TOTAL MAXIMUM DAILY LOAD (TMDL)

for

E. Coli

in the

South Fork Forked Deer River Watershed (HUC 08010205)

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

FINAL

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LIST OF ABBREVIATIONS

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

SUMMARY SHEET

Total Maximum Daily Load for E. Coli in Selected Waterbodies of the 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

Impaired Waterbodies Addressed in This Document (from the Final 2004 303(d) List):

Waterbody ID	Waterbody	RM not Fully Supporting
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	44.0
TN08010205005 – 1000	NIXON CREEK	20.4
TN08010205010 – 1000	SOUTH FORK FORKED DEER RIVER	13.2
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 – 1000	SOUTH FORK FORKED DEER RIVER	21.6
TN08010205012 – 1200	CUB CREEK	27.0
TN08010205031 – 1000	BLACK CREEK	12.9
TN08010205036 – 1000	HALLS CREEK	15.4

Designated Uses:

The designated use classifications for all impaired waterbodies in the South Fork Forked Deer River watershed include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. Use classifications for South Fork Forked Deer River from the mouth to mile 70.3 include navigation.

Water Quality Goal:

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

> The concentration of the E. coli group shall not exceed 126 colony forming units per 100 ml, as a geometric mean based on a minimum of 5 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purposes of determining the geometric mean, individual samples having an E. coli concentration of less than 1 per 100 ml shall be considered as having a concentration of 1 per 100 ml.

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

TMDL Scope:

Waterbodies identified on the Final 2004 303(d) list as impaired due to E. coli. TMDLs are developed for impaired waterbodies primarily on a HUC-12 subwatershed basis. In some cases, where appropriate, TMDLs were developed for an impaired waterbody drainage area only. For eight segments, including Sandy Creek, Central Creek, Anderson Branch, Bond Creek, Cub Creek, and three segments of the South Fork Forked Deer River (TN08010205003-1000, TN08010205010-1000, and TN08010205012-1000), the TMDL analyses were revised due to the availability of new data. These revised TMDLs supercede the Fecal Coliform TMDLs approved by EPA in 2001.

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 Tier II waterbodies and 941 CFU/100 mL maximum water quality criteria for non-Tier II waterbodies. A duration curve is a cumulative frequency graph that represents the percentage of time during which the value of a given parameter is equaled or exceeded. Load duration curves are developed from flow duration curves and can illustrate existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired targets, and the region of the waterbody flow regime represented by these existing loads. Load duration curves were used to determine the load reductions required to meet the target maximum concentrations for E. coli. When sufficient data were available, load reductions were also determined based on the geometric mean criterion.

Analysis of monitoring data suggests the potential for delisting Meridian Creek for E. coli. However, no new data have been collected subsequent to its assessment as not fully supporting designated use classifications due, in part, to E. coli. Therefore, it is recommended that additional data be collected to confirm the status of impairment or to support delisting.

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.

Seasonal Variation:

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

Margin of Safety (MOS):

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

TMDLs, WLAs, & LAs

Summary of TMDLs, WLAs, & LAs for Impaired Waterbodies

HUC-12 Subwatershed (08010205__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs[a]				LAs[e]
				WWTFs[b]		Leaking Collection Systems[c]	MS4s[d]	
				Monthly Avg.	Daily Max.			
			[% Red.]	[CFU/day]	[CFU /day]	[CFU /day]	[% Red.]	[% Red.]
0301 (DA)	Sandy Creek	TN08010205012 – 0400	**83.2**	**NA**	**NA**	**0**	**84.9**	**84.9**
0301 (DA)	Central Creek	TN08010205012 – 0500	**>61.6**	**NA**	**NA**	**0**	**>65.0**	**>65.0**
0301 (DA)	Anderson Branch	TN08010205012 – 0600	**22.7**	**NA**	**NA**	**0**	**30.5**	**30.5**
0301 (DA)	Bond Creek	TN08010205012 – 0700	**>92.0**	**NA**	**NA**	**0**	**>92.8**	**>92.8**
0301	SFFD River	TN08010205012 – 1000	**>69.7**	**8.300×10^{10}**	**6.199×10^{11}**	**0**	**>72.7**	**>72.7**
0303	Cub Creek	TN08010205012 – 1200	**36.4**	**7.646×10^{7}**	**5.710×10^{8}**	**0**	**42.8**	**42.8**
0306	SFFD River	TN08010205012 – 1000	**27.5**	**1.328×10^{10}**	**9.921×10^{10}**	**0**	**NA**	**34.6**
0402	SFFD River	TN08010205003 – 1000	**71.9**	**1.159×10^{10}**	**8.657×10^{10}**	**NA**	**NA**	**74.7**
	SFFD River	TN08010205010 – 1000						
0404	SFFD River	TN08010205001 – 1000	**63.1**	**3.339×10^{9}**	**2.494×10^{10}**	**0**	**NA**	**66.8**
0405	Black Creek	TN08010205031 – 1000	**65.4**	**NA**	**NA**	**0**	**NA**	**68.8**
0406	Halls Creek	TN08010205036 – 1000	**59.7**	**NA**	**NA**	**0**	**NA**	**63.6**
0501	Little Nixon Creek	TN08010205005 – 0100	**76.1**	**NA**	**NA**	**0**	**78.5**	**78.5**
0502	Nixon Creek	TN08010205005 – 1000	**45.7**	**NA**	**NA**	**NA**	**NA**	**51.0**
0503	Meridian Creek	TN08010205005 – 0200	**0.0**	**NA**	**NA**	**NA**	**NA**	**0.0**

Note: NA = Not applicable.

a. There are no CAFOs in the South Fork Forked Deer River watershed. Future CAFOs will be assigned a waste load allocation (WLA) of zero.

b. WLAs for WWTFs expressed as E. coli loads (CFU/day). Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permits.

c. The objective for leaking collection systems is a WLA of zero. It is recognized, however, that a WLA of 0 CFU/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in E. coli loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

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

e. The load allocations (LAs) listed apply to precipitation induced nonpoint sources only. The objective for all other nonpoint sources (leaking septic systems, illicit discharges, and animals access to streams) is a LA of zero. It is recognized, however, that for leaking septic systems a LA of 0 CFU/day may not be practical. For these sources, the LA is interpreted to mean a reduction in E. coli loading to the maximum extent feasible, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

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 2004 303(d) list as not supporting designated uses due to Escherichia coli (E. coli). The South Fork Forked Deer River Watershed lies entirely in the state of Tennessee. TMDL analyses were performed primarily on a 12-digit hydrologic unit area (HUC-12) basis. In some cases, where appropriate, TMDLs were developed for an impaired waterbody drainage area only.

South Fork Forked Deer River watershed Fecal Coliform TMDLs, developed and approved by EPA in 2001, addressed waterbodies identified on the 1998 303(d) list as not supporting designated uses due, in part, to pathogens. The current TMDLs supercede those for eight (8) of the ten (10) waterbodies addressed by the 2001 TMDL report. The eight waterbodies are Sandy Creek, Central Creek, Anderson Branch, Bond Creek, Cub Creek, and three mainstem South Fork Forked Deer River segments (TN08010205003-1000, TN08010205010-1000, and TN08010205012-1000). The remaining two (2) waterbodies have been delisted for pathogens (E. coli). The two delisted waterbodies are Johnson Creek and the North Fork of the South Fork Forked Deer River. The TMDL has been revised based on additional monitoring data.

3.0 WATERSHED DESCRIPTION

The South Fork Forked Deer River watershed (HUC 08010205) is located in west Tennessee (Figure 1) and lies within the Level III Southeastern Plains (65), Mississippi Alluvial Plain (73), and Mississippi Valley Loess Plains (74) ecoregions. The impaired subwatersheds lie in the Level IV Southeastern Plains and Hills (65e), Northern Mississippi Alluvial Plain (73a), Bluff Hills (74a), and Loess Plains (74b) ecoregions as shown in Figure 2 (USEPA, 1997):

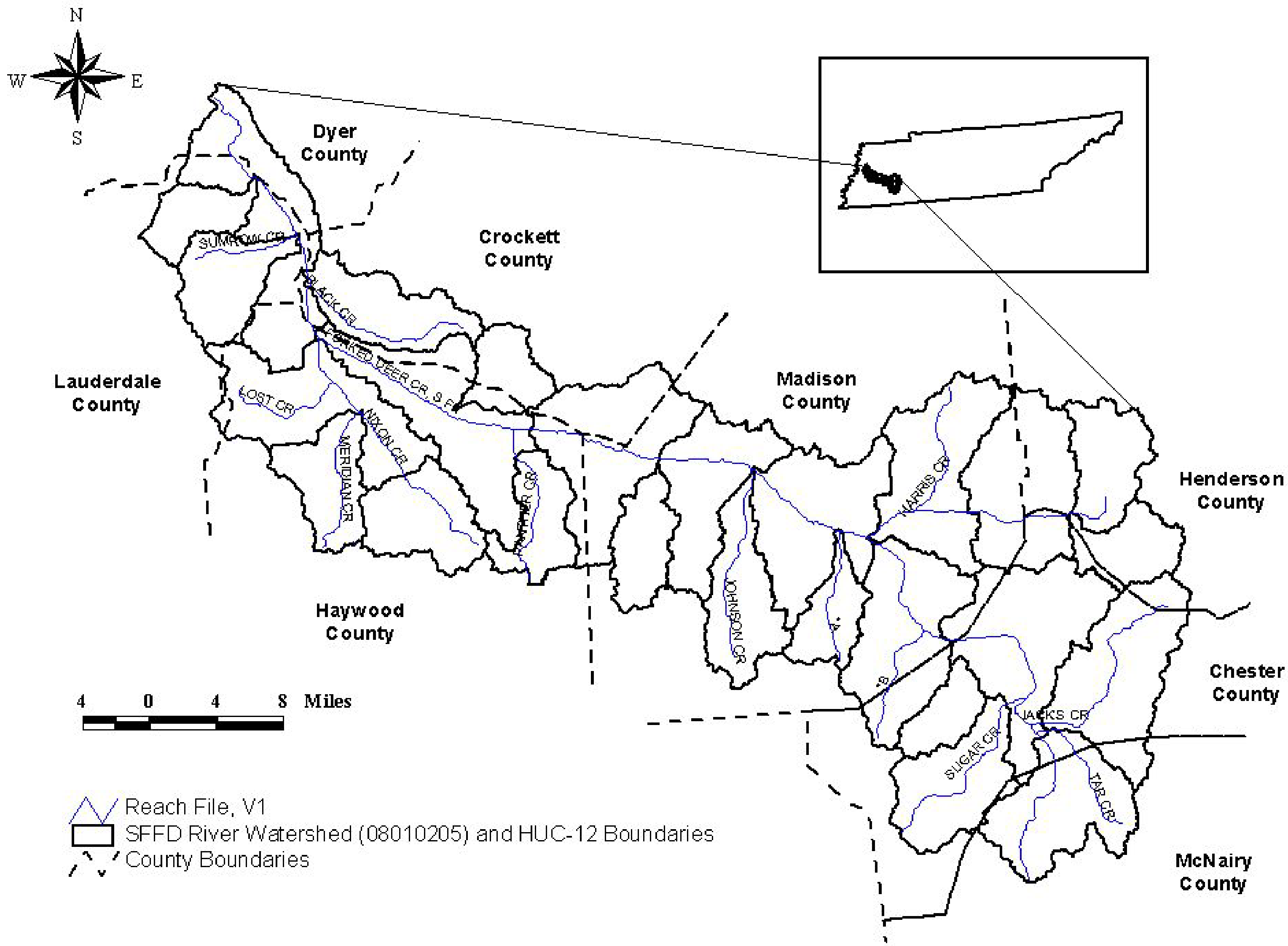

Figure 1. Location of the South Fork Forked Deer River Watershed and HUC-12 Subwatersheds.

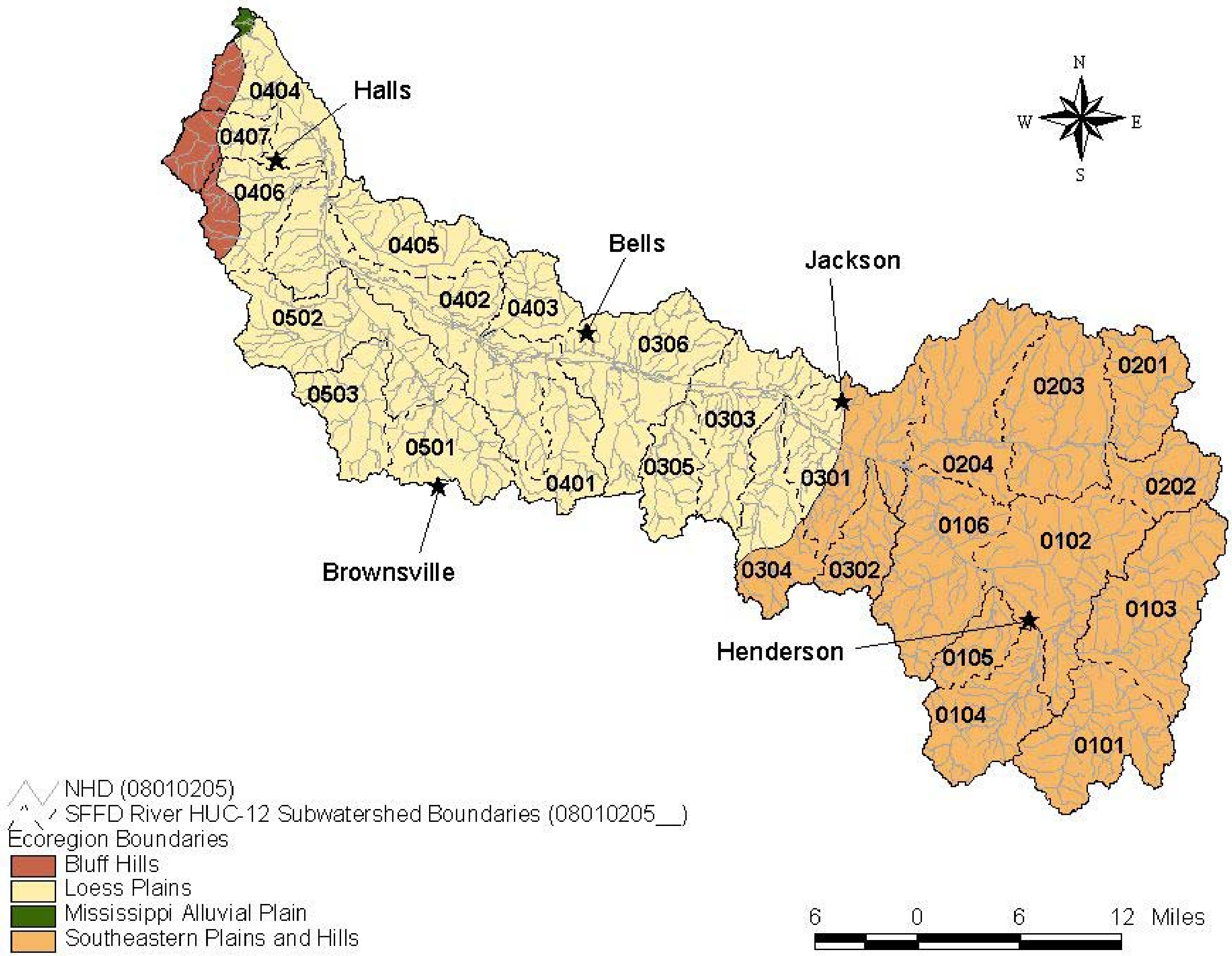

Figure 2. Level IV Ecoregions in the South Fork Forked Deer River Watershed

- The Southeastern Plains and Hills (65e) contain several north-south trending bands of sand and clay formations. With elevations reaching over 650 feet, and more rolling topography and more relief than the Loess Plains to the west, streams have increased gradient, generally sandy substrates, and distinctive faunal characteristics for West Tennessee.

- Within Tennessee, the Northern Mississippi Alluvial Plain (73a) is a relatively homogenous region of Quaternary alluvial deposits of sand, silt, clay, and gravel. It is bounded distinctly on the east by the Bluff Hills (74a) and on the west by the Mississippi River. The two main distinctions in the Tennessee portion of the ecoregion are between areas of loamy, silty, and sandy soils with better drainage, and areas of more clayey soils of poor drainage that may contain wooded swampland and oxbow lakes.

- Along the western edge of the Bluff Hills (74a) ecoregion, bordering the Mississippi Alluvial Plain, are deep loess hilly areas, often called bluff hills. Consisting of sand, clay, silt, and lignite, the bluffs are capped by loess greater than 60 feet deep. The disjunct ecoregion in Tennessee encompasses those thick loess areas that are generally the steepest, most dissected, and forested. 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.

- The Loess Plains (74b) ecoregion within Tennessee consists of gently rolling, irregular plains, with 100-200 feet of local relief. The loess can be over 50 feet thick. Several large river systems and their tributaries cross the ecoregion with wide flood plains that are distinct from the adjacent uplands. Streams of the ecoregion are low-gradient and murky, with silt and sand bottoms. Many of the streams have been deforested and channelized. Valley plugs or channel blockages, where channel aggradation and driftwood accumulation combine to change flow patterns, are common along the low-gradient alluvial streams in this region.

The South Fork Forked Deer River watershed, located in Crockett, Chester, Dyer, Haywood, Henderson, Lauderdale, Madison, and McNairy Counties, Tennessee, has a drainage area of approximately 1065 square miles (mi^2). Watershed land use distribution is based on the Multi-Resolution Land Characteristic (MRLC) databases derived from Landsat Thematic Mapper digital images from the period 1990-1993. Although changes in the land use of the South Fork Forked Deer River watershed have occurred since 1993 as a result of 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. Predominate land use in the South Fork Forked Deer River watershed is agriculture (57.0%) followed by forest (39.7%). Urban areas represent approximately 2.4% of the total drainage area of the watershed. Details of land use distribution of E. coli-impaired subwatersheds in the South Fork Forked Deer River watershed are presented in Appendix A.

4.0 PROBLEM DEFINITION

The State of Tennessee's Final 2004 303(d) list (TDEC, 2005) was approved by the U.S. Environmental Protection Agency (EPA), Region IV in August of 2005. The list identified 14 waterbody segments in the South Fork Forked Deer River watershed as not fully supporting designated use classifications due, in part, to E. coli. See Table 2 and Figure 4. The designated use classifications for these waterbodies include fish and aquatic life, irrigation, livestock watering & wildlife, recreation, and navigation.

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

Land Use	Area	
	[acres]	[%]
Bare Rock/Sand/Clay	1	0.0*
Deciduous Forest	150,324	22.1
Emergent Herbaceous Wetlands	7,879	1.2
Evergreen Forest	21,206	3.1
High Intensity Commercial/ Industrial/Transportation	2,914	0.4
High Intensity Residential	2,391	0.4
Low Intensity Residential	10,727	1.6
Mixed Forest	37,814	5.5
Open Water	5,120	0.8
Other Grasses (Urban/recreational)	2,012	0.3
Pasture/Hay	150,724	22.1
Quarries/Strip Mines/ Gravel Pits	25	0.0*
Row Crops	236,975	34.8
Small Grains	961	0.1
Transitional	951	0.1
Woody Wetlands	51,704	7.6
Total	**681,728**	**100.00**

* < 0.05%

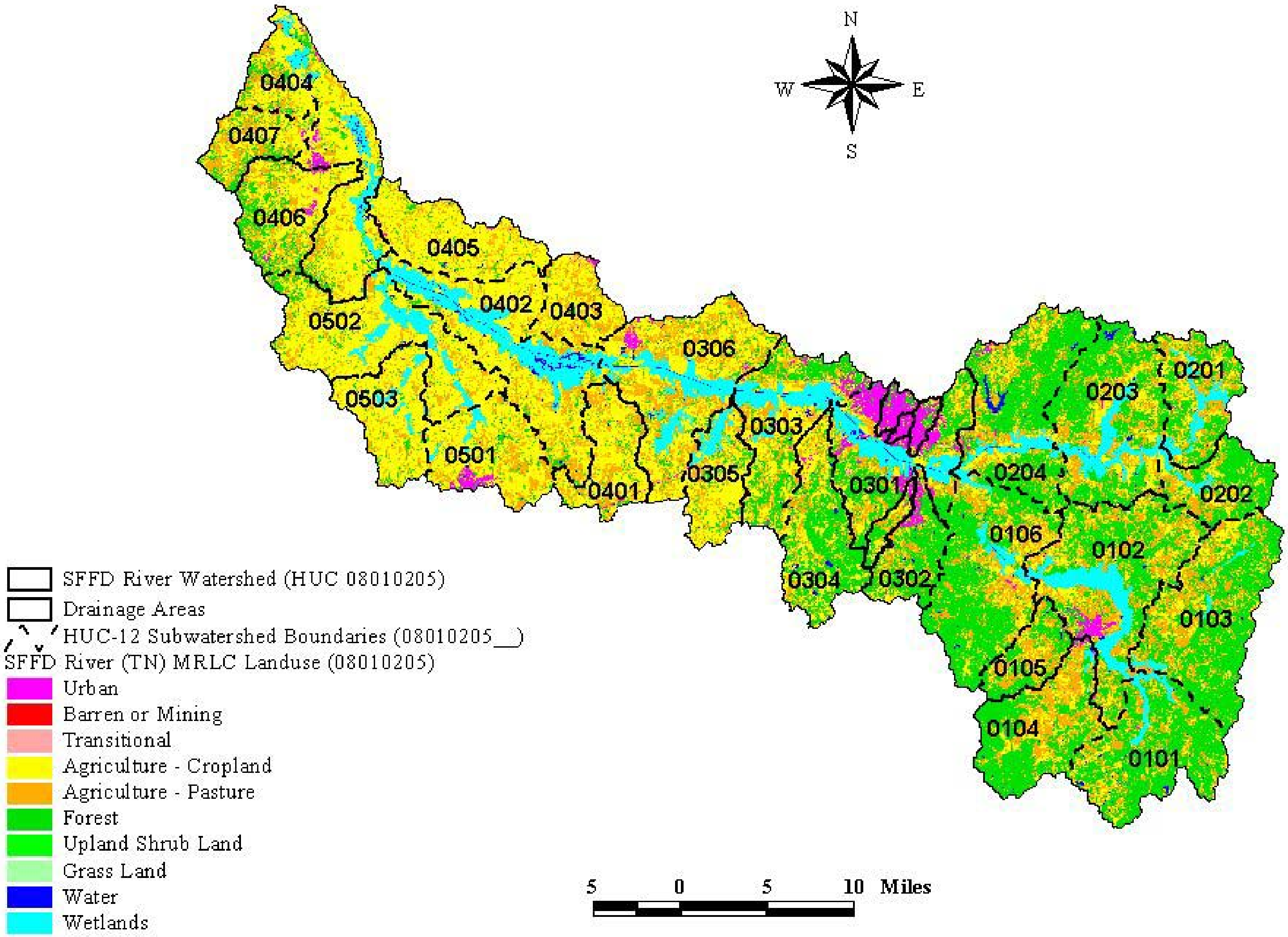

Figure 3. Land Use Characteristics of the South Fork Forked Deer River Watershed

Table 2. Final 2004 303(d) List for E. coli – South Fork Forked Deer River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	CAUSE / TMDL Priority	Pollutant Source
TN08010205001 – 1000	SFFD RIVER	15.6	Loss of biological integrity due to Siltation Physical Substrate Habitat Alterations Escherichia coli	Nonirrigated Crop Production Channelization Undetermined Pathogen Source
TN08010205003 – 1000	SFFD RIVER	6.8	Loss of biological integrity due to Siltation Physical Substrate Habitat Alterations 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 Alterations Escherichia coli	Channelization Discharges from MS4 area
TN08010205009 – 0300	MERIDIAN CREEK	44.0	Loss of biological integrity due to Siltation Physical Substrate Habitat Alterations Escherichia coli	Pasture Grazing Channelization
TN08010205005 – 1000	NIXON CREEK	20.4	Loss of biological integrity due to Siltation Phosphate Physical Substrate Habitat Alterations Escherichia coli	Nonirrigated Crop Production Channelization Discharges from MS4 area
TN08010205010 – 1000	SFFD RIVER	13.2	Loss of biological integrity due to Siltation Physical Substrate Habitat Alterations Escherichia coli	Nonirrigated Crop Production Channelization Undetermined Fecal Source
TN08010205012 – 0400	SANDY CREEK	4.3	Physical Substrate Habitat Alterations Escherichia coli	Discharges from MS4 area Channelization
TN08010205012 – 0500	CENTRAL CREEK	2.0	Escherichia coli	Collection System Failure Discharges from MS4 area
TN08010205012 – 0600	ANDERSON BRANCH	5.2	Biological integrity loss due to undetermined cause Escherichia coli	Collection System Failure Industrial Point Source

Table 2. Final 2004 303(d) List for E. coli – South Fork Forked Deer River Watershed (Cont.)

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	CAUSE / TMDL Priority	Pollutant Source
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 – 1000	SFFD RIVER	21.6	Phosphorus Loss of biological integrity due to Siltation Physical Substrate Habitat Alterations Escherichia coli	Discharges from MS4 area Nonirrigated Crop Production Dredge Mining Sand/Rock/Gravel Mining Land Development Channelization
TN08010205012 – 1200	CUB CREEK	27.0	Escherichia coli	Animal Feeding Operations (NPS)
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
TN08010205036 – 1000	HALLS CREEK	15.7	Escherichia coli	Undetermined Source

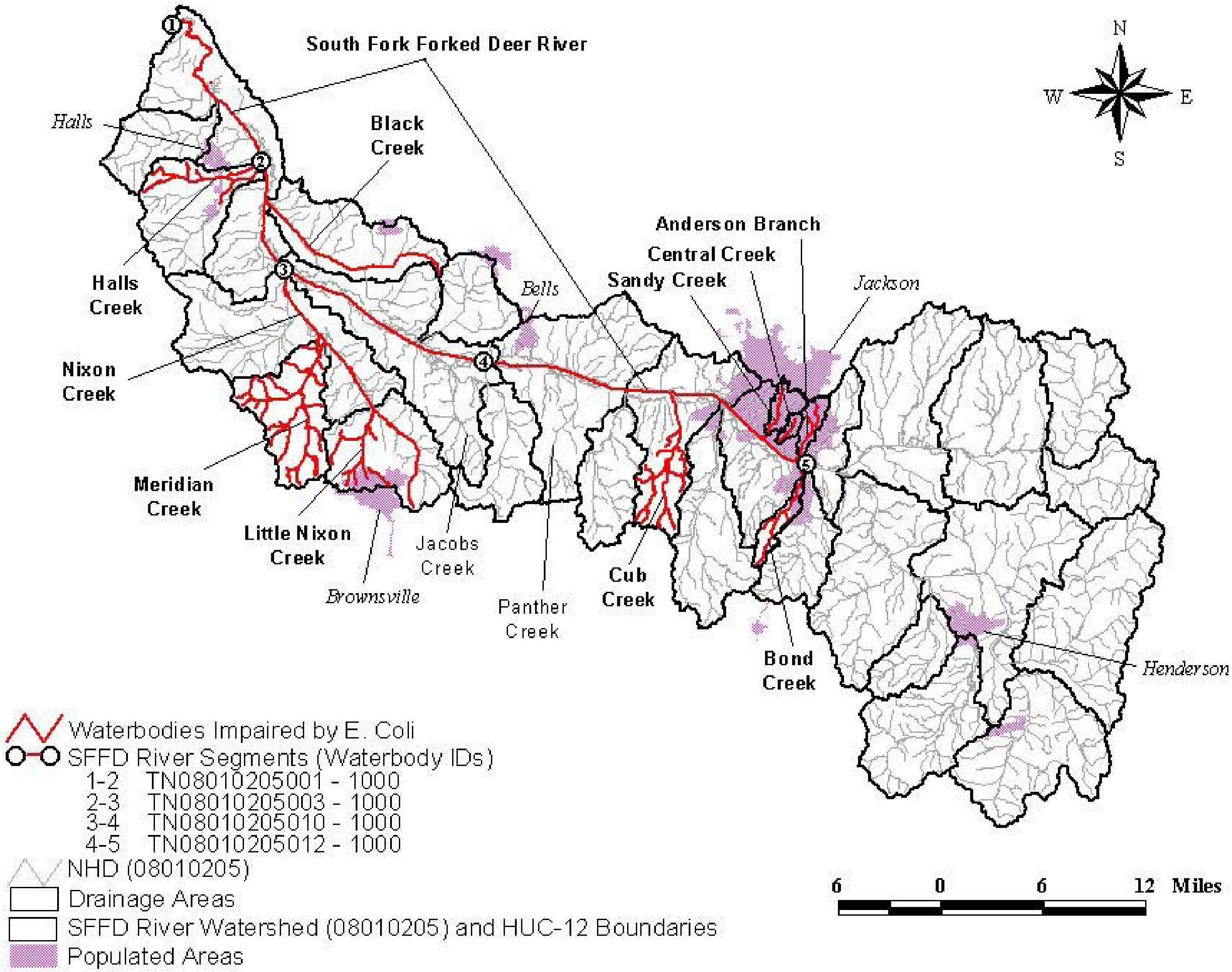

Figure 4. Waterbodies Impaired by E. Coli (as Documented on the Final 2004 303(d) List)

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, January 2004* (TDEC, 2004a). Section 1200-4-3-.03 (4) (f) states:

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

Portions of the South Fork Forked Deer River within the Lake Lauderdale Refuge, the South Fork Waterfowl Refuge, Fort Ridge Wildlife Management Area, and the Col. Forrest Durand Wetland have been designated as Tier II streams. In addition, a portion of Anderson Branch, in the Col. Forrest Durand Wetland, has been designated as a Tier II stream. As of February 2, 2006, none of the other E. coli impaired waterbodies in the South Fork Forked Deer River watershed have been designated as either State Scenic River, Tier II, or Tier III streams.

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

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. Monitoring stations located on Tier II waterbodies have been italicized:

- South Fork Forked Deer River Subwatershed:
  - *SFFDE011.2DY – South Fork Forked Deer River, at Hwy 210*
- South Fork Forked Deer River Subwatershed:
  - *SFFDE030.4HY – South Fork Forked Deer River, at Hwy 54*
  - *SFFDE030.6HY – South Fork Forked Deer River, at Hwy 54*

  - JACOB004.1HY – Jacobs Creek, at Hwy 79
- Little Nixon Creek Subwatershed:
  - LNIXO002.9HY – Little Nixon Creek, at Allen King Road
- Meridian Creek Subwatershed:
  - MERID001.7 HY – Meridian Creek, at Thomas Road
- Nixon Creek Subwatershed:
  - NIXON002.2HY – Nixon Creek, at Rudolph Road
- South Fork Forked Deer River Subwatershed:
  - SFFDE036.7HY – South Fork Forked Deer River, at Hwy 79
  - SFFDE043.2MN – South Fork Forked Deer River, at Roberts Station Road
  - PANTH001.9MN – Panther Creek, at Lower Brownsville Road
- Sandy Creek Subwatershed:
  - SANDY00.55MN – Sandy Creek, at Airways Blvd. (Hwy 70)
- Central Creek Subwatershed:
  - CENTR00.44MN – Central Creek, at State Street
- Anderson Branch Subwatershed:
  - *ANDER00.55MN – Anderson Creek, at Jackson Fairgrounds*
- Bond Creek Subwatershed:
  - BOND001.0MN – Bond Creek, at Perry Switch Road
- South Fork Forked Deer River Subwatershed:
  - *SFFDE052.7MN – South Fork Forked Deer River, at Westover Road*
- Cub Creek Subwatershed:
  - CUB001.6MN – Cub Creek, at Lower Brownsville Road
- Black Creek Subwatershed:
  - BLACK001.6CK – Black Creek, at Spence Road
- Halls Creek Subwatershed:
  - HALLS001.2LE – Halls Creek, at Espy Park Road

The locations of these monitoring stations are shown in Figure 5. Water quality monitoring results for these stations are tabulated in Appendix B. Examination of the data shows exceedances of the 487 CFU/100 mL (Tier II) and 941 CFU /100 mL (non-Tier II) maximum E. coli standard at all monitoring stations where E. coli samples were collected. Water quality monitoring results are summarized in Table 3.

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

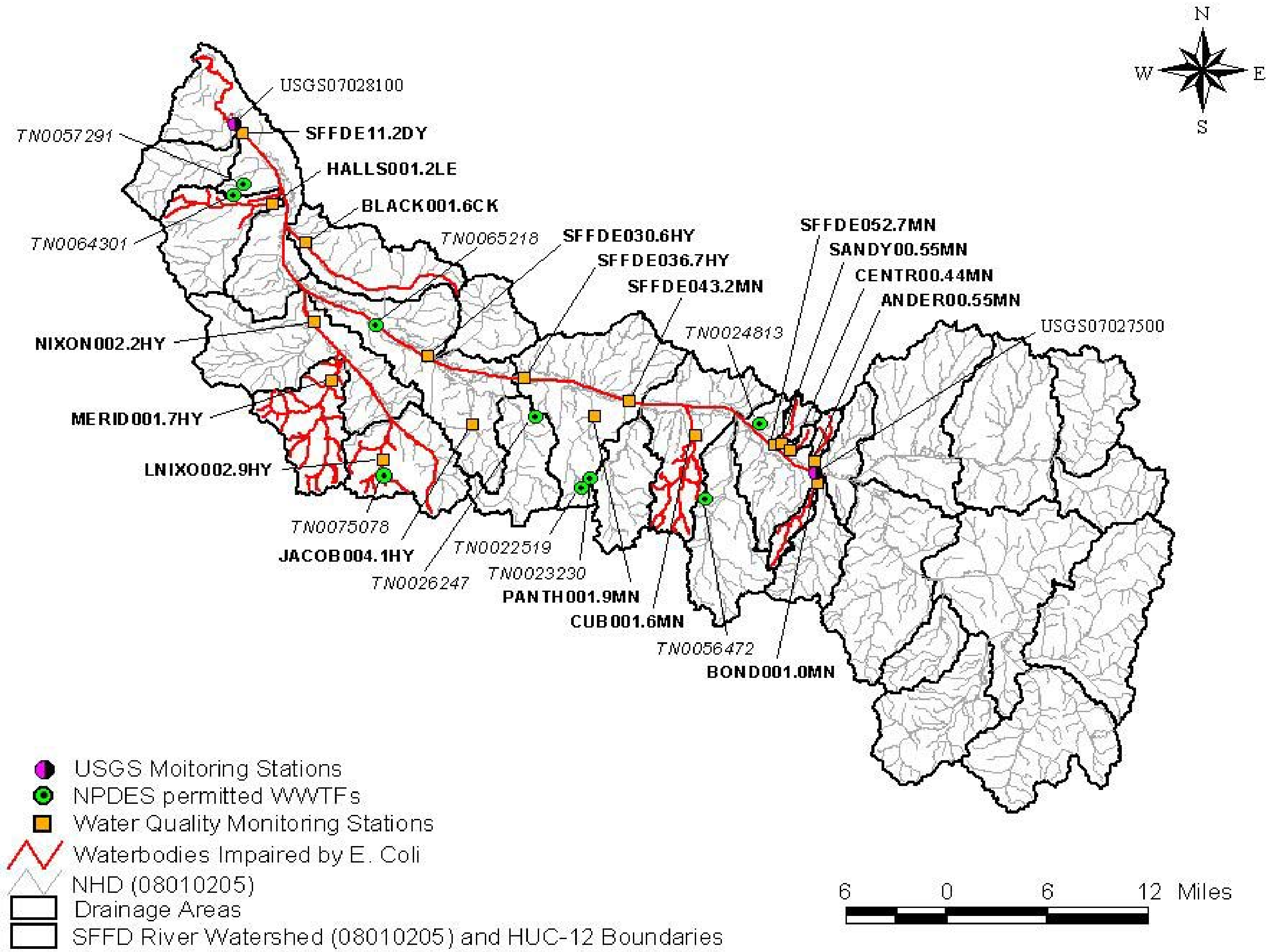

Figure 5. Monitoring Stations and NPDES permitted WWTFs in the South Fork Forked Deer River Watershed

Table 3. Summary of Water Quality Monitoring Data

Monitoring Station	E. Coli (Single Sample Max. WQ Target = 941 CFU/100 mL)*					
	Data Pts.	Date Range	[CFU/100 mL]			Exceed WQ Max. Target
			Min.	Avg.	Max.	
SFFDE011.2DY	*10*	*5/01-3/02*	*19.9*	*345*	*1483*	*2*
SFFDE030.4HY	*11*	*9/98-6/01*	*31.7*	*213*	*980.4*	*1*
SFFDE030.6HY	*25*	*4/01-6/04*	*9.7*	*939*	*8164*	*8*
JACOB004.1HY	6	6/01-3/02	5.2	459	1553.1	1
LNIXO002.9HY	12	4/01-3/02	12.1	2423	19863	4
MERID001.7HY	12	4/01-3/02	2	284	1299.7	1
NIXON002.2HY	11	4/01-3/02	19.3	741	3654	3
SFFDE036.7HY	12	4/01-3/02	23.8	>334	>2419.2	1
SFFDE043.2MN	12	4/01-3/02	52.1	321	980.4	1
PANTH001.9MN	8	6/01-3/02	17.5	603	>2419.2	1
SANDY00.55MN	3	6/01-2/02	325.5	2560	6867	1
CENTR00.44MN	10	6/01-3/02	38.2	>794	>2419.2	3
ANDER00.55MN	*13*	*4/01-3/02*	*9.7*	*837*	*7701*	*2*
BOND001.0MN	18	4/01-3/02, 5/01-6/01	48.8	>1100	>2419.2	7
SFFDE052.7MN	*12*	*4/01-3/02*	*34.1*	*>483*	*>2419.2*	*2*
CUB001.6MN	12	4/01-3/02	12.1	307	1413.6	1
BLACK001.6CK	11	4/01-3/02	32.7	>1133	4106	4
HALLS001.2LE	12	4/01-3/02	7.3	>1981	17329	4

* Single sample maximum water quality target is 487 CFU/100 mL for Tier II waterbodies and 941 CFU/100 mL for other waterbodies. Tier II waterbodies are italicized.

7.0 SOURCE ASSESSMENT

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

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

7.1 Point Sources

7.1.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

Both treated and untreated sanitary wastewater contain coliform bacteria. There were nine (9) NPDES permitted WWTFs in the impaired subwatersheds of the South Fork Forked Deer River watershed authorized to discharge treated sanitary wastewater during the TMDL analysis period. These facilities are tabulated in Table 4 and the locations are shown in Figure 5. Five (5) of the nine facilities are sewage treatment plants (STPs) serving municipalities and four of the five (Jackson Energy Authority – Miller Avenue STP [TN0024813], Bells Lagoon [TN0026247], Halls Lagoon [TN0057291], and Brownsville Lagoon [TN0075078]) 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 protection of the recreation use classification.

The Lauderdale Inn and Truck Stop facility (TN0064301) is no longer active.

Non-permitted point sources of (potential) E. coli contamination of surface waters associated with STP collection systems include leaking collection systems 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.

7.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

Municipal Separate Storm Sewer Systems (MS4s) are considered to be point sources of E. coli. Discharges from MS4s occur in response to storm events through road drainage systems, curb and gutter systems, ditches, and storm drains. Large and medium MS4s serving populations greater than 100,000 people are required to obtain NPDES storm water permits. At present, there are no MS4s of this size in the South Fork Forked Deer River watershed.

As of March 2003, small MS4s serving urbanized areas, or having the potential to exceed instream water quality standards, are required to obtain a permit under the *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2003). An urbanized area is defined as an entity with a residential population of at least 50,000 people and an overall population density of at least 1,000 people per square mile. Jackson, Brownsville, and urbanized areas in Madison County are covered under Phase II of the NPDES Storm Water Program. The Tennessee Department of Transportation (TDOT) is also being issued Phase II MS4 permits for State roads in urban areas. Information regarding storm water permitting in Tennessee may be obtained from the Tennessee Department of Environment and Conservation (TDEC) website at:

http://www.state.tn.us/environment/wpc/stormh2o/.

Table 4. WWTFs Permitted to Discharge Treated Sanitary Wastewater in South Fork Forked Deer River Watershed Impaired Subwatersheds

NPDES Permit No.	Facility Name	Receiving Stream
TN0022519	Denmark TravelCenter	Panther Creek, mile 6.9
TN0023230	Scottish Inn	Panther Creek, mile 6.9
TN0024813	Jackson Energy Authority – Miller Avenue STP	SFFD River, mile 50.8 and 51.1
TN0026247	Bells Lagoon	Old Channel, SFFD River*
TN0056472	Denmark School	Cub Creek, mile 7.8
TN0057291	Halls Lagoon	SFFD River, mile 10.8
TN0064301	Lauderdale Inn and Truck Stop	Drain Field (Halls)
TN0065218	Maury City WWTP	SFFD River, mile 27.1
TN0075078	Brownsville Lagoon	SFFD River, mile 30.6

* Drains to SFFD River, at approximately mile 36

7.1.3 NPDES Concentrated Animal Feeding Operations (CAFOs)

Animal feeding operations (AFOs) are agricultural enterprises where animals are kept and raised in confined situations. AFOs congregate animals, feed, manure and urine, dead animals, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures, fields, or on rangeland (USEPA, 2002a). Concentrated Animal Feeding Operations (CAFOs) are AFOs that meet certain criteria with respect to animal type, number of animals, and type of manure management system. CAFOs are considered to be potential point sources of E. coli loading and are required to obtain an NPDES permit. Most CAFOs in Tennessee obtain coverage under TNA000000, *Class II Concentrated Animal Feeding Operation General Permit*, while larger, Class I CAFOs are required to obtain an individual NPDES permit.

As of May 5, 2005, there were no Class II CAFOs in the South Fork Forked Deer River watershed with coverage under the general NPDES permit. In addition, there are no Class I CAFOs with individual permits located in the watershed.

7.2 Nonpoint Sources

Nonpoint sources of coliform bacteria are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. These sources generally, but not always, involve accumulation of coliform bacteria on land surfaces and wash off as a result of storm events. Nonpoint sources of E. coli loading are primarily associated with agricultural and urban land uses. The vast majority of waterbodies identified on the Final 2004 303(d) list as impaired due to E. coli are attributed to nonpoint agricultural or urban sources.

7.2.1 Wildlife

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

7.2.2 Agricultural Animals

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

- Agricultural livestock grazing in pastures deposit manure containing coliform bacteria onto land surfaces. This material accumulates during periods of dry weather and is available for washoff and transport to surface waters during storm events. The number of animals in pasture and the time spent grazing are important factors in determining the loading contribution.
- Processed agricultural manure from confined feeding operations is often applied to land surfaces and can provide a significant source of coliform bacteria loading. Guidance for issues relating to manure application is available through the University of Tennessee Agricultural Extension Service and the Natural Resources Conservation Service (NRCS).
- Agricultural livestock and other unconfined animals (i.e., deer and other wildlife) often have direct access to waterbodies and can provide a concentrated source of coliform bacteria loading directly to a stream.

Data sources related to livestock operations include the 2002 Census of Agriculture. Livestock data, for counties containing E. coli-impaired subwatersheds, 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, 2004).

Table 5. Livestock Distribution in the South Fork Forked Deer River Watershed

County Name	Livestock Population (2002 Census of Agriculture)*						
	Beef Cow	Milk Cow	Hogs	Sheep	Poultry (Layers)	Poultry (Broilers)	Horses
Crockett	3490	3	474	(D)	111	0	498
Dyer	(D)	(D)	426	18	327	0	1021
Haywood	3016	0	222	10	149	0	600
Lauderdale	(D)	(D)	492	46	136	0	681
Madison	(D)	(D)	(D)	204	874	17	1370

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

7.2.3 Failing Septic Systems

Some 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 2000 county census data of people in E. coli-impaired subwatersheds of 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 2.37 people per household on septic systems, some of which can be reasonably assumed to be failing. As with livestock in streams, discharges of raw sewage provide a concentrated source of coliform bacteria directly to waterbodies.

7.2.4 Urban Development

Nonpoint source loading of coliform bacteria from urban land use areas is attributable to multiple sources. These include: stormwater runoff, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, leaking septic systems, and domestic animals. Impervious surfaces in urban areas allow runoff to be conveyed to streams quickly, without interaction with soils and groundwater. The Central Creek drainage area has the highest percentage of urban land area for impaired subwatersheds in the South Fork Forked Deer River watershed, with 90.8%. Land use for the South Fork Forked Deer River impaired HUC-12 subwatersheds and drainage areas is summarized in Figures 6-13 and tabulated in Appendix A.

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

HUC-12 Subwatershed (08010205__) or Drainage Area	Population on Septic Systems
0301 (SFFD)	2504
Sandy Creek DA	109
Central Creek DA	38
Anderson Branch DA	95
Bond Creek DA	238
0303 (Cub Creek)	2256
0306 (SFFD)	2720
0402 (SFFD)	2200
0404 (SFFD)	2976
0405 (Black Creek)	1603
0406 (Halls Creek)	1262
0501 (Little Nixon Creek)	1214
0502 (Nixon Creek)	2017
0503 (Meridian Creek)	1039

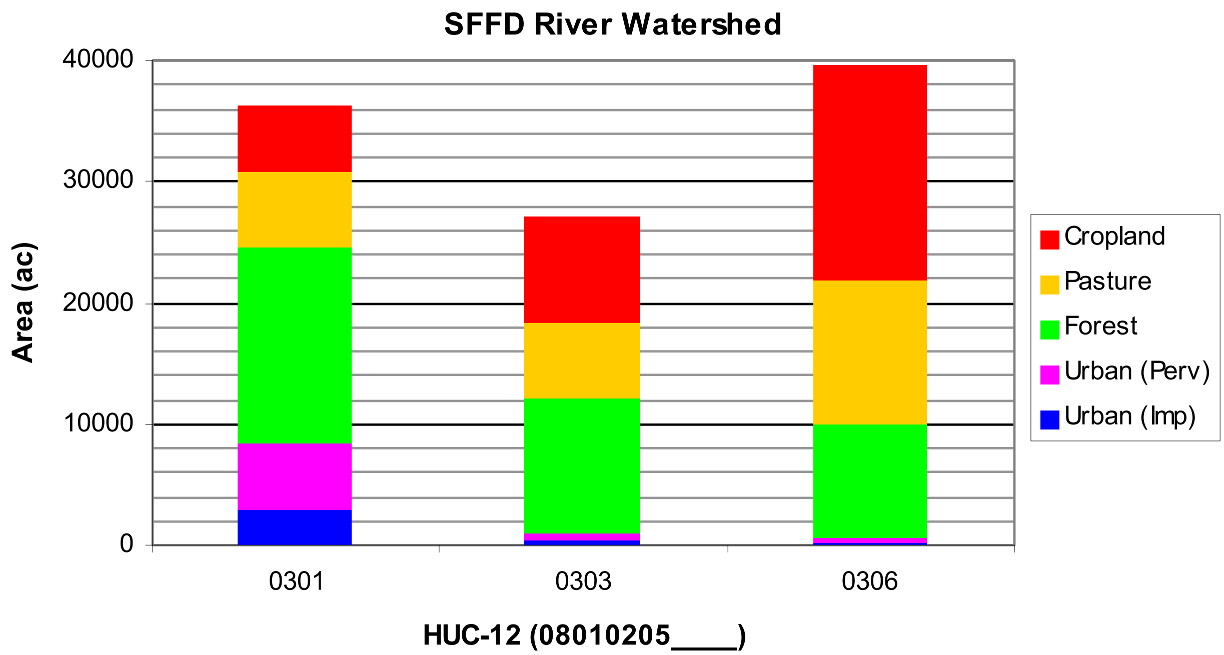

Figure 6. Land Use Area of South Fork Forked Deer River HUC-12 Subwatersheds 0301, 0303, and 0306.

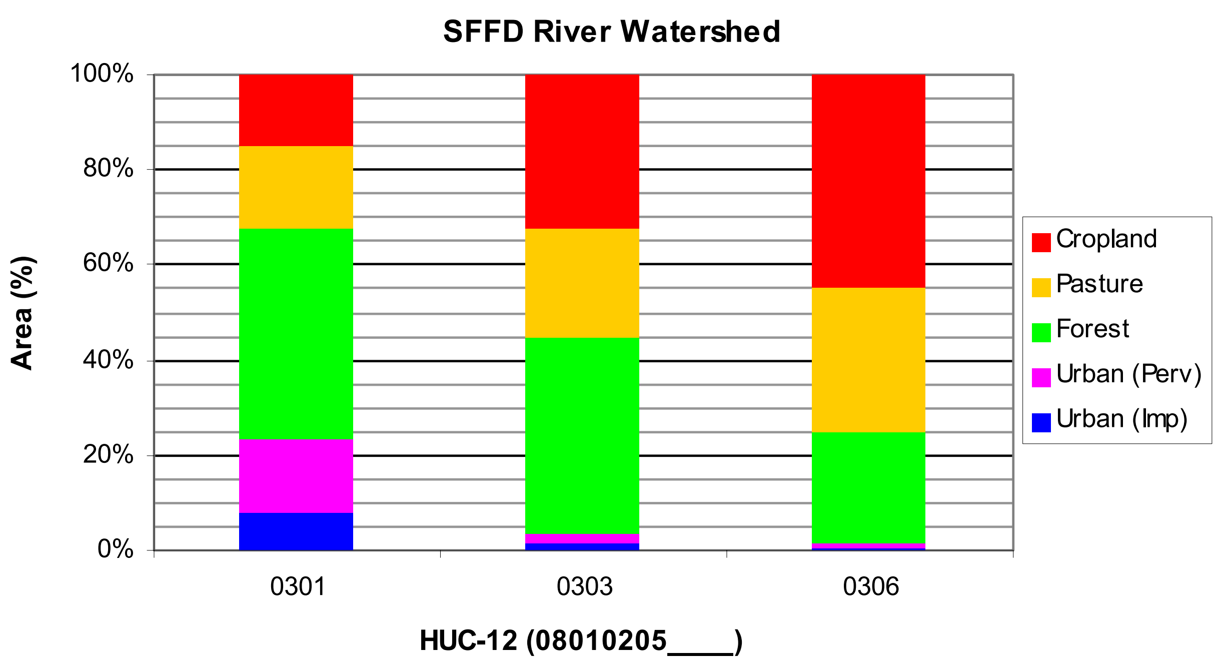

Figure 7. Land Use Percent of South Fork Forked Deer River HUC-12 Subwatersheds 0301, 0303, and 0306.

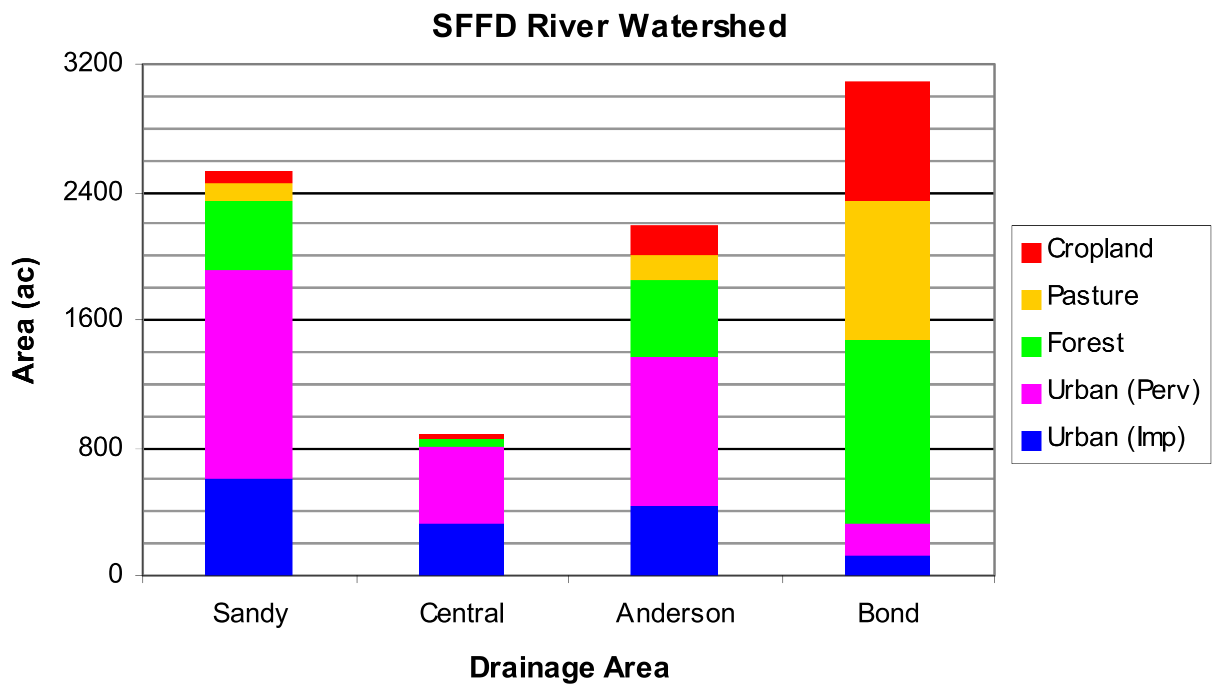

Figure 8. Land Use Area of South Fork Forked Deer River Subwatershed Drainage Areas Sandy Creek, Central Creek, Anderson Branch, and Bond Creek.

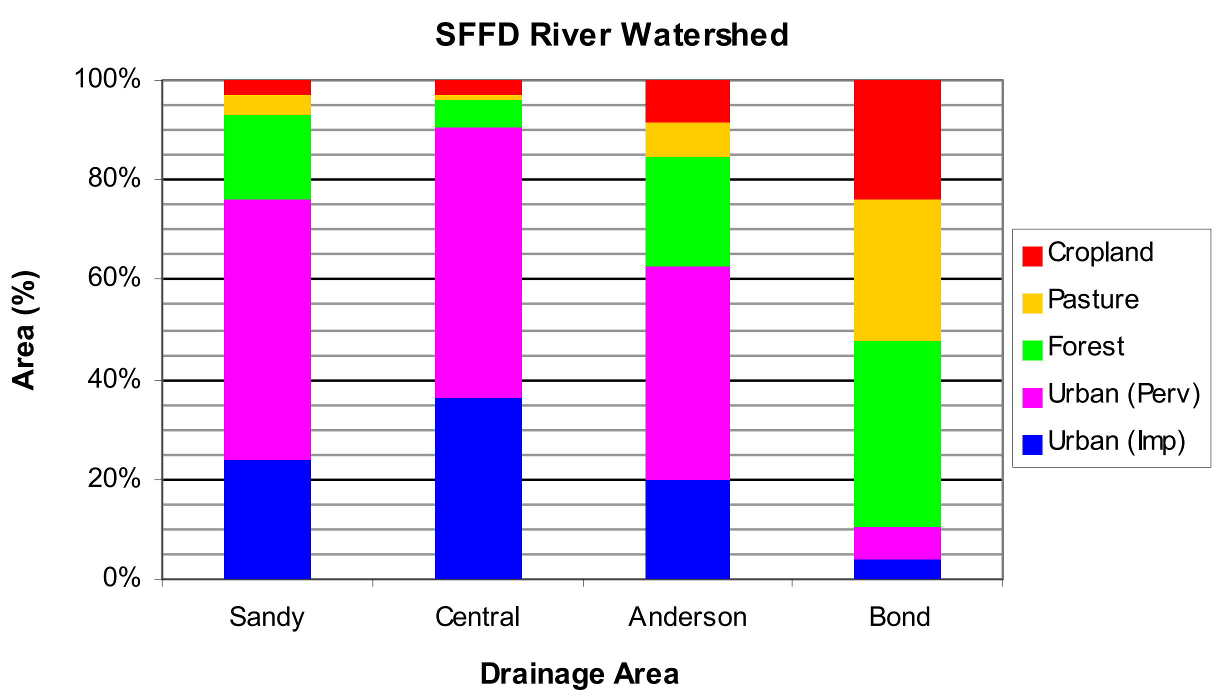

Figure 9. Land Use Percent of South Fork Forked Deer River Subwatershed Drainage Areas Sandy Creek, Central Creek, Anderson Branch, and Bond Creek.

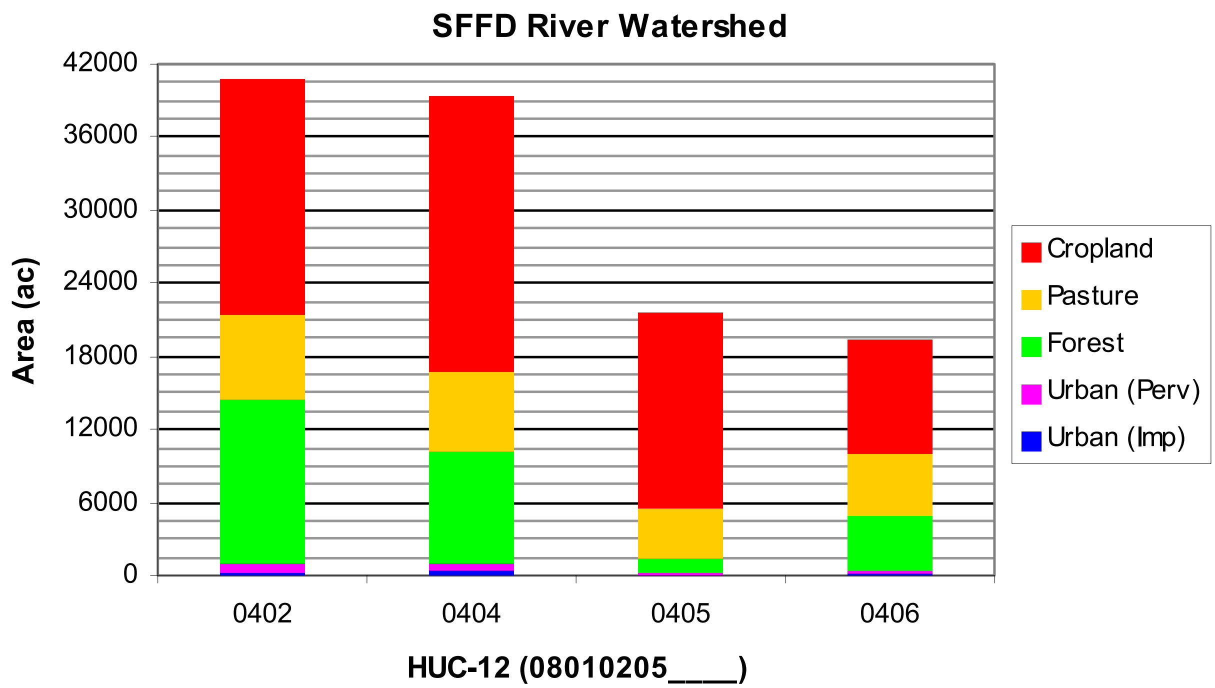

Figure 10. Land Use Area South Fork Forked Deer River HUC-12 Subwatersheds 0402, 0404, 0405, and 0406.

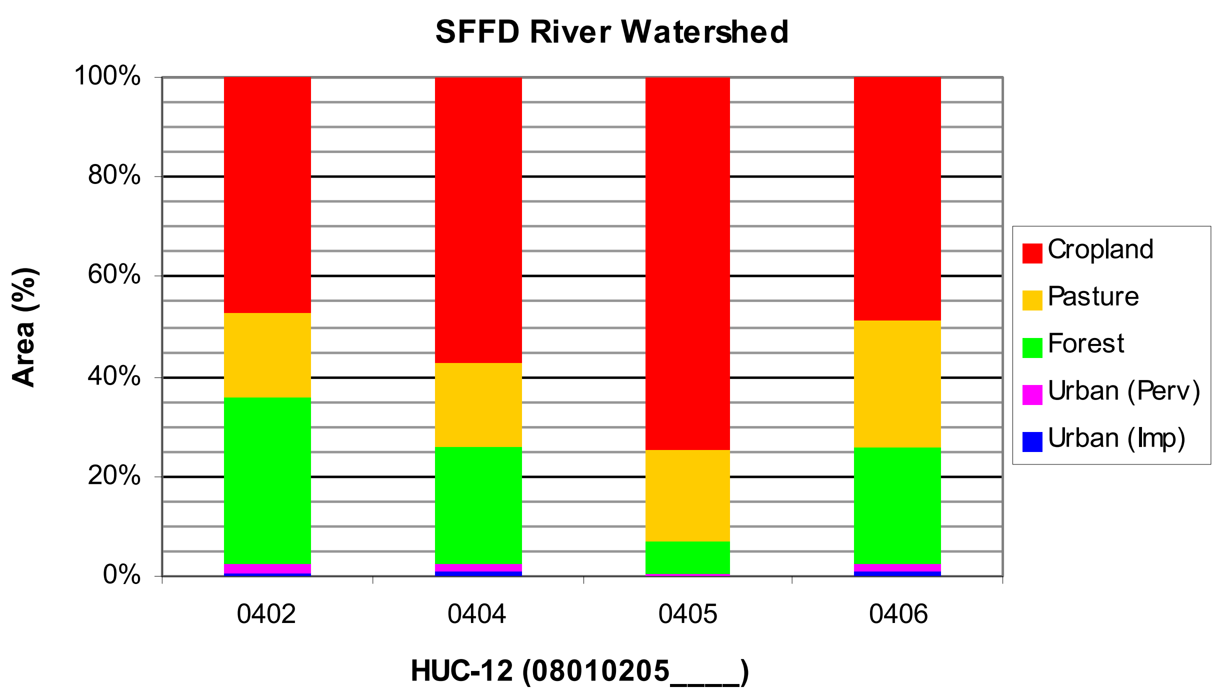

Figure 11. Land Use Percent of South Fork Forked Deer River HUC-12 Subwatersheds 0402, 0404, 0405, and 0406.

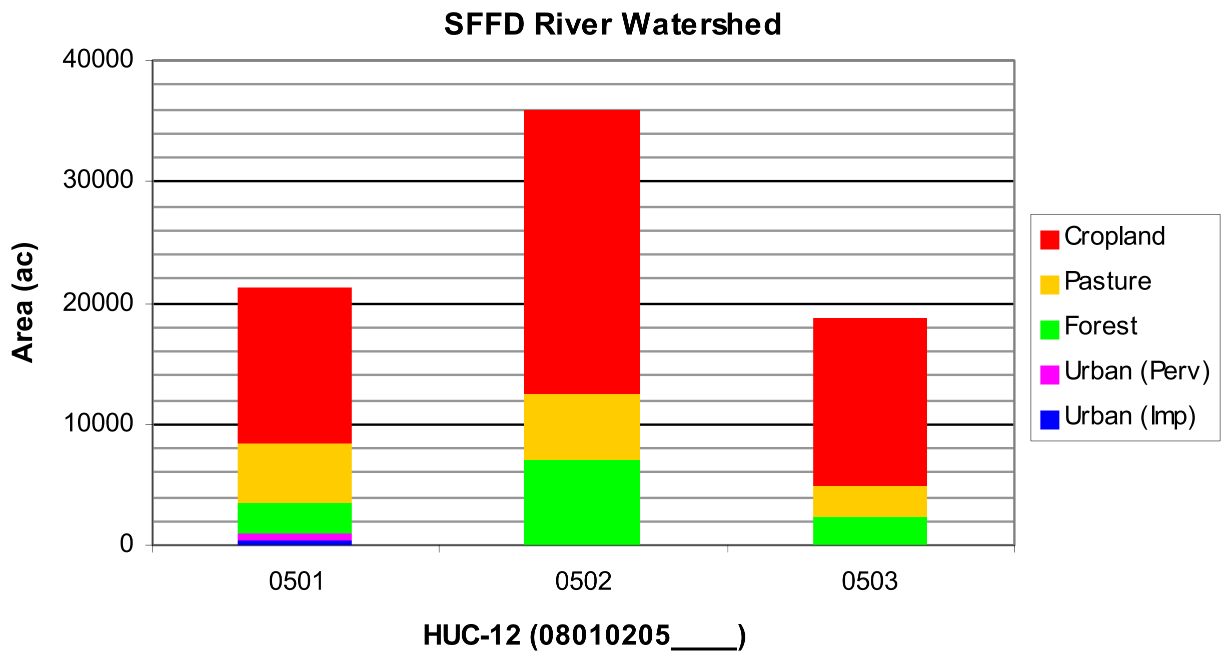

Figure 12. Land Use Area South Fork Forked Deer River HUC-12 Subwatersheds 0501, 0502, and 0503.

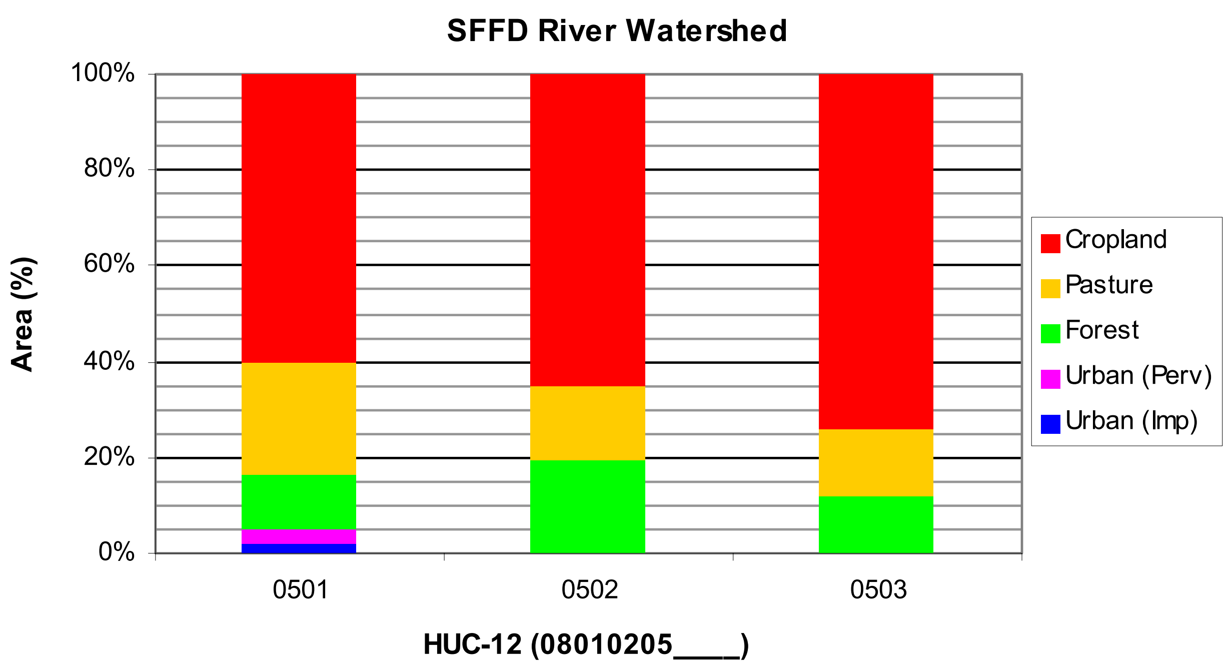

Figure 13. Land Use Percent of South Fork Forked Deer River HUC-12 Subwatersheds 0501, 0502, and 0503.

8.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOAD

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

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

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) 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), and Load Allocation (LA) development for waterbodies identified as impaired due to E. coli on the Final 2004 303(d) list.

8.1 Expression of TMDLs, WLAs, & LAs

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

8.2 Area Basis for TMDL Analysis

The primary area unit of analysis for TMDL development is the HUC-12 subwatershed containing one or more waterbodies assessed as impaired due to E. coli (as documented on the 2004 303(d) List). In some cases, however, TMDLs are 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. The E. coli TMDLs for the South Fork Forked Deer River watershed, with the exception of highly urbanized tributary waterbodies in the Jackson area (HUC-12 080102050301), were developed on a HUC-12 basis. TMDLs for Sandy Creek, Central Creek, Anderson Branch, and Bond Creek were developed on a drainage area 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 regime represented by these existing loads. Load duration curves are considered to be well suited for analysis of periodic monitoring data collected by grab sample. LDCs were developed at monitoring site locations in impaired waterbodies and an overall load reduction calculated to meet E. coli targets according to the methods described in Appendix C.

8.4 Critical Conditions and Seasonal Variation

The critical condition for non-point source E. coli loading is an extended dry period followed by a rainfall runoff event. During the dry weather period, E. coli bacteria builds up on the land surface, and is washed off by rainfall. The critical condition for point source loading occurs during periods of low streamflow when dilution is minimized. Both conditions are represented in the TMDL analyses.

The ten-year period from July 1, 1994 to June 30, 2004 was used to simulate flow. This 10-year period contained a range of hydrologic conditions that included both low and high streamflows. Critical conditions are accounted for in the load duration curve 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. Based on the location of the water quality exceedances on the load duration curves, no one delivery mode for E. coli appears to be dominant (see Section 9.3 and Table 7).

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

8.5 Margin of Safety

There are two methods for incorporating an MOS in the analysis: a) implicitly incorporate the MOS using conservative model assumptions; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. For development of E. coli TMDLs in the 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 (Tier II):	MOS = 49 CFU/100 ml
Instantaneous Maximum (non-Tier II):	MOS = 94 CFU/100 ml
30-Day Geometric Mean:	MOS = 13 CFU/100 ml

8.6 Determination of TMDLs

E. coli load reductions were calculated for impaired segments in the South Fork Forked Deer River watershed using LDCs to evaluate compliance with the single sample maximum target concentrations according to the procedure in Appendix C. When sufficient data were available, load reductions were also developed to achieve compliance with the 30-day geometric mean target concentration. Both instream load reductions (where applicable) for a particular waterbody were compared and the largest calculated load reduction was selected as the TMDL. These TMDL load reductions for impaired segments and subsequent subwatersheds are shown in Table 7. In cases where the geometric mean could not be developed, it is assumed that achieving the load reduction based on the single sample maximum target concentrations should result in attainment of the geometric mean criteria.

8.7 Determination of WLAs & LAs

WLAs for MS4s and LAs for precipitation induced sources of E. coli loading were determined according to the procedures in Appendix C. These allocations represent the higher load reductions necessary to achieve instream targets after application of the explicit MOS. WLAs for existing WWTFs are equal to their existing NPDES permit limits. Since WWTF permit limits require that E. coli concentrations must comply with water quality criteria (TMDL targets) at the point of discharge and recognition that loading from these facilities is 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. WLAs & LAs for South Fork Forked Deer River, Tennessee

HUC-12 Subwatershed (08010205__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs[a]				LAs[e]
				WWTFs[b]		Leaking Collection Systems[c]	MS4s[d]	
				Monthly Avg.	Daily Max.			
			[% Red.]	[CFU/day]	[CFU /day]	[CFU /day]	[% Red.]	[% Red.]
0301 (DA)	Sandy Creek	TN08010205012 – 0400	**83.2**	**NA**	**NA**	**0**	**84.9**	**84.9**
0301 (DA)	Central Creek	TN08010205012 – 0500	**>61.6**	**NA**	**NA**	**0**	**>65.0**	**>65.0**
0301 (DA)	Anderson Branch	TN08010205012 – 0600	**22.7**	**NA**	**NA**	**0**	**30.5**	**30.5**
0301 (DA)	Bond Creek	TN08010205012 – 0700	**>92.0**	**NA**	**NA**	**0**	**>92.8**	**>92.8**
0301	SFFD River	TN08010205012 – 1000	**>69.7**	**8.300×10^{10}**	**6.199×10^{11}**	**0**	**>72.7**	**>72.7**
0303	Cub Creek	TN08010205012 – 1200	**36.4**	**7.646×10^{7}**	**5.710×10^{8}**	**0**	**42.8**	**42.8**
0306	SFFD River	TN08010205012 – 1000	**27.5**	**1.328×10^{10}**	**9.921×10^{10}**	**0**	**NA**	**34.6**
0402	SFFD River	TN08010205003 – 1000	**71.9**	**1.159×10^{10}**	**8.657×10^{10}**	**NA**	**NA**	**74.7**
	SFFD River	TN08010205010 – 1000						
0404	SFFD River	TN08010205001 – 1000	**63.1**	**3.339×10^{9}**	**2.494×10^{10}**	**0**	**NA**	**66.8**
0405	Black Creek	TN08010205031 – 1000	**65.4**	**NA**	**NA**	**0**	**NA**	**68.8**
0406	Halls Creek	TN08010205036 – 1000	**59.7**	**NA**	**NA**	**0**	**NA**	**63.6**
0501	Little Nixon Creek	TN08010205005 – 0100	**76.1**	**NA**	**NA**	**0**	**78.5**	**78.5**
0502	Nixon Creek	TN08010205005 – 1000	**45.7**	**NA**	**NA**	**NA**	**NA**	**51.0**
0503	Meridian Creek	TN08010205005 – 0200	**0.0**	**NA**	**NA**	**NA**	**NA**	**0.0**

Note: NA = Not applicable.

a. There are no CAFOs in the South Fork Forked Deer River watershed. Future CAFOs will be assigned a waste load allocation (WLA) of zero.

b. WLAs for WWTFs expressed as E. coli loads (CFU/day). Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permits.

c. The objective for leaking collection systems is a WLA of zero. It is recognized, however, that a WLA of 0 CFU/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in E. coli loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

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

e. The load allocations (LAs) listed apply to precipitation induced nonpoint sources only. The objective for all other nonpoint sources (leaking septic systems, illicit discharges, and animals access to streams) is a LA of zero. It is recognized, however, that for leaking septic systems a LA of 0 CFU/day may not be practical. For these sources, the LA is interpreted to mean a reduction in E. coli loading to the maximum extent feasible, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

9.0 IMPLEMENTATION PLAN

The TMDLs, WLAs, and LAs developed in Section 8 are intended to be the first phase of a long-term effort to restore the water quality of impaired waterbodies in the 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.

9.1 Point Sources

9.1.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

All present and future discharges from industrial and municipal wastewater treatment facilities are required to be in compliance with the conditions of their NPDES permits at all times, including elimination of bypasses and overflows. In Tennessee, permit limits for treated sanitary wastewater require compliance with coliform water quality standards (ref: Section 5.0) prior to discharge. No additional reduction is required. WLAs for WWTFs are derived from facility design flows and permitted E. coli limits and are expressed as average loads in CFU per day.

9.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

For existing and future regulated discharges from municipal separate storm sewer systems, WLAs will be implemented through Phase I & II MS4 permits. These permits will require the development and implementation of a Storm Water Management Program (SWMP) that will reduce the discharge of pollutants to the "maximum extent practicable" and not cause or contribute to violations of State water quality standards. The *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2003) was issued on February 27, 2003 and requires SWMPs to include six minimum control measures:

- Public education and outreach on storm water impacts
- Public involvement/participation
- Illicit discharge detection and elimination
- Construction site storm water runoff control
- Post-construction storm water management in new development and re-development
- Pollution prevention/good housekeeping for municipal operations

For discharges into impaired waters, the Phase II MS4 General Permit (ref: http://www.state.tn.us/environment/wpc/stormh2o/MS4II.php) requires that SWMPs include a section describing how discharges of pollutants of concern will be controlled to ensure that they do not cause or contribute to instream exceedances of water quality standards. Specific measures and BMPs to control pollutants of concern must also be identified. In addition, MS4s must implement the WLA provisions of an applicable TMDL and describe methods to evaluate whether storm water controls are adequate to meet the WLA.

In order to evaluate SWMP effectiveness and demonstrate compliance with specified WLAs, MS4s must develop and implement appropriate monitoring programs. Instream monitoring, at locations selected to best represent the effectiveness of BMPs, must include analytical monitoring of pollutants of concern. A detailed plan describing the monitoring program must be submitted to the Division of Water Pollution Control Jackson Field Office within 12 months of the approval date of this TMDL. Implementation of the monitoring program must commence within 6 months of plan approval by the Field Office. The monitoring program shall comply with the monitoring, recordkeeping, and reporting requirements of NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems (TDEC, 2003).

9.1.3 NPDES Regulated Concentrated Animal Feeding Operations (CAFOs)

WLAs provided to CAFOs will be implemented through NPDES Permit No. TNA000000, General NPDES Permit for *Class II Concentrated Animal Feeding Operation* or the facility's individual permit. Among the provisions of the general permit are:

- Development and implementation of a site-specific Nutrient Management Plan (NMP) that:
  - Includes best management practices (BMPs) and procedures necessary to implement applicable limitations and standards;
  - Ensures adequate storage of manure, litter, and process wastewater including provisions to ensure proper operation and maintenance of the storage facilities.
  - Ensures proper management of mortalities (dead animals);
  - Ensures diversion of clean water, where appropriate, from production areas;
  - Identifies protocols for manure, litter, wastewater and soil testing;
  - Establishes protocols for land application of manure, litter, and wastewater;
  - Identifies required records and record maintenance procedures.

  The NMP must be submitted to the State for approval and a copy kept on-site.

- Requirements regarding manure, litter, and wastewater land application BMPs.

- Requirements for the design, construction, operation, and maintenance of CAFO liquid waste management systems that are constructed, modified, repaired, or placed into operation after April 13, 2006. Final design plans and specifications for these systems must meet or exceed standards in the NRCS Field Office Technical Guide and other guidelines as accepted by the Departments of Environment and Conservation, or Agriculture.

Provisions of individual CAFO permits are similar. NPDES Permit No. TNA000000, *Class II Concentrated Animal Feeding Operation General Permit* is available on the TDEC website at http://www.state.tn.us/environment/wpc/programs/cafo/.

9.2 Nonpoint Sources

The Tennessee Department of Environment & Conservation has no direct regulatory authority over most nonpoint source discharges. Reductions of E. coli loading from nonpoint sources (NPS) will be achieved using a phased approach. Voluntary, incentive-based mechanisms will be used to implement NPS management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the targeted impaired waters. Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs. Local citizen-led and implemented management measures offer the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. There are links to a number of publications and information resources on EPA's Nonpoint Source Pollution web page (http://www.epa.gov/owow/nps/pubs.html) relating to the implementation and evaluation of nonpoint source pollution control measures.

TMDL implementation activities will be accomplished within the framework of Tennessee's Watershed Approach (ref: http://www.state.tn.us/environment/wpc/watershed/). The Watershed Approach is based on a five-year cycle and encompasses planning, monitoring, assessment, TMDLs, WLAs/LAs, and permit issuance. It relies on participation at the federal, state, local and non-governmental levels to be successful.

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., critical control treatment, pasture and hayland planting, diversions, grade stabilization, heavy use area, etc.) may have contributed to reductions in in-stream concentrations of coliform bacteria in one or more South Fork Forked Deer River E. coli-impaired subwatersheds during the TMDL evaluation period. The Tennessee Department of Agriculture (TDA) keeps a database of BMPs implemented in Tennessee. Those listed in the South Fork Forked Deer River watershed are shown in Figure 14. It is recommended that additional information (e.g., livestock access to streams, manure application practices, etc.) be provided and evaluated to better identify and quantify agricultural sources of coliform bacteria loading in order to minimize uncertainty in future TMDL analysis efforts.

It is further recommended that additional BMPs be implemented and monitored to document performance in reducing coliform bacteria loading to surface waters from agricultural sources. Demonstration sites for various types of BMPs should be established and maintained and their performance (in source reduction) evaluated over a period of at least two years prior to recommendations for utilization for subsequent implementation. E. coli sampling and monitoring are recommended during low-flow (baseflow) and storm periods at sites with and without BMPs and/or before and after implementation of BMPs.

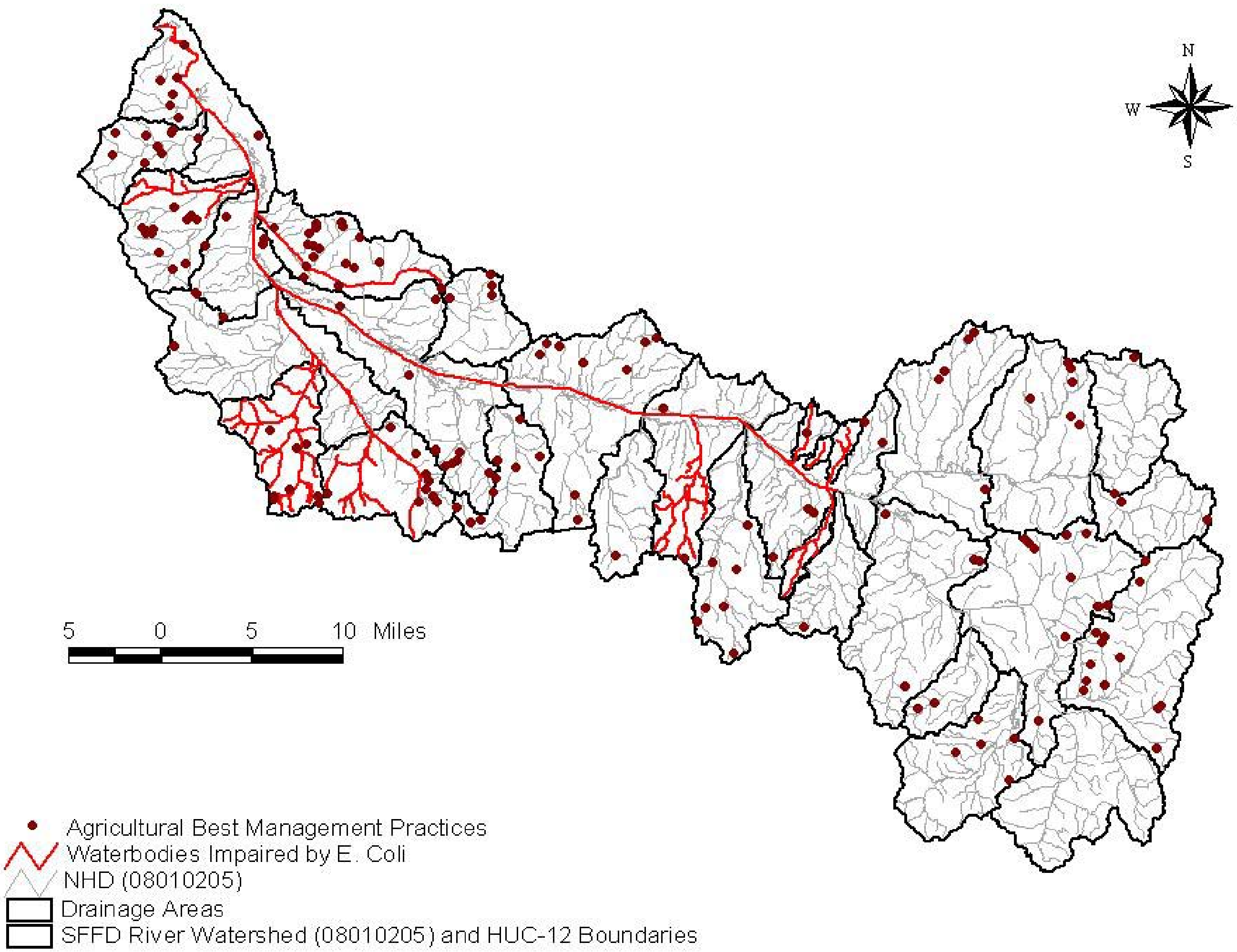

Figure 14. Tennessee Department of Agriculture Best Management Practices in the South Fork Forked Deer River Watershed

9.3 Example Application of Load Duration Curves for Implementation Planning

The Load Duration Curve methodology (Appendix C) is a form of water quality analysis and presentation of data that aids in guiding implementation by targeting strategies to appropriate flow conditions. One of the strengths of this method is that it can be used to interpret possible delivery mechanisms of E. coli by differentiating between point and non-point problems. The load duration curve analysis can be utilized for implementation planning. The E. coli load duration curve for South Fork Forked Deer River at Mile 30.6 (Figure 15) was analyzed to determine the frequency with which water quality monitoring data exceed the E. coli target maximum concentration of 487 CFU/100 mL under five flow conditions (low, dry, mid-range, moist, and high). Observation of the plot suggests the South Fork Forked Deer River subwatershed is impacted by point and non-point-type sources.

Table 8 presents Load Duration Curve analysis statistics for E. coli and example implementation strategies for each source category covering the entire range of flow (Stiles, 2003). Each implementation strategy addresses a range of flow conditions and targets point sources, non-point sources, or a combination of each. Results indicate the implementation strategy for the South Fork Forked Deer River subwatershed will require BMPs targeting non-point sources (dominant under high flow/runoff conditions) and, to a lesser extent, point sources (dominant under low flow/steady state conditions). The implementation strategies listed in Table 8 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.

See Appendix C for a detailed discussion of the Load Duration Curve Methodology applied to the South Fork Forked Deer River watershed.

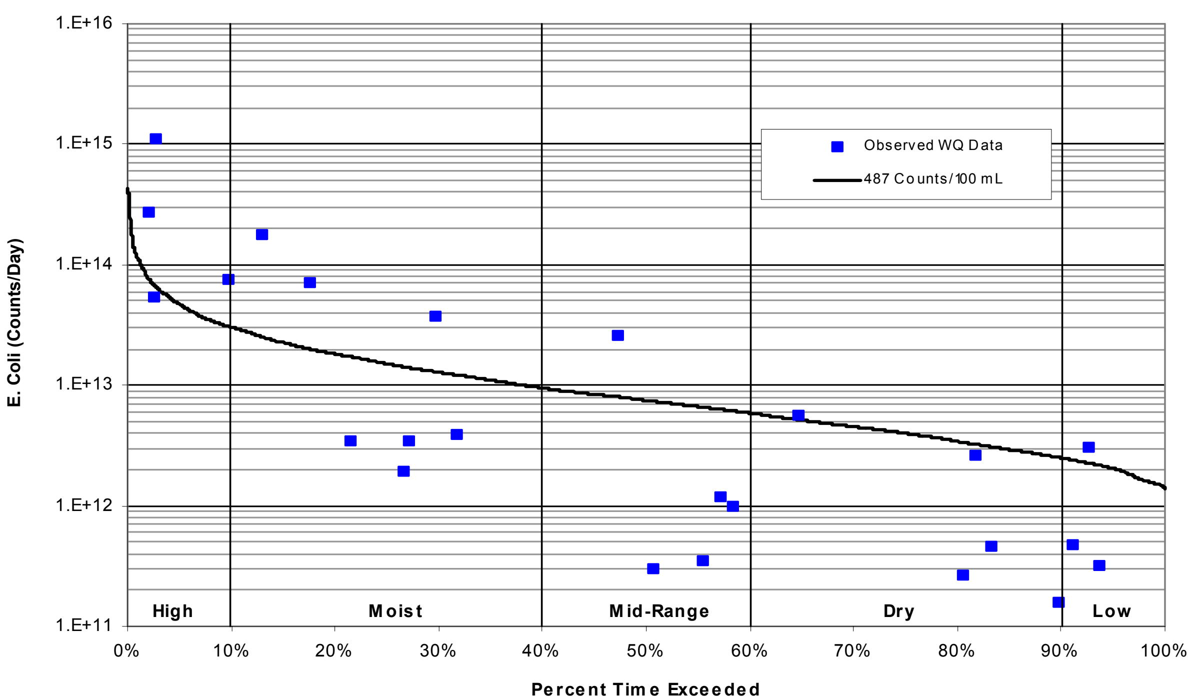

Figure 15. Load Duration Curve for Implementation Planning.

Table 8. Example Implementation Strategies

Flow Condition	High	Moist	Mid-range	Dry	Low
% Time Flow Exceeded	0-10	10-40	40-60	60-90	90-100
Municipal NPDES		L	M	H	H
Stormwater Management		H	H	H	
SSO Mitigation	H	H	M	L	
Collection System Repair		L	M	H	H
Septic System Repair		L	M	H	M
Livestock Exclusion[1]			M	H	H
Pasture Management/Land Application of Manure[1]	H	H	M	L	
Riparian Buffers[1]		H	H	H	
Potential for source area contribution under given hydrologic condition (H: High; M: Medium; L: Low)					

[1] Example Best Management Practices for Agricultural Source reduction. Actual BMPs applied may vary.

9.4 Additional Monitoring

Documenting progress in reducing the quantity of E. coli entering the South Fork Forked Deer River watershed is an essential element of the TMDL Implementation Plan. Additional monitoring and assessment activities are recommended to determine whether implementation of TMDLs, WLAs, & LAs in tributaries and upstream reaches will result in achievement of instream water quality targets for E. coli. Future monitoring activities should also be adequate to assess water quality using the 30-day geometric mean standard.

Tennessee's watershed management approach specifies a five-year cycle for planning and assessment. Each watershed will be examined (or re-examined) on a rotating basis. Generally, in years two and three of the five-year cycle, water quality data are collected in support of water quality assessment (including TMDL development) and planning activities. Therefore, a watershed TMDL is developed one to two years prior to commencement of the next cycle's monitoring period.

Additional monitoring and assessment activities are recommended for the South Fork Forked Deer River watershed E. coli-impaired subwatersheds to verify the assessment status of the stream reaches identified on the Final 2004 303(d) list as impaired due to E. coli. If it is determined that these stream reaches are still not fully supporting designated uses, then sufficient data to enable development of a TMDL must be acquired. Future monitoring activities should be representative of all seasons and a full range of flow and meteorological conditions. In addition, collection of E. coli data at sufficient frequency to support calculation of the geometric mean, as described in Tennessee's General Water Quality Criteria (TDEC, 2004a), is encouraged. Finally, for individual monitoring locations, where historical E. coli data are greater than 1000 colonies/100 mL (or future samples are anticipated to be), a 1:100 dilution should be performed as described in Protocol A of the *Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2004b).

Analysis of monitoring data suggests the potential for delisting Meridian Creek for E. coli. However, no new data have been collected subsequent to its assessment as not fully supporting designated use classifications due, in part, to E. coli. Additional data should be collected to confirm the assessment status of impairment or to support delisting.

9.5 Source Identification

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

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

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

A multi-disciplinary group of researchers at the University of Tennessee, Knoxville (UTK) is developing and testing a series of different microbial assay methods based on real-time PCR to detect fecal bacterial concentrations and host sources in water samples (McKay, 2005). The assays have been used in a study of fecal contamination and have proven useful in identification of areas where cattle represent a significant fecal input and in development of BMPs. It is expected that these types of assays could have broad applications in monitoring fecal impacts from Animal Feeding Operations, as well as from wildlife and human sources. Additional information can be found on the following UTK website: http://web.utk.edu/~hydro/Research/McKayAGU2004Abstract.pdf.

9.6 Evaluation of TMDL Implementation Effectiveness

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

10.0 PUBLIC PARTICIPATION

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

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

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

3) Draft copies of the proposed TMDLs were sent to the city of Jackson, the city of Brownsville, Madison County, and the Tennessee Department of Transportation.

4) Letters were sent to WWTFs located in E. coli-impaired subwatersheds in the South Fork Forked Deer River watershed, permitted to discharge treated effluent containing E. coli, 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. Letters were sent to the following facilities:

    Denmark TravelCenter (TN0022519)
    Scottish Inn (TN0023230)
    Jackson Energy Authority – Miller Avenue STP (TN0024813)
    Bells Lagoon (TN0026247)
    Denmark School (TN0056472)
    Halls Lagoon (TN0057291)
    Maury City WWTP (TN0065218)
    Brownsville Lagoon (TN0075078)

No written comments were received during the proposed TMDL public comment period. No requests to hold public meetings were received regarding the proposed TMDLs as of close of business on May 22, 2006.

11.0 FURTHER INFORMATION

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

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

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

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APPENDIX A

Land Use Distribution in the South Fork Forked Deer River Watershed

Table A-1. MRLC Land Use Distribution of South Fork Forked Deer River Subwatersheds

Land Use	HUC-12 Subwatershed (08010205____) or Drainage Area					
	0301		0303		0306	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	6634	18.2	3977	14.7	1649	4.2
Emergent Herbaceous Wetlands	1010	2.8	1082	4.0	473	1.2
Evergreen Forest	1029	2.8	465	1.7	143	0.4
High Intensity Commercial/Industrial/Transp.	1376	3.8	225	0.8	96	0.2
High Intensity Residential	1200	3.3	106	0.4	94	0.2
Low Intensity Residential	5714	15.7	569	2.1	412	1.0
Mixed Forest	2462	6.8	1977	7.3	1086	2.7
Open Water	337	0.9	222	0.8	313	0.8
Other Grasses (Urban/recreation; e.g. parks)	541	1.5	107	0.4	16	0.0*
Pasture/Hay	6316	17.4	6098	22.5	11906	30.1
Quarries/Strip Mines/Gravel Pits	8	0.0*	0	0.0	0	0.0
Row Crops	5516	15.2	8681	32.0	17635	44.5
Small Grains	0	0.0	155	0.6	156	0.4
Transitional	173	0.5	45	0.2	38	0.1
Woody Wetlands	4069	11.2	3410	12.6	5570	14.1
Total	36385	100.0	27119	100.0	39586	100.0

* <0.05

Table A-1. MRLC Land Use Distribution of South Fork Forked Deer River Subwatersheds (Cont.)

Land Use	HUC-12 Subwatershed (08010205__) or Drainage Area							
	Bond Creek (DA)		Sandy Creek (DA)		Central Creek (DA)		Anderson Branch (DA)	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	802	26.0	191	7.6	8	0.9	220	10.0
Evergreen Forest	95	3.1	66	2.6	2	0.2	42	1.9
High Intensity Commercial/Industrial/Transportatio	90	2.9	201	8.0	151	17.1	157	7.2
High Intensity Residential	33	1.1	267	10.6	169	19.1	183	8.4
Low Intensity Residential	190	6.2	1439	57.0	484	54.6	1022	46.7
Mixed Forest	230	7.4	116	4.6	11	1.3	105	4.8
Open Water	9	0.3	3	0.1	0	0.0	8	0.4
Other Grasses (Urban/recreational; e.g. parks law	13	0.4	57	2.2	24	2.7	106	4.8
Pasture/Hay	875	28.3	102	4.0	11	1.2	157	7.2
Row Crops	744	24.1	74	2.9	26	2.9	181	8.3
Transitional	7	0.2	9	0.4	0	0.0	10	0.5
Woody Wetlands	0	0.0	0	0.0	0	0.0	0	0.0
Total	3087	100.0	2526	100.0	887	100.0	2191	100.0

Table A-1. MRLC Land Use Distribution of South Fork Forked Deer River Subwatersheds (Cont.)

Land Use	HUC-12 Subwatershed (08010205____) or Drainage Area							
	0402		0404		0405		0406	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	1078	2.7	2692	6.8	778	3.6	2459	12.7
Emergent Herbaceous Wetlands	1099	2.8	0	0.0	0	0.0	0	0.0
Evergreen Forest	67	0.2	190	0.5	57	0.3	203	1.1
High Intensity Commercial/Industrial/Transp.	23	0.1	252	0.6	33	0.2	95	0.5
High Intensity Residential	2	0.0*	171	0.4	17	0.1	113	0.6
Low Intensity Residential	8	0.0*	391	1.0	68	0.3	251	1.3
Mixed Forest	558	1.4	1231	3.1	306	1.4	1750	9.1
Open Water	954	2.4	671	1.7	85	0.4	33	0.2
Other Grasses (Urban/recreation; e.g. parks)	0	0.0	387	1.0	8	0.0*	32	0.2
Pasture/Hay	6858	17.2	6657	16.9	3955	18.3	4965	25.7
Row Crops	19374	48.6	22625	57.4	16138	74.7	9405	48.7
Small Grains	1	0.0*	0	0.0	33	0.2	0	0.0
Transitional	6	0.0*	167	0.4	2	0.0*	25	0.1
Woody Wetlands	9828	24.7	3960	10.1	119	0.6	0	0.0
Total	39855	100.0	39395	100.0	21600	100.0	19331	100.0

* <0.05

Table A-1. MRLC Land Use Distribution of South Fork Forked Deer River Subwatersheds (Cont.)

Land Use	HUC-12 Subwatershed (08010205____) or Drainage Area					
	501		502		503	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	923	4.3	1839	5.1	757	4.1
Evergreen Forest	89	0.4	69	0.2	47	0.3
High Intensity Commercial/Industrial/Transp.	88	0.4	22	0.1	15	0.1
High Intensity Residential	315	1.5	3	0.0*	0	0.0
Low Intensity Residential	655	3.1	7	0.0*	7	0.0*
Mixed Forest	531	2.5	719	2.0	207	1.1
Open Water	77	0.4	93	0.3	23	0.1
Other Grasses (Urban/recreation; e.g. parks)	93	0.4	1	0.0*	0	0.0
Pasture/Hay	4938	23.2	5525	15.4	2605	13.9
Row Crops	12825	60.3	23169	64.4	13825	74.0
Small Grains	0	0.0	350	1.0	0	0.0
Transitional	4	0.0*	22	0.1	4	0.0*
Woody Wetlands	741	3.5	4167	11.6	1186	6.4
Total	21279	100.0	35985	100.0	18675	100.0

* <0.05

APPENDIX B

Water Quality Monitoring Data

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

Table B-1. Water Quality Monitoring Data – South Fork Forked Deer River Watershed

Monitoring Station	Date	E. Coli [CFU/100 mL]
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
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
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	97.0
	10/4/01	71.4
	11/6/01	77.6
	12/6/01	387.3

Table B-1. Water Quality Monitoring Data – South Fork Forked Deer River Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
SFFDE030.6HY	12/17/01	**1732.9**
	1/10/02	95.9
	2/21/02	**1299.7**
	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
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
LNIXO002.9HY	4/5/01	**1732.9**
	5/10/01	**1986.3**
	6/7/01	**19863**
	7/12/01	**4160**
	8/9/01	59
	9/13/01	100
	10/4/01	5.2
	11/6/01	17.1
	12/6/01	313.0
	1/10/02	104.6
	2/21/02	727
	3/7/02	12.1
MERID001.7HY	4/5/01	24.3
	5/10/01	408.3
	6/7/01	**1299.7**
	7/12/01	307.6

Table B-1. Water Quality Monitoring Data – South Fork Forked Deer River Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
MERID001.7HY	8/9/01	392
	9/13/01	41.0
	10/4/01	2.0
	11/6/01	28
	12/6/01	66.3
	1/10/02	145
	2/21/02	686.7
	3/7/02	8.6
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
SFFDE036.7HY	4/5/01	118.2
	5/10/01	93.3
	6/7/01	331.0
	7/12/01	328.2
	8/9/01	261.3
	9/13/01	23.8
	10/4/01	153.9
	11/6/01	58.1
	12/6/01	66.2
	1/10/02	120.1
	2/21/02	**>2419.2**
	3/7/02	31.4
SFFDE043.2MN	4/5/01	81.3
	5/10/01	97.8
	6/7/01	387.3
	7/12/01	**980.4**
	8/9/01	686.7
	9/13/01	272.3

Table B-1. Water Quality Monitoring Data – South Fork Forked Deer River Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
SFFDE043.2MN	10/4/01	155.3
	11/6/01	93.3
	12/6/01	57.3
	1/10/02	65
	2/21/02	920.8
	3/7/02	52.1
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
SANDY00.55MN	6/5/01	**6867.0**
	12/4/01	325.5
	2/5/02	**488.8**
CENTR00.44MN	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
ANDER00.55MN	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

Table B-1. Water Quality Monitoring Data – South Fork Forked Deer River Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
ANDER00.55MN	1/8/02	9.7
	2/5/02	31.8
	3/5/02	387.3
	3/5/02	365.4
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**
	6/5/01	**3255**
	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
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
CUB001.6MN	4/4/01	68.9
	5/9/01	182.9
	6/6/01	231.8

Table B-1. Water Quality Monitoring Data – South Fork Forked Deer River Watershed (Cont.)

Monitoring Station	Date	E. Coli [CFU/100 mL]
CUB001.6MN	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
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
	2/21/02	**1533.1**
	3/7/02	47.1
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

APPENDIX C

Load Duration Curve Development
and
Determination of Required Load Reductions

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

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

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

C.1 Development of TMDLs

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

C.1.1 Development of Flow Duration Curves

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

Flow duration curves for impaired waterbodies in the South Fork Forked Deer River Watershed were derived from LSPC hydrologic simulations based on parameters derived from calibration at USGS Stations 07027500, South Fork Forked Deer River at Jackson, and 07028100, South Fork Forked Deer River near Halls (see Appendix D for details of calibration). The data used, in each case, included the period of record from 7/1/94 – 6/30/04. For example, a flow-duration curve for Little Nixon Creek at mile 2.9 was constructed using simulated daily mean flow for the period from 7/1/94 through 6/30/04 (mile 2.9 corresponds to the location of monitoring station LNIXO002.9HY). This flow duration curve is shown in Figure C-1 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record (the highest daily mean flow during this period is exceeded 0% of the time and the lowest daily mean flow is equaled or exceeded 100% of the time). Flow duration curves for other impaired waterbodies were derived using a similar procedure.

C.1.2 Development of Load Duration Curves and Determination of Required Load Reductions

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

E. coli load duration curves for impaired waterbodies in the 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 (Little Nixon Creek is shown as an example):

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

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

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

2. Daily loads were calculated for each of the water quality samples collected at monitoring station LNIXO002.9HY (ref.: Table B-1) by multiplying the sample concentration by the daily mean flow for the sampling date and the required unit conversion factor. LNIXO002.9HY was selected for LDC analysis because it has a relatively high percentage of 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 (7/12/01 sampling event):
   Modeled Flow = 1.574 cfs
   Concentration = 4160 CFU/100 mL
   Daily Load = 1.602×10^{11}

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 Little Nixon Creek is shown in Figure C-6.

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

Example (7/12/01 sampling event):
Target Concentration = 941 CFU/100 mL
Measured Concentration = 4160 CFU/100 mL
Reduction to Target = 77.4%

5. The 90^{th} percentile value for all of the E. coli sampling data at LNIXO002.9HY monitoring site was determined. If the 90^{th} percentile value exceeded the target maximum E. coli concentration, the reduction required to reduce the 90^{th} percentile value to the target maximum concentration was calculated (Table C-5).

   Example: Target Concentration = 941 CFU/100 mL
   90^{th} Percentile Concentration = 3943 CFU/100 mL
   Reduction to Target = 76.1%

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

   Example: Insufficient monitoring data were available for Little Nixon Creek at Mile 2.9
   Sufficient data were available for Bond Creek at Mile 1.0
   Sampling Period = 5/29/01 – 6/7/01
   Geometric Mean Concentration > 1568 CFU/100 mL
   Target Concentration = 126 CFU/100 mL
   Reduction to Target > 92.0%

   Note: One sample value, dated 5/31/01, in the above example was equal to >2419.2. Therefore, the geometric mean and reduction to target were expressed as greater than (>) their respective calculated values.

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

Load duration curves, required load reductions, and TMDLs of other impaired waterbodies were derived in a similar manner and are shown in Figures C-2 through C-20 and Tables C-1 through C-19. Note that Figure C-16 presents E. coli samples on a load duration curve for geometric mean analysis. The target line represents the 30-day geometric mean target rather than the daily maximum target as in the standard load duration curve methodology. Individual samples cannot be compared to corresponding target values. Rather, the geometric mean of all samples is compared to the target concentration. The figure is presented for descriptive purposes.

C.2 Development of WLAs and LAs

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

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

Expanding the terms:

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

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

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

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

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

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

LA terms include:

- $[\Sigma LAs]_{DS}$ is the allowable E. coli load from "other direct sources". These sources include leaking septic systems, illicit discharges, and animals access to streams. The LA specified for all sources of this type is zero CFU/day (or to the maximum extent feasible).

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

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

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

WLAs for MS4s and LAs for precipitation-based nonpoint sources are equal and expressed as the percent reduction in loading required to decrease instream E. coli concentrations to TMDL target values minus MOS. As stated in Section 8.5, an explicit MOS, equal to 10% of the E. coli water quality targets (ref.: Section 5.0), was utilized for determination of the WLAs and LAs:

Instantaneous Maximum (Tier II):

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

Target – MOS = 438 CFU/100 ml

Instantaneous Maximum (non-Tier II):

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

Target – MOS = 847 CFU/100 ml

30-Day Geometric Mean:

Target – MOS = (126 CFU/100 ml) – 0.1(126 CFU/100 ml)

Target – MOS = 113 CFU/100 ml

C.2.1 Development of WLAs for MS4s and LAs for Precipitation-Based Nonpoint Sources

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

8. An allocation LDC was generated for Little Nixon Creek by applying the E. coli "target – MOS" concentration of 847 CFU/100 mL to each of the ranked flows used to generate the flow duration curve (ref.: Section C.1.1) and plotting the results on the target LDC developed in Step 1. The E. coli target maximum allocated load corresponding to each ranked daily mean flow is:

   $(\text{Target Load} – \text{MOS})_{\text{Little Nixon Creek}}$ = (847 CFU/100 mL) x (Q) x (UCF)

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

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

   Example – 7/12/01 sampling event:
   Target Concentration – MOS = 847 CFU/100 mL
   Measured Concentration = 4160 CFU/100 mL
   Reduction to Target – MOS = 79.6%

10. If the 90^{th} percentile value for all of the E. coli sampling data at LNIXO002.9HY monitoring site (calculated in Step 5) exceeded the "target maximum – MOS" E. coli concentration, the reduction required to reduce the 90^{th} percentile value to the "target maximum – MOS" concentration was calculated (Table C-5).

    Example: Target Concentration – MOS = 847 CFU/100 mL
    90^{th} Percentile Concentration = 3943 CFU/100 mL
    Reduction to Target – MOS = 78.5%

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

    Example: Insufficient monitoring data were available for Little Nixon Creek at Mile 2.9
    Sufficient data were available for Bond Creek at Mile 1.0
    Sampling Period = 5/29/01 – 6/7/01
    Geometric Mean Concentration > 1568 CFU/100 mL
    Target Concentration – MOS = 113 CFU/100 mL
    Reduction to Target – MOS = 92.8%

    Note: One sample value, dated 5/31/01, in the above example was equal to >2419.2. Therefore, the geometric mean and reduction to "target – MOS" were expressed as greater than (>) their respective calculated values.

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

Load duration curves, required load reductions, WLAs for MS4s, and LAs for precipitation-based nonpoint sources of other impaired waterbodies were derived in a similar manner and are shown in Figures C-2 through C-20 and Tables C-1 through C-19. TMDLs, WLAs, & LAs for impaired subwatersheds in the South Fork Forked Deer River Watershed are summarized in Table C-20.

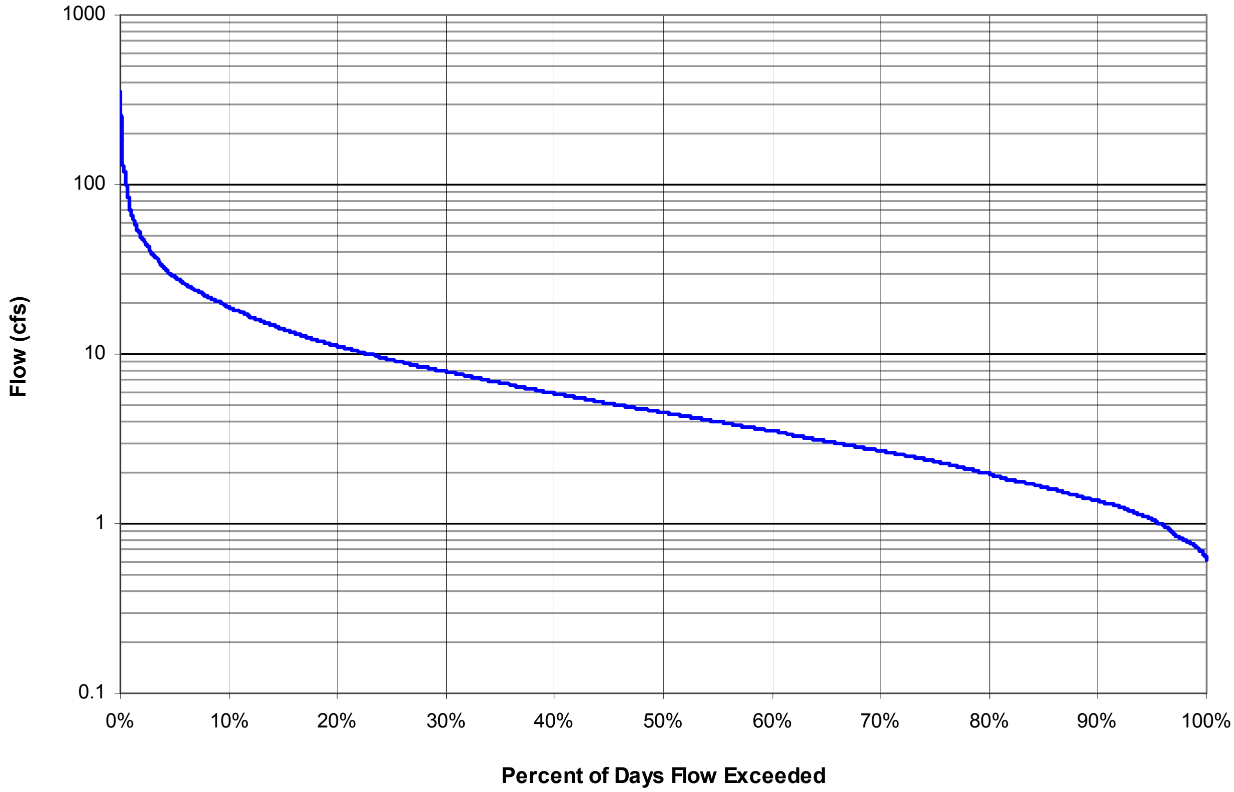

Figure C-1. Flow Duration Curve for Little Nixon Creek at Mile 2.9

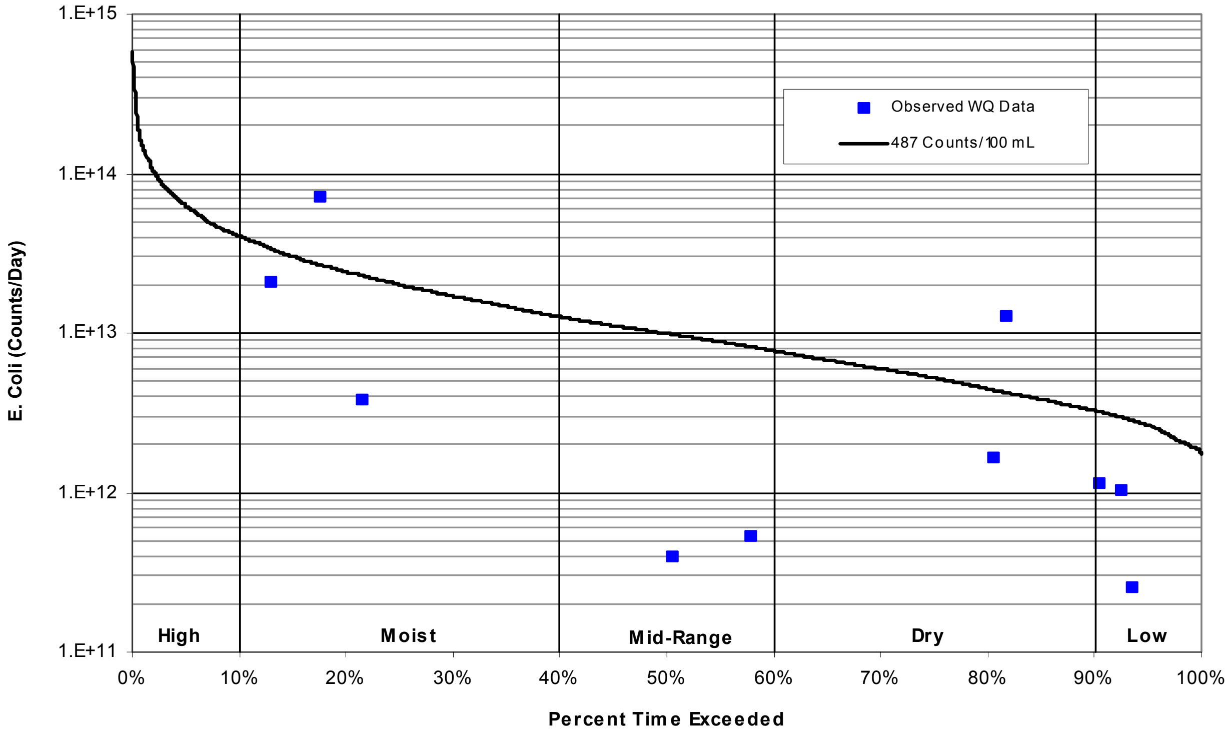

Figure C-2. E. Coli Load Duration Curve for South Fork Forked Deer River at Mile 11.2

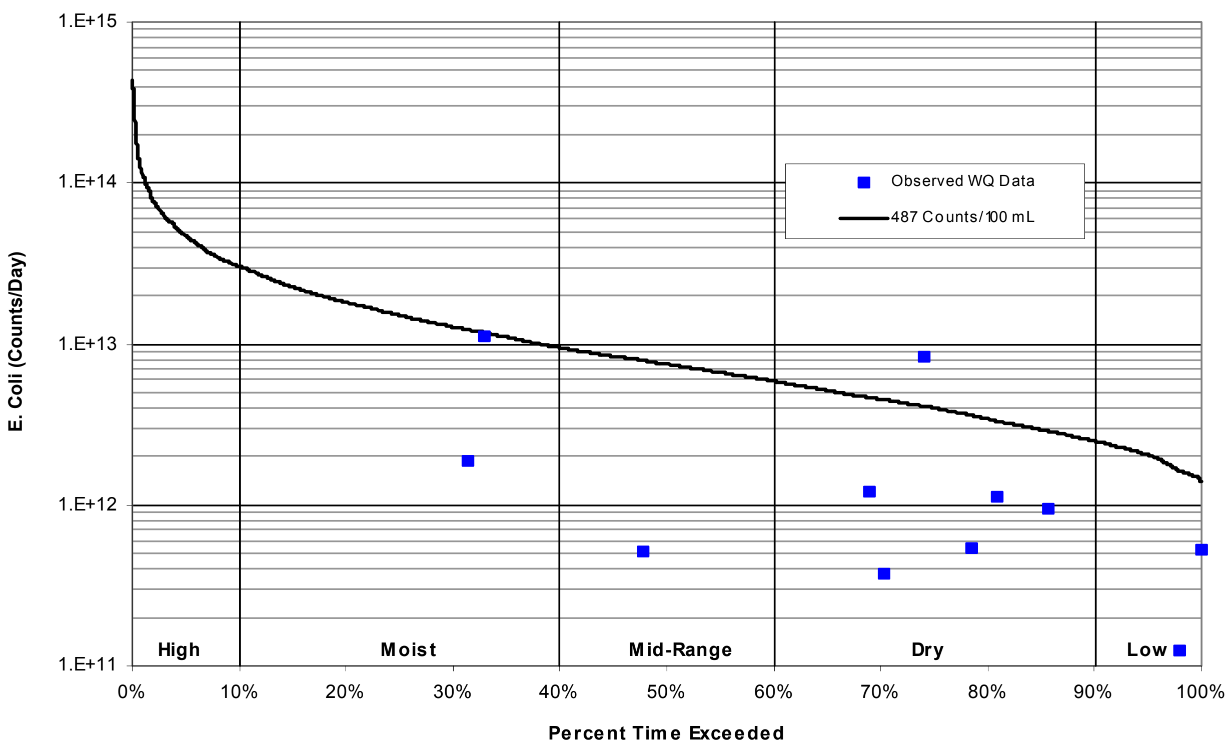

Figure C-3. E. Coli Load Duration Curve for South Fork Forked Deer River at Mile 30.4

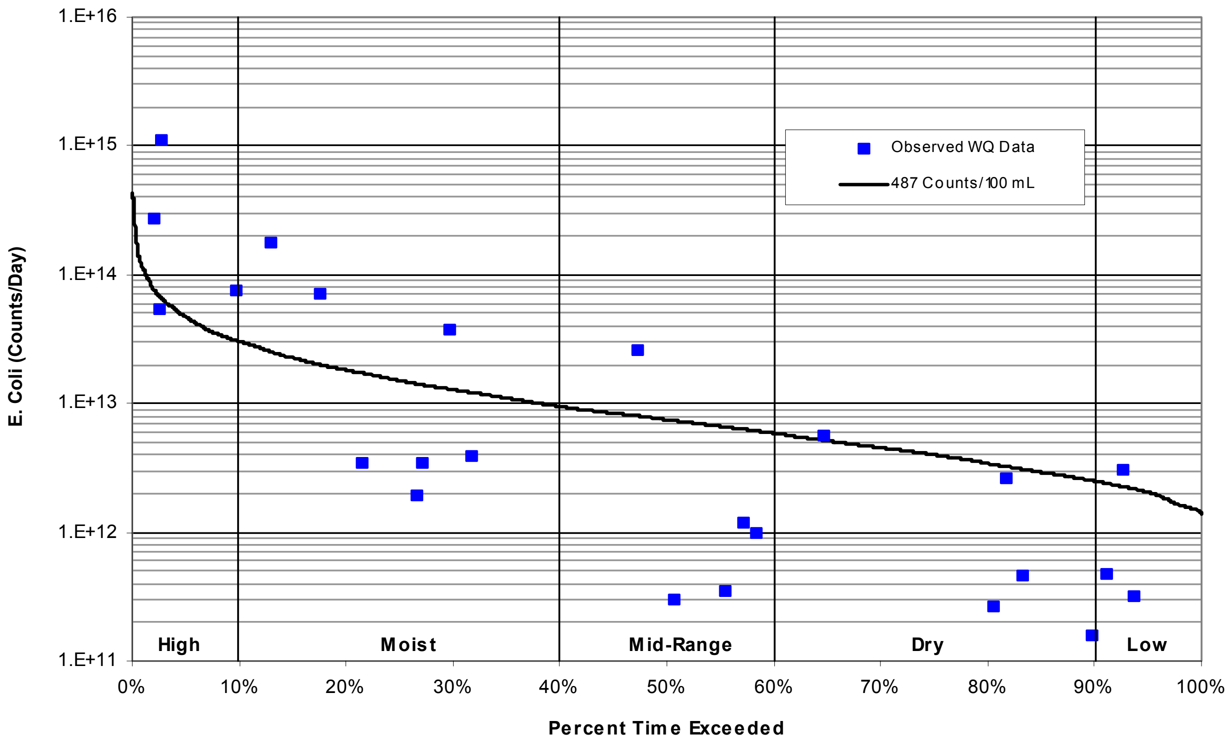

Figure C-4. E. Coli Load Duration Curve for South Fork Forked Deer River at Mile 30.6

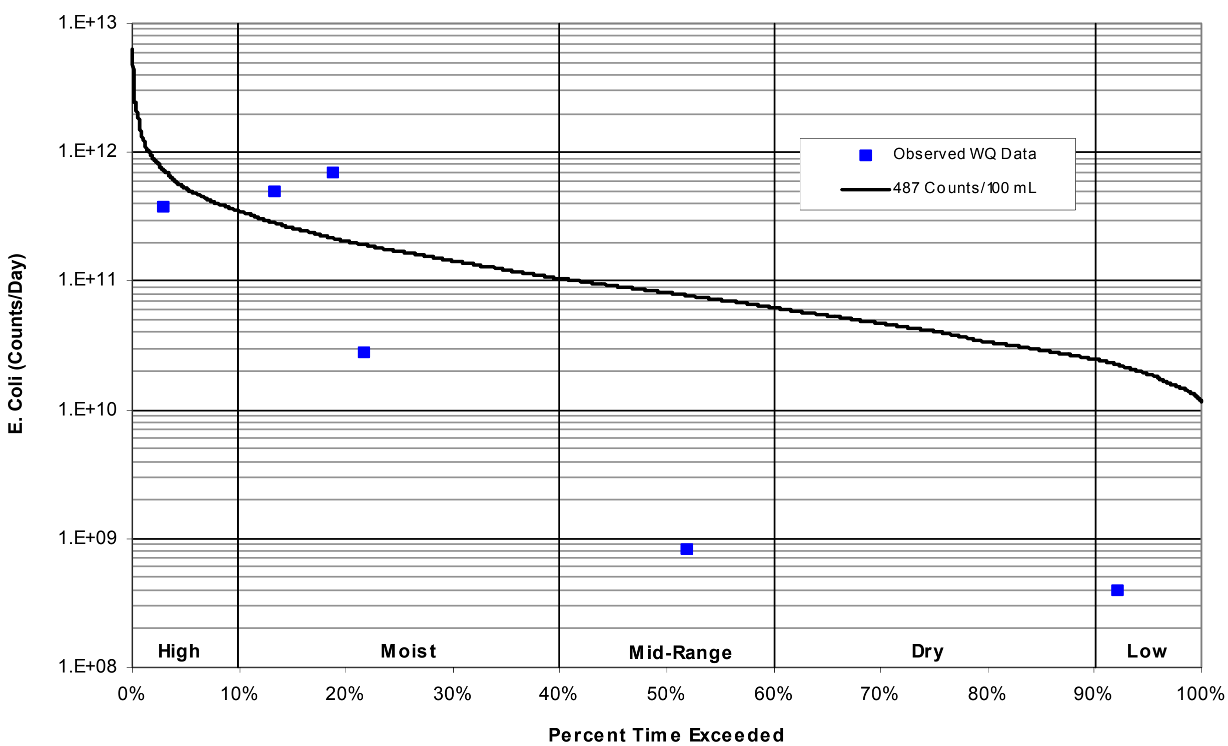

Figure C-5. E. Coli Load Duration Curve for Jacobs Creek at Mile 4.1

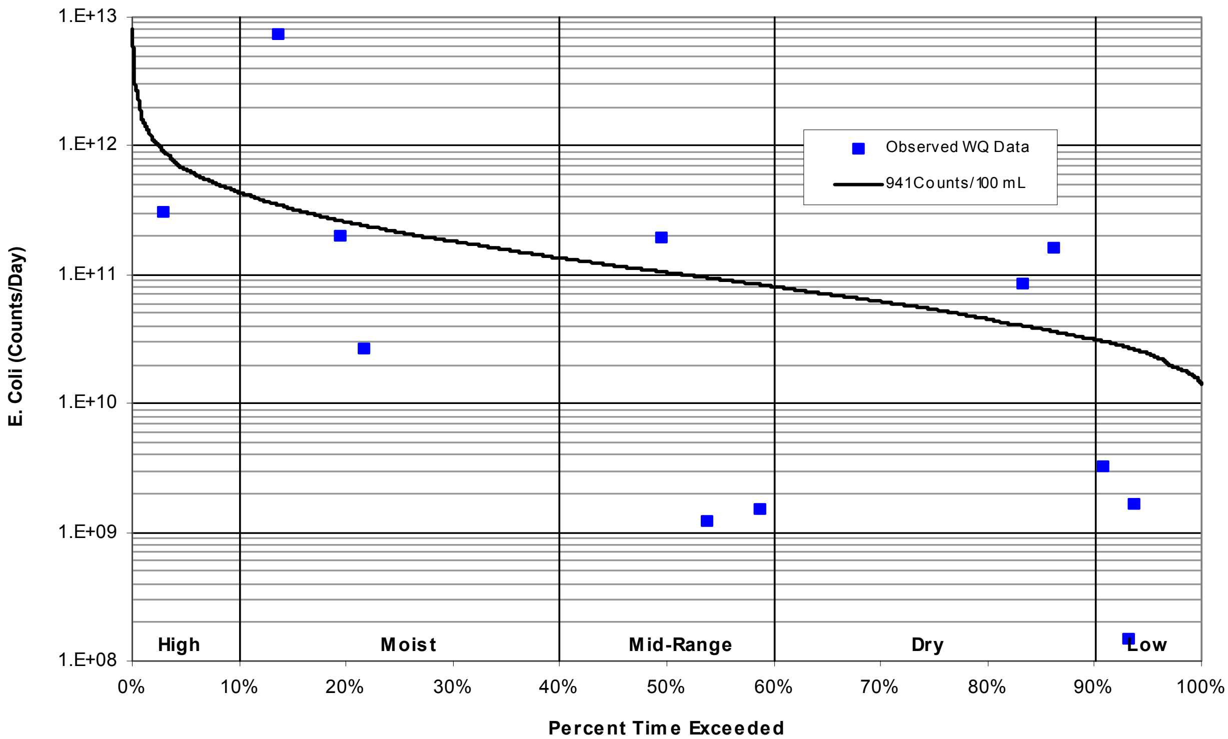

Figure C-6. E. Coli Load Duration Curve for Little Nixon Creek at Mile 2.9

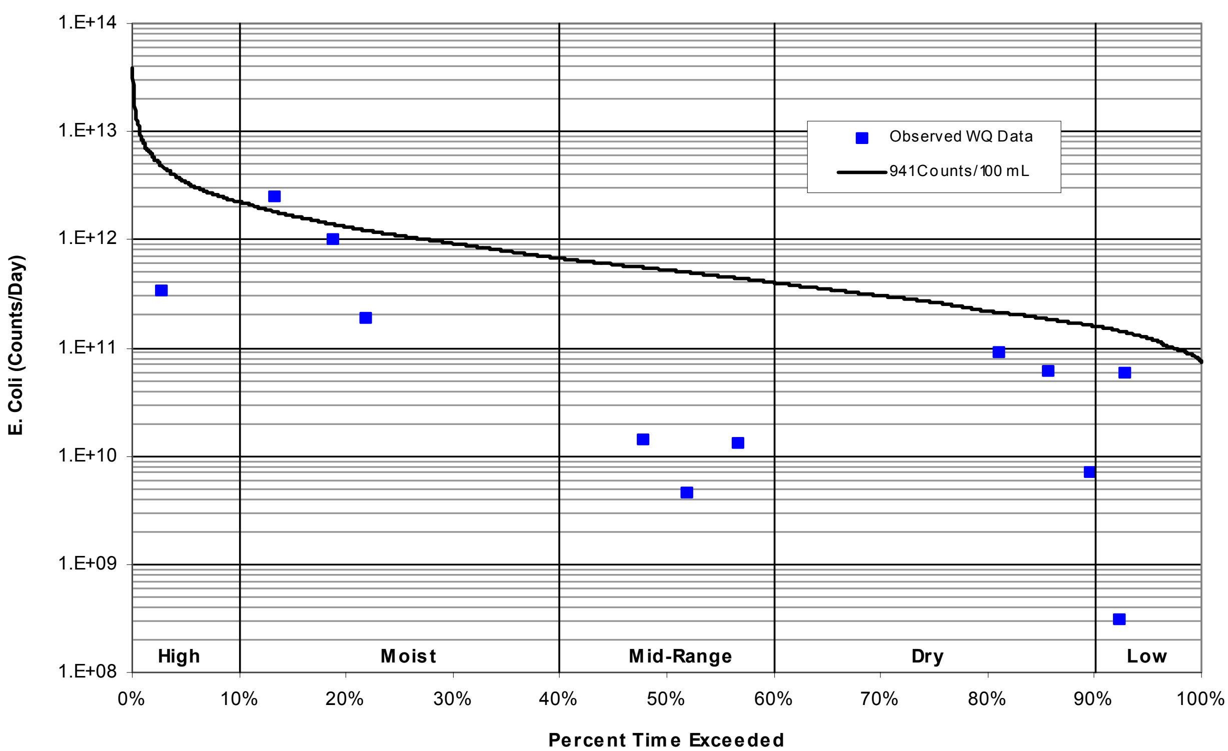

Figure C-7. E. Coli Load Duration Curve for Meridian Creek at Mile 1.7

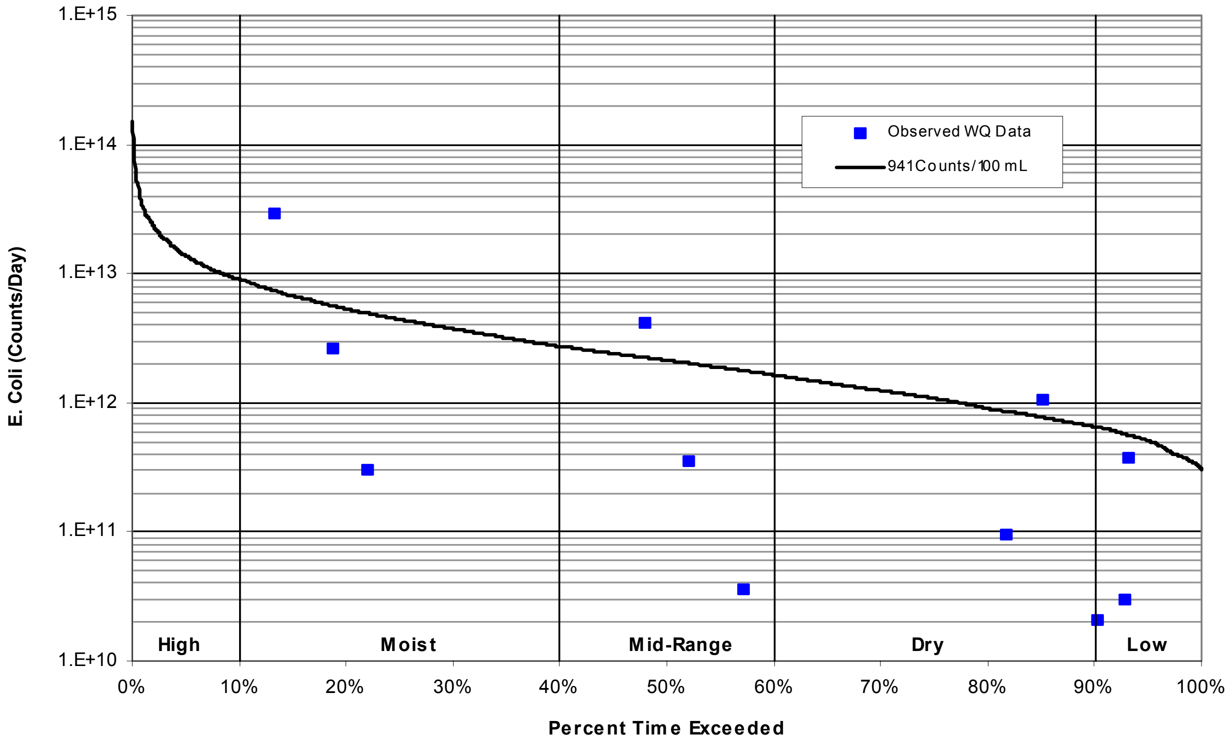

Figure C-8. E. Coli Load Duration Curve for Nixon Creek at Mile 2.2

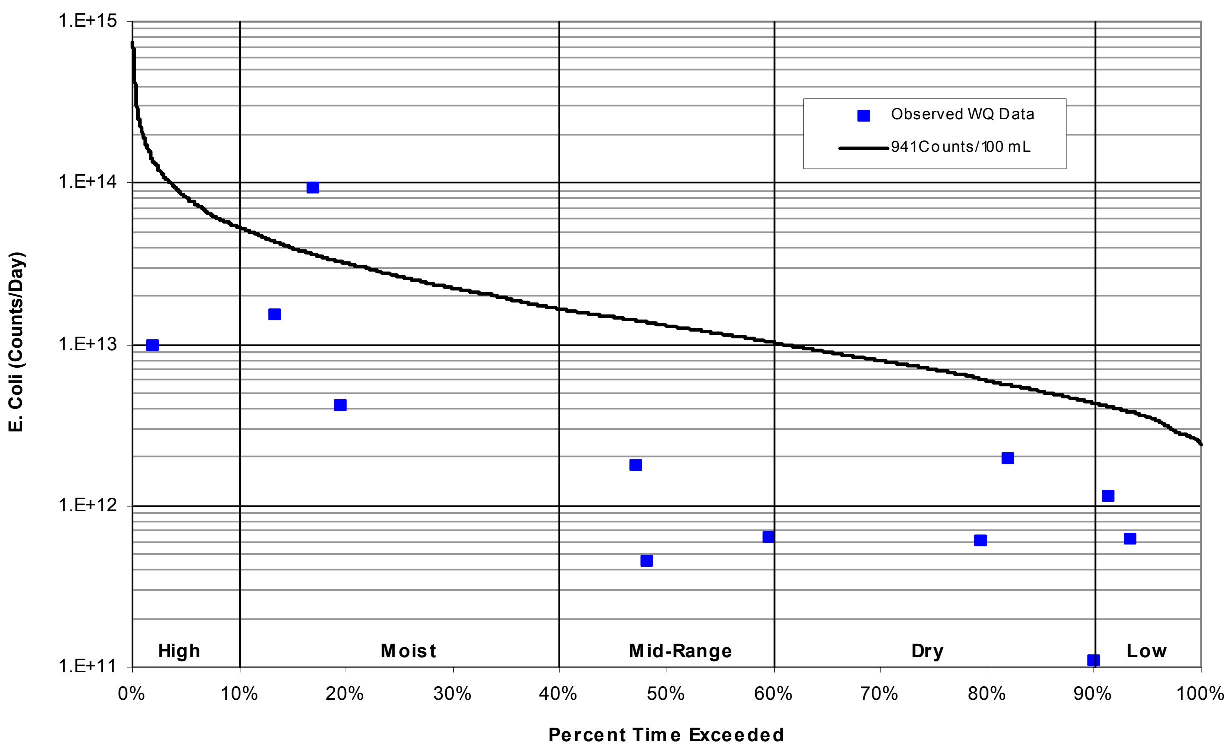

Figure C-9. E. Coli Load Duration Curve for South Fork Forked Deer River at Mile 36.7

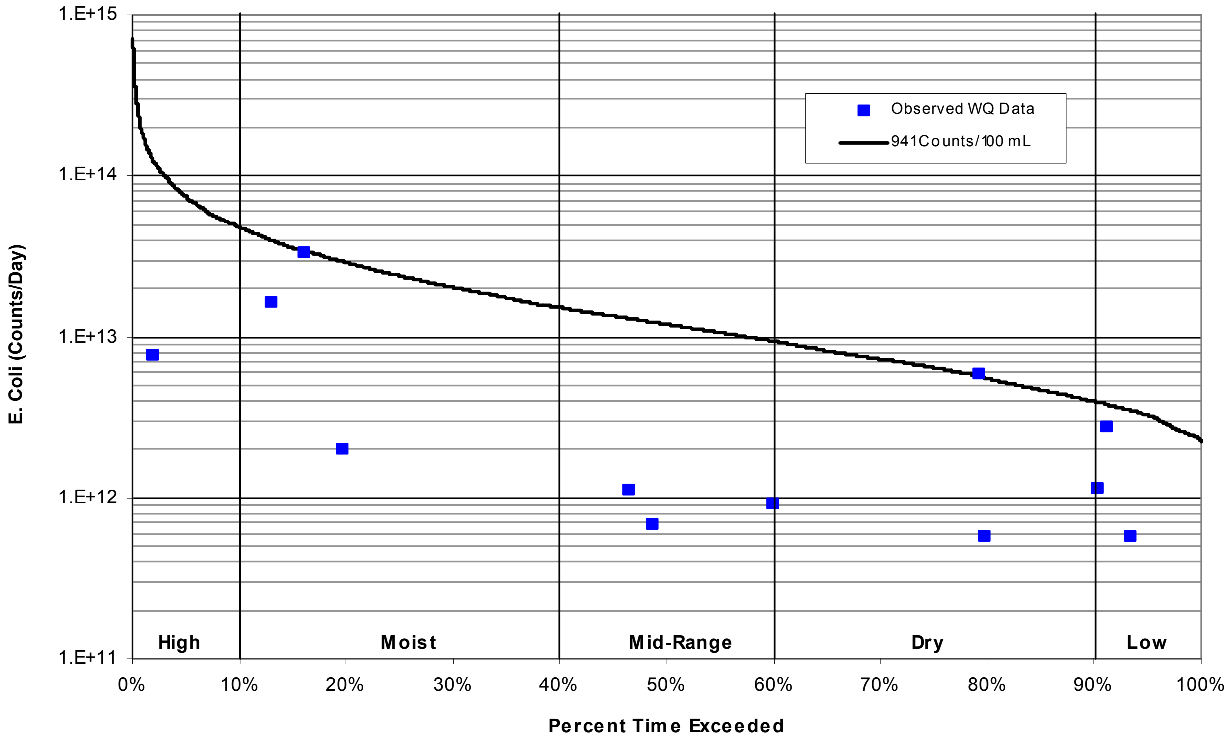

Figure C-10. E. Coli Load Duration Curve for South Fork Forked Deer River at Mile 43.2

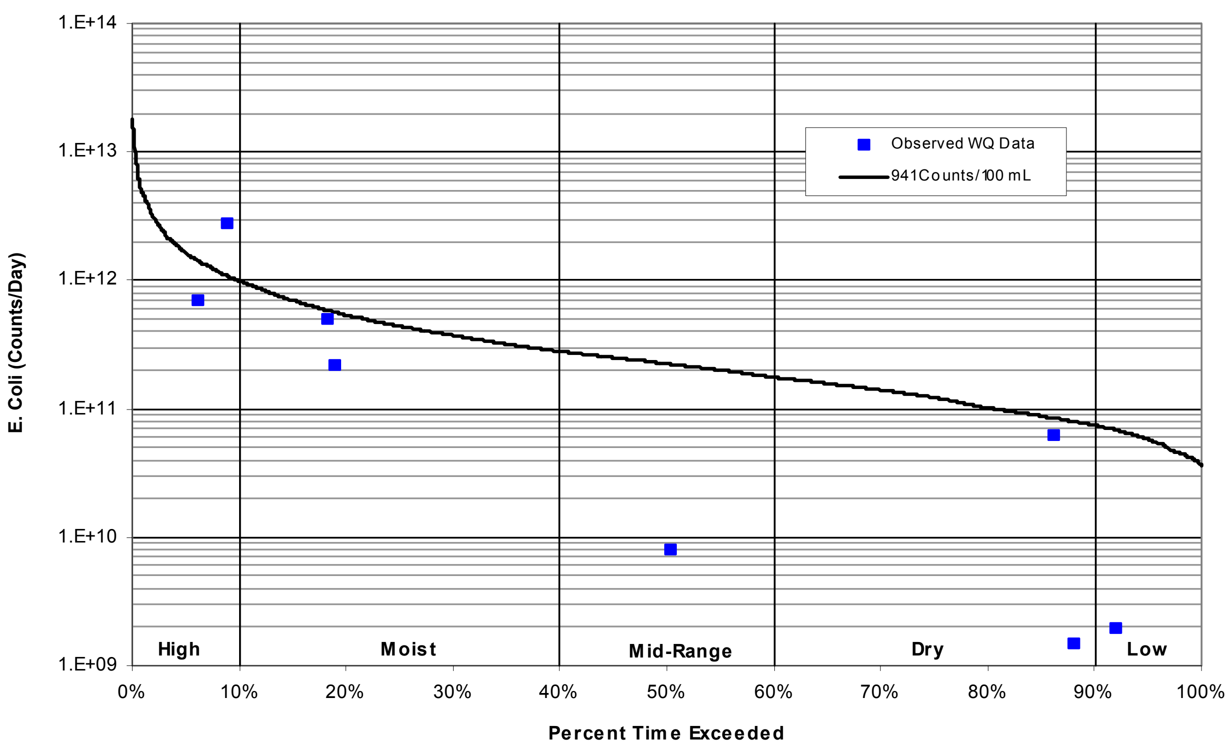

Figure C-11. E. Coli Load Duration Curve for Panther Creek at Mile 1.9

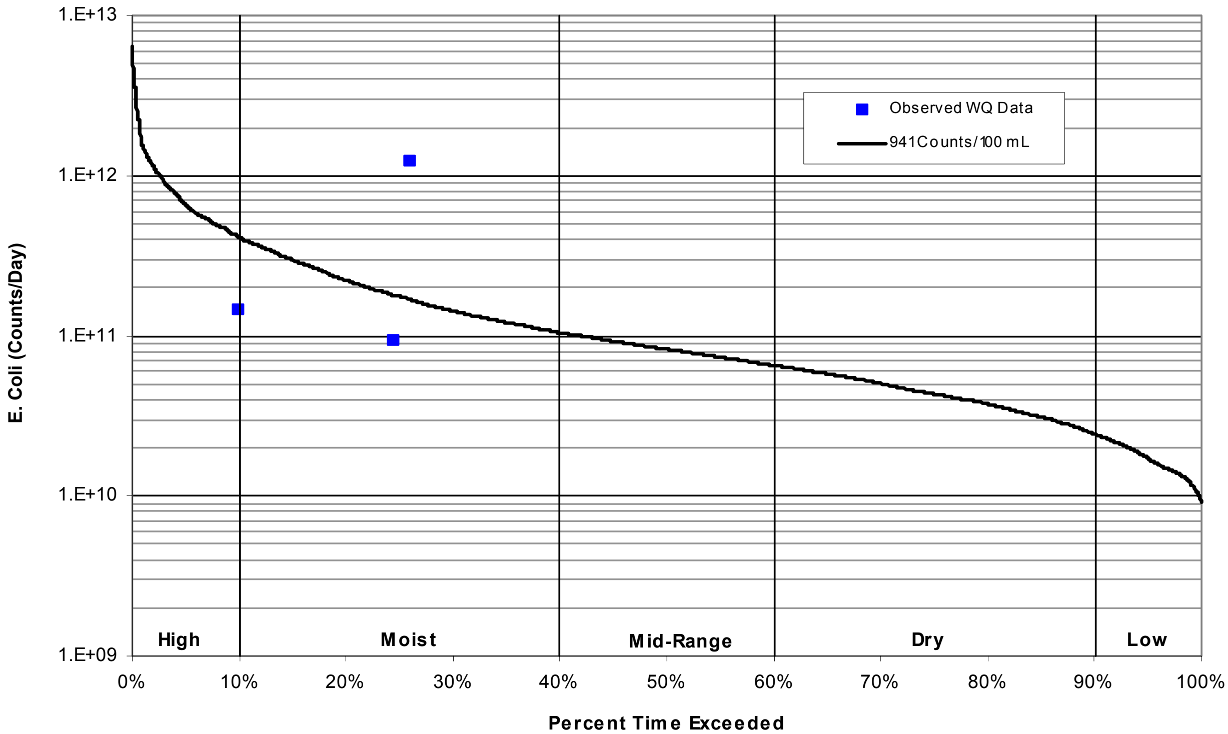

Figure C-12. E. Coli Load Duration Curve for Sandy Creek at Mile 0.55

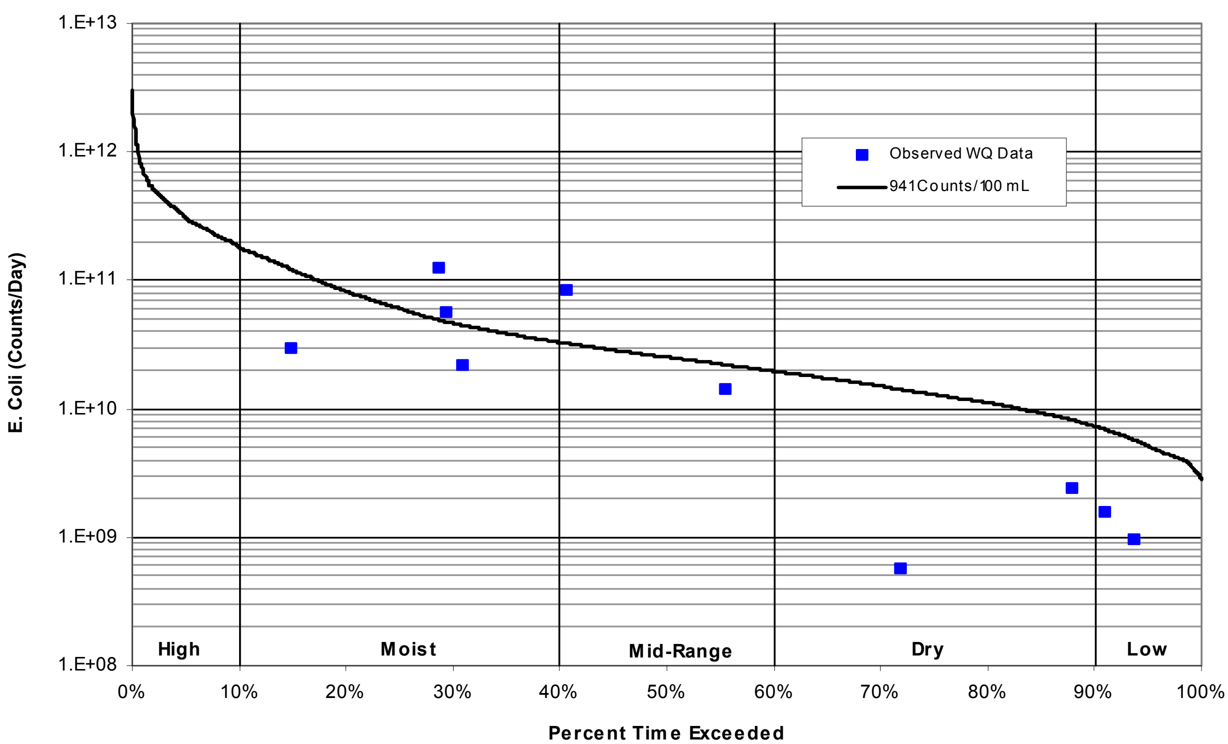

Figure C-13. E. Coli Load Duration Curve for Central Creek at Mile 0.44

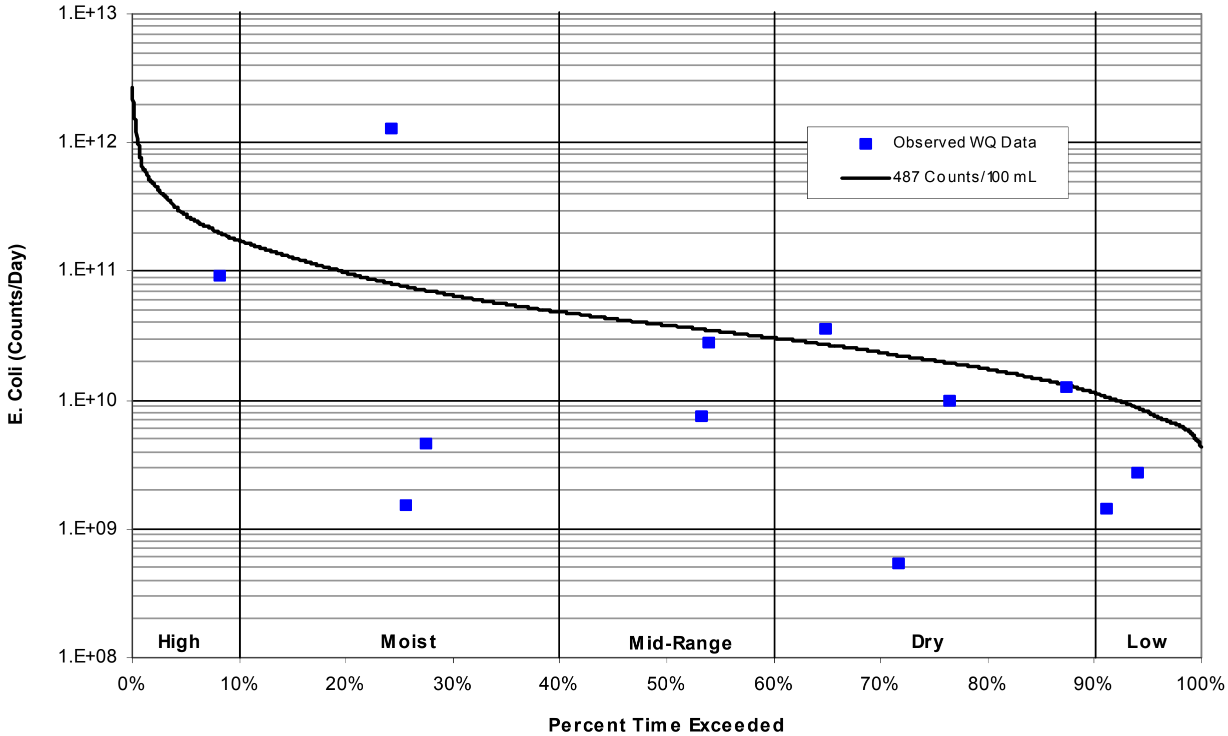

Figure C-14. E. Coli Load Duration Curve for Anderson Branch at Mile 0.55

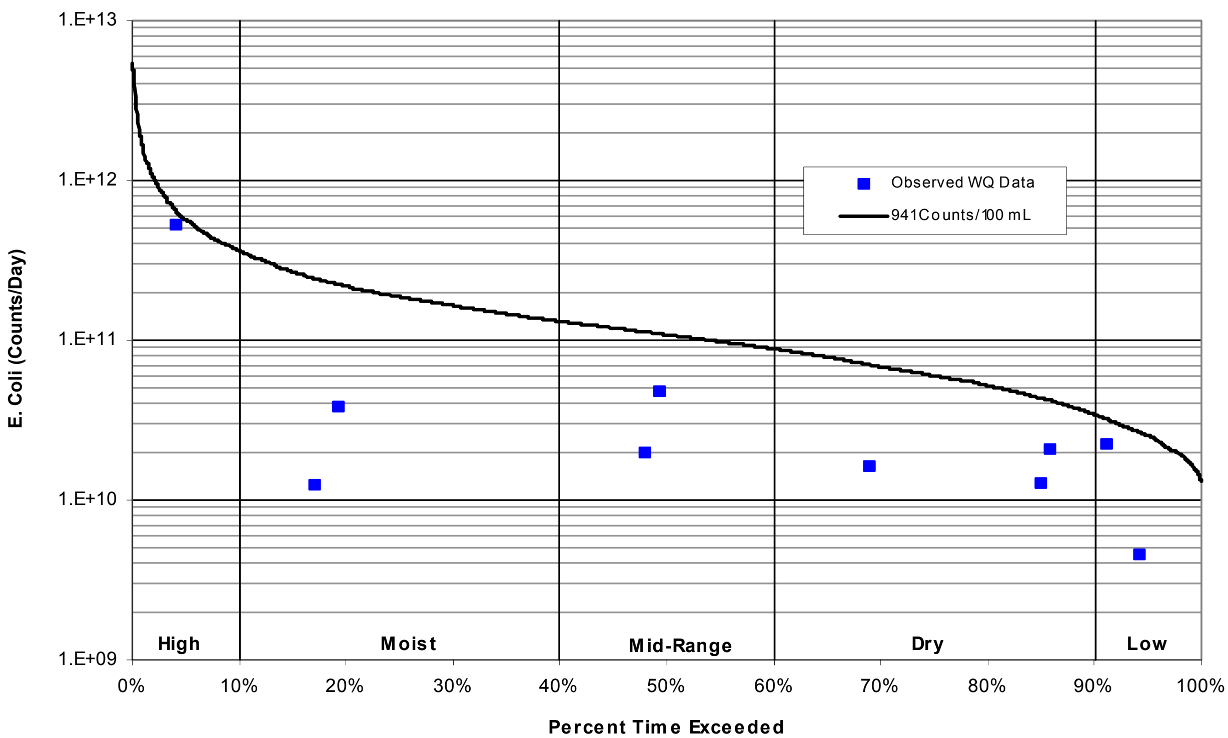

Figure C-15. E. Coli Load Duration Curve for Bond Creek at Mile 1.0

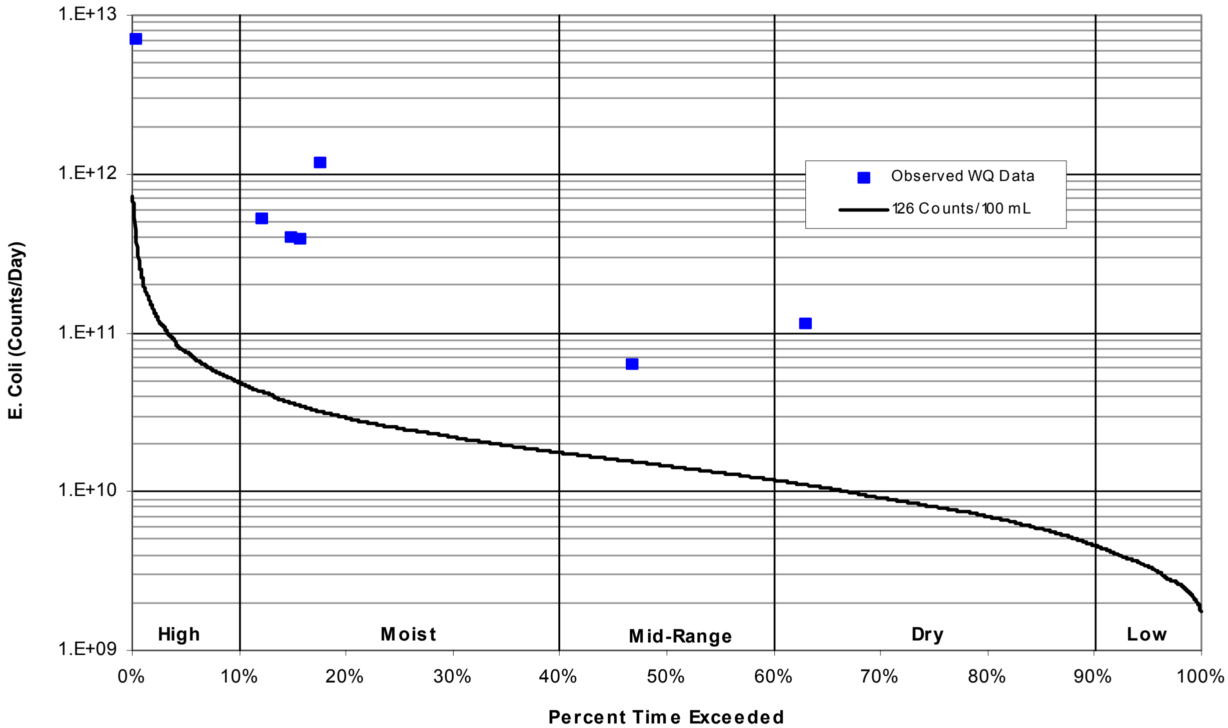

Figure C-16. E. Coli Load Duration Curve for Bond Creek at Mile 1.0 (Geometric Mean data [5/29/01-6/7/01])

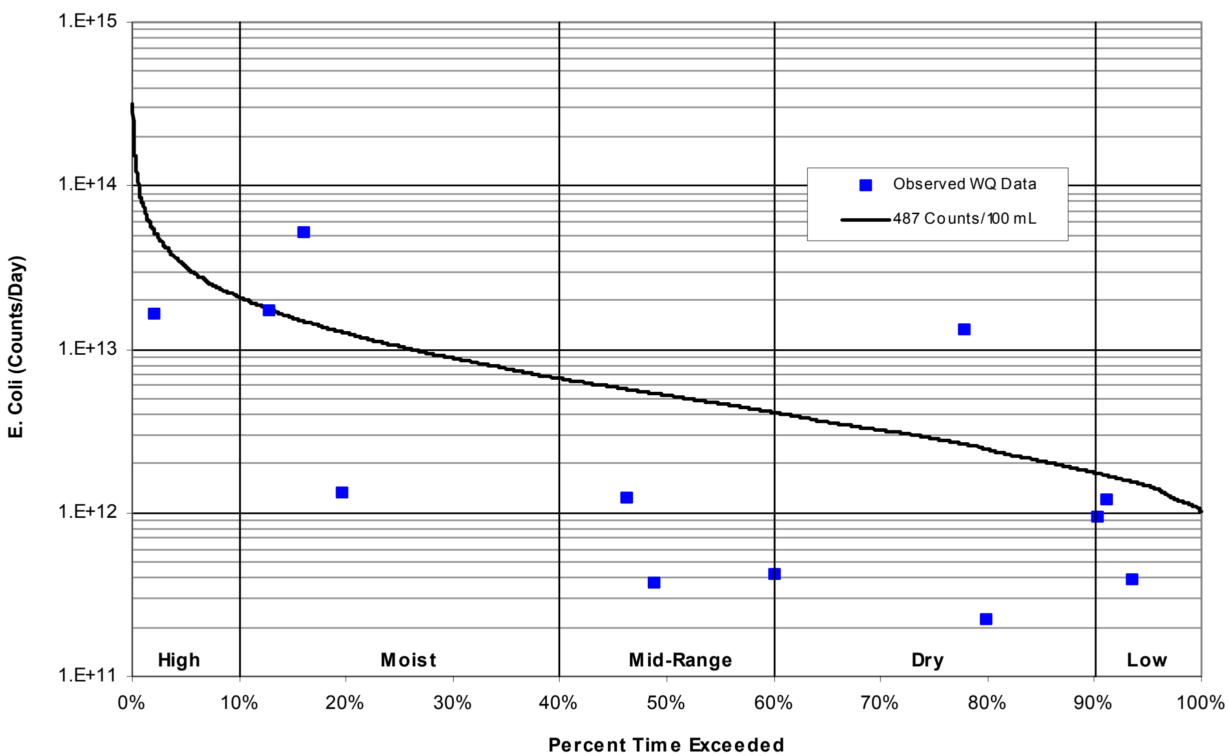

Figure C-17. E. Coli Load Duration Curve for South Fork Forked Deer River at Mile 52.7

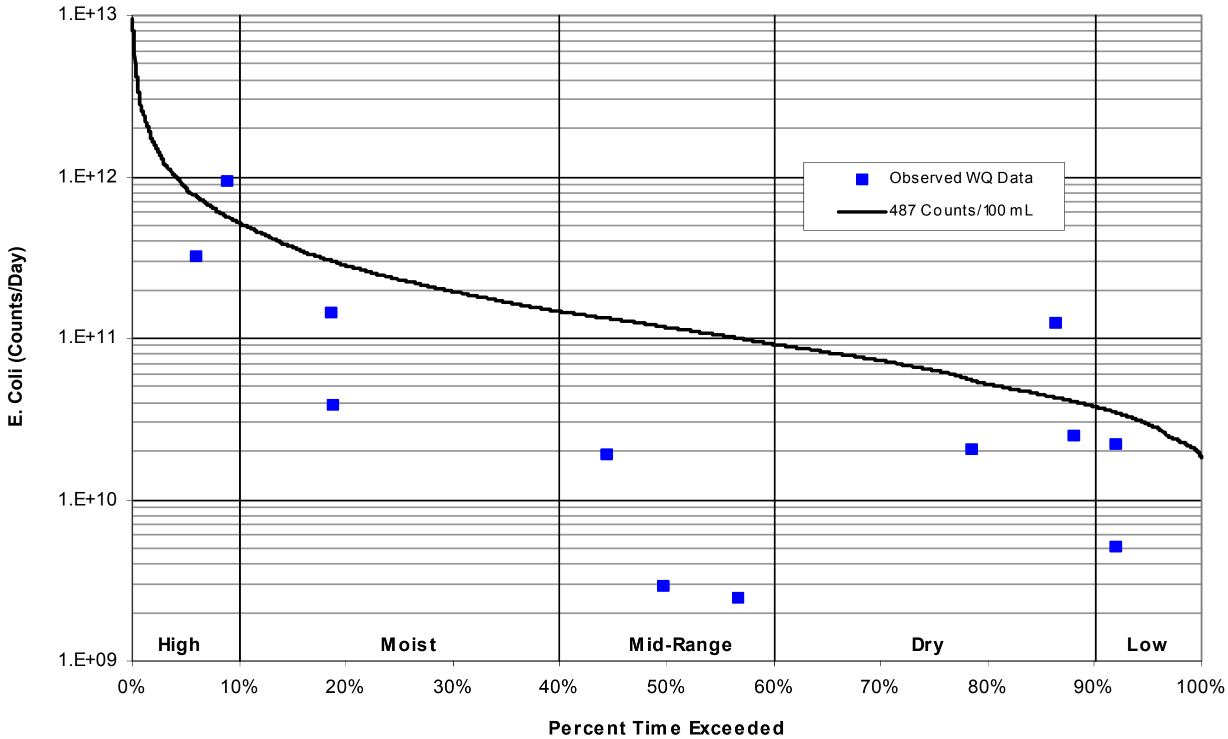

Figure C-18. E. Coli Load Duration Curve for Cub Creek at Mile 1.6

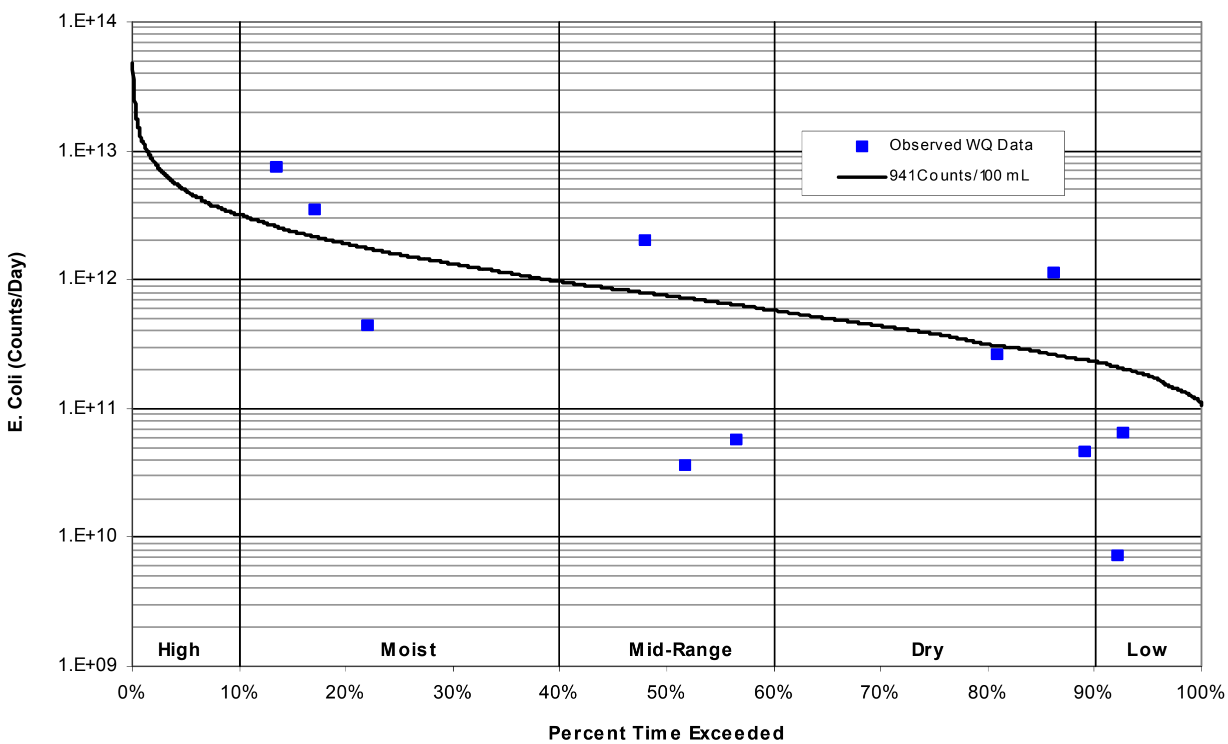

Figure C-19. E. Coli Load Duration Curve for Black Creek at Mile 1.6

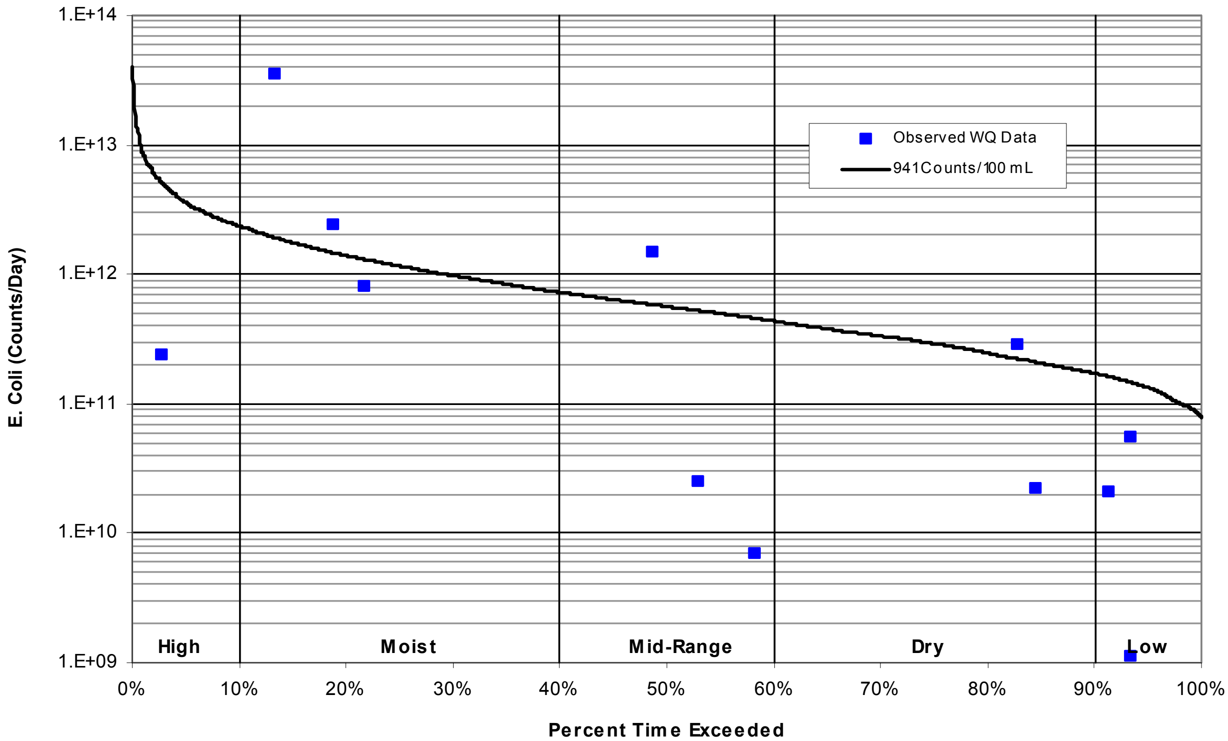

Figure C-20. E. Coli Load Duration Curve for Halls Creek at Mile 1.2

Table C-1. Required Load Reduction for South Fork Forked Deer River at Mile 11.2 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
13.00%	2840.69	6/7/01	302.6	**NR**
17.55%	2242.68	2/21/02	**1299.7**	**62.5**
21.43%	1940.91	1/10/02	80.9	**NR**
50.48%	821.808	3/7/02	19.9	**NR**
57.84%	689.744	11/6/01	31.8	**NR**
80.51%	369.547	5/10/01	181.9	**NR**
81.80%	354.618	7/12/01	**1483**	**67.2**
90.47%	269.038	9/13/01	175	**NR**
92.53%	249.4	8/9/01	171	**NR**
93.48%	239.261	10/4/01	43.5	**NR**
	90th Percentile (all)		**1318**	**63.1**

Table C-2. Required Load Reduction for South Fork Forked Deer River at Mile 30.4 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
31.45%	1028.164	3/29/00	74.8	**NR**
32.88%	991.0688	3/24/99	461.1	**NR**
47.71%	666.111	12/16/98	31.7	**NR**
68.98%	389.4363	9/28/98	128.1	**NR**
70.24%	378.5573	6/27/01	39.9	**NR**
74.10%	343.5066	12/14/00	**980.4**	**50.3**
78.43%	303.9538	6/9/99	72.3	**NR**
80.87%	277.4028	6/20/00	166.9	**NR**
85.74%	240.927	12/1/99	160.7	**NR**
98.00%	136.4305	9/6/00	37.7	**NR**
99.97%	116.4064	9/28/99	184.2	**NR**
	90th Percentile (all)		461	0.0

Table C-3. Required Load Reduction for South Fork Forked Deer River at Mile 30.6 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
1.97%	6404.882	12/17/01	**1732.9**	**71.9**
2.55%	5725.271	12/6/01	387.3	**NR**
2.74%	5523.399	3/12/02	**8164**	**94.0**
9.80%	2574.255	6/19/03	**1203.3**	**59.5**
12.95%	2117.4	6/7/01	**3430**	**85.8**
17.66%	1674.348	2/21/02	**1732.9**	**71.9**
21.57%	1451.958	1/10/02	95.9	**NR**
26.58%	1196.985	12/16/02	66.9	**NR**
27.10%	1176.341	3/25/03	118.7	**NR**
29.62%	1087.449	12/11/03	**1413.6**	**65.5**
31.67%	1018.647	6/8/04	156.5	**NR**
47.28%	673.5231	4/5/01	**1553.1**	**68.6**
50.67%	618.7552	3/7/02	19.9	**NR**
55.46%	554.1684	6/18/02	25.6	**NR**
57.10%	532.3806	3/18/04	90.7	**NR**
58.28%	516.5086	11/6/01	77.6	**NR**
64.74%	434.9475	9/24/02	536	**NR**
80.56%	281.9854	5/10/01	38.6	**NR**
81.77%	271.7169	7/12/01	400	**NR**
83.36%	258.8545	9/16/03	72.7	**NR**
89.79%	211.5625	9/12/01	30.3	**NR**
91.08%	202.2484	9/13/01	97	**NR**
92.69%	189.6284	8/9/01	657	**NR**
93.73%	181.9486	10/4/01	71.4	**NR**
	90th Percentile (all)		**1733**	**71.9**

Table C-4. Required Load Reduction for Jacobs Creek at Mile 4.1 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
2.820%	62.7295	12/6/01	248.1	**NR**
13.304%	23.7982	6/7/01	**866.4**	**43.8**
18.697%	18.0835	2/21/02	**1553.1**	**68.6**
21.736%	16.0144	1/10/02	71.7	**NR**
51.848%	6.52163	3/7/02	5.2	**NR**
92.198%	1.88227	10/4/01	8.5	**NR**
	90th Percentile (all)		**1210**	**59.9**

Table C-5. Required Load Reduction for Little Nixon Creek at Mile 2.9 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
2.90%	39.83805	12/6/01	313	**NR**
13.71%	15.141	6/7/01	**19863**	**95.3**
19.44%	11.43319	2/21/02	727	**NR**
21.68%	10.45713	1/10/02	104.6	**NR**
49.55%	4.576513	4/5/01	**1732.9**	**45.7**
53.71%	4.12741	3/7/02	12.1	**NR**
58.77%	3.641838	11/6/01	17.1	**NR**
83.27%	1.747426	5/10/01	**1986.3**	**52.6**
86.26%	1.574206	7/12/01	**4160**	**77.4**
90.86%	1.320293	9/13/01	100	**NR**
93.13%	1.182573	10/4/01	5.2	**NR**
93.65%	1.144803	8/9/01	59	**NR**
	90th Percentile (all)		**3943**	**76.1**

Table C-6. Required Load Reduction for Meridian Creek at Mile 1.7 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
2.74%	209.38	12/6/01	66.3	**NR**
13.28%	79.2165	6/7/01	**1299.7**	**27.6**
18.75%	60.4925	2/21/02	686.7	**NR**
21.87%	53.2044	1/10/02	145	**NR**
47.80%	24.0517	4/5/01	24.3	**NR**
51.82%	21.755	3/7/02	8.6	**NR**
56.64%	19.1998	11/6/01	28	**NR**
81.03%	9.22684	5/10/01	408.3	**NR**
85.66%	7.99096	7/12/01	307.6	**NR**
89.62%	7.02502	9/13/01	66.3	**NR**
92.25%	6.25182	10/4/01	2	**NR**
92.77%	6.06808	8/9/01	392	**NR**
	90th Percentile (all)		659	0.0

Table C-7. Required Load Reduction for Nixon Creek at Mile 2.2 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
13.25%	322.413	6/7/01	**3654**	**74.2**
18.72%	244.395	2/21/02	435.2	**NR**
21.98%	215.227	1/10/02	57.1	**NR**
47.93%	97.5859	4/5/01	**1732.9**	**45.7**
52.09%	87.8444	3/7/02	166.4	**NR**
57.19%	77.0982	11/6/01	19.3	**NR**
81.80%	37.2474	5/10/01	104.6	**NR**
85.22%	33.3565	7/12/01	**1281**	**26.5**
90.34%	28.0597	9/13/01	30	**NR**
92.86%	24.9621	10/4/01	49.5	**NR**
93.16%	24.2963	8/9/01	624	**NR**
	90th Percentile (all)		**1733**	**45.7**

Table C-8. Required Load Reduction for South Fork Forked Deer River at Mile 36.7 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
1.81%	6166.36	12/5/01	66.2	**NR**
13.30%	1883.46	6/6/01	331	**NR**
16.92%	1575.67	2/20/02	**>2419.2**	**>61.1**
19.44%	1419.35	1/9/02	120.1	**NR**
47.17%	611.232	4/4/01	118.2	**NR**
48.21%	591.72	3/6/02	31.4	**NR**
59.62%	450.424	11/7/01	58.1	**NR**
79.41%	264.253	5/9/01	93.3	**NR**
81.91%	242.928	7/11/01	328.2	**NR**
89.90%	188.448	9/12/01	23.8	**NR**
91.35%	178.792	8/8/01	261.3	**NR**
93.29%	166.051	10/3/01	153.9	**NR**
	90th Percentile (all)		>331	0.0

Table C-9. Required Load Reduction for South Fork Forked Deer River at Mile 43.2 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
1.89%	5513.684	12/5/01	57.3	**NR**
13.00%	1731.737	6/6/01	387.3	**NR**
16.12%	1481.752	2/20/02	920.8	**NR**
19.63%	1278.039	1/9/02	65	**NR**
46.35%	565.6903	4/4/01	81.3	**NR**
48.59%	535.5491	3/6/02	52.1	**NR**
59.87%	408.3671	11/7/01	93.3	**NR**
79.20%	245.9943	7/11/01	**980.4**	**4.0**
79.74%	241.0187	5/9/01	97.8	**NR**
90.25%	171.388	9/12/01	272.3	**NR**
91.19%	164.5426	8/8/01	686.7	**NR**
93.38%	151.7789	10/3/01	155.3	**NR**
	90th Percentile (all)		897	0.0

Table C-10. Required Load Reduction for Panther Creek at Mile 1.9 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	**NR**
6.16%	61.6335	12/5/01	461.1	**NR**
8.81%	47.4673	2/20/02	**>2419.2**	**>61.1**
18.23%	25.4204	6/6/01	816.4	**NR**
18.94%	24.7312	1/9/02	365.4	**NR**
50.34%	9.65035	3/6/02	33.6	**NR**
86.15%	3.67802	7/11/01	686.7	**NR**
88.04%	3.46364	9/12/01	17.5	**NR**
92.03%	2.97003	8/8/01	26.9	**NR**
	90th Percentile (all)		**>1297**	**>27.5**

Table C-11. Required Load Reduction for Sandy Creek at Mile 0.55 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
9.91%	18.1558	12/4/01	325.5	**NR**
24.42%	7.79484	12/5/02	488.4	**NR**
25.90%	7.39189	6/5/01	**6867**	**86.3**
	90th Percentile (all)		**5591**	**83.2**

Table C-12. Required Load Reduction for Central Creek at Mile 0.44 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
14.81%	5.31198	12/4/01	225.4	**NR**
28.72%	2.13241	6/5/01	**>2419.2**	**>61.1**
29.35%	2.06354	1/8/02	**1119.9**	**16.0**
30.91%	1.92808	2/5/02	461.2	**NR**
40.57%	1.40959	8/7/01	**>2419.2**	**>61.1**
55.54%	0.956104	3/5/02	613.1	**NR**
71.83%	0.615933	11/6/01	38.2	**NR**
87.90%	0.357601	7/10/01	275.5	**NR**
90.88%	0.302408	9/11/01	214.3	**NR**
93.76%	0.247064	10/2/01	157.6	**NR**
	90th Percentile (all)		**>2419.2**	**>61.1**

Table C-13. Required Load Reduction for Anderson Branch at Mile 0.55 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli Sample Conc.	E. Coli Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
8.21%	16.5438	12/4/01	228.2	**NR**
24.23%	6.76773	6/5/01	**7701**	**93.7**
25.68%	6.36397	1/8/02	9.7	**NR**
27.54%	5.94232	2/5/02	31.8	**NR**
53.19%	2.98686	4/3/01	101.4	**NR**
53.85%	2.93974	3/5/02	387.3	**NR**
64.82%	2.26927	8/7/01	**648.8**	**24.9**
71.75%	1.85878	11/6/01	12	**NR**
76.43%	1.63575	5/8/01	248.1	**NR**
87.33%	1.10649	7/10/01	461.1	**NR**
91.10%	0.887823	9/11/01	65.7	**NR**
94.09%	0.727186	10/2/01	152.9	**NR**
	90th Percentile (all)		**630**	**22.7**

Table C-14. Required Load Reduction for Bond Creek at Mile 1.0 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli Sample Conc.	E. Coli Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
4.13%	27.8318	12/4/01	770.1	**NR**
17.05%	10.5056	1/8/02	48.8	**NR**
19.27%	9.72917	2/5/02	160.7	**NR**
47.96%	4.91015	4/3/01	166.4	**NR**
49.33%	4.76956	3/5/02	410.6	**NR**
68.96%	3.04671	11/6/01	218.7	**NR**
85.05%	1.88404	8/7/01	275.5	**NR**
85.79%	1.84261	7/10/01	461.1	**NR**
91.10%	1.39926	9/11/01	648.8	**NR**
94.22%	1.15212	10/2/01	161.6	**NR**
	90th Percentile (all)		661	0.0

Table C-15. Required Load Reduction for Bond Creek at Mile 1.0 (Geometric Mean data [5/29/01-6/7/01]) – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli			
			Sample Conc.	Required Load Reduction	Geometric Mean	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]	[CFU/100 mL]	[%]
0.41%	120.371	5/31/01	**>2419.2**	**>79.9**		
12.18%	13.7907	6/4/01	**1553.1**	**68.6**		
14.84%	11.7083	6/6/01	**1413.6**	**65.5**		
15.71%	11.2877	6/7/01	**1413.6**	**65.5**		
17.49%	10.3959	6/5/01	**4611**	**89.4**		
46.73%	5.0219	5/30/01	517.2	5.8		
62.96%	3.57649	5/29/01	**1299.7**	**62.5**	**>1568**	**>92.0**

Table C-16. Required Load Reduction for South Fork Forked Deer River at Mile 52.7 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
1.97%	4590.98	12/5/01	146.7	**NR**
12.81%	1463.8	6/6/01	478.6	**NR**
16.10%	1240.86	2/20/02	**1732.9**	**71.9**
19.68%	1069.6	1/9/02	51.2	**NR**
46.18%	480.735	4/4/01	105.6	**NR**
48.75%	451.497	3/6/02	34.1	**NR**
60.11%	344.415	11/7/01	49.7	**NR**
77.77%	221.205	7/11/01	**>2419.2**	**>79.9**
79.85%	205.814	5/9/01	44.3	**NR**
90.25%	146.527	9/12/01	261.3	**NR**
91.05%	142.696	8/8/01	344.8	**NR**
93.57%	130.58	10/3/01	122.3	**NR**
	90th Percentile (all)		**>1607**	**>69.7**

Table C-17. Required Load Reduction for Cub Creek at Mile 1.6 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
6.05%	63.3366	12/5/01	209.8	**NR**
8.87%	47.6064	2/20/02	**816.4**	**40.3**
18.59%	25.4766	6/6/01	231.8	**NR**
18.81%	25.3374	1/9/02	62.4	**NR**
44.40%	11.193	4/4/01	68.9	**NR**
49.74%	9.84704	3/6/02	12.1	**NR**
56.67%	8.41376	11/7/01	12.1	**NR**
78.54%	4.62177	5/9/01	182.9	**NR**
86.34%	3.60512	7/11/01	**1413.6**	**65.5**
87.98%	3.40828	9/12/01	298.7	**NR**
91.90%	2.93985	8/8/01	307.6	**NR**
91.95%	2.92057	10/3/01	70.8	**NR**
	90th Percentile (all)		**766**	**36.4**

Table C-18. Required Load Reduction for Black Creek at Mile 1.6 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
13.41%	113.616	6/7/01	**2723**	**65.4**
17.03%	93.4553	2/20/02	**1533.1**	**38.6**
21.95%	76.4798	1/10/02	235.9	**NR**
47.88%	34.381	4/5/01	**>2419.2**	**>61.1**
51.71%	31.3461	3/7/02	47.1	**NR**
56.53%	27.709	11/6/01	83.9	**NR**
80.87%	13.3197	5/10/01	798	**NR**
86.26%	11.3528	7/12/01	**4106**	**77.1**
89.16%	10.3713	9/13/01	185	**NR**
92.20%	9.08331	10/4/01	32.7	**NR**
92.58%	8.88725	8/9/01	298	**NR**
	90th Percentile (all)		**>2723**	**>65.4**

Table C-19. Required Load Reduction for Halls Creek at Mile 1.2 – E. Coli Analysis

PDFE	Flow	Sample Date	E. Coli	
			Sample Conc.	Required Load Reduction
[%]	[cfs]		[CFU/100 ml]	[%]
2.79%	219.817	12/6/01	44.1	**NR**
13.28%	83.5391	6/7/01	**17329**	**94.6**
18.81%	63.3876	2/21/02	**1553.1**	**39.4**
21.71%	56.6232	1/10/02	579.4	**NR**
48.70%	25.3337	4/5/01	**>2419.2**	**>61.1**
52.94%	22.8201	3/7/02	45.5	**NR**
58.23%	19.8058	11/6/01	14.6	**NR**
82.73%	9.67248	5/10/01	**1203.3**	**21.8**
84.51%	9.11434	7/12/01	100	**NR**
91.32%	7.08401	9/13/01	121	**NR**
93.38%	6.35192	8/9/01	359	**NR**
93.40%	6.33581	10/4/01	7.3	**NR**
	90th Percentile (all)		**>2333**	**>59.7**

Table C-20. TMDLs, WLAs, & LAs for South Fork Forked Deer River Watershed

HUC-12 Subwatershed (08010205__) or Drainage Area (DA)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs[a]				LAs[e]
				WWTFs[b]		Leaking Collection Systems[c]	MS4s[d]	
				Monthly Avg.	Daily Max.			
			[% Red.]	[CFU/day]	[CFU /day]	[CFU /day]	[% Red.]	[% Red.]
0301 (DA)	Sandy Creek	TN08010205012 – 0400	**83.2**	**NA**	**NA**	**0**	**84.9**	**84.9**
0301 (DA)	Central Creek	TN08010205012 – 0500	**>61.6**	**NA**	**NA**	**0**	**>65.0**	**>65.0**
0301 (DA)	Anderson Branch	TN08010205012 – 0600	**22.7**	**NA**	**NA**	**0**	**30.5**	**30.5**
0301 (DA)	Bond Creek	TN08010205012 – 0700	**>92.0**	**NA**	**NA**	**0**	**>92.8**	**>92.8**
0301	SFFD River	TN08010205012 – 1000	**>69.7**	**8.300×10^{10}**	**6.199×10^{11}**	**0**	**>72.7**	**>72.7**
0303	Cub Creek	TN08010205012 – 1200	**36.4**	**7.646×10^{7}**	**5.710×10^{8}**	**0**	**42.8**	**42.8**
0306	SFFD River	TN08010205012 – 1000	**27.5**	**1.328×10^{10}**	**9.921×10^{10}**	**0**	**NA**	**34.6**
0402	SFFD River	TN08010205003 – 1000	**71.9**	**1.159×10^{10}**	**8.657×10^{10}**	**NA**	**NA**	**74.7**
	SFFD River	TN08010205010 – 1000						
0404	SFFD River	TN08010205001 – 1000	**63.1**	**3.339×10^{9}**	**2.494×10^{10}**	**0**	**NA**	**66.8**
0405	Black Creek	TN08010205031 – 1000	**65.4**	**NA**	**NA**	**0**	**NA**	**68.8**
0406	Halls Creek	TN08010205036 – 1000	**59.7**	**NA**	**NA**	**0**	**NA**	**63.6**
0501	Little Nixon Creek	TN08010205005 – 0100	**76.1**	**NA**	**NA**	**0**	**78.5**	**78.5**
0502	Nixon Creek	TN08010205005 – 1000	**45.7**	**NA**	**NA**	**NA**	**NA**	**51.0**
0503	Meridian Creek	TN08010205005 – 0200	**0.0**	**NA**	**NA**	**NA**	**NA**	**0.0**

Note: NA = Not applicable.

a. There are no CAFOs in the South Fork Forked Deer River watershed. Future CAFOs will be assigned a waste load allocation (WLA) of zero.

b. WLAs for WWTFs expressed as E. coli loads (CFU/day). Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permits.

c. The objective for leaking collection systems is a WLA of zero. It is recognized, however, that a WLA of 0 CFU/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in E. coli loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

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

e. The load allocations (LAs) listed apply to precipitation induced nonpoint sources only. The objective for all other nonpoint sources (leaking septic systems, illicit discharges, and animals access to streams) is a LA of zero. It is recognized, however, that for leaking septic systems a LA of 0 CFU/day may not be practical. For these sources, the LA is interpreted to mean a reduction in E. coli loading to the maximum extent feasible, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

APPENDIX D

Hydrodynamic Modeling Methodology

D.1 Model Selection

The Loading Simulation Program C++ (LSPC) was selected for flow simulation of E. coli-impaired waters in the South Fork Forked Deer River watershed. LSPC is a watershed model capable of performing flow routing through stream reaches. LSPC is a dynamic watershed model based on the Hydrologic Simulation Program - Fortran (HSPF).

D.2 Model Set Up

The impaired waterbodies were delineated into subwatersheds in order to facilitate model hydrologic calibration. Boundaries were constructed so that subwatershed "pour points" coincided with HUC-12 delineations, 303(d)-listed waterbodies, USGS monitoring stations (see Section C.1), and water quality monitoring stations. Watershed delineation was based on the National Hydrography Dataset (NHD) stream coverage and Digital Elevation Model (DEM) data. This discretization facilitates simulation of daily flows at water quality monitoring stations.

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

An important factor influencing model results is the precipitation data contained in the meteorological data files used in these simulations. Weather data from the Jackson Experiment Station meteorological station was available for the time period from January 1970 through June 2004. Meteorological data for a selected 11-year period was used for all simulations. The first year of this period was used for model stabilization with simulation data from the subsequent 10-year period (7/1/94 – 6/30/04) used for TMDL analyses.

D.3 Model Calibration

Hydrologic calibration of the watershed model involves comparison of simulated streamflow to historic streamflow data from USGS stream gaging stations for the same period of time. USGS continuous record stations located in the South Fork Forked Deer River watershed with sufficiently long and recent historical records were selected as the basis of the hydrology calibration. Two USGS stations on the South Fork Forked Deer River were selected due to the transition in Level III ecoregions at the approximate midpoint of the watershed coinciding with one of the USGS stations and the dissimilarity in hydrologic characteristics between the two regions. The other USGS station is located near the mouth of the South Fork Forked Deer River. The calibration involved comparison of simulated and observed hydrographs until statistical stream volumes and flows were within acceptable ranges as reported in the literature (Lumb, et al., 1994).

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

The results of the hydrologic calibrations for South Fork Forked Deer River at Jackson, USGS Station 07027500, and South Fork Forked Deer River near Halls, USGS Station 07028100, are shown in Tables D-1 and D-2 and Figures D-1 and D-2, respectively.

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

Simulation Name:	SFH1206 (calibrated)	**Simulation Period:**	
	SFFD at Jackson	**Watershed Area (ac):**	316800.00
Period for Flow Analysis	(USGS 07027500)		
Begin Date:	**06/01/88**	**Baseflow PERCENTILE:**	2.5
End Date:	**05/31/91**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**85.87**	Total Observed In-stream Flow:	**88.10**
Total of highest 10% flows:	**40.02**	Total of Observed highest 10% flows:	**41.57**
Total of lowest 50% flows:	**9.70**	Total of Observed Lowest 50% flows:	**9.66**
Simulated Summer Flow Volume (months 7-9):	**8.60**	Observed Summer Flow Volume (7-9):	**7.21**
Simulated Fall Flow Volume (months 10-12):	**17.41**	Observed Fall Flow Volume (10-12):	**19.34**
Simulated Winter Flow Volume (months 1-3):	**39.36**	Observed Winter Flow Volume (1-3):	**40.12**
Simulated Spring Flow Volume (months 4-6):	**20.50**	Observed Spring Flow Volume (4-6):	**21.43**
Total Simulated Storm Volume:	**77.06**	Total Observed Storm Volume:	**79.21**
Simulated Summer Storm Volume (7-9):	**6.39**	Observed Summer Storm Volume (7-9):	**4.96**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**-2.53**	10	
Error in 50% lowest flows:	**0.35**	10	
Error in 10% highest flows:	**-3.71**	15	
Seasonal volume error - Summer:	**19.35**	30	
Seasonal volume error - Fall:	**-9.97**	30	
Seasonal volume error - Winter:	**-1.90**	30	
Seasonal volume error - Spring:	**-4.33**	30	
Error in storm volumes:	**-2.72**	20	
Error in summer storm volumes:	**28.63**	50	

Table D-2. Hydrologic Calibration Summary: South Fork Forked Deer River near Halls (USGS 07028100)

Simulation Name:	SFH1224 (calibrated)	**Simulation Period:**	
	SFFD near Halls	**Watershed Area (ac):**	652160.00
Period for Flow Analysis	(USGS 07028100)		
Begin Date:	**10/01/80**	**Baseflow PERCENTILE:**	2.5
End Date:	**09/30/84**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**83.11**	Total Observed In-stream Flow:	**78.92**
Total of highest 10% flows:	**37.81**	Total of Observed highest 10% flows:	**33.36**
Total of lowest 50% flows:	**10.33**	Total of Observed Lowest 50% flows:	**9.94**
Simulated Summer Flow Volume (months 7-9):	**5.02**	Observed Summer Flow Volume (7-9):	**6.47**
Simulated Fall Flow Volume (months 10-12):	**15.97**	Observed Fall Flow Volume (10-12):	**17.04**
Simulated Winter Flow Volume (months 1-3):	**25.18**	Observed Winter Flow Volume (1-3):	**21.77**
Simulated Spring Flow Volume (months 4-6):	**36.94**	Observed Spring Flow Volume (4-6):	**33.65**
Total Simulated Storm Volume:	**73.87**	Total Observed Storm Volume:	**67.87**
Simulated Summer Storm Volume (7-9):	**2.70**	Observed Summer Storm Volume (7-9):	**3.70**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**5.31**	10	
Error in 50% lowest flows:	**3.94**	10	
Error in 10% highest flows:	**13.34**	15	
Seasonal volume error - Summer:	**-22.43**	30	
Seasonal volume error - Fall:	**-6.28**	30	
Seasonal volume error - Winter:	**15.69**	30	
Seasonal volume error - Spring:	**9.79**	30	
Error in storm volumes:	**8.85**	20	
Error in summer storm volumes:	**-26.98**	50	

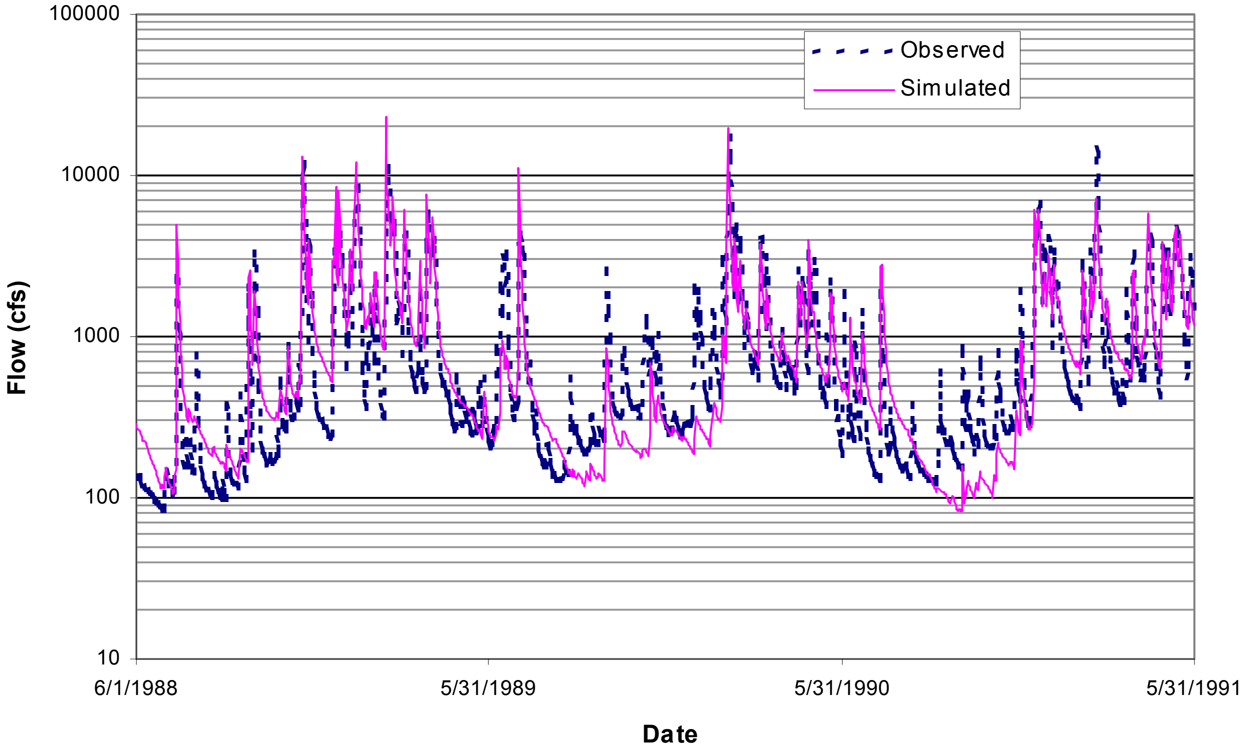

Figure D-1. Hydrologic Calibration: South Fork Forked Deer River at Jackson (USGS 07027500)

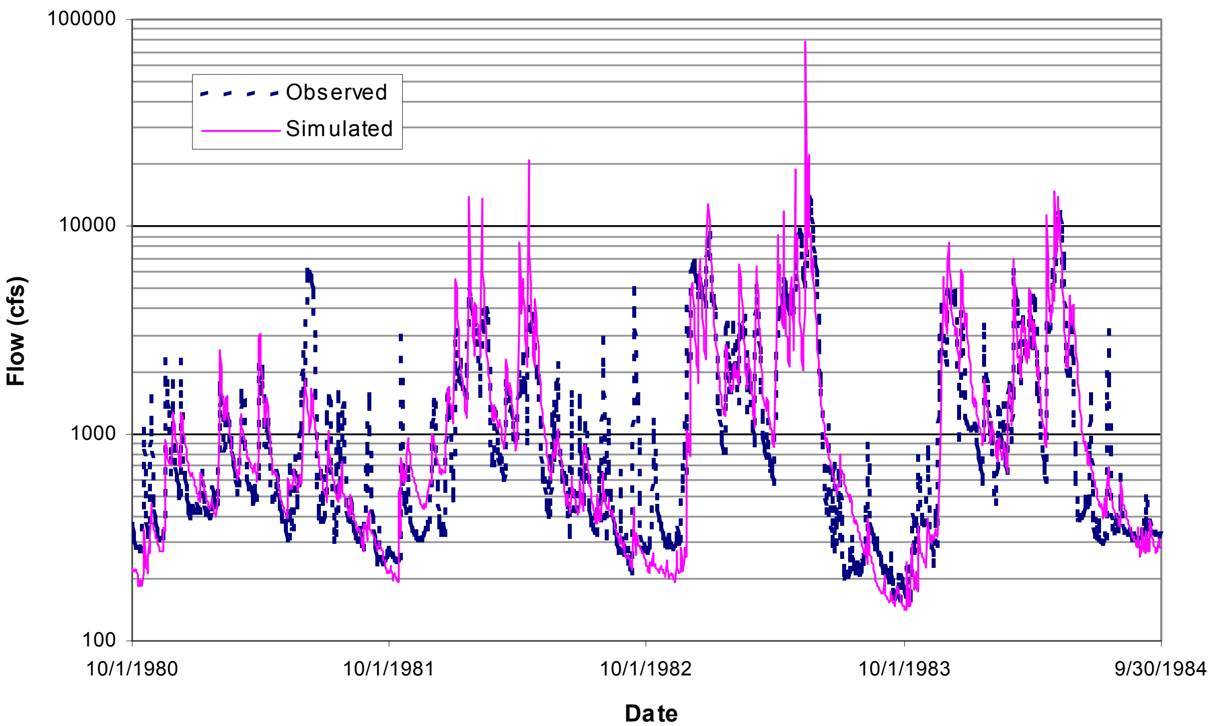

Figure D-2. Hydrologic Calibration: South Fork Forked Deer River near Halls (USGS 07028100)

APPENDIX E

Public Notice of Proposed Total Maximum Daily Loads (TMDLs) for E. Coli in the South Fork Forked Deer River Watershed (HUC 08010205)

DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR E. COLI IN THE 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 (SFFD) 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 are listed on Tennessee's Proposed Final Version Year 2004 303(d) list as not supporting designated use classifications due, in part, to discharge of E. coli from pasture grazing, discharges from MS4 areas, collection system failure, and animal feeding operations. The TMDL utilizes Tennessee's general water quality criteria, recently collected site specific water quality data, continuous flow data from two USGS discharge monitoring stations located in the watershed, a calibrated hydrologic model, and load duration curves to establish allowable loadings of E. coli which will result in reduced in-stream concentrations and attainment of water quality standards. The TMDL requires reductions of E. coli loading on the order of 23-92% for the listed waterbodies.

The proposed SFFD River E. coli TMDL document can be downloaded from the following website:

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

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

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

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

Persons wishing to comment on the proposed TMDL are invited to submit their comments in writing no later than May 22, 2006 to:

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

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

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