TOTAL MAXIMUM DAILY LOAD (TMDL)

For

Fecal Coliform

In

Cane Creek
Hiwassee River Watershed (HUC 06020002)
McMinn County, Tennessee

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LIST OF ABBREVIATIONS

BMP	Best Management Practices
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
DEM	Digital Elevation Model
DMR	Discharge Monitoring Report
EPA	Environmental Protection Agency
EU	Etowah Utilities
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
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
WY	Water Year (October-September)

SUMMARY SHEET
Total Maximum Daily Load (TMDL)
Cane Creek, Hiwassee River

1. Waterbody Information

State: Tennessee
Counties: McMinn

Major River Basin: Lower Tennessee River Basin
Watershed: Hiwassee River (HUC 06020002)

Waterbody Name: Cane Creek
Waterbody ID: TN06020002081CANECR
Location: Cane Creek from mouth to origin
Impacted Stream Length: 1.7 miles
Watershed Area: 12.2 square miles
Tributary to: Conasauga Creek

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 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): 2.161×10^{10} 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): 9.484×10^{11} counts/30 days

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

Total Maximum Daily Load (TMDL): 9.701×10^{11} counts/30 days, 180 counts/100 ml

FECAL COLIFORM TOTAL MAXIMUM DAILY LOAD (TMDL)
HIWASSEE RIVER WATERSHED (HUC 06020002)

Cane Creek (TN06020002081CANECR)

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 Hiwassee River watershed (HUC 06020002) is located in eastern Tennessee, northern Georgia, and southwest North Carolina (Figure 1). The Tennessee portion of the watershed falls primarily within the Level III Ridge and Valley (67) ecoregion. The Cane Creek watershed lies (predominantly) in the Level IV Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f) and Southern Dissected Ridges and Knobs (67i) ecoregions. Ecoregion 67f is heterogeneous, composed predominately of limestone and dolomite, but including other rock formations and strata with varying characteristics. The ridges of 67i are primarily those with abundant shale that have prominent topographic expressions.

Cane Creek is a tributary to Conasauga Creek and has a drainage area of approximately 12.2 square miles (Figure 2). Cane Creek flows south to southwest and enters Conasauga Creek at approximately mile 8.0. Conasauga Creek enters the Hiwassee River at approximately mile 38.6. 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. Predominate land use in the Cane Creek watershed is forest (60.3%) followed by agriculture (28.7%). Urban areas represent approximately 11% of the total drainage area.

3.0 PROBLEM DEFINITION

EPA Region IV approved Tennessee's final 1998 303(d) list (TDEC, 1998) on September 17, 1998. The list identified Cane Creek 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. Therefore, the objective of this study is to develop a fecal coliform TMDL for Cane Creek in the Hiwassee River watershed.

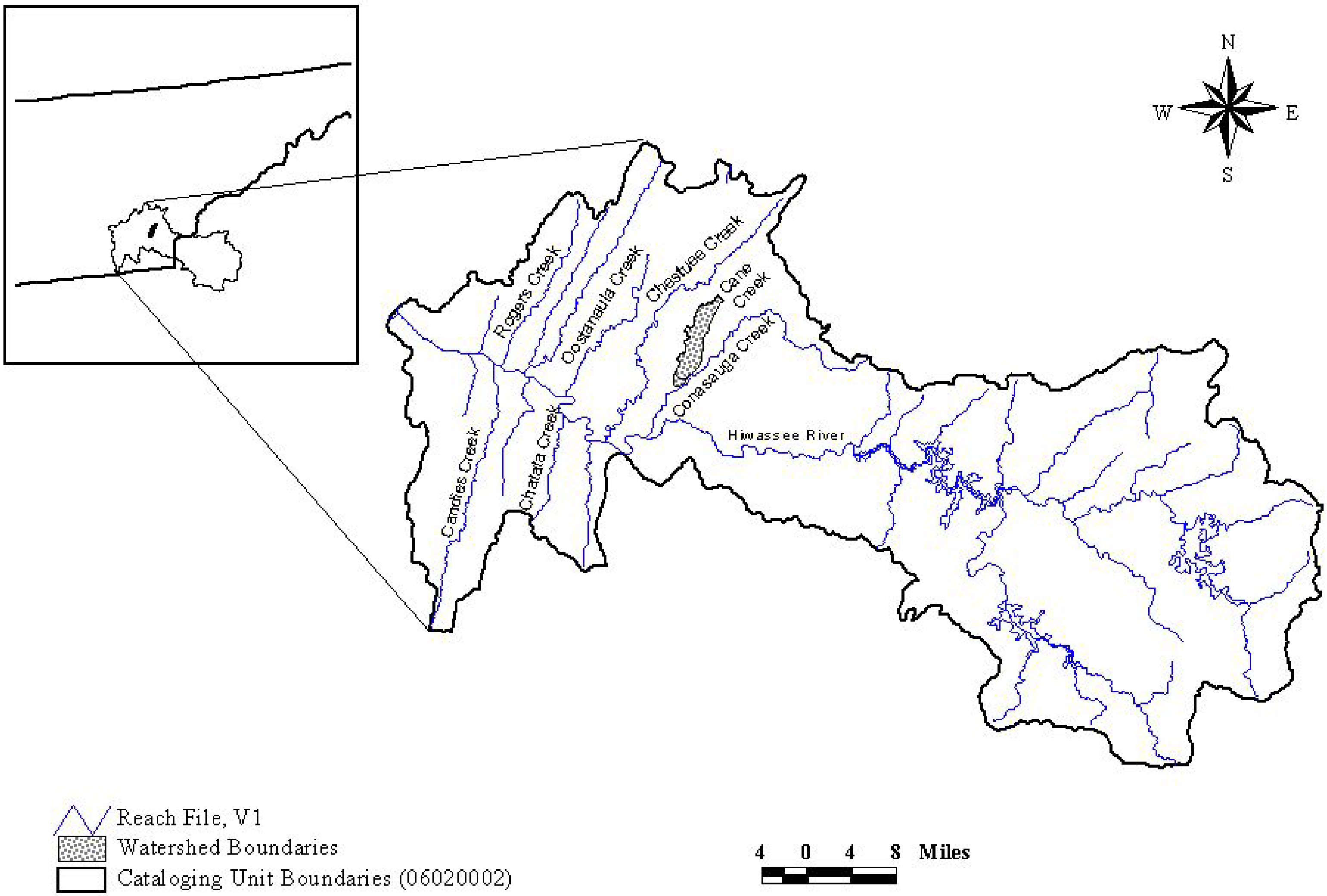

Figure 1. Location of the Hiwassee River and Cane Creek Watersheds.

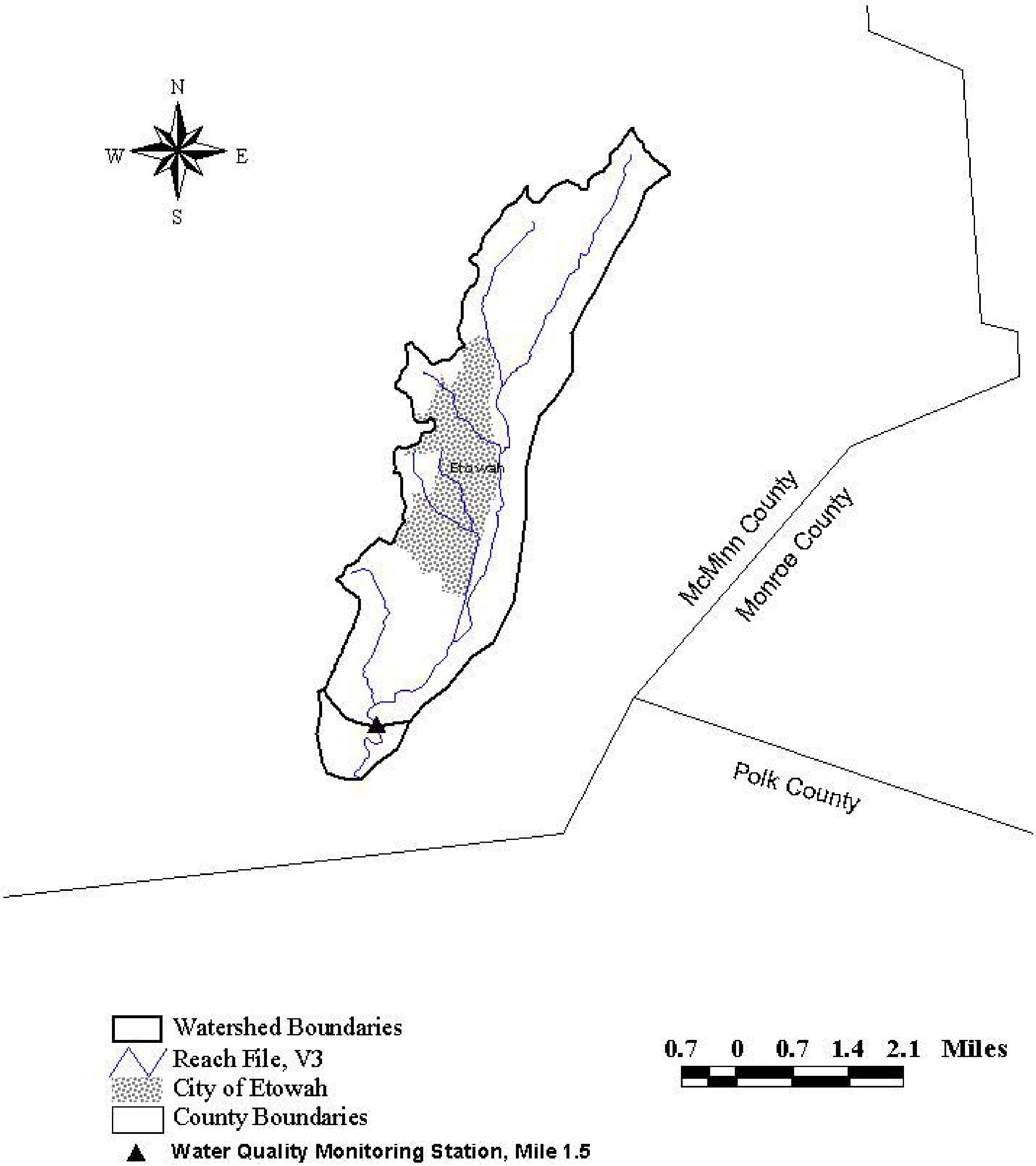

Figure 2. Watershed Boundaries.

Table 1. MRLC Land Use Distribution by Subwatershed

	Canedown (001)		Caneup (002)		Watershed Total	
Land Use	Area (ac)	%	Area (ac)	%	Area (ac)	%
Deciduous	86	19.7	1587	21.4	1673	21.3
Evergreen Forest	41	9.4	1035	14.0	1076	13.7
High Intensity Comm./Industrial /Transportation	0	0.0	208	2.8	208	2.7
High Intensity Residential	0	0.0	73	1.0	73	0.9
Low Intensity Residential	3	0.7	578	7.8	581	7.4
Mixed Forest	91	20.8	1636	22.1	1727	22.0
Open Water	0	0.0	6	0.1	6	0.1
Other Grasses (Urb./recreation; e.g. parks, lawns)	0	0.0	248	3.4	248	3.2
Pasture/Hay	171	39.1	1665	22.5	1836	23.4
Row Crops	45	10.3	365	4.9	410	5.2
Total (mi^2)	437 (0.68)	100	7401 (11.6)	100	7838 (12.2)	100

4.0 TARGET IDENTIFICATION

The designated use classifications for all surface waters in the Cane Creek watershed include Fish & Aquatic Life, Recreation, Irrigation, and Livestock Watering & Wildlife. 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 mean standard is the target value for the TMDL.

The geometric mean standard of 200 counts/100 ml has been selected as the primary target value for the TMDL because it is representative of average stream conditions. In the TMDL, simulated concentrations are expressed in terms of a 10-year plot of the 30-day geometric mean. Critical conditions are determined from this ten-year period (see Section 8.1). A 10-year plot with the proposed reductions is used to show compliance with the geometric mean criteria and to illustrate the criteria has been met for all seasons. An explicit margin of safety (MOS) of 20 counts/100 ml

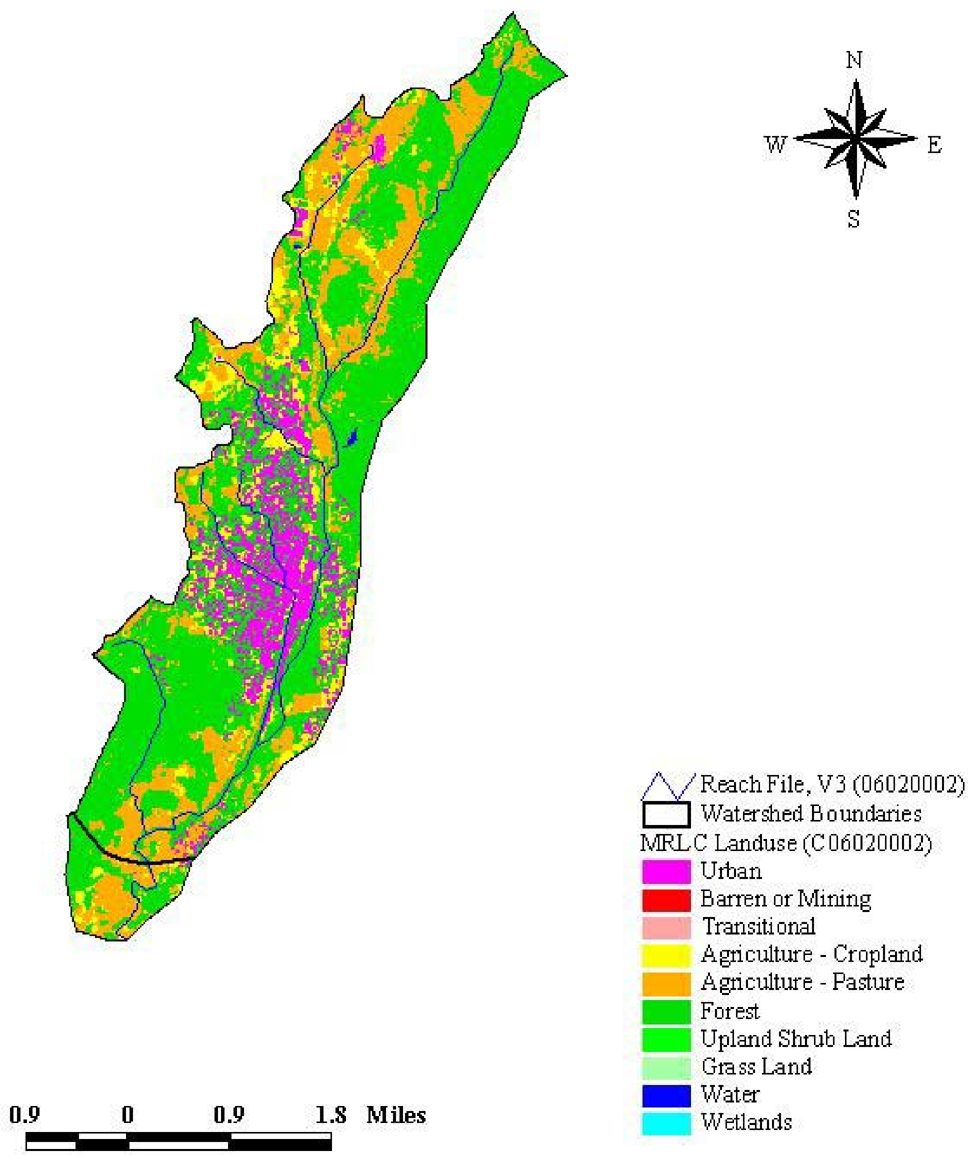

Figure 3. Land Use Distribution

has been included to address uncertainties in the analysis, resulting in an effective target geometric mean concentration of 180 counts/100 ml.

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

5.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

Fecal coliform water quality data have been collected quarterly at Cane Creek mile 1.5 since December 1982. Due to the extensive coverage of this data set and lack of comprehensive data sets at the mouth and/or other downstream locations on Cane Creek, data collected at this location (mile 1.5) were used to calibrate the TMDL model:

Data were not collected at sufficient frequency to calculate 30-day geometric mean values; however, individual samples exceeded the 1000 counts/100 ml maximum (see Table 2). At the water quality sampling location (mile 1.5) utilized for TMDL model calibration, 32% of samples had fecal coliform concentrations exceeding 1000 colonies per 100 ml. Therefore, Cane Creek was scheduled for TMDL evaluation. Due to availability of precipitation data for use in the model, only data collected through December 1999 were used in the water quality calibration.

Table 2. Water Quality Monitoring Data

Watershed/Sampling Location (Mile)	Samples (#)	Samples >200[1] (# / %)	Samples >1000[1] (# / %)	Concentrations (Counts/100 ml)			
				Minimum	Maximum	Mean	Median
Cane Creek (1.5)	56	38 / 68	18 / 32	10	64000	4707	520

[1] Counts/100 ml

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.

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 are two point sources located in the drainage area of Cane Creek that have been issued NPDES permits for discharge of treated sanitary wastewater. The Central High School Package Plant (TN0029475) discharges to an unnamed tributary that enters Cane Creek at approximately mile 8.1. Johns Manville International (TN0042064) discharges to Crockett Spring Branch, a tributary that enters Cane Creek at approximately mile 6.8.

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 Cane Creek 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 Cane Creek 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 Cane Creek in the Hiwassee River watershed are listed in Table 3. 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, 4.18×10^8 counts/day/horse, and 1.38×10^8 counts/day/chicken (NCSU, 1994).

Table 3. Livestock Distribution in the Cane Creek Watershed

Livestock	Canedown (001)	Caneup (002)	Watershed Total
Poultry	12521	121606	134127
Beef Cattle	38	371	409
Dairy	17	162	179
Swine	1	10	11
Horses	3	53	56

6.2.3 Failing Septic Systems

Some fecal coliform loading in the Cane Creek watershed can be attributed to failure of septic systems and illicit discharges of raw sewage. Estimates from county census data of people in the Cane Creek subwatersheds utilizing septic systems are shown in Table 4. 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.

Table 4. Estimated Population on Septic Systems in the Cane Creek Watershed

Subwatershed	No. of People on Septic Systems
Canedown (001)	42
Caneup (002)	848
Cane Creek (Total)	890

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 potential contributors to fecal coliform impairment in the Cane Creek watershed.

7.0 ANALYTICAL APPROACH

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

7.1 Model Selection

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

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 this TMDL, 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.

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 Cane Creek watershed. This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics. Results of the WCS characterizations 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

Two subwatersheds were delineated in order to characterize relative fecal coliform bacteria contributions from each of the contributing drainage areas to the impaired stream (see Figure 2). Boundaries were constructed so that subwatershed “pour points” coincided with the mouth on Conasauga Creek and the primary water quality monitoring station (at mile 1.5). Watershed delineation was based on the Reach File 3 (Rf3) stream coverage and Digital Elevation Model (DEM) data. This discretization allows management and load reduction alternatives to be varied by subwatershed.

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

7.3 Model Calibration

Calibration of the watershed models included both hydrology and water quality components. Hydrologic 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 in the Cane Creek watershed, the USGS gage located at mile 5.66 on Oostanaula Creek (USGS Station 03565500) was used for flow calibration. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge. The Oostanaula Creek model was calibrated and model parameters were applied to the Cane Creek model and adjusted based on physical characteristics and best professional judgment.

The model was 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 the sampling station located at mile 1.5 on Cane Creek. Results show that the model adequately simulates peaks in fecal coliform bacteria in response to storm events and base concentrations during low-flow events.

The details and results of the hydrologic and water quality calibrations are presented in 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, 1990, to December 31, 1999 was used to simulate a continuous 30-day geometric mean concentration to compare to the target. This 10-year period contained a range of 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 for each subwatershed 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 each of the segments evaluated in the Cane Creek watershed, the highest violations of the 30-day geometric mean occurred on October 2, 1993. Therefore, the critical period is September 3 through October 2, 1993.

8.2 Existing Conditions

The existing fecal coliform load for the Cane Creek watershed was determined in the following manner:

- The calibrated model, corresponding to the mouth of Cane Creek, was run for a time period that included the critical condition (9/3/93 – 10/2/93).
- 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., failing septic systems, illicit discharges of fecal coliform bacteria, leaking sewer collection lines, 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 Cane Creek watershed downstream from the city of Etowah. 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 5.

Table 5. Nonpoint Source Loads & In-stream Fecal Coliform Concentrations for Existing Conditions

Subwatershed	Runoff from all Lands	Direct sources	In-Stream Fecal Coliform Concentration
	[Counts/30 days]	[Counts/30 days]	[Counts/100 ml]
At Mile 1.5	4.870×10^{12}	3.519×10^{13}	12,903
At Mouth (Total)	4.890×10^{12}	3.880×10^{13}	10,885

In general, point source loads from NPDES facilities do not significantly contribute to the impairment of Cane Creek since discharges from these facilities are required to be treated to levels corresponding to in-stream water quality criteria. However, the McMinn Central High School Package Plant (TN0029475) had 29 violations of monthly average concentration limits and five (5) violations of daily maximum concentration limits during the period June 1995 to December 1999 (records unavailable prior to June 1995). These releases contribute to fecal coliform loading to and impairment of Cane Creek.

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 this TMDL, 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:

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

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

- The calibrated model was run for a time period that included the critical condition (9/3/93 – 10/2/93).
- 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 subwatershed 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 existing NPDES permitted facilities (Central High School Package Plant and Johns Manville International) were assumed to discharge at design flow and a fecal coliform permit limit 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.
- 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 TMDL, WLAs, & LAs for the Cane Creek watershed are summarized in Table 6.

Table 6. TMDL Components

Watershed	∑WLAs	∑LAs	MOS	TMDL
	[Counts/30 days]	[Counts/30 days]		[Counts/30 days]
At Mouth (Total)	2.161×10^{10}	9.484×10^{11}	Explicit[1] & Implicit	9.701×10^{11}

[1] Explicit MOS = 20 counts/100 ml

8.4.1 Waste Load Allocations

There are two (2) NPDES-permitted facilities that discharge treated sanitary wastewater into Cane Creek. Future facility permits will require end-of-pipe limits equivalent to the water quality standard of 200-counts/100 ml. Future facilities discharging at concentrations less than or equal to the water quality standard will not cause or contribute fecal coliform impairment in the watershed.

8.4.2 Load Allocations

There are two modes of transport for non-point source fecal coliform bacteria loading in the model. First, loading from failing septic systems, illicit connections, leaking sewer system collection lines, 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 Cane Creek watershed. Possible allocation scenarios that would meet in-stream water quality standards for Cane Creek include: 88.7% reduction from runoff and reduction to the maximum extent practicable from "direct sources" of fecal coliform in the stream, resulting in an overall reduction of 97.8%.

Best management practices (BMPs) and control measures 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 to the streams, animal exclusion from streams, riparian buffers, repair of failing septic systems, and facilities meeting their permit limits for discharge of fecal coliform. Fecal coliform loading rates for the allocation scenario are shown in Table 7. Additional monitoring and surveys of the watershed 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 varying monthly loading rates and daily meteorological data over a ten-year period.

Table 7. TMDL Allocations for the Cane Creek Watershed

Watershed	Runoff Load	"Direct Sources"	Point Sources	Overall Reduction (Existing to Allocated Conditions)
	[Counts/30 days]	[Counts/30 days]	[Counts/30 days]	[%]
At Mouth (Total)	5.536×10^{11}	3.948×10^{11}	2.161×10^{10}	97.8

9.0 IMPLEMENTATION PLAN

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

9.1 Awareness and Education

The TMDL model supports existing evidence suggesting there are many sources of fecal coliform bacteria entering Cane Creek along its 20.6 miles, inclusive of tributaries, from the headwaters to the mouth on Conasauga Creek in McMinn County. Before many of these sources can be tackled, the citizens of the watershed must be made aware of the different sources, how those sources are contributing to Cane Creek, and what action alternatives are available to stop these sources of fecal coliform bacteria from reaching the creek and its tributaries. The following actions are recommended:

ELEMENTS OF AWARENESS AND EDUCATION PROGRAM		
ACTION ITEM	**PARTICIPANTS**	**MILESTONE**
Obtain copies of available public education materials that address the various sources of fecal coliform bacteria contamination reaching Cane Creek (e.g., operation and maintenance of septic tanks and field lines, urban area stormwater, pet and animal waste, and other appropriate topics);	Etowah Utilities (EU) (Lead), City of Etowah, McMinn County, Tennessee Valley Authority (TVA), NRCS, Southeast TN Resource Conservation and Development Council (SETRCDC), TN Department of Agriculture (TDA), TN Department of Environment and Conservation (TDEC)	2003
Distribute educational materials to targeted audiences via various methods (e.g., mass mailings, exhibits at special events, classrooms, web sites, and “one-on-one” discussions);	EU (Lead), City of Etowah, McMinn County, NRCS, SETRCDC, TDA	2003 thru 2008

ELEMENTS OF AWARENESS AND EDUCATION PROGRAM (CONT.)		
ACTION ITEM	**PARTICIPANTS**	**MILESTONE**
Develop presentation modules and establish a “Cane Creek Clean Water Speakers Bureau” and seek opportunities to speak to social, civic and business groups, churches, and schools that exist within the watershed;	City of Etowah (Lead), EU, McMinn County, NRCS	2003 thru 2008
Offer a water quality education program to area schools and incorporate a lesson element on non-point sources of pollution.	EU (Lead), City of Etowah	2003 thru 2008

9.2 Monitoring Program

Documenting progress in reducing the quantity of fecal coliform bacteria entering Cane Creek is an essential element of the TMDL Implementation Plan. Documentation requires that data and information be collected, analyzed, and periodically reported to the residents of the Cane Creek watershed. The following actions are recommended:

ELEMENTS OF MONITORING PROGRAM		
ACTION ITEM	**PARTICIPANTS**	**MILESTONE**
Establish a streamflow gaging station on Cane Creek;	EU (Lead), City of Etowah, McMinn County, U. S. Geological Survey (USGS), TDA, TDEC	2003 thru 2008
Monitor fecal coliform bacteria at several locations along Cane Creek at regular intervals, including low, normal, and high flow conditions;	EU (Lead), City of Etowah, McMinn County, TDEC	2003 thru 2008
Conduct project-specific monitoring, which would document the improvements in water quality when various Best Management Practices (BMPs) are installed to solve specific source problems.	SETRCDC (Lead), NRCS, McMinn County, City of Etowah	Variable Dates

9.3 Actions

The goal of a clean Cane Creek requires that the citizens, local governments, businesses, and organizations work together to reduce and remove the numerous sources of fecal coliform bacteria entering the Creek. The following elements of the TMDL Implementation Plan will help achieve the goal:

ELEMENTS OF ACTION PROGRAM		
ACTION ITEM	**PARTICIPANTS**	**MILESTONE**
Identify and prioritize areas within the Cane Creek watershed for their potential to contribute large quantities of fecal coliform bacteria to the creek	City of Etowah (Lead), NRCS, McMinn County, TDA	2003
In lieu of designation of the City of Etowah as a Phase II MS4 regulated by NPDES Permitting Authority[1], develop a Storm Water Inspection and Control Program (SWP). The SWP shall cover a 5-year period after which Etowah will be evaluated for Phase II designation. The SWP should comprise a comprehensive planning process which involves public participation and intergovernmental coordination to reduce the discharge of fecal coliform to the maximum extent practicable using management practices, control techniques, public education, and other appropriate methods and	City of Etowah	2003 thru 2008
Recommended to support the SWP: Requirements that all new and replacement sanitary sewage systems are designed to minimize discharges from the system into the storm sewer system;	City of Etowah, EU	2003 thru 2008
Recommended to support the SWP: 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;	City of Etowah, EU	2003 thru 2008
Recommended to support the SWP: Require NPDES facilities to comply with permit limits (wrt fecal coliform);	EU, City of Etowah, TDEC	2003 thru 2008

ELEMENTS OF ACTION PROGRAM (CONT.)		
ACTION ITEM	**PARTICIPANTS**	**MILESTONE**
Prepare an Annual Cane Creek Clean Water Report, which describes the accomplishments achieved in each of the major parts of the Implementation Plan. Recommendations should be included for further action to reduce sources of fecal coliform causing impairment of water quality.	EU (Lead), City of Etowah, McMinn County, NRCS, TSERCDC, TDA, TDEC, TVA, USGS	2003 thru 2008

[1] At this time, it is not recommended that Etowah be designated a Phase II MS4 under NPDES Permitting Authority. However, it is recommended that the City of Etowah establish a fecal coliform source assessment and reduction program to reduce the sources of fecal coliform impairment to Cane Creek. TDEC will evaluate the progress of implementation strategies in the next phase of TMDL development (five-year cycle). At that time Etowah's status for recommended designation as a Phase II MS4 will be reevaluated.

10. 0 PUBLIC PARTICIPATION

In accordance with 40 CFR § 130.7, announcement of the availability of the proposed fecal coliform TMDL for Cane 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 TMDL was posted on the TDEC website on November 25, 2002 (see Appendix D). The announcement invited public comment until January 9, 2003.

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

3) A stakeholder meeting was held on August 6, 2002 to discuss the proposed TMDL and fecal coliform model results. Attendees included representatives of TDEC, NRCS, TDA, Etowah Utilities, the City of Etowah, and a consultant (Consolidated Technologies, Inc. [CTI]) representing the city of Etowah and Etowah Utilities. Draft copies of the proposed TMDL (excluding Implementation Plan) were provided to each attendee.

4) A Cane Creek TMDL Implementation Plan development meeting was held on September 13, 2002. Attendees included representatives of TDEC, TDA, Etowah Utilities, the City of Etowah, and CTI. Attendees identified essential elements for inclusion in the TMDL Implementation Plan, which was then drafted by TDEC, Chattanooga Environmental Assistance Center personnel. The Draft Implementation Plan was subsequently provided to each contributor for comments and revisions. Only minor revisions were suggested; therefore, follow-up meetings were not required.

No written comments were received during the Proposed TMDL public comment period. No requests to hold public meetings were received regarding the proposed TMDL as of close of business on January 9, 2003.

11.0 FURTHER INFORMATION

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

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

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

Dennis M. Borders, P.E., Watershed Management Section
e-mail: Dennis.Borders@state.tn.us

Sherry H. Wang, Ph.D., Watershed Management Section
e-mail: Sherry.Wang@state.tn.us

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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.

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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.

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APPENDIX A

Monitoring Data for the Cane Creek Watershed

Table A-1. Monitoring Data for Cane Creek, Mile 1.5.

Date	Fecal Coliform (Counts/100 ml)
12/16/82	5800
3/8/83	180
6/7/83	700
9/20/83	160
12/13/83	300
3/13/84	70
6/12/84	1280
9/11/84	70
12/11/84	80
3/12/85	430
9/10/85	260
12/10/85	80
3/11/86	140
6/18/86	160
9/23/86	320
12/9/86	17000
3/10/87	770
6/9/87	200
9/15/87	9600
12/8/87	90
3/15/88	980
6/7/88	10
8/10/88	230
9/13/88	350
12/13/88	1400
3/7/89	3500
6/7/89	6400
3/15/90	128
6/13/90	790
9/11/90	880
12/12/90	42
3/12/91	44
6/11/91	210
9/10/91	130
12/4/91	7000
3/10/92	64000
6/9/92	40000
6/10/92	40000
9/15/92	600
11/4/92	2000
11/4/92	770
12/9/92	1600

Date	Fecal Coliform (Counts/100 ml)
2/16/93	14000
3/31/93	80
6/23/93	490
12/6/93	3200
3/15/94	190
6/20/94	790
9/13/94	250
12/12/94	820
3/13/95	30
6/12/95	31000
9/18/95	1110
12/11/95	550
3/18/96	380
6/10/96	1960

APPENDIX B

Model Development and Calibration

B.1 Model Set Up

The Cane Creek watershed was delineated into 2 subwatersheds in order to characterize relative fecal coliform 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. 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 Conasauga meteorological station were available for the time period from January 1970 through December 1999. Meteorological data for the period 1/1/89-12/31/99 were used for all simulations. The model was allowed to stabilize for one year (1989) before results from the subsequent 10-year simulation were analyzed.

B.2 Model Calibration

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

B.2.1 Hydrologic Calibration

Hydrologic calibration of the watershed model 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 model was derived by calibrating an existing model, developed in a previous TMDL, using a continuous USGS flow gage on Oostanaula Creek: Station 03565500, near Sanford, Tennessee during the period from January 1, 1980 through March 31, 1991. The Oostanaula Creek model was calibrated and model parameters were transferred to the Cane Creek model and adjusted based on physical characteristics of the watershed and best professional judgment.

Initial values for hydrologic variables were taken from an EPA developed default data set. During the calibration process, model parameters were adjusted within reasonable constraints until acceptable agreement was achieved between simulated and observed streamflow. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge. Results of the hydrology calibration for water year 1982 are shown in Figure B-1.

B.2.2 Water Quality Calibration

Cane Creek 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 varying flow and concentration based on the facility's 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 is 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 Cane Creek watershed. A loading rate of 5.0×10^8 counts/animal/day for deer is based on best professional judgment. 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 model, livestock populations (see Table 3) are distributed to subwatersheds based on information derived from WCS. 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 according to application practices 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, horses, and chicken are 1.06×10^{11} counts/day/beef cow, 1.04×10^{11}

counts/day/dairy cow, 1.24×10^{10} counts/day/hog, 4.18×10^{8} counts/day/horse, and 1.38×10^{8} counts/day/chicken (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 each subwatershed is assumed to be relatively constant. However, this rate varies across subwatersheds due to the variable beef cattle populations in each subwatershed. 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 is 2.5×10^{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, 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 initial baseline values of flow and concentration were estimated using the Tetra Tech, Inc. developed spreadsheets and the following assumptions:

- The load attributed to animals having access to streams is initially based on the beef cow population in the watershed. The percentage of animals having access to streams is derived from assumptions on animals in operations that are adjacent to streams and seasonal and behavioral assumptions. 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 coliform concentrations during dry weather conditions.

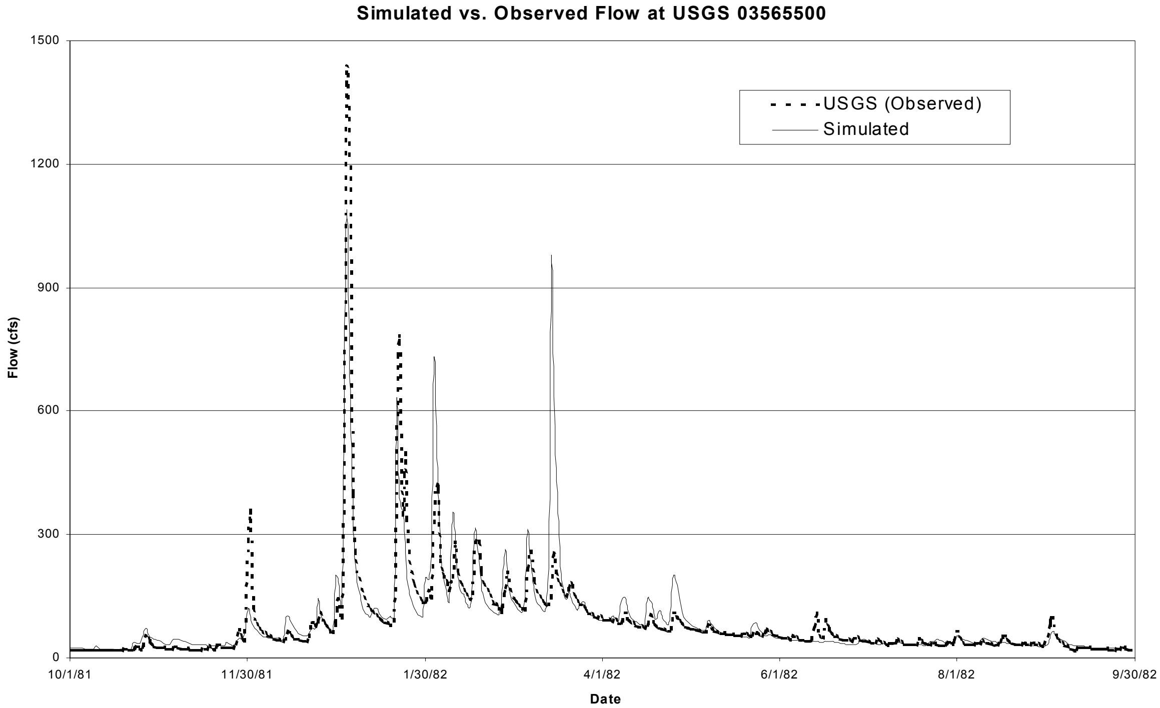
B.2.2.3 Water Quality Calibration Results

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 approximately quarterly at the sampling station at mile 1.5 on Cane Creek in the Hiwassee River watershed were used for comparison with the simulated daily model results. Water quality calibration was conducted at mile 1.5 and extended, through model simulation, to the mouth of Cane Creek to complete the TMDL evaluation.

Comparison of simulated and observed daily fecal coliform concentrations at the sampling station at mile 1.5 on Cane Creek is shown in Figure B-2. Results show that the model adequately simulates 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.



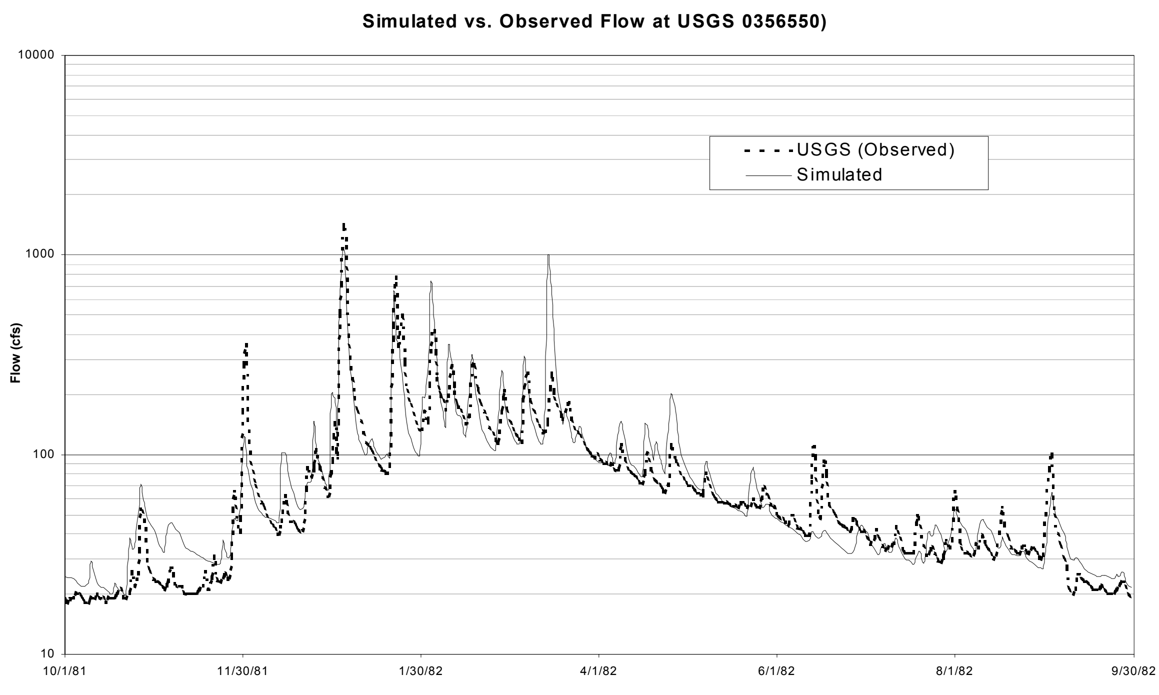


Figure B-1. Hydrologic Calibration at USGS 03565500 (WY 1982).

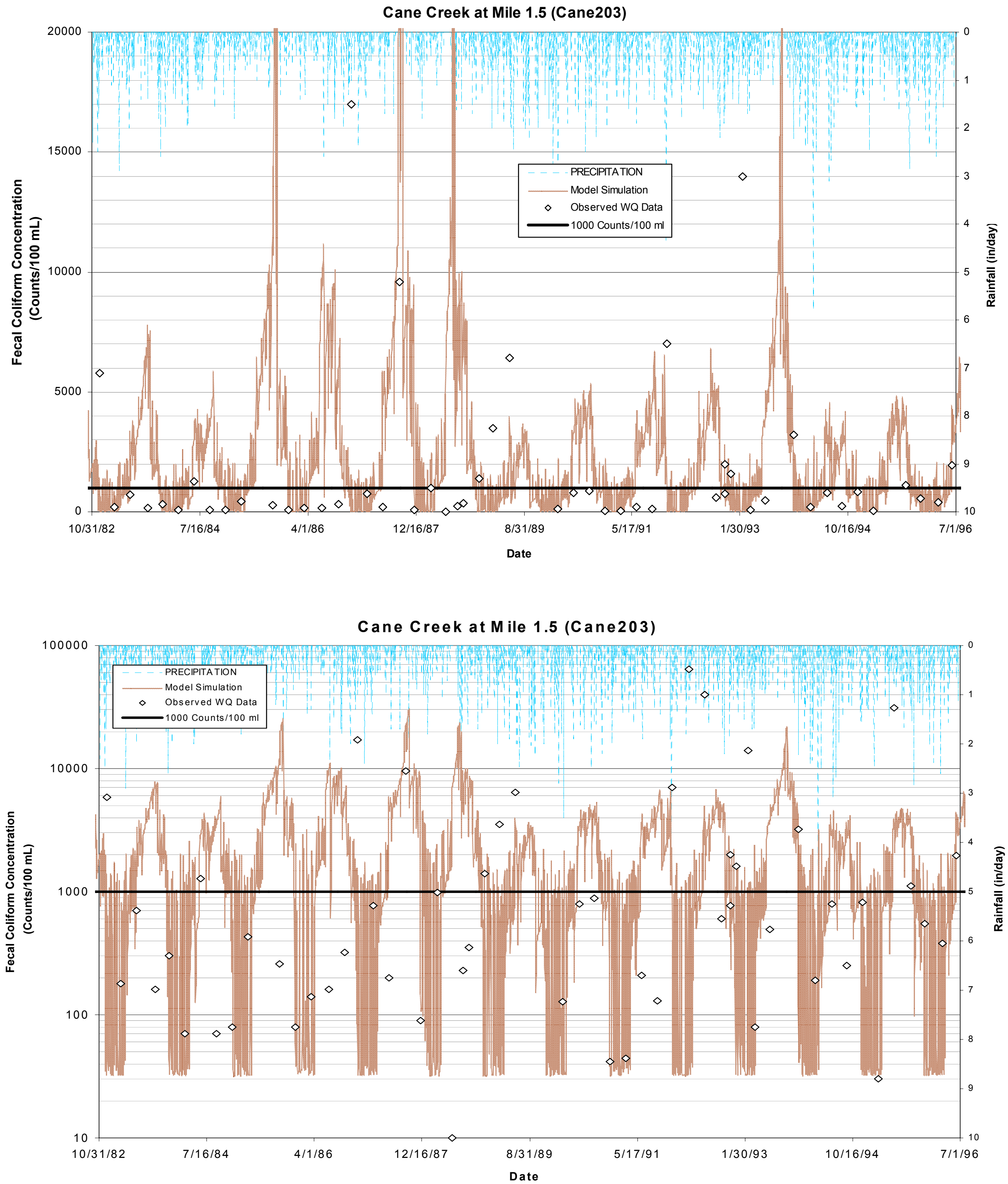


Figure B-2. Water Quality Calibration – Cane Creek at Mile 1.5 (10/31/82 - 7/1/96).

APPENDIX C

Determination of Critical Conditions

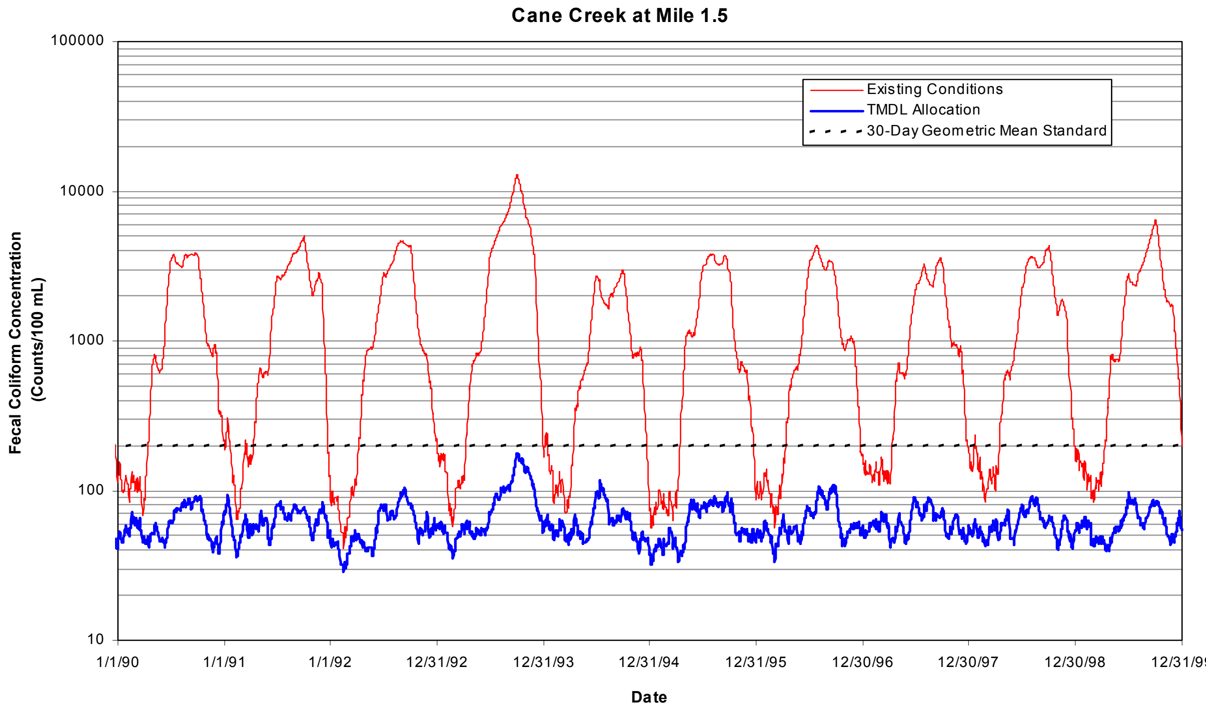


Figure C-1. Simulated 30-DayGeometric Mean Fecal Coliform Concentrations for Cane Creek at Mile 1.5.

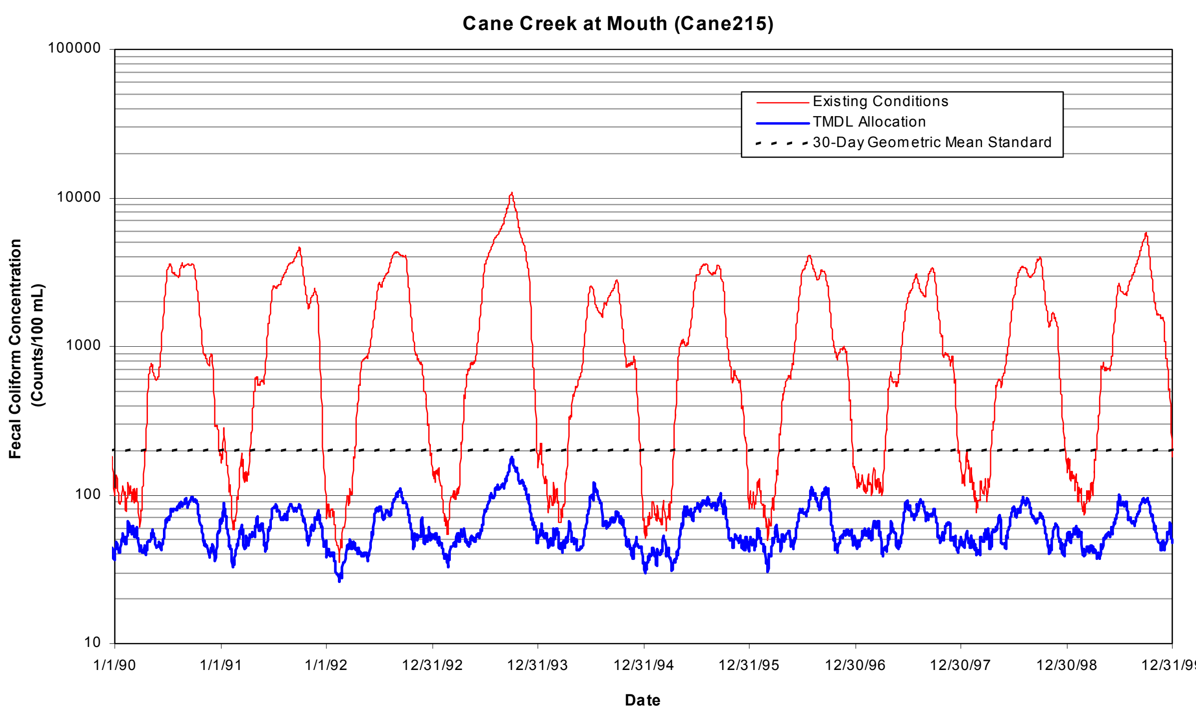


Figure C-2. Simulated 30-Day Geometric Mean Fecal Coliform Concentrations for Cane Creek at Mouth.

APPENDIX D

Public Notice of Proposed Total Maximum Daily Load (TMDL) for Fecal Coliform in Cane Creek Hiwassee River Watershed (HUC 06020002)

DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR FECAL COLIFORM IN CANE CREEK HIWASSEE RIVER WATERSHED (HUC 06020002), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed total maximum daily load (TMDL) for fecal coliform in the Cane Creek watershed, which drains to the Hiwassee River. 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.

Cane Creek is listed on Tennessee's final 1998 303(d) list as not supporting its designated use classifications due, in part, to discharge of fecal coliforms from Septic Tanks and Grazing Related Sources. The TMDL utilizes Tennessee's general water quality criteria, recently collected site specific water quality data, continuous flow data from a USGS discharge monitoring station located in the vicinity of the watershed, and a calibrated dynamic water quality model to establish allowable loadings of fecal coliform which will result in reduced in-stream concentrations and attainment of water quality standards. The TMDL requires reductions on the order of 98% for the Cane Creek Watershed.

The proposed Cane Creek fecal coliform TMDL can be downloaded from the following website:

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

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

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

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

Persons wishing to comment on the proposed TMDL are invited to submit their comments in writing no later than January 9, 2003 to:

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

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

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