TOTAL MAXIMUM DAILY LOAD (TMDL)

For

Fecal Coliform

In

First Creek
Second Creek
Third Creek
Goose Creek
Fort Loudoun Lake Watershed (HUC 06010201)
Knox County, Tennessee

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LIST OF ABBREVIATIONS

BMP	Best Management Practices
BPJ	Best Professional Judgment
CFR	Code of Federal Regulations
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
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NPSM	Nonpoint Source Model
NRCS	Natural Resources Conservation Service
Rf3	Reach File 3
SWMM	Storm Water Management Model
TDA	Tennessee Department of Agriculture
TDEC	Tennessee Department of Environment & Conservation
TMDL	Total Maximum Daily Load
TWRA	Tennessee Wildlife Resources Agency
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WCS	Watershed Characterization System
WLA	Waste Load Allocation
WWTP	Wastewater Treatment Plant
WY	Water Year (October-September)

SUMMARY SHEET
Proposed Total Maximum Daily Load (TMDL)
First Creek, Fort Loudoun Lake

1. 303(d) Listed Waterbody Information

State: Tennessee
County: Knox

Major River Basin: Upper Tennessee River Basin
Watershed: Fort Loudoun Lake (HUC 06010201)

Waterbody Name: First Creek
Waterbody ID: TN06010201FIRSTCR
Location: First Creek from mile 1.17 to origin
Impacted Stream Length: 26.2 miles Not Supporting
Watershed Area: 21.0 square miles
Tributary to: Tennessee River/Fort Loudoun Lake

Constituent(s) of Concern: Fecal Coliform Bacteria

Designated Uses: Fish & Aquatic Life, Recreation, Irrigation, and Livestock Watering & Wildlife

Applicable Water Quality Standard for Recreation (most stringent standard):

> The concentration of the fecal coliform group shall not exceed 200 per 100 ml, nor shall the concentration of the E. coli group exceed 126 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.

2. TMDL Development

Analysis/Modeling: The Non-Point Source Model (NPSM) was used to develop this TMDL. An hourly timestep 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. Watershed/Stream Reach Allocation

Wasteload Allocation (WLA): 2.276×10^{9} counts/30 days

> Note: All future permitted discharges shall meet the water quality standard for fecal coliform bacteria of 200/100 ml.

Load Allocation (LA): 1.068×10^{13} counts/30 days

Margin of Safety (MOS): 20 counts/100 ml; conservative modeling assumptions

Total Maximum Daily Load (TMDL): 1.068×10^{13} counts/30 days, 180 counts/100 ml

SUMMARY SHEET
Proposed Total Maximum Daily Load (TMDL)
Second Creek, Fort Loudoun Lake

1. 303(d) Listed Waterbody Information

State: Tennessee
County: Knox

Major River Basin: Upper Tennessee River Basin
Watershed: Fort Loudoun Lake (HUC 06010201)

Waterbody Name: Second Creek
Waterbody ID: TN06010201SECONDCR
Location: Second Creek from mouth to Mile 3.9
Impacted Stream Length: 3.9 miles Not Supporting
Watershed Area: 6.27 square miles
Tributary to: Tennessee River/Fort Loudoun Lake

Constituent(s) of Concern: Fecal Coliform Bacteria

Designated Uses: Industrial Water Supply, Fish & Aquatic Life, Recreation, Irrigation, and Livestock Watering & Wildlife

Applicable Water Quality Standard for Recreation (most stringent standard):

> The concentration of the fecal coliform group shall not exceed 200 per 100 ml, nor shall the concentration of the E. coli group exceed 126 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.

2. TMDL Development

Analysis/Modeling: The Non-Point Source Model (NPSM) was used to develop this TMDL. An hourly timestep 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. Watershed/Stream Reach Allocation

Wasteload Allocation (WLA): 0 counts/30 days

> Note: All future permitted discharges shall meet the water quality standard for fecal coliform bacteria of 200/100 ml.

Load Allocation (LA): 4.293×10^{12} counts/30 days

Margin of Safety (MOS): 20 counts/100 ml; conservative modeling assumptions

Total Maximum Daily Load (TMDL): 4.293×10^{12} counts/30 days, 180 counts/100 ml

SUMMARY SHEET
Proposed Total Maximum Daily Load (TMDL)
Third Creek, Fort Loudoun Lake

1. 303(d) Listed Waterbody Information

State: Tennessee
County: Knox

Major River Basin: Upper Tennessee River Basin
Watershed: Fort Loudoun Lake (HUC 06010201)

Waterbody Name: Third Creek
Waterbody ID: TN06010201THIRDCR
Location: Third Creek from mile 0.5 to origin
Impacted Stream Length: 20.7 miles Not Supporting
Watershed Area: 18.6 square miles
Tributary to: Tennessee River/Fort Loudoun Lake

Constituent(s) of Concern: Fecal Coliform Bacteria

Designated Uses: Domestic Water Supply, Industrial Water Supply, Fish & Aquatic Life, Recreation, Irrigation, and Livestock Watering & Wildlife

Applicable Water Quality Standard for Recreation (most stringent standard):

> The concentration of the fecal coliform group shall not exceed 200 per 100 ml, nor shall the concentration of the E. coli group exceed 126 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.

2. TMDL Development

Analysis/Modeling: The Non-Point Source Model (NPSM) was used to develop this TMDL. An hourly timestep 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. Watershed/Stream Reach Allocation

Wasteload Allocation (WLA): 0 counts/30 days

> Note: All future permitted discharges shall meet the water quality standard for fecal coliform bacteria of 200/100 ml.

Load Allocation (LA): 1.046×10^{13} counts/30 days

Margin of Safety (MOS): 20 counts/100 ml; conservative modeling assumptions

Total Maximum Daily Load (TMDL): 1.046×10^{13} counts/30 days, 180 counts/100 ml

SUMMARY SHEET
Proposed Total Maximum Daily Load (TMDL)
Goose Creek, Fort Loudoun Lake

1. 303(d) Listed Waterbody Information

State: Tennessee
County: Knox

Major River Basin: Upper Tennessee River Basin
Watershed: Fort Loudoun Lake (HUC 06010201)

Waterbody Name: Goose Creek
Waterbody ID: TN06010201GOOSECR
Location: Goose Creek from mile 0.35 to origin
Impacted Stream Length: 4.9 miles Not Supporting
Watershed Area: 3.20 square miles
Tributary to: Tennessee River/Fort Loudoun Lake

Constituent(s) of Concern: Fecal Coliform Bacteria

Designated Uses: Fish & Aquatic Life, Recreation, Irrigation, and Livestock Watering & Wildlife

Applicable Water Quality Standard for Recreation (most stringent standard):

> The concentration of the fecal coliform group shall not exceed 200 per 100 ml, nor shall the concentration of the E. coli group exceed 126 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.

2. TMDL Development

Analysis/Modeling: The Non-Point Source Model (NPSM) was used to develop this TMDL. An hourly timestep 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. Watershed/Stream Reach Allocation

Wasteload Allocation (WLA): 0 counts/30 days

> Note: All future permitted discharges shall meet the water quality standard for fecal coliform bacteria of 200/100 ml.

Load Allocation (LA): 1.588×10^{12} counts/30 days

Margin of Safety (MOS): 20 counts/100 ml; conservative modeling assumptions

Total Maximum Daily Load (TMDL): 1.588×10^{12} counts/30 days, 180 counts/100 ml

FECAL COLIFORM TOTAL MAXIMUM DAILY LOAD (TMDL)
FORT LOUDOUN LAKE WATERSHED (HUC 06010201)

First Creek (TN06010201FIRSTCR)
Second Creek (TN06010201SECONDCR)
Third Creek (TN06010201THIRDCR)
Goose Creek (TN06010201GOOSECR)

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 nonpoint sources and restore and maintain the quality of their water resources (USEPA, 1991).

2.0 WATERSHED DESCRIPTION

The Fort Loudoun Lake watershed (HUC 06010201) is located in eastern Tennessee (Figure 1) and falls within the Level III Ridge and Valley (67) and Blue Ridge Mountains (66) ecoregions. Each of the four subject watersheds lies entirely within the Ridge and Valley ecoregion. The Second and Third Creek watersheds (in their entirety), most of the First Creek watershed, and a portion of the Goose Creek watershed lie in the Level IV Southern Limestone/Dolomite Valleys and Low Rolling Hills subecoregion (67f), a heterogeneous ecoregion composed predominately of limestone and dolomite, but including other rock formations and strata with varying characteristics. A small portion of the First Creek watershed east of the confluence of First Creek and Whites Creek lies in the Southern Dissected Ridges and Knobs subecoregion (67i). The majority of the Goose Creek watershed lies in the Southern Shale Valleys subecoregion (67g), characterized by well-drained soils and fine-grained rock, primarily shale.

First, Second, Third, and Goose Creeks are tributaries of the Tennessee River/Fort Loudoun Lake and have approximate drainage areas of 21.0, 6.27, 18.6, and 3.20 square miles, respectively (Figure 2). First Creek flows south-southeast and enters the Tennessee River at mile 647.8. Second Creek flows southeast and enters the Tennessee River at mile 647.2. Third Creek flows southeast and enters the Tennessee River at mile 645.9. Goose Creek flows northwest and enters the Tennessee River at mile 646.7. 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 is summarized in Table 1 and shown in Figure 3. The designated use classifications for all surface waters in the Fort Loudoun Lake watershed include Fish & Aquatic Life, Recreation, Irrigation, and Livestock Watering & Wildlife. Use classifications for Second Creek include Industrial Water Supply and for Third Creek, from Mile 4.9 to origin, include Domestic Water Supply and Industrial Water Supply.

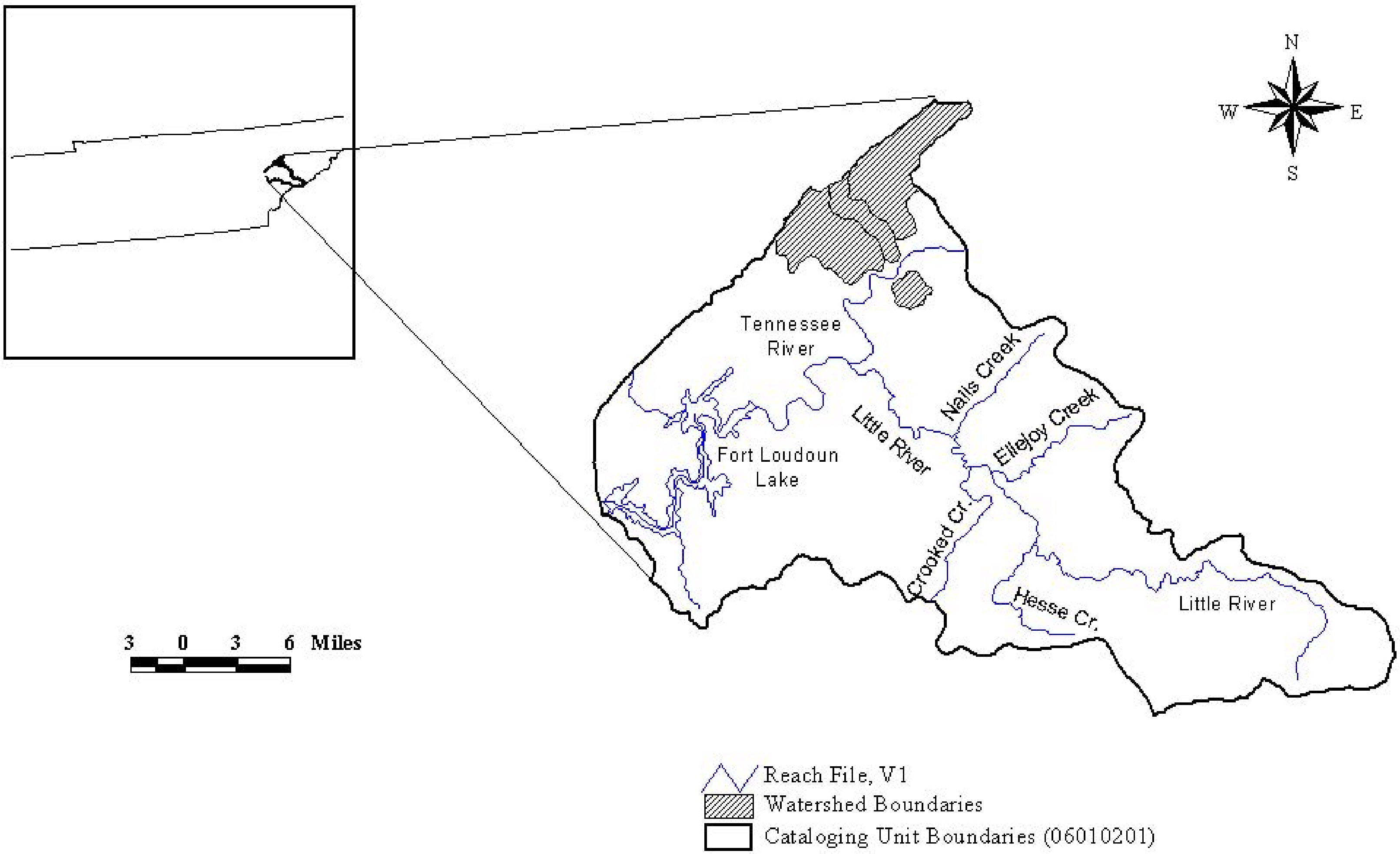

Figure 1. Location of Fort Loudoun Lake and First Creek, Second Creek, Third Creek, and Goose Creek watersheds.

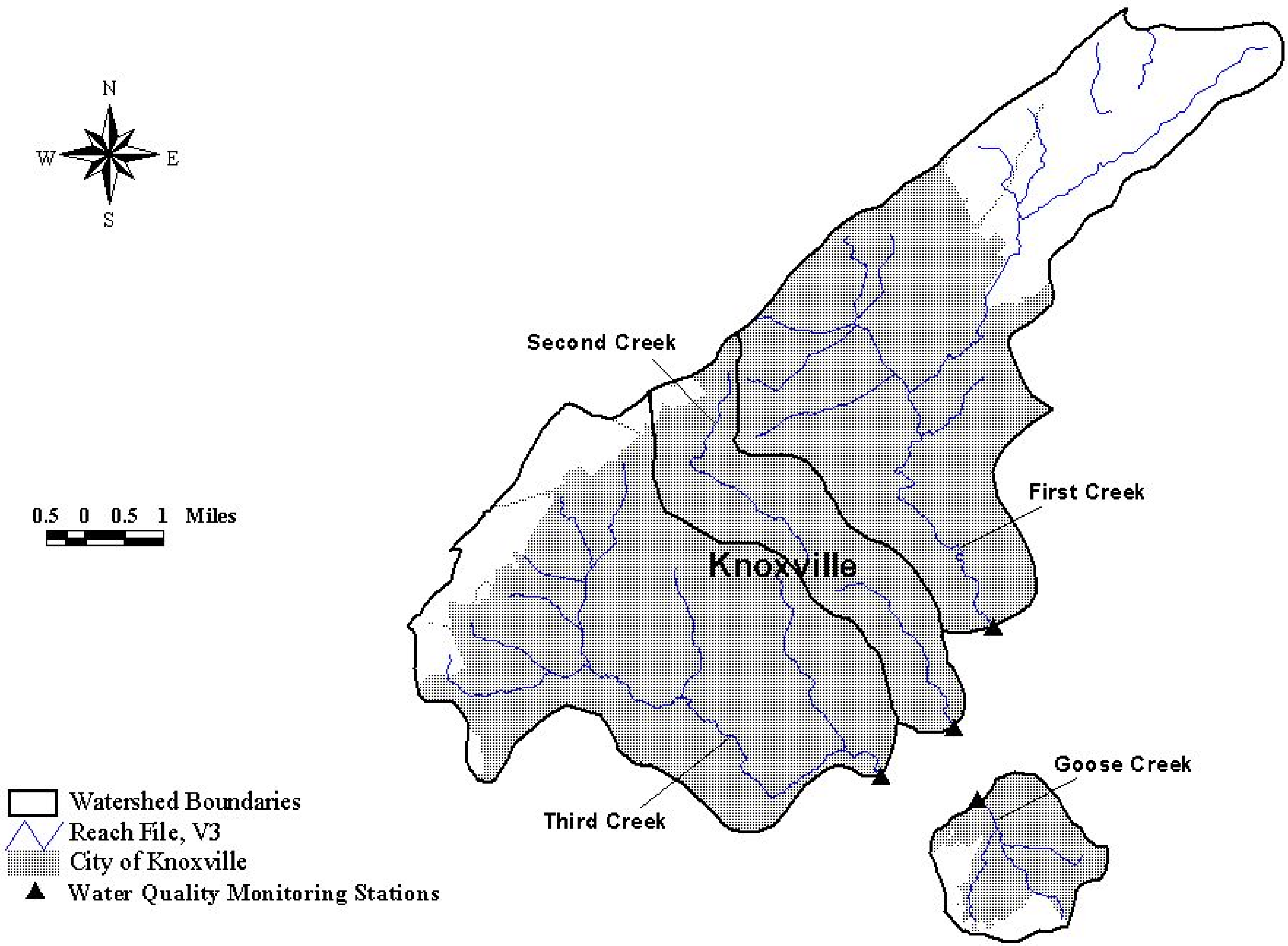

Figure 2. Watershed boundaries.

Table 1. MRLC Land Use Distribution by Watershed

	First Creek at Mile 1.17		Second Creek at Mouth		Third Creek at Mile 0.50		Goose Creek at Mile 0.35	
Land Use	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%
Deciduous Forest	1354	10.1	291	7.3	1119	9.4	324	15.8
Evergreen Forest	1480	11.0	286	7.1	1373	11.6	359	17.6
High Intensity Commercial/Industrial /Transportation	769	5.7	864	21.5	1327	11.2	119	5.8
High Intensity Residential	1087	8.1	778	19.4	965	8.1	171	8.4
Low Intensity Residential	3471	25.8	1026	25.6	3432	28.9	490	23.9
Mixed Forest	2345	17.5	381	9.5	1894	16.0	466	22.8
Open Water	9	0.1	2	0.1	7	0.1	8	0.4
Other Grasses (Urban/recreational; e.g. parks, lawns)	812	6.0	248	6.2	828	7.0	53	2.6
Pasture/Hay	1758	13.1	18	0.4	714	6.0	31	1.5
Row Crops	344	2.6	116	2.9	207	1.7	22	1.1
Transitional	0	0.0	0	0.0	6	0.1	2	0.1
Total (mi^2)	13430 (21.0)	100	4011 (6.27)	100	11873 (18.6)	100	2046 (3.20)	100

3.0 PROBLEM DEFINITION

EPA Region IV approved Tennessee's final 1998 303(d) list (TDEC, 1998) on September 17, 1998. The list identified the waterbodies shown in Table 2 as not fully supporting designated use classifications due, in part, to pathogens. The fecal coliform group is an indicator of the presence of pathogens in a stream. The objective of this study is to develop fecal coliform TMDLs for four of the 303(d)-listed waterbodies in the Fort Loudoun Lake watershed, principally located in the urban area of the city of Knoxville.

4.0 TARGET IDENTIFICATION

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, is 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 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

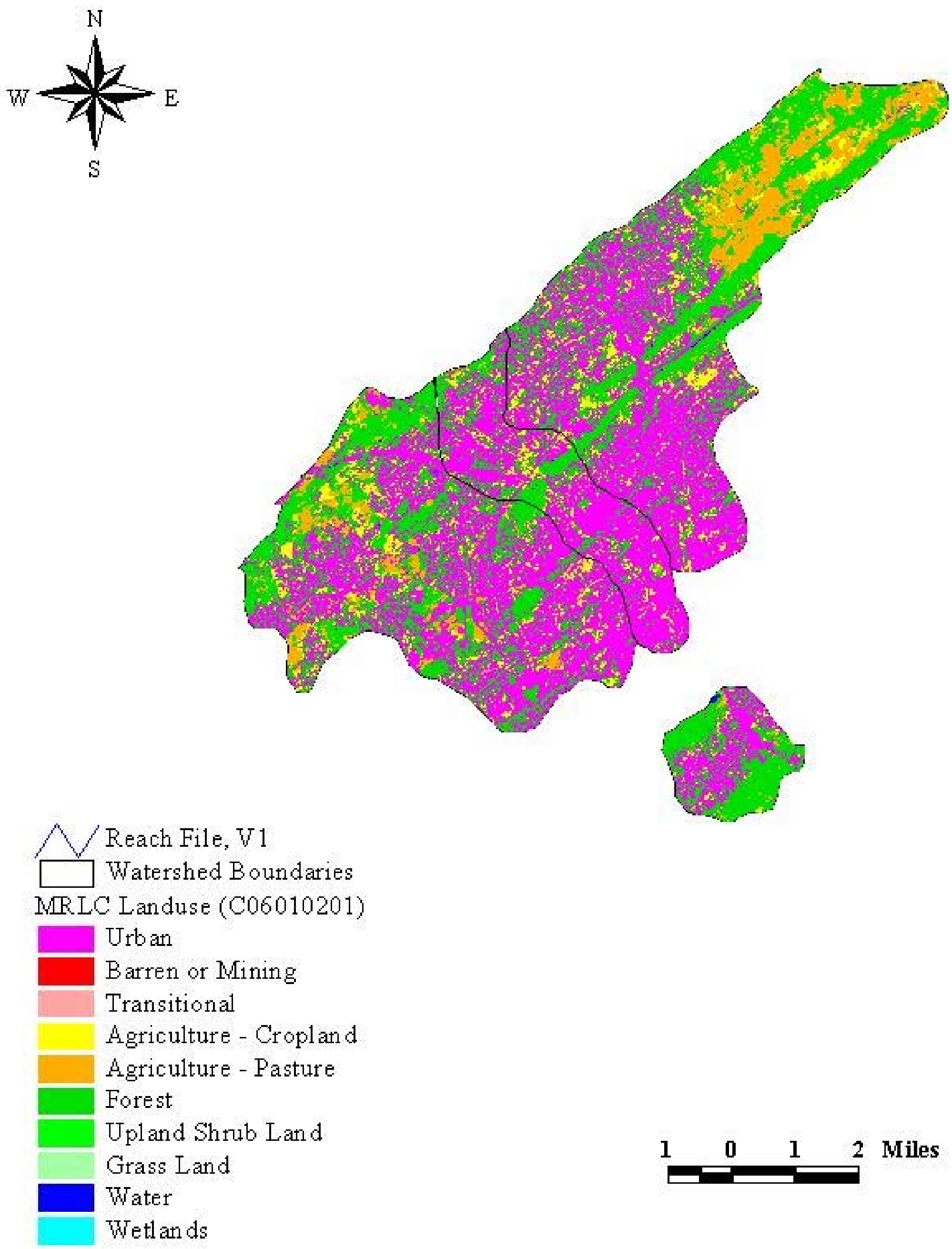

Figure 3. Land Use Distribution.

mean standard is the target value for the TMDLs.

Table 2. Waterbodies Impacted by Pathogens

Waterbody ID	Impacted Waterbody	Not Supporting[1] [miles]
TN06010201FIRSTCR	Fort Loudoun Lake – First Creek	26.2
TN06010201SECONDCR	Fort Loudoun Lake – Second Creek	3.9
TN06010201THIRDCR	Fort Loudoun Lake – Third Creek	20.7
TN06010201GOOSECR	Fort Loudoun Lake – Goose Creek	4.9

[1] Not Supporting Designated Uses.

5.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

Fecal coliform water quality data have been collected at the following monitoring sites on 303(d)-listed streams in the Fort Loudoun Lake watershed since approximately 1989. On each Stream, monitoring locations with the most comprehensive data sets and closest to the mouths (bolded locations) were used to calibrate TMDL models:

- **First Creek** – Miles 0.00, 0.45, **1.17**, 1.73, 2.57, 5.76, 6.33, and 7.28
- **Second Creek** – Miles **0.00**, 0.30, 0.55, 0.68, 0.70, 0.80, 1.10, 1.54, 1.70, 2.00, 2.25, 2.50, 3.35, 5.00, 5.38, and 5.76
- **Third Creek** – Miles 0.00, **0.50**, 0.87, 1.36E, 1.74E, 2.08E, 3.07E, 3.75E, 1.38W, 2.42W, 2.77W, 3.11W, 4.30W, 4.80W, 5.87W, 6.00W, and 6.65W
- **Goose Creek** – Miles 0.00, **0.35**, 0.80E, 0.90E, 0.95E, 1.30E, 1.35E, 1.40E, 1.45E, 1.50E, 1.60E, 1.70E, 1.80E, 1.20W, 1.50W, 1.55W, 1.60W, and 1.65W

Data were not collected at sufficient frequency to calculate 30-day geometric mean values for most of the period of record for all four streams (all sampling locations); however, individual samples exceeded 1000 counts/100 ml maximum at all sites (see Table 3). Concurrently, at the four water quality sampling locations utilized for TMDL model calibration, 34% to 50% of samples had fecal coliform concentrations exceeding 1000 colonies per 100 ml. Therefore, the four segments of Fort Loudoun Lake were listed as not supporting designated uses and were scheduled for TMDL evaluation. Due to availability of precipitation data for use in the model, only data collected through December 1998 were used in the 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, treated sanitary wastewater, stormwater associated with industrial activity, and stormwater from municipal separate storm sewer systems (MS4) that serve over 100,000 people 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.

Table 3. Water Quality Monitoring Data

Watershed/Sampling Location (Mile)	Samples (#)	Samples >200[1] (# / %)	Samples >1000[1] (# / %)	Concentrations (Counts/100 ml)			
				Minimum	Maximum	Mean	Median
First Creek (1.17)	215	187 / 87	90 / 42	64	47000	3235	820
Second Creek (0.00)	224	205 / 92	113 / 50	1	210000	4585	1100
Third Creek (0.50)	184	162 / 88	74 / 40	1	580000	9827	580
Goose Creek (0.35)	198	173 / 87	67 / 34	1	600000	8974	545

[1] Counts/100 ml

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:

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

6.1 Point Sources

There is one point source located in the drainage area of the 303(d)-listed stream segment of First Creek that has been issued an NPDES permit for discharge of treated sanitary wastewater. This facility, Ritta School Wastewater Treatment Plant (WWTP) (TN0028177), has been in compliance, with respect to fecal coliform discharge, for the period coincident with the TMDL modeling study.

6.2 Nonpoint Source Assessment

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 population data were provided by the Tennessee Wildlife Resources Agency (TWRA) for the state of Tennessee. However, no county-specific data were available for east Tennessee nor were statistics available for other animals. Therefore, deer were assumed to populate the Fort Loudoun Lake watershed according to the upper limit of available population data of 36 per square mile. In addition, in order to account for other forms of wildlife, a deer density of 45 animals/square mile is used. Fecal coliform loading due to deer is estimated by EPA to be 5.0×10^8 counts/animal/day.

6.2.2 Agricultural Animals

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

- As with wildlife, agricultural livestock grazing on pastureland 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. 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 for Knox County in the Fort Loudoun Lake watershed are listed in Table 4. Cattle are the predominate livestock in the watershed. Fecal coliform loading rates for livestock in the watershed are estimated to be: 1.06×10^{11} counts/day/beef cow, 1.04×10^{11} counts/day/dairy cow, 1.24×10^{10} counts/day/hog, and 1.22×10^{10} counts/day/sheep (NCSU, 1994).

Table 4. Livestock Distribution in Knox County and Fort Loudoun Lake Watersheds

Livestock	Knox County	First Creek	Second Creek	Third Creek	Goose Creek
Poultry	2056	0	0	0	0
Cattle	24664	761	8	309	13
Dairy	855	26	0	11	0
Beef	12424	383	4	156	7
Swine	851	26	0	11	0
Sheep	649	20	0	8	0

6.2.3 Failing Septic Systems

Some fecal coliform loading in the Fort Loudoun Lake watershed can be attributed to failure of septic systems and illicit discharges of raw sewage. Estimates from county census data of people in selected Fort Loudoun Lake watersheds utilizing septic systems are shown in Table 5. In eastern Tennessee, it is estimated that there are approximately 2.37 people per household on septic systems, some of which can be reasonably assumed to be failing.

6.2.4 Urban Development

Fecal coliform loading from urban areas is potentially 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 the Fort Loudoun Lake watersheds.

Table 5. Estimated Population on Septic Systems in Fort Loudoun Lake Watersheds

Watershed	No. of People on Septic Systems
First Creek	3145
Second Creek	289
Third Creek	1543
Goose Creek	355

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 analyses 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 conditions for the TMDL analyses. Several computer-based tools were also utilized to generate input data for the models.

The Nonpoint Source Model (NPSM) is a watershed model capable of simulating nonpoint source runoff and associated pollutant loadings, accounting 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 resulting water quality response.

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 Fort Loudoun Lake watersheds. 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 washoff 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 Setup

Four watersheds were delineated in order to characterize relative fecal coliform bacteria contributions from each of the contributing drainage areas to the four impaired streams (see Figure

2). Boundaries were constructed so that watershed "pour points" coincided with water quality monitoring stations. 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 watershed.

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 Knoxville meteorological station were used for simulations in all four watersheds.

7.3 Model Calibration

Calibration of the watershed models included both hydrology and water quality components. 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 streamflow data from a U.S. Geological Survey (USGS) stream gaging station for the same period of time. Because there are no currently operating or historical USGS gages with recent streamflow data on unregulated streams in the Fort Loudoun Lake watershed, the USGS gage located at the Sinking Creek Headwaters, in the Watauga River watershed (USGS Station 03486305) was used for flow calibration. The drainage area contributing to this gage is approximately equal to the Goose Creek watershed. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge. The Sinking Creek Headwaters model was calibrated and model parameters were applied to the Fort Loudoun models and adjusted based on physical characteristics and best professional judgment.

The models were also calibrated for water quality. Appropriate model parameters were adjusted to obtain acceptable agreement between simulated in-stream fecal coliform concentrations and observed data collected at sampling stations in First Creek, Second Creek, Third Creek, and Goose Creek of the Fort Loudoun Lake watershed. Results show that each 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 Appendix 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), nonpoint 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:

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

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 (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 streamflow when dilution is minimized. Both conditions are simulated in the water quality model.

The ten-year period from January 1, 1989, to December 31, 1998 was used to simulate a continuous 30-day geometric mean concentration to compare to the target. This 10-year period contained a range of hydrologic conditions that included both low and high streamflows 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 C. From these figures, critical conditions can be determined. The 30-day critical period in each model is the period preceding the largest simulated violation of the geometric mean standard (USEPA, 1991). Meeting water quality standards during this period ensures that water quality standards can be achieved throughout the ten-year period. For the listed segments in the Fort Loudoun Lake watershed, the highest violations of the 30-day geometric mean occurred on September 18, 1995. Therefore, the critical period is August 20 through September 18, 1995.

8.2 Existing Conditions

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

- The calibrated model, corresponding to the portion of the Fort Loudoun Lake watershed that is upstream of the pour point of the listed waterbody segment, was run for a time period that included the critical condition (8/20/95 – 9/18/95).
- 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 direct inputs of fecal coliform bacteria from “direct sources” (i.e., leaking sewer collection lines, failing septic systems, illicit discharges of fecal coliform bacteria, and animal access to streams) have a significant impact on bacteria loading in the watershed. Non-point sources related to urban land uses are also shown to have an impact on the fecal coliform bacteria loading in the four Fort Loudoun Lake watersheds. Reductions in these loading rates reduce the in-stream fecal coliform bacteria levels. Non-point source loading rates representing existing conditions in the model are shown in Table 6.

Point source loads from NPDES facilities do not contribute to the impairment of the listed stream segments since discharges from these facilities are required to be treated to levels corresponding to in-stream water quality criteria. Only one NPDES facility, located in First Creek, has an NPDES permit for discharge of treated sanitary wastewater in the four Fort Loudoun Lake watersheds.

Table 6. Nonpoint Source Loading Rates for Existing Conditions

Watershed	Runoff from all Lands	Direct sources
	[Counts/30 days]	[Counts/30 days]
First Creek	7.760×10^{13}	8.254×10^{12}
Second Creek	3.665×10^{13}	1.488×10^{12}
Third Creek	6.172×10^{13}	6.193×10^{12}
Goose Creek	8.069×10^{12}	5.824×10^{11}

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 explicit and implicit MOS were used. The explicit MOS is 20 counts/100 ml below the in-stream target concentration on each watershed. 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; and all land uses connected directly to streams.

8.4 Determination of TMDLs, WLAs, & LAs

The TMDL is the total amount of pollutant that can be assimilated by a waterbody while maintaining water quality standards. Fecal coliform bacteria TMDLs are expressed as counts per 30-day period since 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 the explicit MOS) of 180 counts/100 ml. As previously stated, the TMDL is calculated using the equation:

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

With MOS = 20 (explicit MOS), the TMDL, $\sum$WLAs, & $\sum$LAs were determined according to the following procedure:

- The calibrated model, corresponding to the portion of the given Fort Loudoun Lake watershed that is upstream of the pour point of the listed waterbody segment was run for a time period that included the critical condition (8/20/95 – 9/18/95).

- Existing NPDES permitted facilities were assumed to discharge at design flows and the fecal coliform permit limit of 200 counts/100 ml.

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

- The ∑WLAs is the load associated with the daily discharge loads of all modeled NPDES permitted facilities summed over the 30-day critical period. The discharge load for each facility represents the design flow at a fecal coliform concentration of 200 counts/100 ml.

- The ∑LAs is the daily fecal coliform load indirectly going to surface waters from all modeled land use areas as a result of buildup/washoff processes plus the daily discharge load sources modeled as "direct sources" and the result summed over the 30-day critical period. (Note: For loading resulting from buildup/washoff processes, there is no distinction in the model between point source discharges covered by an MS4 permit and non-point source discharges. Therefore, storm water discharges covered by the Knoxville MS4 are included in the calculation for ∑LAs).

  The percent reduction is based on the maximum simulated geometric mean concentration for the 30-day critical period for existing and TMDL conditions. The maximum simulated concentrations for the TMDL scenario were less than or equal to 180 counts/100 ml.

The TMDLs, WLAs, & LAs for the listed water bodies are summarized in Table 7.

Table 7. TMDL Components

Watershed	∑WLAs	∑LAs	MOS	TMDL
	[Counts/30 days]	[Counts/30 days]		[Counts/30 days]
First Creek	2.276×10^{9}	1.068×10^{13}	Explicit[1] & Implicit	1.068×10^{13}
Second Creek	0	4.293×10^{12}	Explicit[1] & Implicit	4.293×10^{12}
Third Creek	0	1.046×10^{13}	Explicit[1] & Implicit	1.046×10^{13}
Goose Creek	0	1.588×10^{12}	Explicit[1] & Implicit	1.588×10^{12}

[1] Explicit MOS = 20 counts/100 ml

8.4.1 Waste Load Allocations

There is one NPDES permitted facility that discharges fecal coliform bacteria in the First Creek watershed. Because the facility has operated in compliance with its permit, with respect to discharge of fecal coliform, no reductions are required from the Ritta School WWTP (TN0028177) as part of the TMDL. Future facility permits will require end-of-pipe limits equivalent to the water quality standard of 200-counts/100 ml in all four watersheds.

8.4.2 Load Allocations

There are two modes of transport for non-point source fecal coliform bacteria loading in the models. First, loading from leaking sewer system collection lines, failing septic systems, illicit connections, and animals in the stream (etc.), are modeled as 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.

Model results indicate that non-point sources related to direct inputs and urban runoff have the greatest impact on the fecal coliform bacteria loadings in the four Fort Loudoun Lake watersheds. Possible allocation scenarios that would meet in-stream water quality standards for the listed streams in the Fort Loudoun Lake watersheds include:

- First Creek: 89.3% reduction from runoff and reduction to the maximum extent practicable from "direct sources" of fecal coliform bacteria in the stream, resulting in an overall reduction of 93.8%.

- Second Creek: 90.4% reduction from runoff and reduction to the maximum extent practicable from "direct sources" of fecal coliform bacteria in the stream, resulting in an overall reduction of 92.3%.

- Third Creek: 86.4% reduction from runoff and reduction to the maximum extent practicable from "direct sources" of fecal coliform bacteria in the stream, resulting in an overall reduction of 92.0%.

- Goose Creek: 80.4% reduction from runoff and reduction to the maximum extent practicable from "direct sources" of fecal coliform bacteria in the stream, resulting in an overall reduction of 93.6%.

Best management practices (BMPs) that could be used to implement this TMDL include controlling pollution from urban runoff, identification and elimination of illicit discharges and other unknown "direct sources" of fecal coliform bacteria to the streams, and repair of leaking sewer collection lines and failing septic systems. Fecal coliform loading rates for the allocation scenarios are shown in Table 8. Additional monitoring and surveys of the watersheds may be conducted to validate and verify the various direct sources of fecal coliform bacteria.

8.4.3 Seasonal Variation

Seasonal variation was incorporated in the continuous simulation water quality models by using daily meteorological data over a ten-year period.

Table 8. Load Allocations for Fort Loudoun Lake Watersheds

Watershed	Runoff Load	"Direct Sources"	Overall Reduction (Existing to Allocated Conditions)
	[Counts/30 days]	[Counts/30 days]	[%]
First Creek	1.067×10^{13}	0	93.8
Second Creek	4.293×10^{12}	0	92.3
Third Creek	1.046×10^{13}	0	92.0
Goose Creek	1.588×10^{12}	0	93.6

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 the Fort Loudoun Lake watersheds in order to support the Recreation use classification. This TMDL suggested the need for a multi-phased comprehensive process to obtain and analyze additional information that would support adaptive management and improve long range plans for meeting applicable water quality standards. However, this plan needs also to recognize ongoing efforts and assure that currently planned water quality improvements are not delayed while awaiting further research and study. 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.

This TMDL represents an important step in a long-term restoration project to reduce fecal coliform loading to acceptable levels in affected watersheds. TDEC will evaluate the progress of implementation strategies and modify the TMDL as necessary in five years from the approval of this TMDL. A phased and adaptive approach is preferred by most stakeholders for the initial five-year program.

9.0.1 Phase 1: Within two years of approval of the TMDL, develop an updated status report on fecal coliform levels in the targeted watersheds using all available resources, data, and other information on potential sources. The status report shall include a full survey of current initiatives being conducted within the affected watersheds and an assessment of the effectiveness of those initiatives in achieving fecal coliform reductions. The assessment may also include pilot projects that evaluate certain control technologies and related methods to determine effectiveness. This information will be collected from and provided by all involved stakeholders including permittees, regulatory agencies, and other parties with related resources.

9.0.2 Phase 1: Risk Communication: Immediately develop a plan for public notification of health hazards including the identification and selection of appropriate mechanisms for notifying stream users when stream concentrations exceed water quality standards.

9.0.3 Phase 1: Data Management: Develop a system for tracking and managing data such as expected and potential sources. Develop a GIS-based inventory of sources and stream data. Identify failing septic tank and drainfield systems and areas where subsurface sewage disposal systems are contributing to bacteriological problems in vicinity water bodies.

9.0.4 Phase 1: Private sewers: Develop a framework for reducing to the maximum extent practicable bacteriological contributions to area surface waters from privately owned sewers and privately owned connections to municipal and utility sanitary sewer systems.

9.0.5 Phase 2: Within 30 months of TMDL approval, assemble information from the various stakeholders to best determine relative bacteriological contributions from various sources.

9.0.6 Phase 3: Permits and Strategies: Appropriately modify NPDES permits for point sources and commit to nonpoint source reduction goals.

9.0.7 Phase 3: Public Involvement: TDEC's watershed management approach shall invoke public participation and the meaningful involvement of stakeholders in the watershed management process. At a minimum, stakeholder and public involvement shall include data and research sharing, joint monitoring, source inventory, prioritization, and public outreach events such as presentations and management plan review. All outreach events shall include a component for accepting public comments for consideration.

9.0.8 Phase 4: Management Plan: Within five years of initial TMDL approval, develop a comprehensive management plan that includes long-term reduction targets for pathogens.

9.1 NPDES Municipal Separate Storm Sewer System (MS4) Permit

Permitted municipal entities must develop a storm water management program. The management program 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. Components of the management program include, but are not limited to, the following:

a) *Public Education and Outreach:* Distributing educational materials and performing outreach to inform citizens about the impacts polluted storm water runoff discharges can have on water quality.

b) *Public Participation/Involvement:* Providing opportunities for citizens to participate in program development and implementation, including effectively publicizing public hearings and/or encouraging citizen representatives on a storm water management panel.

c) *Illicit Discharge Detection and Elimination:* Developing and implementing a plan to detect and eliminate illicit discharges to the storm sewer system (includes developing a system map and informing the community about hazards associated with illegal discharges and improper disposal of waste).

d) *Post-Construction Runoff Control:* Developing, implementing, and enforcing a program to address discharges of post-construction storm water runoff from new development and redevelopment areas. Applicable controls could include preventative actions such as protecting sensitive areas (e.g., wetlands) or the use of structural BMPs such as grassed swales or porous pavement.

e) *Pollution Prevention/Good Housekeeping:* Developing and implementing a program with the goal of preventing or reducing pollutant runoff from municipal operations. The program must include municipal staff training on pollution prevention measures and techniques (e.g., regular street sweeping, reduction in the use of pesticides or street salt, or frequent catch basin cleaning).

With respect to fecal coliform pollution reduction, additional activities and programs conducted by city, county, and state agencies are recommended to support the management program:

a) 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.

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

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

9.1.1 Municipal Entities Covered Under Phase 1:

The Knoxville MS4 permit became effective on July 1, 1996 and authorizes existing or new storm water induced point source discharges to surface waters from the Municipal Separate Storm Sewer System and covers all areas located within the corporate boundary of the City of Knoxville. The city is in the sixth year of the existing permit term and is proceeding according to the schedule specified by the permit. Annual reports have been submitted detailing implementation of the storm water management program and the results of sampling activities.

In accordance with the load allocations developed in this TMDL, the Knoxville MS4 permit should be modified to require the review and revision, as necessary, of the storm water management program to accomplish the following:

a) Reduction of fecal coliform loading in point and non-point source storm water runoff discharges from urban streams in the Fort Loudoun Lake watershed in accordance with the Load Allocations specified in Table 8. (For the purposes of this TMDL, the Waste Load Allocations for point source discharges covered under the Knoxville MS4 permit were calculated as a part of the Load Allocations – see Section 8.4)

b) Reduction of fecal coliform loading, to the maximum extent practicable, due to failing septic systems and miscellaneous sources located within the city limits. Miscellaneous sources include, but are not limited to, leaking collection systems, illicit discharges, and unidentified sources.

c) Appropriate discharge and stream monitoring to verify the effectiveness of pollution reduction measures.

In conjunction with Knoxville Utilities Board, the Knox County Phase 2 Program, and the Knox County Health Department, identify further areas where sanitary sewers could serve to relieve impacted waters and to maintain existing areas where good water quality exists.

In addition, the City of Knoxville is encouraged to develop and calibrate a dynamic water quality model, such as the Storm Water Management Model (SWMM), to evaluate urban storm water loading/transport processes and facilitate planning and additional pollution control strategies.

Immediately implement a program to post and maintain advisory signs at streams that are designated as unsafe for recreation. The signs shall be placed along streams that are 303(d) listed for pathogens and verbiage for the signs shall be approved by TDEC prior to placement. The signs shall also provide a phone number to contact for further information. The signage program shall be supplemented by brochures and other media that can provide the public with information concerning the permanent advisories.

9.1.2 Municipal Entities Covered Under Phase 2 Storm Water Regulations

Knox County will be issued a NPDES Municipal Separate Storm Sewer System (MS4) permit 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. The management program 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 management program:

a) 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.

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

c) 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.

d) Reduction of fecal coliform loading in point and non-point source storm water runoff discharges from urban streams in the Fort Loudoun Lake watershed in accordance with the Load Allocations specified in Table 8.

e) Reduction of fecal coliform loading, to the maximum extent practicable, due to failing septic systems and miscellaneous sources located within the city limits. Miscellaneous sources include, but are not limited to, leaking collection systems, illicit discharges, and unidentified sources.

f) Appropriate discharge and stream monitoring to verify the effectiveness of pollution reduction measures.

In conjunction with the City of Knoxville MS4 program, Knoxville Utilities Board, and the Knox County Health Department, identify further areas where sanitary sewers could serve to mitigate impacted waters and to maintain existing areas where good water quality exists.

Immediately implement a program to post and maintain advisory signs at streams that are designated as unsafe for recreation. The signs shall be placed along streams that are 303(d) listed for pathogens and verbiage for the signs shall be approved by TDEC prior to placement. The signs shall also provide a phone number to contact for further information. The signage program shall be supplemented by brochures and other media that can provide the public with information concerning the permanent advisories.

9.2 Agricultural Sources of Fecal Coliform Loading

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 Fort Loudoun Lake 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.

9.3 NPDES Municipal Wastewater Permits and Collection System Operators

The primary wastewater control authority within the Fort Loudoun Lake watershed area impacted by this TMDL is the Knoxville Utilities Board (KUB).

The TMDL model indicates that leaking collection system lines and other “direct sources” may have a significant impact on bacteria loading in the watershed. Thus, collection system operators are important stakeholders within TDEC’s TMDL Program and watershed management approach, and are encouraged to take an active role in the overall watershed stakeholder process.

Permitted municipal wastewater entities with collection system facilities in the affected watershed shall develop public education and notification initiatives that address locations where SSOs may occur during significant rain events. These should include information on projects designed to reduce the likelihood of SSOs in previously identified problem areas. Project information should be available to the public and a means provided for public comment. These public education and notification initiatives shall be developed and made available to the public by June 30, 2003, and kept current thereafter.

Permitted municipal wastewater entities shall develop and maintain a Sewer Overflow Response Plan (SORP). All SORPs shall be submitted to TDEC by June 30, 2002.

Permitted municipal wastewater entities shall seek public input and comment on engineering alternatives and develop long-range plans for SSO reduction as well as seepage elimination as part of Phase 3.

All collection system operators with facilities inside the affected watershed shall provide to TDEC an annual report and engineering plan detailing the prior calendar year’s activities and efforts related to the reduction of sewage releases from their collection systems to the maximum extent practicable. Annual reports shall be submitted to TDEC by June 30 of each year, with initial reports due by June 30, 2002.

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 (e.g., to a level comparable to that conducted during the period approximately 1990-1995 in the Fort Loudoun Lake watersheds) to provide water quality information to characterize seasonal trends and refined source identification and delineation.

Recommended monitoring for the Fort Loudoun Lake watersheds includes monthly (minimum) or weekly grab samples and intensive sampling for one month during the wet season (January-March). In addition, monitoring efforts may 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 discharge should be measured with the collection of each fecal coliform sample in order to characterize the dynamics of fecal coliform transport within the surface-water system.

9.5 Future Efforts

This TMDL represents an important step of a long-term restoration project to reduce fecal coliform loading to acceptable levels (meeting water quality standards) in the First Creek, Second Creek, Third Creek, and Goose Creek watersheds. TDEC will evaluate the progress of implementation strategies and modify the TMDL as necessary in the next phase (next five-year cycle). This will include recommending specific implementation plans for delineated and as yet undefined sources and causes of pollution. Cooperation will be maintained with TDA (for possible 319 non-point source grants) and NRCS for support in developing BMPs. The dynamic loading model will 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. In accordance with TMDL guidance (EPA, 1991a), the TMDLs may be refined after additional monitoring and source characterization data are collected.

10.0 PUBLIC PARTICIPATION

In accordance with 40 CFR § 130.7, announcement of the availability of proposed fecal coliform TMDLs for First Creek, Second Creek, Third Creek, and Goose Creek was made to the public, affected dischargers, and other concerned parties and comments solicited. Steps taken in this regard include:

1) Notice of the proposed TMDLs was posted on the TDEC website on December 17, 2001 (see Appendix D). The announcement invited public comment until February 18, 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) Numerous meetings, communications, and activities were conducted by TDEC Division of Water Pollution Control (DWPC) personnel to develop and explain the

TMDLs and to solicit input from TMDL stakeholders. The following is a partial chronology of these activities:

Date(s)	Activity
1/4/01	Data and information request to The University of Tennessee (UT) Water Resources Research Center (WRRC)
1/5	Knoxville-area streams data request forwarded to TDEC DWPC Permitting Section for submittal to City of Knoxville (COK)
1/19	Follow-up to (1/5) data request – forwarded to COK
1/30	Received water quality data, analyzed by Knoxville Utilities Board (KUB), from the TDEC Knoxville Environmental Assistance Center (KEAC)
2/2	Communication with WRRC re: Knoxville-area urban streams, data sources, etc.
3/13	Follow-up data and information request to COK
3/22	EPA Fecal Coliform TMDL Model presentation at North American Lakes Management Conference (in Knoxville) attended by KUB, COK, and TDEC personnel
3/23 (a.m.)	Meeting with COK personnel re: TMDL development
3/23 (p.m.)	Meeting with KUB personnel re: TMDL development
3/29	Journal article on urban bacterial loading provided to COK
4/2	Received precipitation data from COK
4/17	Meeting with KEAC personnel re: coordination of and schedule for TMDL development
4/19	Meeting with TDEC DWPC Permitting Section and KEAC personnel re: Knoxville permits and enforcement actions
4/20	Contacted Knoxville-Knox County Metropolitan Planning Commission (KMPC) re: landuse data for Knox County
4/20	Contacted Knoxville - Knox County - KUB Geographic Information System (KGIS) re: landuse data for Knox County
4/23	Received GIS Database agreement from KMPC
5/10-5/22	Several communications with COK – information exchange
6/24	Signed GIS Database agreement and sent to KMPC

6/29	Draft TMDL (Document I)* provided to KEAC personnel
7/6	Draft TMDL (Document I)* provided to COK, KUB, Tennessee Clean Water Network (TCWN), and Izaak Walton League (IWL)
7/10 (a.m.)	Meeting with KEAC, TCWN, and IWL personnel re: Draft TMDL model results
7/10 (p.m.)	Meeting with KEAC, COK, and KUB personnel re: Draft TMDL model results
7/12	PowerPoint presentation (from 7/10 meetings) provided to COK and KUB
7/13	Comments on Draft TMDL and PowerPoint presentation received from COK
7/18	Water Quality Forum attended by KEAC, COK, Knox County, KUB, WRRC, Ijams Nature Center (INC), Tennessee Valley Authority (TVA), and AmeriCorps personnel. Topics of discussion included the Draft TMDL, the process for stakeholder involvement, and an invitation (by KEAC) for comment on the Draft TMDL.
7/20	Meeting between KEAC and TCWN re: TCWN TMDL concerns
7/24	Response provided to COK comments (dated 7/13)
7/24	Received landuse data from KMPC
8/1	Monthly Newsletter of the Water Quality Forum, *Water Quality Update*, included an article titled “TDEC seeks input on water quality issue” and a questionnaire to be returned to the KEAC
8/17	Water Quality Forum attended by KEAC, COK, Knox County, KUB, WRRC, INC, TVA, IWL, NRCS, UT students, and others. KEAC requested comments on Draft TMDL Implementation Plan (IP)
8/24	Draft IP provided to COK, KUB, TCWN, WRRC and IWL
9/6	Meeting between KEAC and KUB re: data sharing, data management, and mapping
9/12	Meeting between KEAC and COK re: data sharing, data management, and mapping
10/1	Meeting between KEAC and UT Center for Biotechnology re: fecal coliform typing with regard to source
11/15	Received comments on Draft IP from TCWN
11/29	Revised Draft IP received from KEAC
12/12	Draft TMDLs (Documents I and II, with IP)* provided to KEAC personnel

12/14	KEAC notified the Water Quality Forum (electronic mail group) that the Draft TMDLs were available
12/14	TMDL water quality model simulations (and supporting files) provided to COK
12/17	Proposed TMDL (Document I)* posted on TDEC website
12/17-12/19	Proposed TMDLs (Documents I and II, with IP)* provided to COK, KUB, TCWN, NRCS, INC, TVA and Knox County
12/31	Proposed TMDL (Document II)* posted on TDEC website
1/14/02	Proposed TMDLs (Documents I and II)* placed on Public Notice
1/16	Water Quality Forum attended by KEAC personnel to announce availability of draft TMDLs (on public notice) and to advise attendees on submission of comments
2/15, 2/18	Received comments (dated 2/12/02) on proposed TMDLs from KUB
2/18	End of Public Notice period for TMDLs
3/12	KEAC initiated contact with KUB re: comments on proposed TMDLs
3/19	Conference call with KEAC re: response to KUB comments on proposed TMDLs
3/20-3/21	Meeting between KEAC, TDEC DWPC Director, and KUB re: KUB permit and enforcement actions and language to be contained in each (potential bearing on TMDL Implementation Plan language)
4/3	Draft Responsiveness Summary (to comments dated 2/12/02) provided to KUB

* Document I is the TMDL document (Draft/Proposed) for First Creek, Second Creek, Third Creek, and Goose Creek. Document II is the TMDL document (Draft/Proposed) for Baker Creek, Fourth Creek, and Williams Creek.

Written comments were received from one party during the public comment period. These comments are included in Appendix E and TDEC DWPC responses are contained in Appendix F. No requests to hold public meetings were received regarding the proposed TMDLs as of close of business on February 18, 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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REFERENCES

Horner. 1992. *Water Quality Criteria/Pollutant Loading Estimation/Treatment Effectiveness Estimation*. In R.W. Beck and Associates. Covington Master Drainage Plan, King County Surface Water Management Division. Seattle, Washington.

NCSU. 1994. *Livestock Manure Production and Characterization in North Carolina*, North Carolina Cooperative Extension Service, North Carolina State University (NCSU) College of Agriculture and Life Sciences, Raleigh, January 1994.

TDEC. 1998. *Final 1998 303(d) List, June 1998 (Revised July and September 1998).* State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control.

TDEC. 1999. *State of Tennessee Water Quality Standards, Chapter 1200-4-3 General Water Quality Criteria, October 1999.* State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control.

USDA. 1997. *1997 Census of Agriculture, Volume 1, Geographic Area Series, Part 42*, U.S. Department of Agriculture, National Agricultural Statistics Service. AC97-A-42, March 1999.

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

APPENDIX A

Monitoring Data for Fort Loudoun Lake Watersheds

Table A-1. Monitoring Data[1] for Fort Loudoun Lake Watersheds

Date	First Creek at Mile 1.17	Second Creek at Mile 0.00	Third Creek at Mile 0.50	Goose Creek at Mile 0.35
4/3/89	15000			
4/4/89	24000			
4/5/89	23000			
4/10/89	1800			
4/11/89	18000			
4/17/89	900			
4/19/89	25000			
4/24/89	10000			
4/25/89	4500			
4/26/89	3200			
5/2/89	4200			
5/8/89	1500			
5/12/89	3000			
5/15/89	1000			
5/16/89	900			
5/17/89	990			
5/24/89	450			
5/25/89	360			
5/30/89	600			
5/31/89	420			
6/27/89	8200			
6/28/89	1000			
7/27/89	2800			
7/28/89	280			
8/14/89	480			
9/19/89	730			
10/12/89	370			
10/13/89	250			
10/25/89	100			
10/26/89	300			
10/27/89	150			
10/30/89	100			
11/1/89	340			
11/2/89	170			
11/3/89	64			
11/6/89	6500			
11/9/89			900	
11/10/89			40	
11/15/89			3200	
11/16/89			4200	
11/17/89			450	
11/20/89			350	
11/21/89			380	
11/22/89			150	
11/24/89			120	
12/4/89	250			

Date	First Creek	Second Creek	Third Creek	Goose Creek
12/11/89	82			
2/8/90			420	
2/9/90			600	
2/14/90			480	
2/15/90			270	
2/20/90			130	
2/21/90	860			
2/22/90			180	
2/26/90	1500			
2/28/90	4700			
3/1/90	860			
6/12/90	38000			
6/18/90		1300		
6/19/90		1500		
6/22/90		1600		
6/25/90		1400		
6/26/90		2200		
6/27/90		1800		
6/28/90		600		
6/29/90		3700		
7/2/90	630	11800		
7/3/90	2700	3400		
7/5/90		1100		
7/9/90		550		
7/10/90		1700		
7/11/90		1500		
7/12/90		170000		
7/16/90		9000		
7/17/90		5900		
7/19/90		2100		
7/23/90		3600		
7/24/90		1600		
7/25/90				
7/26/90		1800		
7/27/90		1900		
7/31/90		1600		
8/1/90		5000		
8/3/90		390		
8/8/90		1000		
8/13/90				320
8/17/90				370
8/20/90				540
8/21/90				490
8/23/90				2600
8/24/90				1400
8/28/90	550			
8/29/90	600			
8/30/90		12000		
8/31/90		1400		
9/4/90		2100		
9/6/90		580		1400
9/7/90	2200			

Date	First Creek	Second Creek	Third Creek	Goose Creek
9/12/90		2300		
9/13/90				32000
9/14/90		3700		
9/17/90		2400		
9/18/90				520
9/19/90		42000		
9/20/90	520			500
9/24/90		3600		
9/25/90		1		
9/26/90		720		
9/27/90	290			
10/1/90		17000		
10/2/90		2700		
10/3/90				160
10/5/90				530
10/8/90				80000
10/9/90				1400
10/16/90				160
10/18/90	4800			
10/19/90				590
10/23/90	4900			
10/24/90				390
10/30/90	290			
11/1/90	100			
11/5/90				580
11/12/90	180			
11/26/90	150			
12/5/90	260			
12/6/90				110
12/7/90				210
12/20/90	600			
2/25/91		30		
2/27/91		1		
3/5/91				20
3/6/91				130
3/7/91				40
3/25/91			90	
3/27/91			150	
4/1/91			50	
5/8/91	70			
5/10/91			530	
5/14/91		370		
5/15/91				400
5/16/91			570	
5/21/91		510		
5/22/91			600	
5/23/91			500	
5/24/91			360	
5/29/91	1700			1600
5/30/91			4100	
6/4/91		2100		
6/5/91	600			

Date	First Creek	Second Creek	Third Creek	Goose Creek
6/6/91		4200		
6/7/91				490
6/10/91			450	
6/11/91	380			480
6/14/91	430			
6/17/91			1900	
6/18/91	2200			1900
6/20/91				550
6/24/91			610	
7/1/91		600		
7/8/91			300	
7/9/91	320			
7/10/91				400
7/11/91		580		
7/16/91			3100	
7/23/91		2800		
7/24/91		2400		
7/26/91		1700		
7/30/91		1900		
8/2/91		450		
8/5/91		500		
8/6/91		400		
8/7/91		400		
8/8/91		210000		
8/12/91		400		
8/13/91		2600		
8/15/91		3700		
8/16/91		1000		
8/22/91		6000		
8/27/91		600		
8/30/91		900		
9/3/91		1200		
9/4/91		2100		
9/5/91		480		
9/9/91		700		
9/10/91		1700		
9/11/91		450		
9/13/91		3900		
9/16/91		370		
9/17/91		600		
9/19/91		5000		
9/20/91		470		
9/25/91		12000		
9/26/91		900		
9/27/91		300		
9/30/91		2800		
10/1/91		320		
10/2/91		500		
10/3/91		1300		
10/4/91		2600		
10/7/91		90		
10/8/91		550		

Date	First Creek	Second Creek	Third Creek	Goose Creek
10/10/91		390		
10/11/91		180		
10/14/91		330		
10/15/91		5000		
10/16/91		1400		
10/17/91		600		
10/18/91		510		
10/21/91		280		
10/22/91		580		
10/23/91		420		
10/24/91		240		
10/25/91		470		
10/29/91		370		
10/30/91		500		
10/31/91		570		
11/1/91		800		
11/4/91		1		
11/5/91		500		
11/6/91		420		
11/7/91		550		
11/8/91		7000		
11/11/91		540		
11/12/91		390		
11/13/91		450		
11/15/91		700		
11/18/91	120			
11/19/91				140
11/20/91		420		
11/22/91		24000		
11/25/91			580	
11/27/91				490
12/4/91		1800		
12/5/91	2100			
12/6/91				310
12/9/91		37000		
12/10/91		2500		
12/11/91				230
12/12/91	240			
12/13/91	500			
12/17/91			170	
12/18/91		70		
12/19/91		160		
12/20/91				260
12/27/91				280
12/30/91			110	
1/6/92				240
1/7/92		460		
1/9/92	320			
1/15/92			120	
6/22/92	10000			
6/23/92		1100		2200
7/14/92			1200	

Date	First Creek	Second Creek	Third Creek	Goose Creek
7/22/92			410	210
8/3/92	1100			
8/4/92			260	
8/10/92	560			
8/11/92				2400
8/18/92		9100		
8/24/92				380
8/25/92	510			
8/26/92			2300	
8/31/92				400
9/2/92			220	
9/16/92				360
9/21/92	2800			
1/19/93				20
1/22/93	400			
1/27/93				130
2/2/93	180			
2/24/93	210			
3/1/93				270
3/3/93	160			
3/9/93	450	50		
3/10/93	590	390		
3/12/93	1800	100		
3/16/93	2100	260		
3/17/93			1	
3/18/93				3200
3/22/93				500
3/23/93			10	
3/24/93	44000	1500		
3/30/93			300	
3/31/93				350
4/2/93	270	290		
4/6/93			290	
4/7/93				4000
4/8/93	600	100		
4/13/93			400	
4/14/93				14000
4/16/93	2300	490		
4/20/93			450	
4/21/93				4700
4/22/93	2800	1700		
4/27/93			450	
4/28/93				580
4/29/93	270	1500		
5/4/93			470000	
5/5/93				2400
5/10/93			590	
5/11/93				420
5/12/93	450	600		
5/17/93			320	
5/18/93				5800
5/19/93	43000	16000		

Date	First Creek	Second Creek	Third Creek	Goose Creek
5/24/93			1000	
5/25/93				3500
5/26/93	1000	3300		
6/1/93			2900	
6/4/93				450
6/7/93			2400	
6/8/93				1000
6/9/93	1900	270		
6/14/93			1600	
6/21/93			290	
6/22/93				550
6/23/93	820	700		
6/28/93			2100	
6/29/93				800
6/30/93	810	2500		
7/7/93	800			640
7/8/93		1400		
7/13/93			1400	
7/14/93	3200	10000		
7/19/93			1200	
7/20/93				2000
7/21/93	700	3400		
7/26/93			1700	
7/27/93				910
7/28/93	910	550		
8/2/93			560	
8/3/93				9100
8/4/93	1300	1800		
8/9/93			1300	
8/10/93				1800
8/11/93	1600	390		
8/16/93			270	
8/17/93				580
8/18/93	580	2500		
8/23/93			1300	
8/24/93				420
8/25/93	1300			
8/30/93			580	
8/31/93				600
9/1/93	5100			
9/7/93				600
9/8/93	720	560		
9/13/93			490	
9/14/93				310
9/15/93	730			
9/20/93			2700	
9/22/93	3600	550		
9/27/93			27000	
9/28/93				310000
9/29/93	360	1900		
10/4/93			220	
10/5/93				290

Date	First Creek	Second Creek	Third Creek	Goose Creek
10/6/93	400			
10/11/93			310	
10/12/93				2300
10/13/93	490	2400		
10/20/93	350	730		
10/25/93			310	
10/26/93				210
10/27/93		5000		
11/1/93			380	
11/2/93				510
11/3/93	220	1300		
11/8/93			430	
11/10/93	250	910		
11/15/93			1000	
11/17/93	5800	50000		
11/22/93			70	
11/23/93				100
11/29/93			570	
11/30/93				330
12/1/93	200	590		
12/6/93			16000	
12/7/93				480
12/8/93	1100	200		
12/13/93			530	
12/14/93				270
12/15/93	1400	1500		
12/20/93			140	
12/27/93			410	
12/28/93	200	390		
12/29/93				1400
1/3/94			350	820
1/5/94	800	145		
1/10/94			340	46000
1/12/94	3900	1400		
1/24/94			1685	19000
1/26/94	2700	1400		
1/31/94			550	
2/1/94				20000
2/2/94	330	130		
2/7/94			700	
2/8/94				2600
2/9/94	1900	380		
2/14/94			1400	
2/15/94				20000
2/16/94	460	490		
2/22/94				520
2/23/94		22000		
2/28/94			1700	
3/1/94				120
3/2/94	9000	2000		
3/7/94			510	
3/8/94				140

Date	First Creek	Second Creek	Third Creek	Goose Creek
3/9/94	300	410		
3/14/94			450	
3/16/94	120	280		
3/22/94				350
3/23/94	290	250		
3/29/94				39000
3/30/94	5800	3600		
4/4/94			150	
4/5/94				200
4/6/94	21000	10000		
4/11/94			19000	
4/12/94				1800
4/13/94	24000	30000		
4/18/94			990	
4/19/94				260
4/20/94		280		
4/26/94				520
4/27/94	1000	1800		
5/2/94			500	
5/3/94				550
5/4/94		1600		
5/9/94			500	
5/10/94				1620
5/11/94		730		
5/16/94			25000	
5/17/94				1200
5/18/94		1800		
5/25/94		1600		
5/31/94				2000
6/6/94			5100	
6/7/94				4800
6/8/94		21000		
6/13/94			1450	
6/14/94				1820
6/15/94	1800	2800		
6/20/94			3200	
6/21/94				2200
6/22/94		18000		
6/27/94			580000	
6/28/94				2200
6/30/94		1200		
7/5/94				1000
7/6/94		1100		
7/11/94			10000	
7/13/94		3800		
7/18/94			5700	
7/19/94				2200
7/25/94			100000	
7/26/94				5900
8/1/94			15000	
8/2/94		1700		
8/8/94			2300	

Date	First Creek	Second Creek	Third Creek	Goose Creek
8/9/94				2700
8/10/94	1800			
8/11/94		2700		
8/15/94			53000	
8/16/94				1000
8/17/94	47000			
8/18/94		8200		
8/22/94			2300	
8/23/94				590
8/24/94	910			
8/25/94		900		
9/6/94				2000
9/7/94	1200			
9/14/94	900			
9/15/94		900		
9/19/94			2500	
9/20/94				420
9/21/94	5400	2000		
9/28/94		420		
10/3/94			450	
10/4/94				2100
10/5/94	640	330		
10/10/94			4100	
10/11/94				1300
10/12/94	530			
10/13/94		2000		
10/17/94			320	
10/18/94				300
10/19/94	1500			
10/20/94		2100		
10/24/94			250	
10/25/94				440
10/26/94	3200			
10/27/94		2700		
10/31/94			1100	
11/1/94				900
11/2/94	900			
11/7/94			150	
11/8/94				330
11/9/94	230			
11/10/94		4800		
11/14/94			290	
11/15/94				270
11/16/94	90			
11/17/94		210		
11/22/94				450
11/23/94	380			
12/5/94			4000	
12/6/94				290
12/7/94	240			
12/8/94		290		
12/12/94			700	

Date	First Creek	Second Creek	Third Creek	Goose Creek
12/13/94				230
12/14/94	460	360		
12/19/94			110	
12/20/94				26000
12/21/94	80			
12/28/94	64			
1/2/95				80
1/4/95	130			
1/5/95		180		
1/9/95			1350	290
1/19/95		150		
1/23/95			210	700
1/25/95	1450			
1/30/95			480	240
2/1/95	170			
2/2/95		240		
2/6/95			240	
2/7/95				250
2/8/95	310			
2/9/95		280		
2/13/95			80	
2/14/95				330
2/15/95	1450			
2/16/95		4700		
2/21/95				300
2/22/95	300			
2/28/95				1000
3/1/95	800			
3/2/95		420		
3/6/95			330	
3/7/95				110
3/9/95		580		
3/14/95				100
3/15/95	270			
3/16/95		260		
3/21/95				19000
3/22/95	2500			
3/23/95		400		
3/27/95			2200	
3/28/95				300
3/29/95	580			
4/3/95			200	
4/4/95				220
4/5/95	210			
4/6/95		500		
4/10/95			330	
4/12/95		520		
4/13/95	1000			
4/17/95			450	
4/18/95				730
4/19/95	530			
4/20/95		4200		

Date	First Creek	Second Creek	Third Creek	Goose Creek
4/24/95			4550	
4/25/95				340
5/1/95			3200	
5/3/95	6000			
5/4/95				1200
6/7/95	31000			
6/12/95			130000	
6/13/95				2700
6/14/95	1350			
6/15/95		1550		
6/19/95			1260	
6/20/95				560
6/21/95	3200			
6/22/95		3000		
6/26/95			50000	
6/27/95				1530
6/28/95	42000			
7/3/95			3000	
7/5/95				1100
7/6/95		5300		
7/10/95			600	
7/11/95				380
7/12/95	2600			
7/17/95			20000	
7/18/95				560
7/19/95	1500			
7/20/95		1600		
7/24/95			2100	
7/25/95				3000
7/26/95	2000			
7/31/95			3000	
8/1/95				1100
8/2/95	3900			
8/7/95			37000	
8/8/95				350000
8/9/95	3200			
8/14/95			3900	
8/15/95				1000
8/16/95	1100			
8/21/95			13600	
8/22/95				500
8/24/95		3200		
8/28/95			6000	
8/29/95				1400
9/5/95				2000
9/6/95	1300			
9/7/95		640		
9/11/95			5500	
9/12/95				2300
9/13/95		3700		
9/14/95	22000			
9/18/95			19000	

Date	First Creek	Second Creek	Third Creek	Goose Creek
9/19/95				2100
9/20/95		5200		
9/21/95	3400			
9/25/95			1200	
10/3/95				630
10/9/95			400	
10/10/95				450
10/11/95		1900		
10/12/95	450			
10/16/95			590	
10/17/95				550
10/18/95		2200		
10/19/95	470			
10/23/95			820	
10/25/95		450		
10/30/95			580	
10/31/95				340
11/1/95		450		
11/6/95			700	
11/7/95				600000
11/8/95		600		
11/9/95	1300			
11/13/95			600	
11/14/95				360
11/15/95		20		
11/16/95	380			
11/20/95			500	
11/28/95				230
12/4/95			550	
12/11/95			1600	
12/12/95				350
12/13/95	510			
12/18/95			250	
12/19/95				4600
1/2/96				14000
1/10/96	590	180		
1/16/96				500
1/17/96	300	200		
1/22/96			380	
1/23/96				200
2/12/96			280	
2/14/96	170			
2/26/96			350	
3/4/96	150			
3/11/96			320	
3/27/96	70			
4/5/96				140
4/8/96			350	
4/12/96	140			
4/15/96			450	
5/20/96			4500	
5/31/96				350

Date	First Creek	Second Creek	Third Creek	Goose Creek
6/3/96			1200	
6/5/96	900			
6/19/96				1700
6/21/96	1200			
6/24/96			4500	
7/1/96			1000	
7/3/96				600
7/5/96	540			
7/8/96			2000	
8/5/96			1400	
8/9/96				1400
8/19/96				500
9/9/96			3600	
9/18/96				1700
9/20/96			570	
9/25/96	1200			
9/27/96				400
10/2/96			16000	
10/9/96	1100			
10/18/96				5700
10/30/96	1800			
11/4/96			3200	
11/13/96				200
11/27/96				1
12/2/96			3400	
12/18/96			3600	
12/30/96				2200
1/13/97			1500	20
1/22/97	500			
1/27/97				70
2/14/97			120	
2/17/97				80
2/19/97	2800			
3/5/97				500
3/17/97			120	
3/31/97	490			
4/4/97				180
4/18/97	500			
4/21/97			205	
4/30/97				470
5/30/97	1400			
6/4/97	1000			
6/11/97				4700
6/16/97	1500			
6/20/97			270	
7/2/97				2600
7/9/97	1100			
7/18/97	880			
7/28/97			1270	
8/1/97				540
8/22/97	1200			
8/25/97				1080

Date	First Creek	Second Creek	Third Creek	Goose Creek
8/29/97			320	
9/8/97				630
9/26/97			2000	
10/13/97	2090			
10/27/97				610
11/10/97	350			
12/3/97				90
12/5/97			300	
12/10/97	1545			
1/9/98			280	
1/14/98	65			
1/16/98				220
2/9/98	140			
2/11/98			380	
2/13/98				230
3/2/98	600			
3/13/98				580
4/6/98			480	
4/8/98	5400			
4/15/98				350
5/1/98			14545	
5/4/98				570
5/8/98	2500			
6/8/98				650
6/15/98	2000			
6/19/98			3500	
7/13/98	80			
7/15/98				300
7/16/98			990	

[1] Fecal Coliform data in Counts/100 ml.

APPENDIX B

Model Development and Calibration

B.1 Model Set Up

The Fort Loudoun Lake watershed was delineated into 4 watersheds in order to characterize relative fecal coliform bacteria contributions from significant contributing drainage areas (see Figures 1 and 2). Boundaries were constructed so that watershed "pour points" coincided, when possible, with water quality monitoring stations or USGS 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 watershed. 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 Knoxville meteorological station were available for the time period from January 1970 through December 1998. Meteorological data for the period 1/1/88-12/31/98 were used for all simulations. The model was allowed to stabilize for one year (1988) before results from the subsequent 10-year simulation were analyzed.

B.2 Model Calibration

The calibration of the NPSM watershed models involves both hydrology and water quality components. Each model must be calibrated to appropriately represent hydrologic response in the watershed before subsequent calibrations and reasonable water quality simulations can be performed.

B.2.1 Hydrologic Calibration

Hydrologic calibration of the watershed models involves comparing simulated streamflows to historic streamflow data from a USGS stream gaging station for the same period of time. The hydrology portion of the models was derived by calibrating an existing model, developed in a previous TMDL, using a continuous USGS flow gage on the Sinking Creek Headwaters in the Watauga River Watershed: Station No. 03486305 at Johnson City, Tennessee during the period from October 1, 1991 through September 30, 1992. The Sinking Creek Headwaters model was calibrated and model parameters were transferred to the Fort Loudoun models and adjusted based on physical characteristics and best professional judgment. The portion of the Sinking Creek watershed modeled for the calibration simulations corresponds to the drainage area upstream of the USGS station.

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. Finally, best professional judgment was used to adjust model parameters for specific local differences. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge. Results of the hydrology calibration for water year 1992 are shown in Figure B-1.

B.2.2 Water Quality Calibration

Fort Loudoun Lake watershed data, generated by WCS, were processed through the spreadsheet applications developed by Tetra Tech, Inc. to generate fecal coliform loading data for use as initial input to the NPSM model.

B.2.2.1 Point Sources

For existing conditions, NPDES facilities located in modeled watersheds are represented as point sources of constant flow and concentration based on the facility's average flow and effluent fecal coliform concentration as reported on Discharge Monitoring Reports (DMRs).

B.2.2.2 Nonpoint Sources

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

B.2.2.2.1 Wildlife

Fecal coliform loading from wildlife is considered to be uniformly distributed to forest, pasture, and cropland areas in the modeled watersheds. A loading rate of 5.0×10^8 counts/animal/day for deer is based on best professional judgment (BPJ). 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.

B.2.2.2.2 Land Application of Agricultural Manure

In the water quality models, county livestock populations (see Table 4) are distributed to watersheds based on the percentage of agricultural area in each watershed classified as pasture/hay. 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 are applied uniformly 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.

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

B.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 eastern 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. This rate is 2.37×10^{10} counts/acre-day for each of the four modeled watersheds in Fort Loudoun Lake. Contributions of fecal coliform from wildlife (as noted in Section B.2.2.2.1) are also included in these rates.

B.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 calibrated model, this rate varies from 2.5×10^9 to 3.75×10^9 counts/acre-day and is assumed constant throughout the year.

B.2.2.2.5 Other Sources

As previously stated, there are a number of nonpoint 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 watershed, these miscellaneous sources have been modeled as point sources of constant flow and fecal coliform concentration. The <u>initial</u> 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. Literature values were used to estimate the fecal coliform bacteria concentration in beef cow manure.

- The initial baseline loads attributable to leaking septic systems is based on an assumed failure rate of 20 percent.

These flow and concentration variables were adjusted during water quality calibration to alter simulated in-stream fecal concentrations during dry weather conditions.

B.2.2.3 Water Quality Calibration Results

During water quality calibration, model parameters were adjusted within reasonable limits until acceptable agreement between simulation output and in-stream 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 direct sources described in B.2.2.2.5

Fecal coliform grab samples, collected weekly at sampling stations on First Creek, Second Creek, Third Creek, and Goose Creek in the Fort Loudoun Lake watershed were used for comparison with the simulated daily model results. On all four watersheds, at the sampling locations where the watersheds are delineated and model simulations are conducted (the "pour points"), it is possible to identify seasonal trends with available data. The portion of each Fort Loudoun Lake watershed modeled for water quality calibration represented the drainage area upstream of the monitoring station.

Comparisons of simulated and observed daily fecal coliform concentrations at sampling stations in the listed streams are shown in Figures B-2 to B-5. Results show that the models adequately simulate peaks in fecal coliform bacteria in response to rainfall events and pollutant loading dynamics. 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.

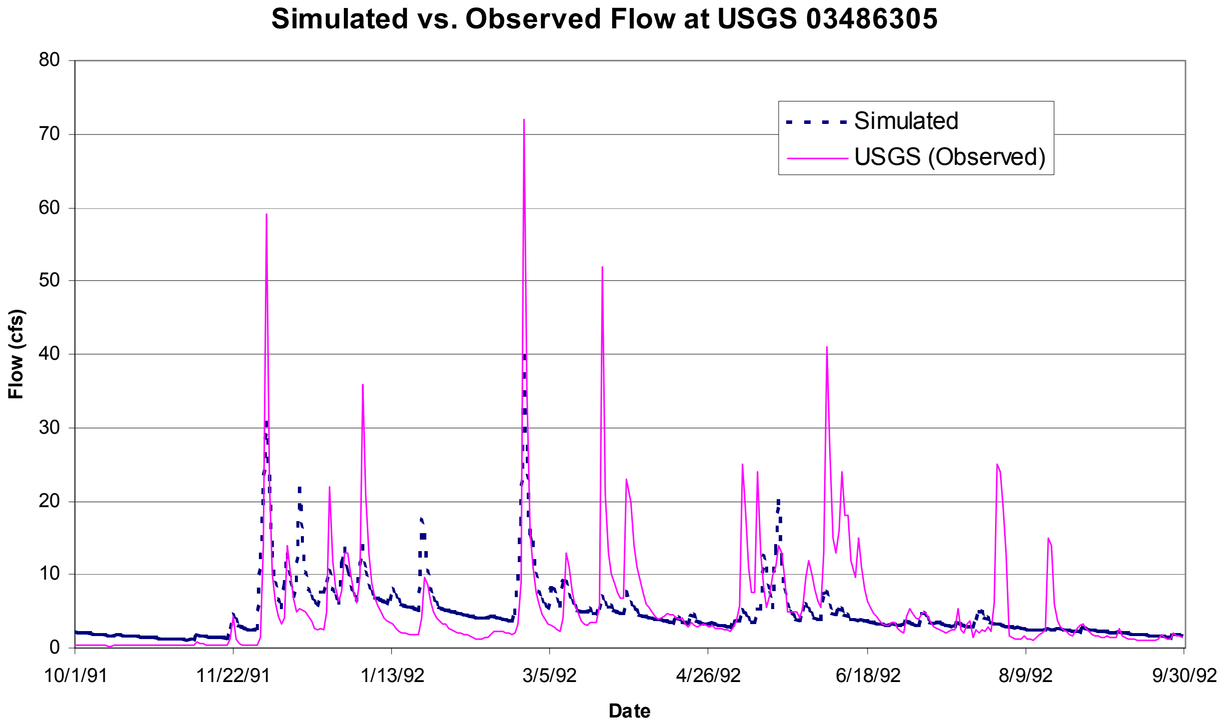


Figure B-1. Hydrology Calibration at USGS 03486305 (WY1992).

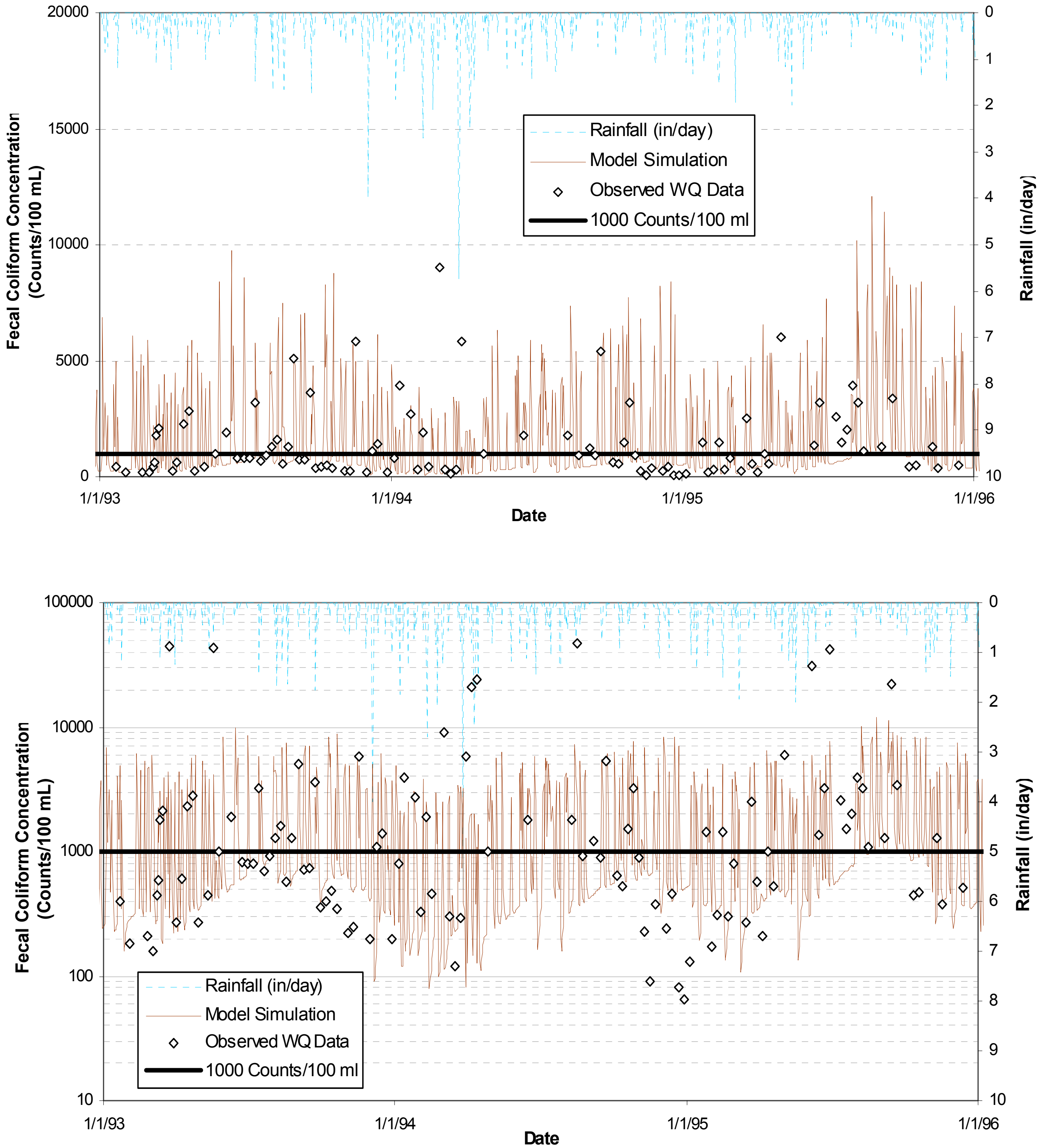
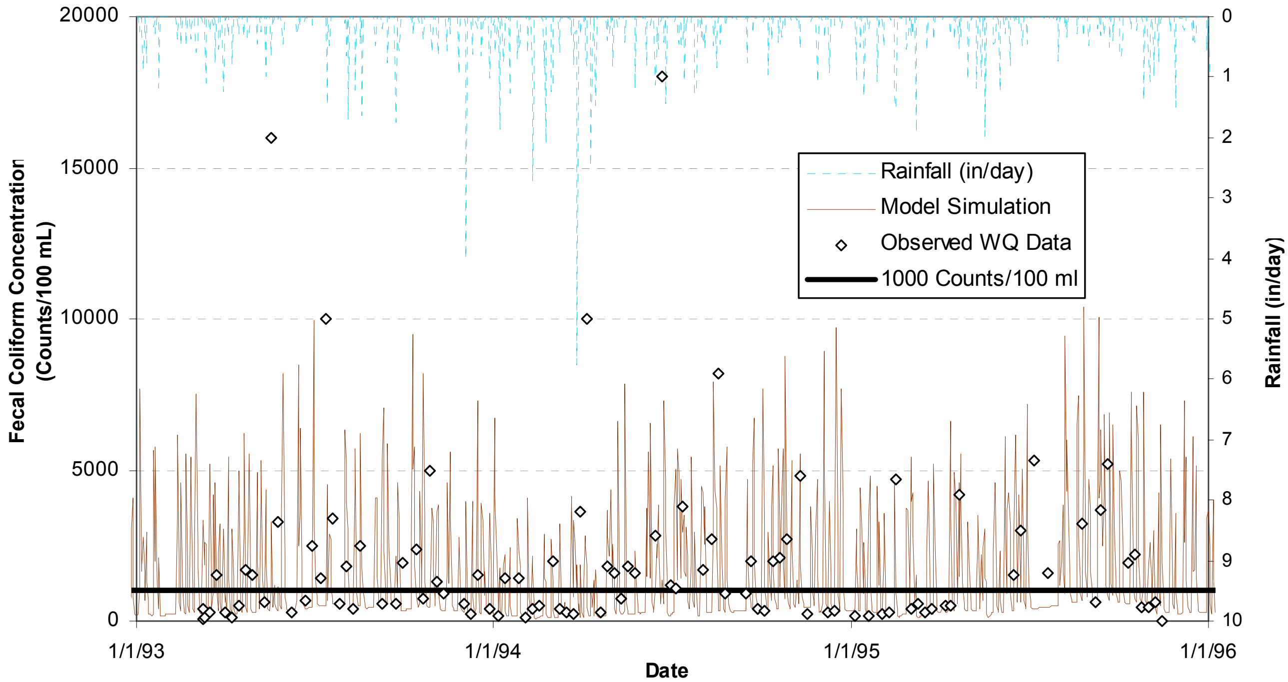


Figure B-2. Water Quality Calibration – First Creek at Mile 1.17 (1993-1995).



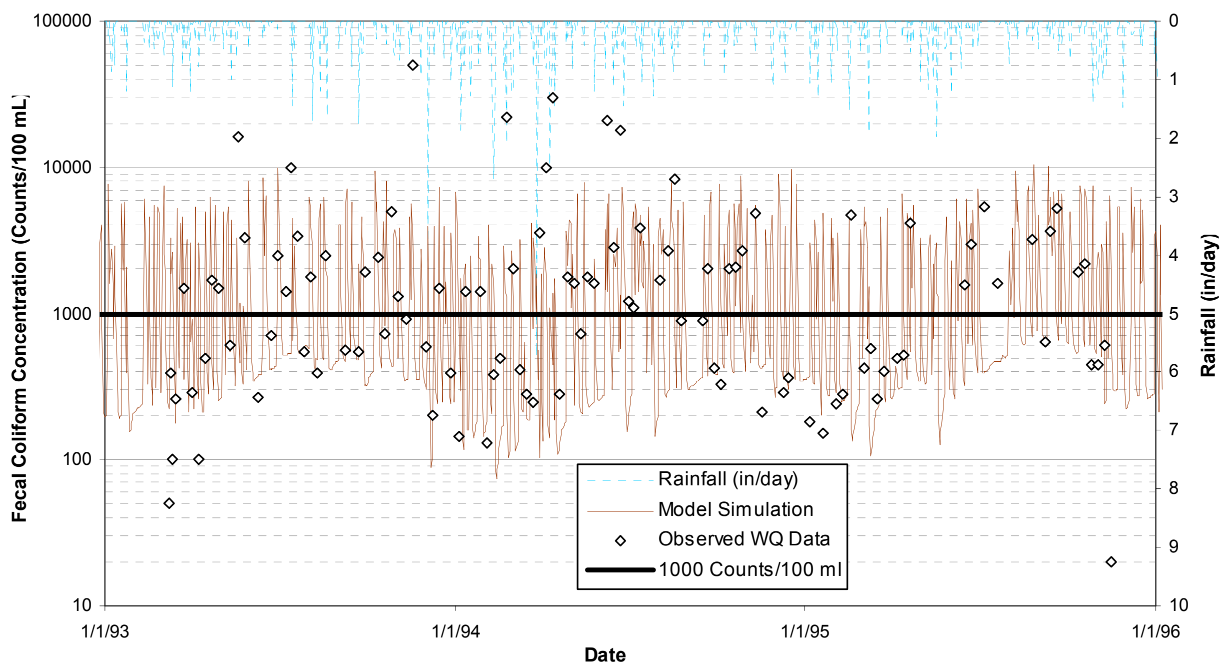
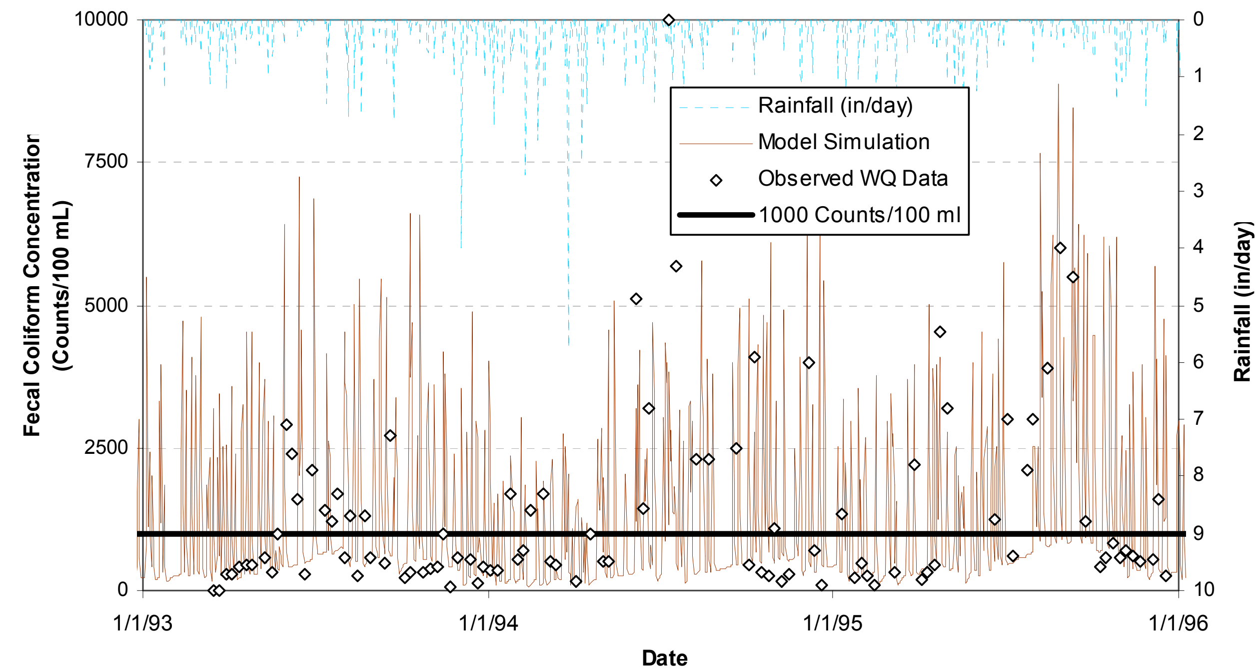


Figure B-3. Water Quality Calibration – Second Creek at Mouth (1993-1995).



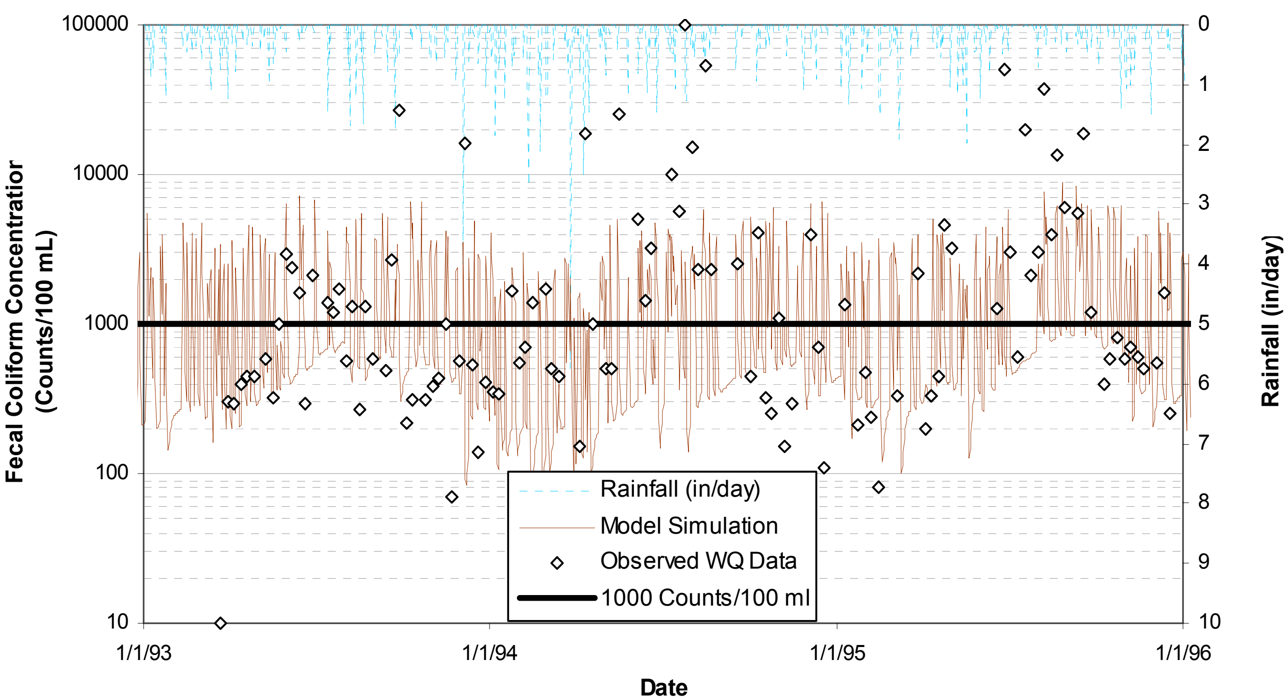
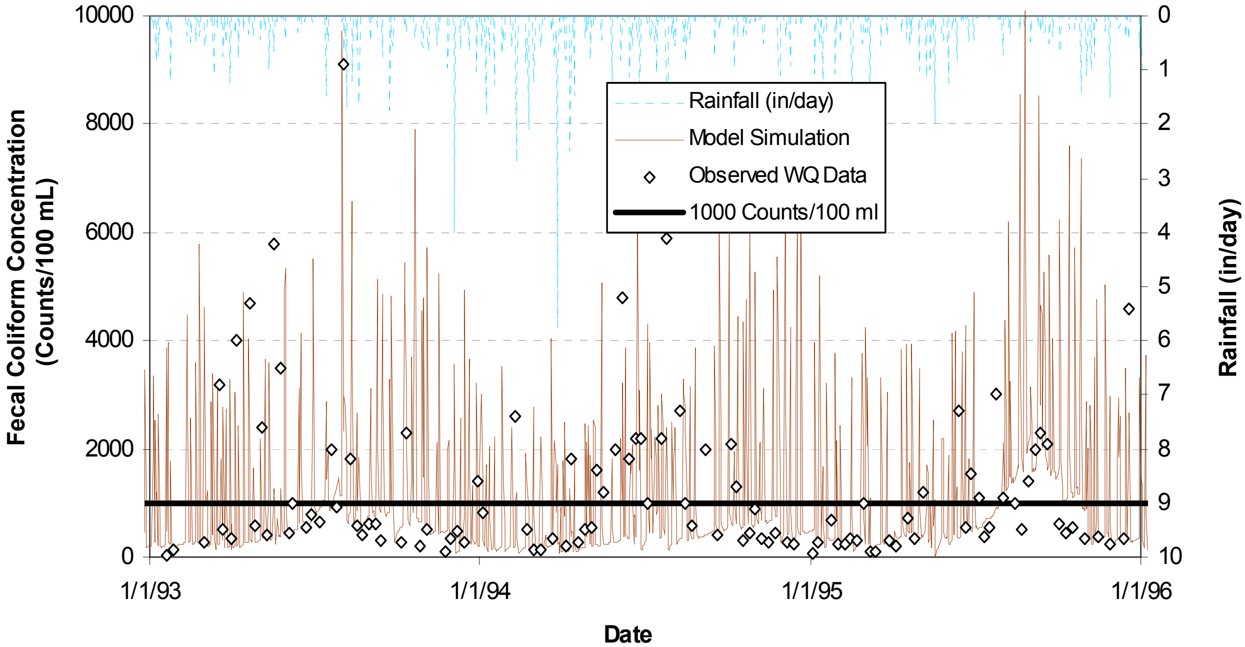


Figure B-4. Water Quality Calibration – Third Creek at Mile 0.50 (1993-1995).



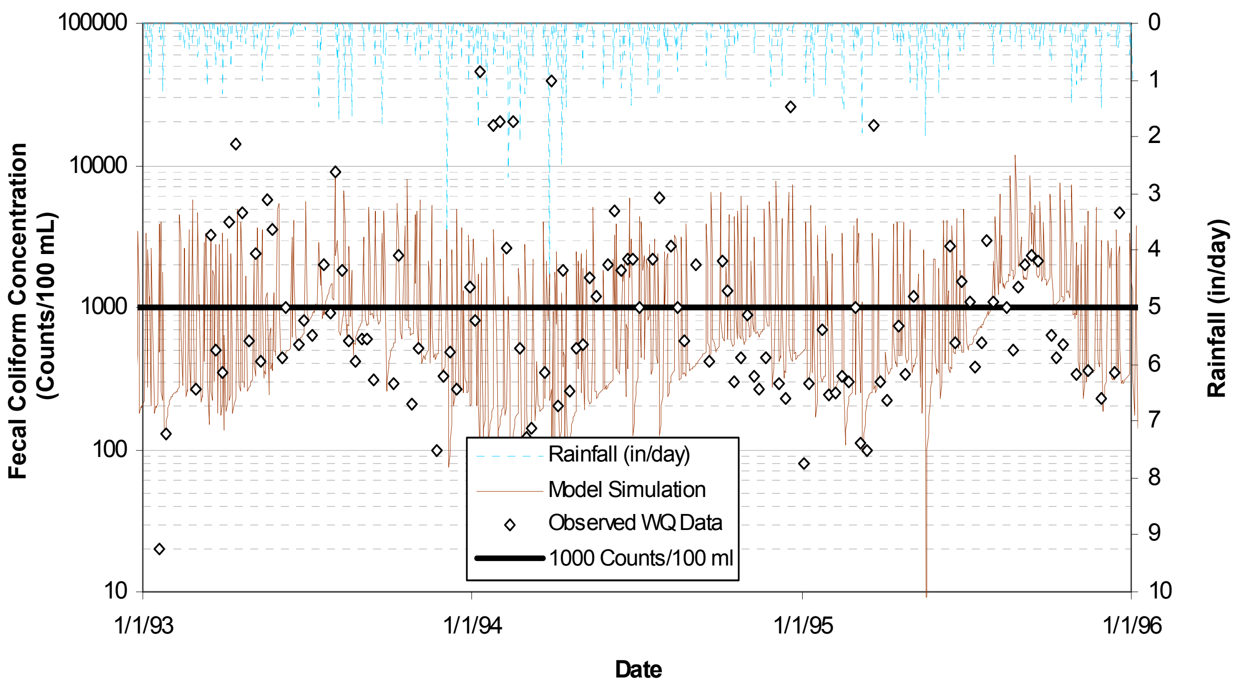


Figure B-5. Water Quality Calibration – Goose Creek at Mile 0.35 (1993-1995).

APPENDIX C

Determination of Critical Conditions

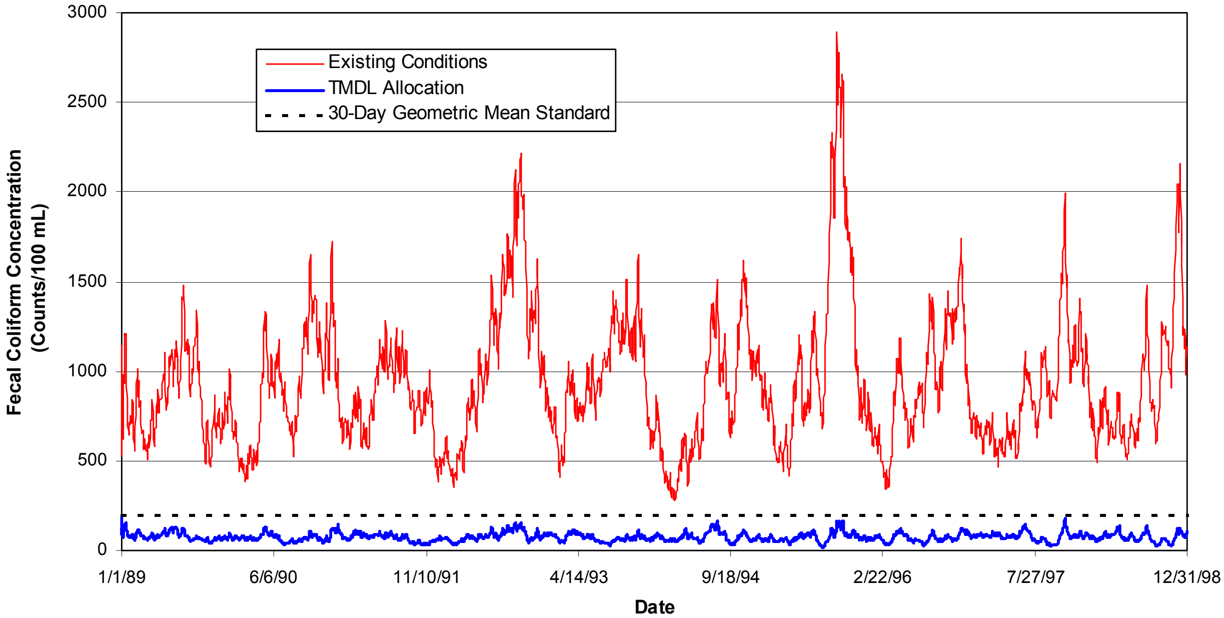


Figure C-1. Simulated 30-DayGeometric Mean Fecal Coliform Concentrations for First Creek at Mile 1.17.

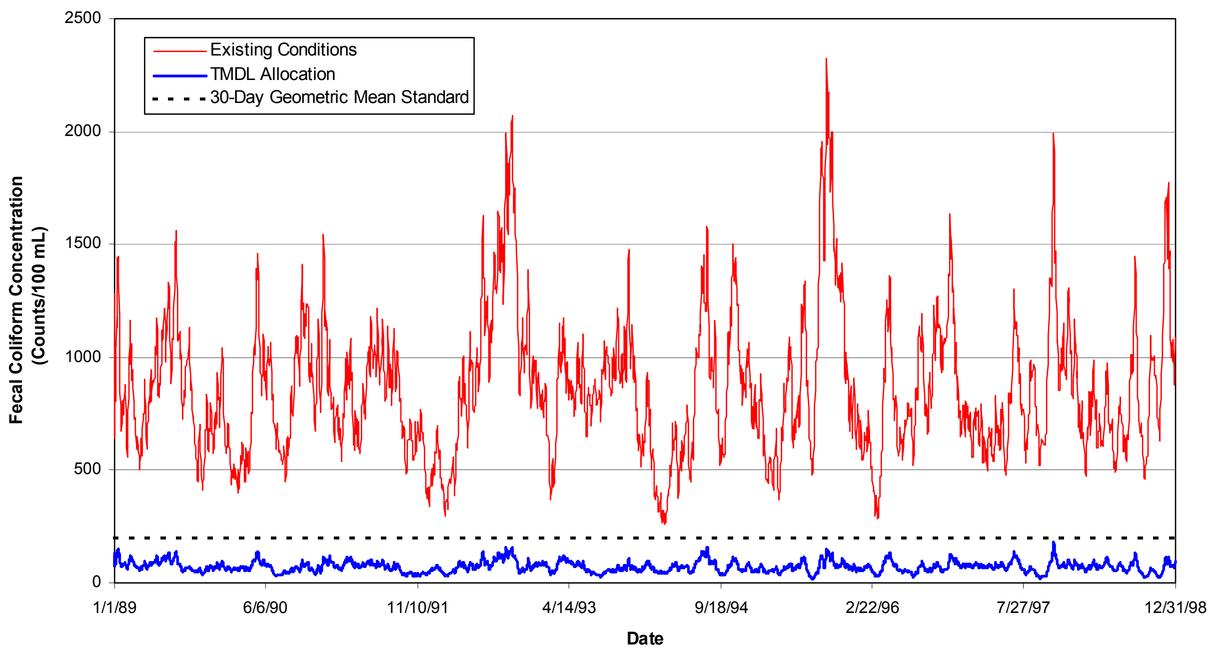


Figure C-2. Simulated 30-Day Geometric Mean Fecal Coliform Concentrations for Second Creek at Mouth.

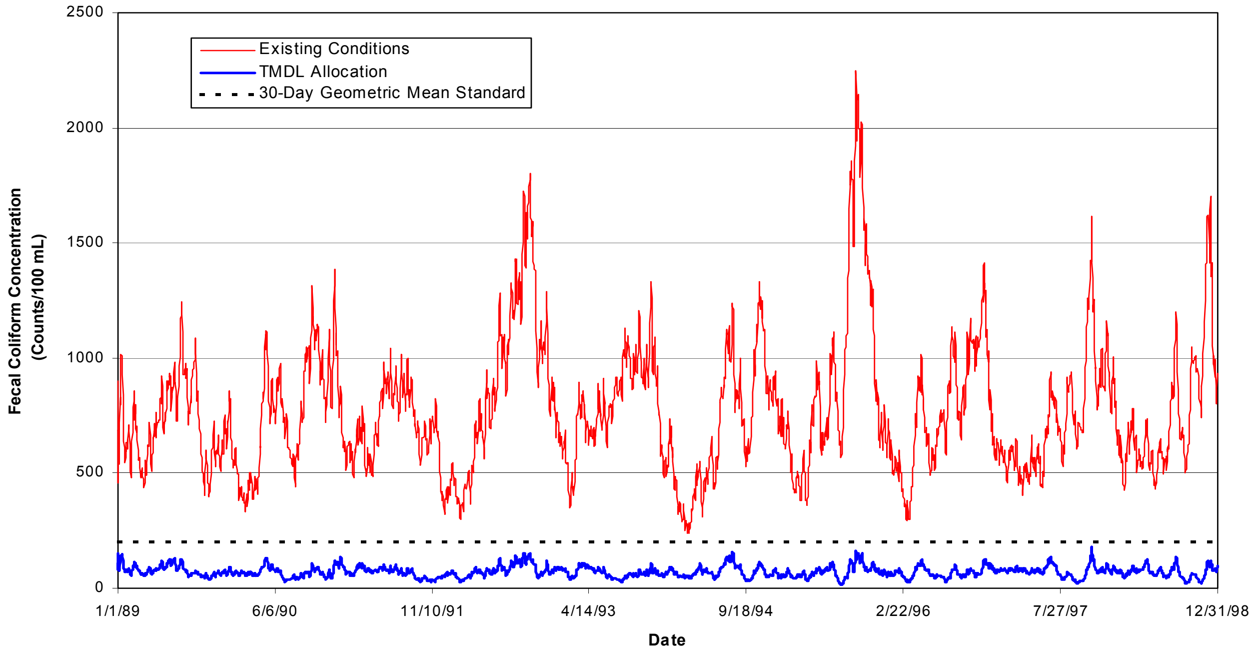


Figure C-3. Simulated 30-Day Geometric Mean Fecal Coliform Concentrations for Third Creek at Mile 0.50.

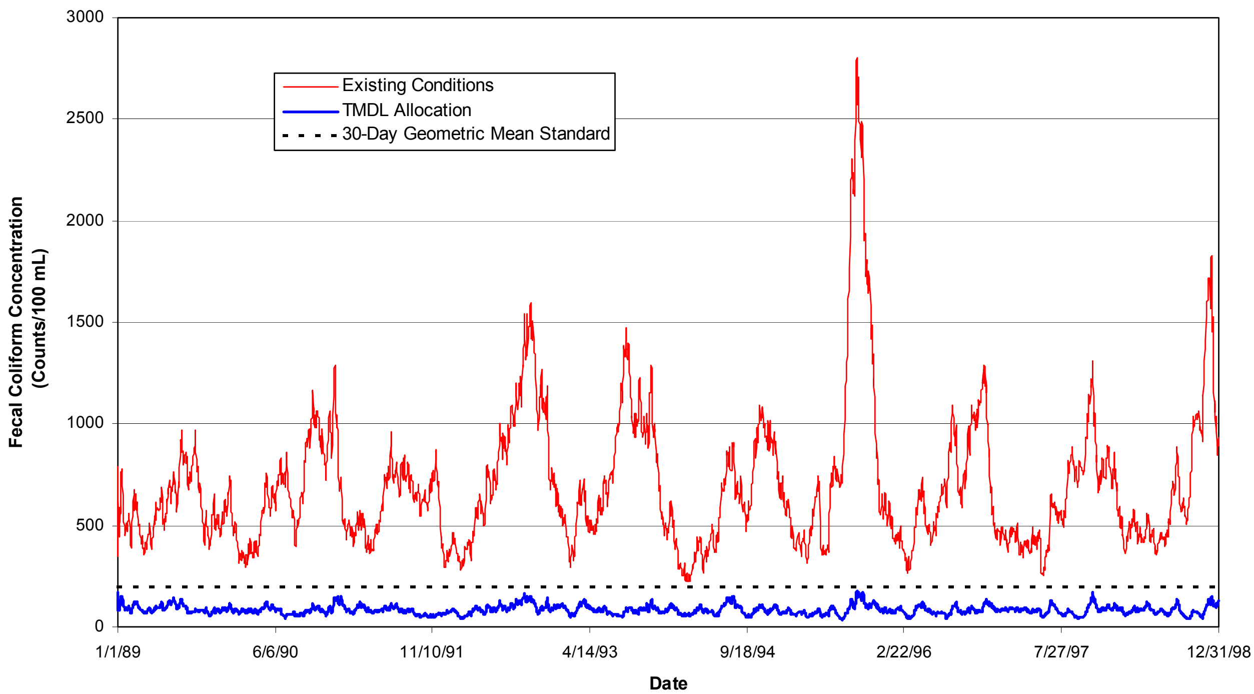


Figure C-4. Simulated 30-Day Geometric Mean Fecal Coliform Concentrations for Goose Creek at Mile 0.35.

APPENDIX D

Public Notice of Proposed Total Maximum Daily Load (TMDL) for Fecal Coliform in the Fort Loudoun Lake Watershed (HUC 06010201)

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 THE FORT LOUDOUN LAKE WATERSHED (HUC 06010103), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed total maximum daily loads (TMDLs) for fecal coliform in the Fort Loudoun Lake watershed. 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.

First Creek, Second Creek, Third Creek, and Goose Creek (TMDL document I) are listed on Tennessee's final 1998 303(d) list as not supporting their designated use classifications due, in part, to pathogens associated with urban stormwater runoff and collection system failure. Baker Creek, Fourth Creek, and Williams Creek (TMDL document II) were not assessed in 1998, and therefore, are not listed on Tennessee's final 1998 303(d) list. However, each of the three waterbodies was assessed in 2000 and each is classified as not supporting its designated use classifications due, in part, to pathogens associated with urban stormwater runoff and collection system failure. The TMDLs require reductions on the order of 91-94% for the seven Fort Loudoun Lake waterbodies.

The proposed Fort Loudoun Lake fecal coliform TMDLs can be downloaded from the following website:

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

Technical questions regarding these TMDLs 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 TMDLs are invited to submit their comments in writing no later than February 18, 2002 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 TMDLs for final submittal to the U.S. Environmental Protection Agency.

The TMDLs 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.

APPENDIX E

Public Comments Received

<u>Knoxville Utilities Board Comments</u>

February 12, 2002

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

Dear Dr. Wang:

RE: TDEC's proposed TMDL for Fecal Coliform in First, Second, Third, and Goose Creeks in the Fort Loudoun Lake Watershed (HUC 06010201)

The Knoxville Utilities Board is pleased to submit the attached comments on the referenced TMDL proposed by TDEC. The comments contained herein reflect KUB's review and opinions of the document.

We look forward to discussing our comments with you at your earliest convenience. If you have any questions or need additional information, please call me at 865-558-2140.

Sincerely,

Ted B. Tyree, P.E.
Manager
Technical Services

cc: Mr. Paul Davis, TDEC – Division of Water Pollution Control
Mr. Dennis Borders, P.E., TDEC – Watershed Management Section
Mr. John West, TDEC – Knoxville EAC

KUB comments on TDEC's proposed TMDL for Fecal Coliform in First, Second, Third, and Goose Creeks in the Fort Loudoun Lake Watershed (HUC 06010201)

1) Page 6, Section 5.0 Water Quality Assessment and Deviation from Target

The proposed TMDL acknowledges that data used for development were not collected at sufficient frequency to calculate 30-day geometric mean values for most of the period of record for all four streams. In lieu of an actual 30-day geometric mean, the TMDL makes reference to the numerous samples that exceeded 1000 counts/100 ml maximum, as the primary basis for the four streams' non-attainment status. Furthermore, due to availability of precipitation data for use in the model, only data collected through December 1998 were used in the water quality calibration.

2) Given these limitations of data, we suggest TDEC reconsider just how representative the data is to current conditions. The bulk of the data used for the model was generated prior to KUB initiating its comprehensive collection system rehabilitation and replacement program in 1997. Prior to that, KUB focused on eliminating the eleven combined sewer overflow points in one area of its collection system downstream of the points at which the four creeks comprising this TMDL empty into Lake Loudoun. Since 1997, KUB has invested over $30M into its rehabilitation and replacement program. Projects completed to date, both at pumping stations and on collection mains, were selected based on a prioritization that targets the elimination of known overflow points.

3) In response to its concerns over the representative nature of the data used for the TMDL, KUB initiated in late October 2001 an effort to generate 30-day geometric mean values for all four streams at the monitoring locations used to calibrate the models. The results of KUB's sampling and analyses are shown in Table 1.

Table 1
Creeks Geometric Mean Calculations
Fecal Coliform Counts (#/100 ml)

Date Sampled	1st Creek Site 1.17	2nd Creek Site 0.00	3rd Creek Site 0.50	Goose Creek Site 0.35
10/22/01	135	250	1285	480
10/23/01	155	110	2000	300
10/24/01	200	460	460	160
10/29/01	155	40	570	1090
10/31/01	30	220	700	220
11/01/01	140	80	390	380
11/02/01	430	110	760	305
11/05/01	120	100	210	480
11/06/01	175	35	530	610
11/07/01	210	20	300	670
Geom. Mean	148	96	585	407

It should be noted that the sampling period above was preceded by approximately six weeks of very little, if any, precipitation. Thus, the geometric mean values reflect "dry weather," low flow conditions. Nonetheless, the above data does raise some interesting questions.

How valid are the assumptions upon which the TMDL model is based? In comparison to the points made in Section 5.0 of the TMDL, only three of the forty data points above exceed 1000 counts/100 ml, with 2000 counts/100 ml being the maximum. Furthermore, the geometric mean calculated for First and Second Creeks, respectively, fall within the target use designation of 200 counts/100 ml (even with the factor of safety). While it is much too early to suggest that First and Second Creeks should be de-listed based on one "dry-weather" geometric mean calculation, it is appropriate to re-consider the rationale offered in Section 5.0 related to TDEC's water quality assessment and perceived deviation from the target. Additional sampling will continue to be done to take into account the effects of seasonal variation.

4) Page 11, Section 8.1 Critical Conditions

The model simulation determined that the critical period is August 20-September 18, 1995. Again, the use of such a period most likely does not accurately reflect the "existing" conditions in the streams. If it does, then one must question to what extent leaking collection systems and/or sanitary sewer overflows are really contributing to the waste loading in the streams.

KUB requests that TDEC consider re-calculating the TMDL using precipitation data and creek monitoring results for the five-year period 1997-2001. As part of the comprehensive flow monitoring effort begun in the mid-1990's, KUB has precipitation data recorded electronically at 15-minute intervals at six different rainfall monitoring stations throughout KUB's wastewater collection system. KUB can provide all of this precipitation data to TDEC to help facilitate a re-calculation of the TMDL for this watershed for the time period 1997-2001.

5) Page 14, Section 8.4.2 Load Allocations

The proposed TMDL document states that loading from leaking sewer system collection lines are modeled as direct sources to the stream and are *independent of precipitation*. The document also states that model results indicate non-point sources related to direct inputs and urban runoff have the greatest impact on fecal coliform bacteria in the four Fort Loudoun Lake watersheds. If leaking sewer system collection lines are independent of precipitation, and a stream potentially meets its designated uses during periods of dry-weather, then perhaps "leaking" sewer collection lines modeled as direct sources are not nearly as much of a contributing factor as is urban runoff. Or, perhaps the dry-weather geometric mean values determined in October and November 2001 reflect, at least in part, the effects of KUB's ongoing, intensive collection system rehabilitation and replacement program in the First Creek drainage basin. Again, these initial results cast further questions on the proposed TMDL's reliance on pre-1999 data as a basis for developing an accurate and representative model.

KUB requests that TDEC reconsider its methodology for assessing the impact of loading from sources modeled as "direct sources."

Possible allocation scenarios that would meet in-stream water quality standards for the listed streams in the Fort Loudoun Lake watershed are listed on the bottom of page 14 of the TMDL document. The terminology "*…..and 100% reduction from direct sources…..*" is used for each of the four creeks. KUB continues to be deeply concerned regarding, and strenuously objects to, the use of such language. TDEC itself has acknowledged that "*100% reduction*" and "*seepage elimination*" are unachievable goals. However, such language continues to be used by TDEC in a regulatory context.

To be consistent with the language used in Section 9.0-Implementation Plan, KUB requests that

TDEC standardize the use of "*...reduction to the maximum extent practicable....*" as substitute language for the numerous references to "*seepage elimination*" and "*elimination of sewage releases" and "100% reduction*."

6) Pages 15-20, Section 9.0 Implementation Plan

KUB is concerned with the content of Section 9.0 in its entirety. The format and content of the Implementation Plan proposed for this Lake Loudoun TMDL represents a dramatic departure from the previous TMDLs drafted to date by TDEC and approved by EPA Region IV. Furthermore, the format and content of the proposed Implementation Plan is unlike any other TMDL Implementation Plan available for review via an internet search, including example TMDLs available from EPA. The specificity with which Section 9.0 is written is unprecedented, and is considered by KUB to be inappropriate for an initial TMDL document. KUB requests that TDEC reconsider their decision to include such specific and prescriptive language within the Fort Loudoun Lake TMDL Implementation Plan.

In addition, comments and requested revisions concerning specific provisions of Section 9.0 follow:

7) Page 16, Section 9.0.2

What is meant by "*unsafe*" water conditions?

8) Page 16, Section 9.0.4

Consistent with other language of Section 9.0, KUB requests that the word "*eliminating*" be replaced with the language "*reducing to the maximum extent practicable.*"

9) Page 16, Section 9.0.6

What is meant by TDEC in Section 9.0.6 regarding Phase 3 – Permits and Strategies? Who is to *"appropriately modify NPDES permits?"* Will this responsibility lie with TDEC? KUB? Stakeholders? or all of the above? Similarly, who is to *"commit to nonpoint source reduction goals?"* KUB would, perhaps, agree to *"consider implementation of"* such actions but would not presently *"commit"* to take future actions when we don't presently know what those actions might be.

10) Page 18, Section 9.1.1 Municipal Entities Covered Under Phase 1

This section proposes that the City of Knoxville's MS4 permit be modified to require the review and revision…..of the SWMP to accomplish the following:

> *b) Reduction of fecal coliform loading, to the maximum extent practicable, due to failing septic systems and miscellaneous sources located within the city limits. Miscellaneous sources include, but are not limited to leaking collection systems, illicit discharges, and unidentified sources.*

KUB requests that the above language for subsection b) at the top of page 18 be deleted in its entirety, and replaced with the following…..

> *b) Reduction of fecal coliform loading, to the maximum extent practicable, due to failing*

septic systems, illicit discharges, and unidentified sources located within the city limits.

The above change avoids the significant legal issue regarding the authority of the City of Knoxville, vis-à-vis KUB, as it relates to the City's MS4 permit. It is KUB's hope that this issue will be resolved following the upcoming public comment period and reissuance by TDEC of the City of Knoxville's MS4 permit.

11) Page 18, Section 9.1.1

In the paragraph following subsection c), replace the language "*are needed in order to*" with the language "*could serve to*."

12) Page 18, Section 9.1.2 Municipal Entities Covered Under Phase 2 Storm Water Regulations

Likewise, KUB requests that similar language for item e) at the top of page 19 be deleted in its entirety, and replaced with the following…..

e) Reduction of fecal coliform loading, to the maximum extent practicable, due to failing septic systems, illicit discharges, and unidentified sources located within the county limits, but outside the city limits.

13) Page 19, Section 9.1.2

In the paragraph following subsection f), replace the language "*are needed in order to*" with the language "*could serve to*". (Note: The same change is suggested to Section 9.3(h) if TDEC does not accept suggested replacement language for Section 9.3.

14) Page 19, Section 9.3 Point Source Facilities

KUB suggests that the title of Section 9.3 be changed from *Point Sources Facilities* to *NPDES Municipal Wastewater Permits and Collection System Operators.*

15) If TDEC proceeds with the inclusion of specific and prescriptive Implementation Plan language, KUB requests that TDEC consider substituting the attached language for Section 9.3. The alternate language is consistent with ongoing discussions currently underway between KUB and TDEC related to post-MOM audit and SSO issues and the TMDL should reflect and be consistent with any resolution of those issues.

1.3 NPDES Municipal Wastewater Permits and Collection System Operators

The primary wastewater control authority within the Fort Loudoun Lake watershed area impacted by this TMDL is the Knoxville Utilities Board (KUB).

TDEC is scheduled to issue KUB new NPDES permits for its primary WWTPs and associated collection systems by July 1, 2002. The new permits will reference this TMDL and reflect the load allocations developed herein.

The TMDL model indicates that leaking collection system lines and other “direct sources” can have a significant impact on bacteria loading in the watershed. Thus, collection system operators are important stakeholders within TDEC’s TMDL Program and watershed management approach, and are encouraged to take an active role in the overall watershed stakeholder process.

Permitted municipal wastewater entities with collection system facilities in the affected watershed should develop public education and notification initiatives that address locations where SSOs may occur during significant rain events. These should include information on projects designed to reduce the likelihood of SSOs in previously identified problem areas. Project information should be available to the public and a means provided for public comment. These public education and notification initiatives should be developed and made available to the public by June 30, 2003, and kept current thereafter.

In addition, permitted municipal wastewater entities must develop and maintain a Sewer Overflow Response Plan (SORP). All SORPs must be submitted to TDEC by June 30, 2002.

All collection system operators with facilities inside the affected watershed must provide to TDEC an annual report and engineering plan detailing the prior calendar year’s activities and efforts related to the reduction of sewage releases from their collection systems to the maximum extent practicable. Annual reports must be submitted to TDEC by June 30 of each year, with initial reports due by June 30, 2002.

APPENDIX F

Response to Public Comments

Responses to Knoxville Utilities Board Comments

Note: responses correspond to numbered comments (see Appendix E)

1) The lack of data "collected at sufficient frequency to calculate 30-day geometric mean values" does not alter or adversely affect the TMDL evaluation methodology. In fact, for each of the TMDLs (2), representing seven (7) streams combined, the quantity of data (and subsequent periods of record) available for analyses exceeded that of most fecal coliform TMDLs previously developed in Tennessee.

2) The subject TMDLs were developed according to an EPA-established protocol and are representative of the respective analysis periods. It is possible, in fact probable, that KUB and other stakeholders have made progress in reducing fecal coliform loading to the subject streams in the time following the TMDL evaluation period. With continued monitoring, subsequent analyses should reflect any progress made.

3) TDEC acknowledges KUB's efforts at collection system rehabilitation and commends KUB for progress to date. However, the rationale offered in Section 5.0 is valid for the period of analysis. The current deviation from the target may be reduced relative to the TMDL evaluation. If this is the case, it will be reflected in subsequent analyses. The TMDL will be revisited during the next five-year watershed cycle.

4) The methodology utilized for the TMDL evaluations was developed by EPA and is currently applied to all fecal coliform TMDLs developed by Tennessee and other Region 4 states (Georgia, Mississippi, Florida, Alabama, South Carolina). EPA Region 4 supports the use of this standardized methodology. These TMDLs are phase I TMDLs and will be revisited in approximately five years. All available monitoring data will be considered at that time.

It is important to note that the target level for the TMDLs is the water quality standard of 200 counts/100 ml (minus 20 counts/100 ml MOS) as a geometric mean. The target is not the level of reduction, as stated in Table 8, applied against the conditions that exist at the time the TMDL is approved. Therefore, any reductions in loading achieved, relative to the levels determined in the TMDL analyses, will ultimately be credited. In other words, if the data collected by KUB in October and November of 2001 are representative of current conditions, then significant progress has already been made and levels of reduction required are now significantly lower. This will be reflected in the next phase of TMDL development. In addition, it is important to continue to monitor conditions on the listed streams in order to document improvement.

5) TDEC will standardize the use of "reduction to the maximum extent practicable" as substitute terminology for "100% reduction" in the TMDL documents.

6) Much of the content of the Implementation Plan is standard and derived from the State's TMDL template. In addition, much of the remainder of the content of the Implementation Plan is site-specific and due to ongoing and planned activities which TDEC and KUB are aware of and expect to occur. Therefore, these items should remain a part of the Implementation Plan. Section 9.3(a) has been removed because March 30, 2002 has already passed and KUB is expected to provide this along with the annual report no later than June 30, 2002. Sections 9.3(c) and 9.3(e) have been removed because of ongoing permit and enforcement negotiations. It is now the position of the State that these items will be better addressed during these negotiations.

7) Section 9.0.2 has been changed to the following:

Phase 1: Risk Communication: Immediately develop a plan for public notification of health hazards including the identification and selection of appropriate mechanisms for notifying stream users when stream concentrations exceed water quality standards.

8) Section 9.0.4 has been edited as requested.

9) It is TDEC's responsibility, in cooperation with all local stakeholders, to modify (as necessary) NPDES permits. It is KUB's responsibility (as with all permittees) to comply with the terms of their permit(s).

10) Because loading from leaking collection systems (including overflows) commingle with other "miscellaneous" sources during storm events and cannot currently be isolated from other sources, it would be unreasonable for the City of Knoxville to ignore this category of sources. The language used in Section 9.1.1.b will not be changed. See below:

Knoxville's MS4 NPDES Permit (TNS068055), Part III.B. Storm Water Management Program (SWMP) Elements, 40 CFR 122.26(d)(2)(iv); Section 2. The Illicit Discharges and Improper Disposal Program (ILL), states, "Specific elements of this program shall include:

g. A program to limit sanitary sewer seepage into the separate storm sewer, subsection (B)(7). The Knoxville Utility Board (KUB) maintains control and operation of the City's municipal sanitary sewer; therefore, compliance with this item is reflected in the permittee's maintenance of adequate legal authority over illicit discharges from the KUB. The permittee shall engage in ongoing communications with the KUB to resolve any such illicit connections or any unauthorized discharges to the MS4 as they are identified."

11) Section 9.1.1 has been edited as requested.

12) See response number 10, above.

13) Section 9.1.2 has been edited as requested.

14) The title of Section 9.3 has been changed as requested.

15) The following language has been substituted for Section 9.3:

The primary wastewater control authority within the Fort Loudoun Lake watershed area impacted by this TMDL is the Knoxville Utilities Board (KUB).

The TMDL model indicates that leaking collection system lines and other "direct sources" may have a significant impact on bacteria loading in the watershed. Thus, collection system operators are important stakeholders within TDEC's TMDL Program and watershed management approach, and are encouraged to take an active role in the overall watershed stakeholder process.

Permitted municipal wastewater entities with collection system facilities in the affected watershed shall develop public education and notification initiatives that address locations where SSOs may occur during significant rain events. These should include information on projects designed to reduce the likelihood of SSOs in previously identified problem areas. Project information should be available to the public and a means provided for public comment. These public education and notification initiatives shall be developed and made available to the public by June 30, 2003, and kept current thereafter.

Permitted municipal wastewater entities shall develop and maintain a Sewer Overflow Response Plan (SORP). All SORPs shall be submitted to TDEC by June 30, 2002.

Permitted municipal wastewater entities shall seek public input and comment on engineering alternatives and develop long-range plans for SSO reduction as well as seepage elimination as part of Phase 3.

All collection system operators with facilities inside the affected watershed shall provide to TDEC an annual report and engineering plan detailing the prior calendar year's activities and efforts related to the reduction of sewage releases from their collection systems to the maximum extent practicable. Annual reports shall be submitted to TDEC by June 30 of each year, with initial reports due by June 30, 2002.