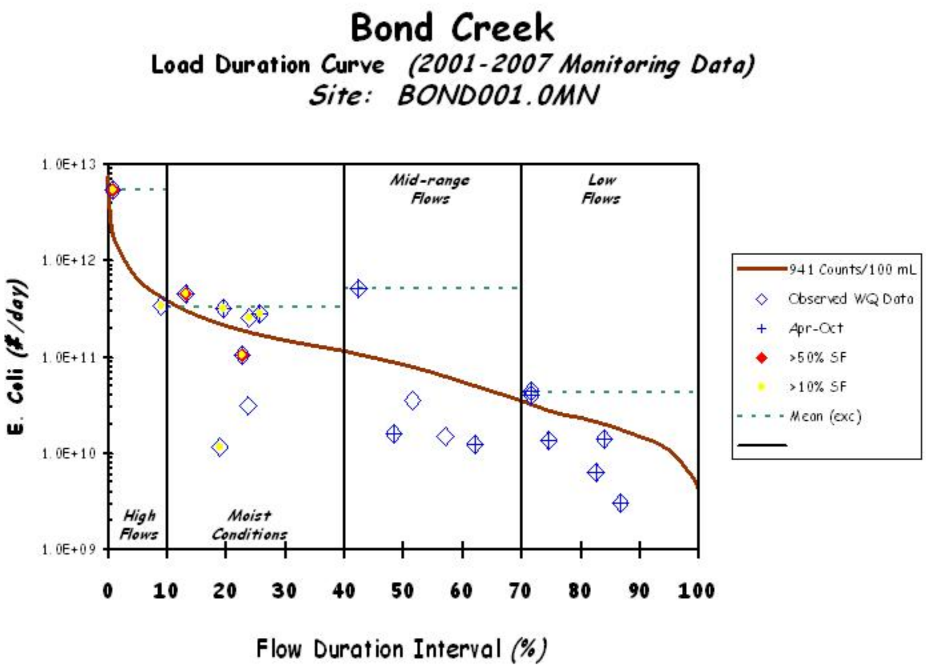

Figure E-12. E. Coli Load Duration Curve for Bond Creek

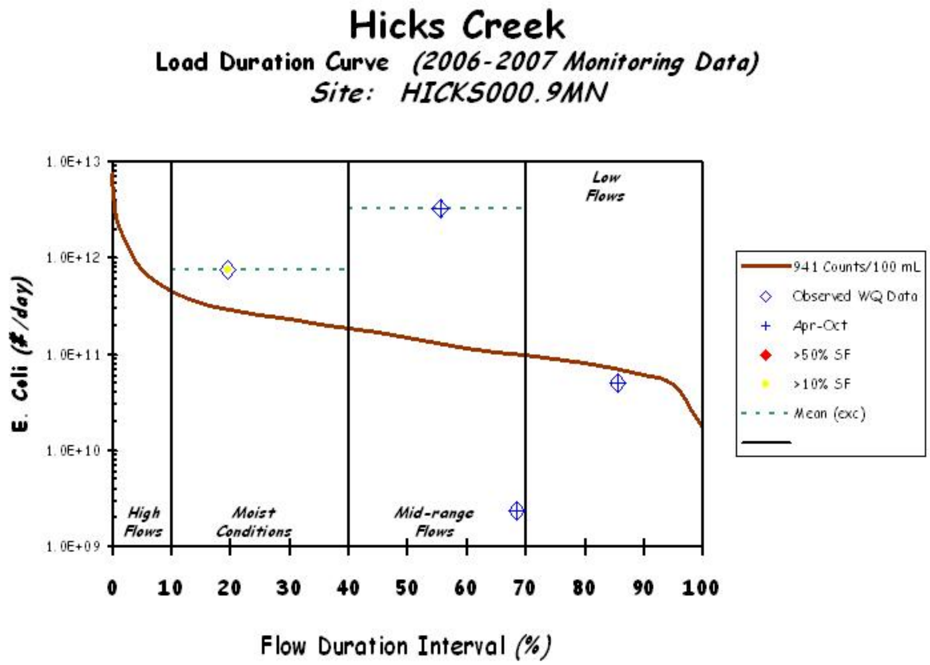

Figure E-13. E. Coli Load Duration Curve for Hicks Creek

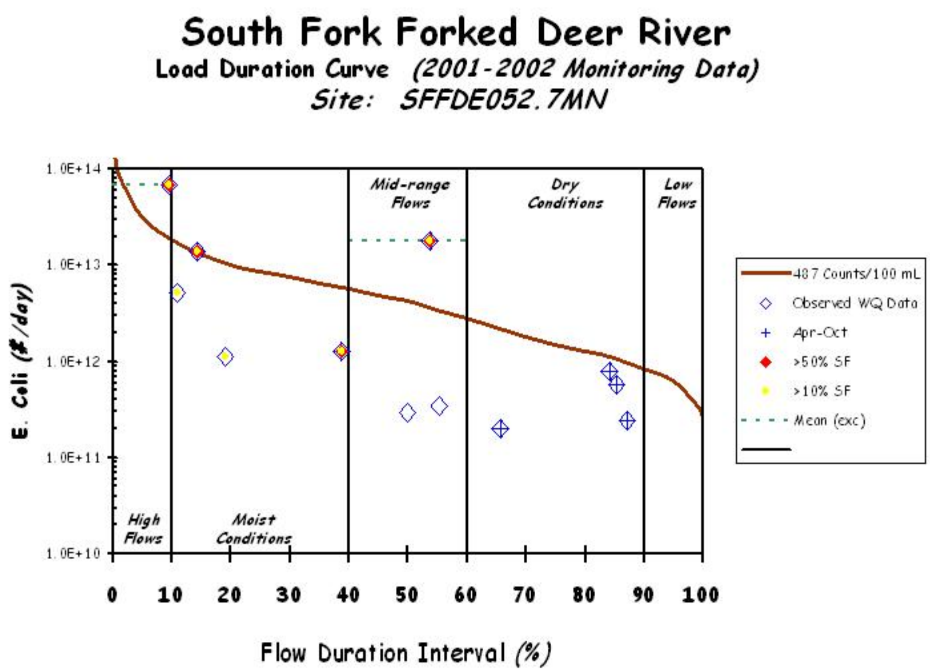

Figure E-14. E. Coli Load Duration Curve for South Fork Forked Deer River – RM52.7

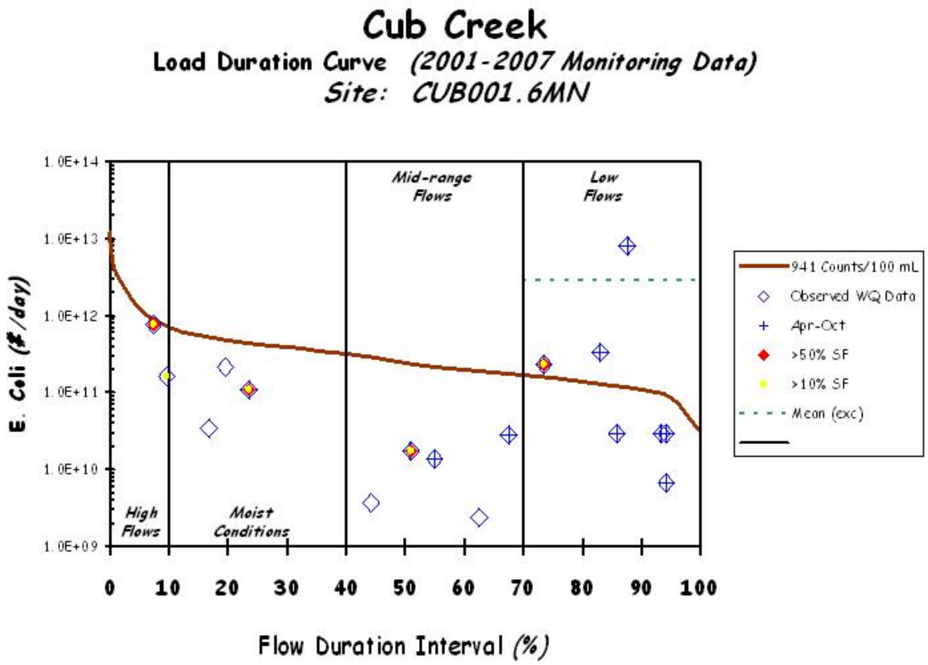

Figure E-15. E. Coli Load Duration Curve for Cub Creek

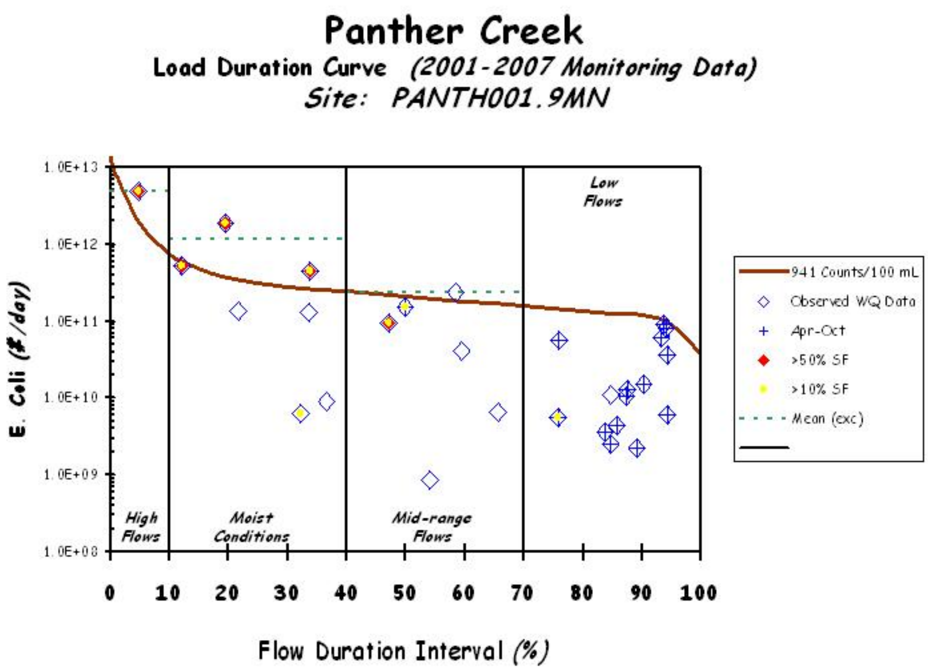

Figure E-16. E. Coli Load Duration Curve for Panther Creek – RM1.9

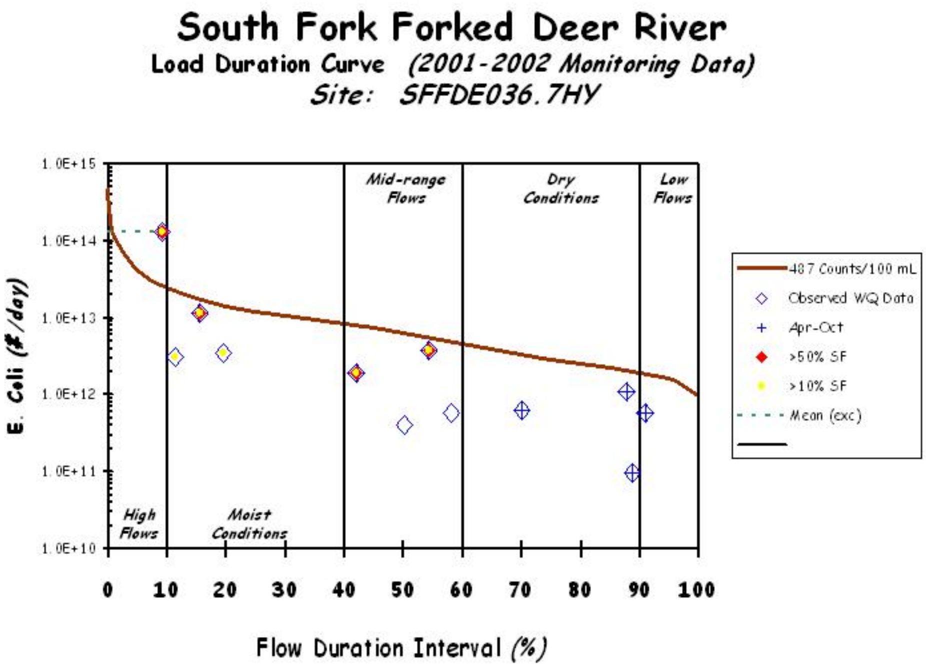

Figure E-17. E. Coli Load Duration Curve for South Fork Forked Deer River – RM36.7

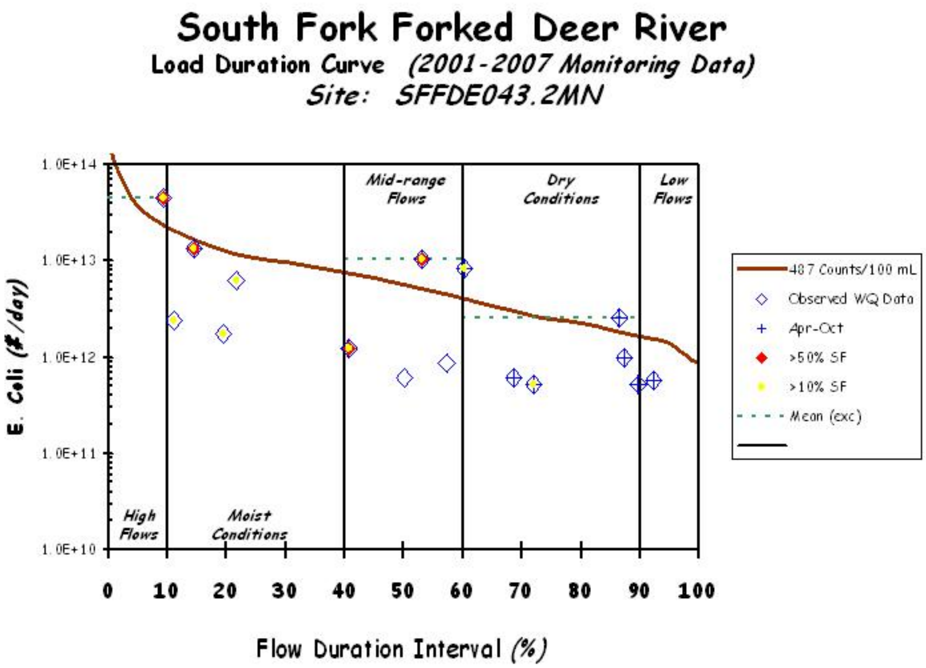

Figure E-18. E. Coli Load Duration Curve for South Fork Forked Deer River – RM43.2

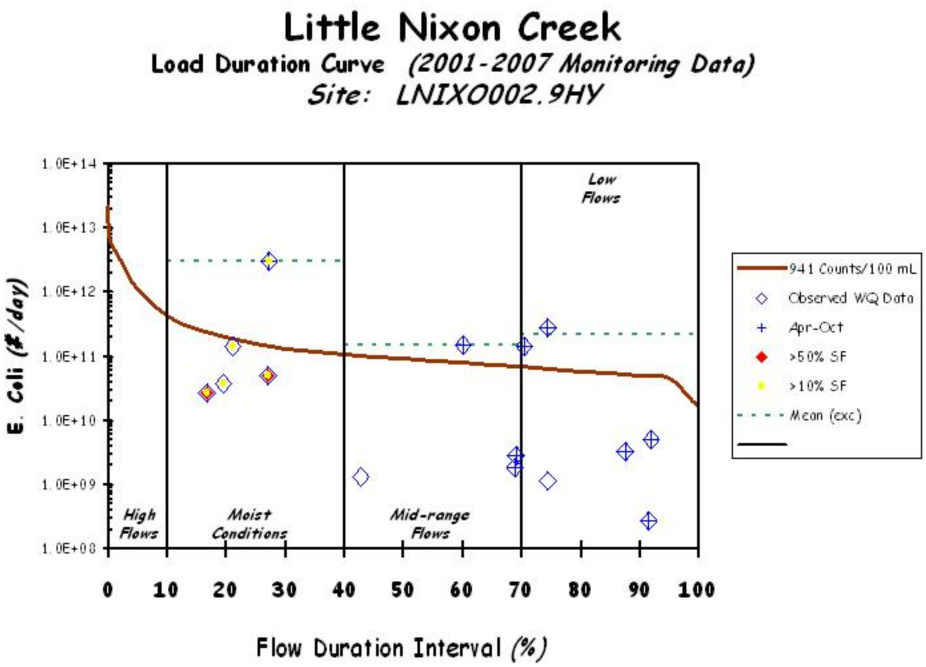

Figure E-19. E. Coli Load Duration Curve for Little Nixon Creek – RM2.9

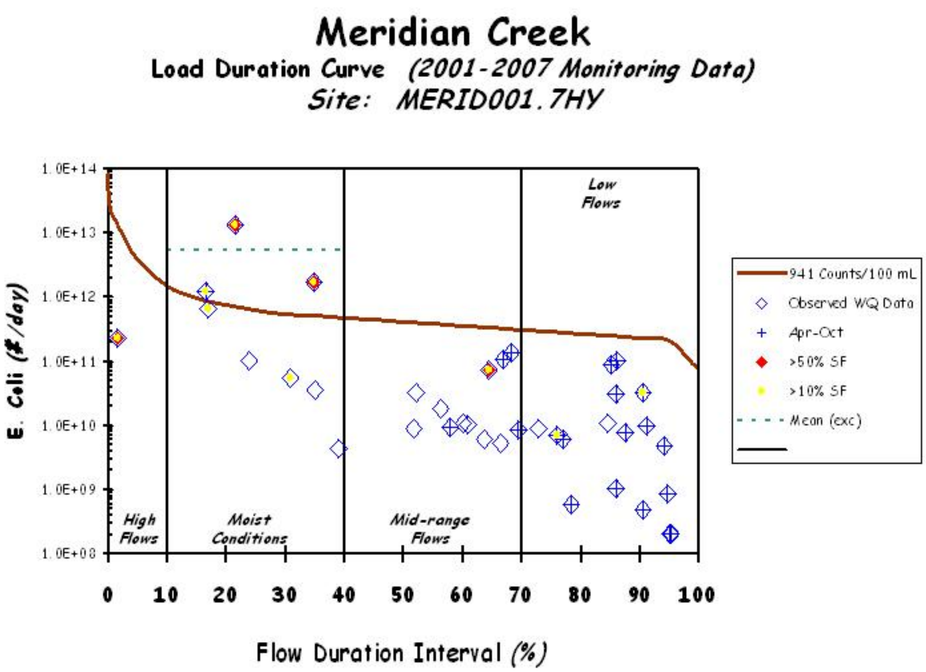

Figure E-20. E. Coli Load Duration Curve for Meridian Creek – RM1.7

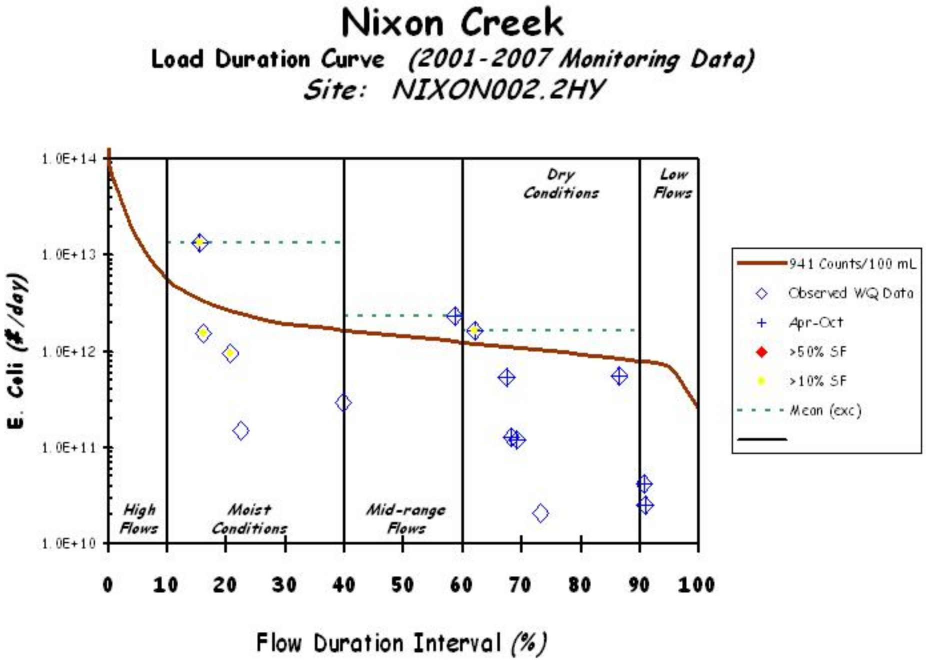

Figure E-21. E. Coli Load Duration Curve for Nixon Creek – RM2.2

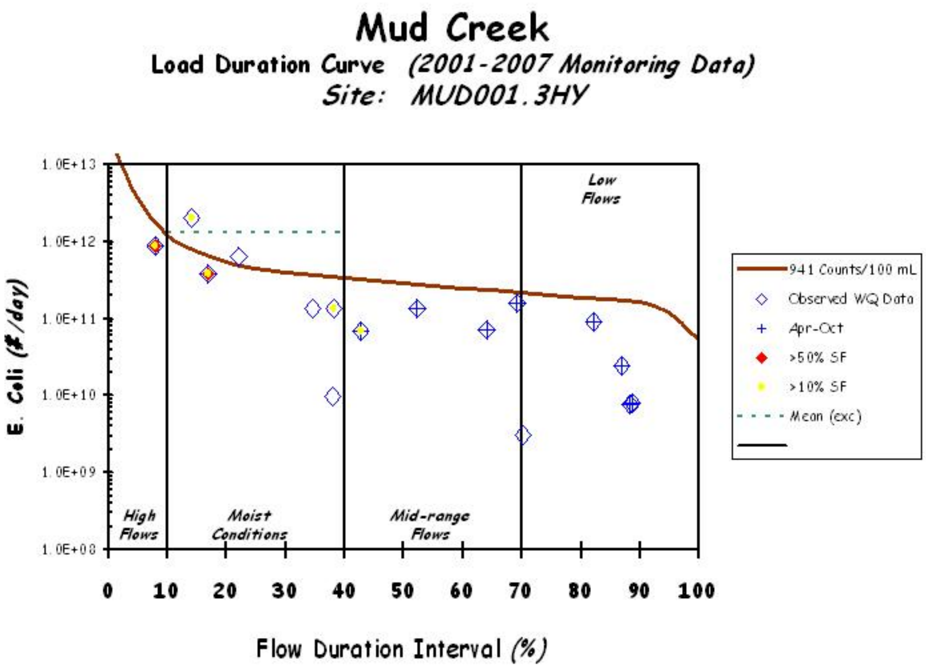

Figure E-22. E. Coli Load Duration Curve for Mud Creek – RM1.3

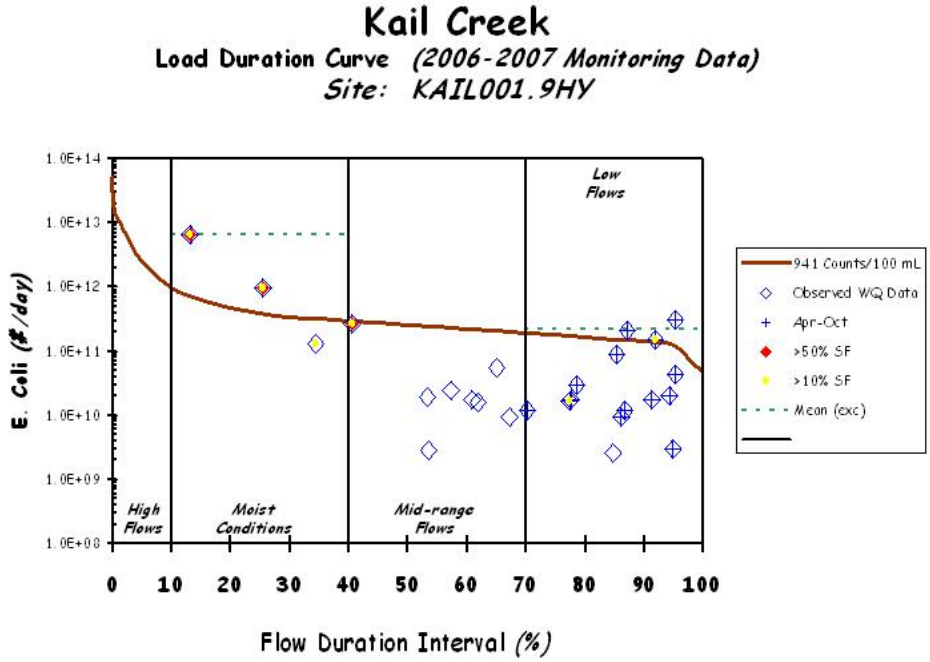

Figure E-23. E. Coli Load Duration Curve for Kail Creek – RM1.9

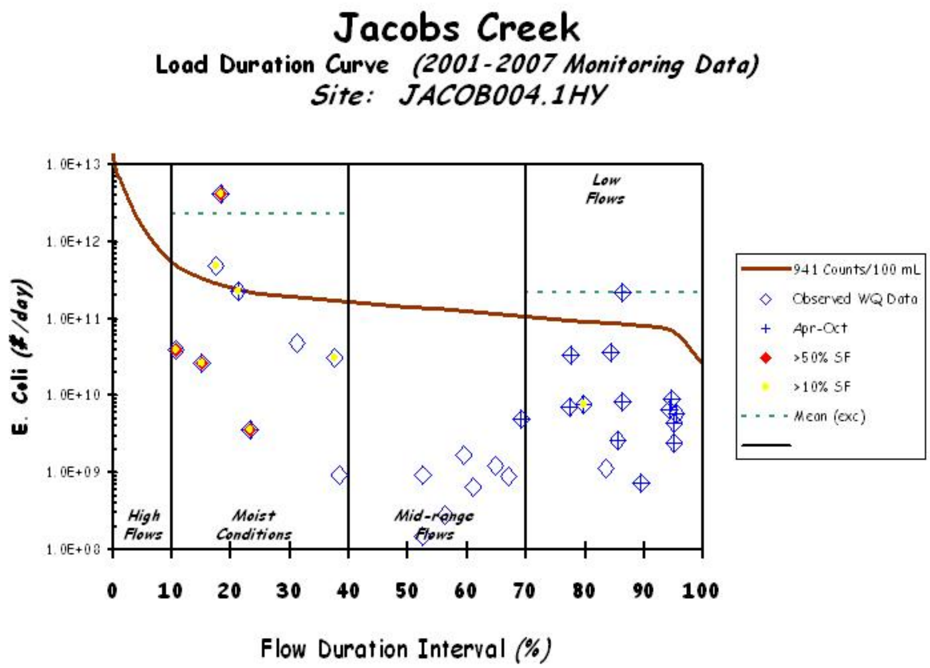

Figure E-24. E. Coli Load Duration Curve for Jacobs Creek – RM4.1

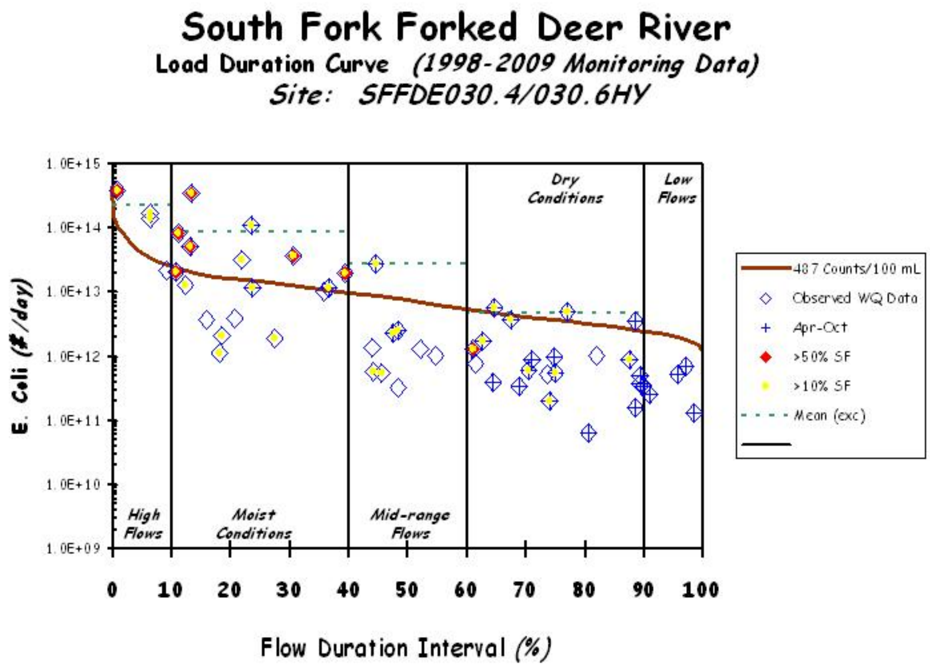

Figure E-25. E. Coli Load Duration Curve for South Fork Forked Deer River – RM30.4/30.6

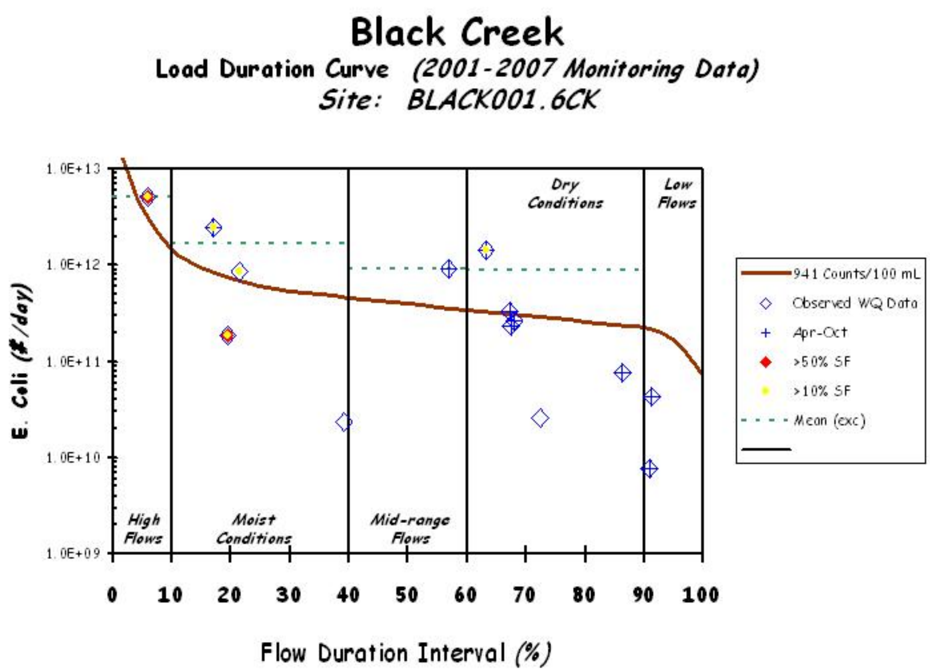

Figure E-26. E. Coli Load Duration Curve for Black Creek – RM1.6

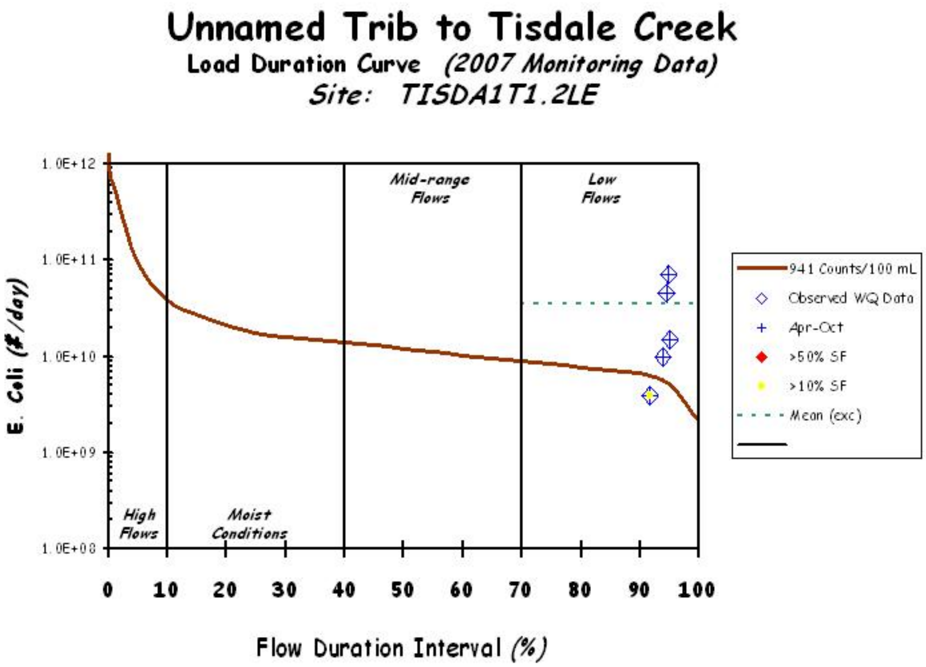

Figure E-27. E. Coli Load Duration Curve for Unnamed Tributary to Tisdale Creek – RM0.7

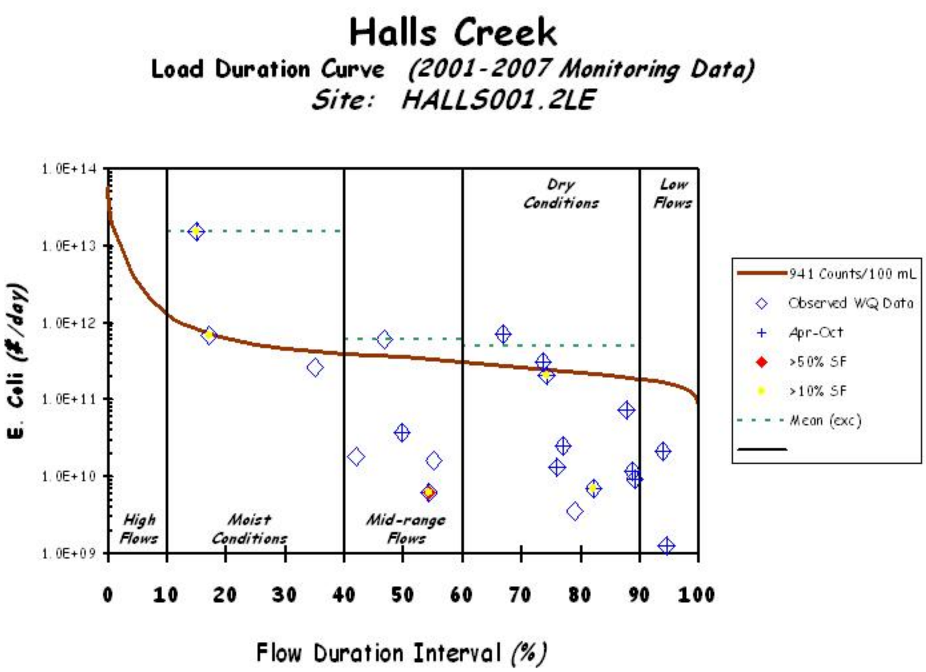

Figure E-28. E. Coli Load Duration Curve for Halls Creek – RM1.2

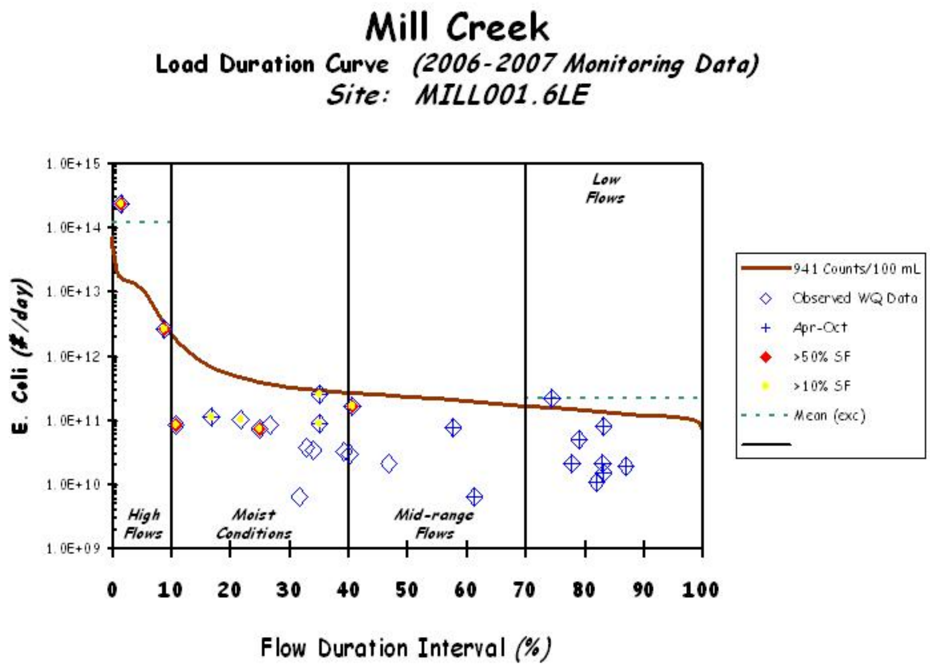

Figure E-29. E. Coli Load Duration Curve for Mill Creek – RM.5

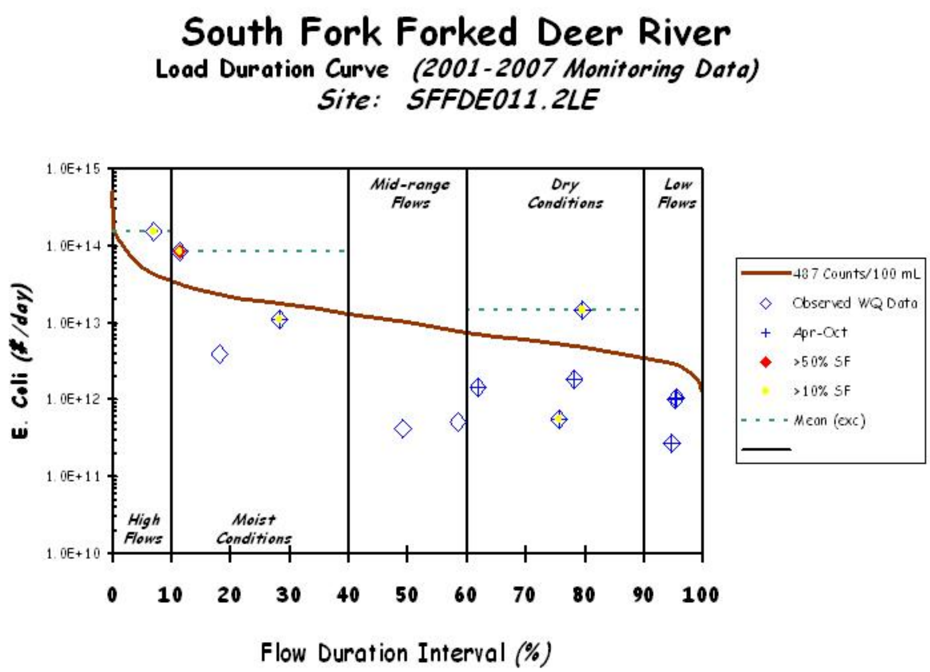

Figure E-30. E. Coli Load Duration Curve for South Fork Forked Deer River – RM11.2

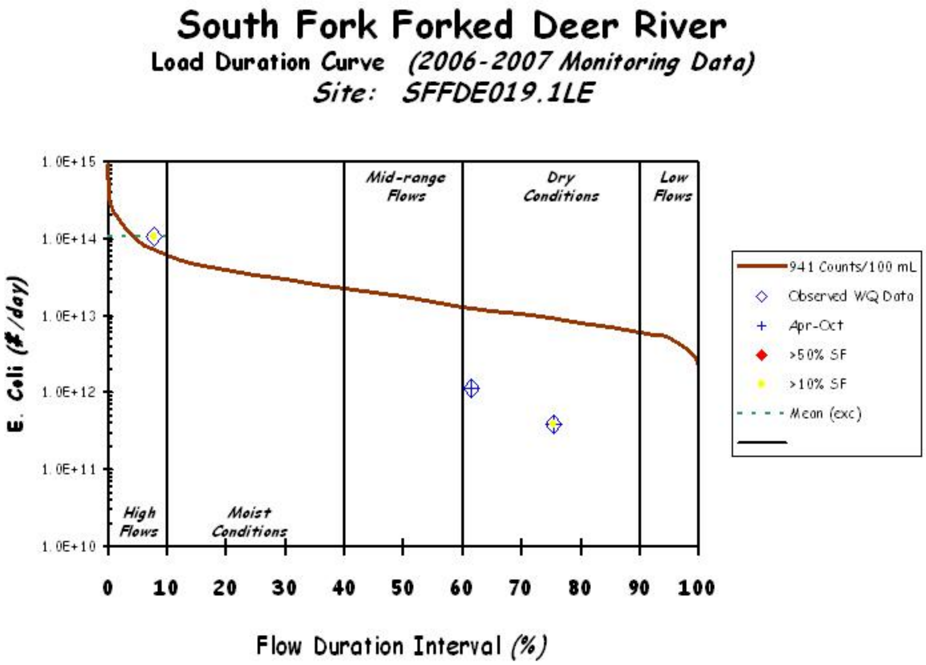

Figure E-31. E. Coli Load Duration Curve for South Fork Forked Deer River – RM19.1

Table E-4. Calculated Load Reduction Based on Daily Loading – South Fork Forked Deer River – RM65.6

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]	[%]	[%]	[%]
12/4/01	High Flows	868.0	8.0%	59.1	1.26E+12	NR	**NR**	**NR**
1/16/07	Moist Conditions	720.0	10.1%	2,400	4.23E+13	**79.7**	**26.6**	**27.3**
1/8/02		469.5	16.4%	83.6	9.60E+11	NR		
2/5/02		385.7	20.9%	75.4	7.12E+11	NR		
6/5/01	Mid-Range Flows	217.9	40.6%	579.4	3.09E+12	**15.9**	**4.0**	**6.1**
3/5/02		173.6	48.9%	36.4	1.55E+11	NR		
4/17/07		143.5	53.6%	6	2.11E+10	NR		
11/6/01		136.9	54.6%	86.5	2.90E+11	NR		
5/8/01	Dry Conditions	89.8	64.7%	90.9	2.00E+11	NR	**NR**	**NR**
7/10/01		60.7	74.2%	143.9	2.14E+11	NR		
7/18/06		52.1	78.9%	36	4.59E+10	NR		
8/7/01		47.7	82.0%	156.5	1.83E+11	NR		
9/11/01		44.4	83.8%	198.9	2.16E+11	NR		
10/2/01		39.4	86.5%	98.5	9.49E+10	NR		
10/10/06	Low Flows	28.7	93.1%	160	1.12E+11	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-5. Calculated Load Reduction Based on Daily Loading – UT to South Fork Forked Deer River – RM0.7

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
8/15/07	Dry Conditions	0.038	99.3%	43	4.04E+07	NR	**6.7**	**7.7**
8/16/07		0.038	99.3%	1,413	1.32E+09	**33.4**		
8/20/07		0.038	99.5%	140	1.29E+08	NR		
8/21/07		0.037	99.5%	326	2.98E+08	NR		
8/22/07		0.037	99.5%	28	2.53E+07	NR		

Note: NR = No reduction required
NA = Not applicable

Table E-6. Calculated Load Reduction Based on Geomean Data – UT to South Fork Forked Deer River – RM0.7

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
8/15/07	0.038	99.3%	43			
8/16/07	0.038	99.3%	1,413			
8/20/07	0.038	99.5%	140			
8/21/07	0.037	99.5%	326			
8/22/07	0.037	99.5%	28	**150.7**	**16.4**	**25.0**

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

Table E-7. Calculated Load Reduction Based on Daily Loading – Bear Creek – RM5.7

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]	[%]	[%]	[%]
1/26/06	High Flows	9.53	6.6%	25.3	5.90E+09	NR	**NR**	**NR**
4/12/06	Mid-Range Flows	1.85	45.8%	140	6.33E+09	NR	**NR**	**NR**
10/6/05	Low Flows	0.39	86.1%	1000	9.61E+09	**5.9**		
8/10/05		0.33	90.6%	325.5	2.63E+09	NR	**3.0**	**6.7**

Note: NR = No reduction required
NA = Not applicable

Table E-8. Calculated Load Reduction Based on Daily Loading – North Fork of South Fork Forked Deer River – RM1.4

Sample Date	Flow Regime	Flow [cfs]	PDFE [%]	Concentration [CFU/100 ml]	Load [CFU/day]	% Reduction to Achieve TMDL [%]	Average of Load Reductions [%]	% Reduction to TMDL – MOS [%]
12/4/01	High Flows	708.9	6.0%	201.4	3.49E+12	NR	**NR**	**NR**
1/8/02	Moist Conditions	349.7	13.3%	83.6	7.15E+11	NR		
2/5/02		285.7	16.6%	126.7	8.86E+11	NR		
6/5/01		167.5	33.4%	235.9	9.67E+11	NR	**NR**	**NR**
4/3/01	Mid-Range Flows	135.4	41.3%	103.9	3.44E+11	NR		
3/5/02		121.7	44.8%	90.9	2.71E+11	NR		
3/7/07		115.7	46.2%	97	2.75E+11	NR		
11/6/01		96.0	51.1%	67.7	1.59E+11	NR		
3/12/07		92.5	51.8%	74	1.68E+11	NR		
3/14/07		85.8	53.5%	89	1.87E+11	NR		
3/19/07		76.0	56.8%	52	9.67E+10	NR		
3/21/07		69.5	58.8%	48	8.16E+10	NR	**NR**	**NR**
5/8/01	Dry Conditions	61.5	62.6%	100.6	1.51E+11	NR		
7/10/01		40.6	72.0%	139.6	1.39E+11	NR		
9/19/06		37.4	74.6%	2,400	2.19E+12	**60.8**		
8/7/01		30.3	81.7%	142.1	1.05E+11	NR		
9/11/01		29.6	82.6%	461.1	3.34E+11	NR		
10/2/01		27.7	84.9%	86.5	5.85E+10	NR		
9/21/06		26.6	85.9%	200	1.30E+11	NR	**8.7**	**9.1**
9/7/06	Low Flows	20.2	91.8%	370	1.83E+11	NR		
6/7/07		19.5	92.5%	84	4.00E+10	NR		
9/14/06		18.3	93.3%	170	7.62E+10	NR		
9/12/06		18.1	93.6%	390	1.73E+11	NR		
6/12/07		16.2	94.9%	114	4.52E+10	NR		
6/14/07		14.8	95.9%	67	2.43E+10	NR		
6/19/07		13.2	96.9%	108	3.50E+10	NR		
6/21/07		12.7	97.3%	89	2.76E+10	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-9. Calculated Load Reduction Based on Geomean Data – North Fork of South Fork Forked Deer River – RM1.4

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]	[%]	[%]
9/7/06	20.19	91.8%	370			
9/12/06	18.11	93.6%	390			
9/14/06	18.31	93.3%	170			
9/19/06	37.36	74.6%	2400			
9/21/06	26.62	85.9%	200	**411.3**	**69.4**	**72.5**
3/7/07	115.70	46.2%	97			
3/12/07	92.54	51.8%	74			
3/14/07	85.80	53.5%	89			
3/19/07	75.97	56.8%	52			
3/21/07	69.47	58.8%	48	**69.3**	**NR**	**NR**
6/7/07	19.48	92.5%	84			
6/12/07	16.22	94.9%	114			
6/14/07	14.83	95.9%	67			
6/19/07	13.23	96.9%	108			
6/21/07	12.67	97.3%	89	**90.8**	**NR**	**NR**

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

Table E-10. Calculated Load Reduction Based on Daily Loading – Sandy Creek – RM0.5

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
12/4/01	Moist Conditions	11.60	13.6%	325.5	9.24E+10	NR		
1/16/07		9.39	16.4%	1,600	3.68E+11	**41.2**		
2/5/02		5.10	26.5%	488.4	6.10E+10	NR	**13.7**	**15.3**
6/5/01	Mid-Range Flows	2.93	42.8%	6,867	4.92E+11	**86.3**		
3/6/07		2.30	50.5%	100	5.64E+09	NR		
3/7/07		2.16	52.3%	12	6.34E+08	NR		
4/17/07		1.88	55.3%	690	3.18E+10	NR		
3/12/07		1.75	56.6%	74	3.16E+09	NR		
3/14/07		1.62	57.9%	2	7.93E+07	NR		
3/19/07		1.42	61.0%	1	3.48E+07	NR		
3/21/07		1.31	62.3%	6.3	2.03E+08	NR	**10.8**	**10.9**

Note: NR = No reduction required
NA = Not applicable

Table E-11. Calculated Load Reduction Based on Daily Loading – Central Creek – RM0.4

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
12/4/01	Moist Conditions	3.36	16.3%	225.4	1.85E+10	NR	4.0	5.7
1/8/02		1.76	24.4%	1119.9	4.83E+10	**16.0**		
2/5/02		1.46	27.7%	461.2	1.64E+10	NR		
1/11/07		1.45	27.8%	290	1.03E+10	NR		
6/5/01	Mid-Range Flows	0.86	42.6%	2419.2	5.11E+10	**61.1**	15.3	17.5
3/5/02		0.64	51.6%	613.1	9.62E+09	NR		
11/6/01		0.51	56.6%	38.2	4.75E+08	NR		
4/12/07		0.40	61.3%	920	8.91E+09	NR		
7/13/06	Low Flows	0.25	70.2%	2000	1.23E+10	**53.0**	19.0	20.2
7/10/01		0.22	72.7%	275.5	1.47E+09	NR		
8/7/01		0.17	79.5%	2419.2	1.00E+10	**61.1**		
9/11/01		0.16	81.6%	214.3	8.19E+08	NR		
10/2/01		0.14	84.4%	157.6	5.32E+08	NR		
10/11/06		0.10	91.3%	11	2.74E+07	NR		

Note: NR = No reduction required
NA = Not applicable

Table E-12. Calculated Load Reduction Based on Daily Loading – Anderson Branch – RM0.5

Sample Date	Flow Regime	Flow [cfs]	PDFE [%]	Concentration [CFU/100 ml]	Load [CFU/day]	% Reduction to Achieve TMDL [%]	Average of Load Reductions [%]	% Reduction to TMDL – MOS [%]
12/4/01	Moist Conditions	13.41	13.9%	228.2	7.49E+10	NR	**NR**	**NR**
1/8/02		8.45	23.4%	9.7	2.00E+09	NR		
2/5/02		7.58	26.6%	31.8	5.89E+09	NR		
1/11/07		7.53	26.9%	120	2.21E+10	NR		
6/5/01	Mid-Range Flows	5.80	42.5%	7701	1.09E+12	**93.7**	**25.5**	**26.3**
4/3/01		5.39	48.9%	101.4	1.34E+10	NR		
3/5/02		5.21	51.3%	387.3	4.93E+10	NR		
11/6/01		4.82	56.3%	12	1.41E+09	NR		
4/12/07		4.49	61.2%	1200	1.32E+11	**59.4**		
5/8/01		4.29	65.1%	248.1	2.60E+10	NR		
7/13/06	Low Flows	4.07	70.2%	180	1.79E+10	NR	**5.2**	**8.9**
7/10/01		3.98	72.6%	461.1	4.49E+10	NR		
8/7/01		3.84	79.3%	648.8	6.09E+10	**24.9**		
9/11/01		3.80	81.5%	65.7	6.11E+09	NR		
10/2/01		3.74	84.5%	152.9	1.40E+10	NR		
10/11/06		3.64	91.0%	520	4.63E+10	**6.3**		

Note: NR = No reduction required
NA = Not applicable

Table E-13. Calculated Load Reduction Based on Daily Loading – Bond Creek – RM1.0

Sample Date	Flow Regime	Flow [cfs]	PDFE [%]	Concentration [CFU/100 ml]	Load [CFU/day]	% Reduction to Achieve TMDL [%]	Average of Load Reductions [%]	% Reduction to TMDL – MOS [%]
5/31/01	High Flows	92.89	0.7%	2419.2	5.50E+12	**61.1**	**30.6**	**32.1**
12/4/01		18.30	8.9%	770.1	3.45E+11	NR		
6/6/01	Moist Conditions	13.13	13.1%	1413.6	4.54E+11	**33.4**	**19.1**	**22.2**
1/8/02		9.63	19.0%	48.8	1.15E+10	NR		
6/7/01		9.39	19.5%	1413.6	3.25E+11	**33.4**		
5/30/01		8.26	22.7%	517.2	1.05E+11	NR		
2/5/02		7.97	23.7%	160.7	3.14E+10	NR		
1/11/07		7.91	24.0%	1300	2.52E+11	**27.6**		
6/4/01		7.47	25.6%	1553.1	2.84E+11	**39.4**		
6/5/01	Mid-Range Flows	4.59	42.5%	4611	5.18E+11	**79.6**	**15.9**	**16.2**
4/3/01		3.87	48.4%	166.4	1.58E+10	NR		
3/5/02		3.50	51.5%	410.6	3.52E+10	NR		
11/6/01		2.77	57.1%	218.7	1.48E+10	NR		
4/12/07		2.19	62.2%	230	1.23E+10	NR		
5/29/01	Low Flows	1.39	71.7%	1299.7	4.43E+10	**27.6**	**8.2**	**10.2**
7/13/06		1.38	71.8%	1200	4.07E+10	**21.6**		
7/10/01		1.22	74.8%	461.1	1.38E+10	NR		
8/7/01		0.93	82.7%	275.5	6.26E+09	NR		
9/11/01		0.87	84.1%	648.8	1.39E+10	NR		
10/2/01		0.77	86.8%	161.6	3.03E+09	NR		

Note: NR = No reduction required
NA = Not applicable

Table E-14. Calculated Load Reduction Based on Geomean Data – Bond Creek – RM1.0

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction to Target GM (126 CFU/100 ml)	Calculated Reduction to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
5/29/01	1.39	71.7%	1299.7			
5/30/01	8.26	22.7%	517.2			
5/31/01	92.89	0.7%	2419.2			
6/4/01	7.47	25.6%	1553.1			
6/5/01	4.59	42.5%	4611	**1633.9**	**92.3**	**93.1**
6/6/01	13.13	13.1%	1413.6	**1661.6**	**92.4**	**93.2**
6/7/01	9.39	19.5%	1413.6	**2031.7**	**93.8**	**94.4**

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

Table E-15. Calculated Load Reduction Based on Daily Loading – Hicks Creek – RM0.9

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
1/11/07	Moist Conditions	12.71	19.5%	2400	7.47E+11	**60.8**	**60.8**	**63.9**
4/12/07	Mid-Range Flows	5.55	55.5%	24000	3.26E+12	**96.1**	**48.0**	**48.2**
7/13/06		4.33	68.6%	22	2.33E+09	NR		
10/11/06	Low Flows	3.02	85.6%	690	5.10E+10	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-16. Calculated Load Reduction Based on Daily Loading – South Fork Forked Deer River – RM52.7

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
2/20/02	High Flows	1603.0	9.5%	1732.9	6.80E+13	**71.9**	**71.9**	**74.7**
12/5/01	Moist Conditions	1432.0	10.9%	146.7	5.14E+12	NR		
6/6/01		1167.0	14.3%	478.6	1.37E+13	NR		
1/9/02		888.2	19.1%	51.2	1.11E+12	NR		
4/4/01		494.5	38.8%	105.6	1.28E+12	NR	**NR**	**NR**
3/6/02	Mid-Range Flows	356.5	50.0%	34.1	2.97E+11	NR		
7/11/01		304.1	53.8%	2419.2	1.80E+13	**79.9**		
11/7/01		283.5	55.3%	49.7	3.45E+11	NR	**26.6**	**27.3**
5/9/01	Dry Conditions	183.9	65.8%	44.3	1.99E+11	NR		
8/8/01		93.1	84.2%	344.8	7.85E+11	NR		
9/12/01		88.9	85.4%	261.3	5.69E+11	NR		
10/3/01		80.7	87.2%	122.3	2.41E+11	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-17. Calculated Load Reduction Based on Daily Loading – Cub 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]	[%]	[%]	[%]
2/20/02	High Flows	39.34	7.3%	816.4	7.86E+11	NR		
12/5/01		32.12	9.6%	209.8	1.65E+11	NR	**NR**	**NR**
1/9/02	Moist Conditions	22.85	16.8%	62.4	3.49E+10	NR		
1/11/07		21.15	19.6%	420	2.17E+11	NR		
6/6/01		19.25	23.5%	231.8	1.09E+11	NR	**NR**	**NR**
3/6/02	Mid-Range Flows	12.71	44.2%	12.1	3.76E+09	NR		
4/4/01		10.53	50.9%	68.9	1.78E+10	NR		
4/12/07		9.528	55.0%	60	1.40E+10	NR		
11/7/01		8.24	62.6%	12.1	2.44E+09	NR		
7/13/06		7.60	67.5%	150	2.79E+10	NR	**NR**	**NR**
7/11/01	Low Flows	6.90	73.5%	1413.6	2.39E+11	**33.4**		
5/9/01		5.60	83.1%	2419.2	3.31E+11	**61.1**		
10/11/06		5.28	85.9%	230	2.97E+10	NR		
5/14/01		5.04	87.6%	64,880	7.99E+12	**98.5**		
9/12/01		4.08	93.5%	298.7	2.98E+10	NR		
10/3/01		3.95	94.2%	70.8	6.85E+09	NR		
8/8/01		3.94	94.3%	307.6	2.96E+10	NR	**27.6**	**28.8**

Note: NR = No reduction required
NA = Not applicable

Table E-18. Calculated Load Reduction Based on Daily Loading – Panther Creek – 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]	[%]	[%]	[%]
2/20/02	High Flows	83.11	4.7%	2419.2	4.92E+12	**61.1**	**61.1**	**64.2**
6/6/01	Moist Conditions	26.11	12.1%	816.4	5.21E+11	NR		
9/18/06		16.48	19.6%	4600	1.85E+12	**79.5**		
1/9/02		15.17	21.8%	365.4	1.36E+11	NR		
1/10/07		11.75	32.2%	22	6.32E+09	NR		
12/5/01		11.52	33.6%	461.1	1.30E+11	NR		
4/11/07		11.49	33.9%	1600	4.50E+11	**41.2**		
3/6/02		11.07	36.7%	33.6	9.10E+09	NR	**17.2**	**18.1**
11/14/06	Mid-Range Flows	9.51	47.2%	410	9.54E+10	NR		
7/11/01		9.10	50.0%	686.7	1.53E+11	NR		
3/8/07		8.52	54.1%	4.1	8.54E+08	NR		
3/15/07		8.00	58.6%	1200	2.35E+11	**21.6**		
3/13/07		7.87	59.6%	210	4.04E+10	NR		
3/22/07		7.29	65.7%	37	6.60E+09	NR	**3.6**	**4.6**
6/5/07	Low Flows	6.23	75.8%	36	5.48E+09	NR		
5/1/07		6.20	76.0%	365	5.54E+10	NR		
8/8/01		5.56	83.8%	26.9	3.66E+09	NR		
9/20/06		5.49	84.9%	19	2.55E+09	NR		
12/7/06		5.49	84.9%	82	1.10E+10	NR		
9/5/06		5.44	85.9%	33	4.39E+09	NR		
9/13/06		5.37	87.5%	81	1.06E+10	NR		
9/25/06		5.36	87.7%	100	1.31E+10	NR		
9/12/01		5.23	89.3%	17.5	2.24E+09	NR		
10/12/06		5.11	90.5%	120	1.50E+10	NR		
6/11/07		4.75	93.4%	517	6.00E+10	NR		

Table E-18 (cont'd). Calculated Load Reduction Based on Daily Loading – Panther Creek – 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]	[%]	[%]	[%]
6/13/07	Low Flows (cont'd)	4.62	93.9%	816	9.22E+10	NR		
6/20/07		4.32	94.3%	770	8.13E+10	NR		
6/18/07		4.29	94.4%	345	3.62E+10	NR		
6/26/07		4.28	94.4%	58	6.08E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-19. Calculated Load Reduction Based on Geomean Data – Panther Creek – 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]	[%]	[%]
9/5/06	5.44	85.9%	33			
9/13/06	5.37	87.5%	81			
9/18/06	16.48	19.6%	4600			
9/20/06	5.49	84.9%	19			
9/25/06	5.36	87.7%	100	**118.5**	**NR**	**NR**
6/5/07	6.23	75.8%	36			
6/11/07	4.75	93.4%	517			
6/13/07	4.62	93.9%	816			
6/18/07	4.29	94.4%	345			
6/20/07	4.32	94.3%	770	**332.0**	**62.0**	**66.0**
6/26/07	4.28	94.4%	58	**365.2**	**65.5**	**69.1**

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

Table E-20. Calculated Load Reduction Based on Daily Loading – South Fork Forked Deer River – RM36.7

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
2/20/02	High Flows	2196.0	9.1%	2419.2	1.30E+14	**79.9**	**79.9**	**81.9**
12/5/01	Moist Conditions	1880.0	11.4%	66.2	3.04E+12	NR	**NR**	**NR**
6/6/01		1450.0	15.5%	331	1.17E+13	NR		
1/9/02		1203.0	19.5%	120.1	3.53E+12	NR		
4/4/01	Mid-Range Flows	663.6	42.0%	118.2	1.92E+12	NR	**NR**	**NR**
3/6/02		538.1	50.2%	31.4	4.13E+11	NR		
7/11/01		467.4	54.3%	328.2	3.75E+12	NR		
11/7/01		412.8	58.1%	58.1	5.87E+11	NR		
5/9/01	Dry Conditions	279.5	70.1%	93.3	6.38E+11	NR	**NR**	**NR**
8/8/01		168.8	87.9%	261.3	1.08E+12	NR		
9/12/01		166.1	88.8%	23.8	9.67E+10	NR		
10/3/01	Low Flows	156.1	91.1%	153.9	5.88E+11	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-21. Calculated Load Reduction Based on Daily Loading – South Fork Forked Deer River – RM43.2

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]	[%]	[%]	[%]
2/20/02	High Flows	1976.6	9.4%	920.8	4.45E+13	**47.1**	**47.1**	**52.4**
12/5/01	Moist Conditions	1718.4	11.2%	57.3	2.41E+12	NR	**NR**	**NR**
6/6/01		1413.8	14.5%	387.3	1.34E+13	NR		
1/9/02		1095.1	19.6%	65	1.74E+12	NR		
1/11/07		1020.0	21.7%	250	6.24E+12	NR		
4/4/01	Mid-Range Flows	619.2	40.8%	81.3	1.23E+12	NR	**12.6**	**13.8**
3/6/02		482.4	50.2%	52.1	6.15E+11	NR		
7/11/01		437.2	53.2%	980.4	1.05E+13	**50.3**		
11/7/01		376.1	57.3%	93.3	8.59E+11	NR		
4/12/07	Dry Conditions	339.2	60.3%	1000	8.30E+12	**51.3**	**13.4**	**15.4**
5/9/01		254.6	68.8%	97.8	6.09E+11	NR		
7/13/06		228.0	72.1%	93	5.19E+11	NR		
8/8/01		151.2	86.7%	686.7	2.54E+12	**29.1**		
9/12/01		147.9	87.5%	272.3	9.86E+11	NR		
10/3/01		138.6	89.9%	155.3	5.27E+11	NR		
10/11/06	Low Flows	129.3	92.4%	180	5.69E+11	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-22. Calculated Load Reduction Based on Daily Loading – Little Nixon Creek – RM2.9

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
1/10/02	Moist Conditions	10.46	16.7%	104.6	2.68E+10	NR		
1/8/07		9.04	19.5%	170	3.76E+10	NR		
2/21/02		8.09	21.2%	727	1.44E+11	NR		
12/6/01		6.42	27.0%	313	4.92E+10	NR		
6/7/01		6.35	27.3%	19,863	3.09E+12	**95.3**	**19.1**	**19.1**
3/7/02	Mid-Range Flows	4.49	42.8%	12.1	1.33E+09	NR		
4/5/01		3.46	60.1%	1732.9	1.47E+11	**45.7**		
4/10/07		3.04	69.0%	25	1.86E+09	NR		
7/11/06		3.04	69.2%	39	2.90E+09	NR	**11.4**	**12.5**
5/10/01	Low Flows	2.98	70.5%	1986.3	1.45E+11	**52.6**		
7/12/01		2.80	74.6%	4160	2.85E+11	**77.4**		
11/6/01		2.80	74.6%	17.1	1.17E+09	NR		
8/9/01		2.27	87.6%	59	3.28E+09	NR		
10/4/01		2.13	91.6%	5.2	2.71E+08	NR		
9/13/01		2.10	92.0%	100	5.13E+09	NR	**21.7**	**22.6**

Note: NR = No reduction required
NA = Not applicable

Table E-23. Calculated Load Reduction Based on Daily Loading – Meridian 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]	[%]	[%]	[%]
12/12/06	High Flows	601.97	1.5%	16	2.36E+11	NR	**NR**	**NR**
6/7/01	Moist Conditions	39.12	16.6%	1299.7	1.24E+12	**27.6**	**24.1**	**25.2**
2/21/02		38.62	17.0%	686.7	6.49E+11	NR		
9/18/06		32.18	21.6%	17,000	1.34E+13	**94.5**		
1/10/02		29.46	23.9%	145	1.04E+11	NR		
1/10/07		23.58	30.8%	96	5.54E+10	NR		
4/11/07		22.29	34.8%	3200	1.75E+12	**70.6**		
12/6/01		22.20	35.1%	66.3	3.60E+10	NR		
3/7/02		20.88	39.0%	8.6	4.39E+09	NR		
3/5/07	Mid-Range Flows	17.56	51.8%	21	9.02E+09	NR	**NR**	**NR**
2/6/07		17.48	52.2%	76	3.25E+10	NR		
3/8/07		16.51	56.3%	45	1.82E+10	NR		
4/5/01		16.09	57.9%	24.3	9.56E+09	NR		
3/15/07		15.48	60.2%	28	1.06E+10	NR		
3/13/07		15.32	60.9%	28	1.05E+10	NR		
3/20/07		14.66	63.8%	17	6.10E+09	NR		
11/14/06		14.57	64.5%	210	7.48E+10	NR		
3/22/07		14.19	66.5%	15	5.21E+09	NR		
7/12/01		14.12	66.9%	307.6	1.06E+11	NR		
5/10/01		13.88	68.4%	408.3	1.39E+11	NR		
7/12/06		13.71	69.6%	26	8.72E+09	NR		

Table E-23 (cont'd). Calculated Load Reduction Based on Daily Loading – Meridian 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]	[%]	[%]	[%]
11/6/01	Low Flows	13.08	72.9%	28	8.96E+09	NR	**NR**	**NR**
6/5/07		12.37	76.1%	23	6.96E+09	NR		
5/1/07		12.18	77.1%	20	5.96E+09	NR		
8/1/06		11.87	78.5%	2	5.81E+08	NR		
12/7/06		10.91	84.7%	40	1.07E+10	NR		
9/20/06		10.82	85.2%	330	8.73E+10	NR		
9/5/06		10.74	86.0%	4	1.05E+09	NR		
9/25/06		10.73	86.1%	120	3.15E+10	NR		
8/9/01		10.69	86.3%	392	1.03E+11	NR		
9/13/06		10.49	87.6%	30	7.70E+09	NR		
10/4/01		10.00	90.6%	2	4.89E+08	NR		
6/26/07		10.00	90.6%	134	3.28E+10	NR		
9/13/01		9.92	91.2%	41	9.95E+09	NR		
6/11/07		9.25	94.2%	21	4.75E+09	NR		
6/13/07		8.97	94.9%	4	8.78E+08	NR		
6/20/07		8.50	95.3%	1	2.08E+08	NR		
6/18/07		8.34	95.4%	1	2.04E+08	NR		

Note: NR = No reduction required
NA = Not applicable

Table E-24. Calculated Load Reduction Based on Geomean Data – Meridian Creek – RM1.7

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction	
					to Target GM (126 CFU/100 ml)	to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
9/5/06	10.74	86.0%	4			
9/13/06	10.49	87.6%	30			
9/18/06	32.18	21.6%	17,000			
9/20/06	10.82	85.2%	330			
9/25/06	10.73	86.1%	120	**151.9**	**17.0**	**25.6**
3/5/07	17.56	51.8%	21			
3/8/07	16.51	56.3%	45			
3/13/07	15.32	60.9%	28			
3/15/07	15.48	60.2%	28			
3/20/07	14.66	63.8%	17	26.3	**NR**	**NR**
3/22/07	14.19	66.5%	15	24.6	**NR**	**NR**
6/5/07	12.37	76.1%	23			
6/11/07	9.25	94.2%	21			
6/13/07	8.97	94.9%	4			
6/18/07	8.34	95.4%	1			
6/20/07	8.50	95.3%	1	4.5	**NR**	**NR**
6/26/07	10.00	90.6%	134	6.5	**NR**	**NR**

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

Table E-25. Calculated Load Reduction Based on Daily Loading – Nixon Creek – RM2.2

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]	[%]	[%]	[%]
6/7/01	Moist Conditions	152.6	15.5%	3654	1.36E+13	**74.2**		
2/21/02		146.6	16.2%	435.2	1.56E+12	NR		
1/9/07		114.4	20.7%	340	9.52E+11	NR		
1/10/02		107.4	22.5%	57.1	1.50E+11	NR		
3/7/02		71.4	39.9%	166.4	2.91E+11	NR	**14.8**	**15.3**
4/5/01	Mid-Range Flows	55.1	58.7%	1732.9	2.34E+12	**45.7**	**45.7**	**50.0**
7/12/01	Dry Conditions	51.9	62.2%	1281	1.63E+12	**26.5**		
4/10/07		48.3	67.5%	460	5.43E+11	NR		
7/11/06		47.8	68.3%	110	1.29E+11	NR		
5/10/01		47.4	69.3%	104.6	1.21E+11	NR		
11/6/01		44.7	73.3%	19.3	2.11E+10	NR		
8/9/01		36.4	86.6%	624	5.55E+11	NR	**4.4**	**5.4**
10/4/01	Low Flows	34.1	90.9%	49.5	4.13E+10	NR		
9/13/01		33.9	91.1%	30	2.49E+10	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-26. Calculated Load Reduction Based on Daily Loading – Mud 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]	[%]	[%]	[%]
6/6/01	High Flows	78.06	8.0%	461.1	8.81E+11	NR	**NR**	**NR**
2/20/02	Moist Conditions	34.27	14.1%	2419.2	2.03E+12	**61.1**		
4/11/07		28.10	17.0%	550	3.78E+11	NR		
1/9/02		21.58	22.1%	1203	6.35E+11	**21.8**		
12/5/01		16.01	34.6%	344.8	1.35E+11	NR		
3/6/02		15.15	38.0%	26	9.64E+09	NR		
1/10/07		15.09	38.2%	370	1.37E+11	NR	**13.8**	**15.4**
7/11/01	Mid-Range Flows	14.09	42.9%	201.4	6.94E+10	NR		
4/4/01		12.16	52.4%	456.9	1.36E+11	NR		
5/9/01		10.26	64.1%	289.4	7.27E+10	NR		
7/12/06		9.65	69.3%	670	1.58E+11	NR	**NR**	**NR**
11/7/01	Low Flows	9.52	70.3%	13.2	3.08E+09	NR		
8/8/01		7.90	82.3%	461.1	8.91E+10	NR		
9/12/01		7.47	87.1%	133.4	2.44E+10	NR		
10/3/01		7.36	88.4%	42.8	7.71E+09	NR		
10/12/06		7.30	88.8%	44	7.86E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-27. Calculated Load Reduction Based on Daily Loading – Kail Creek – 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]	[%]	[%]	[%]
9/18/06	Moist Conditions	30.90	13.2%	8700	6.58E+12	**89.2**		
4/11/07		16.79	25.5%	2400	9.86E+11	**60.8**		
1/10/07		13.90	34.4%	390	1.33E+11	NR	**50.0**	**51.3**
11/14/06	Mid-Range Flows	12.66	40.6%	870	2.69E+11	NR		
3/5/07		10.67	53.4%	72	1.88E+10	NR		
2/6/07		10.63	53.6%	11	2.86E+09	NR		
3/8/07		10.08	57.4%	99	2.44E+10	NR		
3/15/07		9.49	60.9%	76	1.76E+10	NR		
3/13/07		9.34	61.9%	68	1.55E+10	NR		
3/20/07		8.92	65.2%	250	5.46E+10	NR		
3/22/07		8.65	67.3%	44	9.31E+09	NR	**NR**	**NR**
7/12/06	Low Flows	8.36	70.4%	57	1.17E+10	NR		
6/5/07		7.41	77.5%	91	1.65E+10	NR		
5/1/07		7.40	77.6%	98	1.77E+10	NR		
8/1/06		7.27	78.6%	170	3.02E+10	NR		
12/7/06		6.65	84.9%	16	2.60E+09	NR		
9/20/06		6.58	85.5%	540	8.70E+10	NR		
9/5/06		6.54	86.2%	58	9.28E+09	NR		
9/25/06		6.49	86.8%	74	1.18E+10	NR		
9/13/06		6.44	87.3%	1300	2.05E+11	**27.6**		
10/12/06		6.05	91.5%	120	1.77E+10	NR		
6/26/07		5.97	92.0%	1046	1.53E+11	**10.0**		
6/11/07		5.66	94.4%	148	2.05E+10	NR		
6/13/07		5.49	95.0%	22	2.96E+09	NR		
6/20/07		5.20	95.4%	344	4.37E+10	NR		
6/18/07		5.11	95.5%	2420	3.03E+11	**61.1**	**6.6**	**7.7**

Note: NR = No reduction required
NA = Not applicable

Table E-28. Calculated Load Reduction Based on Geomean Data – Kail Creek – 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]	[%]	[%]
9/5/06	6.54	86.2%	58			
9/13/06	6.44	87.3%	1300			
9/18/06	30.90	13.2%	8700			
9/20/06	6.58	85.5%	540			
9/25/06	6.49	86.8%	74	**482.7**	**73.9**	**76.6**
3/5/07	10.67	53.4%	72			
3/8/07	10.08	57.4%	99			
3/13/07	9.34	61.9%	68			
3/15/07	9.49	60.9%	76			
3/20/07	8.92	65.2%	250	**98.4**	**NR**	**NR**
3/22/07	8.65	67.3%	44	**89.1**	**NR**	**NR**
6/5/07	7.41	77.5%	91			
6/11/07	5.66	94.4%	148			
6/13/07	5.49	95.0%	22			
6/18/07	5.11	95.5%	2420			
6/20/07	5.20	95.4%	344	**189.9**	**33.6**	**40.5**
6/26/07	5.97	92.0%	1046	**309.4**	**59.3**	**63.5**

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

Table E-29. Calculated Load Reduction Based on Daily Loading – Jacobs Creek – RM4.1

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]	[%]	[%]	[%]
11/14/06	Moist Conditions	21.09	10.8%	76	3.92E+10	NR	14.7	15.3
1/10/02		14.89	15.1%	71.7	2.61E+10	NR		
2/21/02		12.60	17.5%	1553.1	4.79E+11	**39.4**		
9/18/06		11.98	18.4%	14,000	4.10E+12	**93.3**		
6/7/01		10.56	21.4%	866.4	2.24E+11	NR		
4/11/07		9.76	23.4%	15	3.58E+09	NR		
12/6/01		8.06	31.3%	248.1	4.89E+10	NR		
1/10/07		7.32	37.6%	170	3.04E+10	NR		
3/7/02		7.24	38.5%	5.2	9.21E+08	NR		
2/6/07	Mid-Range Flows	5.99	52.6%	1	1.47E+08	NR	**NR**	**NR**
3/5/07		5.99	52.6%	6.3	9.23E+08	NR		
3/8/07		5.68	56.3%	2	2.78E+08	NR		
3/15/07		5.36	59.6%	13	1.71E+09	NR		
3/13/07		5.25	61.1%	5	6.43E+08	NR		
3/20/07		5.01	64.9%	10	1.23E+09	NR		
3/22/07		4.86	67.2%	7.4	8.79E+08	NR		
7/12/06		4.74	69.3%	42	4.87E+09	NR		
5/1/07	Low Flows	4.14	77.4%	70	7.09E+09	NR		
8/1/06		4.12	77.7%	330	3.33E+10	NR		
6/5/07		3.98	79.9%	79	7.70E+09	NR		
12/7/06		3.81	83.6%	12	1.12E+09	NR		
9/20/06		3.77	84.5%	400	3.69E+10	NR		
9/5/06		3.72	85.7%	29	2.64E+09	NR		
9/25/06		3.68	86.4%	93	8.36E+09	NR		
9/13/06		3.67	86.5%	2400	2.16E+11	**60.8**		
10/4/01		3.50	89.6%	8.5	7.28E+08	NR		
6/11/07		3.13	94.4%	84	6.44E+09	NR		
6/13/07		3.05	94.8%	119	8.87E+09	NR		

Table E-29 (cont'd). Calculated Load Reduction Based on Daily Loading – Jacobs Creek – RM4.1

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]	[%]	[%]	[%]
6/20/07	Low Flows (cont'd)	2.83	95.2%	63	4.36E+09	NR	**4.3**	**4.6**
6/18/07		2.82	95.3%	35	2.41E+09	NR		
6/26/07		2.66	95.6%	88	5.72E+09	NR		

Note: NR = No reduction required
NA = Not applicable

Table E-30. Calculated Load Reduction Based on Geomean Data – Jacobs Creek – RM4.1

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]	[%]	[%]
9/5/06	3.72	85.7%	29			
9/13/06	3.67	86.5%	2400			
9/18/06	11.98	18.4%	14000			
9/20/06	3.77	84.5%	400			
9/25/06	3.68	86.4%	93	**515.1**	**75.5**	**78.1**
3/5/07	5.99	52.6%	6.3			
3/8/07	5.68	56.3%	2			
3/13/07	5.25	61.1%	5			
3/15/07	5.36	59.6%	13			
3/20/07	5.01	64.9%	10	**6.1**	**NR**	**NR**
3/22/07	4.86	67.2%	7.4	**6.3**	**NR**	**NR**
6/5/07	3.98	79.9%	79			
6/11/07	3.13	94.4%	84			
6/13/07	3.05	94.8%	119			
6/18/07	2.82	95.3%	35			
6/20/07	2.83	95.2%	63	**70.5**	**NR**	**NR**
6/26/07	2.66	95.6%	88	**72.0**	**NR**	**NR**

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

Table E-31. Calculated Load Reduction Based on Daily Loading – South Fork Forked Deer River – RM30.4/30.6

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]	[%]	[%]	[%]
12/17/01	High Flows	9015.0	0.8%	1732.9	3.82E+14	**71.9**	**56.9**	**58.7**
3/23/06		2824.0	6.3%	2000	1.38E+14	**75.7**		
12/17/07		2854.0	6.3%	2420	1.69E+14	**79.9**		
12/6/01		2306.0	9.1%	387.3	2.19E+13	NR		
6/20/06	Moist Conditions	2048.0	10.7%	410	2.05E+13	NR	**28.6**	**30.8**
2/21/02		1987.0	11.2%	1732.9	8.42E+13	**71.9**		
1/18/07		1855.0	12.3%	290	1.32E+13	NR		
6/19/03		1772.0	13.1%	1203.3	5.22E+13	**59.5**		
3/12/02		1734.0	13.4%	8164	3.46E+14	**94.0**		
1/10/02		1550.0	15.9%	95.9	3.64E+12	NR		
3/25/08		1458.0	18.2%	31	1.11E+12	NR		
12/15/04		1447.0	18.5%	58.1	2.06E+12	NR		
3/25/03		1377.0	20.7%	118.7	4.00E+12	NR		
3/4/09		1338.0	22.0%	980	3.21E+13	**50.3**		
6/7/01		1293.0	23.5%	3430	1.09E+14	**85.8**		
9/29/09		1289.0	23.7%	365	1.15E+13	NR		
12/16/02		1183.0	27.5%	66.9	1.94E+12	NR		
12/11/03		1062.0	30.7%	1413.6	3.67E+13	**65.5**		
3/24/99		906.4	35.9%	461.1	1.02E+13	NR		
9/24/02		893.1	36.6%	536	1.17E+13	**9.1**		
12/14/00		836.4	39.4%	980.4	2.01E+13	**50.3**		
3/29/00	Mid-Range Flows	743.9	44.1%	74.8	1.36E+12	NR		
12/16/98		736.2	44.3%	31.7	5.71E+11	NR		
4/5/01		731.4	44.7%	1553.1	2.78E+13	**68.6**		
3/16/05		715.4	45.7%	31.3	5.48E+11	NR		
6/4/08		676.1	47.7%	142.1	2.35E+12	NR		

Table E-31 (cont'd). Calculated Load Reduction Based on Daily Loading – South Fork Forked Deer River – RM30.4/30.6

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]	[%]	[%]	[%]
3/7/02	Mid-Range Flows (cont'd)	661.4	48.5%	19.9	3.22E+11	NR		
6/8/04		661.4	48.5%	156.5	2.53E+12	NR		
3/18/04		589.6	52.1%	90.7	1.31E+12	NR		
11/6/01		540.1	54.7%	77.6	1.03E+12	NR	**7.6**	**8.0**
12/14/05	Dry Conditions	443.0	61.2%	120	1.30E+12	NR		
3/21/07		438.5	61.6%	70	7.51E+11	NR		
6/20/00		420.4	62.7%	166.9	1.72E+12	NR		
6/27/01		397.8	64.6%	39.9	3.88E+11	NR		
6/15/05		396.5	64.8%	579.4	5.62E+12	**1539**		
7/12/01		373.4	67.6%	400	3.65E+12	NR		
5/10/01		360.6	68.9%	38.6	3.41E+11	NR		
6/9/99		346.7	70.6%	72.3	6.13E+11	NR		
6/23/09		342.4	71.1%	105	8.80E+11	NR		
12/8/08		320.9	73.8%	68	5.34E+11	NR		
6/18/02		318.3	74.2%	25.6	1.99E+11	NR		
9/28/98		313.3	74.9%	128.1	9.82E+11	NR		
9/16/03		312.4	75.1%	72.7	5.56E+11	NR		
9/26/06		295.2	77.1%	690	4.98E+12	**29.4**		
9/27/04		270.5	80.7%	9.7	6.42E+10	NR		
12/1/99		262.8	82.1%	160.7	1.03E+12	NR		
9/9/08		223.1	87.7%	162	8.84E+11	NR		
8/9/01		216.6	88.7%	657	3.48E+12	**25.9**		
9/12/01		215.9	88.7%	30.3	1.60E+11	NR		
10/4/01		212.8	89.4%	71.4	3.72E+11	NR		
9/13/01		211.9	89.5%	97	5.03E+11	NR	**3.4**	**4.5**

Table E-31 (cont'd). Calculated Load Reduction Based on Daily Loading – South Fork Forked Deer River – RM30.4/30.6

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]	[%]	[%]	[%]
6/7/07	Low Flows	208.9	90.0%	67	3.42E+11	NR		
9/14/05		201.2	91.0%	51.2	2.52E+11	NR		
9/19/07		169.1	95.8%	129	5.34E+11	NR		
9/28/99		157.9	97.2%	184.2	7.12E+11	NR		
9/6/00		139.8	98.6%	37.7	1.29E+11	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-32. Calculated Load Reduction Based on Daily Loading – Black 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]	[%]	[%]	[%]
2/20/02	High Flows	78.06	8.0%	1533.1	5.19E+12	**38.6**	**38.6**	**43.5**
6/7/01	Moist Conditions	34.27	14.1%	2723	2.45E+12	**65.4**		
1/10/02		28.10	17.0%	235.9	1.86E+11	NR		
1/9/07		15.15	38.0%	1200	8.62E+11	**21.6**		
3/7/02		15.09	38.2%	47.1	2.32E+10	NR	**21.8**	**24.0**
4/5/01	Mid-Range Flows	78.06	8.0%	2419.2	9.22E+11	**61.1**	**61.1**	**64.2**
7/12/01	Dry Conditions	14.09	42.9%	4106	1.43E+12	**77.1**		
4/10/07		12.16	52.4%	1000	3.32E+11	**5.9**		
7/11/06				700	2.32E+11	NR		
5/10/01				798	2.63E+11	NR		
11/6/01		10.26	64.1%	83.9	2.59E+10	NR		
8/9/01		9.65	69.3%	298	7.51E+10	NR	**13.8**	**15.4**
10/4/01	Low Flows	9.52	70.3%	32.7	7.73E+09	NR		
9/13/01		7.30	88.8%	185	4.34E+10	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-33. Calculated Load Reduction Based on Daily Loading – UT to Tisdale Creek – RM0.7

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
7/10/07	Low Flows	0.28	91.9%	556	3.86E+09	NR		
7/11/07		0.26	94.1%	1565	1.00E+10	**39.9**		
7/2/07		0.24	94.6%	7701	4.50E+10	**87.8**		
7/9/07		0.22	95.1%	12,997	7.13E+10	**92.8**		
7/5/07		0.22	95.2%	2755	1.50E+10	**65.8**	**57.3**	**59.1**

Note: NR = No reduction required
NA = Not applicable

Table E-34. Calculated Load Reduction Based on Geomean Data – UT to Tisdale Creek – RM0.7

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]	[%]	[%]
7/2/07	0.24	94.6%	7701			
7/5/07	0.22	95.2%	2755			
7/9/07	0.22	95.1%	12997			
7/10/07	0.28	91.9%	556			
7/11/07	0.26	94.1%	1565	**2992.4**	**95.8**	**96.2**

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

Table E-35. Calculated Load Reduction Based on Daily Loading – Halls 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]	[%]	[%]	[%]
6/7/01	Moist Conditions	36.26	14.9%	17,329	1.54E+13	**94.6**		
1/9/07		31.72	17.1%	870	6.75E+11	NR		
1/10/02		18.58	35.0%	579.4	2.63E+11	NR	**31.5**	**31.8**
12/6/01	Mid-Range Flows	17.05	42.0%	44.1	1.84E+10	NR		
2/21/02		16.10	46.8%	1553.1	6.12E+11	**39.4**		
4/10/07		15.57	49.9%	100	3.81E+10	NR		
7/10/07		14.77	54.3%	17	6.14E+09	NR		
3/7/02		14.56	55.2%	45.5	1.62E+10	NR	**7.9**	**8.8**
4/5/01	Dry Conditions	11.90	66.9%	2419.2	7.04E+11	**61.1**		
5/10/01		10.70	73.7%	1203.3	3.15E+11	**21.8**		
7/2/07		10.61	74.4%	816	2.12E+11	NR		
7/11/06		10.32	76.1%	52	1.31E+10	NR		
7/12/01		10.17	77.1%	100	2.49E+10	NR		
11/6/01		9.88	79.1%	14.6	3.53E+09	NR		
7/11/07		9.37	82.3%	31	7.11E+09	NR		
8/9/01		8.47	87.8%	359	7.44E+10	NR		
7/9/07		8.31	88.8%	59	1.20E+10	NR		
7/12/07		8.18	89.2%	47	9.41E+09	NR	**8.3**	**9.2**
9/13/01	Low Flows	7.26	94.0%	121	2.15E+10	NR		
10/4/01		7.15	94.7%	7.3	1.28E+09	NR	**NR**	**NR**

Note: NR = No reduction required
NA = Not applicable

Table E-36. Calculated Load Reduction Based on Geomean Data – Halls Creek – RM1.2

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]	[%]	[%]
7/2/07	10.61	74.4%	816			
7/9/07	8.31	88.8%	59			
7/10/07	14.77	54.3%	17			
7/11/07	9.37	82.3%	31			
7/12/07	8.18	89.2%	47	**65.4**	**NR**	**NR**

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

Table E-37. Calculated Load Reduction Based on Daily Loading – Mill Creek – RM1.5

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
9/18/06	High Flows	408.85	1.4%	24,000	2.40E+14	**96.1**	**78.4**	**80.2**
4/11/07		45.26	8.7%	2400	2.66E+12	**60.8**		
3/13/07	Moist Conditions	34.19	10.7%	100	8.36E+10	NR	**NR**	**NR**
9/25/06		20.64	16.8%	230	1.16E+11	NR		
1/10/07		15.83	21.7%	260	1.01E+11	NR		
3/20/07		14.15	24.9%	210	7.27E+10	NR		
11/14/06		13.46	26.7%	260	8.56E+10	NR		
2/6/07		12.27	31.7%	21	6.31E+09	NR		
3/15/07		12.09	32.9%	130	3.85E+10	NR		
3/5/07		11.95	34.0%	120	3.51E+10	NR		
9/13/06		11.73	35.1%	880	2.53E+11	NR		
9/20/06		11.74	35.1%	310	8.90E+10	NR		
3/8/07		11.11	39.2%	120	3.26E+10	NR		

Table E-37 (cont'd). Calculated Load Reduction Based on Daily Loading – Mill Creek – RM1.5

Sample Date	Flow Regime	Flow	PDFE	Concentration	Load	% Reduction to Achieve TMDL	Average of Load Reductions	% Reduction to TMDL – MOS
		[cfs]	[%]	[CFU/100 ml]	[CFU/day]	[%]	[%]	[%]
12/7/06	Mid-Range Flows	10.95	40.3%	110	2.95E+10	NR	**NR**	**NR**
7/12/06		10.91	40.6%	610	1.63E+11	NR		
3/22/07		10.02	46.8%	89	2.18E+10	NR		
5/1/07		8.34	57.8%	388	7.92E+10	NR		
10/12/06		7.78	61.3%	34	6.47E+09	NR		
6/5/07	Low Flows	6.39	74.5%	1414	2.21E+11	**33.5**	**4.2**	**4.8**
6/11/07		6.07	77.9%	147	2.18E+10	NR		
6/13/07		5.93	79.1%	345	5.01E+10	NR		
9/5/06		5.69	82.0%	78	1.08E+10	NR		
6/20/07		5.54	83.1%	157	2.13E+10	NR		
8/1/06		5.53	83.2%	110	1.49E+10	NR		
6/18/07		5.53	83.2%	613	8.29E+10	NR		
6/26/07		5.10	87.1%	155	1.94E+10	NR		

Note: NR = No reduction required
NA = Not applicable

Table E-38. Calculated Load Reduction Based on Geomean Data – Mill Creek – RM1.5

Sample Date	Flow	PDFE	Concentration	Geometric Mean	Calculated Reduction to Target GM (126 CFU/100 ml)	Calculated Reduction to Target – MOS (113 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[CFU/100 ml]	[%]	[%]
9/5/06	5.69	82.0%	78			
9/13/06	11.73	35.1%	880			
9/18/06	408.85	1.4%	24,000			
9/20/06	11.74	35.1%	310			
9/25/06	20.64	16.8%	230	651.6	**80.7**	**82.7**
3/5/07	11.95	34.0%	120			
3/8/07	11.11	39.2%	120			
3/13/07	34.19	10.7%	100			
3/15/07	12.09	32.9%	130			
3/20/07	14.15	24.9%	210	131.5	**4.2**	**14.1**
3/22/07	10.02	46.8%	89	123.9	**NR**	**8.8**
6/5/07	6.39	74.5%	1414			
6/11/07	6.07	77.9%	147			
6/13/07	5.93	79.1%	345			
6/18/07	5.53	83.2%	613			
6/20/07	5.54	83.1%	157	369.6	**65.9**	**69.4**
6/26/07	5.10	87.1%	155	237.6	**47.0**	**52.4**

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

Table E-39. Calculated Load Reduction Based on Daily Loading – South Fork Forked Deer River – RM11.2

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]	[%]	[%]	[%]
1/9/07	High Flows	3624.0	6.9%	1700	1.51E+14	**71.4**	**74.2**	**74.2**
2/21/02	Moist Conditions	2692.0	11.4%	1299.7	8.56E+13	**62.5**	**20.8**	**22.1**
1/10/02		1955.0	18.1%	80.9	3.87E+12	NR		
6/7/01		1520.0	28.2%	302.6	1.13E+13	NR		
3/7/02	Mid-Range Flows	876.0	49.3%	19.9	4.26E+11	NR	**NR**	**NR**
11/6/01		652.8	58.5%	31.8	5.08E+11	NR		
4/10/07	Dry Conditions	596.7	61.9%	100	1.46E+12	NR	**16.8**	**17.6**
7/11/06		452.4	75.7%	50	5.53E+11	NR		
5/10/01		421.1	78.2%	181.9	1.87E+12	NR		
7/12/01		406.0	79.6%	1483	1.47E+13	**67.2**		
10/4/01	Low Flows	255.7	94.8%	43.5	2.72E+11	NR	**NR**	**NR**
8/9/01		246.0	95.5%	171	1.03E+12	NR		
9/13/01		244.9	95.6%	175	1.05E+12	NR		

Note: NR = No reduction required
NA = Not applicable

Table E-40. Calculated Load Reduction Based on Daily Loading – South Fork Forked Deer River – RM19.1

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]	[%]	[%]	[%]
1/9/07	High Flows	3188.0	7.7%	1400	1.09E+14	**32.8**	**32.8**	**38.1**
4/10/07	Dry Conditions	539.1	61.5%	86	1.13E+12	NR	**NR**	**NR**
7/11/06		410.5	75.4%	39	3.92E+11	NR		

Note: NR = No reduction required
NA = Not applicable

Table E-41 Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the South Fork Forked Deer River Watershed (HUC 08010205)

Waterbody Description (TN08010205__)	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]
South Fork Forked Deer River Waterbody ID: **018 – 1000** HUC-12: 0106	High Flows	0 – 10	722 – 3,402	1,235	NR	2.841×10^{13}	2.841×10^{12}	4.666×10^{10}	0	1.685×10^{8}	1.685×10^{8}
	Moist	10 – 40	222 – 722	336	26.6	7.727×10^{12}	7.727×10^{11}			4.560×10^{7}	4.560×10^{7}
	Mid-Range	40 – 60	110 – 222	167	4.0	3.830×10^{12}	3.830×10^{11}			2.244×10^{7}	2.244×10^{7}
	Dry	60 – 90	33.2 – 110	58.9	NR	1.356×10^{12}	1.356×10^{11}			7.746×10^{6}	7.746×10^{6}
	Low Flows	90 – 100	11.8 – 33.2	25.0	NR	5.748×10^{11}	5.748×10^{10}			3.107×10^{6}	3.107×10^{6}
UT to South Fork Forked Deer River Waterbody ID: **018 – 1200** HUC-12: 0106	High Flows	0 – 10	1.89 – 10.8	3.34	16.4[b]	7.682×10^{10}	7.682×10^{9}	NA	NA	1.474×10^{8}	1.474×10^{8}
	Moist	10 – 40	0.61 – 1.89	0.94		2.162×10^{10}	2.162×10^{9}			4.149×10^{7}	4.149×10^{7}
	Mid-Range	40 – 70	0.19 – 0.61	0.36		8.280×10^{9}	8.280×10^{8}			1.589×10^{7}	1.589×10^{7}
	Low Flows	70 – 100	0.03 – 0.19	0.12		2.760×10^{9}	2.760×10^{8}			5.296×10^{6}	5.296×10^{6}
Bear Creek Waterbody ID: **028 – 0300** HUC-12: 0203	High Flows	0 – 10	6.51 – 39.0	11.74	NR	1.409×10^{11}	1.409×10^{10}	NA	NA	7.506×10^{7}	7.506×10^{7}
	Moist	10 – 40	2.21 – 6.51	3.36	NA	4.032×10^{10}	4.032×10^{9}			2.148×10^{7}	2.148×10^{7}
	Mid-Range	40 – 70	0.69 – 2.21	1.25	NR	1.500×10^{10}	1.500×10^{9}			7.992×10^{6}	7.992×10^{6}
	Low Flows	70 – 100	0.10 – 0.69	0.41	3.0	4.920×10^{9}	4.920×10^{8}			2.622×10^{6}	2.622×10^{6}
North Fork of South Fork Forked Deer River Waterbody ID: **028 – 1000** HUC-12: 0204	High Flows	0 – 10	428 – 2,408	789	69.4[b]	1.815×10^{13}	1.815×10^{12}	1.781×10^{08}	0	1.572×10^{8}	1.572×10^{8}
	Moist	10 – 40	140 – 4287	212		4.879×10^{12}	4.879×10^{11}			4.225×10^{7}	4.225×10^{7}
	Mid-Range	40 – 60	67.1 – 140	80.9		1.861×10^{12}	1.861×10^{11}			1.611×10^{7}	1.611×10^{7}
	Dry	60 – 90	21.6 – 67.1	37.0		8.505×10^{11}	8.505×10^{10}			7.363×10^{6}	7.363×10^{6}
	Low Flows	90 – 100	5.50 – 21.6	16.0		3.673×10^{11}	3.673×10^{10}			3.179×10^{6}	3.179×10^{6}
Sandy Creek Waterbody ID: **012 – 0400** HUC-12: 0302	High Flows	0 – 10	15.5 – 76.3	29.4	NA	6.755×10^{11}	6.755×10^{10}	NA	0	2.411×10^{8}	2.411×10^{8}
	Moist	10 – 40	3.16 – 15.5	5.44	13.7	1.251×10^{11}	1.251×10^{10}			4.465×10^{7}	4.465×10^{7}
	Mid-Range	40 – 70	0.89 – 3.16	1.90	10.8	4.370×10^{10}	4.370×10^{9}			1.559×10^{7}	1.559×10^{7}
	Low Flows	70 – 100	0.13 – 0.89	0.49	NA	1.127×10^{10}	1.127×10^{9}			4.022×10^{6}	4.022×10^{6}
Central Creek Waterbody ID: **012 – 0500** HUC-12: 0302	High Flows	0 – 10	6.05 – 31.3	11.9	NA	2.732×10^{11}	2.732×10^{10}	NA	0	2.958×10^{8}	2.958×10^{8}
	Moist	10 – 40	0.93 – 6.05	1.70	4.0	3.910×10^{10}	3.910×10^{9}			4.233×10^{7}	4.233×10^{7}
	Mid-Range	40 – 70	0.25 – 0.93	0.54	15.3	1.242×10^{10}	1.242×10^{9}			1.345×10^{7}	1.345×10^{7}
	Low Flows	70 – 100	0.03 – 0.25	0.13	19.0	2.990×10^{9}	2.990×10^{8}			3.237×10^{6}	3.237×10^{6}
Anderson Branch Waterbody ID: **012 – 0600** HUC-12: 0302	High Flows	0 – 10	17.4 – 72.3	29.6	NA	3.548×10^{11}	3.548×10^{10}	NA	0	1.488×10^{8}	1.488×10^{8}
	Moist	10 – 40	5.99 – 17.4	7.89	NR	9.468×10^{10}	9.468×10^{9}			3.970×10^{7}	3.970×10^{7}
	Mid-Range	40 – 70	4.08 – 5.99	4.91	25.5	5.892×10^{10}	5.892×10^{9}			2.471×10^{7}	2.471×10^{7}
	Low Flows	70 – 100	3.43 – 4.08	3.73	5.2	4.476×10^{10}	4.476×10^{9}			1.877×10^{7}	1.877×10^{7}

Table E-41 (cont'd) Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the South Fork Forked Deer River Watershed (HUC 08010205)

Waterbody Description (TN08010205__)	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]
Bond Creek Waterbody ID: **012 – 0700** HUC-12: 0302	High Flows	0 – 10	16.6 – 73.8	27.6	93.8^b	6.353×10^{11}	6.353×10^{10}	NA	0	1.795×10^{8}	1.795×10^{8}
	Moist	10 – 40	4.99 – 16.6	7.89		1.757×10^{11}	1.757×10^{10}			4.965×10^{7}	4.965×10^{7}
	Mid-Range	40 – 70	1.52 – 4.99	3.05		7.015×10^{10}	7.015×10^{9}			1.982×10^{7}	1.982×10^{7}
	Low Flows	70 – 100	0.19 – 1.52	0.84		1.932×10^{10}	1.932×10^{9}			5.459×10^{6}	5.459×10^{6}
Hicks Creek Waterbody ID: **012 – 0900** HUC-12: 0302	High Flows	0 – 10	19.5 – 95.0	33.1	NA	7.620×10^{11}	7.620×10^{10}	NA	NA	1.336×10^{8}	1.336×10^{8}
	Moist	10 – 40	8.17 – 19.5	11.0	60.8	2.535×10^{11}	2.535×10^{10}			4.443×10^{7}	4.443×10^{7}
	Mid-Range	40 – 70	4.23 – 8.17	5.64	48.0	1.297×10^{11}	1.297×10^{10}			2.274×10^{7}	2.274×10^{7}
	Low Flows	70 – 100	0.76 – 4.23	3.06	NR	7.038×10^{10}	7.038×10^{9}			1.234×10^{7}	1.234×10^{7}
South Fork Forked Deer River Waterbody ID: **012 – 1000** HUC-12: 0302	High Flows	0 – 10	1,542 – 7,342	2,635	71.9	3.162×10^{13}	3.162×10^{12}	4.684×10^{10}	0	8.750×10^{7}	8.750×10^{7}
	Moist	10 – 40	475 – 1,542	718	NR	8.618×10^{12}	8.618×10^{11}			2.374×10^{7}	2.374×10^{7}
	Mid-Range	40 – 60	235 – 475	355	26.6	4.261×10^{12}	4.261×10^{11}			1.167×10^{7}	1.167×10^{7}
	Dry	60 – 90	69.5 – 235	126	NR	1.509×10^{12}	1.509×10^{11}			4.038×10^{6}	4.038×10^{6}
	Low Flows	90 – 100	23.1 – 69.5	52.4	NA	6.284×10^{11}	6.284×10^{10}			1.597×10^{6}	1.597×10^{6}
Cub Creek Waterbody ID: **012 – 1200** HUC-12: 0305	High Flows	0 – 10	31.6 – 155	54.4	NR	6.528×10^{11}	6.528×10^{10}	5.699×10^{8}	0	1.022×10^{8}	1.022×10^{8}
	Moist	10 – 40	13.9 – 31.6	18.8	NR	2.250×10^{11}	2.250×10^{10}			3.516×10^{7}	3.516×10^{7}
	Mid-Range	40 – 70	7.30 – 13.9	9.50	NR	1.140×10^{11}	1.140×10^{10}			1.777×10^{7}	1.777×10^{7}
	Low Flows	70 – 100	1.39 – 7.30	5.36	27.8	6.432×10^{10}	6.432×10^{9}			9.981×10^{6}	9.981×10^{6}
Panther Creek Waterbody ID: **012 – 1400** HUC-12: 0306	High Flows	0 – 10	32.2 – 342	80.4	65.5^b	9.679×10^{11}	9.679×10^{10}	1.211×10^{9}	0	9.626×10^{7}	9.626×10^{7}
	Moist	10 – 40	10.6 – 32.2	13.7		1.640×10^{11}	1.640×10^{10}			1.625×10^{7}	1.625×10^{7}
	Mid-Range	40 – 70	6.83 – 10.6	8.40		1.008×10^{11}	1.008×10^{10}			9.935×10^{6}	9.935×10^{6}
	Low Flows	70 – 100	1.64 – 6.83	5.48		6.576×10^{10}	6.579×10^{9}			6.435×10^{6}	6.435×10^{6}
South Fork Forked Deer River Waterbody ID: **012 – 1000** HUC-12: 0306	High Flows	0 – 10	1,894 – 8,777	3,163	47.1	3.796×10^{13}	3.796×10^{12}	4.684×10^{10}	0	8.581×10^{7}	8.581×10^{7}
	Moist	10 – 40	632 – 1,894	915	NR	1.098×10^{13}	1.098×10^{12}			2.473×10^{7}	2.473×10^{7}
	Mid-Range	40 – 60	342 – 632	485	12.6	5.815×10^{12}	5.815×10^{11}			1.305×10^{7}	1.305×10^{7}
	Dry	60 – 90	138 – 342	210	13.4	2.524×10^{12}	2.524×10^{11}			5.596×10^{6}	5.596×10^{6}
	Low Flows	90 – 100	74.7 – 138	117	NR	1.403×10^{12}	1.403×10^{11}			3.058×10^{6}	3.058×10^{6}
Little Nixon Creek Waterbody ID: **005 – 0100** HUC-12: 0401	High Flows	0 – 10	18.4 – 207	48.2	NA	1.109×10^{12}	1.109×10^{10}	NA	NA	2.224×10^{8}	2.224×10^{8}
	Moist	10 – 40	4.71 – 18.4	6.91	19.1	1.589×10^{11}	1.589×10^{10}			3.188×10^{7}	3.188×10^{7}
	Mid-Range	40 – 70	3.00 – 4.71	3.73	11.4	8.579×10^{10}	8.579×10^{9}			1.721×10^{7}	1.721×10^{7}
	Low Flows	70 – 100	0.71 – 3.00	2.35	21.7	5.405×10^{10}	5.405×10^{9}			1.084×10^{7}	1.084×10^{7}

Table E-41 (cont'd) Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the South Fork Forked Deer River Watershed (HUC 08010205)

Waterbody Description **(TN08010205__)**	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]
Meridian Creek Waterbody ID: **005 – 0200** HUC-12: 0402	High Flows	0 – 10	62.3 – 757	171	17.0[b]	3.922×10^{12}	3.922×10^{11}	NA	NA	NA	9.235×10^{8}
	Moist	10 – 40	20.6 – 62.3	27.9		6.415×10^{11}	6.415×10^{10}				1.510×10^{8}
	Mid-Range	40 – 70	13.6 – 20.6	16.8		3.869×10^{11}	3.869×10^{10}				9.109×10^{7}
	Low Flows	70 – 100	3.33 – 13.6	10.9		2.496×10^{11}	2.496×10^{9}				5.876×10^{7}
Nixon Creek Waterbody ID: **005 – 1000** HUC-12: 0403	High Flows	0 – 10	244 – 2,557	634	NA	1.458×10^{13}	1.458×10^{12}	NA	NA	2.003×10^{8}	2.003×10^{8}
	Moist	10 – 40	71.2 – 244	97.4	14.8	2.241×10^{12}	2.241×10^{11}			3.079×10^{7}	3.079×10^{7}
	Mid-Range	40 – 60	53.8 – 71.2	62.6	45.7	1.439×10^{12}	1.439×10^{11}			1.977×10^{7}	1.977×10^{7}
	Dry	60 – 90	34.5 – 53.8	43.7	4.4	1.006×10^{12}	1.006×10^{11}			1.382×10^{7}	1.382×10^{7}
	Low Flows	90 – 100	11.4 – 34.5	30.6	NR	7.027×10^{11}	7.027×10^{10}			9.654×10^{6}	9.654×10^{6}
Mud Creek Waterbody ID: **011 – 1000** HUC-12: 0501	High Flows	0 – 10	52.2 – 689	160	NR	3.682×10^{12}	3.682×10^{11}	4.089×10^{8}	0	NA	2.160×10^{8}
	Moist	10 – 40	14.7 – 52.2	19.4	13.8	4.460×10^{11}	4.460×10^{10}				2.614×10^{7}
	Mid-Range	40 – 70	9.55 – 14.7	11.7	NR	2.680×10^{11}	2.680×10^{10}				1.570×10^{7}
	Low Flows	70 – 100	2.36 – 9.55	7.68	NR	1.766×10^{11}	1.766×10^{10}				1.034×10^{7}
Kail Creek Waterbody ID: **010 – 0100** HUC-12: 0502	High Flows	0 – 10	41.3 – 482	108	73.9[b]	2.476×10^{12}	2.476×10^{11}	NA	NA	NA	1.891×10^{8}
	Moist	10 – 40	12.8 – 41.3	17.0		3.910×10^{11}	3.910×10^{10}				2.986×10^{7}
	Mid-Range	40 – 70	8.39 – 12.8	10.4		2.394×10^{11}	2.394×10^{10}				1.829×10^{7}
	Low Flows	70 – 100	2.04 – 8.39	6.63		1.525×10^{11}	1.525×10^{10}				1.165×10^{7}
Jacobs Creek Waterbody ID: **010 – 0200** HUC-12: 0503	High Flows	0 – 10	23.7 – 302	69.1	75.5[b]	1.589×10^{12}	1.589×10^{11}	NA	NA	NA	2.033×10^{8}
	Moist	10 – 40	7.07 – 23.7	9.27		2.132×10^{11}	2.132×10^{10}				2.729×10^{7}
	Mid-Range	40 – 70	4.69 – 7.07	5.77		1.327×10^{11}	1.327×10^{10}				1.698×10^{7}
	Low Flows	70 – 100	1.15 – 4.69	3.74		8.602×10^{10}	8.602×10^{9}				1.101×10^{7}
South Fork Forked Deer River Waterbody ID: **010 – 1000** HUC-12: 0503	High Flows	0 – 10	2,141 – 8,271	3,336	56.9	4.003×10^{13}	4.003×10^{12}	7.672×10^{11}	0	NA	7.193×10^{7}
	Moist	10 – 40	825 – 2,141	1,255	28.6	1.506×10^{13}	1.506×10^{12}				2.608×10^{7}
	Mid-Range	40 – 60	453 – 825	628	7.6	7.531×10^{12}	7.531×10^{11}				1.226×10^{7}
	Dry	60 – 90	208 – 453	313	3.4	3.751×10^{12}	3.751×10^{11}				5.321×10^{6}
	Low Flows	90 – 100	105 – 208	175	NR	2.100×10^{12}	2.100×10^{11}				2.291×10^{6}
Black Creek Waterbody ID: **031 – 1000** HUC-12: 0504	High Flows	0 – 10	64.4 – 748	173	38.6	2.074×10^{12}	2.074×10^{11}	NA	NA	NA	1.003×10^{8}
	Moist	10 – 40	20.0 – 64.4	26.1	21.8	3.134×10^{11}	3.134×10^{10}				1.517×10^{7}
	Mid-Range	40 – 60	14.9 – 20.0	17.3	61.1	2.080×10^{11}	2.080×10^{10}				1.006×10^{7}
	Dry	60 – 90	9.77 – 14.9	12.1	13.8	1.457×10^{11}	1.457×10^{10}				7.049×10^{6}
	Low Flows	90 – 100	3.20 – 9.77	7.29	NR	8.748×10^{10}	8.748×10^{9}				4.233×10^{6}

Table E-41 (cont'd) Summary of TMDLs, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the South Fork Forked Deer River Watershed (HUC 08010205)

Waterbody Description (TN08010205__)	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 Tisdale Creek Waterbody ID: **036 – 0110** HUC-12: 0505	High Flows	0 – 10	1.70 – 24.5	4.09	95.8[b]	4.908 x 10^{10}	4.908 x 10^{9}	NA	NA	NA	8.506 x 10^{7}
	Moist	10 – 40	0.60 – 1.70	0.77		9.240 x 10^{9}	9.240 x 10^{8}				1.601 x 10^{7}
	Mid-Range	40 – 70	0.39 – 0.60	0.48		5.760 x 10^{9}	5.760 x 10^{8}				9.983 x 10^{6}
	Low Flows	70 – 100	0.10 – 0.39	0.31		3.720 x 10^{9}	3.720 x 10^{8}				6.447 x 10^{6}
Halls Creek Waterbody ID: **036 – 1000** HUC-12: 0505	High Flows	0 – 10	56.8 – 689	146	NA	1.755 x 10^{12}	1.755 x 10^{11}	NA	NA	NA	9.333 x 10^{7}
	Moist	10 – 40	17.4 – 56.8	22.7	31.5	2.719 x 10^{11}	2.749 x 10^{10}				1.446 x 10^{7}
	Mid-Range	40 – 60	13.5 – 17.4	15.6	7.9	1.866 x 10^{11}	1.866 x 10^{10}				9.922 x 10^{6}
	Dry	60 – 90	8.00 – 13.5	10.5	8.3	1.260 x 10^{11}	1.260 x 10^{10}				6.700 x 10^{6}
	Low Flows	90 – 100	3.95 – 8.00	70.7	NR	8.484 x 10^{10}	8.484 x 10^{9}				4.511 x 10^{6}
Mill Creek Waterbody ID: **001 – 0200** HUC-12: 0506	High Flows	0 – 10	36.9 – 481	93.7	80.7[b]	2.156 x 10^{12}	2.156 x 10^{11}	NA	NA	NA	1.704 x 10^{8}
	Moist	10 – 40	11.0 – 36.9	14.1		3.234 x 10^{11}	3.234 x 10^{10}				2.555 x 10^{7}
	Mid-Range	40 – 70	6.77 – 11.0	8.80		2.024 x 10^{11}	2.024 x 10^{10}				1.599 x 10^{7}
	Low Flows	70 – 100	2.55 – 6.77	5.31		1.221 x 10^{11}	1.221 x 10^{10}				9.650 x 10^{6}
South Fork Forked Deer River Waterbody ID: **001 – 1000** HUC-12: 0507	High Flows	0 – 10	2,925 – 10.153	4,404	74.2	5.285 x 10^{13}	5.285 x 10^{12}	8.893 x 10^{11}	0	NA	7.188 x 10^{7}
	Moist	10 – 40	1,096 – 2,925	1,634	20.8	1.960 x 10^{13}	1.960 x 10^{12}				2.580 x 10^{7}
	Mid-Range	40 – 60	628 – 1,096	859	NR	1.031 x 10^{13}	1.031 x 10^{12}				1.292 x 10^{7}
	Dry	60 – 90	299 – 628	458	16.8	5.501 x 10^{12}	5.501 x 10^{11}				6.255 x 10^{6}
	Low Flows	90 – 100	109 – 299	252	NR	3.028 x 10^{12}	3.058 x 10^{11}				2.828 x 10^{6}
South Fork Forked Deer River Waterbody ID: **003 – 1000** HUC-12: 0507	High Flows	0 – 10	2,708 – 9,671	4,098	32.8	9.425 x 10^{13}	9.425 x 10^{12}	8.537 x 10^{11}	0	NA	1.417 x 10^{8}
	Moist	10 – 40	970 – 2,708	1,497	NA	3.443 x 10^{13}	3.443 x 10^{12}				5.083 x 10^{7}
	Mid-Range	40 – 60	561 – 970	767	NA	1.764 x 10^{13}	1.764 x 10^{12}				2.534 x 10^{7}
	Dry	60 – 90	264 – 561	415	NR	9.542 x 10^{12}	9.542 x 10^{11}				1.305 x 10^{7}
	Low Flows	90 – 100	100 – 264	225	NA	5.177 x 10^{12}	5.177 x 10^{11}				6.420 x 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 SOUTH FORK FORKED DEER RIVER WATERSHED (HUC 08010205), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed Total Maximum Daily Load (TMDL) for E. coli in the South Fork Forked Deer 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 South Fork Forked Deer River 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 3-93.8% in the listed waterbodies.

The South Fork Forked Deer 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 November 14, 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

Public Comments Received

RECEIVED
NOV 14 2011

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
ENVIRONMENTAL COMPLIANCE OFFICE
SUITE 300 - JAMES K. POLK BUILDING
505 DEADERICK STREET
NASHVILLE, TENNESSEE 37243-0334

October 27, 2011

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

Re: Comments on Proposed E. Coli Total Maximum Daily Load for South Fork Forked Deer River Watershed

TDEC has recently issued a draft document for public comment presenting a proposed Total Maximum Daily Load (TMDL) for E. coli in the South Fork Forked Deer River Watershed (HUC 08010205). In Section 7.1.2 of that document, the Tennessee Department of Transportation (TDOT) Municipal Separate Storm Sewer System (MS4), regulated under Permit TNS077585, is listed as a possible point source for the pollutant loading that is the subject of the TMDL. Inclusion as a possible point source for this stream impairment will trigger requirements in the TDOT MS4 Permit that could include stormwater effluent sampling, in-stream monitoring, and the implementation of control measures at the discharge points. TDOT does not believe that the inclusion of its MS4 as a point source for the pollutant loading which is the subject of this TMDL is appropriate and requests that the draft document be modified to remove the TDOT MS4 as a possible point source. The rationale for this request includes the following points:

1. The subject TMDL affects a total of 21 impaired stream segments in the South Fork Forked Deer River Watershed. However, Table 2 of the subject document identifies that only 7 of those stream segments include as a pollutant source "Discharges from MS4 area." Those 7 stream segments include designated reaches of:

    - Little Nixon Creek
    - Nixon Creek
    - Sandy Creek
    - Central Creek
    - Anderson Branch
    - Bond Creek
    - South Fork Forked Deer River from Mud Creek to Meridian Creek

Data from TDOT's stormwater outfall mapping program has determined that the TDOT MS4 has point source discharges (outfalls) to these 7 stream segments at a total of only 20 locations. No TDOT owned or operated facilities regulated under its MS4 Permit (e.g. maintenance garages, rest areas, welcome centers, weigh stations, salt storage, etc.) discharge directly to the stream segments of interest. Typically, the TDOT MS4 includes only the area within the Right-of-Way (ROW) of a state highway. ROW widths can vary from a minimum of about 40 ft. to a maximum of several hundred feet, depending on the number of roadway lanes, the presence of a median, and the general layout of the highway. Outfalls from the TDOT MS4 are the points where underground stormwater conveyance systems and/or surface ditches from the roadway discharge to Waters of the State. An individual outfall may convey drainage from as little as a 100 ft. of the ROW to several miles, depending on the local topography and roadway design. Much of the roadway runoff from the TDOT MS4 drains as sheet flow to adjacent gravel shoulders and vegetated areas and never enters the conveyance structures leading to the outfalls. Based upon the TDOT MS4 Program outfall mapping effort, the total area within the TDOT MS4 that drains to the point source outfalls of interest is estimated to be less than 200 acres. However, the total drainage area of the 7 impaired stream segments (see subject document Table A-2) is 199,767 acres. The TDOT MS4 accounts for less than 0.1% of the drainage area contributing to these stream segments and thus, is a negligible contributor to this hydrologic system. Additionally, the other major MS4 identified in the TMDL document as a possible source is the City of Jackson. The Jackson MS4 includes a drainage areas contributing to the 7 identified stream segments of over 5,000 acres. Again, the contribution of the TDOT MS4 is insignificant in relation to other identified sources.

2. The TDOT MS4 Program has been acquiring and analyzing samples of stormwater runoff from state highways over the past two years. These samples have been acquired from a variety of highway scenarios across the State, ranging from high traffic volume interstate highways in urban commercial areas to low traffic volume highways in rural agricultural areas. To date, a total of 117 stormwater samples draining from the TDOT MS4 have been evaluated for E. coli. Of these 117 analyses, only 14 have detected the presence of E. coli, and only six of the measured E. coli results have exceeded the sample maximum value selected as the appropriate numerical target for TMDL development in Tennessee (see subject document Section 5.0). Based on these stormwater sampling results from the TDOT MS4, only about 5% of the stormwater discharges from the TDOT MS4 would be expected to contribute E. coli contamination at levels that could impact the watershed. Again, the TDOT MS4 is obviously a negligible contributor to the E. coli contamination observed in this watershed.

3. The California Department of Transportation (Caltrans), when faced with similar issues, sponsored an extensive investigation into the presence of human pathogens in urban highway storm drains. The study focused on the validity of the use of organisms, such as coliforms and E. coli, as indicators of the presence of actual human pathogens in drainage systems. The study evaluated stormwater runoff from highways and controlled discharges of sterile water through the systems as a means to evaluate the source and presence of these organisms. In summary, the study had the following conclusions:

    - The use of total coliforms, fecal coliforms, and E. coli as indicator organisms for human pathogens is based on the assumption that these organisms do not compete well in the natural environment. However, these organisms have been shown to reproduce and compete in warm soils, and to be normal members of the microbial community;
    - Significant concentrations of indicator organisms, such as E. coli, are nearly ubiquitous in urban drainage;

- Pathogens can be found in urban drainage, but there does not appear to be a relationship between the presence of pathogens and the concentration of indicator organisms, such as E. coli;
- Highway facilities, including maintenance stations, do not appear to be a significant source of pathogens in urban drainage.

The complete Caltrans report for this study can be found at:

http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-02-025.pdf

From this evaluation of the proposed TMDL, the stormwater runoff from the TDOT MS4 has been shown to be a negligible contributor to the hydrologic regime of the subject watershed, and two independent studies have demonstrated that highway runoff is not a significant vector of E. coli or human pathogens. Inclusion of the TDOT MS4 as a possible contaminant source for this TMDL would potentially result in the expenditure of significant State resources to maintain TDOT MS4 Permit compliance. This potential expenditure does not appear to be justified by the insignificant impact of the TDOT MS4 to this watershed contamination and, based on this information, TDOT respectfully requests that this draft TMDL document be revised to remove the TDOT MS4 as a possible source for the subject contamination.

If you have any questions, or require additional information and documentation, please call me at 615-741-4732 or email me at Barry.Brown@tn.gov.

Sincerely,

Barry C. Brown
Director, Environmental Compliance Office
TDOT Environmental Division

Cc: John Nichols, TDOT
Project Files

APPENDIX H

Response to Public Comments Received

TDEC has considered the comments submitted by TDOT. The TDOT MS4 will not be considered as a potential source of E. coli loading. Changes have been made to Section 7.1.2 summarizing the arguments made by TDOT.

TDEC has made corrections to the allocations for Anderson Branch in response to a comment from EPA. The allocations in the Summary Table, Table 7, Table C-1, and Table E-41 are now calculated using water quality standard for Exceptional Tennessee Waters (487 cfu/mL).