TOTAL MAXIMUM DAILY LOAD (TMDL)

For

Fecal Coliform

In

North Fork Forked Deer River
Turkey Creek
& Other Impaired Waterbodies

Located In The

North Fork Forked Deer Watershed (HUC 08010204)
Carroll, Crockett, Dyer, Gibson, Henderson,
& Madison Counties, Tennessee

Prepared by:

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and

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LIST OF ABBREVIATIONS

BMP	Best Management Practices
BPJ	Best Professional Judgment
CFS	Cubic Feet per Second
DEM	Digital Elevation Model
DMR	Discharge Monitoring Report
DWPC	Division of Water Pollution Control
EPA	Environmental Protection Agency
GIS	Geographic Information System
HSPF	Hydrological Simulation Program - FORTRAN
HUC	Hydrologic Unit Code
LA	Load Allocation
MFFDR	Middle Fork Forked Deer River
MGD	Million Gallons per Day
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
NFFDR	North Fork Forked Deer River
NPDES	National Pollutant Discharge Elimination System
NPSM	Non-point Source Model
NRCS	Natural Resources Conservation Service
Rf3	Reach File 3
RM	River Mile
STORET	STORage RETrieval database
TDEC	Tennessee Department of Environment & Conservation
TMDL	Total Maximum Daily Load
TWRA	Tennessee Wildlife Resources Agency
USGS	United States Geological Survey
WCS	Watershed Characterization System
WLA	Waste Load Allocation

SUMMARY SHEET
Total Maximum Daily Load (TMDL)

1. 303(d) Listed Waterbody Information

State: Tennessee

County: Dyer, Gibson, Crockett, Madison, and Henderson

Major River Basin: Obion – Forked Deer Basin

Watershed: North Fork Forked Deer River (NFFDR) - HUC08010204

Impaired Waterbodies (1998 303(d) List:

NFFDR (TN08010204001) – 27.4 mi. not supporting

Turkey Creek (TN08010204015) – 24.3 mi. partially supporting

Impaired Waterbodies (2000 Assessment):

Waterbody ID	Segment Name	Size [mi.]	Use Support	Reference to 1998 303(d) List Waterbody ID
TN08010204001_1000	NFFDR – mouth to Pond Creek	15.5	Partial	TN08010204001
TN08010204003_1000	Pond Creek – mouth to headwaters	24.7	Not	—
TN08010204007_1000	MFFDR – mouth to Cypress Creek	15.3	Partial	—
TN08010204010_1000	MFFDR – Cypress Ck. to Sugar Ck.	9.5	Partial	—
TN08010204010_1100	Beech Ck. – mouth to headwaters	23.8	Partial	—
TN08010204014_0100	Dry Creek – mouth to headwaters	9.0	Not	—
TN08010204017_1000	Buck Creek – mouth to headwaters	39.8	Not	—
TN08010204022_1000	Doakville Ck. – mouth to headwaters	36.0	Partial	—
TN08010204023_1000	Lewis Creek – mouth to headwaters	46.3	Partial	—

Constituent(s) of Concern: Fecal Coliform Bacteria

Designated Uses: Fish and Aquatic Life, Recreation, Livestock Watering & Wildlife, Irrigation, and Navigation (main stem only)

Applicable Fecal Coliform Water Quality Standard for Recreation (most stringent):

The concentration of the fecal coliform group shall not exceed 200 per 100 ml as a geometric mean based on a minimum of 10 samples collected from a given sampling site over a period of not more than 30 days with individual samples being collected at intervals of not less than 12 hours. In addition, the concentration of the fecal coliform group in any individual sample shall not exceed 1,000 per 100 ml.

2. TMDL Development

Analysis/Modeling:

The Non-Point Source Model (NPSM) was used to develop this TMDL. An hourly time step was used to simulate hydrologic and water quality conditions with results expressed as daily averages.

Critical Conditions:

A simulation period of 10 years was used to assess the water quality standards for this TMDL representing a range of hydrologic and meteorological conditions.

Seasonal Variation:

A simulation period of 10 years was used to assess the water quality standards for this TMDL. This period includes seasonal variations.

3. **Allocation Watershed/Stream Reach:**

Waterbody	WLA [a] (counts/30days)	LA (counts/30days)	MOS [b]	TMDL (counts/30days)	Percent Reduction [c]
N Fork Forked Deer River [d]	3.80×10^{12}	2.24×10^{15}	Implicit & Explicit	2.24×10^{15}	71
Pond Creek	0	2.89×10^{13}	Implicit & Explicit	2.89×10^{13}	45
Doakville Creek	0	4.55×10^{13}	Implicit & Explicit	4.55×10^{13}	75
Lewis Creek	0	2.46×10^{13}	Implicit & Explicit	2.46×10^{13}	46
Middle Fork Forked Deer River [e]	5.44×10^{10}	1.11×10^{15}	Implicit & Explicit	1.11×10^{15}	83
Buck Creek	0	1.48×10^{14}	Implicit & Explicit	1.48×10^{14}	95
Turkey Creek	1.14×10^{8}	1.23×10^{13}	Implicit & Explicit	1.23×10^{13}	78
Beech Creek	0	See Note f	Implicit & Explicit	See Note f	83 [g]
Dry Creek	0	See Note f	Implicit & Explicit	See Note f	83 [g]

Notes:

a. All future permitted discharges shall meet the water quality standard for fecal coliform bacteria of 200/100ml.
b. Margin of safety (MOS) equivalent to 20-counts/100 ml and conservative modeling assumptions.
c. Percent reduction of instream fecal coliform concentration between existing and TMDL conditions.
d. TMDL for North Fork Forked Deer River (NFFDR) at the confluence with South Fork Forked Deer River.
e. TMDL for Middle Fork Forked Deer River (MFFDR) at the confluence with NFFDR.
f. Beech Creek and Dry Creek are small tributaries to the MFFDR. Insufficient data available to develop a numerical model of these watersheds.
g. The percent reduction required for compliance of the MFFDR to meet water quality criteria applies to all tributaries where a numerical model was not developed.

FECAL COLIFORM TOTAL MAXIMUM DAILY LOAD (TMDL) NORTH FORK FORKED DEER RIVER WATERSHED (HUC 08010204)

North Fork Forked Deer River (TN08010204001) Turkey Creek (TN08010204015) & Other Impaired Waterbodies

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 water bodies that are not meeting designated uses. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources (USEPA, 1991).

2.0 WATERSHED DESCRIPTION

The North Fork Forked Deer River (NFFDR) watershed (HUC 08010204) is located in western Tennessee in Dyer, Gibson, Crockett, Madison, Carroll, and Henderson Counties (Figure 1). The watershed primarily falls within the Level III Mississippi Valley Loess Plains (74) ecoregion and Southeastern Plains (65) ecoregions. The eastern portion of the watershed is in the Level IV Southeastern Plains and Hills subecoregion (65e) and is typified by increased gradients, generally sandy substrates, and distinctive faunal characteristics for West Tennessee. The majority of the watershed is located in the Level IV Loess Plains subecoregion (74b). Irregular plains, level to gently rolling, with wide, flat bottomlands and floodplains, characterize the physiography of the region. Streams in this subecoregion are generally low gradient and murky with silt and sand bottoms, and most have been channelized (USEPA, 1997). Small sections of the watershed, near the mouth, are in the Level IV Bluff Hills (74a) and Loess Plains (74b) subecoregions. Soils in the watershed have moderate to high runoff potential. In the Dyersburg area, the soils are more permeable, hence the high groundwater usage for public water supply.

The NFFDR watershed drains an area of approximately 956 square miles. Lewis Creek, Pond Creek, Doakville Creek, and the Middle Fork Forked Deer River (MFFDR) are tributaries of the NFFDR. Buck Creek, Beech Creek, Turkey Creek, and Dry Creek are tributaries of the MFFDR. 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. Land use for this time period is summarized in Table 1 and shown in Figure 2. Predominate land use in the NFFDR watershed is agriculture (72%) followed by forest (24%). Urban areas represent less than 5% of the total drainage area, but the density of urban areas to the impaired reaches is also considered a potential source of impairment.

Figure 1 Location of the NFFDR Watershed

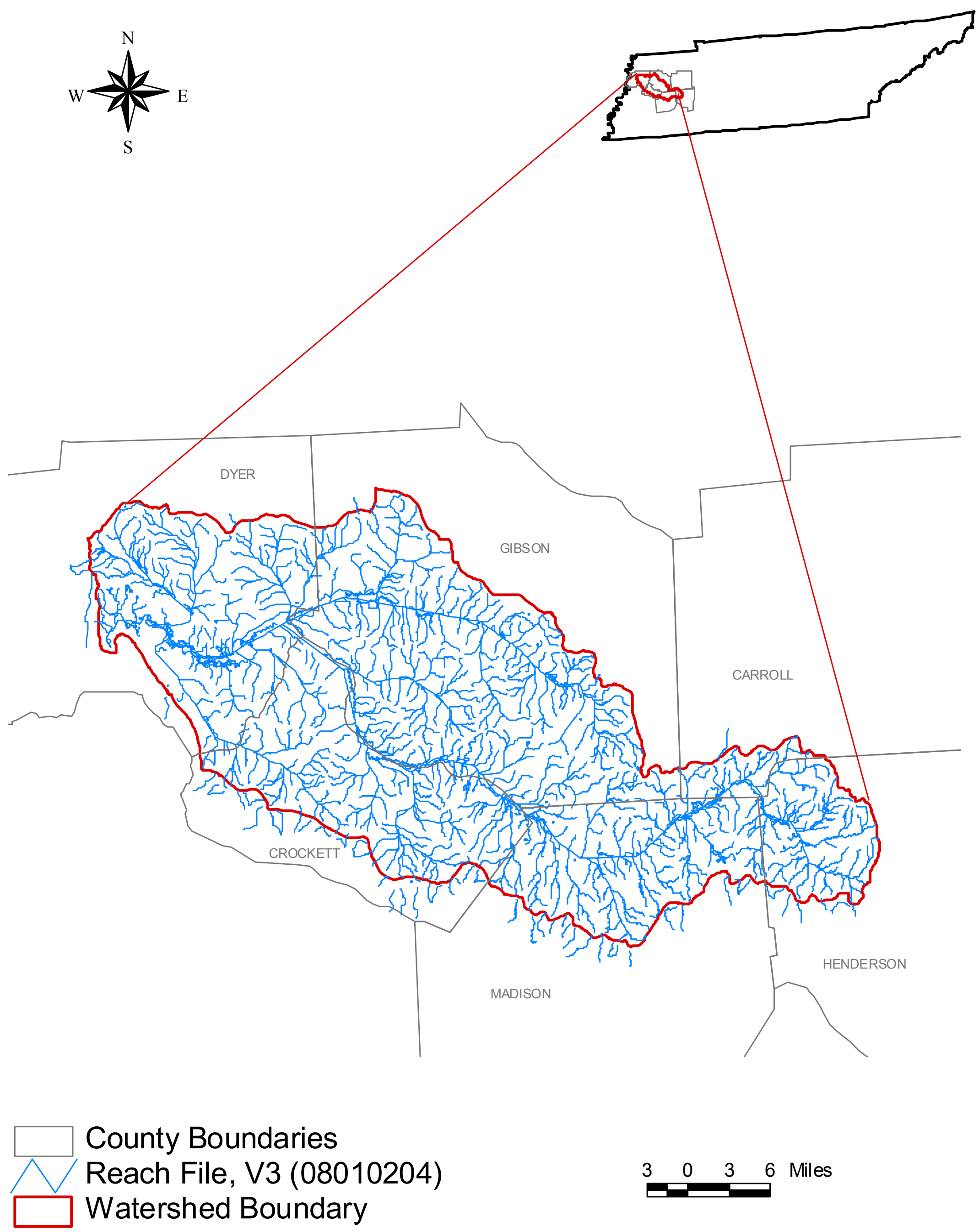


Table 1 Land Use Distribution in the NFFDR Watershed

Land Use	Pond Creek		Doakville Creek		Lewis Creek		MFFDR		Buck Creek	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Bare Rock/Sand/Clay	22	0.0	0	0.0	0	0.0	51	0.0	0	0.0
Deciduous Forest	1,462	3.3	1,404	4.4	4,239	10.1	56,473	18.2	733	2.3
Evergreen Forest	138	0.3	61	0.2	322	0.8	4,795	1.5	87	0.3
High Intensity Commercial/ Industrial/ Transport.	352	0.8	89	0.3	977	2.3	969	0.3	34	0.1
High Intensity Residential	48	0.1	54	0.2	547	1.3	1,316	0.4	0	0.0
Low Intensity Residential	212	0.5	197	0.6	1,343	3.2	6,006	1.9	27	0.1
Mixed Forest	717	1.6	471	1.5	2,691	6.4	15,577	5.0	833	2.6
Open Water	377	0.8	60	0.2	191	0.5	3,454	1.1	211	0.7
Other Grasses Urban/Recreational	10	0.0	49	0.2	193	0.5	209	0.1	0	0.0
Pasture/Hay	8,944	20.0	10,971	34.1	13,801	32.7	83,669	26.9	14,582	46.4
Quarries/Strip Mines/Gravel Pits	0	0.0	0	0.0	0	0.0	122	0.0	0	0.0
Row Crops	30,641	68.6	18,558	57.8	17,797	42.2	116,828	37.6	13,852	44.1
Small Grains	111	0.2	0	0.0	0	0.0	1,795	0.6	0	0.0
Transitional	110	0.2	2	0.0	69	0.2	353	0.1	7	0.0
Woody Wetlands	6	1,534	212	0.7	10	0.0	19,313	6.2	1,066	3.4
Total	44,679	100.0	32,129	100.0	42,180	100.0	310,930	100.0	31,432	100.0

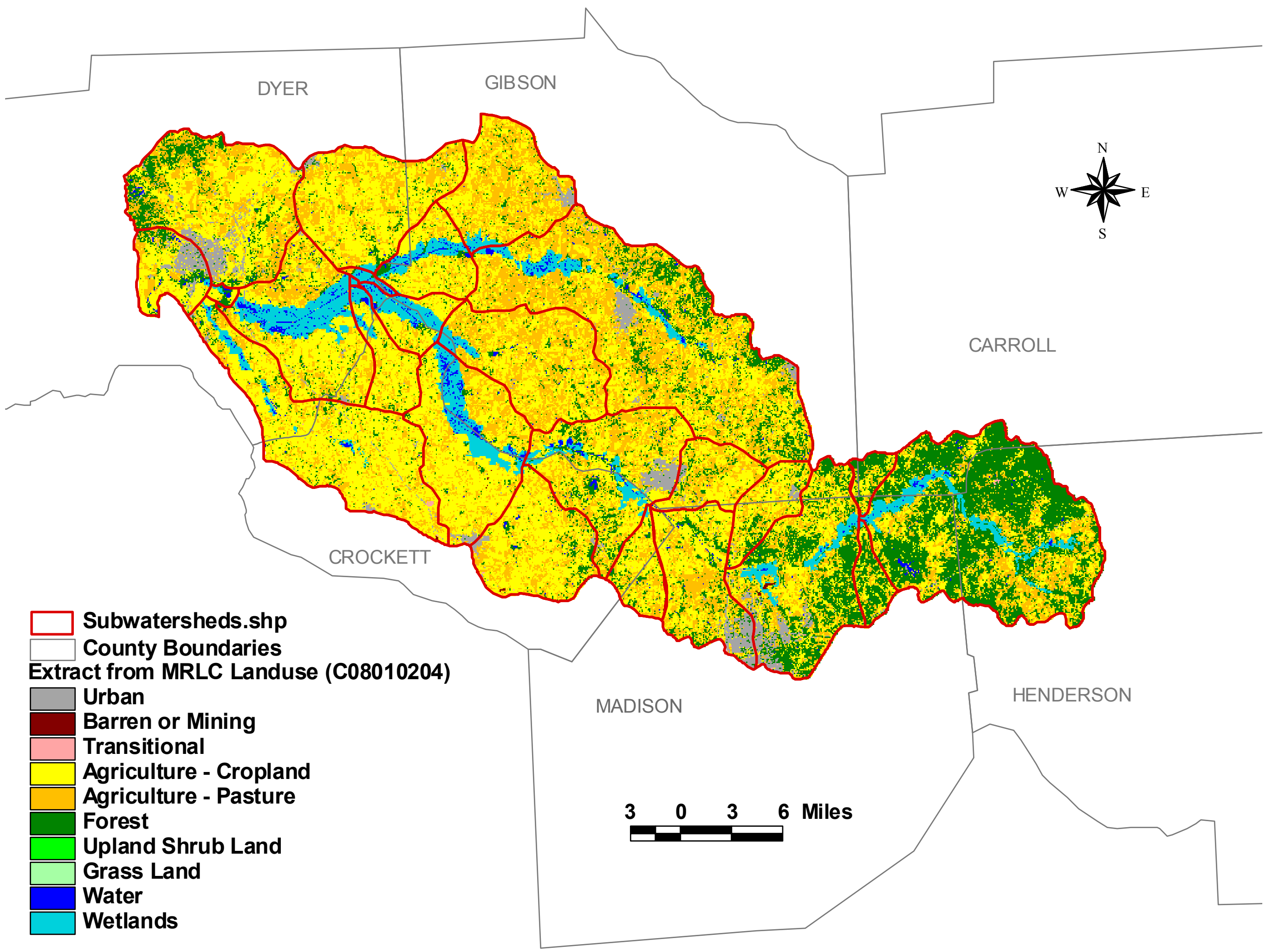
Note: Waterbody Drainage areas correspond to the following delineated subwatersheds: Pond Creek – Subwatershed 003
Doakville Creek – Subwatershed 022
Lewis Creek – Subwatershed 023
MFFDR – Subwatersheds 007, 008, 009, 010, 010a, 011, 012, 013, 014, 014a, 015, 016, & 017
Buck Creek – Subwatershed 017

Table 1 Land Use Distribution in the NFFDR Watershed (Continued)

Land Use	Turkey Creek		Beech Creek		Dry Creek		Total NFFDR	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Bare Rock/Sand/Clay	0	0.0	0	0.0	0	0.0	73	0
Deciduous Forest	1,144	12.0	574	6.8	1,289	33.8	77,507	12.7
Evergreen Forest	110	1.1	59	0.7	233	6.1	6,389	1.0
High Intensity Commercial/ Industrial/ Transportation	35	0.4	2	0.0	2	0.0	3,378	0.6
High Intensity Residential	28	0.3	0	0.0	0	0.0	2,892	0.5
Low Intensity Residential	212	2.1	0	0.0	3	0.1	11,355	1.9
Mixed Forest	465	4.7	326	3.9	320	8.4	25,367	4.1
Open Water	21	0.2	29	0.3	3	0.1	7,260	1.2
Other Grasses Urban/Recreational	1	0.0	0	0.0	0	0.0	860	0.1
Pasture/Hay	2,963	30	2,705	32.1	699	18.3	181,604	29.7
Quarries/Strip Mines/Gravel Pits	0	0.0	0	0.0	0	0.0	122	0
Row Crops	4,525	46.0	4,623	54.8	1,225	32.2	257,919	42.1
Small Grains	338	3.4	53	0.6	0	0.0		
Transitional	25	0.3	5	0.1	1	0.0	639	0.1
Woody Wetlands	0	0.0	55	0.7	37	1.0	36,728	6.0
Total	9,867	100.0	8,433	100.0	3,812	100.0	612,093	100.0

Note: Waterbody Drainage areas correspond to the following delineated subwatersheds: Turkey Creek – Subwatershed 015
Beech Creek – Subwatershed 010a
Dry Creek – Subwatershed 014a
Total NFFDR – All Subwatersheds

Figure 2 MRLC Land Use Distribution – North Fork Forked Deer River Watershed



3.0 PROBLEM DEFINITION

EPA Region IV approved Tennessee's final 1998 303(d) list on September 17, 1998. The list identified 27.4 miles of the NFFDR as not fully supporting designated uses and Turkey Creek as partially supporting designated uses due, in part, to pathogens. The fecal coliform group is an indicator of the presence of pathogens in a stream.

Although Tennessee did not issue an updated 303(d) list in 2000, waterbodies in the NFFDR watershed were reassessed. In this assessment, Pond Creek, Lewis Creek, Doakville Creek, Buck Creek, Beech Creek, Dry Creek, and segments of the NFFDR and MFFDR were identified as partially or not supporting designated use classifications due, in part, to pathogens. Turkey Creek was identified as not supporting designated uses due to siltation and other habitat alterations, but was no longer assessed as impaired due to pathogens. With respect to pathogens, the results of the 2000 assessment are summarized in Table 2 (TDEC, 2000). TMDLs have been developed for all waterbodies in the NFFDR watershed listed on the 1998 303(d) list or the 2000 assessment as impaired due to pathogens.

Table 2 Waterbodies in the NFFDR Watershed Impaired Due to Pathogens

Waterbody ID	Segment Name	Size [mi.]	Use Support	Reference to 1998 303(d) List Waterbody ID
TN08010204001_1000	NFFDR – mouth to Pond Creek	15.5	Partial	TN08010204001
TN08010204003_1000	Pond Creek – mouth to headwaters	24.7	Not	—
TN08010204007_1000	MFFDR – mouth to Cypress Creek	15.3	Partial	—
TN08010204010_1000	MFFDR – Cypress Ck. to Sugar Ck.	9.5	Partial	—
TN08010204010_1100	Beech Ck. – mouth to headwaters	23.8	Partial	—
TN08010204014_0100	Dry Creek – mouth to headwaters	9.0	Not	—
TN08010204017_1000	Buck Creek – mouth to headwaters	39.8	Not	—
TN08010204022_1000	Doakville Ck. – mouth to headwaters	36.0	Partial	—
TN08010204023_1000	Lewis Creek – mouth to headwaters	46.3	Partial	—

4.0 TARGET IDENTIFICATION

The designated use classifications for streams in the NFFDR watershed include: fish and aquatic life, irrigation, livestock watering & wildlife, recreation, and navigation. Of the use classifications with numeric criteria for fecal coliform bacteria, the recreation use classification is the most stringent and will be used as the target level for TMDL development. The fecal coliform water quality criteria for protection of the recreation use classification, as established by *State of Tennessee Water Quality Standards, Chapter 1200-4-3 General Water Quality Criteria, October, 1999*. Section 1200-4-3-.03 (4) (f) states, in part, that the concentration of the fecal coliform group shall not exceed 200 per 100 ml as a geometric mean based on a minimum of 10 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. In addition, the concentration of the fecal coliform group in any individual sample shall not exceed 1,000 per 100 ml.

The geometric mean standard of 200 counts/100 ml has been selected as the primary target value for the TMDLs because it is representative of average stream conditions . In the TMDL, simulated concentrations are expressed in terms of a 10-year geometric mean plot. Critical conditions are determined from this ten-year period (see Section 8.1). A 10-year graph with the proposed reductions is used to show compliance with the geometric mean criteria and to illustrate the criteria has been met for all seasons. An explicit margin of safety (MOS) of 20 counts/100 ml has been included to address uncertainties in the analysis, resulting in an effective target geometric mean concentration of 180 counts/100 ml.

The instantaneous criteria are difficult to model and insufficient data are available to calibrate the water quality model for the instantaneous maximum. By meeting the geometric mean criteria, compliance with the instantaneous criteria is expected to be met during most flow regimes.

5.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

With respect to fecal coliform, the existing water quality of impaired streams in the NFFDR watershed can be characterized by data collected since 1992 at the following monitoring sites (see Figure 3):

- STORET Station NFFDE007.3DY – NFFDR at Highway 211
- STORET Station NFFDE20.5DY – NFFDR at Highway 104
- STORET Station BUCK001.2GI – Buck Creek at Eaton Brazil Road
- STORET Station MFFDE007.0GI – MFFDR at Highway 188/Friendship Eaton Road Bridge Crossing (data available from 1992 through 1996)
- STORET Station MFFDE005.2CK – MFFDR at Highway 188 Eaton (1998 only)
- STORET Station MFFDE1C49.5HE – MFFDR at Law Road
- STORET Station POND001.1DY – Pond Creek at Sorrel Chapel Road
- STORET Station POND11.11CK – Pond Creek at Chestnut Bluff Road
- STORET Station LEWIS004.4DY – Lewis Creek at Hogwallow Road
- STORET Station DOAKV002.0DY – Doakville Creek at Tatumville Road
- STORET Station TURKE00.74MN – Turkey Creek at Mason Road
- STORET Station DRY00.27MN – Dry Creek at Highway 152
- STORET Station BEECH01.78CK – Beech Creek at Todd Levee Road

Although insufficient data were collected to calculate 30-day geometric mean values, individual samples exceeded 1,000-counts/100 ml maximum for fecal coliform at the NFFDR, MFFDR, Pond Creek, Buck Creek, and Dry Creek sites (see Table 3). Doakville Creek and Lewis Creek were assessed as impaired due to elevated E.coli concentrations, while Beech Creek was assessed as impaired due to high enterococcus concentrations. Turkey Creek was listed on the 1998 303(d) list as impaired due to pathogens based on point source discharge monitoring.

All of the waterbodies listed on the 1998 303(d) list or assessed in 2000 as not fully supporting designated uses due to pathogens were scheduled for TMDL evaluation. Due to limited precipitation data available for use in the model, only fecal coliform data collected through December 1999 were used for water quality calibration.

6.0 SOURCE ASSESSMENT

An important part of the TMDL analysis is the identification of source categories, source subcategories, or individual sources of fecal coliform bacteria in the watershed and the amount of pollutant loading contributed by each of these sources. Sources are broadly classified as either point or non-point sources.

A point source can be defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Point source discharges of industrial wastewater and treated sanitary wastewater must be authorized by National Pollutant Discharge Elimination System (NPDES) permits. NPDES permitted facilities discharging treated sanitary wastewater are considered primary point sources of fecal coliform bacteria.

Non-point sources of fecal 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 fecal coliform bacteria on land surfaces and wash off as a result of storm events. Typical non-point sources of fecal coliform bacteria include:

- Wildlife
- Land application of agricultural manure
- Livestock grazing
- Leaking septic systems
- Urban development (including leaking sewer collection lines)
- Animals having access to streams

6.1 Point Sources

There are a number of point sources located in the drainage areas of the 303(d) listed stream segments that possess NPDES permits for discharges of treated sanitary wastewater. The permitted flow and fecal coliform loading for these facilities are summarized in Table 4. The fecal coliform bacteria load is based on the permitted flow and concentration of 200 counts per 100 ml. Permitted flows are based on the facility design flow for municipal facilities and long term average (LTA) flow for industrial dischargers. Certain industrial facilities and municipal water treatment plants are included in the TMDL analysis as they have the potential to impact stream flow. The location of relevant point source dischargers is shown in Figure 4.

Figure 3 Water Quality Monitoring Stations in the NFFDR Watershed

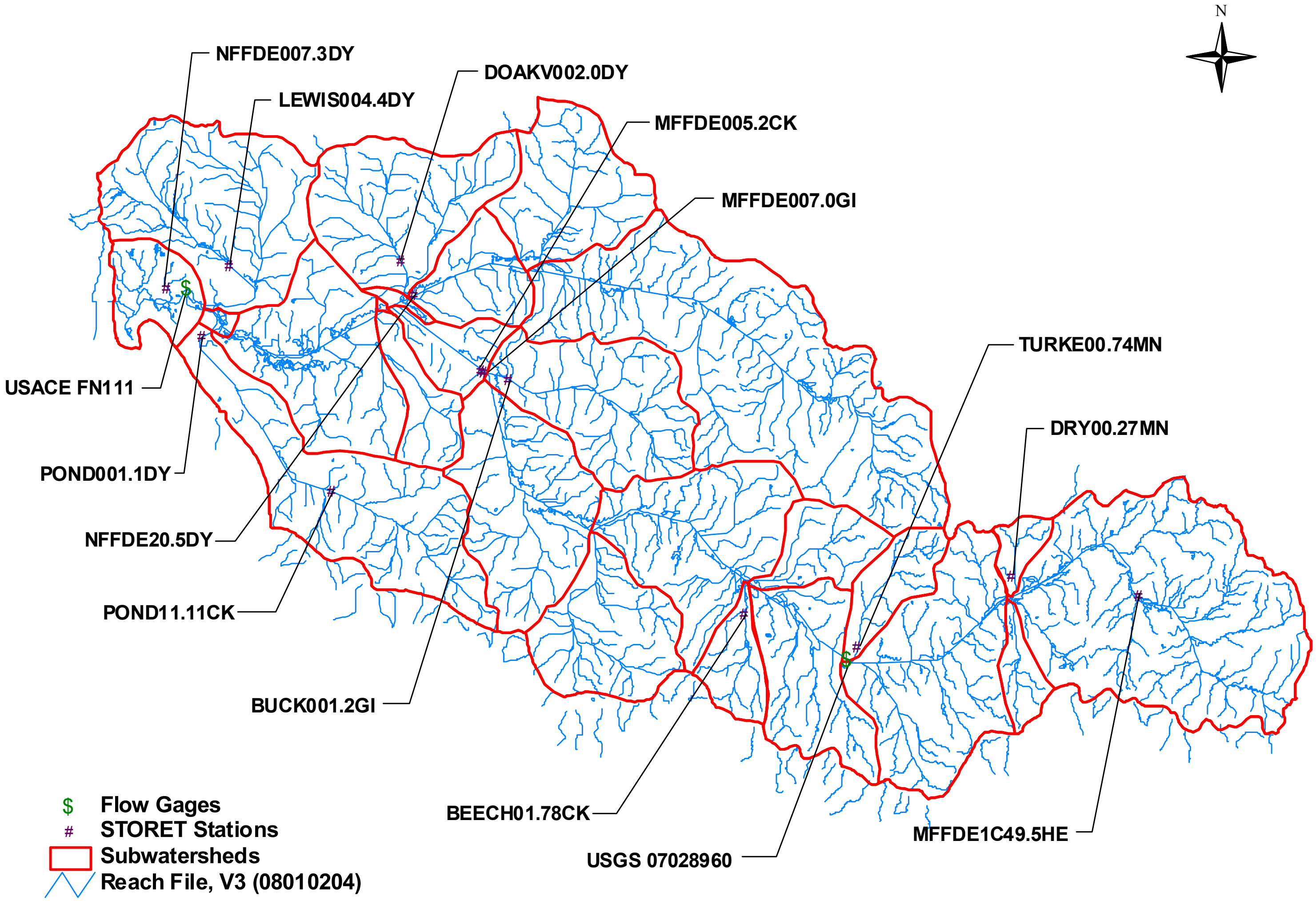


Table 3 NFFDR Watershed Fecal Coliform Ambient Monitoring Data

Sample Date	Monitoring Station							
	NFFDE1C4.0DY	NFFDE007.3DY	NFFDE020.5DY	MFFD005.2CK	MFFD007.0GI	MFFDE021.5GI	MFFDE1C49.5HE	BUCK001.2GI
	[counts/100 ml]							
9/10/92	460				590		240	
9/16/92			28					
12/15/92	140				120		96	
3/24/93	2100		950		1200		570	
6/15/94	2100		1200		3300		310	
9/16/93			2800		8500		3200	
12/15/93	9300				1200			
3/17/94			36		120		40	
9/20/94			40		3000		190	
12/5/94			270		800		2000	
3/15/95			76		2600		180	
6/21/95			1200		2700		900	
9/20/95			720		10000		250	
12/20/95			1000		2800		1100	
6/11/96		480	290		3100		920	
4/14/98		2000		140		75		1600
4/15/98		410		100		4100		580
4/16/98		610		920		130		5800
7/21/98		1600				<320		1500
7/22/98		310		110		<320		1400
7/23/98		510		1100		650		120
9/28/98		120						
12/16/98		490						
3/24/99		89						
4/20/99								
4/21/99								
6/9/99		180						
6/15/99								
6/16/99								
6/17/99								
8/12/99								
9/28/99		120						
12/1/99		34						
3/30/00		352						
6/20/00		980						
9/6/00		42						
12/14/00		2000						
3/13/01		2800						
6/27/01		100						

Table 3 NFFDR Watershed Fecal Coliform Ambient Monitoring Data (Continued)

Sample Date	Monitoring Station						
	POND001.1DY	POND11.11CK	DOAKV002.0DY	BEECH01.78CK	DRY00.27MN	TURKE00.74MN	LEWIS004.4DY
	[counts/100 ml]						
9/10/92							
12/15/92							
3/24/93							
6/15/94							
9/16/93							
12/15/93							
3/17/94							
9/20/94							
12/5/94							
3/15/95							
6/21/95							
9/20/95							
12/20/95							
6/11/96							
4/14/98							
4/15/98							
4/16/98							
7/21/98							
7/22/98							
7/23/98							120
9/28/98							
12/16/98							
3/24/99							
4/20/99			700				380
4/21/99			970				480
6/9/99							
6/15/99	1800	2300					
6/16/99				590			
6/17/99					2500	230	
8/12/99				270			
9/28/99							
12/1/99							
3/30/00							
6/20/00							
9/6/00							
12/14/00							
3/13/01							
6/27/01							

Table 4 NPDES Facilities in the NFFDR Watershed

Facility Name	NPDES Permit No.	Sub-watershed [c]	Design Flow [MGD]	Fecal Coliform Loading [b] [counts/day]
Westover Elem. School	TN0055247	014	0.01	7.57×10^{7}
Nova School	TN0023264	012	0.012	9.08×10^{7}
East Elem. School	TN0056481	012	0.004	3.03×10^{7}
Medina Lagoon #1	TN0026191	015	0.15	1.14×10^{9}
Humboldt STP	TN0062588	010	2.6	1.97×10^{10}
Alamo – STP	TN0024988	008	0.404	3.06×10^{9}
Trenton Lagoon	TN0021750	020	0.75	5.68×10^{9}
Dyer STP	TN0021563	021	0.675	5.11×10^{9}
Dyer Fruitbox Mfg. Co.	TN0021652	021	0.000864[a]	NA
Dyersburg Suburban Consolidate	TN0075035	001	0.642[a]	NA
Jackson Energy Auth. – Middle Fork STP	TN0075876	011	4.0	3.03×10^{10}
NW Dyersburg UD WTP	TN0056243	023	0.009[a]	NA
Dyersburg Fabrics	TN0000230	023	0.048[a]	NA
Friendship STP	TN0058955	004	0.09	6.81×10^{8}
Dr. Pepper	TN0064017	003	0.036[a]	NA
Dyersburg UD WTP	TN0060828	001	0.042[a]	NA
Ameristeel – W. Tennessee Steel Mill Div.	TN0074811	012	0.74[a]	NA
Dyersburg STP	TN0023477	001	9.45	7.15×10^{10}
Heckethorn Mfg. Co., Inc.	TN0000027	001	0.16[a]	NA
C & C Ice Company	TN0075949	010	0.0015[a]	NA

a. For industrial facilities, the design flow represents the long term average (LTA) flow.
b. Loading based on Monthly Average permit limit (200 counts/ 100 ml) at design flow.
c. See Figure 5.

Discharge monitoring reports (DMRs) submitted by NPDES facilities were reviewed to identify facilities discharging fecal coliform bacteria in excess of permit limits. From this review, most facilities were in compliance with permit limits and, in most cases, discharge fecal coliform bacteria at levels below permit limits. Several facilities, however, had one or more reporting periods where the daily maximum fecal coliform concentration exceeded the daily maximum permit limit. For the period from 1/98 through 7/01, these included:

NPDES Permit No.	Facility	Periods Out of Compliance
TN0062588	Humboldt STP	7
TN0024988	Alamo STP	2
TN0021750	Trenton Lagoon	1
TN0023477	Dyersburg STP	1
TN0026191	Medina Lagoon	1
TN0055247	Westover Elem. School	12[a]

a. Period 1998 - 2001

6.2 Non-point Sources

6.2.1 Wildlife

Wildlife deposit fecal coliform bacteria with their feces onto land surfaces where it can be transported during storm events to nearby streams. Deer densities for several counties in the NFFDR watershed, provided by the Tennessee Wildlife Resources Agency (TWRA), range from 18 to 32 animals per square mile. Fecal coliform loading due to deer is estimated by EPA to be 5.0 x 10^8 counts/animal/day.

6.2.2 Agricultural Animals

Agricultural animals are the source of several types of fecal coliform loading to streams in the NFFDR watershed:

- As with wildlife, agricultural livestock grazing on pastureland or forestland deposit fecal coliform bacteria with their feces onto land surfaces where it can be transported during storm events to nearby streams.

- Processed agricultural manure from confined feeding operations is generally collected in lagoons and applied to land surfaces during the months April through October. In the NFFDR watershed, manure is applied only to pastureland since chemical fertilizer is used on cropland. Data sources for confined feeding operations are tabulated by county and include the Census of Agriculture (USDA, 1997) and the Natural Resources Conservation Service (NRCS).

- Agricultural livestock and other unconfined animals (i.e., deer and other wildlife) often have direct access to streams that pass through pastures.

Livestock data from the 1997 Census of Agriculture for the major counties in the NFFDR watershed are listed in Table 5. Estimates of county horse population are based on 1999 data provided by the Tennessee Agricultural Statistics Service (TASS, 1999). Cattle, swine, and horses are the predominate livestock in these counties. Fecal coliform loading rates for livestock in the watershed are estimated to be: 1.06×10^{11} counts/day/beef cow, 1.24×10^{10} counts/day/hog, 1.04×10^{11} counts/day/dairy cow, 1.38×10^{8} counts/day/layer chicken, 1.22×10^{10} counts/day/sheep, and 4.18×10^{8} counts/day/horse (NCSU, 1994).

6.2.3 Failing Septic Systems

Some fecal coliform loading in the NFFDR watershed can be attributed to failure of septic systems and illicit discharges of raw sewage. Estimates from 1997 county census data of people in selected subwatersheds utilizing septic systems are shown in Table 6. In western Tennessee, EPA estimates that there are approximately 2.5 people per household on septic systems, some of which can be reasonably assumed to be failing.

Table 5 Livestock Distribution By County

Livestock	Dyer	Crockett	Gibson	Madison	Henderson
Cattle	10982	6250	21779	12437	28924
Beef	-	3588	9766	-	12709
Dairy	-	10	221	-	65
Swine	1311	-	7506	10210	10485
Poultry (layers)	12	7	624	487	26
Sheep	-	39	74	-	182
Horses	500	742	2851	1473	1456

Figure 4 Point Sources in the NFFDR Watershed

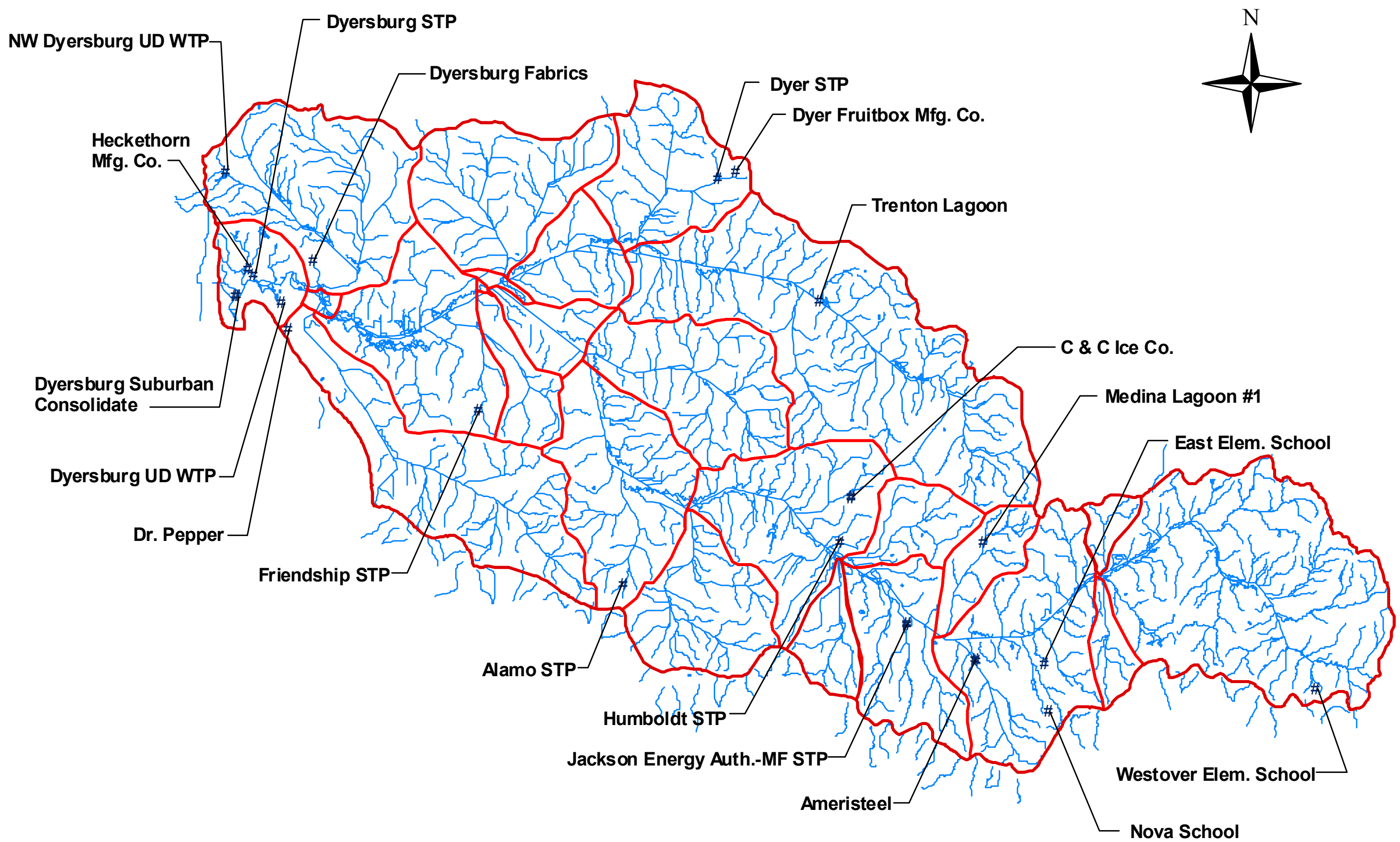


Table 6 Estimated Population on Septic Systems at Select Locations in the NFFDR Watershed

Subwatershed	Population on Septic Systems
NFFDR at mouth of Forked Deer R (includes entire watershed)	36,421
MFFDR at confluence with NFFDR	20,436
Turkey Creek	714
Pond Creek	2,435
Doakville Creek	1,882
Lewis Creek	1,883
Buck Creek	1,798

6.2.4 Urban Development

Fecal coliform loading from urban areas is attributable to multiple sources including storm water runoff, leaks and overflows from sanitary sewer systems, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, leaking septic systems, and domestic animals. Urban runoff and storm water processes are considered to be significant contributors to fecal coliform impairment in segments of the NFFDR near Dyersburg, and in segments of the MFFDR near Humboldt and Jackson.

7.0 ANALYTICAL APPROACH

Establishing the relationship between in-stream water quality and source loading is an important component of TMDL development. It allows the determination of the relative contribution of sources to total pollutant loading and the evaluation of potential changes to water quality resulting from implementation of various management options. This relationship can be developed using a variety of techniques ranging from qualitative assumptions based on scientific principles to numerical computer modeling. In this section, the numerical modeling techniques developed to simulate fecal coliform bacteria fate and transport in the watershed are discussed.

7.1 Model Selection

A dynamic computer model was selected for fecal coliform analysis in order to: a) simulate the time varying nature of fecal coliform bacteria deposition on land surfaces and transport to receiving waters; b) incorporate seasonal effects on the production and fate of fecal coliform bacteria; and c) identify the critical condition for the TMDL analysis. Several computer-based tools were also utilized to generate input data for the model.

The Non-point Source Model (NPSM) is a watershed model capable of simulating non-point source runoff and associated pollutant loadings, account for point source discharges, and performing flow and water quality routing through stream reaches. NPSM is based on the Hydrologic Simulation Program - Fortran (HSPF). In these TMDLs, NPSM was used to simulate point source discharges, simulate the deposition and transport of fecal coliform bacteria from land surfaces, and compute the resulting water quality response. Model details are provided in Appendix A.

In addition to NPSM, 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 the NFFDR watershed. This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics.

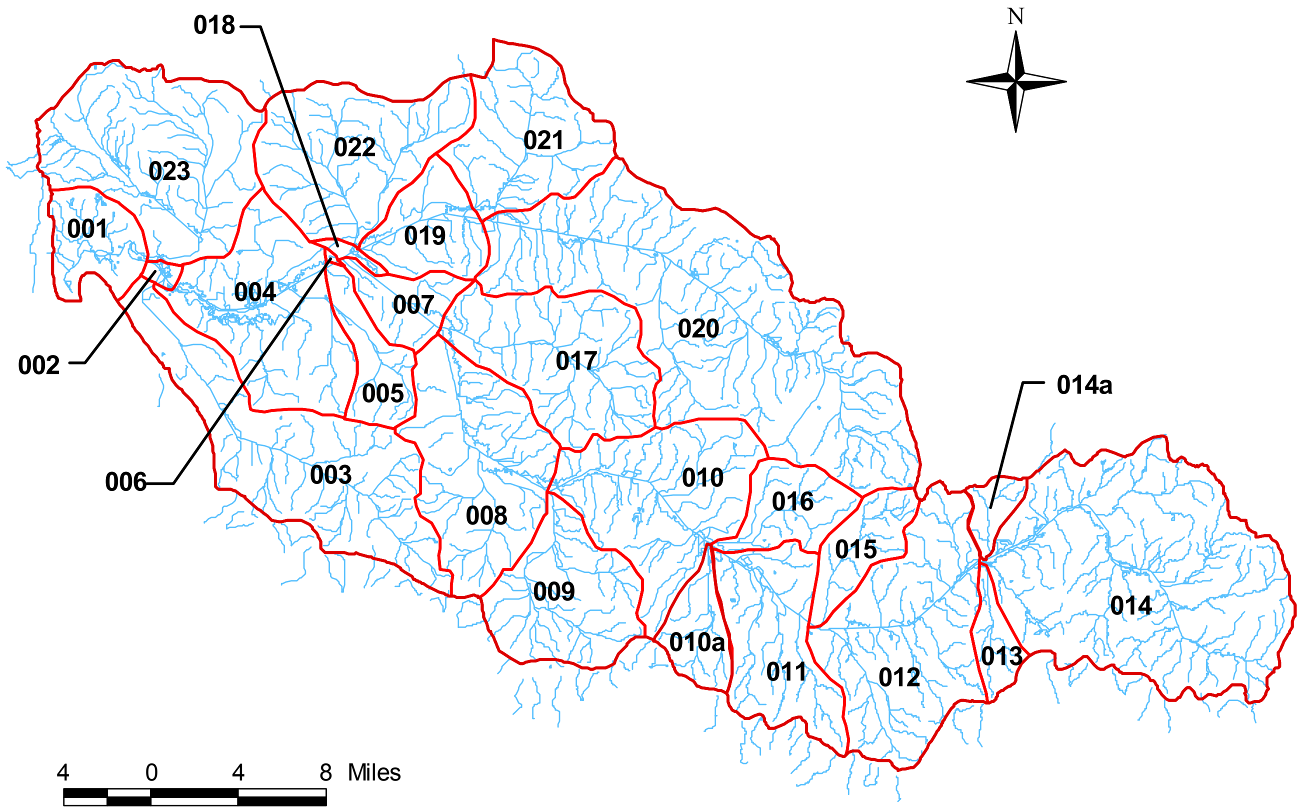
Results of the WCS characterization are input to a spreadsheet developed by Tetra Tech, Inc. to estimate NPSM input parameters associated with fecal coliform buildup (loading rates) and wash off from land surfaces. In addition, the spreadsheet can be used to estimate direct sources of fecal coliform loading to water bodies from leaking septic systems and animals having access to streams. Information from the WCS and spreadsheet tools were used as initial input for variables in the NPSM model.

7.2 Model Set Up

The NFFDR watershed was delineated into 25 subwatersheds in order to characterize relative fecal coliform bacteria contributions from significant contributing drainage areas (see Figure 5). Boundaries were constructed so that subwatershed "pour points" coincided, when possible, with water quality monitoring stations or flow gages. Watershed delineation was based on the Reach File 3 (Rf3) stream coverage and Digital Elevation Model (DEM) data. This discretization allows management and load reduction alternatives to be varied by subwatershed.

An important factor influencing model results is the precipitation data contained in the meteorological data file used in the simulation. The pattern and intensity of rainfall affects the build-up and wash-off of fecal coliform bacteria from the land into the streams, as well as the dilution potential of the stream. Meteorolgical data from the Jackson Experimental Station were used for simulations in all subwatersheds.

Figure 5 Delineated Subwatersheds



7.3 Model Calibration

Calibration of the watershed model included both hydrology and water quality components. The hydrology calibration was performed first and involved adjustment of the model parameters used to represent the hydrologic cycle until acceptable agreement was achieved between simulated flows and historic stream flow data in the watershed for the same period of time. A USGS stream gaging station on the MFFDR near Fairview, TN (USGS 07028960) and a US Army Corps of Engineers (USACE) stream gage on the NFFDR near Dyersburg, TN were used in the hydrology calibration (see Figure 3). Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge.

The model was also calibrated for water quality. Appropriate model parameters were adjusted to obtain acceptable agreement between simulated instream fecal coliform concentrations and observed data collected at sampling stations throughout the NFFDR watershed. Results show that the model adequately simulates peaks in fecal coliform bacteria in response to storm events and base concentrations during low flow events. The details and results of the hydrologic and water quality calibrations are presented in Appendices A and B.

8.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOAD

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), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

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

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

8.1 Critical Conditions

The critical condition for non-point source fecal coliform loading is an extended dry period followed by a rainfall runoff event. During the dry weather period, fecal coliform 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 stream flow when dilution is minimized. Both conditions are simulated in the water quality model.

The ten-year period from January 1, 1990, to December 31, 1999 was used to simulate a continuous 30-day geometric mean concentration to compare to the target. This 10-year period contained a range of hydrological conditions that included both low and high stream flows from which critical conditions were identified and used to derive the TMDL values.

The ten-year simulated geometric mean concentrations for existing conditions are presented in Appendix B. From these figures, critical conditions can be determined. The 30-day critical period in the model is the period preceding the largest simulated violation of the geometric mean criteria during average flow conditions (EPA, 1991). Meeting the water quality criteria during this period ensures that water quality criteria can be achieved throughout the ten-year period. The critical period for each of the listed or impaired waterbodies in the NFFDR watershed is:

Waterbody	Critical Period
NFFDR, MFFDR, Doakville Creek, Buck Creek	4/16/98 – 5/15/98
Pond Creek, Lewis Creek	5/19/97 – 6/17/97
Turkey Creek	7/2/98 – 7/31/98

8.2 Existing Conditions

The existing fecal coliform load for each of the 303(d) listed waterbodies in the NFFDR watershed was determined in the following manner:

- The calibrated model, corresponding to the portion of the NFFDR watershed that is upstream of the pour point of the listed waterbody segment was run for a time period that included the critical condition.

- The daily fecal coliform load indirectly going to surface waters from all land uses was added to the direct daily discharge load of modeled point sources and the result summed for the 30 day critical period. This value represents the existing load.

Model results indicate that non-point sources related to agricultural and urban land uses are the largest sources of fecal coliform bacteria loading in the NFFDR watershed. Direct inputs of fecal coliform bacteria from “other sources” (i.e., animal access to streams, illicit discharges of fecal coliform bacteria, failing septic systems, and leaking sewer collection lines) are also shown to have an impact on bacteria loading in the watershed. Reductions in these loading rates reduce the in-stream fecal coliform bacteria levels. Non-point source loading rates and the geometric mean in-stream concentration simulated during the critical period, representing existing conditions in the model are shown in Table 7.

In general, point source loads from NPDES facilities do not significantly contribute to the impairment of the listed stream segments since discharges from these facilities are required to be treated to levels corresponding to instream water quality criteria.

Table 7 Non-point Source Loading Rates and In-stream Fecal Coliform Bacteria Concentrations for Existing Conditions

Subwatershed	Runoff from All Lands	Other Direct Sources	In-Stream Fecal Coliform Bacteria Concentration[1]
	[Counts / 30 days]	[Counts / 30 days]	[Counts / 100 ml]
NFFDR at mouth (includes all modeled areas)	9.15×10^{15}	7.55×10^{12}	619
MFFDR @ confluence of NFFDR	6.40×10^{15}	7.57×10^{12}	1084
Pond Creek	1.12×10^{14}	6.65×10^{11}	325
Lewis Creek	1.21×10^{14}	9.99×10^{11}	335
Turkey Creek	5.40×10^{14}	1.27×10^{11}	678
Bucks Creek	1.59×10^{15}	9.99×10^{11}	3514
Doakville Creek	2.86×10^{14}	2.77×10^{11}	723

1. Fecal coliform bacteria concentrations represent the maximum simulated geometric mean concentration during the critical period (see Section 8.1).

8.3 Margin of Safety

There are two methods for incorporating an MOS in the analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. In these TMDLs, both and explicit and implicit MOS were used. The explicit MOS is applied to the load allocation portion only and is equivalent to 20 counts/100 ml below the in-stream target concentration . The implicit MOS includes the use of conservative modeling assumptions and a 10-year continuous simulation that incorporates a range of meteorological events. Conservative modeling assumptions used include: septic systems discharging directly into the streams; development of the TMDL using loads based on the design flow and fecal coliform permit limits of NPDES facilities; all land uses connected directly to streams; decay of fecal coliform bacteria was assumed negligible once manure was applied to the land; and a conservative value was used to estimate the in-stream decay of fecal coliform in the waterbodies.

8.4 Determination of TMDL, WLAs, & LAs

The TMDL is the total amount of pollutant that can be assimilated by a water body while maintaining water quality standards. Fecal coliform bacteria TMDLs are expressed as counts per 30 day period as this is how the water quality standard is expressed. The TMDL, therefore, represents the maximum fecal coliform bacteria load that can be assimilated by a stream during the critical 30-day period while maintaining the fecal coliform bacteria water quality standard (including explicit MOS) of 180 counts/100 ml. The TMDL components were estimated according to the following procedure:

- The calibrated model, corresponding to the portion of the NFFDR watershed that is upstream of the pour point of the listed waterbody segments was run for a time period that included the critical period.

- Existing NPDES permitted facilities were assumed to discharge at either design flows (for municipal facilities) or at LTA flows (for industrial facilities), and a fecal coliform permit limit of 200 counts/100 ml, where applicable.

- Fecal coliform land loading variables and the magnitude of loading from sources modeled as "other direct sources" were adjusted within reasonable range of known values until the resulting fecal coliform concentration at the pour point of the listed water body segment is less than 180 counts/100ml (includes explicit MOS).

- The $\sum$WLAs is the load associated with the daily discharge loads of all modeled NPDES permitted facilities summed over the 30-day critical period. The bacteria load for each facility is based on the permitted flow and a fecal coliform concentration of 200 counts/100 ml.

- The $\sum$LAs is the daily fecal coliform load indirectly going to surface waters from all modeled land use areas as a result of buildup/wash off processes plus the daily discharge load sources modeled as "other direct sources" and the result summed over the 30 day critical period.

- The percent reduction is based on the maximum simulated load discharging from the watershed for the 30-day critical period for existing and TMDL conditions. The maximum simulated concentrations for the TMDL scenario were less than 180 counts/100 ml at all monitoring stations.

The TMDL components for the listed water bodies are summarized in Table 8.

Table 8 TMDL Components

Subwatershed	∑WLAs [counts/30 day]	∑LAs [counts/30 day]	MOS[a]	TMDL [counts/30 day]
NFFDR at mouth (includes all areas)	3.80×10^{12}	2.24×10^{15}	Explicit & Implicit	2.24×10^{15}
MFFDR at confluence of NFFDR	5.44×10^{10}	1.11×10^{15}	Explicit & Implicit	1.11×10^{15}
Pond Creek	0	2.89×10^{13}	Explicit & Implicit	2.89×10^{13}
Lewis Creek	0	2.46×10^{13}	Explicit & Implicit	2.46×10^{13}
Turkey Creek	1.14×10^{9}	1.26×10^{13}	Explicit & Implicit	1.26×10^{13}
Bucks Creek	0	1.48×10^{14}	Explicit & Implicit	1.48×10^{14}
Doakville Creek	0	4.55×10^{13}	Explicit & Implicit	4.55×10^{13}

a. Explicit MOS = 20 counts/30 day applied to the LA component only as this represents the largest source contributing to the TMDL. Applying a MOS to the WLA component would have a negligible impact on the overall TMDL value.

8.4.1 Waste Load Allocations

There are 11 NPDES permitted that discharge fecal coliform bacteria in the NFFDR watershed. Existing NPDES facilities have permit limits that meet instream water quality standards and no further reductions are required. Future facility permits will require end-of-pipe limits equivalent to the water quality standard of 200-counts/100 ml. Future facilities discharging at concentrations less than the water quality standard will not cause or contribute fecal coliform bacteria impairment in the watershed.

8.4.2 Load Allocations

There are two modes of transport for non-point source fecal coliform bacteria loading in the model. First, loading from failing septic systems, animals in the stream, and leaking sewer system collection lines are modeled as “other direct sources” to the stream and are independent of precipitation. The second mode involves loading resulting from fecal coliform accumulation on land surfaces and wash-off during storm events. Fecal coliform applied to land is subject to a die-off rate and an absorption rate before it is transported to the stream. In the model, once the fecal coliform was applied to the land it was not subject to a die-off rate and is considered a conservative assumption.

Model results indicate that non-point sources related to agricultural and urban runoff and direct inputs have the greatest impact on the fecal coliform bacteria loadings in the NFFDR watershed. One possible allocation scenario that would meet instream water quality standards for the listed streams in the NFFDR watershed includes (Note: in-stream fecal coliform reductions include the effects of dilution and decay):

- NFFDR at mouth: 78% load reduction from runoff and 60% load reduction from "other direct sources" of fecal coliform bacteria in the stream, resulting in an in-stream fecal coliform reduction of 71 percent from the simulated peak geometric mean concentration for existing conditions of 619 counts/100 ml to 180 counts/100ml.

- MFFDR at confluence of NFFDR: 83% load reduction from runoff and a 60% load reduction from "other direct sources" of fecal coliform bacteria in the stream, resulting in an in-stream fecal coliform reduction of 83 percent from the simulated peak geometric mean concentration for existing conditions of 1084 counts/100 ml to 180 counts/100ml

- Pond Creek: 74% load reduction from runoff and 60% load reduction from "other direct sources" of fecal coliform bacteria in the stream, resulting in an in-stream fecal coliform reduction of 45 percent from the simulated peak geometric mean concentration for existing conditions of 325 counts/100 ml to 180 counts/100ml.

- Lewis Creek: 80% load reduction from runoff and a 60% load reduction from "other direct sources" of fecal coliform bacteria in the stream, resulting in an in-stream fecal coliform reduction of 46 percent from the simulated peak geometric mean concentration for existing conditions of 335 counts/100 ml to 180 counts/100ml.

- Doakville Creek: 81% load reduction from runoff and a 60% load reduction from "other direct sources" of fecal coliform bacteria in the stream, resulting in an in-stream fecal coliform reduction of 75 percent from the simulated peak geometric mean concentration for existing conditions of 723 counts/100 ml to 180 counts/100ml.

- Turkey Creek: 78% load reduction from runoff and a 70% load reduction from "other direct sources" of fecal coliform bacteria in the stream, resulting in an in-stream fecal coliform reduction of 73 percent from the simulated peak geometric mean concentration for existing conditions of 678 counts/100 ml to 180 counts/100ml.

- Buck Creek: 91% load reduction from runoff and a 60% load reduction from "other direct sources" of fecal coliform bacteria in the stream, resulting in an in-stream fecal coliform reduction of 95 percent from the simulated peak geometric mean concentration for existing conditions of 3514 counts/100 ml to 180 counts/100ml.

- Dry Creek and Beech Creek: Similar load reductions as required for MFFDR.

These reductions of non-point source loading are summarized in Table 9.

Table 9 Load Allocations in NFFDR Watershed

Subwatershed	Runoff Load	"Other Direct Sources"	Overall In-stream Reduction (Existing to Allocated Conditions)[a]
	[counts/30 days]	[counts/30 days]	[%]
NFFDR at mouth	2.24×10^{15}	3.09×10^{12}	71
MFFDR at confluence of NFFDR	1.11×10^{15}	2.16×10^{12}	83
Pond Creek	2.89×10^{13}	2.66×10^{11}	45
Lewis Creek	2.46×10^{13}	5.70×10^{10}	46
Turkey Creek	1.26×10^{13}	3.82×10^{10}	73
Bucks Creek	1.48×10^{14}	4.00×10^{11}	95
Doakville Creek	4.54×10^{13}	1.11×10^{11}	75

a. The percent reduction of in-stream fecal coliform bacteria concentrations based on the simulated geometric mean concentration for existing conditions (from Table 6) during critical conditions and the target concentration of 180 counts/100 ml.

8.4.3 Seasonal Variation

Seasonal variation was incorporated in the water quality model by using varying monthly loading rates and daily meteorological data.

9.0 IMPLEMENTATION PLAN

The TMDL analysis was performed using the best data available to specify WLAs & LAs that will meet the water quality criteria for pathogens (fecal coliform) in NFFDR watershed so as to support its designated use classifications. The following recommendations and strategies are targeted toward source identification, collection of data to support additional modeling and evaluation, and subsequent reduction in sources that are causing impairment of water quality.

9.1 Point Source Facilities

All discharges from industrial and municipal point source facilities are required to be in compliance with the conditions of their NPDES permit at all times.

9.2 Urban Sources of Fecal Coliform Loading

The City of Jackson, the City of Dyersburg, and Madison County will be issued NPDES Municipal Separate Storm Sewer System (MS4) permits under the Phase 2 storm water regulations. Applications are due by March 10, 2003. Each permitted entity will be required to develop a Storm Water Management Program (SWMP). The SWMP covers the duration of the permit (5-year renewable) and comprises a comprehensive planning process which involves public participation and intergovernmental coordination to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques, public education, and other appropriate methods and provisions. With respect to fecal coliform pollution reduction, additional activities and programs conducted by city, county, and state agencies are recommended to support the SWMP:

- Field screening and monitoring programs to identify the types and extent of fecal coliform water quality problems, relative degradation or improvement over time, areas of concern, and source identification.

- Requirements that all new and replacement sanitary sewage systems are designed to minimize discharges from the system into the storm sewer system.

- Mechanisms for reporting and correcting illicit connections, breaks, surcharges, and general sanitary sewer system problems with potential to release to the municipal separate storm sewer system.

- Require NPDES facilities to comply with permit limits.

9.3 Agricultural Sources of Fecal Coliform Loading

The Tennessee Department of Environment & Conservation (TDEC) should coordinate with the Tennessee Department of Agriculture (TDA) and the Natural Resources Conservation Service (NRCS) to address issues concerning fecal coliform loading from agricultural land uses in the NFFDR watershed. It is recommended that additional information (such as livestock populations by subwatershed, animal access to streams, manure application practices, etc.) be evaluated to better identify and quantify agricultural sources of fecal coliform loading in order to minimize uncertainty in future modeling efforts. It is further recommended that BMPs be utilized to reduce the amount of fecal coliform bacteria transported to surface waters from agricultural sources to the maximum extent practicable.

9.4 Stream Monitoring

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.

Continued monitoring of the fecal coliform concentration at multiple water quality sampling points in the watershed is critical in characterizing sources of fecal coliform contamination and documenting future reduction of loading. In the next watershed cycle, monitoring should be expanded to provide water quality information to characterize seasonal trends and refined source identification and delineation. Recommended monitoring for the NFFDR watershed includes monthly grab samples and intensive sampling for one month during the wet season (January-March). In addition, monitoring efforts should be refined and enhanced in order to characterize dry and wet season base flow conditions (concentrations) and promote selective storm response (hydrograph) characterization. Lastly, stream flow should be measured or estimated with the collection of each fecal coliform sample to characterize the dynamics of fecal coliform transport within the surface-water system.

9.5 Future Efforts

This TMDL represents the first phase of a long-term restoration project to reduce fecal coliform loading to acceptable levels (meeting water quality standards) in the NFFDR watershed. TDEC, coordinating with the TDA, will evaluate the progress of implementation strategies and refine the TMDL as necessary in the next phase (next five-year cycle). This will include recommending specific implementation plans for identified problem areas with as yet undefined sources and causes of pollution. Cooperation will be maintained with TDA (for possible 319 non-point source grants) and NRCS for developing BMPs. The dynamic loading model may be upgraded and refined in the next phase to more effectively link sources (including background and agricultural) to impacts and characterize the processes (loading, transport, decay, etc.) contributing to exceedances of fecal coliform concentrations (loading) in impacted water bodies. The phased approach will assure progress toward water quality standards attainment in the future.

10.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, announcement of the availability of proposed fecal coliform TMDLs for the North Fork Forked Deer River, Turkey Creek, and other impaired waterbodiesinthe NFFFR watershed was made to the public, effected dischargers, and other concerned parties and comments solicited. Steps taken in this regard include:

1) Notice of the proposed TMDLs was posted on the Tennessee Department of Environment and Conservation website on January 15, 2002 (see Appendix C). The announcement invited public comment until March 4, 2002.

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 are sent to approximately 90 interested persons or groups who have requested this information.

3) A letter was sent to point source facilities in the NFFDR study area that are permitted to discharge treated sanitary wastewater advising them of the proposed fecal coliform TMDLs and their availability on the TDEC website. The letter also stated that a written copy of the draft TMDL document would be provided on request. Letters were sent to the following facilities:

   Dyer STP (TN0021563)
   JEA Middle Fork STP (TN0075876)
   Friendship STP (TN0058955)
   Westover Elementary School (TN0055247)
   Medina Lagoon #1 (TN0026191)
   Alamo STP (TN0024988)
   Dyersburg STP (TN0023477)
   Nova School (TN0023264)
   East Elementary School (TN0056481)
   Trenton Lagoon (TN0021750)
   Humboldt STP (TN0062588)

4) A draft copy of the proposed fecal coliform TMDLs was sent to the City of Jackson, City of Dyersburg, and Madison County. These three entities will be issued MS4 permits under the Phase II storm water regulations.

No written comments were received during the public comment period. No requests to hold public meetings were received regarding the proposed TMDLs as of close of business on March 4, 2002.

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:

www.state.tn.us/environment/wpc/tmdl.htm

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

Model Development and Calibration

A.1 Model Set Up

The NFFDR watershed was delineated into 25 subwatersheds in order to characterize relative fecal coliform bacteria contributions from significant contributing drainage areas (see Figure 5). Boundaries were constructed so that subwatershed "pour points" coincided, when possible, with water quality monitoring stations or continuous flow gages. Watershed delineation was based on the Rf3 stream coverage and Digital Elevation Model (DEM) data. This discretization allows management and load reduction alternatives to be varied by subwatershed. Initial input for model variables was developed using WCS and the associated spreadsheet tools.

An important factor influencing model results is the precipitation data contained in the meteorological data file used in the simulation. The pattern and intensity of rainfall affects the build-up and wash-off of fecal coliform bacteria from the land into the streams, as well as the dilution potential of the stream. Weather data from the Jackson Experiment Station were available for the time period from January 1970 through December 1999 and were used for all simulations. The model was used to analyze a 10-year time period from 1990 through 1999 to evaluate the impact of a range of rainfall events on current loadings to the watershed. The model was allowed to stabilize for one year (1989) before results from the 10-year simulation were analyzed.

A.2 Model Calibration

The calibration of the NPSM watershed model involves both hydrology and water quality components. The model must be calibrated to appropriately represent hydrologic response in the watershed before subsequent calibrations and reasonable water quality simulations can be performed. A sensitivity analysis is part of the calibration process to evaluate the impact model parameters have on the simulated results.

A.2.1 Hydrologic Calibration

The hydrology calibration of the watershed model involves comparing simulated stream flows to historic stream flow data from a continuous stream gaging station for the same period of time. On the NFFDR, the US Army Corps of Engineers (USACE) and USGS operate several continuous flow gages in the NFFDR watershed. For the hydrology calibration on the main stem of the NFFDR, the USACE gage FN111 located near Dyersburg was used to compare simulated and observed stream flows (see Figure 3 for flow gage locations). The period of record of stream measurements at this gage were from 1995 through 1998. Simulated and observed stream flow hydrolographs as well as statistical analysis of the results were compared on an annual basis. On the main stem of the MFFDR, the USGS gage near Fairview, Tennessee (07028960) was used to compare simulated and observed streamflows . Although the period of record available at this station was from September 17, 1997 through the present, only data collected through December 31, 1999 was used for the calibration as this was the extent the model could simulate stream flow. For the MFFDR, the simulated and observed hydrographs as well as the statistical analysis of the results were compared on a water year basis (i.e., October through September). The results of the hydrology calibration and statistical analysis for selected years are shown in figures A-1 through A-4.

An important component to the hydrology calibration is accurate representation of the stream geometry. The default stream geometry is based on the data included in the Rf1 stream coverage. Because many of the streams in western TN have been channelized, the USGS and USACE were solicited for information on stream geometry in the NFFDR watershed. The USGS provided cross sectional data for the MFFDR at Fairview, TN. The channel geometry representing this segment of the model was adjusted using the data provided by the USGS, and is included as Figure A-5.

Initial values for hydrological 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 stream flow. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge.

A.2.2 Water Quality Calibration

NFFDR watershed data, generated by WCS, was processed through the spreadsheet applications developed by Tetra Tech, Inc. to generate fecal coliform loading data for use as <u>initial</u> input to the NPSM model. In the model, in-stream decay of fecal coliform bacteria was conservatively estimated using the values reported in Lombardo (1972). For freshwater streams, decay ranges from 0.008 1/hr to 0.13 1/hr, with a median value of 0.048 1/hr.

The sensitivity of the model to changes in non-point source loading rates is a critical element of the calibration process. The model is very sensitive to loads applied directly into the stream (e.g., leaking septic systems, animal access to streams, etc.) and if the loads are too high, then the model will not accurately simulate the response to rainfall runoff.

A.2.2.1 Point Sources

For existing conditions, NPDES facilities located in modeled subwatersheds are represented as point sources of constant flow and concentration based on the facility's design flow (or LTA flow for industrial facilities), and permit effluent fecal coliform concentration (see Table 4).

A.2.2.2 Non-point Sources

A number of non-point source categories are not associated with land loading processes and are represented as direct, instream source contributions in the model. These may include, but are not limited to, failing septic systems, leaking sewer lines, animals in streams, direct discharge of raw sewage, and undefined sources. All other non-point sources involve land loading of fecal coliform bacteria and wash off as a result of storm events. Only a portion of the load from these sources is actually delivered to streams due to the mechanisms of wash off (efficiency), decay, and incorporation into soil (adsorption, absorption, filtering) before being transported to the stream. Therefore, land loading non-point sources are represented as indirect contributions to the stream. Buildup, washoff, and die-off rates are dependent on seasonal and hydrologic processes.

Initial input for non-point sources of fecal coliform loading in the water quality model was developed using watershed information generated with WCS and the Tetra Tech loading calculation spreadsheets.

A.2.2.2.1 Wildlife

Fecal coliform loading from wildlife is assumed to be uniformly distributed to forest, pasture, cropland, and wetland areas in the modeled subwatersheds. A loading rate of 5.0×10^8 counts/animal/day for deer is based on best professional judgment (BPJ) of EPA. An animal density of 45 animals/square mile is used to account for deer and all other wildlife. The resulting fecal coliform loading is 3.52×10^7 counts/acre/day and is considered background. This rate is assumed constant throughout the year and is the only load applied to forest, wetlands, and cropland.

A.2.2.2.2 Land Application of Agricultural Manure

In the water quality model, county livestock populations (see Table 5) are distributed to subwatersheds based on the percentage of agricultural area in each subwatershed classified as pasture/hay in the MRLC database. Fecal coliform loading rates were calculated from livestock populations based on manure application rates, literature values for bacteria concentrations in livestock manure, and the following assumptions:

- Fecal content in manure was adjusted to account for die-off due to known treatment/storage methods.

- Manure application rates from the various animal sources vary monthly according to management practices. Hog manure is applied from March through September; beef cattle manure is applied throughout the year.

- The fraction of manure available for runoff is dependent on the method of manure application. In the water quality model, the fraction available is estimated based on incorporation into the soil.

- In the NFFDR watershed, manure is not applied to cropland, only pastureland.

- Fecal coliform production rates used in the model for cattle, hogs, poultry, sheep, and horses are: 1.06×10^{11} counts/day/beef cow, 1.24×10^{10} counts/day/hog, 1.04×10^{11} counts/day/dairy cow, 1.38×10^8 counts/day/layer chicken, 1.22×10^{10} counts/day/sheep, and 4.18×10^8 counts/day/horse (NCSU, 1994).

An example calculation estimating the load available for runoff from agricultural lands is provided in Figure B-6. Since manure is not applied to cropland in the NFFDR watershed, the only source of fecal coliform bacteria from cropland is from wildlife that deposits feces on the land surface. The in-stream loading from cropland is considered background.

A.2.2.2.3 Grazing Animals

Cattle spend time grazing on pastureland and deposit feces onto the land. During storm events, a portion of this material containing fecal coliform bacteria is transported to streams. Beef cattle are assumed to spend all their time in pasture. The percentage of feces deposited during grazing time is used to estimate fecal coliform loading rates from pastureland. Because there is no assumed monthly variation in animal access to pastures in western Tennessee, the fecal loading rate does not vary significantly throughout the year. Therefore, the loading rate to pastureland used in the model is assumed to be constant in each county. This rate varies in each county depending on the cattle population. The approximate loads from grazing cattle for the subwatersheds in the various counties are as follows: 3.5×10^8 counts/acre-day for subwatersheds in Dyer County; 9.8×10^9 counts/acre-day for subwatersheds in Gibson and Crockett counties; 2×10^9 counts/acre-day for subwatersheds in Madison County; and 1.58×10^{10} counts/acre-day for subwatersheds in Henderson County. Contributions of fecal coliform from wildlife (as noted in Section B.2.2.2.1) are also included in these rates.

A.2.2.2.4 Urban Development

Urban land use represented in the MRLC database includes areas classified as: high intensity commercial, industrial, transportation, low intensity residential, high intensity residential, and transitional. Associated with each of these classifications is a percent of the land area that is impervious. A single, area-weighted loading rate from urban areas is used in the model and is based on the percentage of each urban land use type in the watershed and build-up and accumulation rates referenced in Horner (1992). In the water quality model, this rate is assumed constant for all urban areas throughout the year at a rate of approximately 7.02×10^9 counts/acre-day.

A.2.2.2.5 Other Sources

As previously stated, there are a number of non-point sources of fecal coliform bacteria that are not associated with land loading and washoff processes. These include animal access to streams, failing septic systems, leaking sewer lines, illicit discharges, and other undefined sources. In each subwatershed, all of these miscellaneous sources have been grouped together and modeled as a point source of constant flow and fecal coliform load. The initial baseline values of flow and concentration were estimated using the Tetra Tech, Inc. developed spreadsheets and the following assumptions:

- The load attributed to animals having access to streams is initially based on the beef cow population in the watershed. It was assumed that 50 % have access to streams and, of those, 25% defecate in or near the stream banks during a portion of the day. The resulting percentage of time fecal coliform bacteria is discharged into the streams from grazing animals is 0.025 percent. Literature values were used to estimate the fecal coliform bacteria concentration in beef cow manure.

- The initial baseline loads attributable to leaking septic systems are based on an assumed failure rate of 10 percent, and literature values for effluent flow and concentration.

These flow and concentration variables were adjusted during water quality calibration to match simulated instream fecal concentrations during dry weather conditions.

A.2.2.3 Water Quality Calibration Results

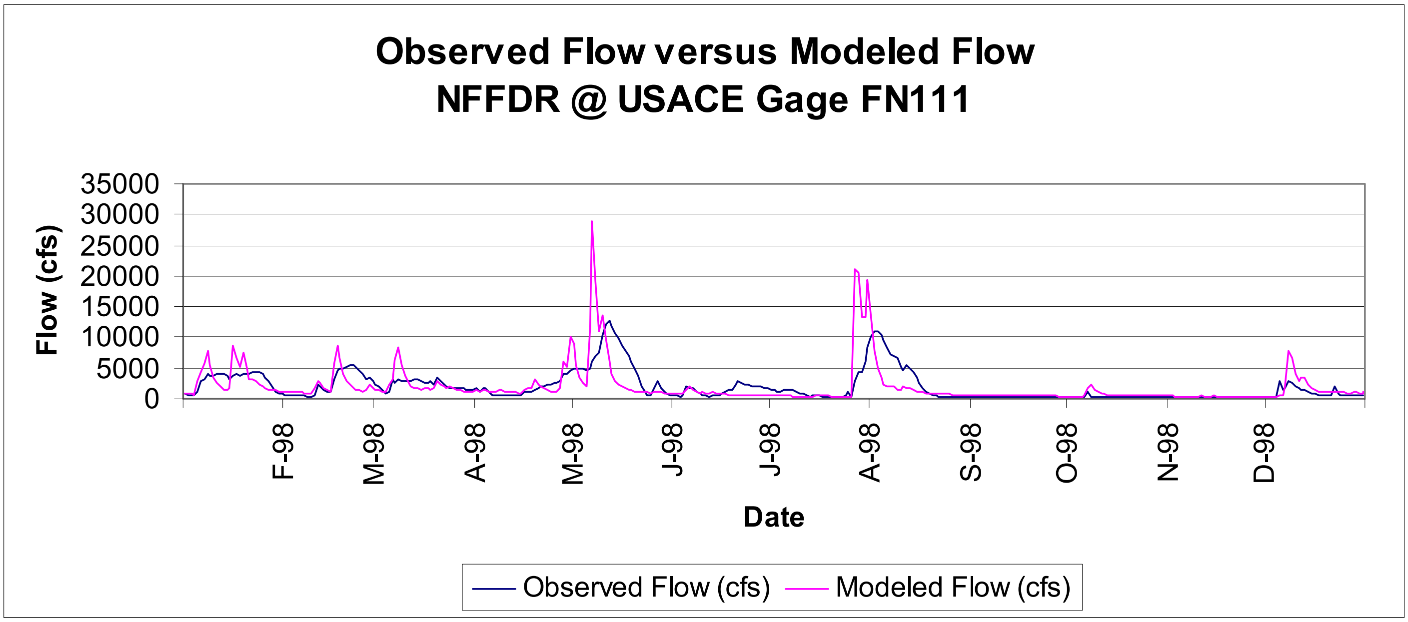
During water quality calibration, model parameters were adjusted within appropriate limits until acceptable agreement between simulation output and instream observed data was achieved. Model variables adjusted include:

- Rate of fecal coliform bacteria accumulation
- Maximum storage of fecal coliform bacteria
- Rate of surface runoff that will remove 90% of stored fecal coliform bacteria
- Concentration of fecal coliform bacteria in interflow
- Concentration of fecal coliform bacteria in groundwater
- Concentration of fecal coliform bacteria and rate of flow of “other direct sources” described in B.2.2.2.5

Fecal coliform grab samples, collected quarterly by TDEC at sampling stations in the listed segments of the NFFDR watershed were used for comparison with the simulated daily model results. Only with data collected at ambient stations on the main stems of the NFFDR and MFFDR (stations NFFDE020.5DY, MFFDE007.0GI, and MFFDE1C49.5HE) is it possible to identify seasonal trends.

Comparisons of simulated and observed daily fecal coliform concentrations at sampling stations in the NFFDR watershed are shown in Figures A-7 to A-11. Results show that the model reasonably simulates peaks in fecal coliform bacteria in response to rainfall events. Often a high observed value is not simulated in the model due to lack of rainfall at the meteorological station as compared to the rainfall occurring in the watershed, or is the result of an unknown source that is not included in the model.

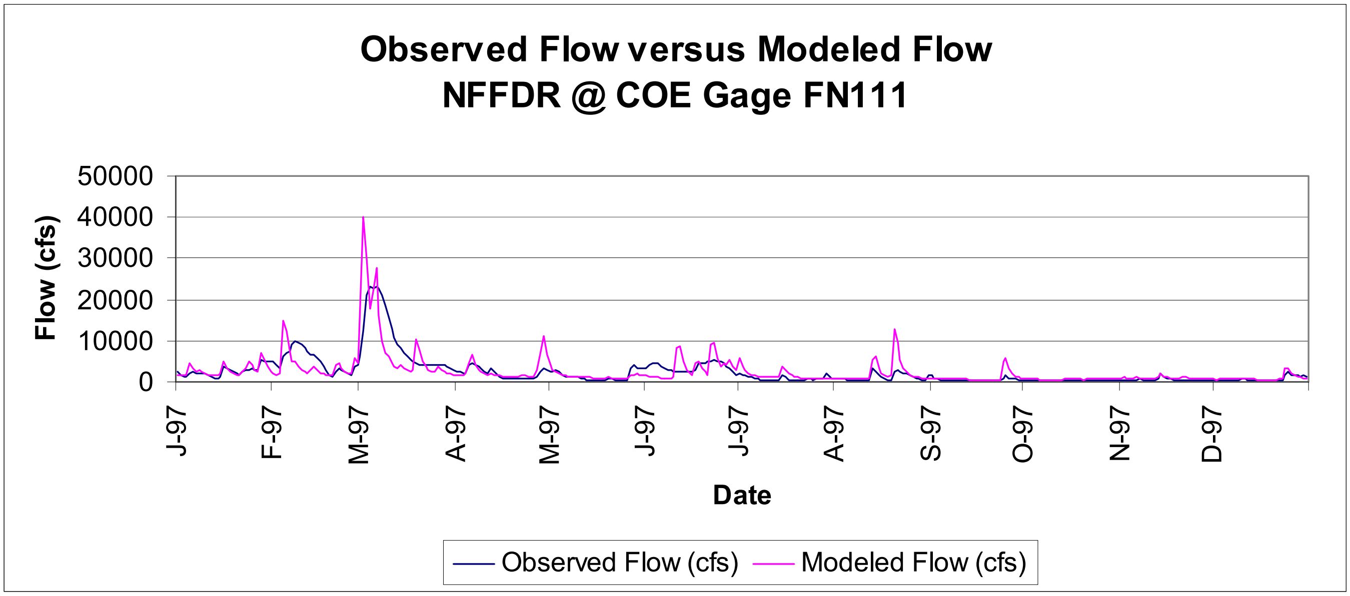
The 30-day critical period for the main stem of the NFFDR and MFFDR, Buck Creek, and Doakville Creek is April 16, 1998 through May 15, 1998. For Pond Creek, and Lewis Creek the critical period is May 19, 1997 through June 17, 1997. For Turkey Creek the critical period is July 2, 1998 through July 31, 1998. During this time period the simulated flow at the NFFDR gage matched the observed flow within 12 percent and at the MFFDR gage, the flows matched within 3 percent. A good match in the hydrology calibration provides a strong confidence in the water quality calibration.



Simulation Name:	North Fork Forked Deer R	**1st day of one year simulation:**	January 1, 1998
		Watershed Area (ac):	612,093
Total Simulated In-stream Flow:	**28.55**	Total Observed In-stream Flow:	**28.03**
Total of highest 10% flows:	**13.92**	Total of Observed highest 10% flows:	**10.70**
Total of lowest 50% flows:	**4.26**	Total of Observed Lowest 50% flows:	**2.90**
Simulated Summer Flow Volume (months 7-9):	**6.84**	Observed Summer Flow Volume (7-9):	**6.74**
Simulated Fall Flow Volume (months 10-12):	**3.47**	Observed Fall Flow Volume (10-12):	**1.97**
Simulated Winter Flow Volume (months 1-3):	**9.02**	Observed Winter Flow Volume (1-3):	**9.17**
Simulated Spring Flow Volume (months 4-6):	**9.22**	Observed Spring Flow Volume (4-6):	**10.15**
Total Simulated Storm Volume:	**23.44**	Total Observed Storm Volume:	**24.97**
Simulated Summer Storm Volume (7-9):	**5.56**	Observed Summer Storm Volume (7-9):	**6.84**

Errors (Simulated-Observed)		*Recommended Criteria*
Error in total volume:	**1.84**	10
Error in 50% lowest flows:	**31.93**	10
Error in 10% highest flows:	**23.15**	15
Seasonal volume error - Summer:	**1.51**	30
Seasonal volume error - Fall:	**43.23**	30
Seasonal volume error - Winter:	**-1.63**	30
Seasonal volume error - Spring:	**-10.08**	30
Error in storm volumes:	**-6.51**	20
Error in summer storm volumes:	**-23.11**	50

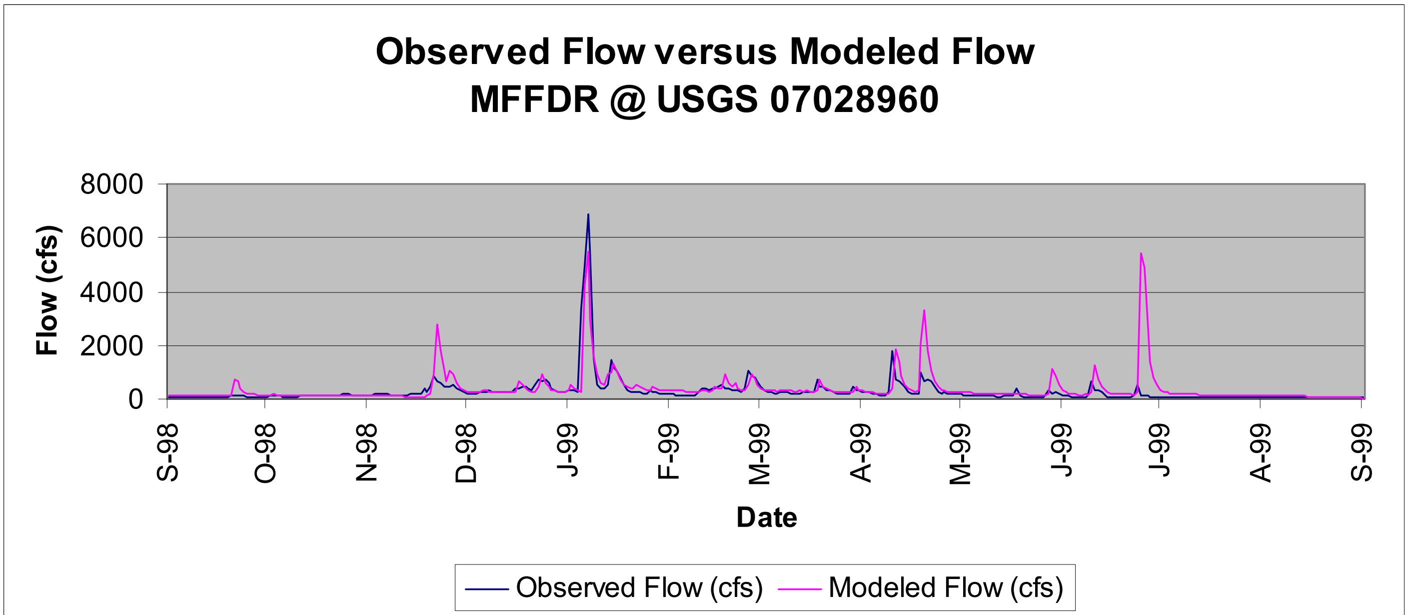
Figure A-1. Hydrology Calibration at USACE Gage FN111 (Calendar Year 1998).



Simulation Name:	North Fork Forked Deer R	**1st day of one year simulation:**	January 1, 1997
		Watershed Area (ac):	612,093
Total Simulated In-stream Flow:	**36.21**	Total Observed In-stream Flow:	**33.79**
Total of highest 10% flows:	**15.48**	Total of Observed highest 10% flows:	**14.60**
Total of lowest 50% flows:	**6.00**	Total of Observed Lowest 50% flows:	**3.66**
Simulated Summer Flow Volume (months 7-9):	**6.04**	Observed Summer Flow Volume (7-9):	**3.13**
Simulated Fall Flow Volume (months 10-12):	**3.04**	Observed Fall Flow Volume (10-12):	**1.94**
Simulated Winter Flow Volume (months 1-3):	**18.15**	Observed Winter Flow Volume (1-3):	**20.38**
Simulated Spring Flow Volume (months 4-6):	**8.98**	Observed Spring Flow Volume (4-6):	**8.34**
Total Simulated Storm Volume:	**29.41**	Total Observed Storm Volume:	**29.07**
Simulated Summer Storm Volume (7-9):	**4.33**	Observed Summer Storm Volume (7-9):	**6.04**

Errors (Simulated-Observed)		*Recommended Criteria*
Error in total volume:	**6.68**	10
Error in 50% lowest flows:	**38.90**	10
Error in 10% highest flows:	**5.73**	15
Seasonal volume error - Summer:	**48.21**	30
Seasonal volume error - Fall:	**36.25**	30
Seasonal volume error - Winter:	**-12.30**	30
Seasonal volume error - Spring:	**7.12**	30
Error in storm volumes:	**1.15**	20
Error in summer storm volumes:	**-39.58**	50

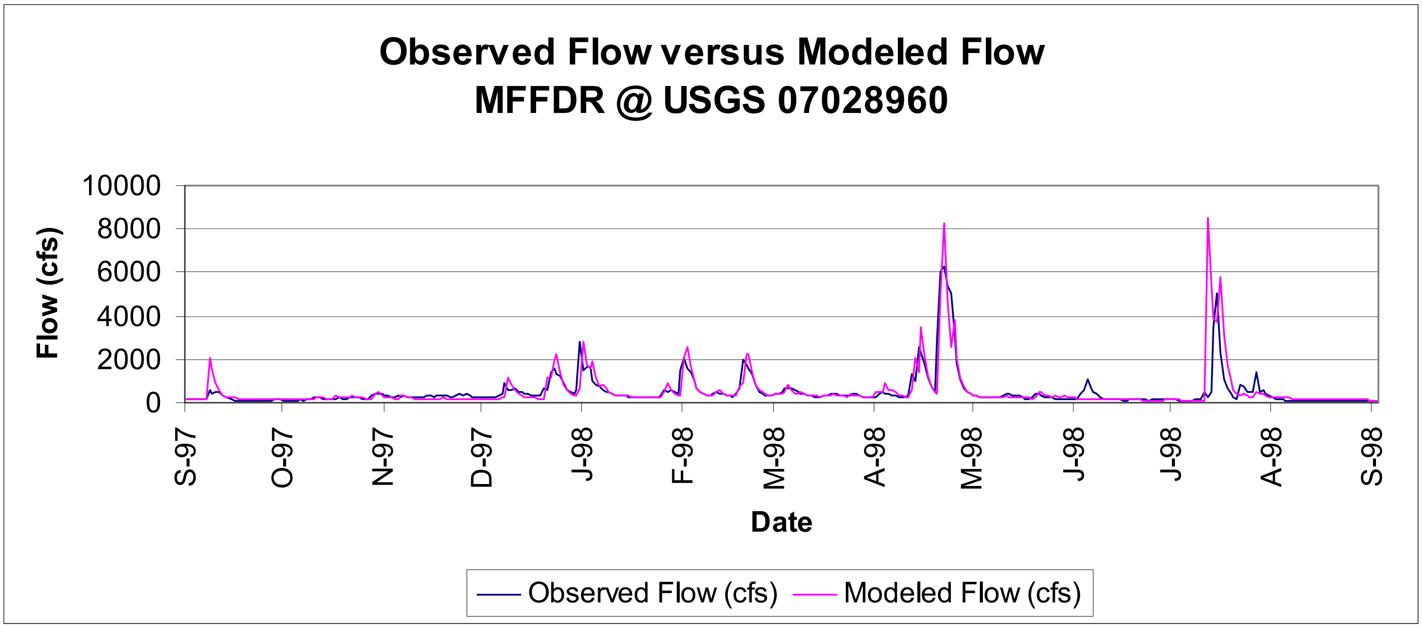
Figure A-2. Hydrology Calibration at USACE Gage FN111 (Calendar Year 1997).



Simulation Name:	MIddle Fork Forked Deer R	1st day of one year simulation:	September 18, 1998
USGS 07028960		Watershed Area (ac):	128,023
Total Simulated In-stream Flow:	26.37	Total Observed In-stream Flow:	19.24
Total of highest 10% flows:	11.81	Total of Observed highest 10% flows:	8.58
Total of lowest 50% flows:	4.79	Total of Observed Lowest 50% flows:	3.05
Simulated Summer Flow Volume (months 7-9):	7.02	Observed Summer Flow Volume (7-9):	4.70
Simulated Fall Flow Volume (months 10-12):	5.72	Observed Fall Flow Volume (10-12):	1.52
Simulated Winter Flow Volume (months 1-3):	4.03	Observed Winter Flow Volume (1-3):	2.83
Simulated Spring Flow Volume (months 4-6):	9.60	Observed Spring Flow Volume (4-6):	10.19
Total Simulated Storm Volume:	25.57	Total Observed Storm Volume:	15.70
Simulated Summer Storm Volume (7-9):	6.82	Observed Summer Storm Volume (7-9):	7.02

Errors (Simulated-Observed)		*Recommended Criteria*
Error in total volume:	27.03	10
Error in 50% lowest flows:	36.31	10
Error in 10% highest flows:	27.41	15
Seasonal volume error - Summer:	33.07	30
Seasonal volume error - Fall:	73.42	30
Seasonal volume error - Winter:	29.88	30
Seasonal volume error - Spring:	-6.25	30
Error in storm volumes:	38.59	20
Error in summer storm volumes:	-2.95	50

Figure A-3. Hydrology Calibration at USGS 07028960 (Water Year 1999).



Simulation Name:	MIddle Fork Forked Deer R	1st day of one year simulation:	September 17, 1997
USGS Gage: 07028960		Watershed Area (ac):	128,023
Total Simulated In-stream Flow:	**36.93**	Total Observed In-stream Flow:	**33.60**
Total of highest 10% flows:	**19.01**	Total of Observed highest 10% flows:	**15.38**
Total of lowest 50% flows:	**6.03**	Total of Observed Lowest 50% flows:	**5.92**
Simulated Summer Flow Volume (months 7-9):	**12.47**	Observed Summer Flow Volume (7-9):	**12.68**
Simulated Fall Flow Volume (months 10-12):	**9.04**	Observed Fall Flow Volume (10-12):	**5.99**
Simulated Winter Flow Volume (months 1-3):	**4.20**	Observed Winter Flow Volume (1-3):	**3.86**
Simulated Spring Flow Volume (months 4-6):	**11.22**	Observed Spring Flow Volume (4-6):	**11.08**
Total Simulated Storm Volume:	**33.75**	Total Observed Storm Volume:	**29.25**
Simulated Summer Storm Volume (7-9):	**11.67**	Observed Summer Storm Volume (7-9):	**12.47**

Errors (Simulated-Observed)		*Recommended Criteria*
Error in total volume:	**9.01**	10
Error in 50% lowest flows:	**1.81**	10
Error in 10% highest flows:	**19.09**	15
Seasonal volume error - Summer:	**-1.65**	30
Seasonal volume error - Fall:	**33.82**	30
Seasonal volume error - Winter:	**8.08**	30
Seasonal volume error - Spring:	**1.20**	30
Error in storm volumes:	**13.34**	20
Error in summer storm volumes:	**-6.85**	50

Figure A-4. Hydrology Calibration at USGS 07028960 (Water Year 1998).

Figure A-5. Channel Geometry of MFFDR at Fairview, TN

Middle Fork Forked Deet River at Fairview, TN

Width	95 ft	
Area	480	
Velocity	3.74	
Gage Heigl	9.4	Assumed gage datum of 10 feet to determine cross-section
Flow	1790	

Station	Depth	Elevation
320	0	10
330	2.2	7.8
333	3.6	6.4
336	4.3	5.7
339	5.8	4.2
342	6.3	3.7
345	6.2	3.8
348	6.3	3.7
351	6.5	3.5
354	6.4	3.6
357	6.6	3.4
360	6.5	3.5
363	6.3	3.7
366	6.2	3.8
369	6.2	3.8
372	6.1	3.9
375	6.2	3.8
378	6.3	3.7
381	6.4	3.6
384	6.2	3.8
387	6.3	3.7
390	6	4
393	5.8	4.2
396	5.9	4.1
400	5.5	4.5
404	4.7	5.3
409	4	6
415	0	10

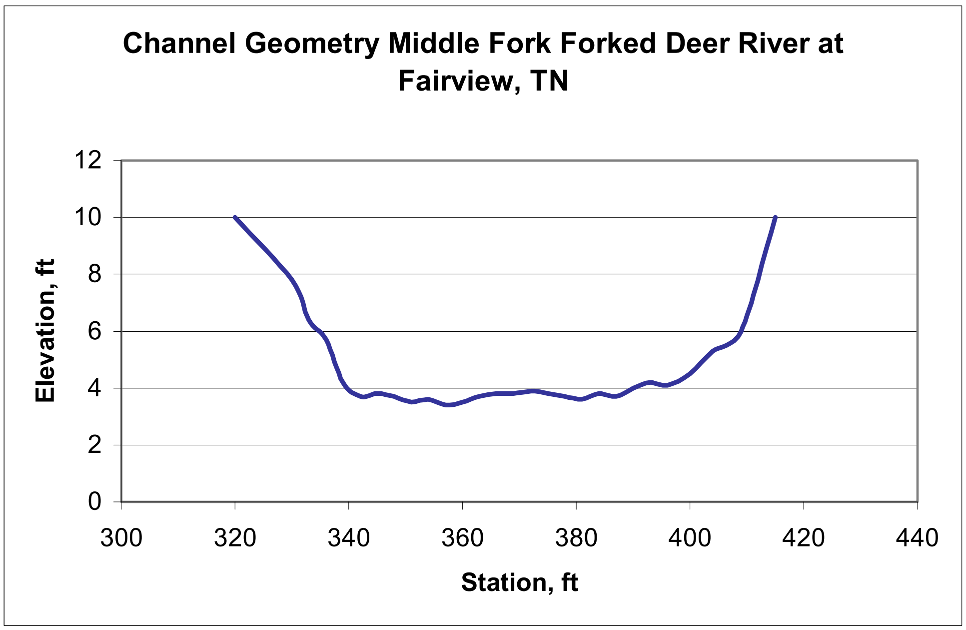


Figure A-6. Calculation of Runoff Load from Agricultural Animals

EXAMPLE CALCULATION OF RUNOFF LOAD (example shown for runoff from pastureland in Gibson Co)

COUNTY	AGRICULTURAL ANIMALS (NRCS and WWW.NASS.GOV for horses)							
	CATTLE	BEEF	DAIRY	SWINE	SHEEP	POULTRY	HORSES	cattle access to stream
Gibson	21779	9766	221	7506	74	624	2851	yes
Dyer	10982	-	-	1311	-	12	500	yes
Crockett	6250	3588	10	-	39	7	742	yes
Madison	12437	-	-	10210	-	487	1473	yes
Henderson	28924	12709	65	10485	182	26	1456	yes

LOAD ESTIMATES BASED ON ANIMAL POPULATION AND LAND APPLICATION OF MANURE

Runoff from pastureland (COUNTS/DAY) = Number animals * Fecal concentration (counts/animal/day) * Fecal content multiplier * Runoff rate * monthly application rate

Model units are in terms of counts/acre-day and are calculated by dividing the load by the area of pasture land in the county (calculation not shown)

Hog Manure Available for Wash-off

Fecal concentration	1.24E+10	counts/animal/day (NCSU, 1994)
Manure fecal content multiplier	0.75	(assume 25% dies-off in lagoon - EPA conservative assumption)
Fraction available for runoff	0.63	(EPA assumption)

Hog manure application rates (NRCS):

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Fraction of manure applied each month	0	0	0.075	0.1575	0.1335	0.1335	0.1335	0.1335	0.1585	0.075	0	0	1

Hog manure runoff from pastureland (counts/day):

Gibson County	0.00E+00	0.00E+00	5.24E+12	1.10E+13	9.32E+12	9.32E+12	9.32E+12	9.32E+12	1.11E+13	5.24E+12	0.00E+00	0.00E+00

Beef Cattle Manure Available for Wash-off

Fecal concentration	1.06E+11	counts/animal/day (NCSU, 1994)
Manure fecal content multiplier	1	(a value of 1 assumes fresh application - worse case scenario)
Fraction available for runoff	0.6	(EPA assumption)

Beef cattle manure application rates (NRCS):

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Fraction of manure applied each month	0.0833	0.0833	0.0833	0.0833	0.0833	0.0834	0.0834	0.0834	0.0834	0.0833	0.0833	0.0833	1

Beef manure runoff from pastureland (counts/day):

Gibson County	5.17E+13	5.17E+13	5.17E+13	5.17E+13	5.17E+13	5.18E+13	5.18E+13	5.18E+13	5.18E+13	5.17E+13	5.17E+13	5.17E+13

Figure A-6. Calculation of Runoff Load from Agricultural Animals (Continued)

Dairy Cattle Manure Available for Wash-off

Fecal concentration	1.04E+11	counts/animal/day (NCSU, 1994)
Manure fecal content multiplier	1	(a value of 1 assumes fresh application - worse case scenario)
Fraction available for runoff	0.63	(EPA assumption)

Dairy cattle manure application rates (NRCS):

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Fraction of manure applied each month	0	0.0835	0.075	0.1585	0.05	0.1335	0.05	0.1335	0.075	0.1585	0	0.0825	1

Dairy manure runoff from pastureland (counts/day):

	January	February	March	April	May	June	July	August	September	October	November	December
Gibson County	0.00E+00	1.21E+12	1.09E+12	2.30E+12	7.24E+11	1.93E+12	7.24E+11	1.93E+12	1.09E+12	2.30E+12	0.00E+00	1.19E+12

Poultry Litter Available for Wash-off (from layers)

Fecal concentration	1.38E+08	counts/animal/day (NCSU, 1994)
Manure fecal content multiplier	1	(a value of 1 assumes fresh application - worse case scenario)
Fraction available for runoff	0.2029	(EPA assumption)

Poultry litter application rates (NRCS):

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Fraction of litter applied each month	0	0	0.075	0.1575	0.1335	0.1335	0.1335	0.1335	0.1585	0.075	0	0	1

Poultry litter runoff from pastureland (counts/day):

	January	February	March	April	May	June	July	August	September	October	November	December
Gibson County	0.00E+00	0.00E+00	1.31E+09	2.75E+09	2.33E+09	2.33E+09	2.33E+09	2.33E+09	2.77E+09	1.31E+09	0.00E+00	0.00E+00

Horse Manure Available for Wash-off

Fecal concentration	4.18E+08	counts/animal/day (NCSU, 1994)
Manure fecal content multiplier	0.75	(a value of 1 assumes fresh application - worse case scenario)
Fraction available for runoff	0.63	(EPA assumption)

Horse manure application rates (NRCS):

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Fraction of manure applied each month	0.0833	0.0833	0.0833	0.0833	0.0833	0.0834	0.0834	0.0834	0.0834	0.0833	0.0833	0.0833	1

Horse manure runoff from pastureland (counts/day):

	January	February	March	April	May	June	July	August	September	October	November	December
Gibson County	4.69E+10	4.69E+10	4.69E+10	4.69E+10	4.69E+10	4.70E+10	4.70E+10	4.70E+10	4.70E+10	4.69E+10	4.69E+10	4.69E+10

Runoff load from pastureland (counts/day)	January	February	March	April	May	June	July	August	September	October	November	December
from all animals - Gibson County	5.18E+13	5.30E+13	5.81E+13	6.51E+13	6.18E+13	6.31E+13	6.19E+13	6.31E+13	6.40E+13	5.93E+13	5.18E+13	5.30E+13

Estimation of load from animal access to streams (for calculation purposes assume only beef cattle have access to streams)
assume 50 % of beef cattle in the watershed have access to streams and of those 25% defecate in or near the stream banks about 3 minutes per day
(resulting stream access is 0.00025 (i.e., 0.5 x 0.25 x 3min/(24*60))

Total load from cattle in stream =number beef cows in watershed * fecal concentration * 0.00025

MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: **NFFDR @ Sta NFFDE007.3DY**

MODEL RUN: **1**

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2

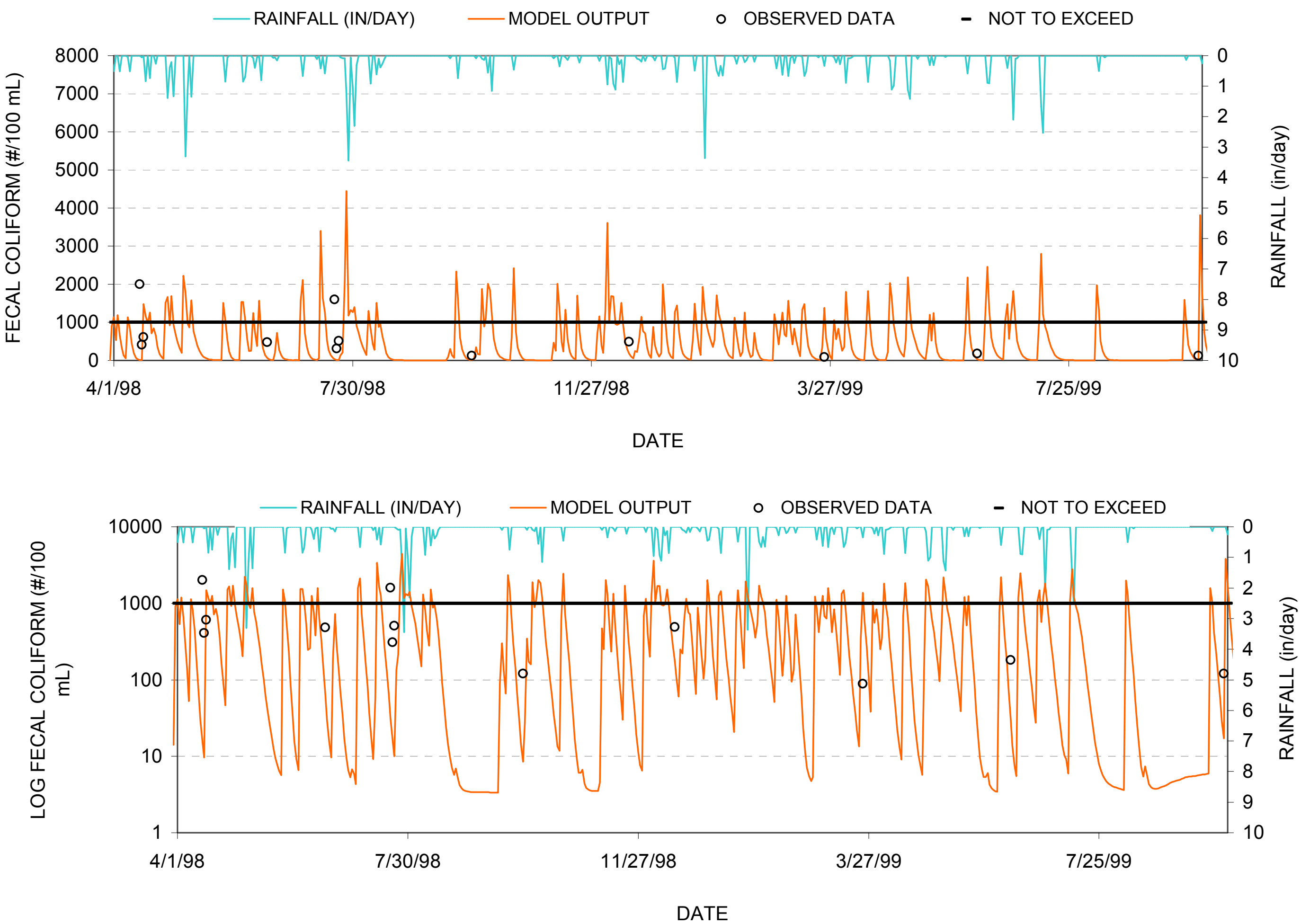


Figure A-7. Water Quality Calibration - NFFDR at STORETStation NFFDE007.3DY

Figure A-8. Water Quality Calibration for NFFDR - STORET Station NFFDE020.5DY.

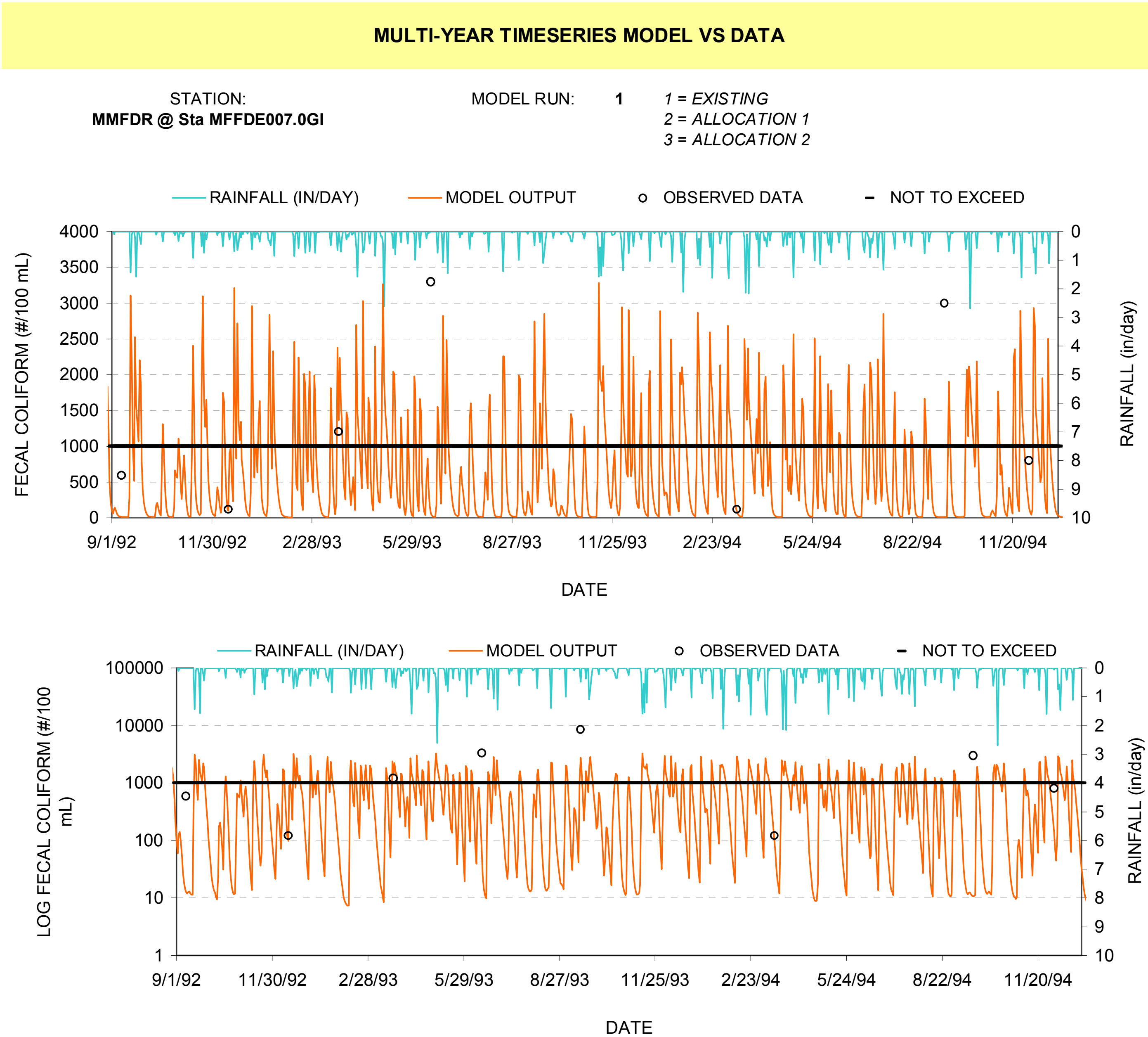


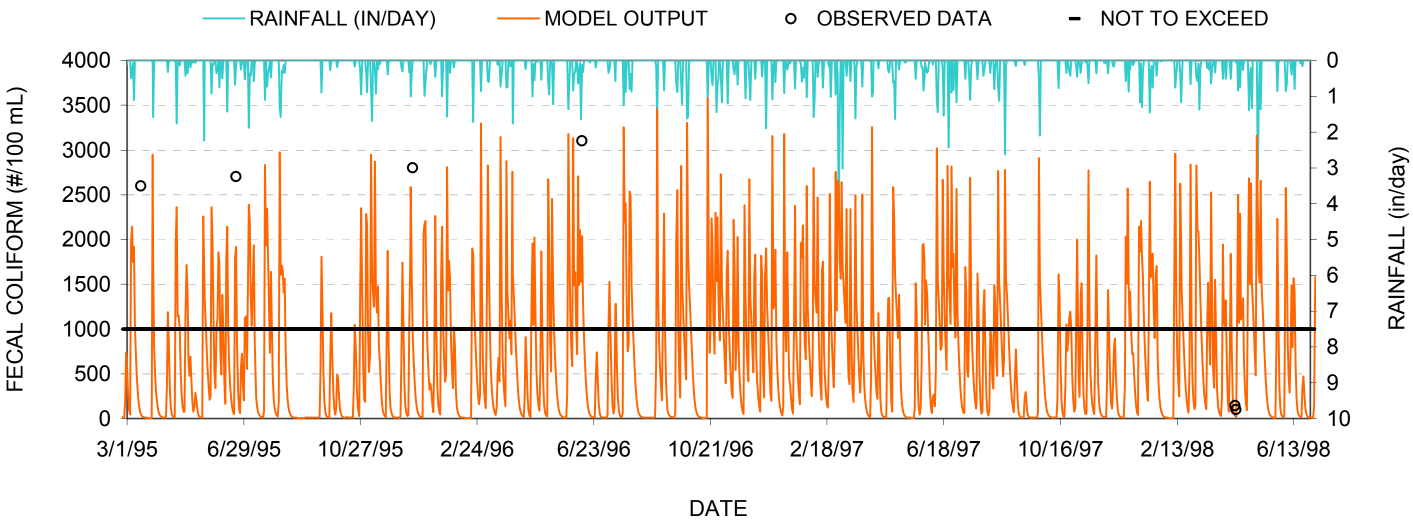
Figure A-9. Water Quality Calibration - MFFDR at STORET Station MFFDE007.0GI (1992 - 1994).

MULTI-YEAR TIMESERIES MODEL VS DATA

STATION:
MMFDR @ Sta MFFDE007.0GI

MODEL RUN: **1**

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2



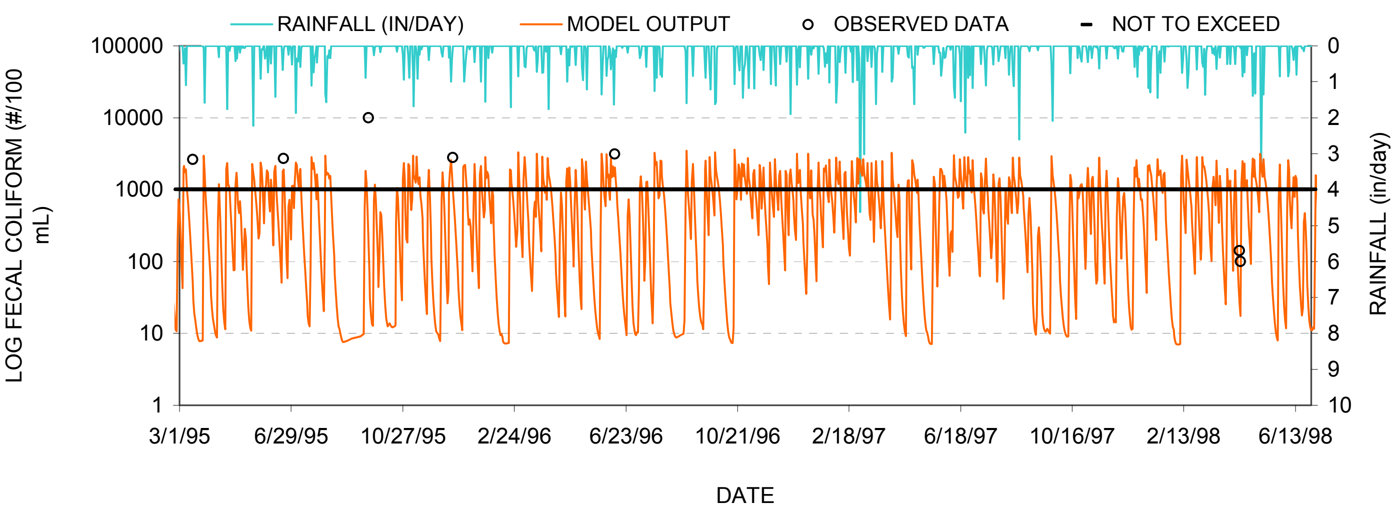


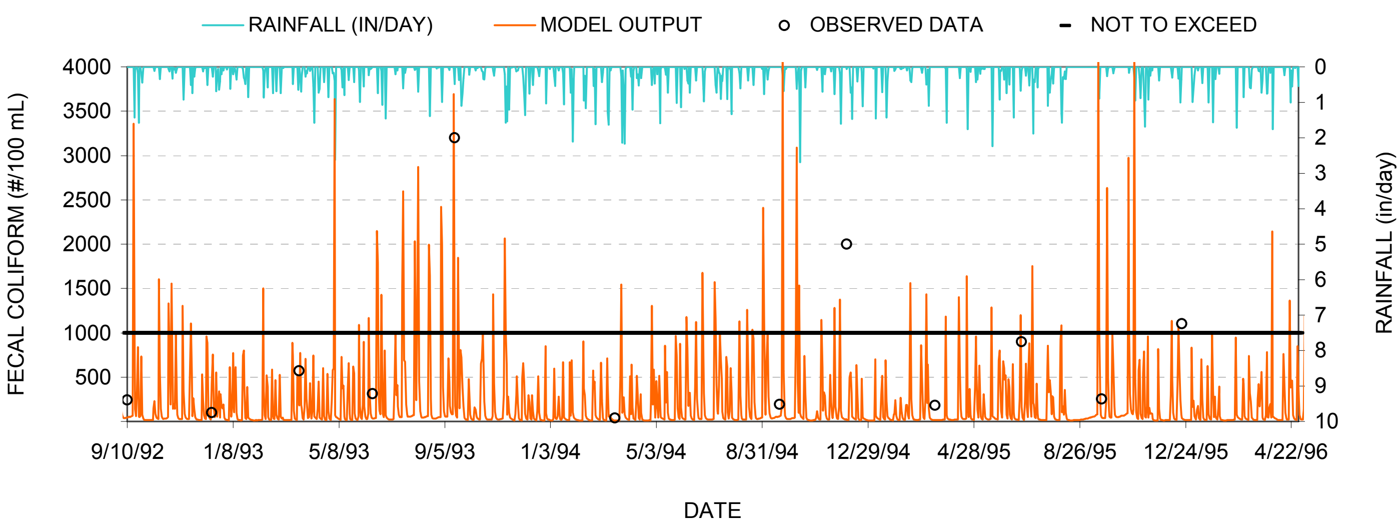
Figure A-10. Water Quality Calibration - MFFDR at STORET Station MFFDEE007.0GI (1995 - 1998).

MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: **MFFDR @ Sta MFFDE1C49.5HE**

MODEL RUN: **1**

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2



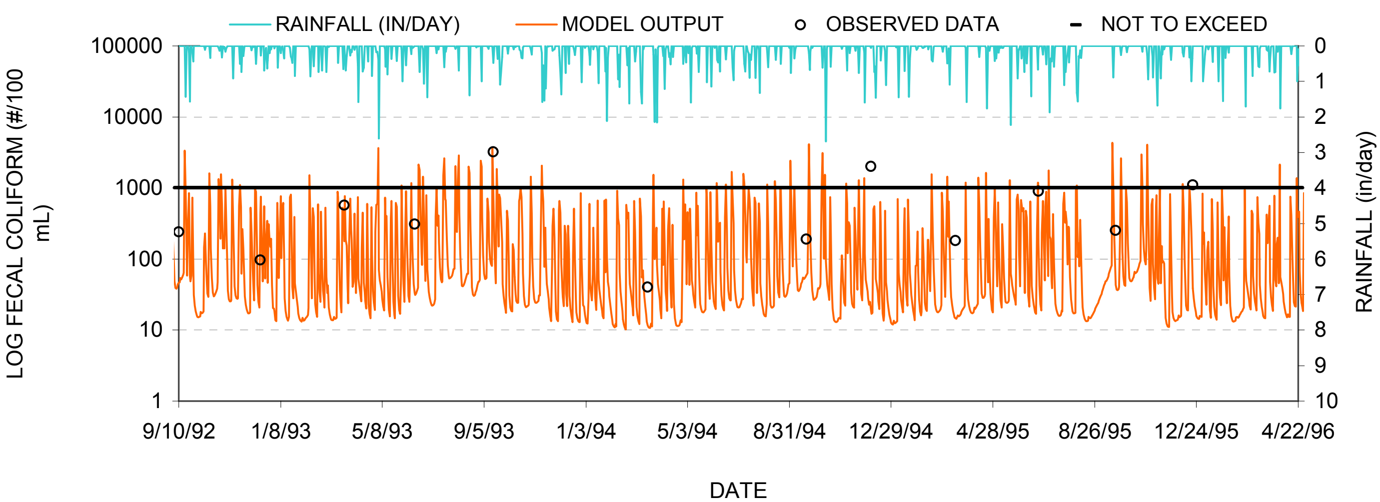


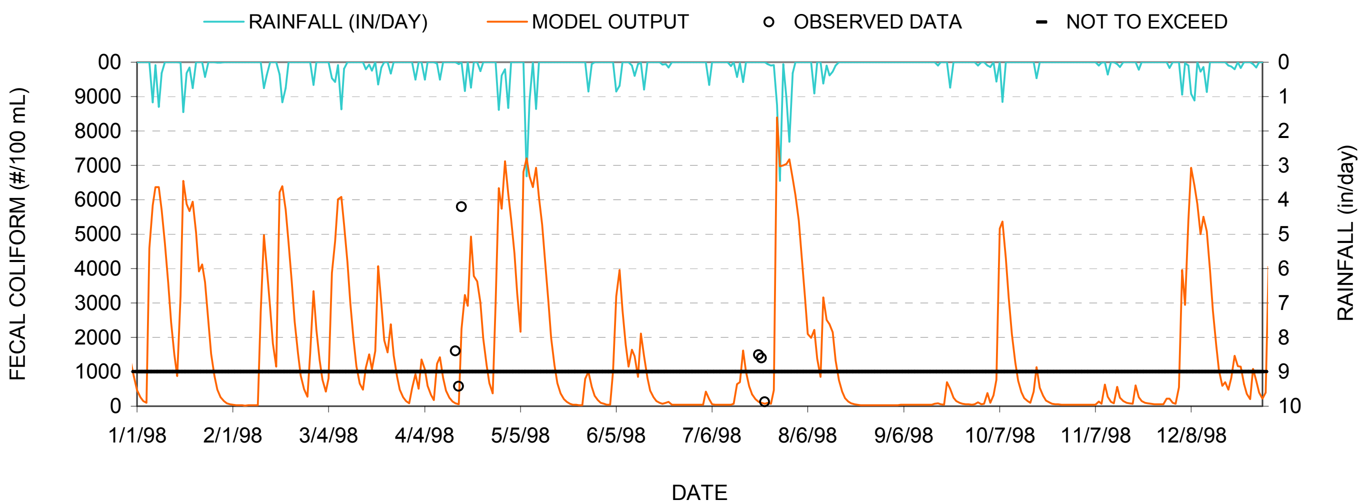
Figure A-11. Water Quality Calibration - MFFDR at STORET Station MFFDE1C49.5HE (near headwaters).

MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: **BUCK001.2GI**

MODEL RUN: **1**

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2



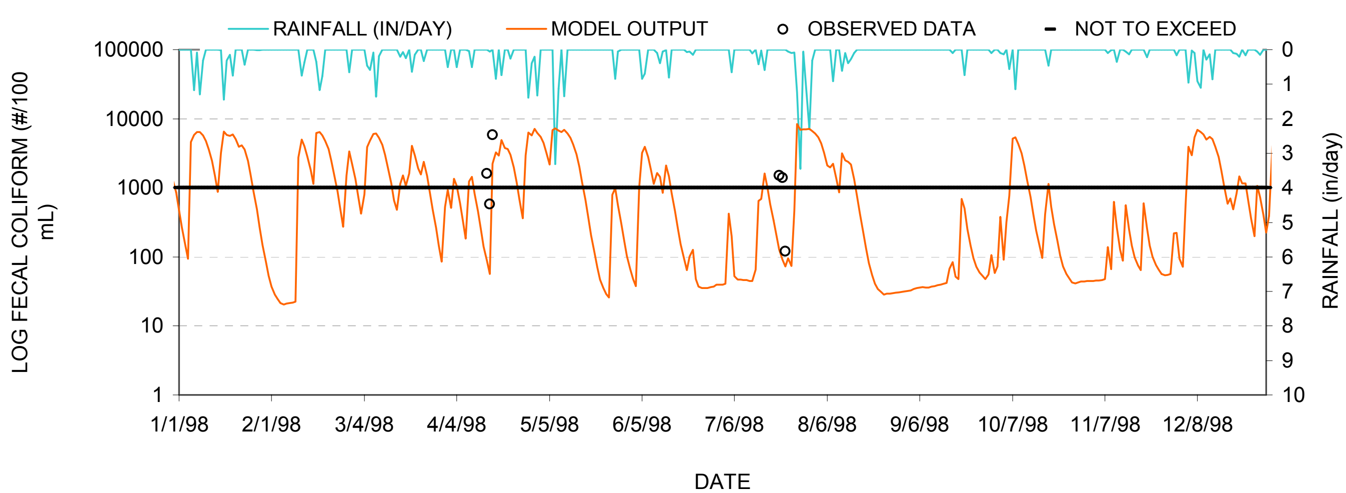


Figure A-12. Water Quality Calibration - Buck Creek at STORET Station BUCK001.2GI

APPENDIX B

Determination of Critical Conditions

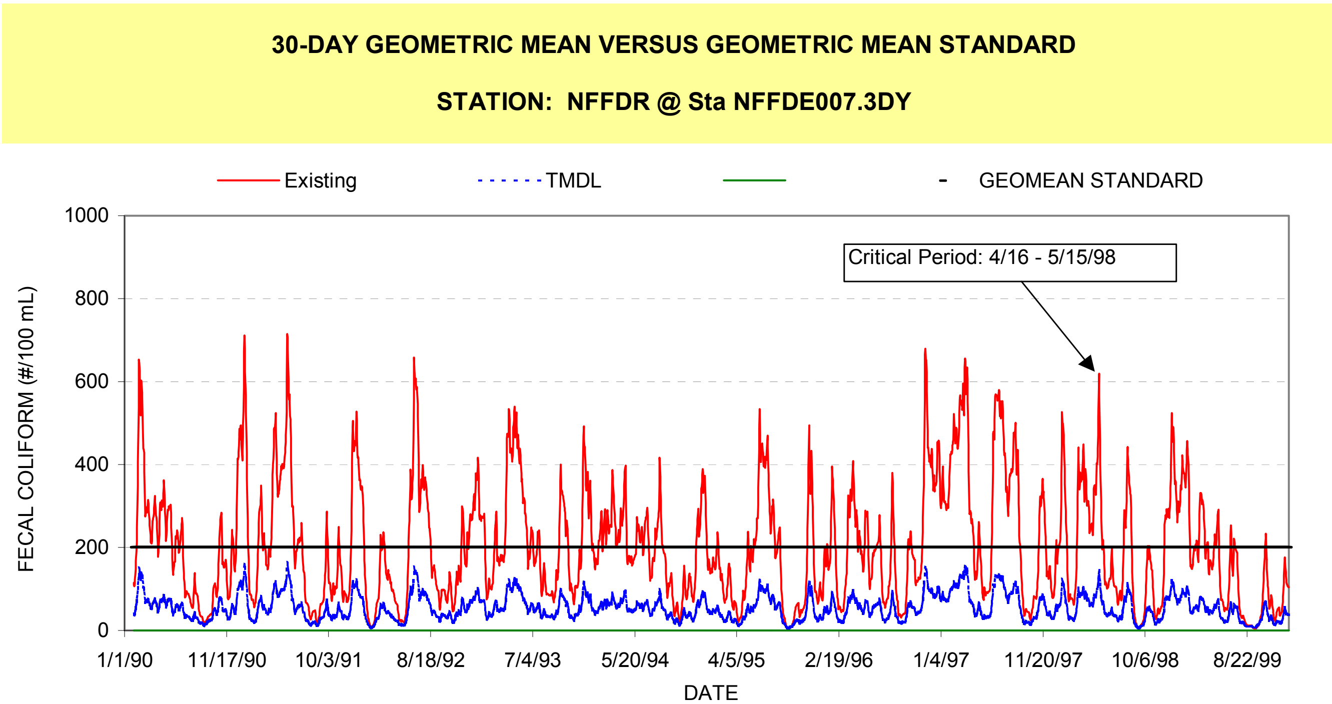


Figure B-1. Simulated 30-Day Geometric Mean Concentration in NFFDR (Station NFFDE007.3DY)

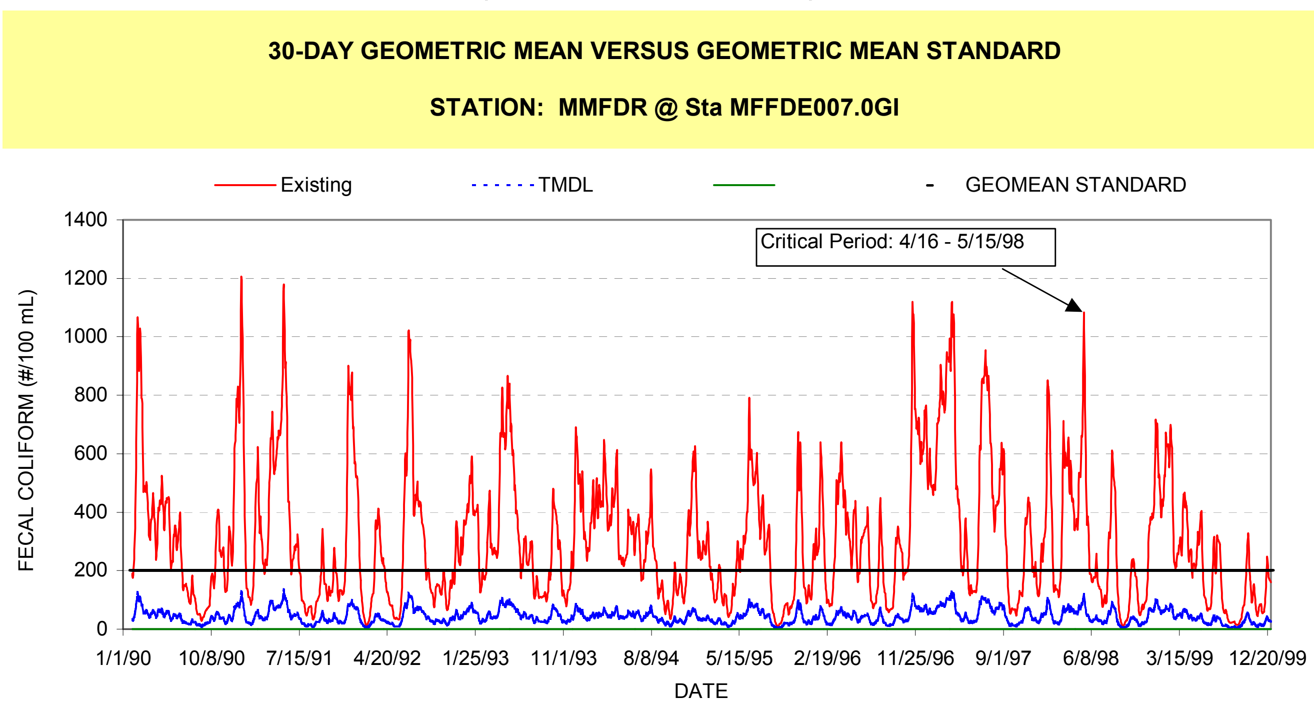


Figure B-2. Simulated 30-Day Geometric Mean Concentration in MFFDR (Station MFFDE007.0GI)

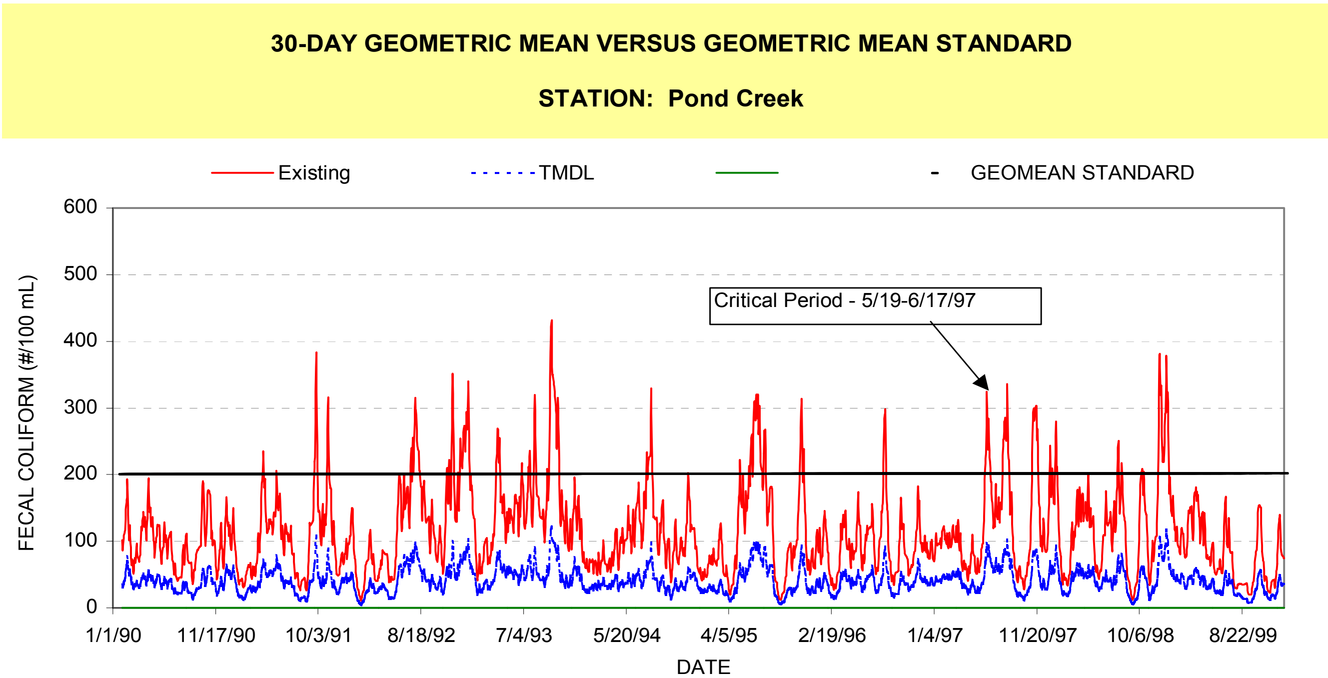


Figure B-3. Simulated 30-Day Geometric Mean Concentration for Pond Creek

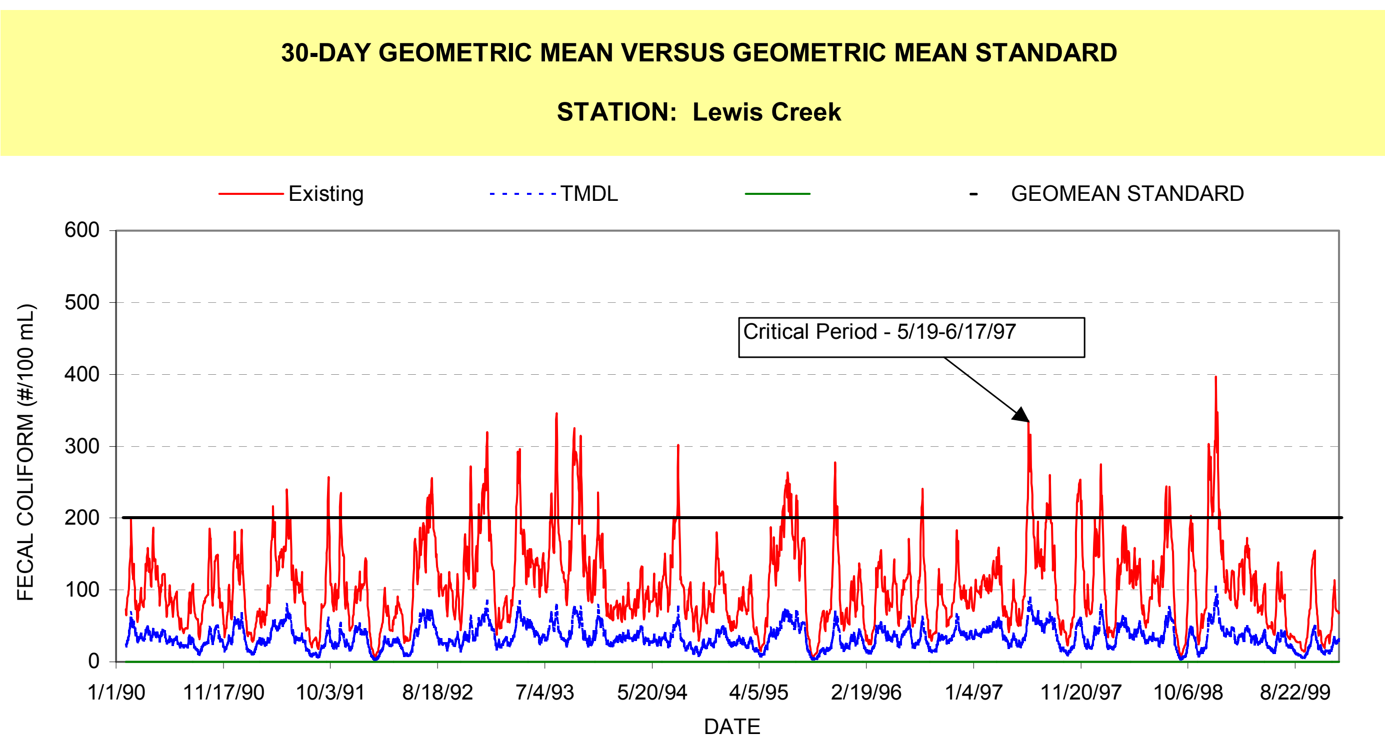


Figure B-4. Simulated 30-Day Geometric Mean Concentration for Lewis Creek

30-DAY GEOMETRIC MEAN VERSUS GEOMETRIC MEAN STANDARD

STATION: Doakville Creek

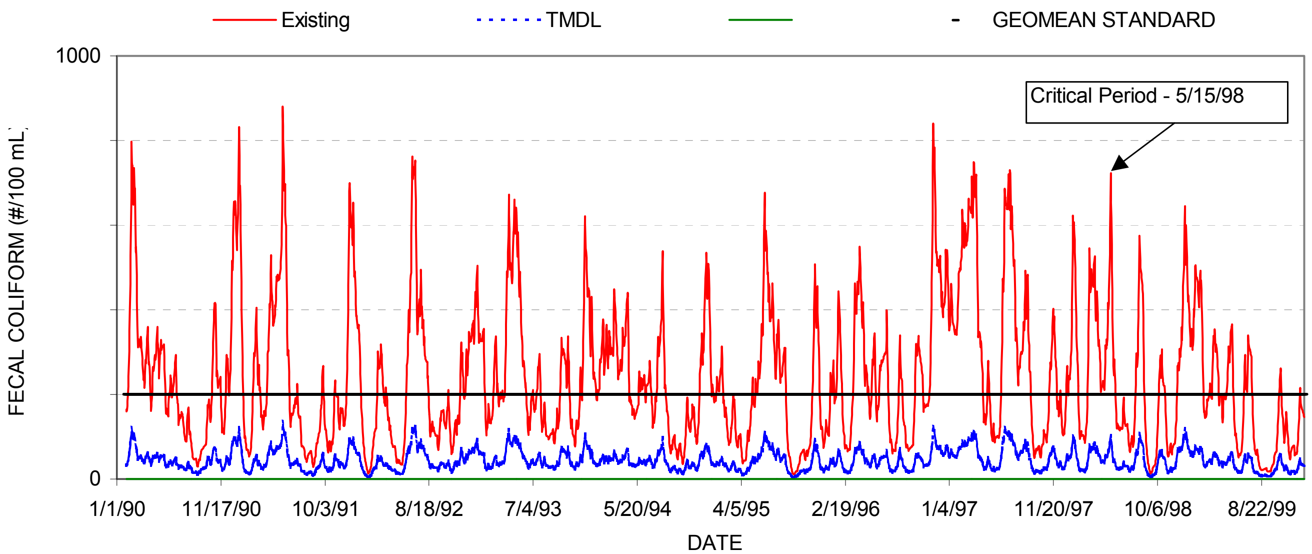


Figure B-5. Simulated 30-Day Geometric Mean Concentration for Doakville Creek

30-DAY GEOMETRIC MEAN VERSUS GEOMETRIC MEAN STANDARD

STATION: Turkey Creek

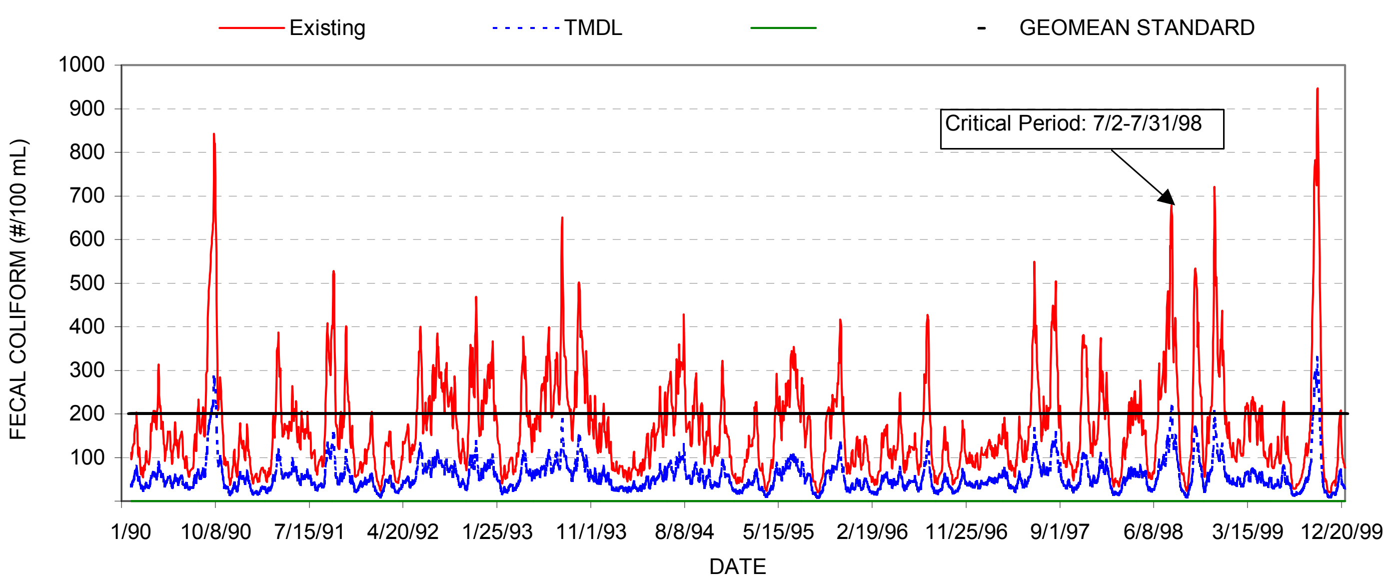


Figure B-6. Simulated 30-Day Geometric Mean Concentration for Turkey Creek

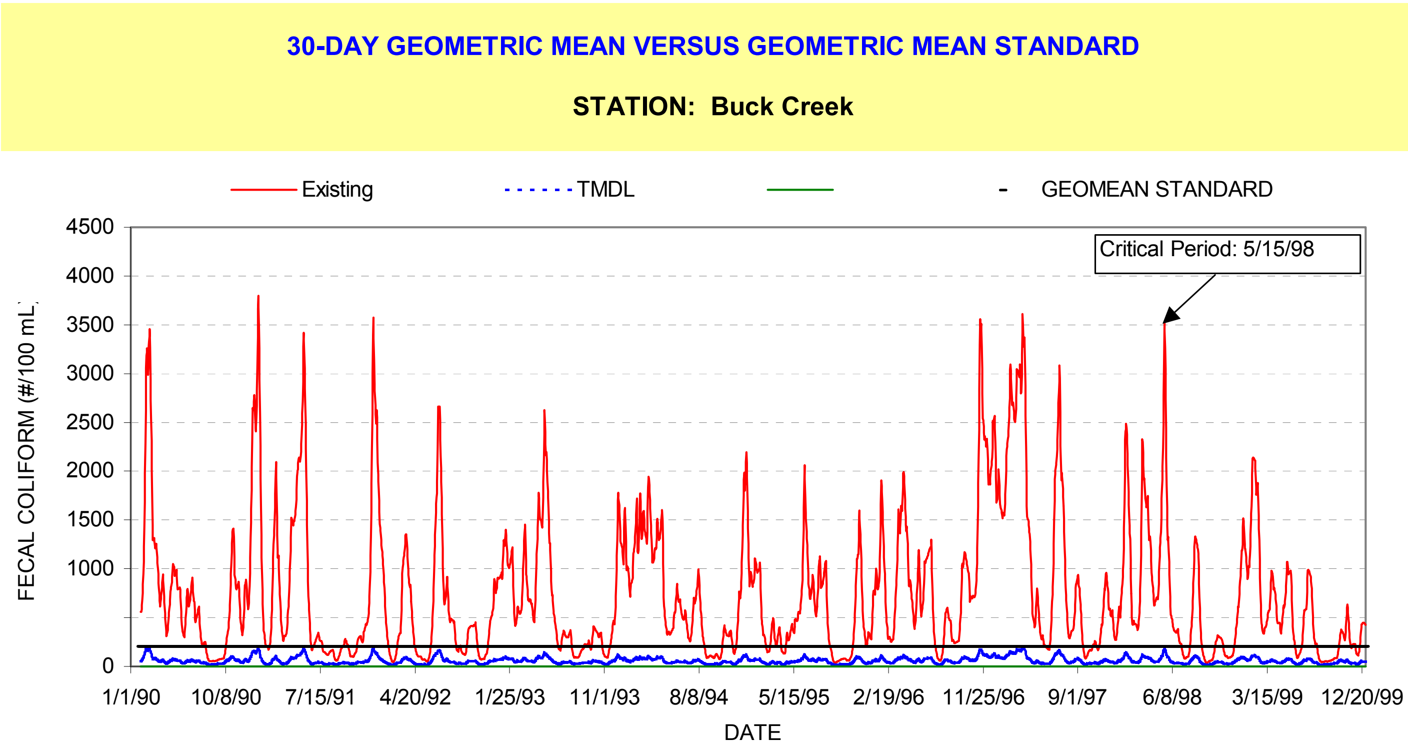


Figure B-7. Simulated 30-Day Geometric Mean Concentration for Buck Creek

APPENDIX C

Public Notice Announcement

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

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR FECAL COLIFORM IN NORTH FORK FORKED DEER RIVER TURKEY CREEK & OTHER IMPAIRED WATERBODIES NORTH FORK FORKED DEER RIVER WATERSHED (HUC 08010204), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed Total Maximum Daily Loads (TMDLs) for fecal coliform in North Fork Forked Deer River (NFFDR) 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.

Turkey Creek and one segment of the North Fork Forked Deer River (mouth to Pond Creek) are listed on Tennessee's final 1998 303(d) list as not supporting designated use classifications due, in part, to pathogens associated with urban storm water runoff and agriculture. Also included in the TMDL analyses are the Middle Fork Forked Deer River, Beech Creek, Buck Creek, Doakville Creek, Lewis Creek, and Pond Creek. These waterbodies were assessed in 2000 and also classified as not supporting designated use classifications due, in part, to pathogens. The TMDLs utilize Tennessee's general water quality criteria, continuous record station flow data, in-stream water quality monitoring data, a calibrated dynamic water quality model, and an appropriate Margin of Safety (MOS) to establish allowable loadings of fecal coliform which will result in reduced in-stream concentrations and the attainment of water quality standards. The TMDLs require reductions in in-stream fecal coliform loading of approximately 45% to 90% in the four listed waterbodies.

The proposed fecal coliform TMDLs may be downloaded from the Department of Environment and Conservation website:

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

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

Bruce R. Evans, P.E., Watershed Management Section
Telephone: 615-532-0668

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

Persons wishing to comment on the TMDLs are invited to submit their comments in writing no later than March 4, 2002 to:

Division of Water Pollution Control
Watershed Management Section
6th Floor, L & C Annex
401 Church Street
Nashville, TN 37243-1534

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

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