Total Maximum Daily Load
for
Fecal Coliform
in
Roan Creek,
including Forge Creek and Town Creek

Watauga River Watershed, Tennessee

(HUC 06010103)

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SUMMARY SHEET

Total Maximum Daily Load (TMDL) for Fecal Coliform in Roan Creek

1. 303(d) Listed Waterbody Information

State: Tennessee
County: Johnson

Major River Basin: Holston River Basin
Watershed (Hydrologic Unit Code): Watauga River (06010103)

Location: Roan Creek from mile 16.5 to Forge Creek (approximately mile 19.2), including Forge Creek and Town Creek.
Impaired Stream Length: 6.7 miles
Watershed Area: 77.4 square miles
Waterbody ID: TN06010103033

Constituent of Concern: Fecal Coliform

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

Applicable Coliform Water Quality Standard for Recreation (more stringent of two standards):

> The concentration of a 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. For the purposes of determining the geometric mean, individual samples having a fecal coliform group or *E. coli* concentration of less than 1 per 100 ml shall be considered as having a concentration of 1 per 100 ml. 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)/Hydrologic Simulation Program – Fortran (HSPF) was used to develop this TMDL. Daily timesteps were used to simulate hydrologic and water quality conditions. The model was developed for the entire 303(d)-listed segment.

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

Seasonal Variation: A continuous 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

Waste Load Allocation: 2.726×10^{11} counts per 30 days

> Note: All future permitted discharges shall meet end-of-pipe criteria of 200 counts/100 ml for fecal coliform.

Load Allocation: 1.010×10^{13} counts per 30 days

Margin of Safety: Implicit (conservative modeling assumptions)

Total Maximum Daily Load (TMDL): 1.037×10^{13} counts per 30 days

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EXECUTIVE SUMMARY

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries that do not meet minimum water quality standards for designated use classifications. States are required to develop Total Maximum Daily Loads (TMDLs) for these waterbodies. The TMDL process establishes the maximum amount of a pollutant that a waterbody can assimilate without exceeding water quality standards and allocates this load between all contributing pollutant sources. The purpose of the TMDL is to establish water quality objectives required to reduce pollution from both point and nonpoint sources, and to restore and maintain the quality of water resources.

Tennessee's 1998 303(d) list identified Roan Creek (TN06010103033) as a water quality limited stream impaired by pathogens and not supporting its designated use for Recreation. Waters of this use classification must meet the following quality standards for coliform:

> The concentration of a 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. For the purposes of determining the geometric mean, individual samples having a fecal coliform group or *E. coli* concentration of less than 1 per 100 ml shall be considered as having a concentration of 1 per 100 ml. In addition, the concentration of the fecal coliform group in any individual sample shall not exceed 1,000 per 100 ml.

For this TMDL evaluation, the water quality standard of the 30-day geometric mean fecal coliform concentration of 200 counts/100 ml defines the target endpoint. To date, insufficient data have been collected to evaluate water quality with respect to E. coli in the Roan Creek watershed. The State of Tennessee now routinely collects E. coli samples concurrently with fecal coliform and will consider both in future evaluations. Currently, evaluation of fecal coliform only is in accordance with EPA's guidance.

The analysis performed to develop the TMDL for fecal coliforms in Roan Creek utilized dynamic hydrologic and water quality modeling techniques that incorporated physical characteristics of the watershed, meteorology, hydrologic response parameters, and water quality source loading, transport, and decay parameters. Land use in the watershed was characterized from Landsat Thematic Mapper digital images collected during the period 1990-1993. Fecal coliform contributions represented in model simulations were derived from land use activities, point sources, and other direct in-stream contributions. These included manure application, urban development, wildlife, Sewage Treatment Plant (STP) effluent, sanitary sewer overflows, septic systems, and cattle grazing. Initial model parameterization values for urban, agricultural, and forest land uses were provided by EPA. The Mountain City Sewage Treatment Plant was the only National Pollutant Discharge Elimination System (NPDES) permitted discharger included in the modeling analysis.

A simulation period of ten years (1/1/89 - 12/31/98) was used to develop the fecal coliform TMDL. This ten-year period included a wide range of hydrologic conditions including low and high streamflows. The range of hydrologic conditions was considered adequate to identify the conditions critical to fecal coliform concentrations in Roan Creek as well as determining the 30-day geometric mean concentration for TMDL calculation. To achieve the TMDL, load reductions were applied until the simulated 30-day geometric mean of fecal coliform concentrations did not exceed the water quality standard of 200 counts per 100 ml. Modeling assumptions were considered conservative to constitute an implied margin of safety.

Model results indicate that there are two primary categories of sources impacting fecal coliform loading in the Roan Creek watershed under existing conditions: 1) NPDES-permitted point sources and 2) other direct in-stream sources modeled as point sources (including sanitary sewer system overflows, leaking sewer lines, failing septic systems, straight pipes [illicit connections], animals [including cattle], and unverified sources). The two source categories provide the greatest source contribution during the summer dry season when seasonal low flow dominates and dilution of sources is minimized and, together, account for over 80% of existing loading to the Roan Creek watershed under critical conditions. Nonpoint sources are considered to be a secondary, but significant, source of fecal coliform contamination to Roan Creek.

A possible allocation scenario that would meet in-stream water quality standards on all segments of Roan Creek includes nonpoint source loading reductions of 35-90% to non-NPDES direct in-stream sources, up to 100% to NPDES-related point source categories, and 50% to urban land use loading. Reductions to non-NPDES direct in-stream sources consist of 75-90% reduction of failing septic systems and 35-72.8% reduction to other direct in-stream sources. Reductions to the Mountain City Sewage Treatment Plant effluent are variable according to the magnitude of exceedances as reported in monthly discharge monitoring reports. The STP will be required to meet permitted discharge limits. In addition, sanitary sewer overflows (NPDES-related discharge) must be completely eliminated (100% reduction).

Recommended strategies for subsequent reduction of sources causing impairment of water quality are targeted toward STP effluent and related overflow control, field surveys for improved source delineation and identification, reduction of septic system failure rates, urban stormwater management efforts to identify and eliminate sources related to urban stormwater runoff, and additional monitoring to support model refinement and re-evaluation of load reductions.

The Total Maximum Daily Load for fecal coliform in Roan Creek, at the ROAN016.5 monitoring station (most downstream monitored location in the watershed), is 1.037×10^{13} counts per 30 days. This is consistent with the fecal coliform water quality standard of 200 counts/100 ml as a 30-day geometric mean.

1.0 INTRODUCTION

1.1 Background

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 water body 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).

Tennessee's 303(d) list was approved by EPA Region IV on September 17, 1998. The list identified Roan Creek (TN06010103033) as a water body that does not meet the minimum water quality standard for fecal coliform, due to Municipal Point Source. The objective of this study is to develop a fecal coliform TMDL for Roan Creek.

1.2 Watershed Description

The Watauga River watershed (HUC 06010103) is in the northeast region of Tennessee and northwest North Carolina (Figure 1). Roan Creek is a tributary to the Watauga River and lies in the Level III Blue Ridge Mountains (66) ecoregion. Roan Creek enters the Watauga River at approximately river mile 44.3. Roan Creek (at mile 16.5) (Figure 2) drains an area of 77.4 square miles. Town Creek, a major tributary to Roan Creek at mile 17.7, drains the northwest portion of the watershed and flows through Mountain City, Tennessee. Forge Creek, also a major tributary to Roan Creek at mile 19.2, drains the northeast portion of the watershed and is primarily forested. The Roan Creek headwaters drain the southeast portion of the watershed, an area that is primarily forest and pastureland.

The land use characteristics of the Roan Creek watershed were determined using data from Tennessee's Multiple Resolution Land Coverage (MRLC). This coverage is based on Digital Landsat Thematic Mapper imagery for 1990-1993. Table 1 presents land use distribution in the watershed. The dominant land use in the watershed is forest (81.4%), followed by agricultural (primarily pasture) (16.3%), and urban with approximately 2.3%.

Designated beneficial uses and water quality standards are established by the State of Tennessee in the *State of Tennessee Water Quality Standards, Chapters 1200-4-3, General Water Quality Criteria,* and *1200-4-4, Use Classifications for Surface Waters, October, 1999.* The impaired water body has two designated use classifications that comprise fecal coliform criteria: 1) Fish and Aquatic Life and 2) Recreation.

For the purposes of TMDL development, the most stringent of the applicable water quality criteria is designated as the water quality objective for impaired waters. The Recreation use classification is the most stringent for pathogens (fecal coliform). Waters of this class must meet the following quality standards for fecal coliform:

> 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.

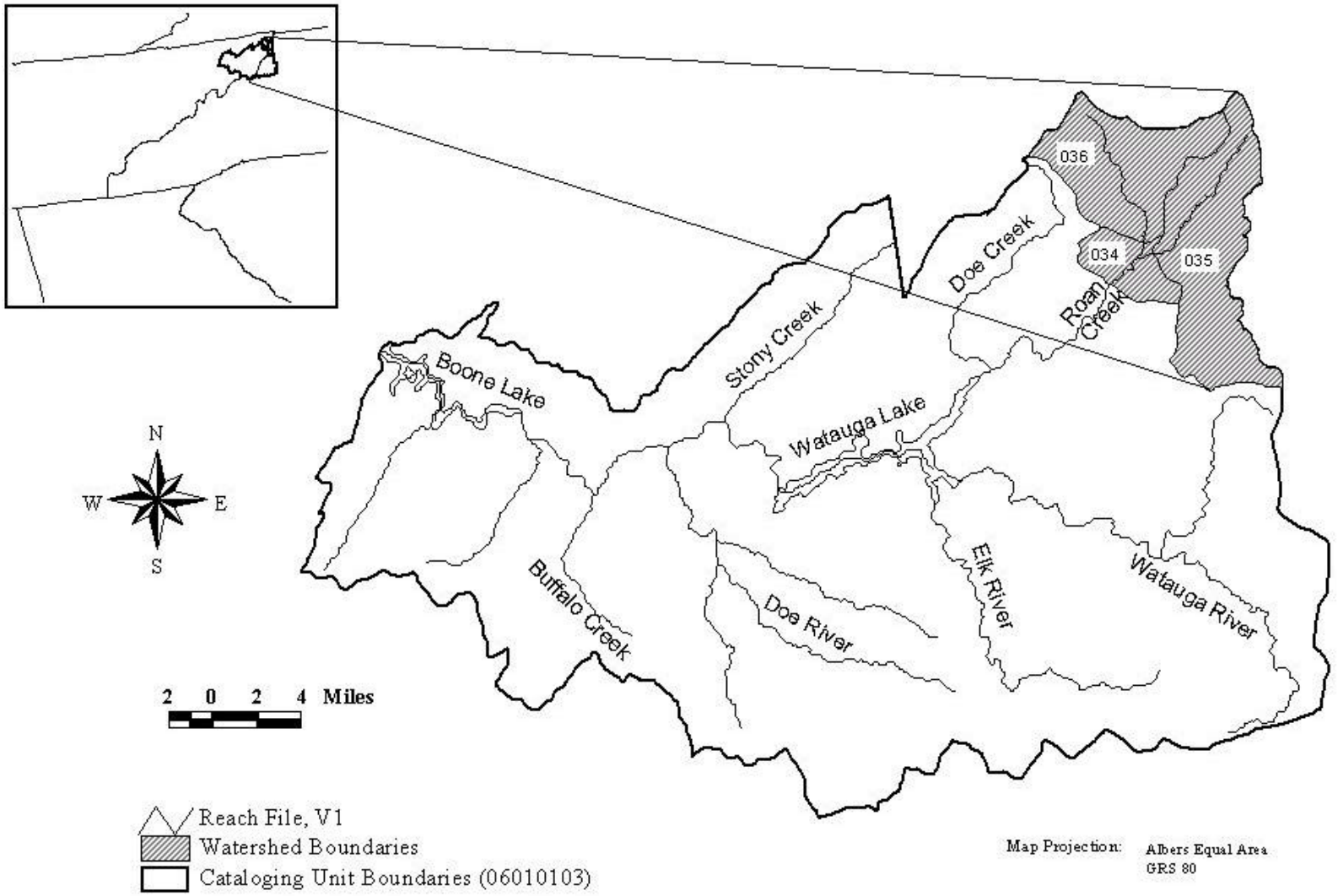

Figure 1. Location of Watauga River and Roan Creek watersheds.

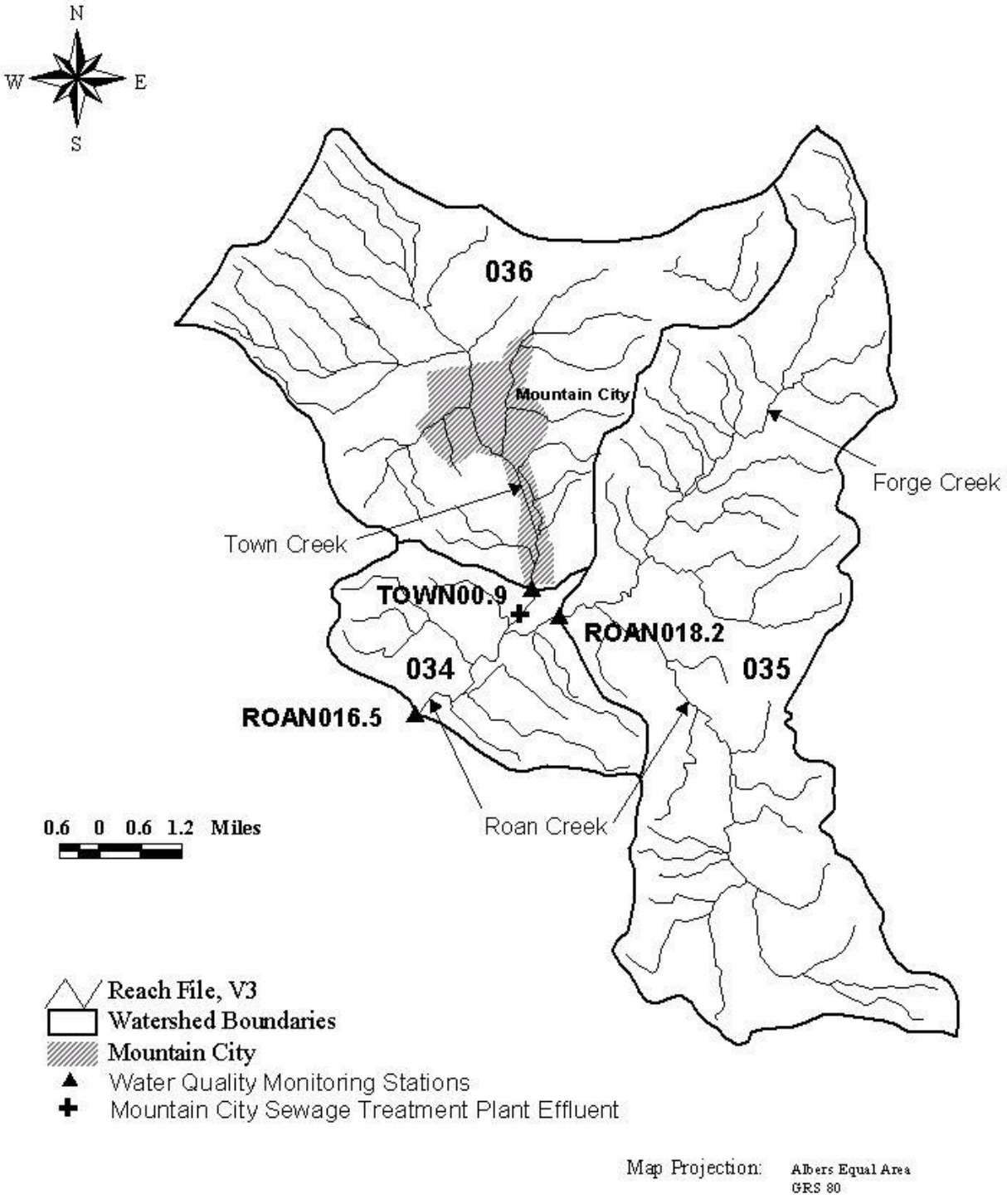

Figure 2. Roan Creek watershed.

Table 1. MRLC Landuse Distribution by Subwatershed.

	034		035		036		Watershed Totals	
Landuse	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%
Bare Rock/Sand/Clay	3	*	10	*	16	0.1	28	0.1
Deciduous Forest	2478	41.6	14543	58.8	6470	34.3	23491	47.4
Emergent Herbaceous Wetlands	0	0.0	4	*	2	*	6	*
Evergreen Forest	834	14.0	2753	11.1	3531	18.7	7118	14.4
High Intensity Commercial/Industrial/ Transportation	11	0.2	136	0.6	272	1.4	420	0.8
High Intensity Residential	0	0.0	1	*	90	0.5	92	0.2
Low Intensity Residential	15	0.3	57	0.2	561	3.0	634	1.3
Mixed Forest	929	15.6	4412	17.8	4022	21.3	9363	18.9
Open Water	0	0.0	7	*	4	*	11	*
Other Grasses (Urban/recreational; e.g. parks, lawns)	5	0.1	21	0.1	166	0.9	193	0.4
Pasture/Hay	1113	18.7	1970	8.0	3052	16.2	6135	12.4
Quarries/Mines/Gravel	0	0.0	65	0.3	0	0.0	65	0.1
Row Crops	566	9.5	703	2.8	669	3.5	1938	3.9
Woody Wetlands	1	*	4	*	10	0.1	14	*
Total	5954	100	24687	100	18866	100	49507	100

* Less than 0.1%.

1.3 Water Quality Target

A major component of the TMDL is the establishment of in-stream numeric endpoints, or targets, used to evaluate the attainment of water quality meeting designated use criteria. The target represents the restoration objective expected to be achieved by implementation of load reductions specified by the TMDL evaluation. In addition, the target serves to facilitate evaluation of progress toward attainment of water quality standards by allowing comparison to observed in-stream conditions. For this TMDL, the fecal coliform 30-day geometric mean standard for Recreation (200 counts/100 ml) is the target level to evaluate impairment and establish the TMDL.

1.4 Water Quality Monitoring Program

Data from three water quality sampling sites on Roan Creek and its tributaries (Appendix A) were used to determine water body impairment and for listing the waterbodies on the Tennessee 1998 303(d) list. Insufficient data were collected for calculation of 30-day geometric means of fecal coliform according to water quality standards. Concurrently, at the three sampling locations, 19% to 25% of samples had fecal coliform concentrations exceeding 1,000 colonies per 100 ml. Table 2 presents fecal coliform data statistics for the three water quality sampling sites.

Table 2. Water Quality Monitoring Station Fecal Coliform Data Analysis.

Subwatershed	Water Quality Station	Samples (#)	Concentrations (Counts/100 ml)			
			Minimum	Maximum	Mean	Median
034	ROAN016.5	16	128	29000	2449	395
035	ROAN018.2	16	58	14000	1486	400
036	TOWN00.9	16	10	2000	495	225

2.0 SOURCE ASSESSMENT

Potential sources of fecal coliform are numerous and often occur in combination. Untreated or inadequately treated municipal sewage commonly constitutes a major source of fecal coliform in impaired surface waters. Urban stormwater runoff, sanitary and combined sewer overflows, and failing septic systems can be sources of fecal coliform. Rural stormwater runoff can contribute significant loads of fecal coliform from livestock pastures, animal feedlots, and cropland where manure application is practiced. Wildlife can also contribute fecal coliform. Sources of fecal coliform loads can be assigned to two broad classes: point source loads and nonpoint source loads. Point sources of fecal coliform are identified as entering a water body from discrete, identifiable locations, usually pipes. Nonpoint sources of fecal coliform are diffuse sources usually not identified as entering a water body at discrete locations. These sources generally involve land activities that contribute fecal coliform to streams during rainfall runoff events.

2.1 Point Source Assessment

Municipal Publicly Owned Treatment Works (POTWs) service urban areas located in the Roan Creek watershed, including Mountain City, TN. The Mountain City Sewage Treatment Plant (STP) discharges to the Roan Creek watershed via Town Creek at mile 0.4. The Mountain City STP is the only National Pollutant Discharge Elimination System (NPDES) facility permitted to discharge fecal coliform to the Roan Creek watershed.

2.2 Nonpoint Source Assessment

Nonpoint sources are considered to be a secondary, but significant, source of fecal coliform contamination to Roan Creek. Land use in the watershed (in 1990-1993) consisted of approximately 2.3% urban, 16.3% agricultural (primarily pasture – 12.4%), and 81.4% forested. Nonpoint sources of fecal coliform loading contributing to water quality impairment in the Roan Creek watershed are largely attributable to direct inputs to the waterbody (including leaking septic systems, animals having access to streams, and undefined sources) and urban runoff/stormwater.

2.2.1 Wildlife

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 counties nor were statistics available for other animals. Therefore, deer were assumed to populate the Roan Creek watershed according to the upper limit of available population data of 36 per square mile. In addition, in order to account for other wildlife sources of fecal coliform in the watershed, the number of deer per square mile was increased to 45 for water quality model simulations. It is assumed that the wildlife population remains constant throughout the year and that wildlife is uniformly distributed on all land classified in the MRLC database as forest, pasture, cropland, and wetlands.

2.2.2 Livestock Estimates

Table 3 shows agricultural livestock distribution in the watershed. The livestock data, with the exception of horses, are based on the 1997 Agricultural Census compiled and reported by county and distributed to the subwatersheds based on the percentages of agricultural areas in each subwatershed classified as pasture/hay. Horse data were estimated from 1999 Agricultural Census data in Tennessee Agricultural District 60 (TASS, 1999). In a moderately-sized watershed such as Roan Creek, there is some uncertainty in livestock distribution on the basis of county populations.

Table 3. Livestock Distribution by Subwatershed.

Livestock (individuals)	Beef Cows	Dairy Cows	Total Cattle	Hogs	Sheep	Horses	Chickens
034	500	100	750	125	25	50	200
035	260	3	390	10	27	35	75
036	140	5	210	12	10	30	75
Total	900	108	1350	147	62	115	350

2.2.3 Land Application of Agricultural Manure

Processed agricultural manure from confined hog, dairy cattle, and poultry operations is generally collected in lagoons and applied to land surfaces during the months of March through October. Hog manure is assumed to be applied to pasture only. Dairy cattle account for less than 5% of the total cattle in the watershed. It is assumed that dairy cattle are kept in feed lots; therefore, 100% of dairy cattle waste is collected and applied to pasture and cropland in the watershed. Poultry manure is assumed to be applied to pasture and cropland. Horse manure is assumed to be collected and applied to pasture only.

2.2.4 Grazing Animals

Beef cattle, horses, and sheep spend time grazing on pastureland and depositing manure onto the land. During rainfall runoff events, this manure is available for washoff and is transported to surface streams. It is assumed that animal access to the pastures is unlimited year-round, resulting in uniform fecal coliform loading rates throughout the year. The percentage of manure deposited during grazing on the land versus access to streams is used to estimate the fecal coliform loading rates from pastureland.

A portion of grazing animals have direct access to streams flowing through pastures as a drinking water source. Manure deposited in these streams by grazing animals is considered a direct point source in the water quality model. The input is considered as a constant flow and concentration according to the percentage of time spent in-stream.

2.2.5 Failing Septic Systems

Table 4 shows estimates from county census data of people in the Roan Creek watershed on septic systems. In this area, there are approximately 2.37 people per household on septic systems. However, the census data do not delineate between urban (Mountain City) and non-urban (Johnson County) areas. The majority of the population within the city limits is on city sewer service while virtually all of the population outside city limits (in Johnson County) is on septic systems. Assumed septic failure rates vary from 20 to 50%, in part to account for discrepancies in the census data. Failing septic systems are represented in the water quality model as point sources (summed by subwatershed) having constant flow and concentration.

Table 4. Septic Systems in the Roan Creek Watershed.

Subwatershed	Septic Systems	Population Served	Failing Septic Systems*
034	151	359	76
035	578	1370	289
036	581	1377	291

* Estimated/assumed.

2.2.6 Urban Development

Fecal coliform loading from urban areas is potentially attributable to multiple sources including stormwater runoff, leaks and overflows from the sanitary sewer system, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, and domestic animals. Urban runoff and stormwater processes are considered to be significant contributors to fecal coliform impairment in Roan Creek. Urban sources with direct input to the stream (e.g., leaking sanitary collection lines, illicit discharges, straight pipe connections to the stream) are suspected to occur in the watershed and are included as point source inputs in water quality model simulations. Overflowing sanitary sewers and leaking collection lines have been well documented and are considered significant sources of fecal coliform bacteria in the Roan Creek watershed. For the TMDL analysis, sanitary sewage system overflows are assumed to occur in the vicinity of Mountain City, in subwatershed 036, Town Creek.

3.0 MODELING APPROACH

Establishing the relationship between in-stream water quality and source loadings is an important component of TMDL development. It provides for the identification of sources and their relative contributions (links sources to impairment) and supports examination of potential water quality improvements resulting from various remediation scenarios designed to meet water quality criteria. For the Roan Creek fecal coliform TMDL evaluation, a dynamic loading model was utilized to develop this relationship. Fecal coliform source delineation methodology and the modeling techniques used to simulate dynamic loading, transport, and fate in the Roan Creek watershed follow.

3.1 Model Selection

The Nonpoint Source Model (NPSM) is a Windows and ArcView geographic information system (GIS) based interface to the EPA watershed model Hydrologic Simulation Program - Fortran (HSPF). HSPF is a spatially distributed, lumped parameter, continuous simulation model used to analyze the dynamic hydrologic and water quality characteristics of watersheds and river basins. HSPF calculates nonpoint source loadings of selected pollutants for specified land use categories in the watershed, represents subsequent pollutant runoff response to hydrologic influences (i.e., precipitation, evapotranspiration, etc.), simulates point sources as constant or variable flow and concentration, and simulates flow and pollutant routing through a stream network to the outlet at the pour point of the watershed. The NPSM/HSPF watershed model was utilized to link the sources of fecal coliform to impacts and to characterize the processes (loading, transport, decay) contributing to exceedances of fecal coliform concentrations in the Roan Creek watershed.

In addition to the NPSM/HSPF, the Watershed Characterization System (WCS), a GIS tool, was used to display, analyze, and compile GIS information to support water quality model simulations for the Roan 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 characterization are input to a spreadsheet designed by EPA to estimate NPSM/HSPF input parameters associated with fecal coliform buildup (loading rates) and washoff from land surfaces. In addition, the spreadsheet estimates direct loadings to water bodies due to animals having access to streams and septic system failures. Computed loading rates from the WCS and spreadsheet tools were used in the NPSM/HSPF to simulate the loading and transport of fecal coliform and the resulting water quality response.

3.2 Model Setup

The Roan Creek watershed was delineated into three subwatersheds (Figure 2), corresponding to the three water quality monitoring stations, in order to characterize the relative fecal coliform contributions from various land uses and point source-type discharges. Subwatershed 036 (Town Creek), encompassing the city of Mountain City, is approximately 5% urban while subwatershed 034 (Roan Creek) and 035 (Forge Creek) are each less than 1% urban. Subwatershed delineation was based on EPA's River Reach Files Version 1 (RF1) segmented stream coverage and elevation data (USEPA, 1998). This discretization allows for management and load reduction alternatives to be varied by subwatershed. For a simplified approach to modeling landuse loading of fecal coliform, the MRLC landuse data were combined into the following four categories: urban, forest, cropland, and pasture (Table 5).

A continuous simulation period from January 1, 1988 to December 31, 1998 was used in the water quality analysis for Roan Creek. The period from January 1, 1988 to December 31, 1988 was used to allow the model results to stabilize. The period from August 6, 1996 to November 18, 1998 was used to calibrate the water quality model. Therefore, the model results had more than adequate simulation time to stabilize prior to the occurrence of available observed water quality data. A ten-year simulation period, January 1, 1989 to December 31, 1998, was used to identify the critical period from which to develop the TMDL (see Sect. 3.5).

Table 5. Land Use Distribution in the Roan Creek Watershed.

Subwatershed	Urban		Forest		Pasture		Cropland		Total	
	acres	%	acres	%	acres	%	acres	%	acres	%
034	26	0.4	4250	71.4	1113	18.7	566	9.5	5955	12.0
035	194	0.8	21812	88.4	1970	8.0	703	2.8	24679	49.9
036	923	4.9	14217	75.4	3052	16.2	669	3.5	18861	38.1
Total	1143	2.3	40279	81.4	6135	12.4	1938	3.9	49495	100

3.3 Fecal Coliform Source Representation

Both point and nonpoint sources are represented in the water quality model. 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 include, but are not limited to, failing septic systems, leaking sewer lines, animals having access to streams, and undefined sources. All other nonpoint sources are land loading sources and therefore rainfall runoff generated. These sources are only partially available 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. The following sections describe the assumptions used for the various sources described in Section 2.0.

3.3.1 Wildlife

Fecal coliform loading from wildlife is represented in water quality model simulations based on deer population. In the model, deer are uniformly distributed to forest, pasture, cropland, and wetland areas at a density of 45 per square mile to account for other forms of wildlife other than deer. The fecal coliform loading rate applied for deer, 5.0 x 10^8 counts/day/deer, was derived from the EPA spreadsheet described in Section 3.1.

3.3.2 Land Application of Agricultural Manure

Fecal coliform accumulation and buildup rates resulting from land application of hog, cattle, poultry, and horse manure can be represented in model simulations as monthly input values or constants when uniform loading rates are assumed year-round. Manure application rates for cropland were represented as monthly variable. Hog manure is assumed to be applied only to pasture. Dairy cattle manure is assumed to be applied to pastureland and cropland. Poultry manure is assumed to be applied to pasture and cropland. Horse manure is assumed to be collected and applied to pasture only. The animal fecal loading rates are: 1.08×10^{10} counts/day/hog (ASAE, 1997), 1.83×10^{11} counts/day/dairy cow (ASAE, 1997), 1.36×10^{8} counts/day/chicken (ASAE, 1997), and 4.20×10^{8} counts/day/horse (ASAE, 1997).

3.3.3 Grazing Animals

Beef cattle, horses, and sheep deposit fecal coliform directly to pastureland during grazing. It is assumed there is no monthly variation in access to pastures; therefore, fecal coliform loading rates are considered to be uniform throughout the year. Contributions of fecal coliform from wildlife are included in the pasture loading rate. The animal fecal loading rates are: 5.71×10^{10} counts/day/beef cattle (ASAE, 1997), 4.20×10^{8} counts/day/horse (ASAE, 1997), 1.20×10^{10} counts/day/sheep (ASAE, 1997), and 5.0×10^{8} counts/day/deer.

3.3.4 Urban Development

Urban areas are represented in the model as two components: pervious and impervious. Initially, a single area-weighted loading rate for urban areas, based on buildup and accumulation rates referenced in Horner (1992), was used in the model. Urban loading rates were adjusted in model simulations and remained constant throughout the year for each of the three subwatersheds.

It was apparent, in calibrating the water quality model to reproduce existing conditions, that dry weather phenomena (exclusive of rainfall runoff generated loading) represent the critical conditions in the Roan Creek watershed. Significant contributions to high concentrations of fecal coliform at low flows, from urban sources, are probable in the Town Creek subwatershed (036). These sources may include leaking sewer lines, illicit connections, and improper disposal of wastes. Point source loads were included for each subwatershed in model simulations to account for direct in-stream sources. They are included with animals having access to streams and unverified sources.

3.3.5 NPDES Point Sources

The Mountain City Sewage Treatment Plant (STP) effluent is represented in model simulations as a point source having monthly variable flow and concentration. Data from monthly Discharge Monitoring Reports (DMRs) were used as input for the point source file. In addition, documented collection system (sanitary sewer) overflows are represented in model simulations as a single point source having constant flow equal to 5% of STP design flow and a constant fecal coliform concentration of 10,000 counts per 100 ml. This is the low end of the range of concentrations for combined sewer overflows reported by Schueler (1999). This is considered to be a conservative and reasonable estimate since overflows in Mountain City are documented to be due largely to excessive infiltration and inflow.

3.4 Model Calibration

Calibration of a dynamic loading model involves both hydrologic and water quality components. The model must be calibrated to appropriately represent hydrologic response in the watershed before reasonable water quality simulations and subsequent calibration can be performed. The hydrologic calibration involves comparison of simulated streamflows to historic continuous streamflow data from a stream gaging station in the watershed.

Simulated streamflows are generated from input and adjustment of model parameters, including meteorological (precipitation, evapotranspiration, temperature), physical (areas, overland flowpath lengths, slopes, Manning's roughness coefficients, stream cross-sections), and hydrologic response (infiltration; upper zone, lower zone, and groundwater storage; recession and interflow parameters) to represent the hydrologic cycle. Parameters are adjusted according to and within reasonable constraints until an acceptable agreement is achieved between simulated and observed results. Due to the absence of a USGS stream gaging station in the Roan Creek watershed, hydrologic calibration of the Roan Creek model consisted of modification of the Sinking Creek hydrologic model. All physical parameters were adjusted accordingly and best professional judgment was used to adjust other parameters as necessary. The Roan Creek model hydrologic parameters are presented in Appendix B.

Quarterly fecal coliform data are available from three water quality monitoring stations in the Roan Creek watershed from the period 8/96 to 8/00. However, precipitation data were not available for 1999 and 2000 in a usable format for NPSM/HSPF model input; therefore, the post-1998 data could not be used for model calibration. Because few samples were collected during highflow conditions, the uncertainty of the model calibration increases. Graphical representation of model calibration results shows that the model adequately simulates baseflow concentrations and storm runoff response where samples are available for comparison.

3.5 Critical Conditions

Fecal coliform contributions to Roan Creek may be attributed to point and nonpoint sources. Critical conditions for waters impaired by nonpoint sources generally occur during periods of wet-weather storm runoff. However, among the categories of nonpoint sources to Roan Creek are sources that have the potential to occur as direct input to the stream as well as sources whose primary transport mechanism is groundwater, thus being more significant, relative to flow, during dry-weather periods.

The critical condition for fecal coliform impairment from nonpoint, land-loading sources is a rainfall runoff (storm) event preceded by an extended period of dry weather. An extended period of dry weather on the order of twelve days or more allows for the maximum buildup of fecal coliform on the land surface, according to Roan Creek watershed water quality model analyses. This fecal coliform accumulated on the land is then available for washoff by precipitation events. Critical conditions for direct contributions to the stream, represented as point sources in model simulations, occur during low flow and subsequent reduced dilution of available fecal coliform. Both conditions are simulated in the NPSM/HSPF model.

Observed fecal coliform sample concentration versus flow analyses were conducted for all sampling locations on Roan Creek. These analyses indicated that there were no significant correlations in the relationships at any of the sampling locations. This suggests that fecal coliform impairment is not strictly a storm runoff phenomenon. In fact, according to the water quality model calibration, the critical condition occurs during periods of dry weather low flow. The highest 30-day geometric mean concentrations of fecal coliform occur during the summer and fall at all water quality sampling locations on an annual basis. However, it is important to note that, according to modeling results, storm-driven processes contribute significantly to impairment and must be addressed in the allocation and subsequent reduction of fecal coliform loadings to Roan Creek.

The ten-year simulation period from January 1, 1989 to December 31, 1998 was used to calibrate the water quality model and identify the critical conditions from which to base the fecal coliform TMDL. This ten-year period contained a range of hydrologic conditions including low and high streamflows. The range of hydrologic conditions was considered adequate to identify the conditions critical to fecal coliform in Roan Creek as well as determining the 30-day geometric mean concentration and subsequent loading for TMDL calculation. The critical period was determined to be during seasonal low flows occurring in the summer and fall.

4.0 MODEL RESULTS

4.1 Existing Conditions

Model results indicate that the primary sources of fecal coliform contamination in the Roan Creek watershed are point sources (STP-related) and direct input of fecal coliform to the stream from various sources (e.g., failing septic systems, illicit dischargers, cattle, other animals having access to streams, and other unverified sources) in non-urban areas. Nonpoint sources are a secondary, but significant, source of fecal coliform contamination to Roan Creek.

4.2 Critical Conditions

Results of the ten-year simulation of the 30-day geometric mean concentration for existing conditions at the outlet of the Roan Creek watershed (034) are shown in Figure 3. Critical conditions can be determined from this figure. The 30-day critical period, according to the model simulation, is the time period preceding and including the highest simulated exceedance of the 30-day geometric mean standard. Achieving the water quality criteria for this period ensures that water quality criteria will be achieved for the remainder of the ten-year period and suggests that water quality criteria will be achieved for a very high percentage of time beyond the simulation period. For Roan Creek, the highest exceedance of the 30-day geometric mean fecal coliform concentration standard occurred on November 2, 1995 at the outlet (pour point) of the watershed and on September 22, 1995 at the other two subwatersheds modeled. Therefore, the critical periods are October 4, 1995 through November 2, 1995 for the subwatershed at the outlet of the watershed and August 24, 1995 through September 22, 1995 for the other two subwatersheds. Table 6 shows the maximum 30-day geometric mean fecal coliform concentrations at each of the three modeled segments/subwatersheds and the corresponding levels of reduction required to achieve the 30-day geometric mean standard of 200 counts/100 ml at each.

Table 6. Roan Creek watershed simulated maximum 30-day geometric mean fecal coliform concentrations for existing (1989-1998) conditions.

Subwatershed	Max. 30-day Geometric Mean Fecal Coliform Concentration (Counts/100 ml)	Percent Reduction Required to Achieve Water Quality Standard
034	430	53
035	357	44
036	653	69

5.0 ALLOCATION

5.1 Total Maximum Daily Load

The TMDL process quantifies the amount of pollutant that can be assimilated in a water body, 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 [WLAs]), nonpoint source loads (Load Allocations [LAs]), and an appropriate margin of safety (MOS) which takes into account any lack of knowledge concerning the relationship between the effluent limitations and water quality:

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

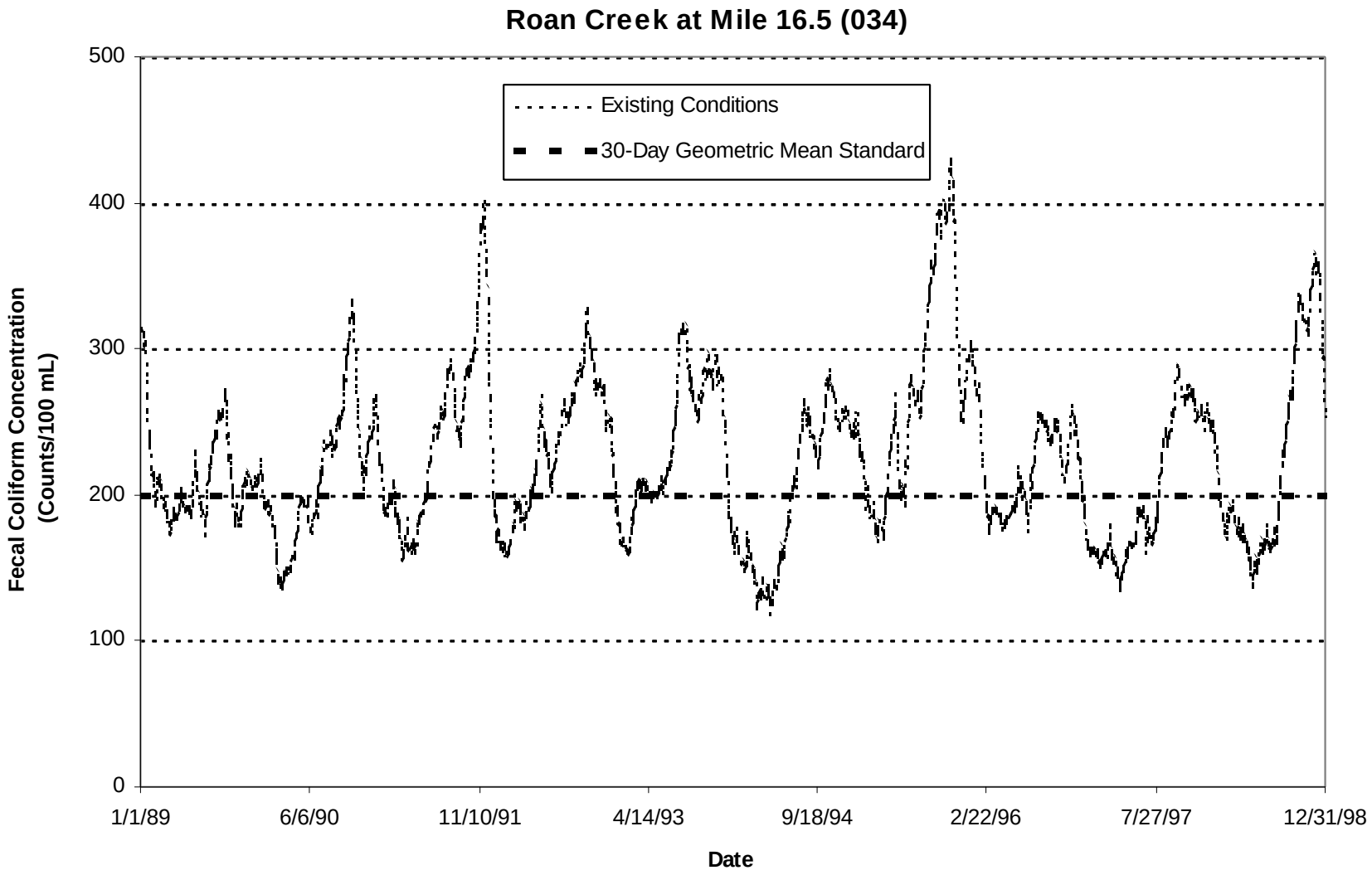

Figure 3. Roan Creek model simulation of existing conditions (30-day geometric mean).

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.

The total maximum daily load of fecal coliform was determined by adding the WLA and the LA. The MOS was implicitly included in the TMDL analysis and does not factor directly in the TMDL equation as shown above. The TMDL for Roan Creek at water quality monitoring station ROAN016.5 (most downstream monitored point in the watershed) is 1.037×10^{13} counts per 30 days.

5.2 Waste Load Allocations

The WLA for Roan Creek is 2.726×10^{11} counts per 30 days. This represents discharge from the Mountain City Sewage Treatment Plant at a constant design flow rate of 1.2 million gallons per day (MGD) with a constant fecal coliform concentration of 200 counts per 100 ml. There are currently no other NPDES-permitted fecal coliform dischargers in the Roan Creek watershed. All future NPDES facilities will be required to meet end-of-pipe criteria for fecal coliform discharge.

5.3 Load Allocations

The LA for Roan Creek is 1.010×10^{13} counts per 30 days. This includes runoff from pervious and impervious land surfaces, septic systems, and other direct in-stream sources (including leaking sewer lines, straight pipe connections, illicit discharges, animals [including cattle], and unverified sources). Sanitary sewer overflows are not allocated (LA = 0) because they are required to be eliminated.

Modeling results indicate dual impacts to fecal coliform loading in the Roan Creek watershed. Urban sources (including stormwater runoff and sanitary sewer overflows) provide significant source contribution in the winter wet season when storm runoff events dominate streamflow. Direct in-stream sources (including failing septic systems, leaking sewer lines, animals having access to streams, and unverified sources) provide the greatest source contribution during the summer dry season when seasonal low flow dominates and dilution of direct sources is minimized. Direct in-stream sources are the most significant in terms of contribution to exceedances of water quality criteria.

Reducing loading from agricultural practices in the Roan Creek watershed had a limited impact in allocation modeling simulations (what-if scenarios). In fact, the difference between existing conditions and a 100% reduction in agricultural loading, exclusive of direct in-stream loading by cattle (and other sources), was approximately 2% at each of the three subwatersheds modeled. Therefore, impacts from agricultural land use loading are considered to be negligible and reductions are unnecessary. In addition, no loading reduction was considered for forested land.

5.4 Allocation Strategy

The allocation strategy for Roan Creek source load reduction consisted of eliminating STP exceedances and overflows from model simulations, then applying reductions to fecal coliform loading until subwatersheds 035 and 036 (headwaters subwatersheds) were adjusted to meet water quality standards. Water quality impairment in subwatershed 034 was found to be attributable to Mountain City STP exceedances and impairment from upstream sources in the Town and Forge Creek subwatersheds. Reduction of sources, to acceptable levels (meeting water quality standards), in subwatersheds 035 and 036 resulted in attainment of water quality standards in subwatershed 034.

Allocation modeling scenarios were investigated in order to meet fecal coliform Recreational Use in-stream water quality criteria at water quality monitoring locations in Roan Creek. One possible allocation scenario included source loading reductions to point sources (STP effluent and overflow elimination), direct in-stream sources, and

urban land use loading. Reductions to urban land use loading were applied uniformly to all land uses in each of the three subwatersheds. Reductions applied to sources in the subwatersheds consisted of the following: 100% reduction in sanitary sewer overflows and variable reductions to the Mountain City STP effluent to achieve end-of-pipe criteria for fecal coliform discharge, 75-90% reduction in failing septic systems, 35-72.8% reduction to loading from other direct in-stream sources (including animals having access to streams and unverified sources), and 50% reduction in urban land use loading rates. The reduction applied to Mountain City STP effluent for the 30-day critical period was equivalent to 96.3%. See Appendix D for detailed allocation information by subwatershed.

5.5 Seasonal Variation

Seasonal variation is accounted for in the dynamic water quality model by simulations covering ten years. Changes in meteorologic inputs and hydrology indicate distinctive seasonal changes and variability in modeled watershed response. In addition, different sources dominate water quality during different seasons (see Sect. 5.3, paragraph 1, above).

5.6 Margin of Safety

The MOS is a required component of TMDL development. There are two basic methods for incorporating the MOS (USEPA, 1991): 1) implicitly incorporate the MOS using conservative model assumptions to develop allocations, or 2) explicitly specify a portion of the total TMDL as the MOS and use the remainder for allocations. For the Roan Creek fecal coliform TMDL, the MOS was implicitly incorporated into the modeling analysis by incorporation of conservative model assumptions. Conservative model assumptions include the following:

A 10-yr modeling period covering extreme wet and dry periods to identify the critical time period (worst case scenario) for load reductions and allocation.

STP effluent modeled at constant design flow and permitted concentration limits in allocation simulations. It is probable that STP effluent flows and concentrations will be at significantly lower levels most of the time.

Septic system failures are assumed to contribute their total fecal coliform loading rates directly to streams, including those from areas not in proximity to streams, and no decay (die-off) is considered.

All land uses are assumed to be connected directly to streams.

6.0 IMPLEMENTATION STRATEGY

The TMDL analysis was performed using the best data available to specify Load Allocations that will meet the water quality criteria for fecal coliform in Roan Creek so as to support its designated use classifications. The following recommendations and strategies are targeted toward NPDES permit compliance, source delineation, collection of data to support additional modeling and evaluation, and subsequent reduction in sources causing impairment of water quality.

6.1 NPDES Permit Compliance

A Commissioner's Order was issued against the Town of Mountain City on February 11, 1993 for non-compliance with permit TN0024945, Mountain City STP. The Order imposed a moratorium on further connections, line extensions, or increased flow from existing connections to the wastewater system until a number of improvements have been completed to return the sewage system (including the collection system) to compliance with the provisions of the NPDES permit. These include, but are not limited to, removal of excess infiltration and inflow by collection

system rehabilitation, increased pumping capacity, plant expansion and upgrades, and proper operation and maintenance of the treatment plant and collection system.

In order to meet water quality criteria for Roan Creek, the Mountain City STP (including sewer collection system) must meet the provisions of its NPDES permit, specifically with respect to effluent limits on discharge of fecal coliform of 200 counts per 100 ml as the 30-day geometric mean. In addition, all future NPDES facilities will be required to meet end-of-pipe criteria for fecal coliform discharge.

6.2 Urban Stormwater Management

Contributions to high concentrations of fecal coliform under low flow and high flow conditions, from urban sources, are probable. This is particularly true in the Mountain City area. These sources may include leaking sewer lines, illicit connections, improper disposal of wastes, and domestic and non-domesticated animals (e.g., birds). Efforts to minimize sources causing impairment to Roan Creek and its tributaries (e.g., Town Creek) should be coordinated with those described above in Section 6.1.

Development of a Storm Water Quality Management Program (SWQMP) is recommended to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques, public education, and other appropriate methods and provisions. Activities and programs that may be conducted by city, county, and state agencies are recommended to support the SWQMP: 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; development and implementation of a plan to detect and eliminate illicit discharges to the storm sewer system; information provided to the community about hazards associated with illegal discharges and improper disposal of waste; and mechanisms for reporting illicit connections, breaks, surcharges, and general sanitary sewer system problems with potential to release to the storm sewer system.

6.3 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. Current monitoring methodology has focused on quarterly sampling over an extended period of time (several years). This type of sampling provides some indication of long-term trends and supports dynamic water quality model calibration. In the next watershed cycle, monitoring should be expanded to provide water quality information to characterize seasonal trends and refined source identification and delineation.

Recommended monitoring for the Roan Creek watershed includes monthly grab samples and intensive sampling for one month each during the wet (January-March) and dry (August-October) seasons. In addition, monitoring efforts may be refined and enhanced in order to characterize dry and wet season baseflow 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. Consideration should be given to installation of a USGS continuous stream gage or development of a partial stage-discharge relationship to support improved model calibration. A single gage could serve as an index site for all water quality monitoring stations in the Roan Creek watershed. This information will support future dynamic modeling efforts yielding meaningful results and reduced uncertainty.

6.4 Field Surveys

Many of the model input parameters utilized in dynamic water quality simulations in support of this TMDL development were based on estimations and assumptions. Therefore, a significant component of the implementation strategy for addressing fecal coliform exceedances in Roan Creek is collection of data by field reconnaissance. Information on current manure management methods in the watershed is needed to verify the modeling assumptions or to adjust simulations accordingly. Input in this area should be coordinated with the Tennessee Department of Agriculture (TDA), University of Tennessee Agricultural Extension Service, and the NRCS.

In addition, a number of field surveys are recommended for verification or refinement of estimates (ground-truthing) of sources of fecal coliform to Roan Creek. Efforts supported by the City of Mountain City, the Johnson County Health Department, the Tennessee Department of Environment and Conservation (TDEC), TDA, TWRA, NRCS, and others should be initiated for collecting these data and conducting the following surveys:

1. Septic system data (population serviced by, age of, proximity to stream, etc.) including failure rates by county or subwatershed

2. Unverified sources: domestic animals, leaking sewer lines, illicit discharges, improper waste disposal, etc.

3. Livestock populations by subwatersheds (including horses, sheep, and other agricultural animals)

4. Cattle access to streams (and other agricultural animals, feeding operations, etc.)

5. Wildlife population estimates by county (in east Tennessee) or subwatershed (deer, waterfowl, etc.)

6.5 Future Efforts

This TMDL represents the first phase of a long-term restoration project to reduce fecal coliform loading to acceptable levels (meeting water quality standards) in the Roan Creek watershed. TDEC will evaluate the progress of implementation strategies and refine the TMDL as necessary in the next phase (next five-year cycle). This will include recommending specific implementation plans for delineated and as yet undefined sources and causes of pollution. Cooperation will be maintained with TDA (for possible 319 nonpoint source grants) and NRCS for developing BMPs. The dynamic loading model may be 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.

7.0 FURTHER INFORMATION

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

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

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

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APPENDIX A

WATER QUALITY DATA

Table A1. Roan Creek Water Quality (Fecal Coliform) Data.

Water Quality Monitoring Station[1]	Date	FC[2]
ROAN016.5 (034)	8/6/96	1600
ROAN016.5 (034)	10/22/96	460
ROAN016.5 (034)	2/4/97	1700
ROAN016.5 (034)	5/14/97	178
ROAN016.5 (034)	8/19/97	420
ROAN016.5 (034)	11/18/97	128
ROAN016.5 (034)	2/26/98	252
ROAN016.5 (034)	5/19/98	340
ROAN016.5 (034)	8/4/98	300
ROAN016.5 (034)	11/18/98	190
ROAN016.5 (034)	2/9/99	230
ROAN016.5 (034)	5/13/99	700
ROAN016.5 (034)	8/17/99	720
ROAN016.5 (034)	11/2/99	29000
ROAN016.5 (034)	02/09/00	370
ROAN016.5 (034)	08/03/00	2600
ROAN018.2 (035)	8/6/96	2000
ROAN018.2 (035)	10/22/96	130
ROAN018.2 (035)	2/4/97	490
ROAN018.2 (035)	5/14/97	940
ROAN018.2 (035)	8/19/97	300
ROAN018.2 (035)	11/18/97	58
ROAN018.2 (035)	2/26/98	82
ROAN018.2 (035)	5/19/98	174
ROAN018.2 (035)	8/4/98	310
ROAN018.2 (035)	11/18/98	70
ROAN018.2 (035)	2/9/99	250
ROAN018.2 (035)	5/13/99	1250
ROAN018.2 (035)	8/17/99	910
ROAN018.2 (035)	11/2/99	14000
ROAN018.2 (035)	02/09/00	510
ROAN018.2 (035)	08/03/00	2300
TOWN00.9 (036)	8/6/96	710
TOWN00.9 (036)	10/22/96	1330
TOWN00.9 (036)	2/4/97	1700
TOWN00.9 (036)	5/14/97	200
TOWN00.9 (036)	8/19/97	260
TOWN00.9 (036)	11/18/97	10
TOWN00.9 (036)	2/26/98	80
TOWN00.9 (036)	5/19/98	164
TOWN00.9 (036)	8/4/98	170
TOWN00.9 (036)	11/18/98	10
TOWN00.9 (036)	2/9/99	68
TOWN00.9 (036)	5/13/99	320
TOWN00.9 (036)	8/17/99	102
TOWN00.9 (036)	11/2/99	550
TOWN00.9 (036)	02/09/00	250
TOWN00.9 (036)	08/03/00	2000

[1] ROAN016.5 = Roan Creek Mile 16.5 (subwatershed 034)
ROAN018.2 = Roan Creek Mile 18.2 (subwatershed 035, Forge Creek)
TOWN00.9 = Town Creek Mile 0.9 (subwatershed 036)
[2] Fecal Coliform Concentration (Counts/100 ml)

APPENDIX B

HYDROLOGIC CALIBRATION

Table B1. NPSM/HSPF Hydrology Parameters and Value Ranges

Name	Definition	Units	Range of Values				Sinking Creek Starter	Roan Creek Calibration	Function of:	Comments
			Typical		Possible					
			Min	Max	Min	Max				
PWAT-PARM2										
FOREST	Fraction forest cover	none	0	0.5	0	0.95	0.284-0.394	0.227-0.390	Forest cover	% evergreen (forest land use only)
LZSN	Lower zone nominal soil moisture storage	inches	3	8	2	15	5	7	Soils, climate	Calibration
INFILT	Index to infiltration capacity of the soil	in/hr	0.01	0.25	0.001	0.5	0.05	0.125	Soils, land use	Calibration, divides surface/subsurface flow
LSUR	Length of overland flow plane	feet	200	500	100	700	500	500	Topography	Estimate from maps or GIS
SLSUR	Slope of overland flow plane	none	0.01	0.15	0.001	0.3	0.029-0.15	0.15	Topography	Estimate from maps or GIS
KVARY	GW recession flow parameter	1/inches	0	3	0	5	0	0	Baseflow recession variation	Used when recession rate varies w/ GW levels
AGWRC	Basic GW recession rate	none	0.92	0.99	0.85	0.999	0.98	0.98	Baseflow recession	Calibration
PWAT-PARM3										
PETMAX	Temperature below which ET is reduced	deg. F	35	45	32	48	40	40	Climate, vegetation	Reduces ET near freezing, when SNOW is active
PETMIN	Temperature below which ET is set to zero	deg. F	30	35	30	40	35	35	Climate, vegetation	Reduces ET near freezing, when SNOW is active
INFEXP	Exponent in infiltration equation	none	2	2	1	3	2	2	Soils variability	Usually default to 2.0
INFILD	Ratio of max/mean infiltration capacities	none	2	2	1	3	2	2	Soils variability	Usually default to 2.0
DEEPFR	Fraction of GW inflow to deep recharge	none	0	0.2	0	0.5	0.35	0.0	Geology, GW recharge	Calibration
BASETP	Fraction of remaining ET from baseflow	none	0	0.05	0	0.2	0	0	Riparian vegetation	Direct ET from riparian vegetation
AGWETP	Fraction of remaining ET from active GW	none	0	0.05	0	0.2	0	0	Marsh/wetlands extent	Direct ET from shallow GW
PWAT-PARM4										
CEPSC	Interception storage capacity	inches	0.03	0.2	0.01	0.4	monthly	Monthly	Vegetation type/density, land use	Monthly values usually used
UZSN	Upper zone nominal soil moisture storage	inches	0.1	1	0.05	2	0.7	0.7	Surface soil conditions, land use	Accounts for near surface retention
NSUR	Manning's n (roughness) for overland flow	none	0.15	0.35	0.1	0.5	0.3	0.2-0.3	Surface conditions, land use	Monthly values often used for croplands
INTFW	Interflow inflow parameter	none	1	3	1	10	5	4	Soils, topography, land use	Calibration, based on hydrograph separation
IRC	Interflow recession parameter	none	0.5	0.7	0.3	0.85	0.5	0.5	Soils, topography, land use	Often start with a value of 0.7, then adjust
LZETP	Lower zone ET parameter	none	0.2	0.7	0.1	0.9	Monthly	monthly	Vegetation type/density, root depth	Monthly values usually used
MON-INTERCEPT	Monthly interception storage capacity	inches	0.03	0.2	0.01	0.4			Vegetation type/density, land use	Monthly values usually used
	January						0.01	0.01		
	February						0.01	0.01		
	March						0.03	0.03		
	April						0.08	0.08		
	May						0.12	0.12		
	June						0.12	0.12		
	July						0.12	0.12		
	August						0.12	0.12		
	September						0.12	0.12		
	October						0.06	0.06		
	November						0.03	0.03		
	December						0.01	0.01		
MON-LZETPARM	Monthly lower zone ET parameter	none	0.2	0.7	0.1	0.9			Vegetation type/density, root depth	Monthly values usually used
	January						0.2	0.2		
	February						0.2	0.2		
	March						0.2	0.2		
	April						0.3	0.3		
	May						0.4	0.4		

	June						0.4	0.4		
	July						0.4	0.4		
	August						0.3	0.3		
	September						0.3	0.3		
	October						0.2	0.2		
	November						0.2	0.2		
	December						0.2	0.2		

GW = groundwater
ET = evapotranspiration

APPENDIX C

WATER QUALITY CALIBRATION

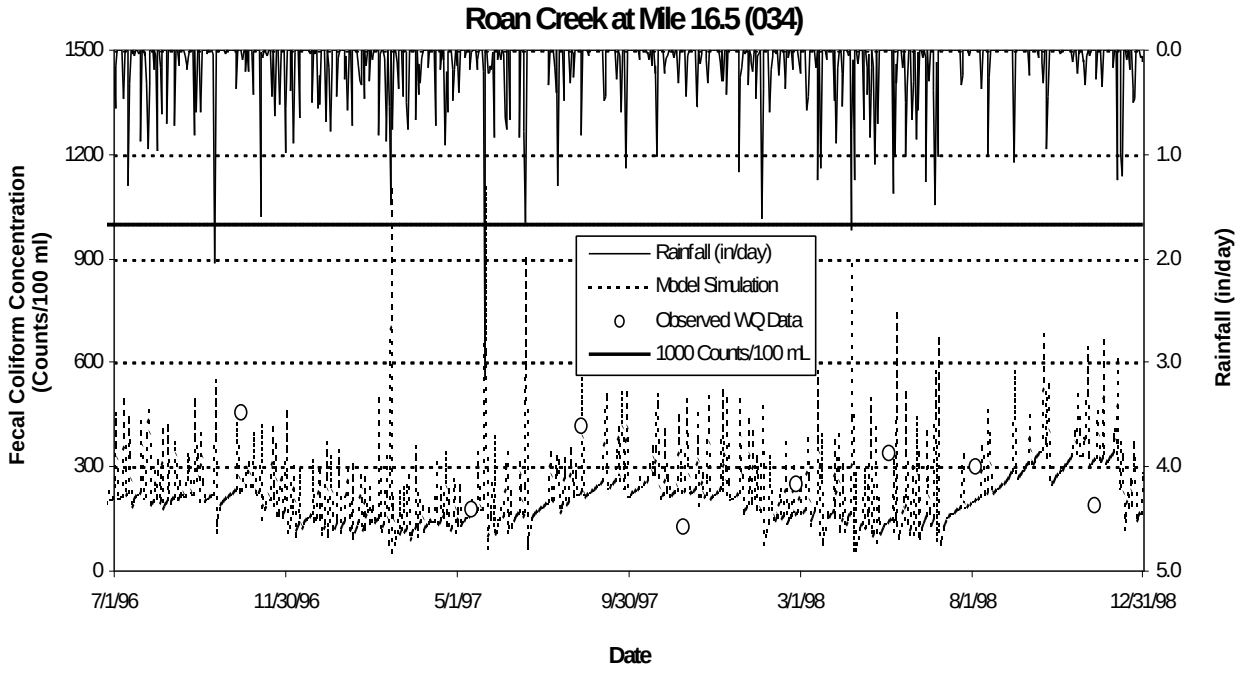

Figure C1. Roan Creek water quality model simulation of fecal coliform concentration versus observed data at ROAN016.5 (034), July 1, 1996 – December 31, 1998.

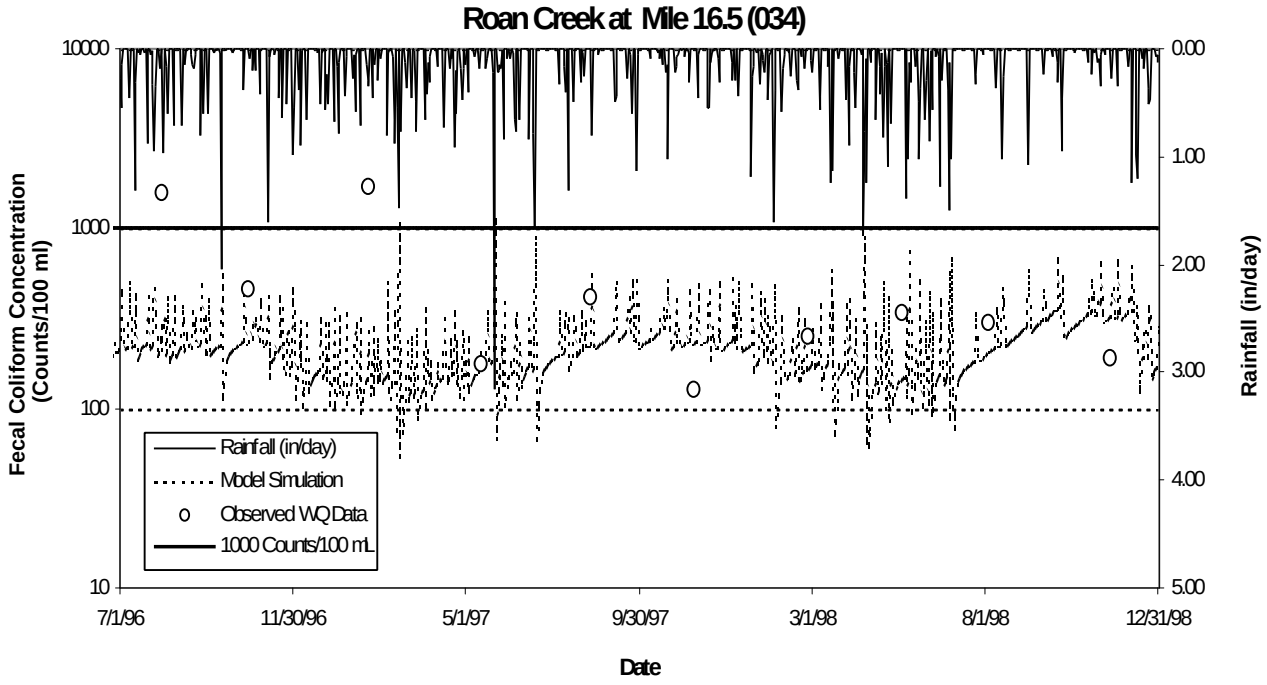

Figure C2. Roan Creek water quality model simulation of fecal coliform concentration versus observed data (log scale) at ROAN016.5 (034), July 1, 1996 – December 31, 1998.

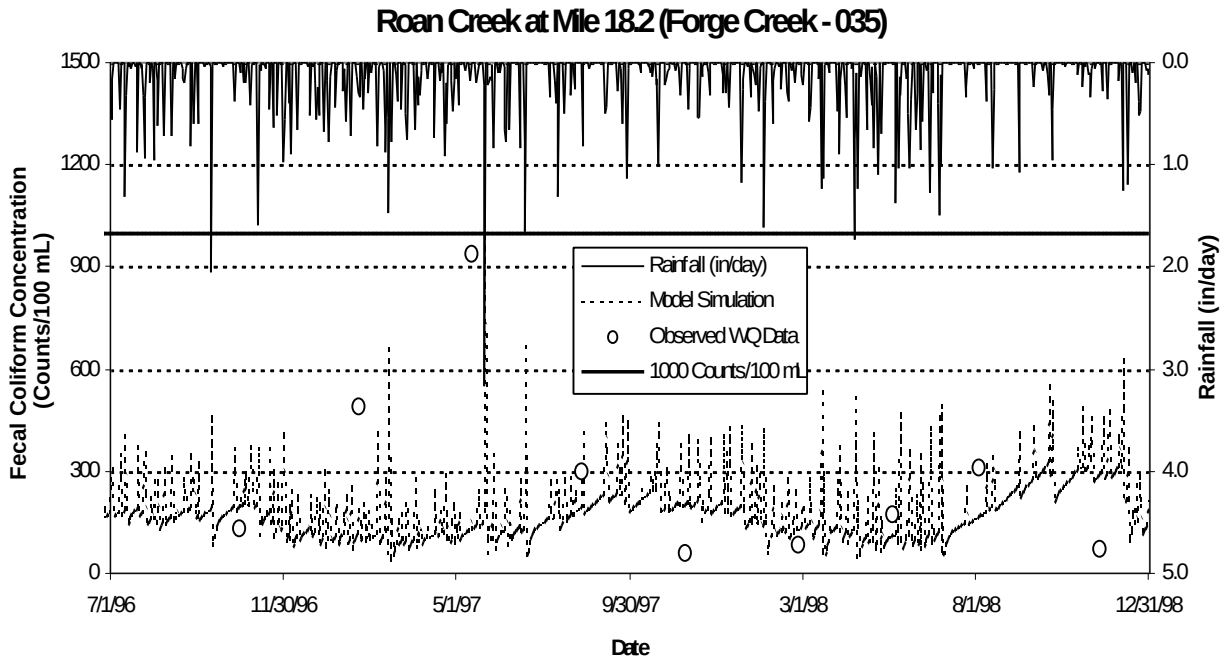

Figure C3. Roan Creek water quality model simulation of fecal coliform concentration versus observed data at ROAN018.2 (Forge Creek - 035), July 1, 1996 – December 31, 1998.

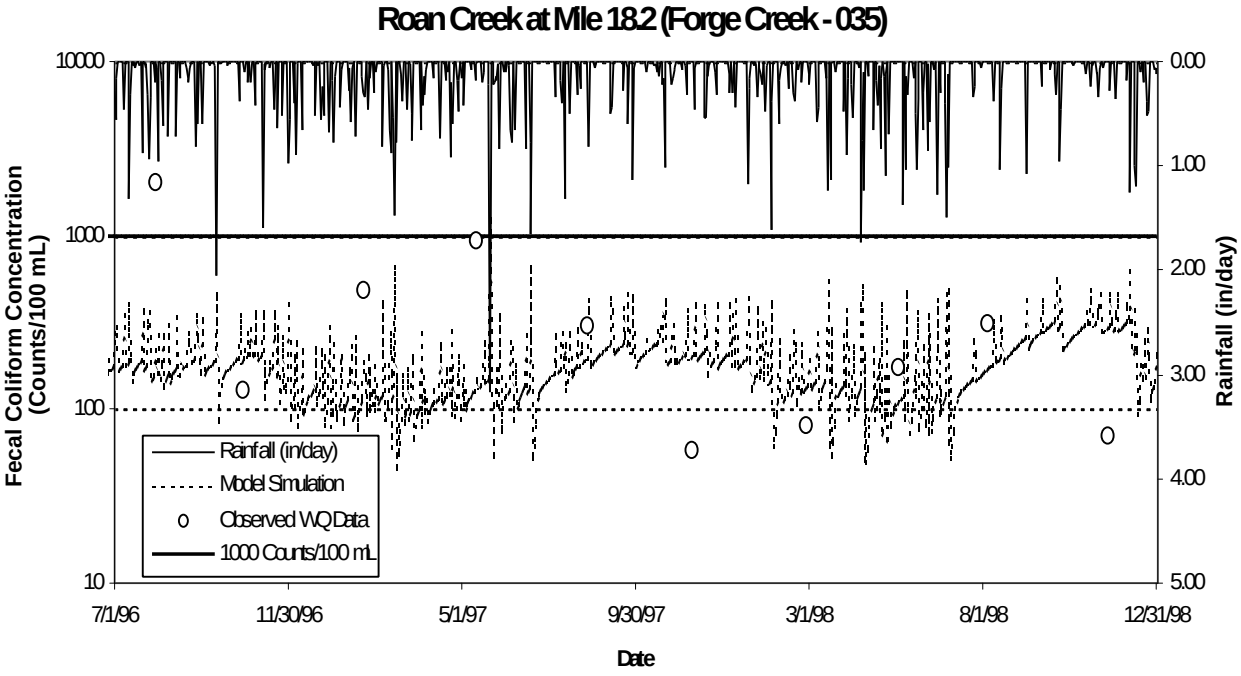

Figure C4. Roan Creek water quality model simulation of fecal coliform concentration versus observed data (log scale) at ROAN018.2 (Forge Creek - 035), July 1, 1996 – December 31, 1998.

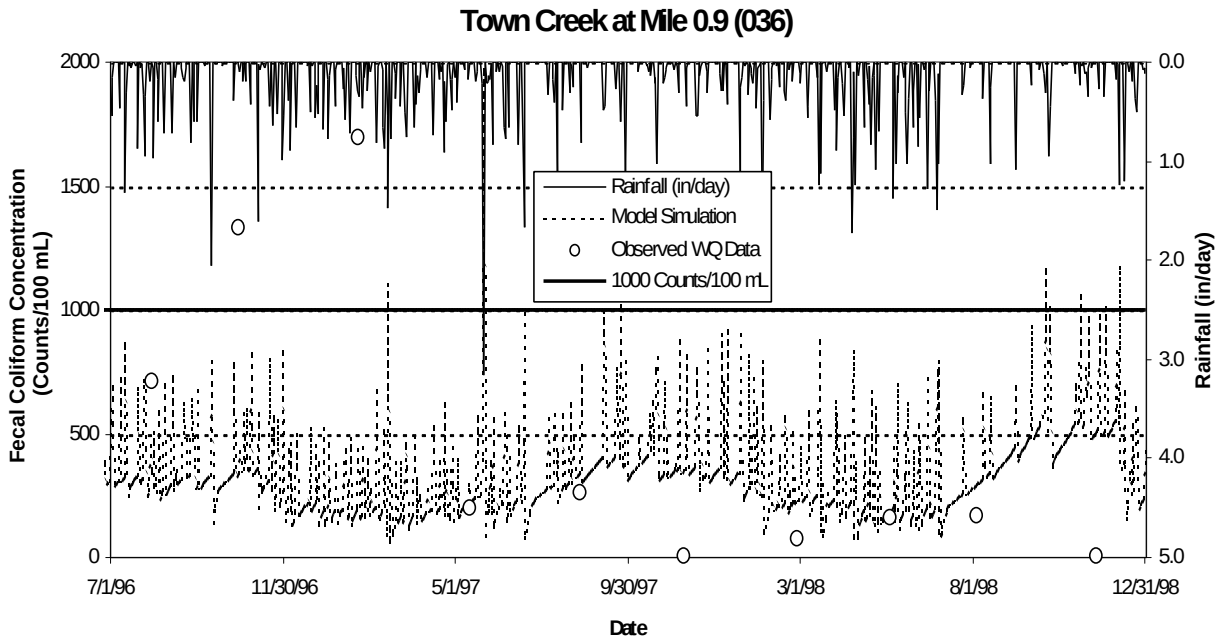

Figure C5. Roan Creek water quality model simulation of fecal coliform concentration versus observed data at TOWN00.9 (Town Creek - 036), July 1, 1996 – December 31, 1998.

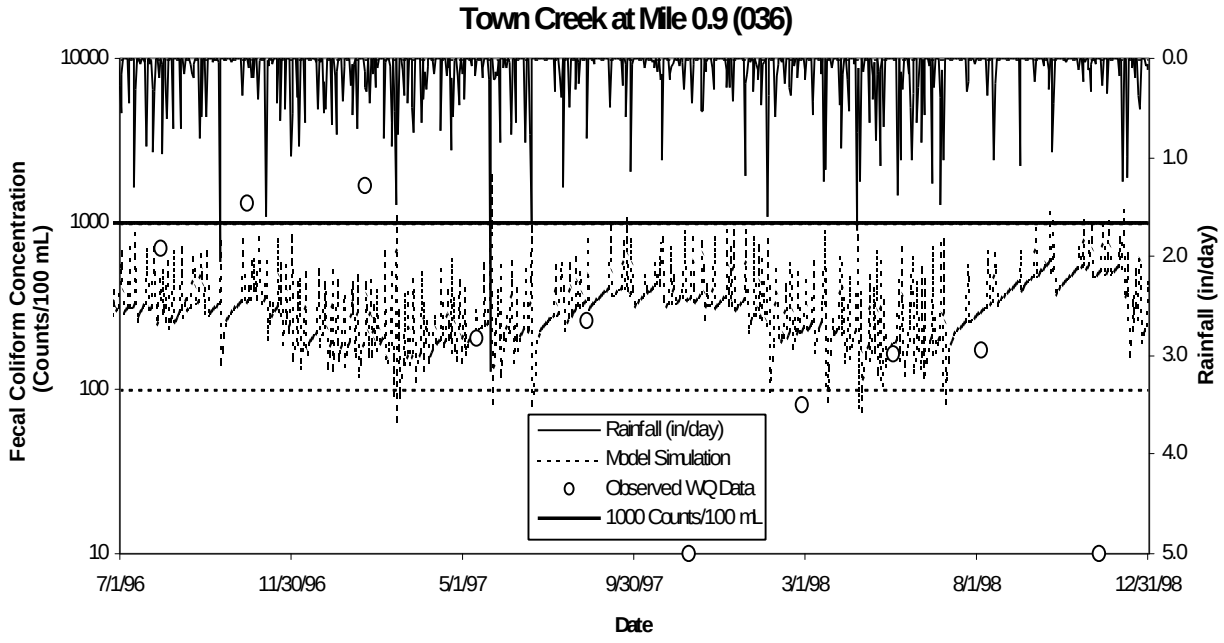

Figure C6. Roan Creek water quality model simulation of fecal coliform concentration versus observed data (log scale) at TOWN00.9 (Town Creek - 036), July 1, 1996 – December 31, 1998.

APPENDIX D

TMDL ALLOCATION RESULTS

Table D1. Roan Creek Water Quality Allocation Analysis

Calibrated (existing conditions) Water Quality model parameters:

SW#	% SSF	% OIS	MC STP	% SSO	Urban SQO/ACQOP	Urban SQOLIM	Urban IOQC/AOQC	Pas SQO/ACQOP	Pas SQOLIM	Pas IOQC/AOQC	Calibrated model max. 30-d geo. mean
036	20	0.25	0	5	1.00E+09	2.5E+09	28320	2.51E+10	6.27E+10	14900	**653**
035	20	0.25	0	0	1.00E+09	2.5E+09	28320	2.95E+10	7.37E+10	14900	**357**
034	50	0.5	DMR	0	1.00E+09	2.5E+09	28320	2.51E+10	6.27E+10	14900	**430**

TMDL Allocation Water Quality model parameters:

SW#	% SSF	% OIS	MC STP	% SSO	Urban SQO/ACQOP	Urban SQOLIM	Urban IOQC/AOQC	Pas SQO/ACQOP	Pas SQOLIM	Pas IOQC/AOQC	Allocated model max. 30-d geo. mean
036	5	0.068		0	5.00E+08	1.25E+09	14160				**199**
035	5	0.134			5.00E+08	1.25E+09	14160				**199**
034	5	0.325	Permitted								**199**

Note: only parameter values that have been adjusted are listed (i.e., parameter values not listed were not adjusted)

TMDL Allocation Water Quality model; **Percent Reductions** (relative to existing conditions) to meet criteria:

SW#	% SSF	% OIS	MC STP	% SSO	Urban SQO/ACQOP	Urban SQOLIM	Urban IOQC/AOQC	Pas SQO/ACQOP	Pas SQOLIM	Pas IOQC/AOQC	% Reduction*
036	75	72.8		100	50	50	50				**70**
035	75	46.4			50	50	50				**44**
034	90	35	Variable								**54**

* Percent reduction at subwatershed outlet required to meet criteria (30-day geometric mean concentration less than or equal to 200 counts/100 ml) according to calibrated model.

SW# = Subwatershed number
SSF = Septic System Failure
OIS = Other direct In-Stream sources (including unverified sources)
MC STP = Mountain City Sewage Treatment Plant (effluent)
SSO = Sanitary Sewer Overflows (as a percent of STP design flow with fecal coliform concentration of 10,000 counts/100 ml)
DMR = Discharge Monitoring Reports (monthly input from)
Urban = Pervious and impervious (except for IOQC/AOQC: pervious only)
Pas = Pasture
Permitted = Mountain City STP permitted discharge (design flow with fecal coliform concentration of 200 counts/100 ml)

Table D2. Roan Creek Water Quality Loading Analysis: Existing Conditions

Subwatershed #	Land Loading (Counts/30 days)		Direct In-Stream Loading (Counts/30 days)				Total (Counts/30 days)
	Pervious	Impervious	Septic Systems	OIS[1]	MC STP[2]	SSO[3]	
036	6.281E+11	2.878E+12	2.189E+11	5.594E+12	0	7.862E+11	1.011E+13
035	6.653E+11	9.048E+11	2.174E+11	4.255E+12	0	0	6.043E+12
034	2.090E+11	8.762E+10	1.426E+11	4.082E+12	7.434E+12	0	1.196E+13
Total	1.502E+12	3.870E+12	5.789E+11	1.393E+13	7.434E+12	7.862E+11	**2.810E+13**

[1] OIS = Other direct In-Stream sources (including unverified sources)
[2] MC STP = Mountain City Sewage Treatment Plant (effluent)
[3] SSO = Sanitary Sewer Overflows

Table D3. Roan Creek Water Quality Loading Analysis: TMDL Allocation

Subwatershed #	Land Loading (Counts/30 days)		Direct In-Stream Loading (Counts/30 days)				Total (Counts/30 days)	TMDL (Counts/30 days)
	Pervious	Impervious	Septic Systems	OIS[1]	MC STP[2]	SSO[3]		
036	6.071E+11	1.481E+12	5.472E+10	1.522E+12	0	0	3.665E+12	3.665E+12
035	6.624E+11	4.656E+11	5.443E+10	2.282E+12	0	0	3.464E+12	3.464E+12
034	2.090E+11	8.762E+10	1.426E+10	2.653E+12	2.726E+11	0	3.236E+12	**1.037E+13**
Total	1.479E+12	2.034E+12	1.234E+11	6.457E+12	2.726E+11	0	1.037E+13	

[1] OIS = Other direct In-Stream sources (including unverified sources)
[2] MC STP = Mountain City Sewage Treatment Plant (effluent)
[3] SSO = Sanitary Sewer Overflows

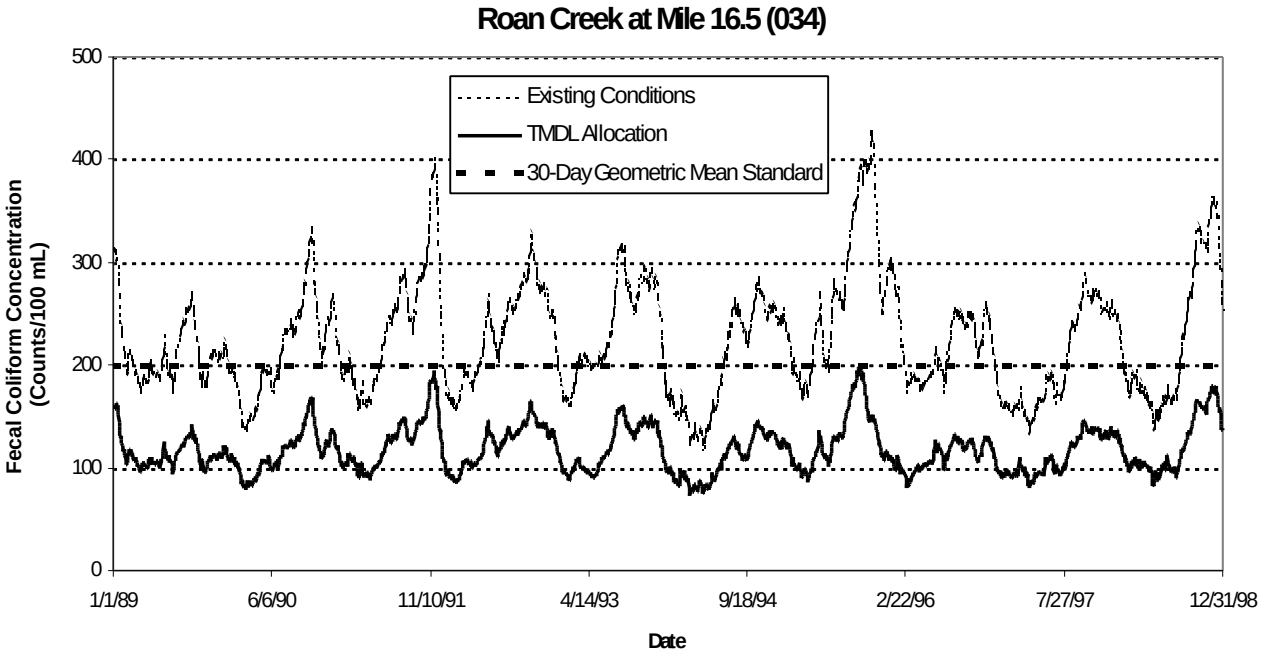

Figure D1. Roan Creek model simulation of existing conditions versus TMDL allocation at ROAN016.5 (034), (30-day geometric means).

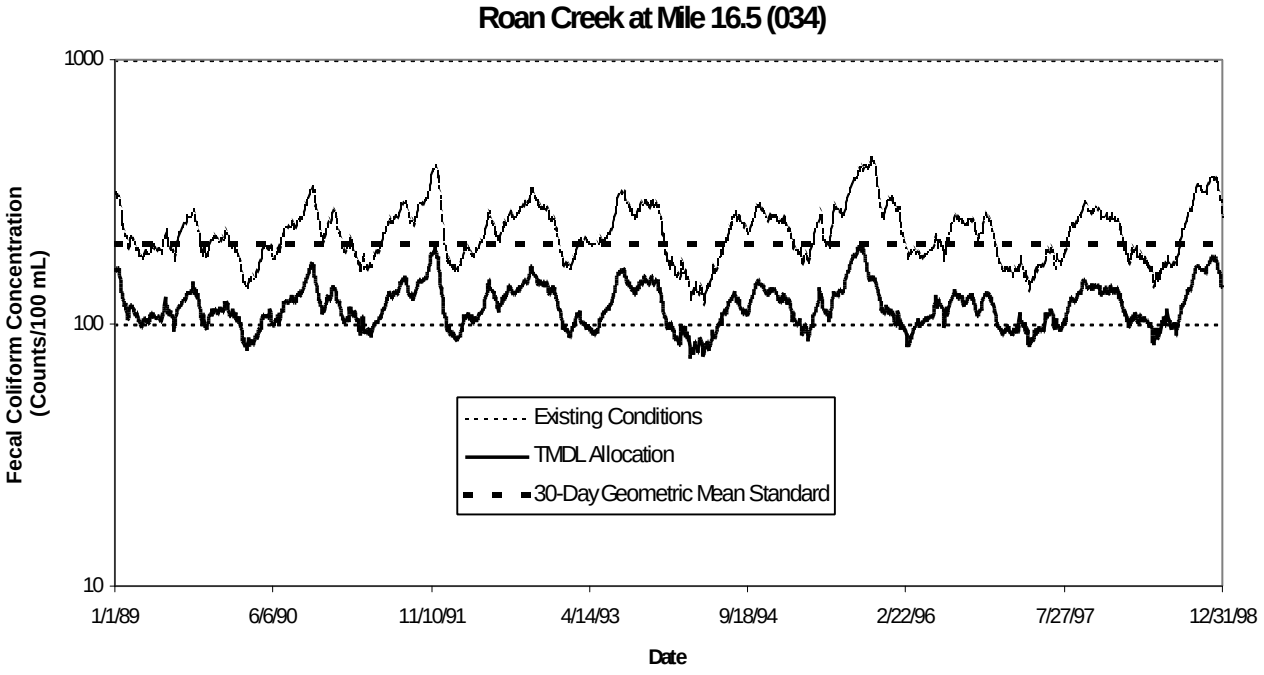

Figure D2. Roan Creek model simulation of existing conditions versus TMDL allocation (log scale) at ROAN016.5 (034), (30-day geometric means).

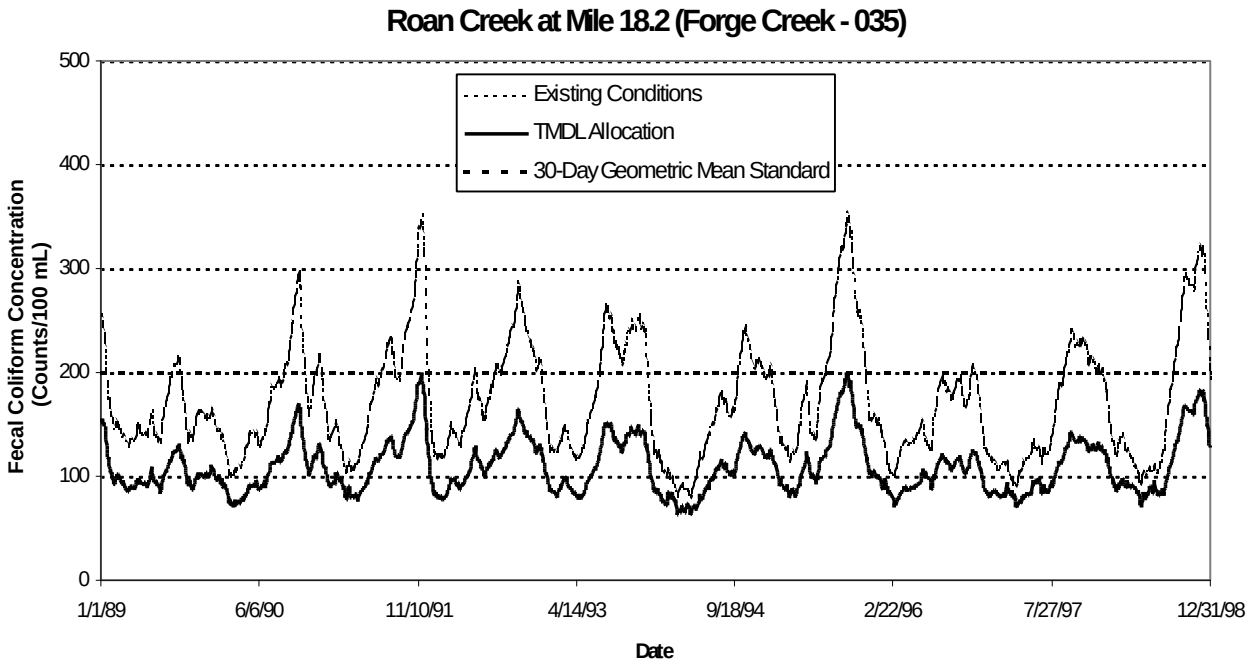

Figure D3. Roan Creek model simulation of existing conditions versus TMDL allocation at ROAN018.2 (Forge Creek - 035), (30-day geometric means).

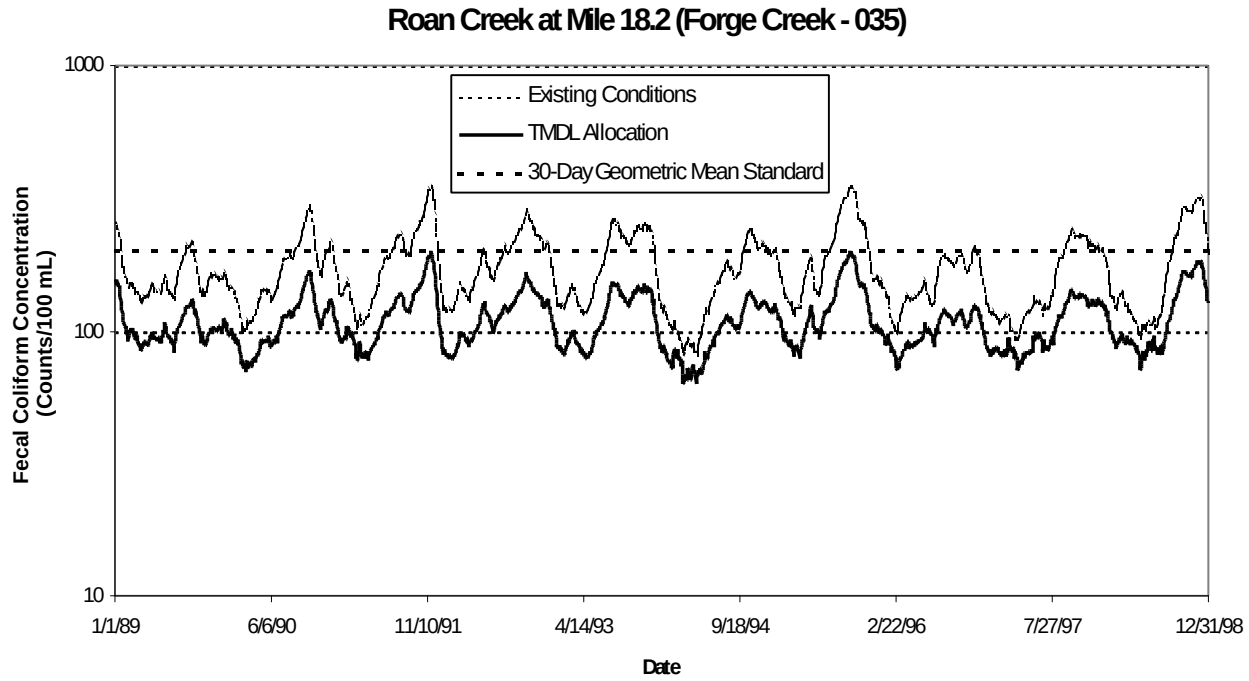

Figure D4. Roan Creek model simulation of existing conditions versus TMDL allocation (log scale) at ROAN018.2 (Forge Creek - 035), (30-day geometric means).

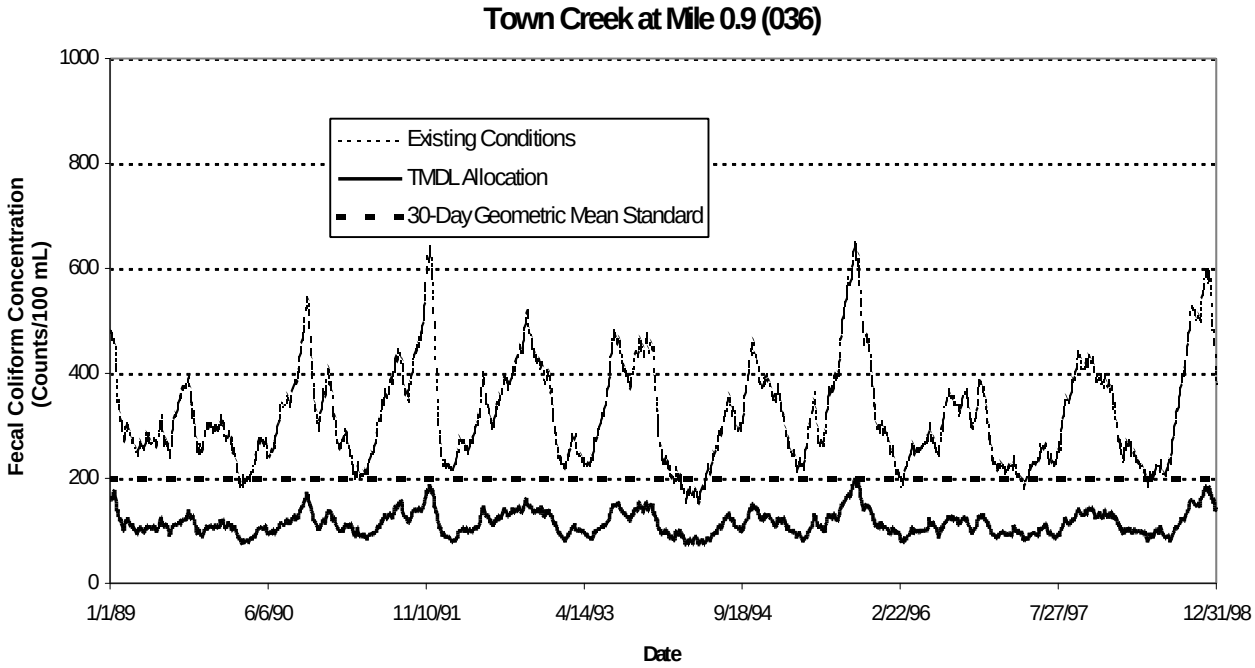

Figure D5. Roan Creek model simulation of existing conditions versus TMDL allocation at TOWN00.9 (036), (30-day geometric means).

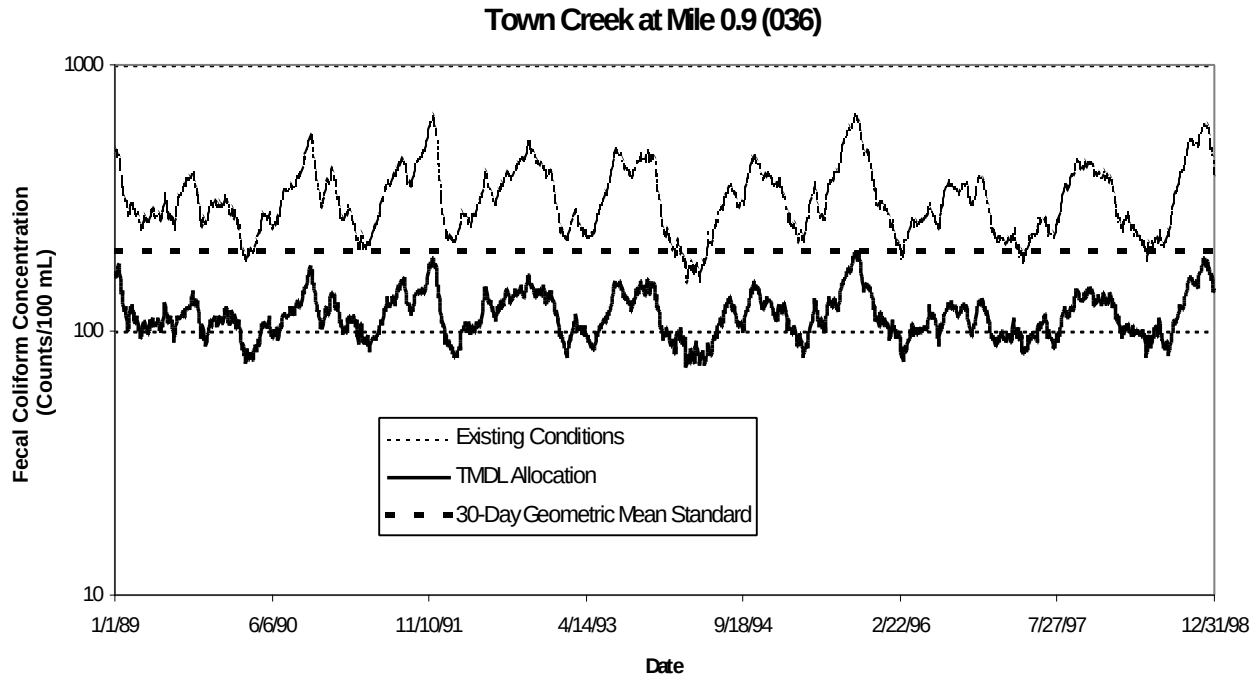

Figure D6. Roan Creek model simulation of existing conditions versus TMDL allocation (log scale) at TOWN00.9 (036), (30-day geometric means).

APPENDIX E

PUBLIC NOTICE OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR FECAL COLIFORM IN ROAN CREEK

DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR FECAL COLIFORM IN ROAN CREEK, WATAUGA RIVER WATERSHED (HUC 06010103), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed total maximum daily load (TMDL) for fecal coliform in the Roan Creek watershed, which drains to Watauga River at approximately river mile 44.3. 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.

Roan 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 Municipal Point Source. 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 proximity to 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 of approximately 54% for Roan Creek.

The proposed Roan 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 25, 2001 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.

APPENDIX F

RESPONSE TO PUBLIC COMMENTS FOR PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR FECAL COLIFORM IN ROAN CREEK

Comments received on the Proposed TMDL for Fecal Coliform in Roan Creek

A. The following is the first of two transmittals of comments received during the public notice period. It has been transcribed, verbatim, from the original hardcopy transmittal. Responses follow the comments.

To: Dennis Borders Date: 1-8-01

From: David Merinar
USDA – Natural Resources Conservation Service
307 College St.
Mountain City, Tn. 37683

tele: 423-727-7011 ext. #3

Re: Summary of Livestock Numbers – Johnson County

Dennis,

Enclosed please find my estimated livestock numbers for the Forge, Roan, and Town creek watersheds. The NRCS does not maintain exact livestock numbers by watershed. These numbers were estimates by the Extension Agent and myself based upon our personal knowledge of the subject watersheds. If my office can be of additional assistance please feel free to contact me.

Sincerely,

David R. Merinar

District Conservationist

ENCLOSURES
CC: Jenny Adkins

Summary of Livestock Count Estimates by County

Counties	Livestock (counts)					
	Beef Cow	Cattle	Chickens	Hogs	Milk Cow	Sheeps
ASHE	8313	19081		281	264	892
JOHNSON	4360	10422	~~15~~ 1000	~~74~~ 250	~~506~~ 400	~~164~~ 250
WATAUGA	4126	11186		21	166	207

Summary of Livestock Count Estimates by Watershed

Watersheds	Drainage Area (mi^2)	Livestock (counts)						
		Beef Cow	Cattle	Chickens	Hogs	Milk Cow	Sheeps	Horses
Roan Creek (034)	9.3	256 500	611 750	1 200	4 125	30 100	10 25	35 50
Forge Creek (035)	38.6	534 260	1287 390	1 75	10 10	50 3	27 27	62 35
Town Creek (036)	29.5	702 140	1677 210	2 75	12 12	81 5	26 10	96 30

Note:
The plural of sheep is sheep

Response to Comments Received on the Proposed TMDL for Fecal Coliform in Roan Creek

Table 3 has been changed to reflect the estimated livestock numbers provided.

Comments received on the Proposed TMDL for Fecal Coliform in Roan Creek

B. The following is an unedited electronic transmittal of the second of two sets of comments received during the public notice period. Responses follow the comments.

January 24, 2001

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

Re: Comments on Roan Creek TMDL - send via Email

Dear Sherry:

On behalf of the Southern Environmental Law Center representing the Tennessee Clean Water Network and the Tennessee Environmental Council, the following comments are submitted regarding the proposed TMDL for fecal coliform for Roan Creek. Some of the issues raised in this TMDL are similar to those in other TMDLs for which we also submitted comments. To date we have not received any response to our previous comments, thus making it difficult to resolve some of the issues and participate in the state's TMDL process. There is no mention in the document of any efforts to involve the public in development of this TMDL prior to release of the draft, and we are not aware of any such effort.

Specific comments for which we request a response are as follows:

1. The Executive Summary on page vi contains a description of the requirements of Section 303(d) of the Clean Water Act that is somewhat incorrect. Another explanation is given on the following page in section 1.1 that is slightly different and more accurately reflects the regulations.

2. The 303d listing for this TMDL covers three streams for pathogens. This TMDL only addresses fecal coliform and makes no mention of *E. coli*, which is another pathogen for which there is a state standard that needs to be met. If the TMDL for fecal coliform is intended to cover all pathogens, it needs to be explained. The TMDL value is given for only one most downstream location and does not allocate or otherwise explain how this is to be applied to the two tributary streams and along the reaches of Roan Creek.

3. The 303d list states that the control strategy is a Commissioner's Order against the town of Mountain City. In the TMDL document, this is further described as part of the implementation strategy, and explained that the Order was issued in 1993 and contains a moratorium. Under EPA regulations, compliance schedules must generally be for less than three years, and in this case, the Order has been in place for eight years, and the problem apparently persists. Thus is may be assumed that the Order is either inadequate or not being enforced. Please provide information regarding compliance with the Order, including the number of requests for connections since the moratorium and which have been issued or denied, and any penalties issued along what has been paid or reduced. Also, please provide information regarding the STP's compliance with its permit, including bypasses for the past year.

4. The TMDL is developed only for the 30-day mean standard and no explanation is given as to how this covers the daily maximum or single sample standard. Thus it appears that there is actually no total daily maximum load proposed in this document, especially considering that this is proposed as a TMDL for pollutants for which daily maximum standards exist. Compliance with the mean does not assure compliance with the maximum. These issues have been raised in previous TMDL comments, but no response has been received. As with other draft TMDLs, this document states that there were insufficient data to calculate the 30-day mean, thus further raising the question of how this can be justified as the target with any accuracy. It is suggested that due to the lack of data and uncertainties associated with this, that a greater margin of safety (MOS) be applied and the TMDL revised so as to address all applicable standards.

5. The MOS is stated as being implicitly incorporated into the modeling, but this is not well justified. Along with the issues discussed above, the MOS is further called into questioned by the modeling outputs showing a lack of agreement between observed and predicted values in Appendix C. This might be due in part to the observed values being single samples (daily maximums) and the model being run for means. If that is the case, then there is an inconsistent mixing of units limiting the accuracy of the model. Therefore the MOS claim is not justified.

The MOS should not just be based on consideration of the critical period, but also on the adequacy of the data and accuracy of the predictions. As stated in section 3.4 of the document, there was only quarterly sampling at three stations, with lack of precipitation data for 1999 and 2000, and "Because few samples were collected during high flow conditions, the uncertainty of the model calibration increases". Thus the claim that the MOS is implicitly incorporated does not seem reasonable. It is suggested that this be considered a first phase TMDL, and that a portion of the loading be set aside as an explicit MOS (or a lower target value used - this is essentially the same thing, but perhaps less clear) until better data and certainty are developed if later phases are needed.

It is also stated in section 3.3.5 that bypass flows are assumed to have a fecal count of 10,000, and that this is at "...the low of the range of concentration for combined sewer overflows reported...". It is further stated here that this is considered to be a conservative assumption. If this assumed value is a the low end of the expected range, then this would be a non-conservative assumption. From other information provided it appears that the sewer overflow problem is from a separate, rather than a combined system, thus meaning that fecal counts would be even higher, further calling into question the assumptions. If such data do not already exist, it would seem that actual sampling of the bypass flows should be required of the city, or be done as part of this TMDL

effort. This could further help in documenting the problem and success of corrections, and reduce the need for a large, explicit MOS.

6. The WLA is given as a single value for Roan Creek for the STP. However the STP is described as discharging to Town Creek, and it is presumed that no WLA is being assigned to the sewer overflow point source discharges. It is unclear how this is justified at a constant flow that does not account for peak flows when the bypasses are likely to occur, and is based on the effluent exactly at the in-stream water quality mean standard. If the stream is already overloaded with bacteria from bypasses and other sources, it would seem that permit limits would have to be at some value lower than the standard to allow for improvements and an MOS.

7. The question of quality control of samples was also raised with a previous fecal TMDL, but has not been resolved. There is no information in this TMDL document regarding sampling procedures and holding times in keeping with approved methods.

8. Plans for additional monitoring include going to monthly grabs and some intensive sampling. While this is commended, it still might not be enough for geometric mean determinations. Otherwise, the TMDL does not propose a plan to bring these waters into compliance with standards, other than more of the same of what has been going on for years - mainly waiting for compliance with the Order to eliminate bypassing. Thus there is no reasonable assurance in this TMDL that it will result in protection of the streams involved.

It is suggested that the Order be amended as needed and strictly enforced to see that no additional flows are added and corrective actions are made immediately. Further, the Order should be established as an enforceable court order as required by the state Water Quality Control Act in Section 69-3-115(e). No new permits for additional fecal loads should be allowed until corrections are made and capacity exists, and current permit limits should be adjusted downward to allow for a margin of safety.

9. In downloading the TMDL from your web site some loss of format was encountered. If not already the practice, we suggest that your office try downloading and printing a copy from the site before it is put out on notice to avoid problems and frustrations by the public.

We look forward to your response to these comments as well as previously submitted ones on other TMDLs. Thank you for your efforts in the evolving TMDL program, and we are available for discussion or working with your division on this.

Sincerely,

Barry Sulkin
4443 Pecan Valley Road
Nashville, TN 37218

cc: SELC, TEC, TCWN

Response to Comments Received on the Proposed TMDL for Fecal Coliform in Roan Creek

1. The Division acknowledges the comment but does not believe the description of requirements of Section 303(d) of the Clean Water Act in the Executive Summary is incorrect.

2. To date, insufficient data have been collected to evaluate water quality with respect to E. coli in the Roan Creek watershed. The State of Tennessee now routinely collects E. coli samples concurrently with fecal coliform and will consider both in future evaluations. Currently, evaluation of fecal coliform only is in accordance with EPA's guidance.

   The TMDL analysis was conducted on each of the three reaches, as stated in the title, "Proposed Total Maximum Daily Load for Fecal Coliform in **Roan Creek**, including **Forge Creek** and **Town Creek**". See Table D2 for loading analyses for existing conditions for each of the three reaches/subwatersheds. See Table D3 for loading analyses for the allocation scenario, including load allocations, waste load allocations, and TMDL values, for each of the three reaches/subwatersheds.

3. The 3-yr compliance schedule restriction pertains only to compliance schedules in NPDES permits. There are no state or federal restrictions on the length of compliance schedules in enforcement orders. The City failed to meet the complete construction date in the Commissioner's Order and paid a $25,000 contingent penalty late last year. There is one outstanding compliance item, the submittal of an engineering report evaluating the effectiveness of the corrective actions required under the Order. The Division expects that report to be submitted later this year.

4. As stated in Section 1.3, "For this TMDL, the fecal coliform 30-day geometric mean standard for Recreation is the target level to evaluate impairment and establish the TMDL." This is in accordance with EPA's established protocol for fecal coliform TMDLs. However, it remains a requirement to achieve the maximum level of 1000 counts/100 ml according to water quality standards.

   These issues were addressed in Appendix F of the EPA-approved "Total Maximum Daily Load for Fecal Coliform in Sinking Creek" which was posted on the following TDEC website on 12/13/00: www.state.tn/environment/wpc/tmdl.htm.

5. Observed values are randomly collected with respect to water quality and may be daily minimums, maximums, means, or any value in between. The MOS is not just based on consideration of the critical period but on the conservativeness incorporated in model parameters and assumptions. Section 5.5 has been expanded to further describe conservative model assumptions to support an implicit MOS.

   The TMDL **is** considered a first phase TMDL. As stated in Section 6.5, "This TMDL represents the **first phase** of a long-term restoration project to reduce fecal coliform loading to acceptable levels (meeting water quality standards) in the Roan Creek watershed. TDEC will evaluate the progress of implementation strategies and refine the TMDL as necessary in the **next phase**". Furthermore, Section 6.5 states, "The dynamic loading model may be 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."

   Section 3.3.5 discusses collection system overflows. 40 CFR §122.41 (m)(1)(i) defines a bypass as "the intentional diversion of waste streams from any portion of a treatment facility." The Mountain City STP has not had documented problems with bypasses. Section 3.3.5 states, "documented collection system (sanitary sewer) **overflows** are represented in model simulations as a single point source having constant flow equal to 5% of STP design flow and a constant fecal coliform concentration of 10,000 counts per 100 ml." It is standard practice for municipal permits to define a sanitary sewer overflow event as "an unpermitted discharge of wastewater from the collection or treatment system other than through the permitted outfall that is directly related to a specific rainfall event".

The last sentence of Section 3.3.5 has been edited as follows: "This is considered to be a reasonable estimate since overflows in Mountain City are documented to be due largely to excessive infiltration and inflow." Whether the assumption is conservative or not, the assumption is considered reasonable, because as a calibration parameter, it produces reasonable agreement with observed results.

6. The Town Creek water quality monitoring station is located at mile 0.9; therefore, the subwatershed is delineated at this location. The STP effluent is located at mile 0.4 on Town Creek, downstream from the water quality monitoring station and, hence, downstream from the Town Creek subwatershed. The STP effluent is located in the Roan Creek subwatershed. See Figure 2.

   Bypasses and overflows are not permitted. Sanitary sewer overflows, documented in Mountain City, are required to be eliminated. Therefore, they are assigned a waste load allocation (WLA) of zero. If the STP discharges at permit limits that are equal to the water quality standard, it will not contribute to impairment.

7. The Sinking Creek Fecal Coliform TMDL was approved by EPA on 12/12/00 and was posted on the State of Tennessee web site (***www.state.tn/environment/wpc/tmdl.htm***) on 12/13/00. The subject issue was originally raised September 1999 during the public comment period for the Proposed Fecal Coliform TMDL for Nonconnah Creek. The following is transcribed directly from Appendix F of the approved Sinking Creek TMDL:

   > The six-hour holding time was not a problem with the Fecal Coliform TMDL for Nonconnah Creek. The original comment, as transcribed in abbreviated form in the summary of comments in the Division's formal submittal to EPA, dated October 12, 1999, is reiterated as follows: *"For the data for which documentation was available, there appear to be sampling protocol problems. For unrelated sites, some samples were held beyond allowable holding times. A few lab sheets faxed from the Memphis Field Office showed both the sample and analysis dates. Some samples were taken on one day and the test run on the next, thus exceeding the holding time and invalidating the results."* The Division's response to the aforementioned comment, included in the summary of comments in the formal submittal to EPA (October 12, 1999) stated, *"According to the Division of Water Pollution Control's Environmental Field Office Manager in Memphis, all water quality samples utilized in the TMDLs met sample holding times and sampling protocols were followed. In addition, according to personnel at the State Analytical Laboratory in Nashville, TN, the fecal coliform test is a 24-hour test. When the sample is received, a reagent is added and the sample is incubated for 24 hours prior to the analysis. Therefore, the test date must be 24 hours later than the collection and received (by Lab) dates for all samples which met holding times*." Likewise, according to the Division's Environmental Assistance Center Manager in Johnson City, all Sinking Creek fecal coliform samples met sample holding times and sampling protocols were followed.

   Again, according to the Division's Environmental Assistance Center Manager in Johnson City, all Roan Creek fecal coliform samples met sample holding times and sampling protocols were followed.

8. The implementation plan for this Phase 1 TMDL includes NPDES permit compliance, an expanded data collection program to support additional modeling and evaluation, recommended development of a Storm Water Quality Management Program (SWQMP), and recommended field surveys for verification and/or refinement of estimates (ground-truthing) of sources of fecal coliform to Roan Creek. Many of these activities are recommended to be coordinated with various city, county, state, and federal agencies. In addition, it was stated that the Roan Creek Fecal Coliform TMDL "represents the first phase of a long-term restoration project to reduce fecal coliform loading to acceptable levels (meeting water quality standards) in the Roan Creek watershed." TDEC will revisit and revise the TMDL as appropriate during the next five-year cycle.

Section 69-3-115(e) of the Tennessee Water Quality Control Act does **not** require an order to be established as an enforceable court order. The aforementioned section of the Act states, "Whenever any order or assessment has become a final action under this section, a notarized copy of the same **may** be filed in the office of the clerk of the chancery court of Davidson County...." (emphasis added). This provision of the act is discretional and is used only in rare circumstances. Mountain City completed construction of the wastewater treatment plant expansion during the summer of 2000 and has been in compliance with permit limits since September 2000, with the exception of one daily maximum limit exceedance of TSS and one daily maximum limit exceedance of settleable solids during the month of November 2000. No bypass/overflow events were reported. While it is acknowledged that Mountain City has had a long history of compliance problems, the Division believes the plant upgrades and on-going collection system repairs will greatly reduce the discharge of untreated wastewater to Roan Creek.

9. The Division is exploring ways to improve format conversion from Word to PDF files.

Lastly, it should be noted that public comments on Proposed TMDLs are included in their entirety, as well as formal responses by the State of Tennessee, in the final EPA-approved TMDLs. **Final TMDLs are currently posted on the following web site**: www.state.tn/environment/wpc/tmdl.htm.