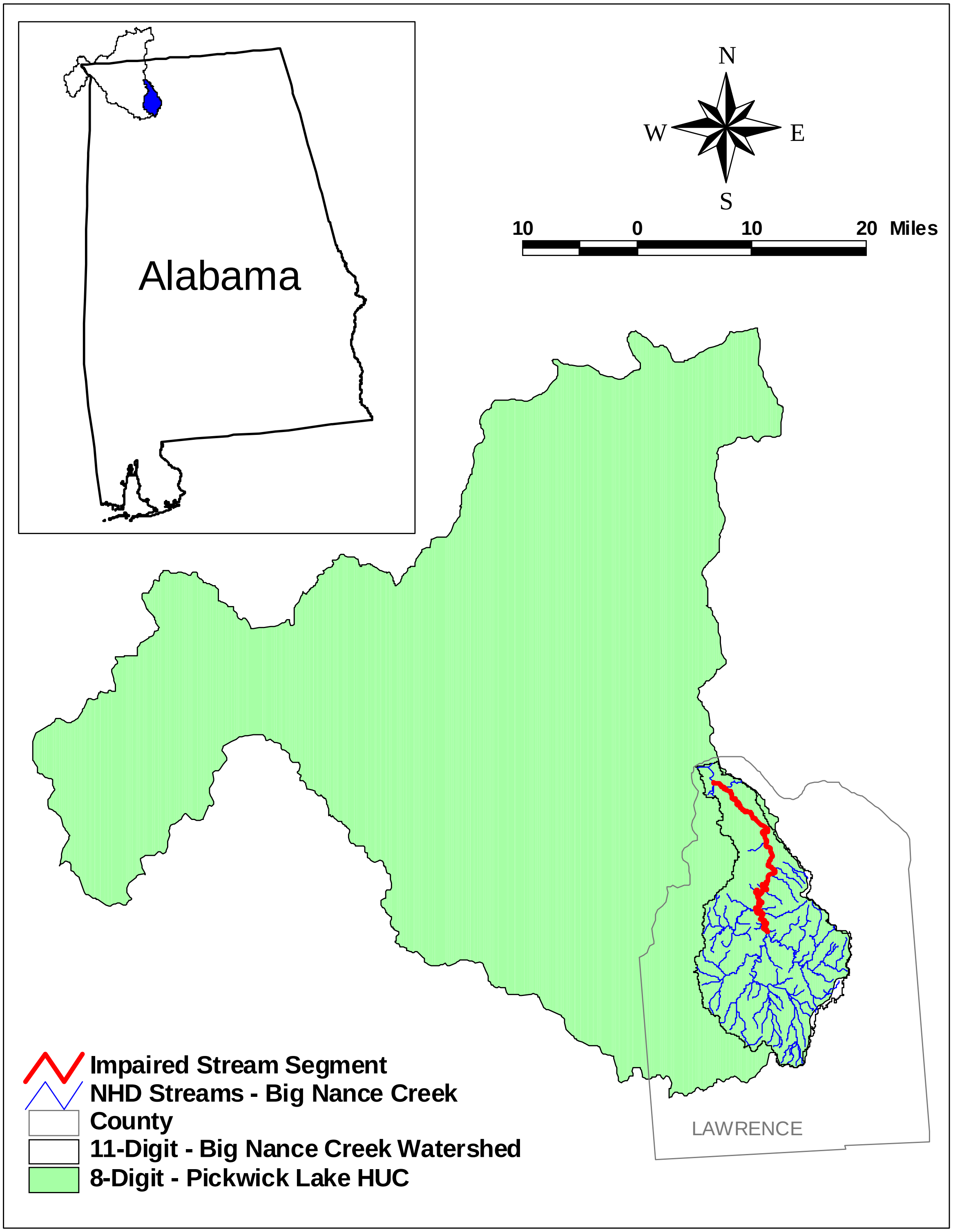
Alabama Department of Environmental Management

FINAL
Big Nance Creek TMDL Development for Fecal Coliform

Water Quality Branch
Water Division
February 2002

Big Nance Creek Watershed (06030005010) in the Pickwick Lake Basin (0603005)



LIST OF ABBREVIATIONS

ADEM	Alabama Department of Environmental Management
BMP	Best Management Practices
CFS	Cubic Feet per Second
DEM	Digital Elevation Model
DMR	Discharge Monitoring Report
EPA	Environmental Protection Agency
GIS	Geographic Information System
HSPF	Hydrological Simulation Program - FORTRAN
HUC	Hydrologic Unit Code
LA	Load Allocation
LSPC	Loading Simulation Program C++
MGD	Million Gallons per Day
MOS	Margin of Safety
MPN	Most Probable Number
MRLC	Multi-Resolution Land Characteristic
NED	National Elevation Database
NHD	National Hydrography Dataset
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
RF3	Reach File 3
STORET	STORage RETrieval database
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WCS	Watershed Characterization System
WLA	Waste Load Allocation

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1 Executive Summary

Big Nance Creek is located in the northwest portion of Alabama near the Pickwick Lake Reservoir in the Tennessee River basin. The Big Nance Creek watershed is approximately 191 square miles, located entirely within Lawrence County. The two incorporated populated areas in the watershed are Courtland and Moulton.

Big Nance Creek has been on the State of Alabama's §303(d) use impairment lists since 1992. It is listed due to pesticides, ammonia, nutrients, siltation, organic enrichment / dissolved oxygen, and pathogens(fecal coliform). This report presents only the fecal coliform TMDL. Big Nance Creek is listed on the 1996-§303(d) use impairment list for the same pollutants with the impaired length being 24 miles. Its use designation is Fish and Wildlife for the entire segment. The sources of impairment are shown on the §303(d) list as non-irrigated crop production, specialty crop production, feedlots, and animal holding / management areas. The data that listed Big Nance Creek as being impaired for fecal coliform were listed as being collected in 1991.

The following report addresses the results of the TMDL analysis for fecal coliform. In accordance with ADEM water quality criteria, the bacteria of the fecal coliform group shall not exceed a geometric mean of 1,000/100 ml October-May or 200/100ml June-September; nor exceed a maximum of 2,000/100 ml in any sample in a stream classified as Fish and Wildlife.

Table 1-1 Maximum Allowable Pollutant Loads by Source

Pollutant	Point Source Loads* (counts/yr)	Non-point Source Loads (counts/yr)
Fecal Coliform	3.95E+11	9.40E+13

* NPDES permitted loads based on limit of 200 per 100ml

Table 1-2 Maximum Allowable Pollutant Loads for Non-point Sources

Pollutant	Forest (counts/yr)	Pasture/Hay (counts/yr)	Row Crops (counts/yr)	Urban (counts/yr)
Fecal Coliform	8.15E+11	6.74E+13	1.97E+12	2.33E+10

Table 1-3 Maximum Allowable Pollutant Loads for Direct Inputs

Pollutant	Cattle in Streams (counts/yr)	Failing Septics (counts/yr)
Fecal Coliform	2.05E+13	3.35E+12

2 Basis for §303(d) Listing

2.1 Introduction

Section 303(d) of the Clean Water Act (CWA) as amended by the Water Quality Act of 1987 and EPA's Water Quality Planning and Management Regulations [(Title 40 of the Code of Federal Regulations (CFR), Part 130)] require states to identify waterbodies which are not meeting water quality criteria applicable to their designated use classifications. The identified waters are prioritized based on severity of pollution with respect to designated use classifications. Total maximum daily loads (TMDLs) for all pollutants causing violation of applicable water quality criteria are established for each identified water. Such loads are established at levels necessary to implement the applicable water quality criteria with seasonal variations and margins of safety. The TMDL process establishes the allowable loading of pollutants, or other quantifiable parameters for a waterbody, based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water-quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources (USEPA, 1991).

The State of Alabama has identified Big Nance Creek as being impaired by fecal coliform for a length of 24 miles, as reported on the 1996 §303(d) list of impaired waters. Big Nance Creek is designated a Water Quality Priority Area for NRCS-EQIP federal cost share program for addressing nonpoint sources. Big Nance Creek is located entirely within Lawrence County and drains into Wilson Lake in the Pickwick Lake 8-digit hydrologic unit of the Tennessee River basin.

The TMDL developed for Big Nance Creek illustrates the steps that can be taken to address a waterbody impaired by high fecal coliform levels. The TMDL is consistent with a phased-approach: estimates are made of needed pollutant reductions, load reduction controls are implemented, and water quality is monitored for plan effectiveness. Flexibility is built into the plan so that load reduction targets and control actions can be reviewed if monitoring indicates continuing water quality problems.

2.2 Problem Definition

The Big Nance Creek watershed is approximately 191 square miles. The watershed is comprised primarily of forested areas at 49% of total land use, with the remainder classified as 28% pasture/hay and 20% row crops. The primary row crop in the Big Nance Creek watershed is cotton. Beef cattle and poultry operations combined for $83 million in cash receipts in Lawrence County in 1999 (AASS 2001).

Waterbody Impaired: Big Nance Creek

Water Quality Criterion Violation: Bacteria

Pollutant of Concern: Fecal Coliform

Water Use Classification: Fish and Wildlife

The impaired stream segment, Big Nance Creek, is classified as Fish and Wildlife. Usage of waters in this classification is described in ADEM Admin. Code R. 335-6-10-.09(5)(a), (b), (c), and (d).

(a) Best usage of waters:

Fishing, propagation of fish, aquatic life, and wildlife, and any other usage except for swimming and water-contact sports or as a source of water supply for drinking or food processing purposes.

(b) Conditions related to best usage:

The waters will be suitable for fish, aquatic life and wildlife propagation. The quality of salt and estuarine waters to which this classification is assigned will also be suitable for the propagation of shrimp and crabs.

(c) Other usage of waters:

It is recognized that the waters may be used for incidental water contact and recreation during June through September, except that water contact is strongly discouraged in the vicinity of discharges or other conditions beyond the control of the Department or the Alabama Department of Public Health.

(d) Conditions related to other usage:

The waters, under proper sanitary supervision by the controlling health authorities, will meet accepted criteria of water quality for outdoor swimming places and will be considered satisfactory for swimming and other whole body water-contact sports.

Fecal Coliform Loading Criteria:
Alabama's water quality criteria document (ADEM Admin. Code R. 335-6-10-.09-(5)(e)(7.)) states: "Bacteria of the fecal coliform group shall not exceed a geometric mean of 1,000/100 ml; nor exceed a maximum of 2,000/100 ml in any sample. The geometric mean shall be calculated from no less than five samples collected at a given station over a 30-day period at intervals not less than 24 hours. For incidental water contact and recreation during June through September, the bacterial quality of water is acceptable when a sanitary survey by the controlling health

authorities reveals no source of dangerous pollution and when the geometric mean fecal coliform organism density does not exceed 100/100 ml in coastal waters and 200/100 ml in other waters. The geometric mean shall be calculated from no less than five samples collected at a given station over a 30-day period at intervals not less than 24 hours. When the geometric mean fecal coliform organism density exceeds these levels, the bacterial water quality shall be considered acceptable only if a second detailed sanitary survey and evaluation discloses no significant public health risk in the use of the waters. Waters in the immediate vicinity of discharges of sewage or other wastes likely to contain bacteria harmful to humans, regardless of the degree of treatment afforded these wastes, are not acceptable for swimming or other whole body water-contact sports."

3 Technical Basis for TMDL Development

3.1 Water Quality Target Identification

The water quality target for pathogen TMDLs is determined by the stream's use classification and the water quality criteria described in Section 2.2. The water quality criteria for pathogen, or bacteria, in impaired segments are based on fecal coliform bacteria concentrations. Due to recreational contact in the summer months, there is a seasonal variation of the water quality criterion. Therefore, the target is based on in-stream fecal coliform concentrations and varies seasonally. The water quality criteria consider two forms of compliance: first, the instantaneous fecal coliform concentration may not exceed a maximum of 2,000 per 100mL. Second, the geometric mean of the fecal coliform concentration may not exceed 1,000 per 100mL during November to May or 200 per 100mL during June to September.

3.2 Source Assessment

A source assessment is an important part of defining the TMDL for any pollutant. The data and sources must be understood to be able to distinguish between point and nonpoint source impacts. Typically, the point source impacts can be quantified through permit limits and/or direct measurements at a certain location. A source assessment was performed on the Big Nance Creek watershed to determine the predominant sources of fecal coliform loading into the system. The Watershed Characterization System (WCS) was used to develop characterization reports, tables, and figures for the watershed. WCS was developed by EPA Region 4 to facilitate these types of data gathering for TMDL report writing. The WCS is an ArcView based program that has multiple datasets for Region 4 states. Datasets include populated areas, county and state borders, watershed boundaries, agricultural census data, roads, land use coverages, stream networks and characteristics, NPDES permitted locations, and elevation maps. The WCS has built-in tools that allow for characterizations to occur at any watershed level.

3.2.1 General Sources of Fecal Coliform

Fecal coliform loadings can be derived from point and nonpoint 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 contributions can typically be attributed to the following sources:

- Municipal wastewater facilities,
- Illicit discharges,
- Animals having direct access to streams,
- Leaking sewers in urban areas, and
- Failing septic systems in rural areas.

Municipal wastewater treatment facilities are permitted through the National Pollutant Discharge Elimination System (NPDES). Larger treatment facilities have chlorination systems that remove fecal coliform bacteria in the effluent before it is discharged. The treatment facilities treat human waste received from the collection system and then discharge their effluent into a nearby stream. Illicit discharges are facilities that are currently discharging fecal coliform bacteria when they are not permitted or they are violating their defined permit limit by exceeding the fecal coliform concentration.

Agricultural livestock and other unconfined animals (i.e., deer and other wildlife) also often have direct access to streams that pass through pastures. When cattle are not denied access to stream reaches, they represent a major potential source of direct fecal coliform loading to the stream. To account for the potential influence of cattle loads deposited directly in stream reaches within the watersheds, fecal coliform loads from cattle in streams are calculated as a direct source into the stream. According to the 1999 Clean Water Action Plan Workplan, "All pasture needs grazing management to abate runoff of nutrients to receiving waters. Livestock (beef cattle) are unconfined and have direct access to streams the year round."

In urban settings, sewer lines typically run parallel to the stream in the floodplain. If there is a leaking sewer line, high concentrations of fecal coliform can flow into the stream or leach into the groundwater. Groundwater monitoring wells can signal if there are leaking sewer lines contributing to the problem. Septic systems are common in unincorporated portions of watersheds and may be direct or indirect sources of bacterial pollution via ground and surface waters. Onsite septic systems have the potential to deliver fecal coliform bacteria loads to surface waters due to system failure and malfunction.

Nonpoint sources of fecal coliform bacteria do not have one discharge point, but rather, occur over the entire length of a stream or waterbody. On the land surface, fecal coliform bacteria accumulate over time and then wash off during rain events. As the runoff transports the sediment over the land surface, more fecal coliform bacteria are collected and carried to the stream. While accumulating, the bacteria also die and decay. The net loading into the stream is determined by the local watershed hydrology. Nonpoint sources of fecal coliform can be quantified from the following list of contributors:

- Urban runoff,
- Wildlife in forested areas,
- Manure application to row crops and/or pasture,
- Confined Animal Feeding Operations (CAFOs), and

- Livestock grazing.

Fecal coliform loading from urban areas is potentially attributable to multiple sources including storm water runoff, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, leaking septic systems, and domestic animals.

Wildlife deposit feces onto land surfaces where it can be transported during storm events to nearby streams. Wildlife deposits can be from a wide range of species in Alabama, but common wildlife include deer, raccoons, and waterfowl.

Agricultural animals are also a potential source of several types of fecal coliform loading to streams in the Big Nance Creek watershed. Livestock data are reported by county and published by the USDA in the Census of Agriculture (USDA, 1997). The available livestock data include population estimates for cattle, beef cows, dairy cows, hogs, sheep, and poultry (broilers and layers).

3.2.2 Point Sources in the Big Nance Creek Watershed

ADEM maintains a database of current NPDES permits and GIS files that locate each permitted outfall. This database includes municipal, semi-public/private, industrial, mining, and industrial storm water. Concentrated animal feeding operations (CAFOs) permits are included in the nonpoint source loads. Table 3-1 shows the permitted point sources in the watershed that discharge into or upstream of the impaired segment. Table 3-2 contains the permit limitations for the significant point sources that were considered in the model development. Figure 3-1 shows the location of each facility considered a significant source relative to the impaired segment.

Table 3-1 Contributing Point Sources in the Big Nance Creek Watershed

NPDES Permit	Type of Facility (Industrial, Municipal, Semi-Public/Private, Mining, Industrial Stormwater)	Facility Name	Significant Contributor (Yes/No)
AL0048585	Municipal	Courtland WPCP	No
AL0020672	Municipal	Moulton WPCP	Yes*
AL0043036	Semi-Public/Private	Hatton Schools	No

*refer to Section 6-2 for discussion of the Moulton plant.

Table 3-2 NPDES Permit Limits for Contributing Point Sources

NPDES Permit	Facility Name	Flow (mgd)	Fecal Coliform (#/100mL) Summer	Fecal Coliform (#/100mL) Winter
AL0048585	Courtland WPCP	0.150	200	1,000
AL0020672	Moulton WPCP	1.250	N/A	N/A
AL0043036	Hatton Schools	0.0275	N/A	N/A

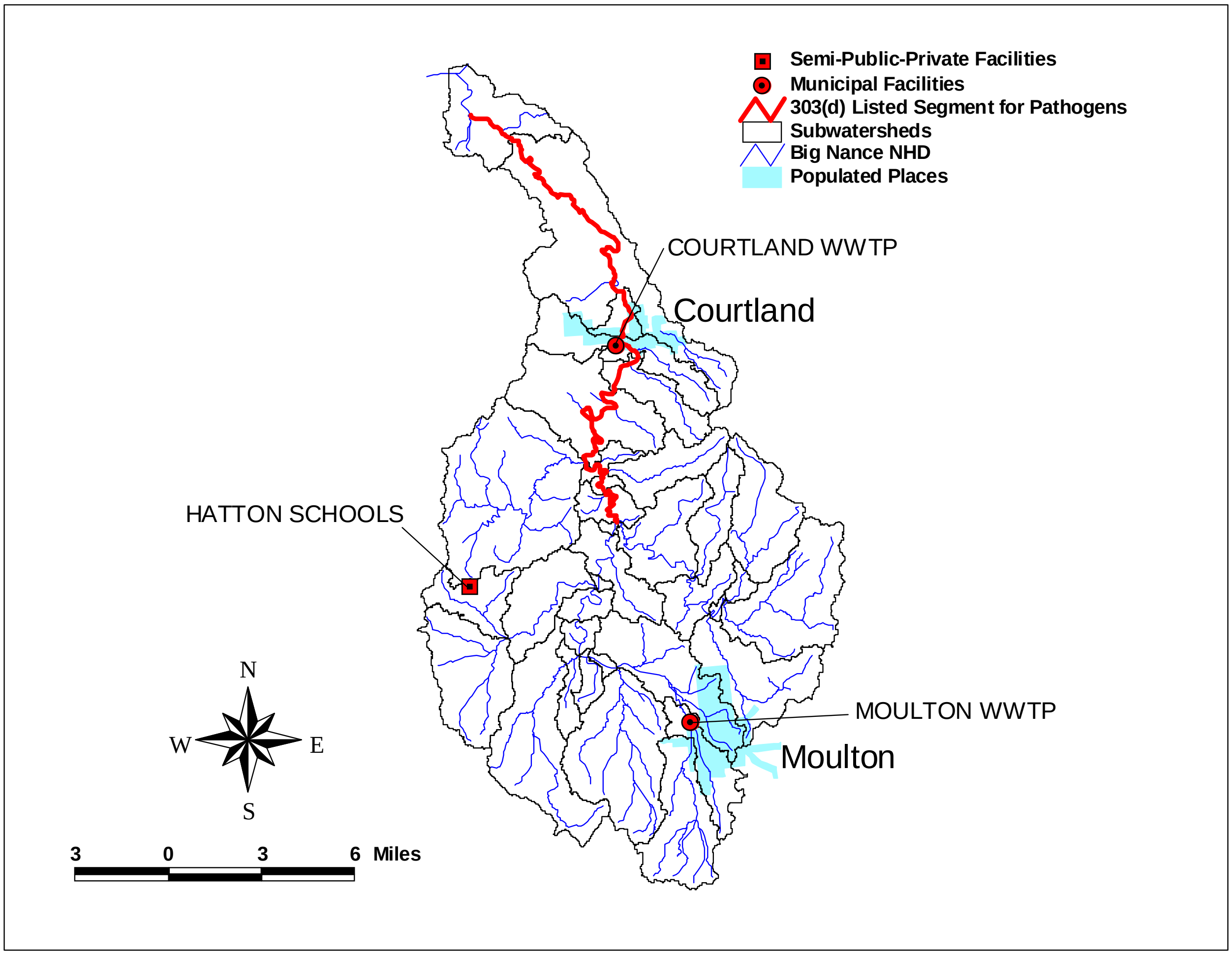

Figure 3-1 NPDES Point Sources Located in the Big Nance Creek Watershed

3.2.3 Non-Point Sources in the Big Nance Creek Watershed

The type of land use within the Big Nance Creek watershed is significant for determining sources of fecal coliform inputs. The two urban areas in the watershed, Moulton and Courtland, should have little influence on fecal coliform concentrations as urban runoff. As shown in Table 3-3, the urban component is 1.2% of the land use. The land use coverage is dominated by forest at 49% with row crops and pasture comprising the rest at 20% and 28%, respectively. Table 3-3, displays all of the land use coverages by subwatershed. Figure 3-2 shows the distribution of the land use for the entire watershed.

Table 3-3 Land Use Distribution for the Big Nance Creek Watershed

Subwatershed	Cropland	Forest	High Commercial/ Industrial/ Transportation	High Density Residential	Low Density Residential	Pasture	Transitional	Water	Total Acres
01	8005.8	6458.0	32.2	28.7	120.8	2392.7	8.5	665.6	17712.2
02	4616.1	6713.0	237.1	7.8	48.5	1492.9	0.0	29.6	13145.0
03	104.5	4793.2	3.1	0.0	0.2	359.8	21.6	4.9	5287.3
0301	1533.8	7447.8	45.4	1.1	1.8	3339.4	179.0	94.1	12642.4
04	396.3	1777.1	0.9	0.0	0.0	683.0	103.6	9.3	2970.2
0401	857.3	6317.4	9.6	0.7	28.0	1428.2	54.0	16.5	8711.7
0402	1715.5	6437.3	9.3	0.0	5.3	3399.2	145.9	111.0	11823.6
040201	467.2	2585.7	100.5	2.4	20.7	2026.2	14.9	8.2	5225.9
05	232.4	999.0	2.0	0.0	0.4	368.3	0.0	4.9	1607.0
0501	466.1	1993.3	2.2	0.0	0.2	1160.7	0.0	4.4	3626.9
0502	1209.6	2310.4	2.4	0.0	0.0	2092.5	0.0	5.1	5620.0
050201	554.9	987.0	12.0	3.1	25.8	917.1	0.0	3.3	2503.2
06	105.2	373.8	0.0	0.0	0.0	493.7	0.0	2.0	974.7
0601	1325.9	3120.8	21.6	0.0	2.0	4081.7	0.0	4.2	8556.2
07	811.3	1949.9	217.7	30.9	145.4	2429.2	0.4	27.6	5612.4
0701	1482.0	2615.7	97.9	0.0	0.4	3879.8	0.0	14.5	8090.3
08	937.8	2932.0	91.6	14.7	155.9	3205.3	15.1	22.0	7374.4
Total (acres)	24821.8	59811.4	885.6	89.4	555.5	33749.6	543.1	1027.2	121483.
Percentage	20%	49%	0.7%	0.1%	0.5%	28%	0.4%	0.8%	100%

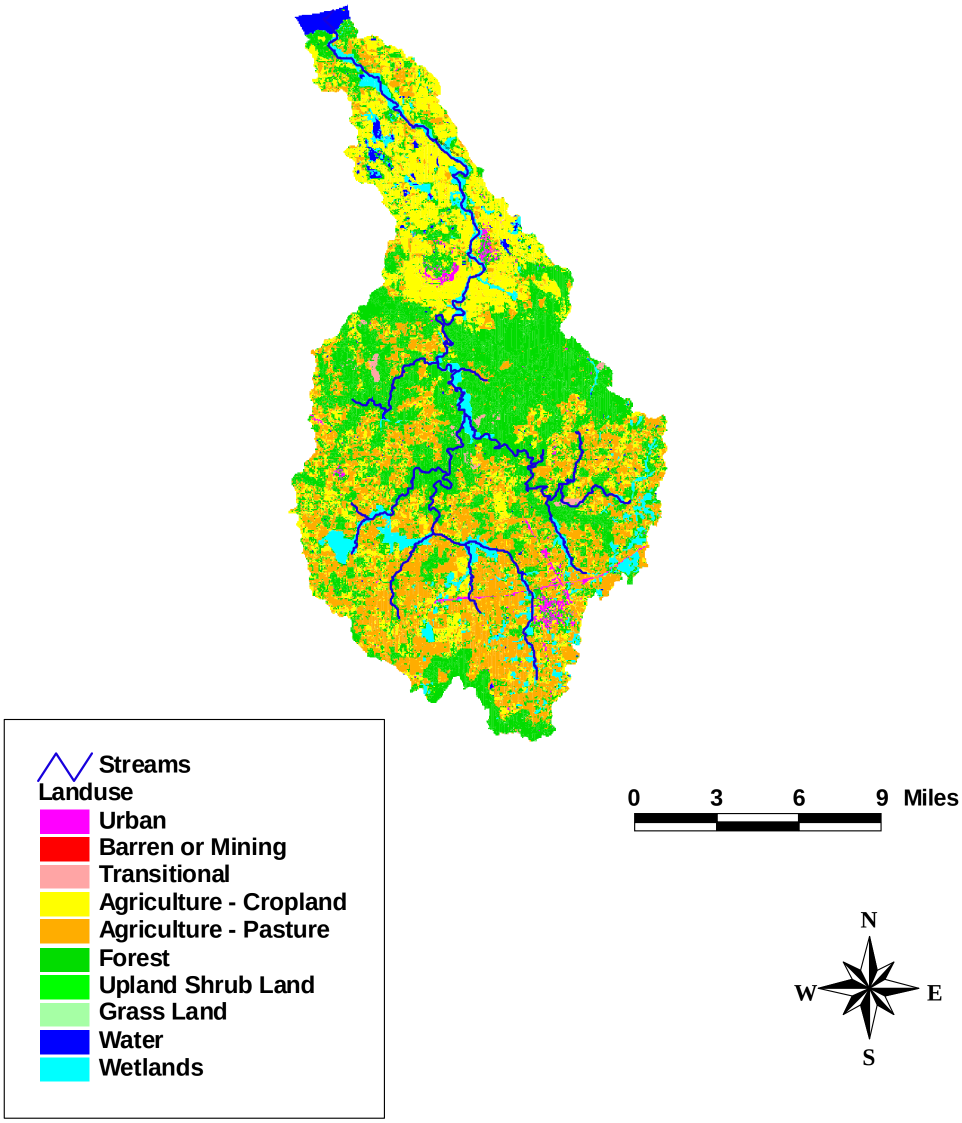

Figure 3-2 Land Use Distribution in the Big Nance Creek Watershed

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

Confined livestock operations also generate manure, which can be applied to pastureland and cropland as a fertilizer. Processed agricultural manure from confined hog, dairy cattle, and some poultry operations is generally collected in lagoons and applied to land surfaces during the growing season, at rates which often vary on a monthly basis.

The agricultural animal census has varied widely over the past decade. Animal counts in Lawrence County show consistently rising poultry production, with a peak of cattle production in 1997 and subsequent decline. The TVA Pickwick Watershed Team (Muscle Shoals Unit), in a 2000 report titled “Big Nance Creek Aerial Survey, Non-point Source Pollution Inventory and Integrated Pollutant Source Index (IPSI),” named beef cattle as the primary source of biochemical oxygen demand, nitrogen and phosphorus pollution in the watershed, and furthermore, identified many cattle operations that are adjacent to streams and a high potential impact on water quality.

Estimates of animal populations in the Big Nance Creek watershed from the local Soil and Water Conservation District have been combined with other sources to determine the total animal counts in each watershed. Table 3-4 shows animal count estimates for the Big Nance Creek watershed.

Table 3-4 Estimates of Animal Counts in the Big Nance Creek Watershed.

Livestock	Count	*Source*	Manure Application (Crop/Pasture)
Beef Cattle	9720	SWCS	Pasture
Dairy Cows	165	SWCS	Crop
Swine	540	SWCS	Crop
Sheep	74	USDA 97/WCS	Pasture
Chickens	4,000,000	Clean Water Action Plan Workplan 99	Pasture
Horses	2920	TVA	pasture

The best estimate of poultry population has been obtained from the FY99 Alabama Clean Water Action Plan Workplan.

The Clean Water Action Plan Workplan also states: “All pasture needs grazing management to abate runoff of nutrients to receiving waters. Livestock (beef cattle) are unconfined and have direct access to streams the year round.” Runoff of animal waste includes high fecal coliform counts in addition to nutrients.

Fecal coliform loading rates for livestock in the watershed are estimated to be: 1.06 x 10^{11} counts/day/beef cow, 1.24 x 10^{10}counts/day/hog, 1.04 x 10^{11} counts/day/dairy cow, 1.38 x 10^{8} counts/day/layer chicken, and 1.22 x 10^{10} counts/day/sheep (NCSU, 1994).

Poultry litter is normally piled for a period before it is applied to hay fields. Within the Big Nance Creek watershed, poultry production nearly doubled between 1987 and 1997 (USDA 1997). It is assumed that for modeling purposes that chicken litter is applied evenly to pastureland within the watershed; however, concentrated application at high rates to small areas of pasture may comprise a high risk of fecal coliform runoff.

Hog farms in the Big Nance Creek watershed operate by confining the animals or allowing them to roam in small pastures or pens. It is assumed that all of the hog manure produced by either farming method is applied to available cropland.

On dairy farms, the cows are confined for a limited period each day during which time they are fed and milked. This is estimated to be four hours per day for each dairy cow. It is assumed that manure from dairy operations is applied to pasture at a constant rate.

Beef cattle are assumed to be in pasture year round. Therefore, beef cow manure is applied only to pastureland and at a constant monthly rate. This rate varies between watersheds, depending on the density of animals per acre. Aerial survey has determined that 15% of pasture is “heavily overgrazed” or in “poor” condition in the Big Nance Creek watershed (TVA, 2000).

Distributions of animals within each subwatershed division are estimated from the density of animals per acre of pasture within the Big Nance Creek watershed as a whole. The overall number of animals (except beef cattle) is apportioned to each subwatershed based on the acreage of pasture within that subwatershed. For beef cattle, the density of cattle within each subwatershed is based on the numbers of identified sites from aerial surveys (TVA, 2000) and the estimated size of each identified site; however, the total number of beef cattle is taken from the SWCS estimate and distributed according to the relative density determined from the aerial survey. Estimates of animal counts within each subwatershed are shown in Table 3-5.

Table 3-5 Animal Counts for Subwatersheds of Big Nance Creek

Subwatershed	Beef Cattle	Dairy Cattle	Hogs	Sheep	Poultry	Horses
01	545	15	46	5	594,707	105
02	340	10	29	3	371,063	75
03	82	2	7	1	89,435	30
0301	761	22	65	7	830,013	440
04	156	4	13	1	169,750	80
0401	326	9	28	3	354,978	200
0402	775	22	66	7	844,882	425
040201	462	13	39	4	503,613	125
05	84	2	7	1	91,536	45
0501	265	8	22	3	288,482	135
0502	477	14	40	5	520,085	145
050201	209	6	18	2	227,955	85
06	113	3	10	1	122,711	70
0601	930	26	79	9	1,014,522	335
07	554	16	47	5	603,772	80
0701	884	25	75	8	964,332	290
08	731	21	62	7	796,682	255
Total	9,720	165	540	74	4,000,000	2,920

3.3 Loading Capacity – Linking Numeric Water Quality Targets and Pollutant Sources

EPA regulations define the TMDL loading, or assimilative capacity, as the greatest amount of loading that a waterbody can receive without violating water quality criteria (40 CFR Part 130.2(f)). TMDL endpoints represent the in-stream water quality targets used in quantifying TMDLs and their individual components.

The endpoints for the Big Nance Creek TMDL are the fecal coliform water quality criteria. The maximum instantaneous concentration is 2,000 counts per 100mL and the maximum geometric mean is 1,000 counts per 100mL from October through May and 200 counts per 100mL from June through September.

In this TMDL analysis, the fecal coliform sources are modeled independently of each other. The cattle in the streams, failing septic systems, and point source loads are not hydrology-based, and are therefore, direct loads into the model. The land use runoff from urban, cropland, pasture, and forest areas are based on the calibrated hydrology. All of these potential sources are modeled in a way that can provide a direct linkage between the instream response of transport and die-off to the fecal coliform sources. This method of modeling allows for sensitivity runs to be made to quantify the relative impact on instream concentrations from each source.

3.4 Data Availability and Analysis

Data were retrieved from the ADEM and TVA water quality studies in the Tennessee River Basin. The primary water quality stations are shown in Figure 3-3 and were used in the TMDL analyses.

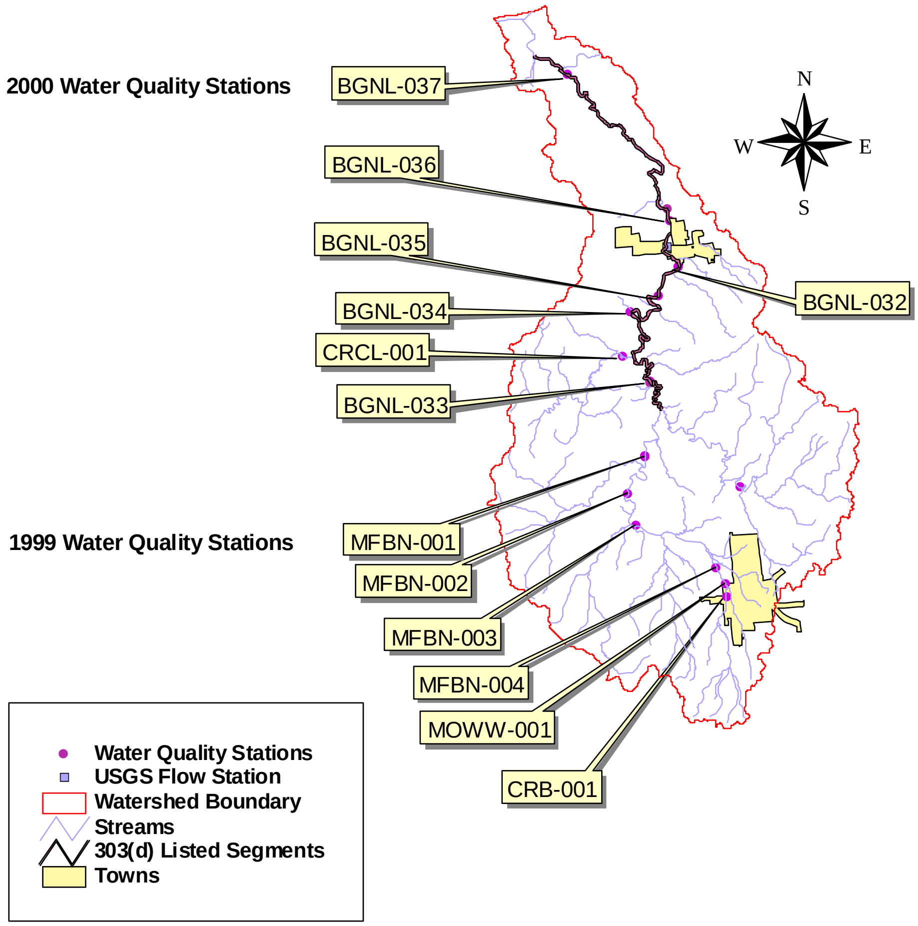

Figure 3-3 Location of the Flow and Fecal Coliform Monitoring Stations in the Big Nance Creek Watershed for 1999 (Upstream Sites) and 2000 (Downstream Sites)

Appendix 9.2 shows detailed locator maps and table of fecal coliform monitoring sampling locations. A complete listing of the available flow and fecal coliform data can also be found in Appendix 9.2.

Figures 3-4 and 3-5 present flow data at the Courtland gage versus fecal coliform concentrations in 1999 and 2000. The stations plotted are shown in Figure 3-3. The flow versus fecal coliform plots show that there is a relationship between runoff events and elevated fecal coliform concentrations. The plots also show that there are high concentrations of fecal coliform during dry periods, so there are direct sources that need to be addressed in the TMDL. Therefore, wet and dry weather events are considered in the TMDL.

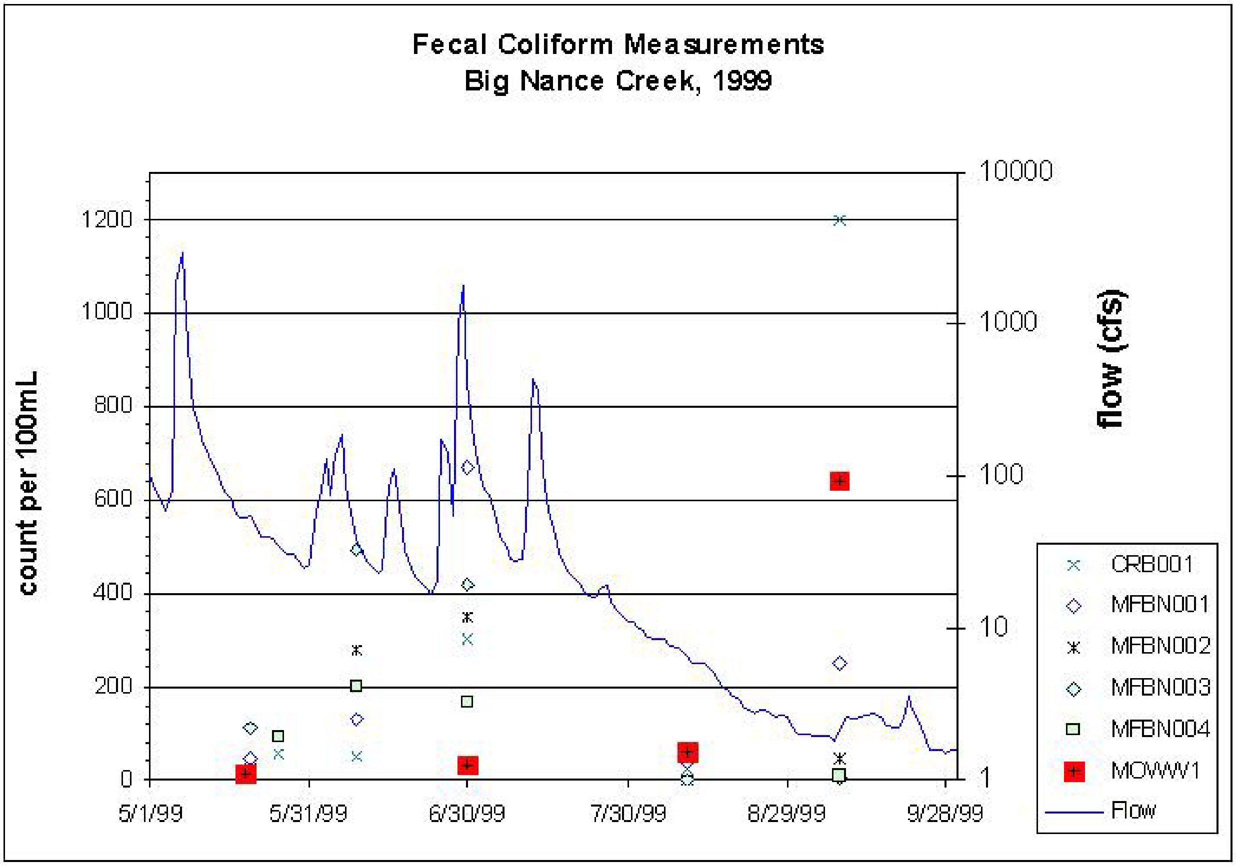

Figure 3-4 1999 Fecal Coliform Concentrations in the Big Nance Creek Watershed compared to Flow at Courtland (USGS03586500)

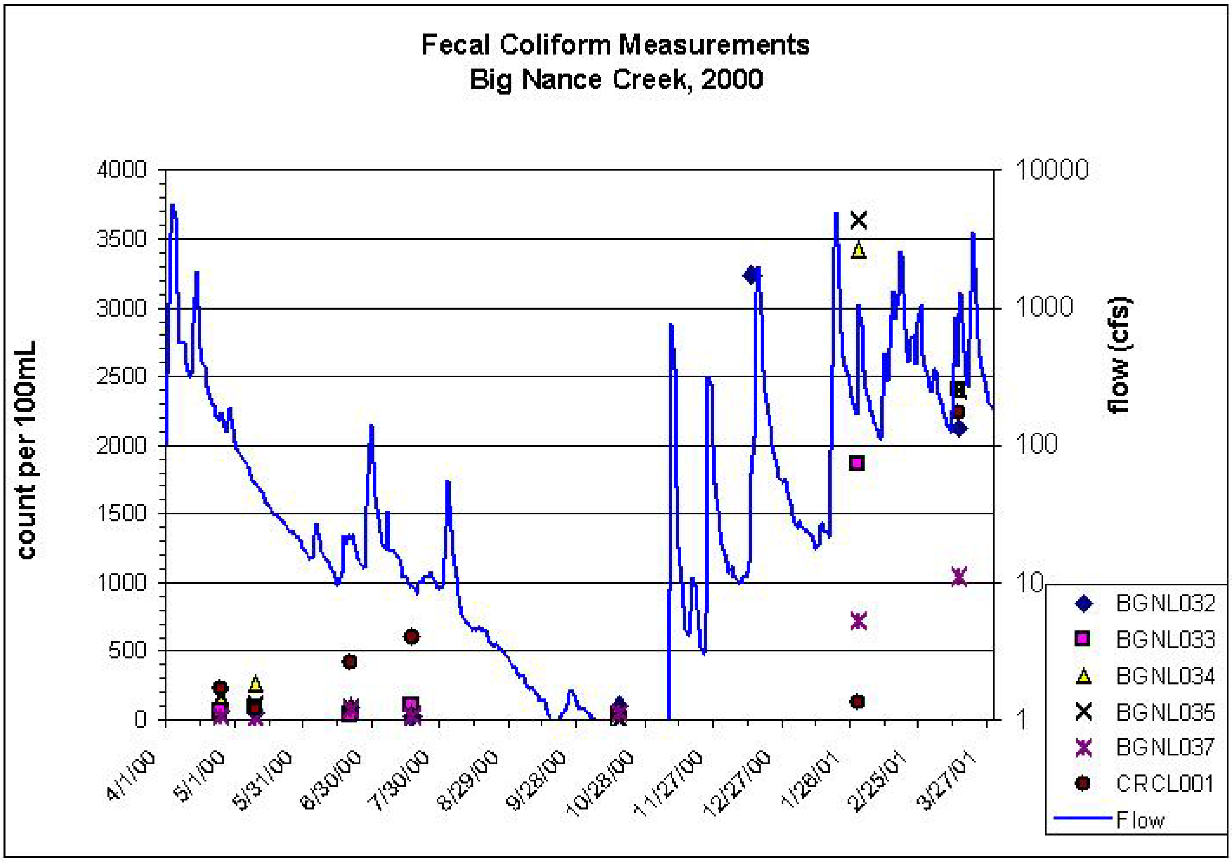

Figure 3-5 2000 Fecal Coliform Concentrations in the Big Nance Creek Watershed compared to Flow at Courtland (USGS03586500)

3.5 Critical Conditions

The critical condition for nonpoint 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 and direct source (discharges, cattle in streams, and failing septic systems) loading occurs during periods of low stream flow when dilution is minimized. Both conditions are simulated in the water quality model. A definitive time period was used to simulate a daily and a continuous 30-day geometric mean concentration to compare to the targets. For the TMDL in Big Nance Creek, this time period is 10 years and covers a range of hydrological conditions that included both low and high stream flows. The time period between April 2000 through March 2001 was determined to be an appropriate critical condions run because it had extended low flow periods followed by runoff events.

3.6 Margin of Safety (MOS)

There are two methods for incorporating a MOS in the analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) by explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations. An implicit MOS was incorporated in this TMDL. Implicit MOS includes conservative modeling assumptions and a continuous simulation that incorporates a range of meteorological events. Conservative modeling assumptions used include: septic systems discharging directly into the streams, conservative estimates of in-stream decay, point sources discharging at permitted flows and the geometric mean for fecal coliform, and all land areas considered to be connected directly to streams. Fecal coliform decay (die-off) on the land surface was not computed in the model. Therefore, the rates developed by the FCLES and loads delivered to the model did not account for this decay and would be a conservative load.

4 Hydrology and Water Quality Model Development

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.

4.1 Hydrology Model Selection and Setup

Based on the considerations described above, analysis of the monitoring data, review of the literature, and past fecal coliform modeling experience, the Loading Simulation Program C++ (LSPC) was used to represent the source-response linkage in the Big Nance Creek watershed. LSPC is a comprehensive data management and modeling system that is capable of representing loading from nonpoint and point sources found in the Big Nance Creek watershed and simulating in-stream processes. LSPC is based on the Mining Data Analysis System (MDAS), with modifications for non-mining applications such as nutrient and fecal coliform modeling. MDAS was developed by EPA Region 3 through mining TMDL applications in Region 3.

LSPC is a system designed to support TMDL development for areas impacted by nonpoint and point sources. The most critical component of LSPC to TMDL development is the dynamic watershed model, because it provides the linkage between source contributions and in-stream response. The comprehensive watershed model is used to simulate watershed hydrology and pollutant transport as well as stream hydraulics and in-stream water quality. It is capable of simulating flow, sediment, metals, nutrients, pesticides, and other conventional pollutants, as well as temperature and pH for pervious and impervious lands and waterbodies. LSPC was configured for the Big Nance Creek watershed to simulate the watershed as a series of hydrologically connected subwatersheds. Configuration of the model involved subdivision of the Big Nance Creek watershed into modeling units and continuous simulation of flow and water quality for these units using meteorological, land use, point source loading, and stream data. The only pollutant simulated was fecal coliform bacteria. This section describes the configuration process and key components of the model in greater detail.

To represent watershed loadings and resulting concentrations of fecal coliform bacteria in Big Nance Creek, Muddy Fork, Clear Fork, Crow Branch, and Crooked Creek, the watershed was divided into 35 subwatersheds. These 35 subwatersheds correspond to the 17 TVA HUCs shown in Figure 4-1. The delineation was based on elevation data (the 30m resolution National Elevation Dataset from USGS), stream connectivity (from EPA's National Hydrography Dataset stream coverage), and locations of monitoring stations. LSPC was calibrated for hydrology using flow data from 1990 to 2001. The Huntsville airport precipitation and meteorological data were used through 1996. Beginning in 1997, precipitation data were retrieved from a local station in Moulton to better represent the hydrology and to extend the calibration period through June 2001. These weather data were applied to all subwatersheds in the Big Nance Creek watershed.

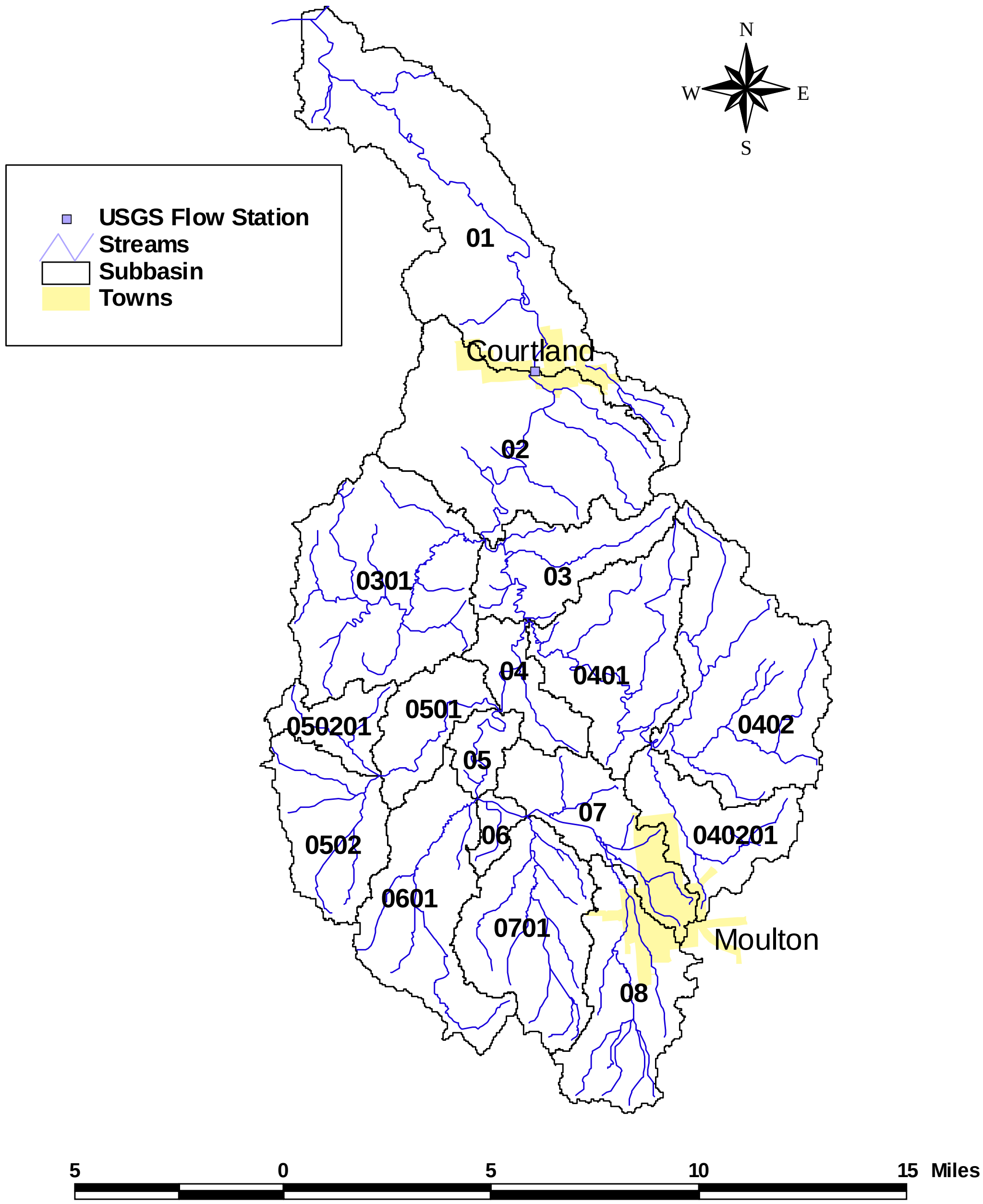

Figure 4-1 Subwatershed Delineation for the Big Nance Creek Watershed (TVA HUCs)

4.2 Hydrology Model Summary

The hydrology was calibrated for a 10-year period from July 1991 until June 2001, comparing model predictions to daily mean flow values measured at the USGS streamflow gauge at Courtland (Station 03586500). Model parameters used to represent characteristic soil types and variables in the hydrologic cycle were adjusted until acceptable agreement was achieved between simulated flows and historic streamflow data from the USGS gauging station. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge.

A summary of the hydrologic calibration is shown in Appendix 9.3, including a 10-year analysis and graphs comparing model output to measured flow at Courtland for the years 1997-2000.

4.3 Water Quality Model Selection and Setup

A dynamic computer model was selected for fecal coliform analysis in order to: a) simulate the time varying nature of fecal coliform deposition on land surfaces and transport to receiving waters; b) incorporate seasonal effects on the production and fate of fecal coliform bacteria; and c) identify the critical condition for the TMDL analysis. Several computer-based tools were also utilized to generate input data for the model. In-stream decay of fecal coliform bacteria is included in the model at a rate of 0.5 per day. This rate represents the literature value by Baudisova (1997).

In addition to LSPC, the Watershed Characterization System (WCS), a geographic information system (GIS) tool, is used to display, analyze, and compile available information to support water quality model simulations. Results of the WCS characterization are input to a spreadsheet developed by Tetra Tech, Inc. called the Fecal Coliform Loading Estimation Spreadsheet (FCLES). The FCLES spreadsheet is used to estimate modeling parameters associated with fecal coliform buildup and washoff loading rates. The spreadsheet is also used to estimate direct sources of fecal coliform loading to water bodies from leaking/failing septic systems and animals having access to streams, cattle in particular. Information from the WCS and FCLES spreadsheet tool were used as initial inputs for variables in the LSPC model.

For modeling purposes, the fecal coliform sources were represented by the following components:

- Runoff loads from each land use category (buildup of fecal coliform and washoff due to runoff)
- Point source loads from NPDES permitted discharges, and
- Direct source loads from cattle in the streams and failing septic systems.

The LSPC model model is a build-up and wash-off model. It represents the pollutant by accumulating the pollutant over time, storing the pollutant to some maximum limit, and then transporting the pollutant through overland flow to the stream. The model represents these processes with an accumulation rate (ACQOP) and the storage limit (SQOLIM). The FCLES tool calculates both of these values by using the livestock numbers and manure application rates, which are based in literature values and the WCS data. WSQOP is defined as the rate of surface runoff (in/hr) that results in 90% washoff in one hour. This parameter is user-defined and was determined for each land use by EPA recommended ranges. ACQOP and SQOLIM may be varied monthly or stay constant during the simulation. If specific data such as timing of manure applications, livestock rotations, and crop rotations are known, these rates can be calculated monthly. For the Big Nance Creek watershed modeling, the rates were input as constant values.

Typically, point source loads for model calibrations are computed with the following priorities: (1) daily measured values from the discharger, (2) Discharge Monitoring Reports (DMRs) with monthly average values, (3) NPDES permitted values with not-to-exceed or geometric means, or (4) an appropriate water quality criterion (geometric mean to approximate a conservative monthly average). Daily flow and daily fecal coliform data would be the most appropriate for modeling if available. Since no daily fecal coliform monitoring has been recorded for the three point sources in the Big Nance Creek watershed until April of 2000, and only the Moulton plant has been monitored since then, the permitted flows and fecal coliform concentration of the summer geometric mean criterion were used to load the model.

Table 4-1 Point Source Loads Used in Modeling

NPDES Permit	Facility Name	Model Flow (mgd)	Model Fecal Coliform Concentration (counts/100ml)	Fecal Coliform Load (counts/day)
AL0048585	Courtland	0.15	200	5.7E7
AL0020672	Moulton	1.25	200	4.7E8
AL0043036	Hatton Schools	0.0275	200	1.0E7

Other direct source loads in the Big Nance Creek watershed were determined to be cattle in the streams and failing septic systems. From conversations with NRCS and SWCS, cattle "commonly have access to the streams," as verified by aerial photography by TVA which shows cattle tracks in streambeds and impacted riparian zones.

The TVA aerial survey of beef cattle operations has been used to calculate the relative densities of beef cattle operations in each subwatershed unit. In addition, sites identified as "adjacent to streams" are applied as point sources to the model and "high potential impact" sites are estimated to have three times more fecal coliform load per animal than normal "adjacent" sites. Cattle operations identified by TVA and beef cattle counts derived from the SWCS total are shown in Table 4-2.

Table 4-2 Total Beef Cattle Distribution by Subwatershed and Sites Adjacent to Streams

Watershed Description	Subbasin	Beef Cattle	Sites	Adjacent To Stream	High Potential Impact
Big Nance Creek - Mile 0 to Mile 12	01	377	14	6	0
Big Nance Creek - Mile 12 to Crooked Creek	02	202	15	4	0
Big Nance Creek - Crooked Creek to Clear Fork	03	94	5	4	0
Crooked Creek	0301	1,440	69	33	1
Muddy Fork - Clear Fork to Rutherford Creek	04	256	13	4	0
Clear Fork - Muddy Fork to Wade Creek	0401	592	36	16	0
Wade Creek	0402	1,400	66	43	0
Eddy Creek	040201	417	19	11	0
Muddy Fork - Rutherford Creek to Borden Creek	05	148	7	3	0
Rutherford Creek - Muddy Fork to Unnamed Trib	0501	458	20	12	1
Rutherford Creek (Upper)	0502	525	19	12	0
Unnamed Trib to Rutherford Creek	050201	269	14	11	0
Muddy Fork	06	229	11	7	0
Borden Creek	0601	1,131	50	31	0
Muddy Fork - Moore Creek to Crow Branch	07	283	10	6	1
Moore Creek	0701	1,050	37	29	2
Crow Branch	08	848	39	27	0
	Total	9,720	444	259	5

The fecal coliform loading concentration for cattle reaching the stream is 7.4E8 counts per 100ml. This concentration was derived from a literature value for fecal coliform production rates for cattle of 1.06E11 counts per animal per day (NCSU, 1994) and a total mass of beef cattle waste of 31.7 pounds per animal per day (ASAE, 1998). The density of cattle waste (including urine) is approximated as the density of water. The FCLES tool assumes that cattle are in the stream 2% of the day and 25% defecate in the stream. Table 4-3 presents the fecal coliform loads that are used in the model after calibration.

Table 4-3 Cattle Adjacent to Streams and Direct Fecal Coliform Load

Subwatershed	Adjacent Cattle	Cattle Waste Load (lbs/day)	Fecal Coliform Load (counts/day)	Fecal Coliform Load (counts/yr)
01	215	0.62	2.29E+10	8.35E+12
02	54	0.16	5.74E+09	2.1E+12
03	81	0.23	8.61E+09	3.14E+12
0301	929	2.67	9.88E+10	3.61E+13
04	108	0.31	1.15E+10	4.19E+12
0401	269	0.77	2.86E+10	1.04E+13
0402	1,064	3.06	1.13E+11	4.13E+13
040201	256	0.74	2.72E+10	9.94E+12
05	94	0.27	9.99E+09	3.65E+12
0501	431	1.24	4.58E+10	1.67E+13
0502	404	0.58	2.15E+10	7.84E+12
050201	229	0.33	1.22E+10	4.45E+12
06	175	0.25	9.3E+09	3.4E+12
0601	767	1.10	4.08E+10	1.49E+13
07	256	0.37	1.36E+10	4.97E+12
0701	1,050	1.51	5.58E+10	2.04E+13
08	660	0.95	3.51E+10	1.28E+13
Total	7,041	15.16	5.6E+11	2.05E+14

Estimates of failing onsite septic systems are taken from the TVA aerial surveys of 1999, which identifies indications of failing systems from “distinctive moisture patterns,” “effluent plumes with visible fieldline patterns,” and “suspect locations on very steep slopes or in close proximity to streams,” and all houses with outhouses (TVA, 2000). Estimates of failing septic systems and associated fecal coliform load are shown in Table 4-4.

Table 4-4 Failing Onsite Septic Systems in the Big Nance Creek Watershed

Subwatershed	Failing Septics	People Served	Septic Flow (gal/day)	Fecal Load (counts/day)	Fecal Load (counts/yr)
01	15	36	2,489	9.4E+08	3.4E+11
02	18	43	2,986	1.1E+09	4.1E+11
03	3	7	498	1.9E+08	6.9E+10
0301	29	69	4,811	1.8E+09	6.7E+11
04	6	14	995	3.8E+08	1.4E+11
0401	30	71	4,977	1.9E+09	6.9E+11
0402	44	104	7,300	2.8E+09	1.0E+12
040201	35	83	5,807	2.2E+09	8.0E+11
05	1	2	166	6.3E+07	2.3E+10
0501	8	19	1,327	5.0E+08	1.8E+11
0502	6	14	995	3.8E+08	1.4E+11
050201	8	19	1,327	5.0E+08	1.8E+11
06	6	14	995	3.8E+08	1.4E+11
0601	22	52	3,650	1.4E+09	5.0E+11
07	7	17	1,161	4.4E+08	1.6E+11
0701	28	66	4,645	1.8E+09	6.4E+11
08	26	62	4313	1.6E+09	6.0E+11
Total	292	692	48,443	1.83E+10	6.7E+12

4.4 Water Quality Model Summary

4.4.1 Calibrated Model

The model was calibrated for water quality by comparing the fecal coliform concentrations from the model verses the observed data. Appropriate model parameters were adjusted to obtain acceptable agreement between simulated fecal coliform concentrations and observed data collected at BNC-A, BNC-B, MFBN-001, MFBN-002, MFBN-003, MFBN-004, BGNL-032, BGNL-033, BGNL-035, BGNL-037, and CRCL-001 sampling stations indicated in Appendix 9.2. The appendix gives a detailed list of stations in Table 9-1 along with 4 plots showing the locations of the stations by year. Figure 3-3 shows the stations with measurements in 1999 and 2000. The parameters that were adjusted to obtain a calibrated model were the build-up and washoff of fecal coliform for each land use, and the direct loads of cattle in the streams and failing septic systems as described in Section 4.3. Samples for fecal coliform were collected in 1991, 1997, 1998, 1999, and 2000, but close attention was paid to the critical periods in 2000 – 2001. The only data collected in 1999 were on Muddy Fork, an upstream tributary of Big Nance Creek. Figure 4-2 shows the calibration results for the existing conditions at BGNL-033 (BNC-B) for 1997. Figure 4-3 shows the calibration results for the existing conditions at BGNL-035 for January 2000 through March 2001. The results are presented on a logarithmic scale so that the base conditions can be viewable in the plot. It was important in the calibration to achieve a baseline condition of fecal coliform concentrations along with the peak runoff events. All of the calibration results are presented in Appendix 9.4 for the stations listed in Appendix 9.2. The geometric mean plots are presented in Appendix 9.4 as well.

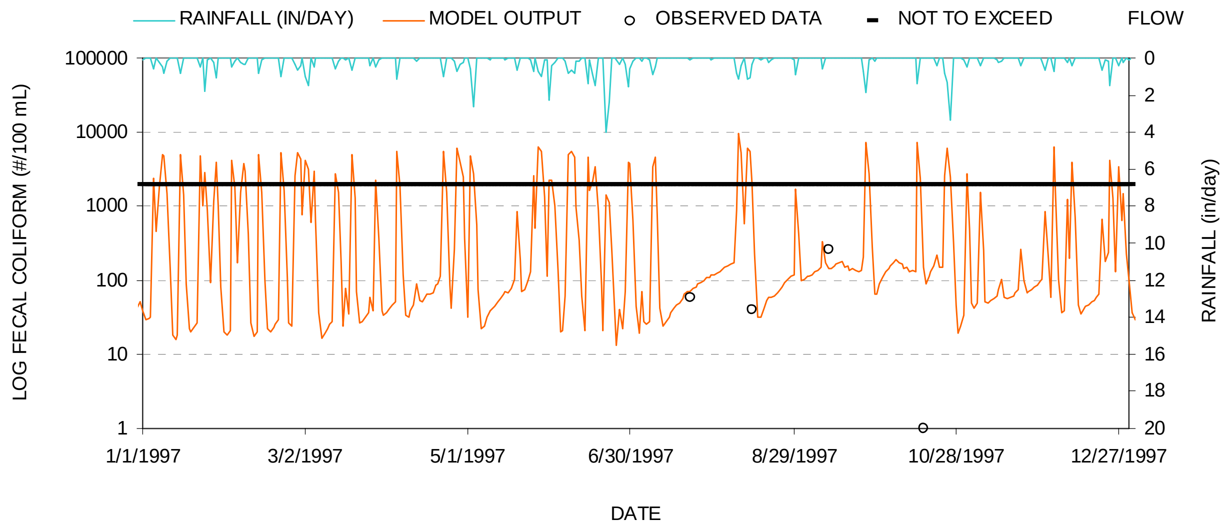

Figure 4-2 Model versus Observed Fecal Coliform at BGNL-033 for 1997 (Logarithmic Scale)

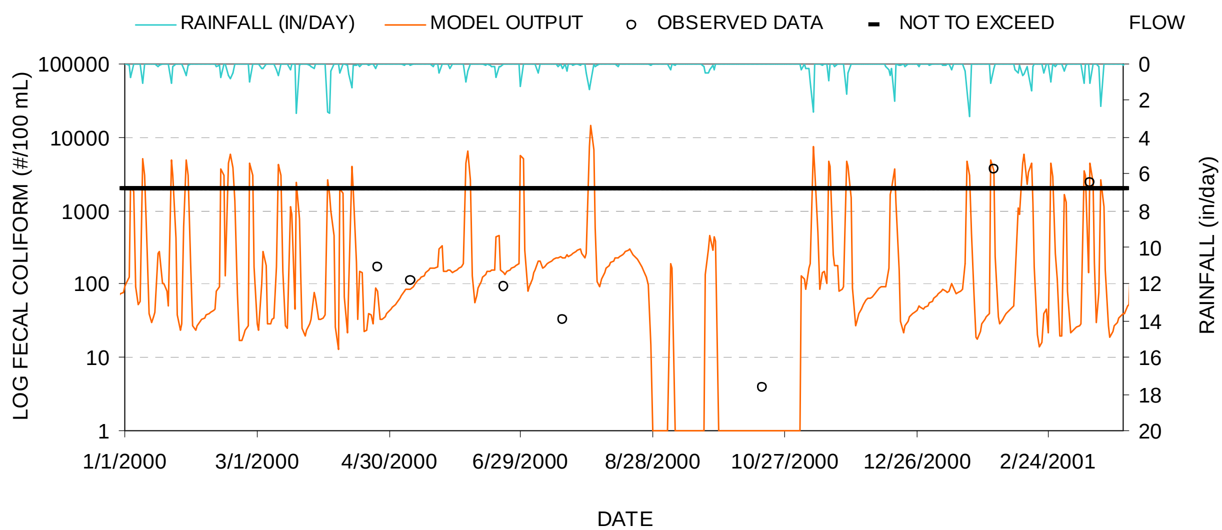

Figure 4-3 Model versus Observed Fecal Coliform at BGNL-035 for January 2000 through March 2001 (Logarithmic Scale)

4.4.2 Load Reduction Model

The calibrated model represents the existing conditions in Big Nance Creek. The calibrated model was used as a starting point for the load reduction scenarios. Multiple model runs were developed to analyze point and direct source sensitivity compared to runoff sensitivity. Figure 4-4 presents the comparison. The steady sources in the figure legend refer to the point source discharges, cattle in the streams, and the failing septic systems. These loads did not vary monthly in the model due to lack of data to prove the variations, so they are modeled as steady-state loads. The model output line shows the impact that runoff can have on the fecal coliform concentrations.

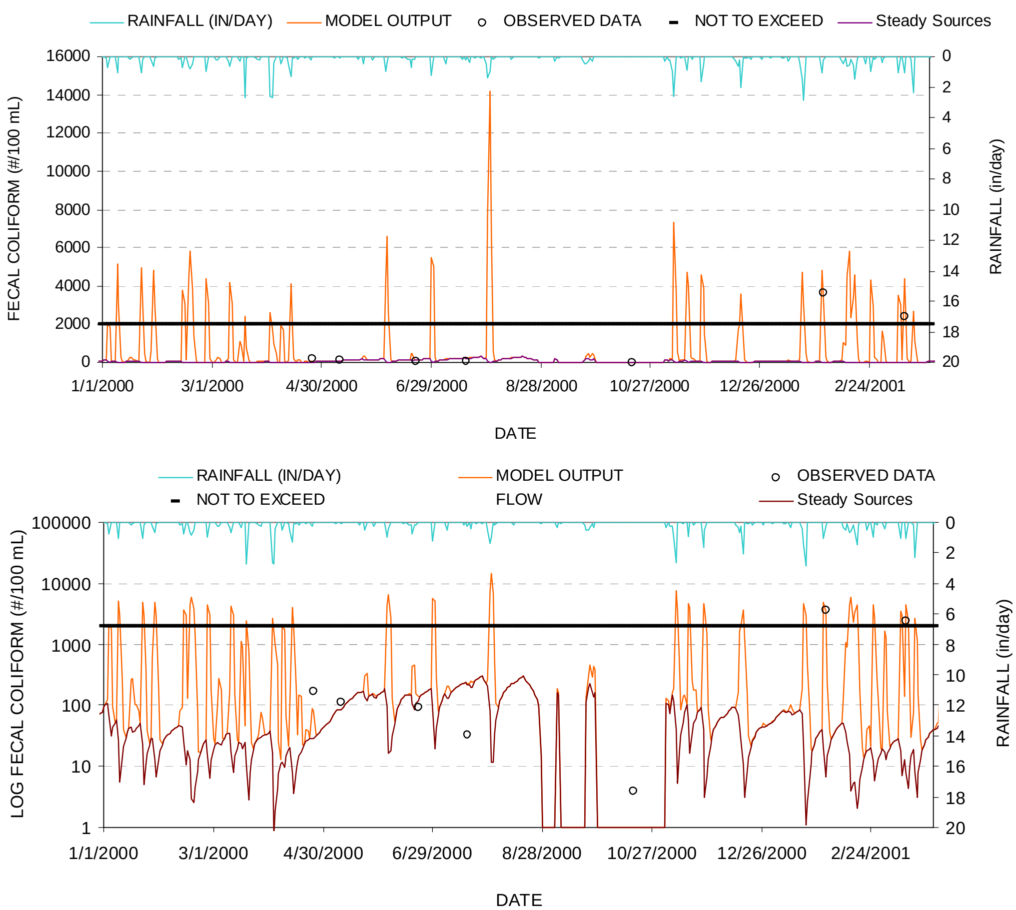

Figure 4-4 Sensitivity of Fecal Coliform Runoff versus Point and Direct Sources at BGNL-035 in Big Nance Creek

From the sensitivity analysis, it was determined that if there were violations of the fecal coliform criteria, runoff would violate the instantaneous criterion and point and direct sources would violate the geometric mean criterion in the summer months. The model did not show any violations of the geometric mean criterion in the winter months. Therefore, for load reduction scenarios, the runoff from the land was reduced to meet the 2,000 counts per 100 mL as the instantaneous limit. For the summer geometric mean of 200 counts per 100 mL for the summer months, cattle in the stream and failing septic systems were reduced to meet this limit. The impaired segment on Big Nance Creek has a designation of Fish and Wildlife.

The existing fecal coliform load for the listed segment is represented as the sum of the daily discharge load of the direct sources (cattle access to streams and failing septic systems), the point sources loads, and the daily fecal coliform load indirectly going to surface waters from all land uses (e.g., surface runoff) for 2000.

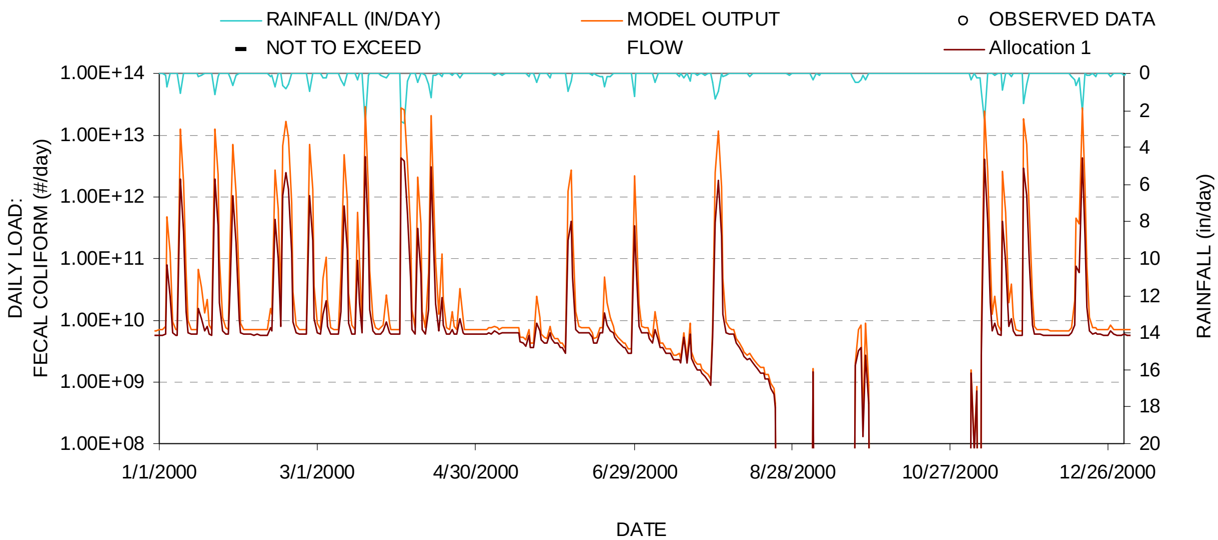

Figure 4-5 Existing Load versus Allocated Load at BGNL-033 (BNC-B) for 2000

4.4.3 Required Reductions

From the reduction scenarios discussed in the previous section, the existing load and allocated loads were determined. Instead of reducing the fecal coliform load globally, certain sources were addressed. These particular sources were identified from developing the sensitivity runs to understand the system and what sources were driving the fecal coliform impairment. Therefore, load reductions can be presented by a percent reduction of the existing load for each source.

A summary of the required reductions for point and non-point source loads is presented in Table 4-5. The existing and allocated loads are 5.0E14 and 9.44E13 counts per year, respectively. The loads, and therefore the TMDL, are shown in units of counts per year. It was determined that due to the variablility of the daily load due to watershed runoff, the annual load for the critical time period would be appropriate along with Figure 4-5. This figure is a plot of the daily load (counts per day) of fecal coliform for the existing conditions and the TMDL.

Table 4-5 Required Load Reductions for Point and Non-Point Sources

Source	Existing Loading Fecal Coliform (counts/yr)	Estimated Percent Source Reduction	Allocated Delivered Load (counts/yr)
Urban	2.33E+10	0.0%	2.33E+10
Cropland	1.31E+13	85.0%	1.97E+12
Forest and Other	8.15E+11	0.0%	8.15E+11
Pasture	4.49E+14	85.0%	6.74E+13
Failing Septic Systems	6.70E+12	50.0%	3.35E+12
Cattle in Streams	3.07E+13	33.3%	2.05E+13
		Load Allocation:	**9.40E+13**
Municipal Point Sources	3.95E+11	0.0%	3.95E+11
Total Existing Load	**5.0E+14**	**Wasteload Allocation:**	**3.95E+11**
		TMDL:	**9.44E+13**

The required reductions will be sought through TMDL implementation with follow up monitoring to determine the effectiveness of implementation. Follow up monitoring as discussed further in this document will be conducted according to basin rotation.

4.5 Seasonal Variation

Seasonal variation was incorporated in the continuous water quality model by daily meteorological data input to drive the hydrology and a 10-year simulation time period. The runoff events were allocated to the instantaneous target and the direct and point source loads were allocated to the geometric means. The summer months were the limiting factor in order to meet the geometric mean all year.

5 Conclusions

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality criteria 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 (WLAs), nonpoint source loads (LAs), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

TMDL = WLAs + LAs + MOS

The objective of a TMDL is to allocate loads among known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality criteria 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. For fecal coliform bacteria, the TMDLs are expressed as counts per year. The TMDL represents the maximum load that can occur over the year while maintaining the water quality criteria. The fecal coliform allocated load is more indicative of the TMDL because it represents daily fluctuations due to hydrology.

6 TMDL Implementation

6.1 Non-Point Source Approach

Big Nance Creek is impaired primarily by nonpoint sources. For 303(d) listed waters impaired primarily by nonpoint source (NPS) pollutants, necessary reductions will be sought during TMDL implementation using a phased approach. Voluntary, incentive-based mechanisms will be used to implement NPS management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the targeted impaired water. Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs. Local citizen-led and implemented management measures offer the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. Therefore, TMDL implementation activities will be coordinated through interaction with local entities in conjunction with Clean Water Partnership efforts.

The fiscal year 1999 Clean Water Action Plan Workplan for the Big Nance Creek watershed (ADEM, 1999) incorporates as a main objective the implementation of Best Management Practices (BMPs) to limit nonpoint sources. Coordinated with NRCS federal cost-sharing programs and ASWCC state-funded cost-sharing programs, BMPs currently under installation in the Big Nance Creek watershed include:

- Animal Waste Management Systems
  - Waste Storage Structures
  - Composters
  - Incinerators
  - Heavy Use Area protection
- Alternative Livestock Water Sources
  - Wells, Springs, Ponds, Troughs
- Riparian Areas, Stream Management Zones
  - Tree/Shrub Planting
  - Fencing (livestock exclusion)
- Livestock Exclusion; Streambank Protection; Rotational Grazing Systems
  - Fencing (livestock exclusion)
  - Stream Crossings
- Miscellaneous BMPs

  - Critical Area Planting
  - Pasture and Hayland Planting
- Erosion Control Systems
  - Conservation Tillage
  - Grassed Waterway Buffers
  - Cover and Green Manure Crop
  - Terracing
  - Field Borders

According to the TVA Muscle Shoals Unit, 600 acres adjacent to streams in the Big Nance Creek watershed were preserved as riparian buffers in the year 2000, corresponding to 25 miles of protected streams. Through September 2001, 22 additional miles of buffers were installed. In many cases the buffers include fencing the streambank to exclude livestock, and planting woody vegetation to limit nonpoint source runoff.

TMDL implementation will employ concurrent education and outreach, training, technology transfer, and technical assistance with incentive-based pollutant management measures. The ADEM Office of Education and Outreach (OEO) will assist in the implementation of TMDLs in cooperation with public and private stakeholders. Planning and oversight will be provided by or coordinated with the Alabama Department of Environmental Management's (ADEM) Section 319 nonpoint source grant program in conjunction with other local, state, and federal resource management and protection programs and authorities. The CWA Section 319 grant program may provide limited funding to specifically ascertain NPS pollution sources and causes, identify and coordinate management programs and resources, present education and outreach opportunities, promote pollution prevention, and implement needed management measures to restore impaired waters.

Depending on the pollutant of concern, resources for corrective actions may be provided, as applicable, by the Alabama Cooperative Extension System (education and outreach); the USDA-Natural Resources Conservation Service (NRCS) (technical assistance) and Farm Services Agency (FSA) (federal cost-share funding); and the Alabama Soil and Water Conservation Committee (state agricultural cost share funding and management measure implementation assistance) through local Soil and Water Conservation Districts, or Resource Conservation and Development Councils (funding, project implementation, and coordination). Additional assistance from such agencies as the Alabama Department of Public Health (septic systems), Alabama Department of Agriculture and Industries (pesticides), and the Alabama Department of Industrial Relations and Dept of Interior - Office of Surface Mining (abandoned minelands), Natural Heritage Program and US Fish and Wildlife Service (threatened and endangered species), may also provide practical TMDL implementation delivery systems, programs, and information. Land use issues will be addressed through the Nonpoint Source Education for Municipal Officials (NEMO) program. Memorandums of Agreement (MOAs) may be used as a tool to formally define roles and responsibilities.

Additional public/private assistance is available through the Alabama Clean Water Partnership Program (CWP). The CWP program uses a local citizen-based environmental protection approach to coordinate efforts to restore and protect the state's resources in accordance with the goals of the Clean Water Act. Interaction with the state or river basin specific CWP will facilitate TMDL implementation by providing improved and timely communication and information exchange between community-based groups, units of government, industry, special interest groups, and individuals. The CWP can assist local entities to plan, develop, and coordinate restoration strategies that holistically meet multiple needs, eliminate duplication of efforts, and allow for effective and efficient use of available resources to restore the impaired waterbody or watershed.

Other mechanisms that are available and may be used during implementation of this TMDL include local regulations or ordinances related to zoning, land use, or storm water runoff controls. Local governments can provide funding assistance through general revenues, bond issuance, special taxes, utility fees, and impact fees. If applicable, reductions from point sources will be addressed by the NPDES permit program. The Alabama Water Pollution Control Act empowers ADEM to monitor water quality, issue permits, conduct inspections, and pursue enforcement of discharge activities and conditions that threaten water quality. In addition to traditional "end-of-pipe" discharges, the ADEM NPDES permit program addresses animal feeding operations and land application of animal wastes. For certain water quality improvement projects, the State Clean Water Revolving Fund (SRF) can provide low interest loans to local governments.

Long-term physical, chemical, and biological improvements in water quality will be used to measure TMDL implementation success. As may be indicated by further evaluation of stream water quality, the effectiveness of implemented management measures may necessitate revisions of this TMDL. The ADEM will continue to monitor water quality according to the rotational river basin monitoring schedule as allowed by resources. In addition, assessments may include local citizen-volunteer monitoring through the Alabama Water Watch Program and/or data collected by agencies, universities, or other entities using standardized monitoring and assessment methodologies. Core management measures will include, but not be limited to water quality improvements and designated use support, preserving and enhancing public health, enhancing ecosystems, pollution prevention and load reductions, implementation of NPS controls, and public awareness and attitude/behavior changes.

6.2 Point Source Approach

For the waste load allocation, point source loads are set at a maximum fecal coliform concentration of 200 counts per 100ml, the same as the summertime (June-September) geometric mean criterion for the impaired segment of Big Nance Creek. The municipal plant in Courtland currently has a NPDES permit limit of 200 counts per 100 ml in the summer, and 1000 counts per 100 ml the remainder of the year. The other two point sources, Hatton Schools and Moulton, do not have a permit limit for fecal coliform.

Although the Moulton plant does not have a permit limit for fecal coliform, it began monitoring effluent fecal coliform concentration in April 2000 concurrent with a renewed NPDES permit requiring such monitoring. After noticing that the fecal coliform counts were consistently very high, the plant engineer discovered that the chlorination contact tank was holding suspended solids that may have been harboring bacteria during the chlorination process. Since December of 2000, the chlorination tank has been cleaned of solids monthly, resulting in a dramatic decrease in fecal coliform concentrations. Figure 6-1 shows the trend in fecal coliform discharge in 2000-01.

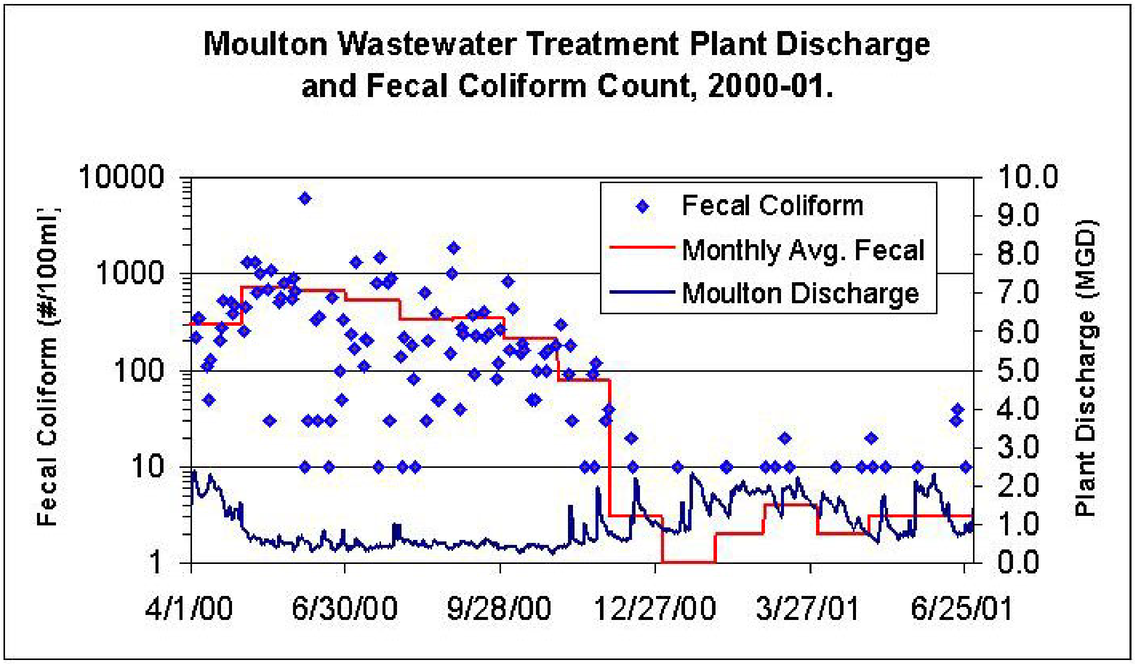

Figure 6-1 Moulton Wastewater Treatment Facility Chlorination Issue

The appropriate waste load allocation for point sources is 200 counts per 100 ml at permitted plant discharge. From the limited data available, it appears that Moulton can easily meet this concentration limit, although infiltration after rain events frequently causes inflow to exceed the plant design and permitted flow of 1.25 MGD.

7 Follow Up Monitoring

ADEM has adopted a basin approach to water quality management; an approach that divides Alabama's fourteen major river basins into five groups. Each year, the ADEM water quality resources are concentrated in one of the basin groups. One goal is to continue to monitor §303(d) listed waters. This monitoring will occur in each basin according to the following schedule:

Table 7-1 Monitoring Schedule for Alabama River Basins

River Basin Group	Schedule
Cahaba / Black Warrior	2002
Tennessee	2003
Choctawhatchee / Chipola / Perdido-Escambia / Chattahoochee	2004
Tallapoosa / Alabama / Coosa	2005
Escatawpa / Upper Tombigbee / Lower Tombigbee / Mobile	2006

Monitoring will help further characterize water quality conditions resulting from the implementation of best management practices in the watershed.

8 Public Participation

A thirty-day public notice will be provided for this TMDL. During this time, copies of this TMDL will be available upon request, and the public will be invited to provide comments.

Appendix 9.1 – References

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Appendix 9.2 - Fecal Coliform Monitoring Stations

Table 9-1 Description of All Water Quality Stations in the Big Nance Creek Watershed

Year	Station	Stream Section	Road Crossing	Latitude	Longitude	Duplicity
1991	BNC-B	Big Nance Creek	Lawrence County Rd. 151	34.5989	-87.3356	same as BGNL-033
1997	BNC-A	Big Nance Creek	Downstream of Alt 72 Bridge	34.6906	-87.3142	same as BGNL-032
1997	BNC-B	Big Nance Creek	Lawrence County Rd. 151	34.5989	-87.3356	same as BGNL-033
1998	BGNL-032	Big Nance Creek	Next to Lawrence County Rd. 150 nr. S.Courtland	34.6592	-87.3102	same as BNC-A
1998	BGNL-033	Big Nance Creek	Lawrence County Rd. 151	34.5991	-87.3356	same as BNC-B
1998	CLFL-012	Clear Fork	AL Hwy 33	34.5389	-87.2833	
1998	MBNL-034	Muddy Fork	AL Hwy 157	34.5605	-87.3434	same as MFBN-01
1999	CRB01	Crow Branch	Crow Branch @ Court Street.	34.4815	-87.2988	
1999	MFBN01	Muddy Fork	AL Hwy 157.	34.5595	-87.3433	same as MBNL-034
1999	MFBN02	Muddy Fork	Lawrence Co. Rd. 236.	34.5408	-87.3568	
1999	MFBN03	Muddy Fork	Lawrence Co. Rd. 234.	34.5237	-87.3533	
1999	MFBN04	Muddy Fork	Lawrence Co. Rd. 167.	34.4976	-87.3033	
1999	MOWW1	Crow Branch	Outfall to Crow Branch.	34.4888	-87.2987	
2000	CRCL-001	Crooked Creek	Lawrence County Rd. 150			
2000	BGNL-032	Big Nance Creek	Next to Lawrence County Rd. 150 nr. S.Courtland	34.6592	-87.3102	
2000	BGNL-033	Big Nance Creek	Lawrence County Rd. 151	34.5991	-87.3356	same as BNC-B
2000	BGNL-034	Big Nance Creek	off Harmony Road near Harmony Church	34.6375	-87.3439	
2000	BGNL-035	Big Nance Creek	Harmony Road bridge	34.6444	-87.3253	
2000	BGNL-036	Big Nance Creek	Downstream of Alt 72 Bridge	34.6906	-87.3142	same as BNC-A
2000	BGNL-037	Big Nance Creek	Lawrence County Rd. 314 near Red Bank	34.7658	-87.3717	

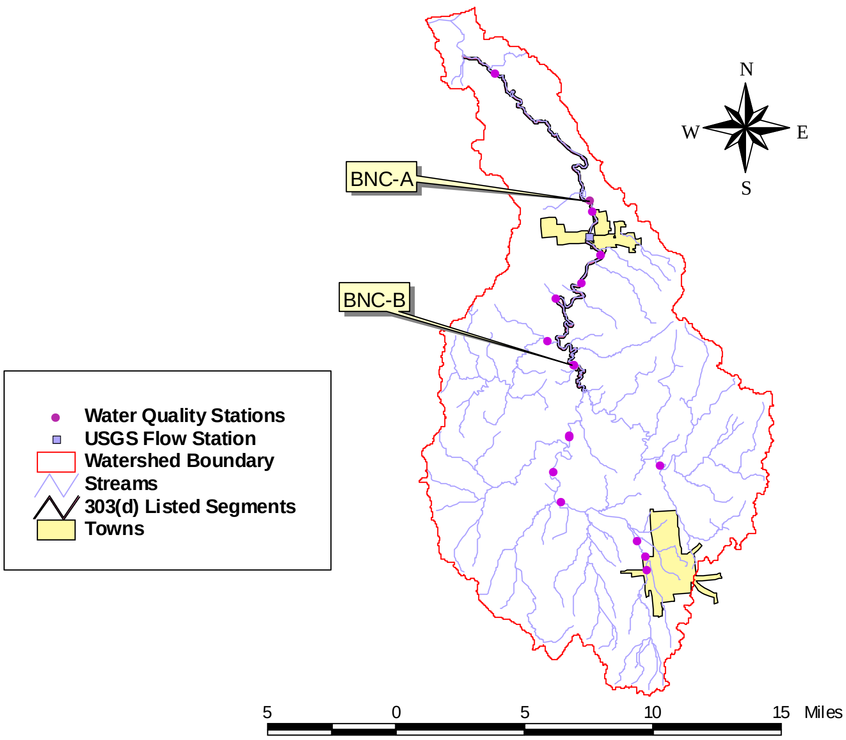


Figure 9-1 Locations of Water Quality Stations Monitored during 1997 in the Big Nance Creek Watershed

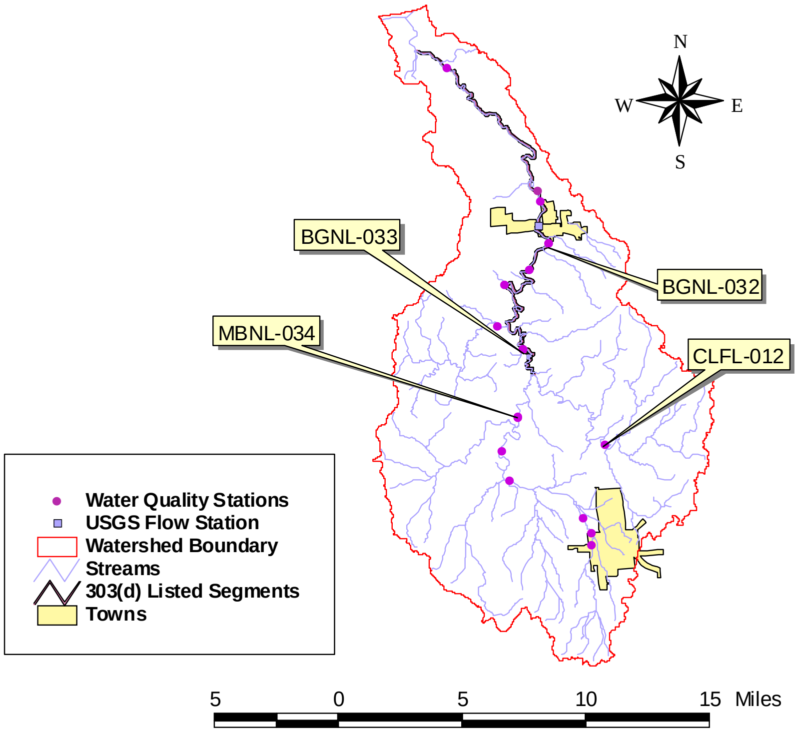


Figure 9-2 Locations of Water Quality Stations Monitored during 1998 in the Big Nance Creek Watershed

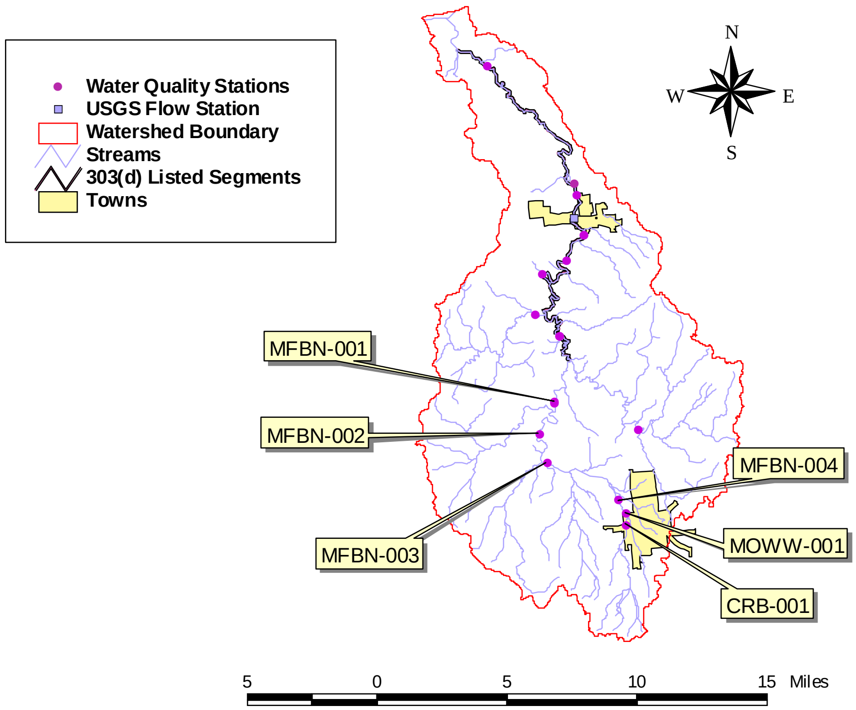


Figure 9-3 Locations of Water Quality Stations Monitored during 1999 in the Big Nance Creek Watershed

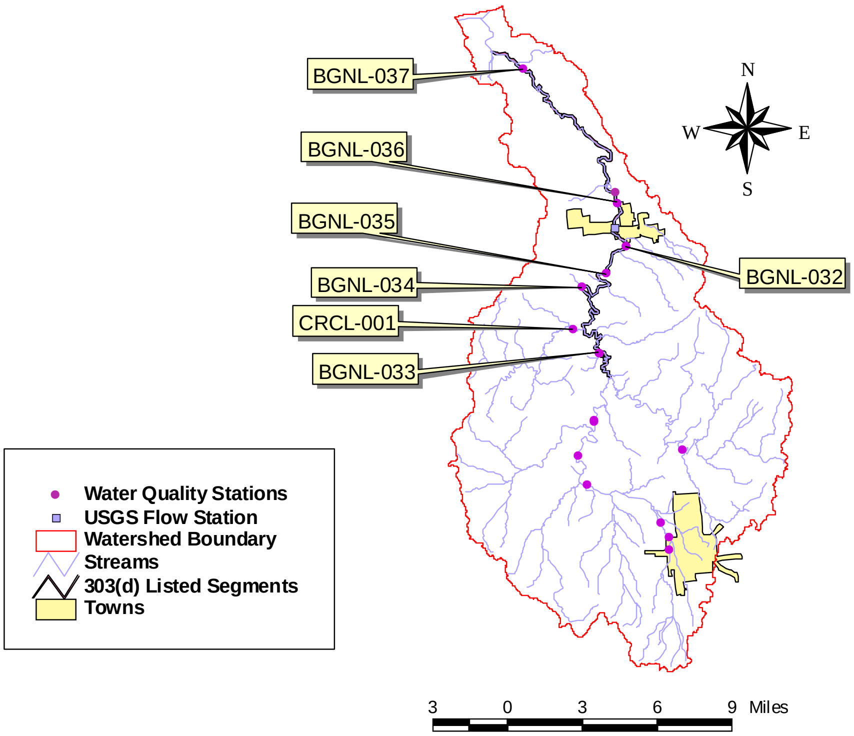


Figure 9-4 Locations of Water Quality Stations Monitored during 2000 in the Big Nance Creek Watershed

Table 9-2 Summary of Water Quality Data Collected in the Big Nance Creek Watershed

Data collected in 1991 for ADEM CWS 1992.					
Station	**Date**	**Time**	**Fecal Coliform (#/100ml)**	**Water Temp (deg C)**	
BNC-B	6/6/91	15:20	110	24	
BNC-B	7/9/91	7:40	750	24	
BNC-B	8/7/91	9:30	0	26	
BNC-B	9/4/91	8:10	310	24	
BNC-B	10/2/91	11:15	50	18	
Data collected by TVA in the Tennessee River Basin from July through October 1997.					
Station	**Date**	**Time**	**Fecal Coliform (#/100ml)**	**Streamflow (cfs)**	**Water Temp (deg C)**
BNC-A	6/30/97	16:20	INT	NM	23.8
BNC-A	7/22/97	15:30	120	NM	22.6
BNC-A	8/14/97	8:00	140	NM	24
BNC-A	9/11/97	8:00	283	NM	21.4
BNC-A	10/16/97	15:30	300	NM	16.1
BNC-B	6/30/97	13:00	INT	782	23.3
BNC-B	7/22/97	15:00	60	17.9	26.1
BNC-B	8/14/97	8:00	40	201	24.5
BNC-B	9/11/97	13:30	267	7	22.4
BNC-B	10/16/97	14:40	<1	NM	3.64
Data collected for TN basin nonpoint source watershed screening and CWA §303(d) evaluations, 1998.					
Station	**Date**	**Time**	**Fecal Coliform (#/100ml)**	**Streamflow (cfs)**	**Water Temp (deg C)**
BGNL-032	7/21/98	0.53	17	22.9	27
BGNL-033	7/21/98	0.49	57	11.0	27
CLFL-012	7/21/98	0.41	120	3.9	27
MBNL-034	7/21/98	0.45	75	3.6	27

Data collected as part of CWA §303(d) evaluations, ADEM Birmingham Field Operations, 1999.					
Station	Date	Time	Fecal Coliform (#/100ml)	Streamflow (cfs)	Water Temp (deg C)
CRB 001	5/25/99	9:45	55		19.4
CRB 001	8/10/99	10:30	22	0	26
CRB 001	9/8/99	10:00	1200	0	26.1
CRB 001	6/9/99	11:00	50		23.3
CRB 001	6/30/99	11:40	300		23.2
MFBN001	5/20/99	10:00	45	23.4	19.7
MFBN001	6/9/99	8:30	128	21.5	23
MFBN001	8/10/99	14:30	35	1.4	28.2
MFBN001	9/8/99	13:30	250	1.9	26
MFBN001	6/30/99	9:30	670		24.2
MFBN002	5/20/99	15:30	24	11.7	21
MFBN002	8/10/99	13:40	2		26.4
MFBN002	9/8/99	12:30	45		29.2
MFBN002	6/9/99	9:30	280		25
MFBN002	6/30/99	10:20	350		23.5
MFBN003	5/20/99	12:30	112	4.5	21
MFBN003	6/9/99	10:00	490	13.9	26
MFBN003	7/7/99	10:35			27.7
MFBN003	8/10/99	13:30	2		32.6
MFBN003	9/8/99	12:50	5		26.5
MFBN003	6/30/99	10:48	420		23.1
MFBN004	5/25/99	9:00	92	3.7	20.3
MFBN004	6/9/99	10:30	200	6.6	24.2
MFBN004	8/10/99	12:15	60	0.9	26.5
MFBN004	9/8/99	10:30	7	0.4	25.1
MFBN004	6/30/99	11:12	169		23.5
MOWW001	8/10/99	11:00	60		26.8
MOWW001	9/8/99	10:20	640		27.2
MOWW001	5/19/99	12:10	12		21.7
MOWW001	6/30/99	12:15	31		23

Data collected as part of CWA §303(d) evaluations, ADEM 2000-01.					
Station	**Date**	**Time**	**Fecal Coliform (#/100ml)**	**Streamflow (cfs)**	**Water Temp (deg C)**
BGNL032	4/25/00	11:45	60	N/A	16.6
BGNL032	5/10/00	13:15	57	N/A	20.9
BGNL032	6/21/00	13:45	92	N/A	24.62
BGNL032	7/18/00	14:15	20	N/A	24.04
BGNL032	10/17/00	13:30	108		15.39
BGNL032	12/14/00	12:35	3240		6.4
BGNL032	3/15/01	10:50	2120		12.14
BGNL033	4/25/00	9:15	57	None	15
BGNL033	5/10/00	10:15	92	17.82	21.53
BGNL033	6/21/00	9:45	32	10.27	24.32
BGNL033	7/18/00	11:00	104	1.5	25.72
BGNL033	10/17/00	11:29	38		17.1
BGNL033	12/14/00	10:25			5.63
BGNL033	1/30/01	11:20	1860	Nonwadeable.	9.32
BGNL033	3/15/01	13:15	2400	Nonwadeable.	11.79
BGNL034	4/25/00	11:00	164	N/A	15.14
BGNL034	5/10/00	12:00	260	N/A	22
BGNL034	6/21/00	11:45	101	N/A	27.21
BGNL034	7/18/00	12:20	55	N/A	25.17
BGNL034	10/17/00	12:30	71		15.8
BGNL034	12/14/00	11:50			5.51
BGNL034	1/30/01	11:50	3420		9.7
BGNL034	3/15/01	12:25	2400		12.21
BGNL035	4/25/00	11:30	172	N/A	15.71
BGNL035	5/10/00	12:15	112	N/A	20.1
BGNL035	6/21/00	13:15	92	N/A	25.13
BGNL035	7/18/00	12:40	33	N/A	25.32
BGNL035	10/17/00	12:45	4		16
BGNL035	12/15/00	12:15			6.5
BGNL035	1/30/01	12:10	3640		9.75
BGNL035	3/15/01	11:15	2400		11.83

Data collected as part of CWA §303(d) evaluations, ADEM 2000-01 (continued).					
Station	**Date**	**Time**	**Fecal Coliform (#/100ml)**	**Streamflow (cfs)**	**Water Temp (deg C)**
BGNL037	4/25/00	13:00	27	N/A	16.56
BGNL037	5/10/00	14:00	15	N/A	21.35
BGNL037	6/21/00	14:15	76	N/A	24.62
BGNL037	7/18/00	13:45	23	N/A	24.21
BGNL037	10/17/00	14:30	48		18.3
BGNL037	12/14/00	13:02			7.5
BGNL037	1/30/01	13:25	720		9.74
BGNL037	3/15/01	10:10	1040		13.16
CRCL001	4/25/00	10:00	232	13.46	15.25
CRCL001	5/10/00	11:15	77	2.3	20.63
CRCL001	6/21/00	11:30	420	0.9	24.3
CRCL001	7/18/00	12:00	600	0.6	23.48
CRCL001	10/17/00				
CRCL001	12/14/00	11:06			6.02
CRCL001	1/30/01	11:33	124		7.76
CRCL001	3/15/01	12:50	2240		13.5

Notes: NM = not measured.

Appendix 9.3 - Model Results for Hydrology Calibration

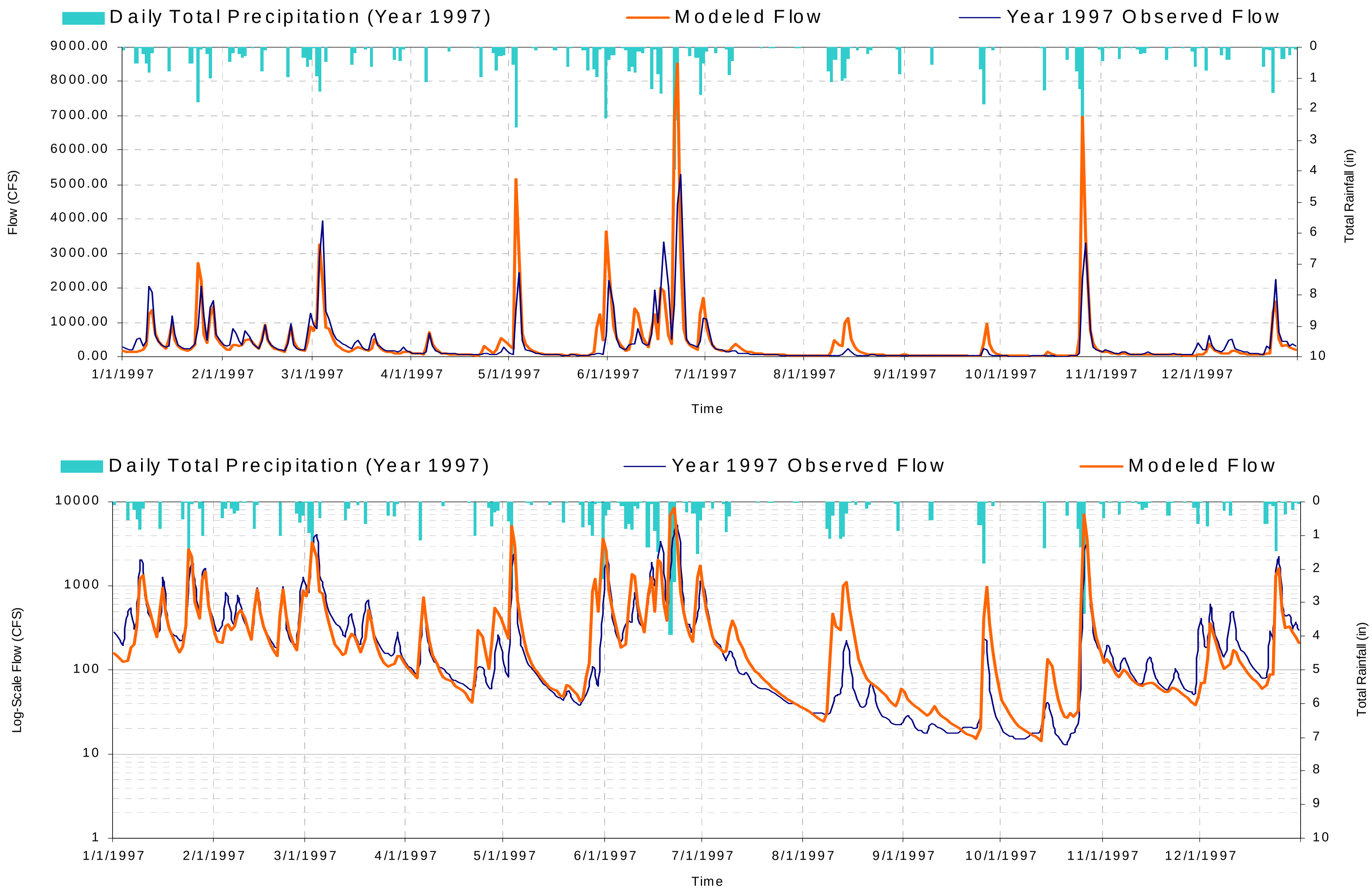


Figure 9-5 Hydrology Calibration for 1997 at USGS03586500 (Courtland, AL)

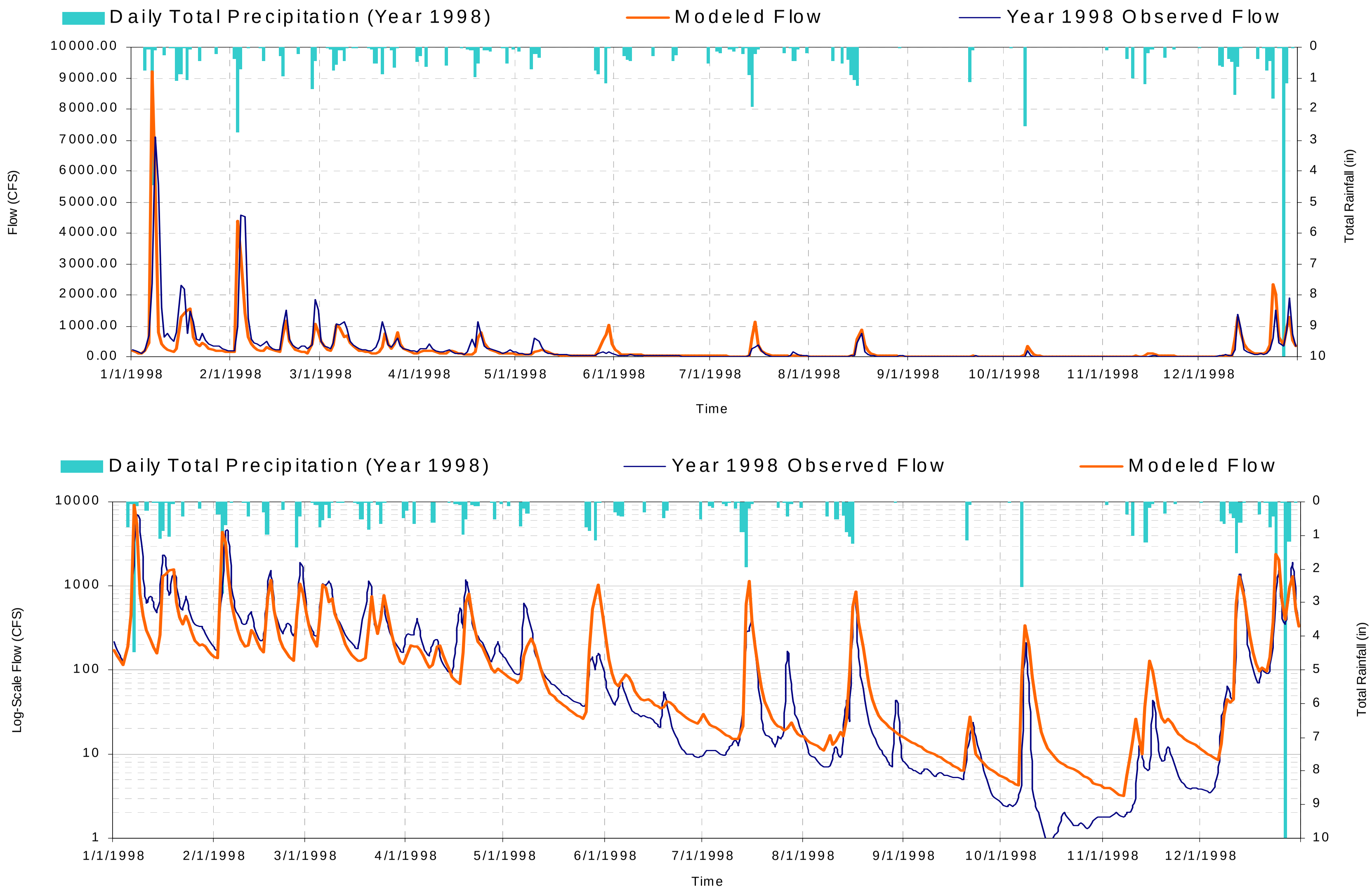


Figure 9-6 Hydrology Calibration for 1998 at USGS03586500 (Courtland, AL)

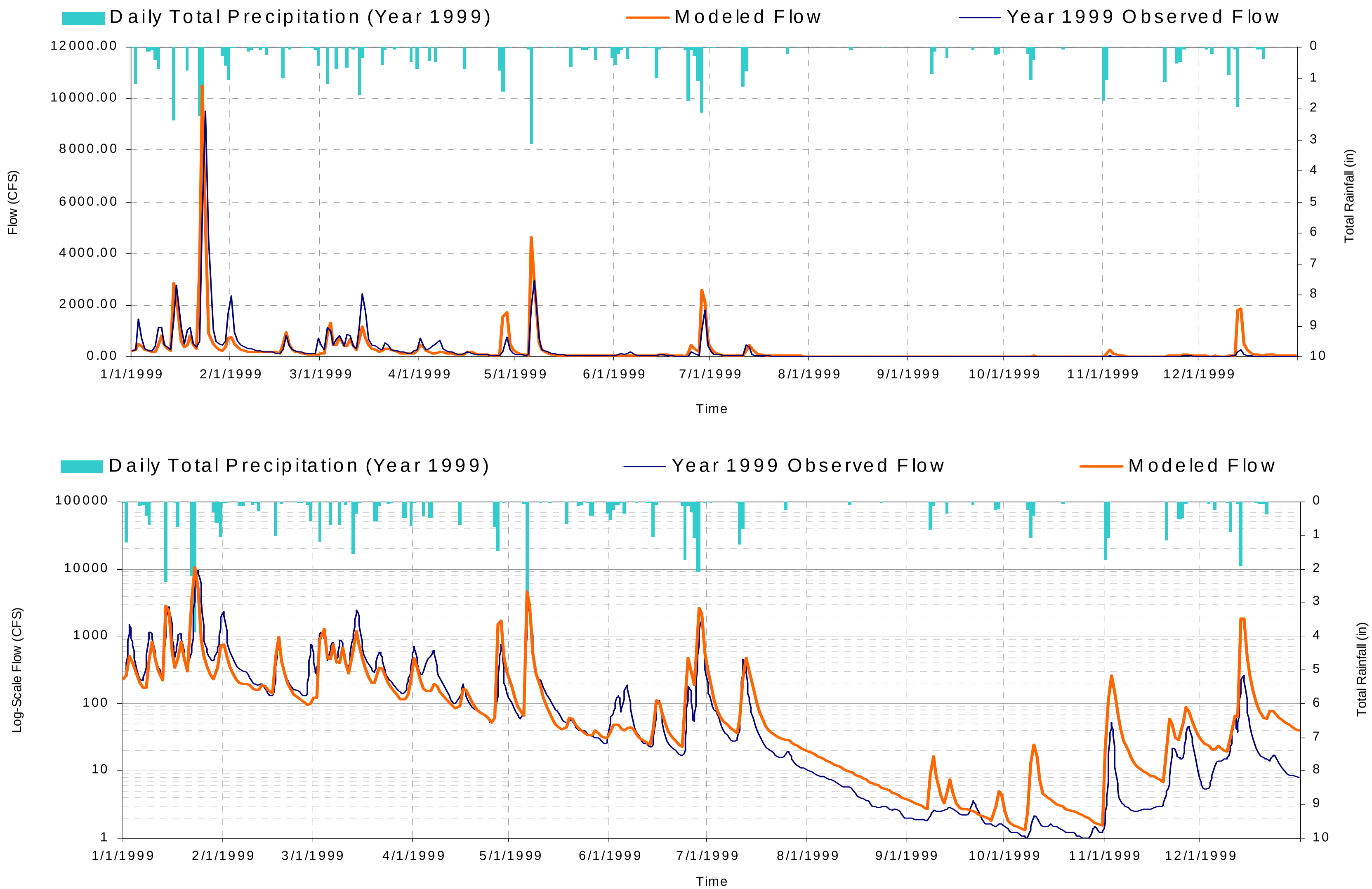


Figure 9-7 Hydrology Calibration for 1999 at USGS03586500 (Courtland, AL)

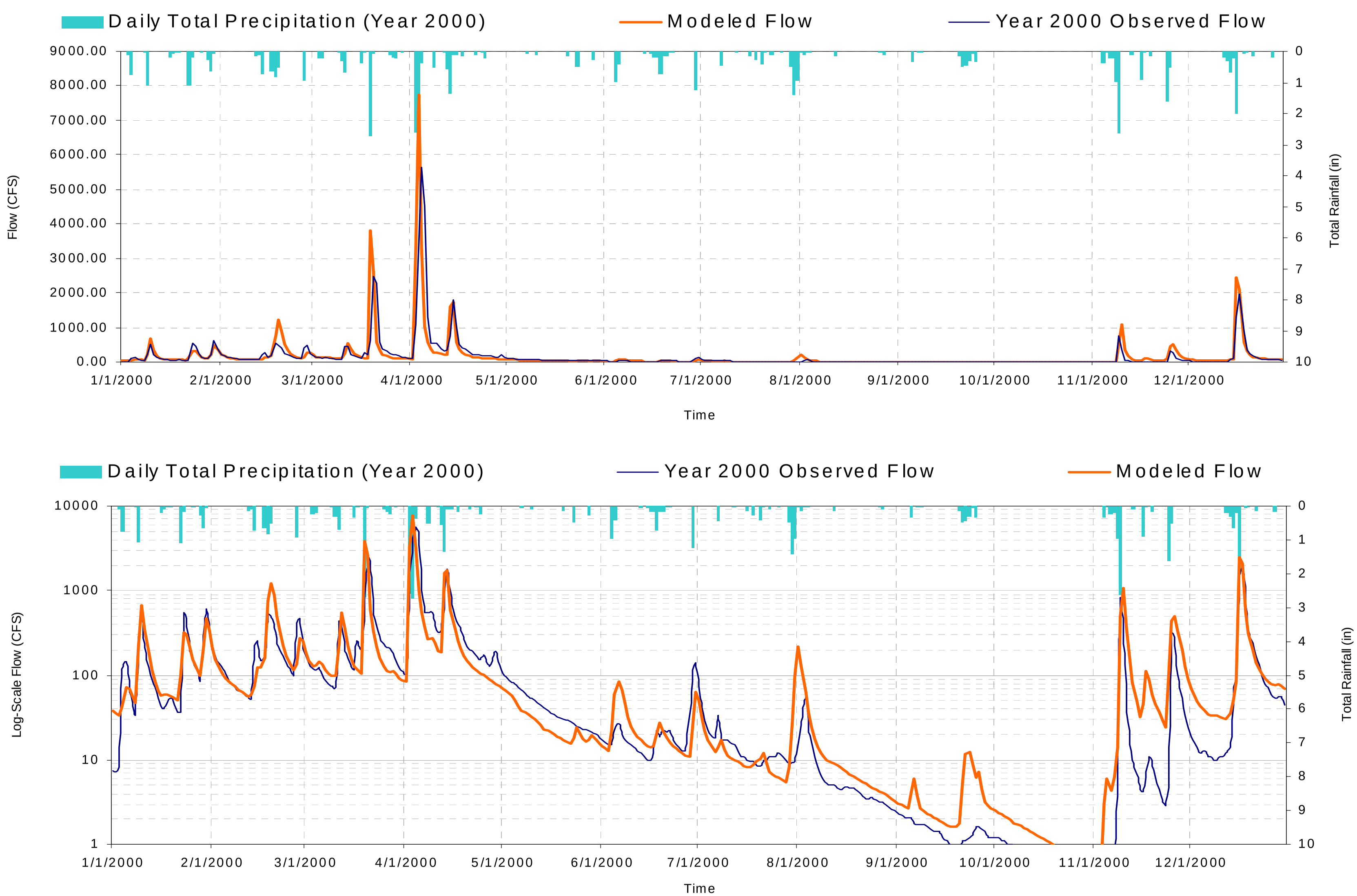


Figure 9-8 Hydrology Calibration for 2000 at USGS03586500 (Courtland, AL)

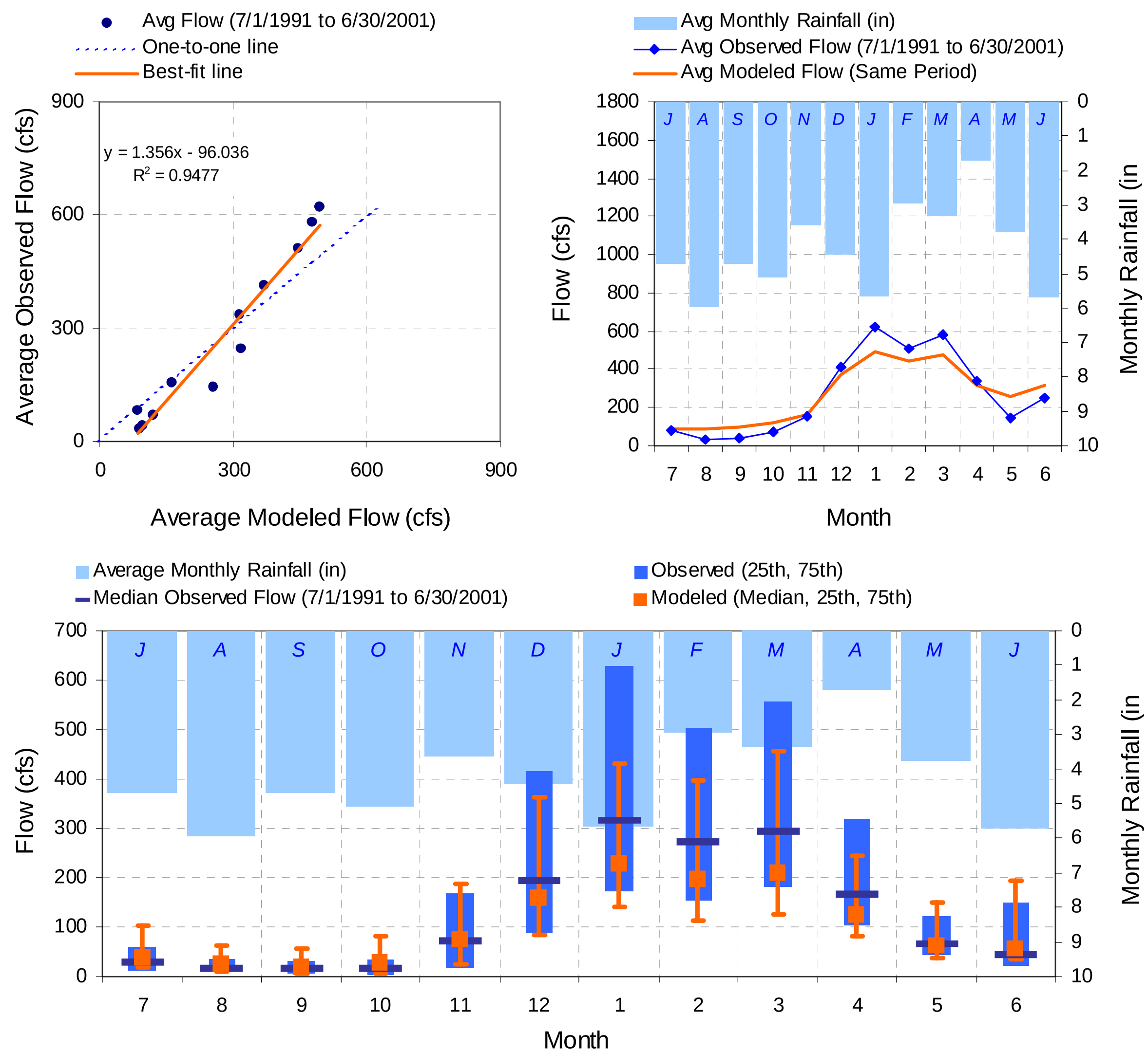


Figure 9-9 10-Year Analysis of the Hydrology Calibration

Appendix 9.4 - Model Results for Fecal Coliform Calibrations

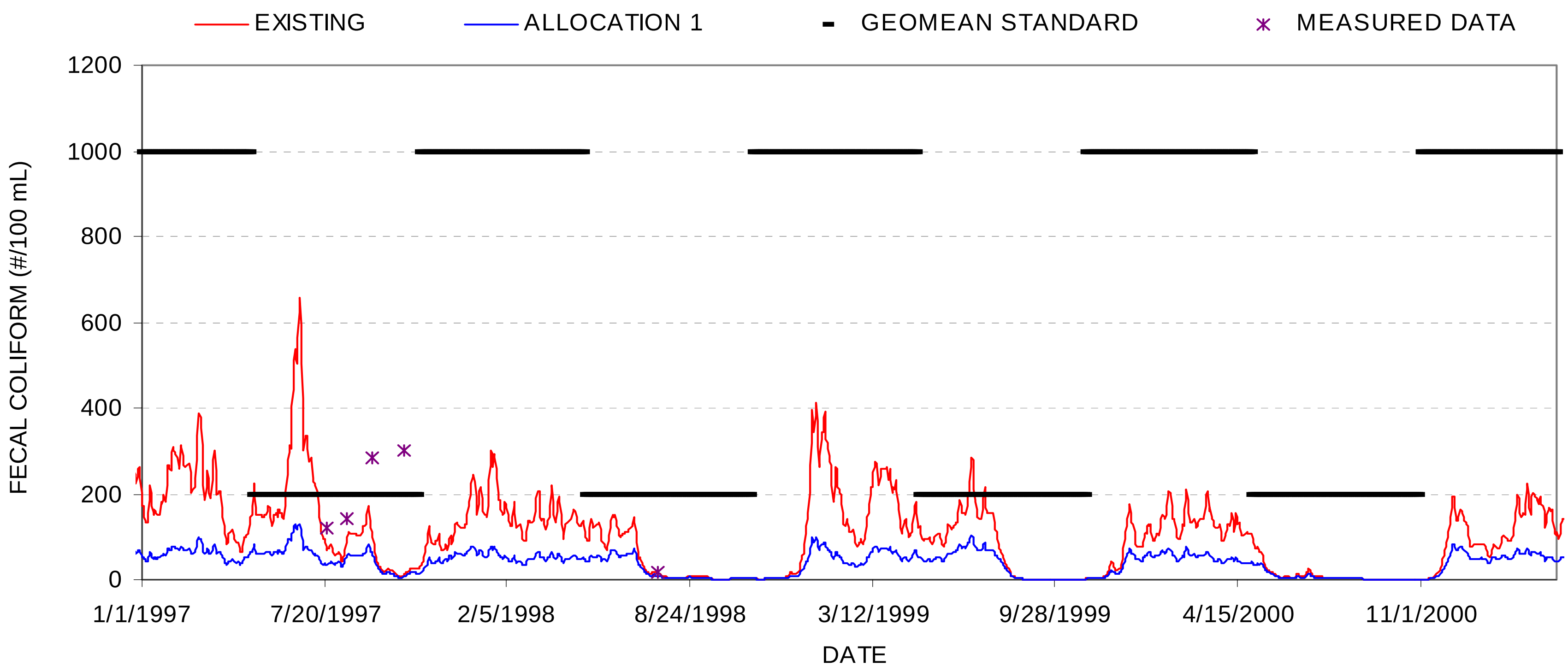


Figure 9-10 BNC-A: Big Nance Creek Downstream of Alt. US 72 Bridge; Geometric Mean Calculations

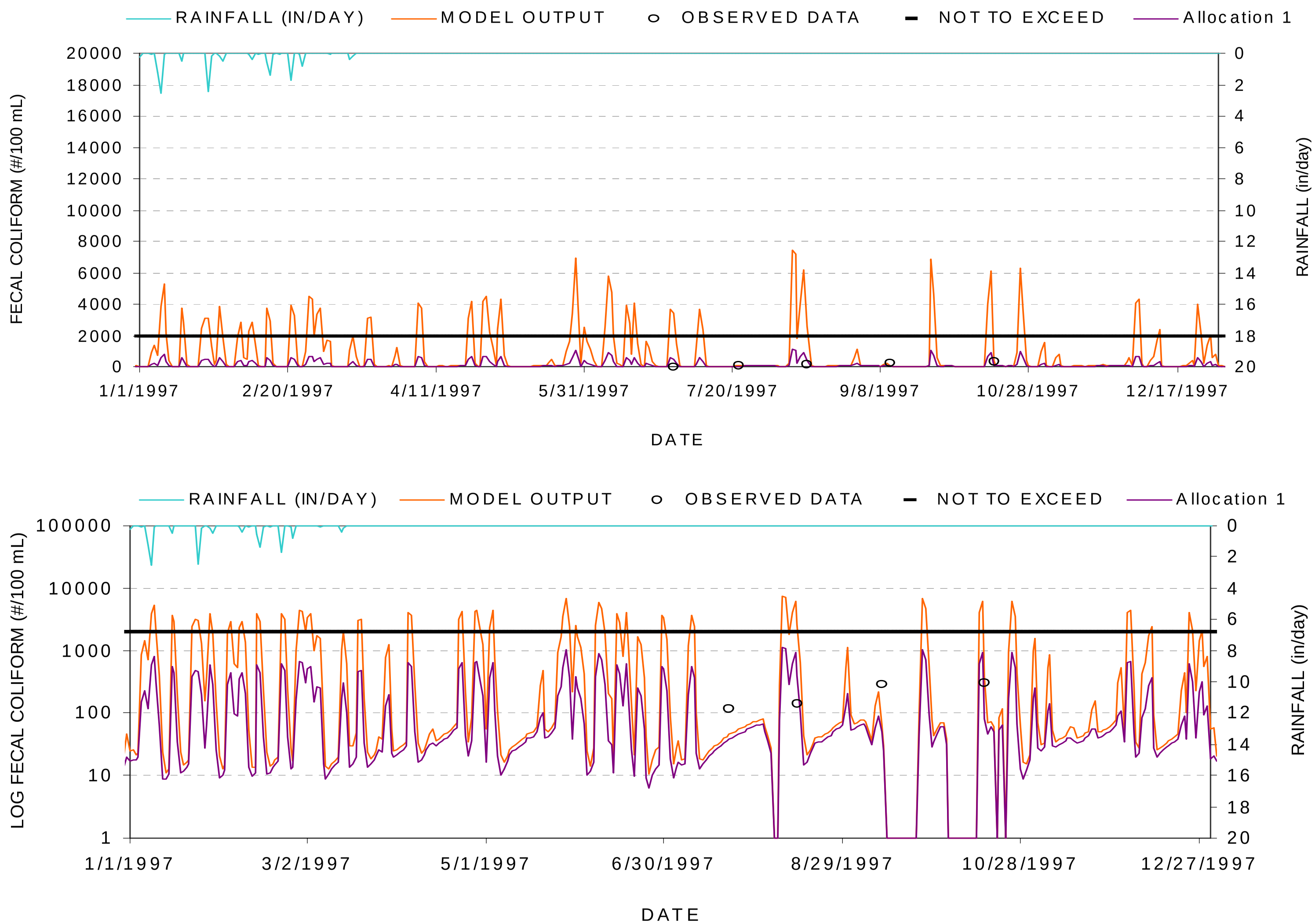


Figure 9-11 BNC-A: Big Nance Creek Downstream of Alt. US 72 Bridge; 1999 Calibration and Allocation

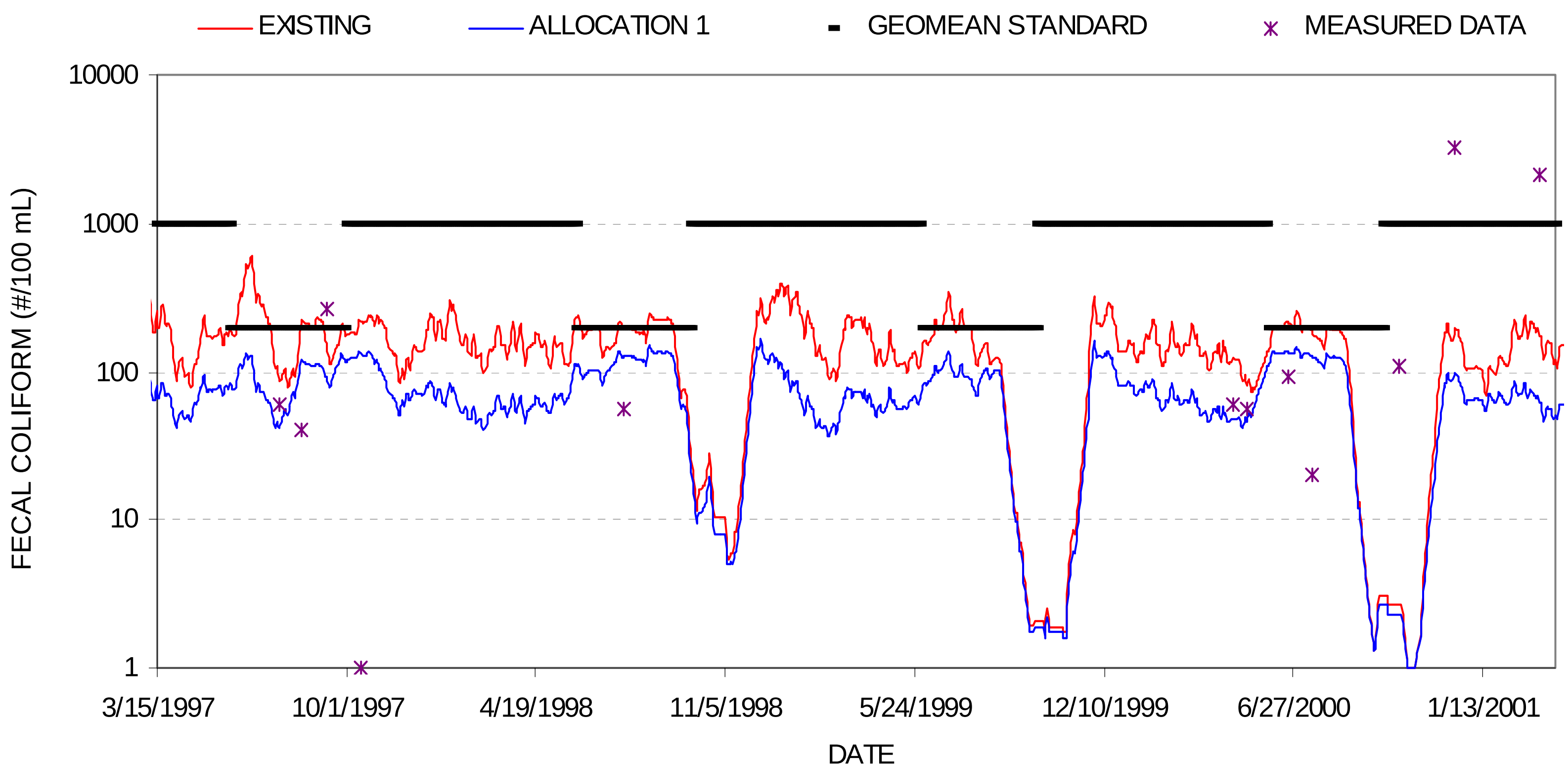


Figure 9-12 BNC-B: Big Nance Creek at Lawrence Co. Rd 151; Geometric Mean Calculations

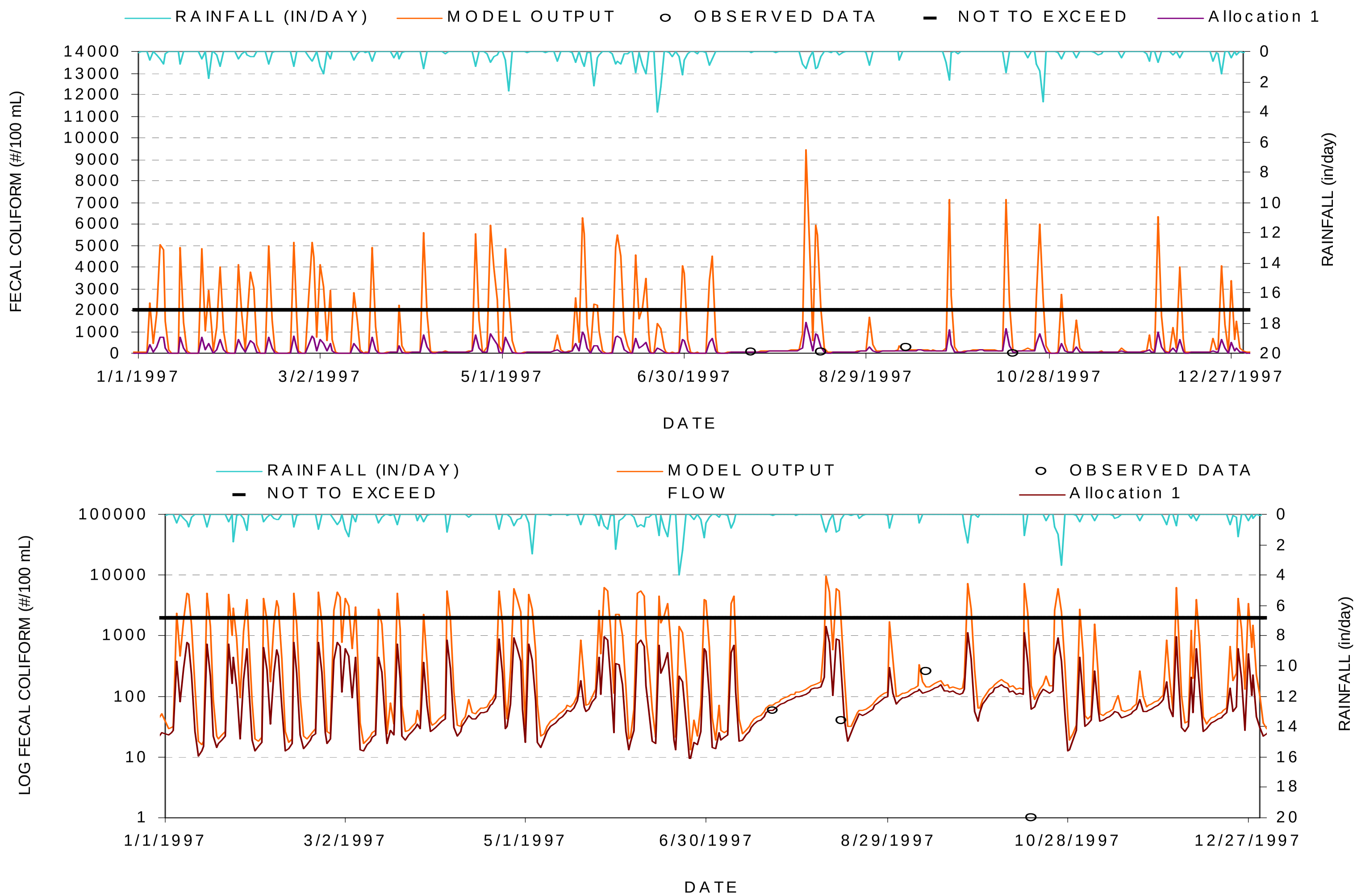


Figure 9-13 BNC-B: Big Nance Creek at Lawrence Co. Rd. 151; 1997 Calibration and Allocation

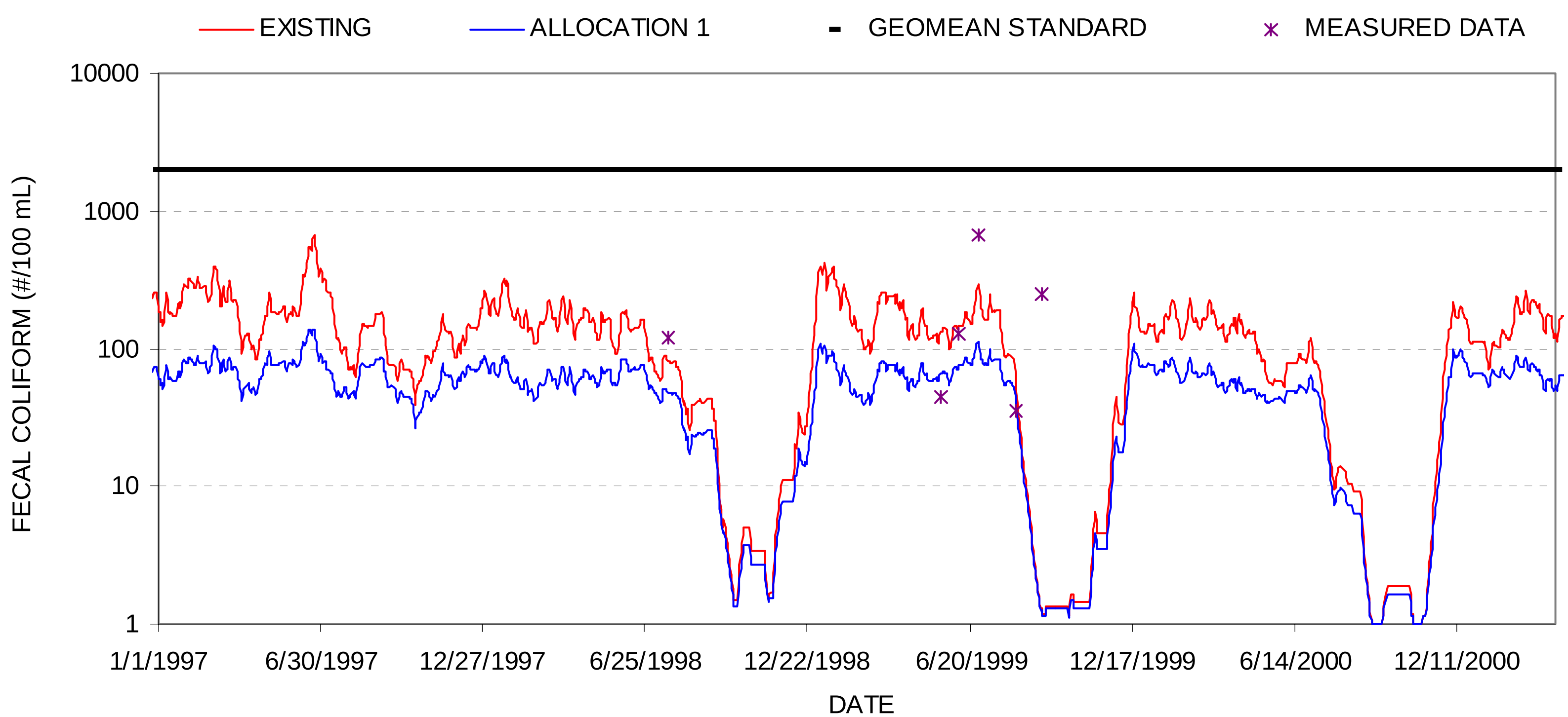


Figure 9-14 MFBN-001: Muddy Fork Below Rutherford Creek; Geometric Mean Calculations

Figure 9-15 MFBN-001: Muddy Fork Downstream of Rutherford Creek; 1999 Calibration and Allocation

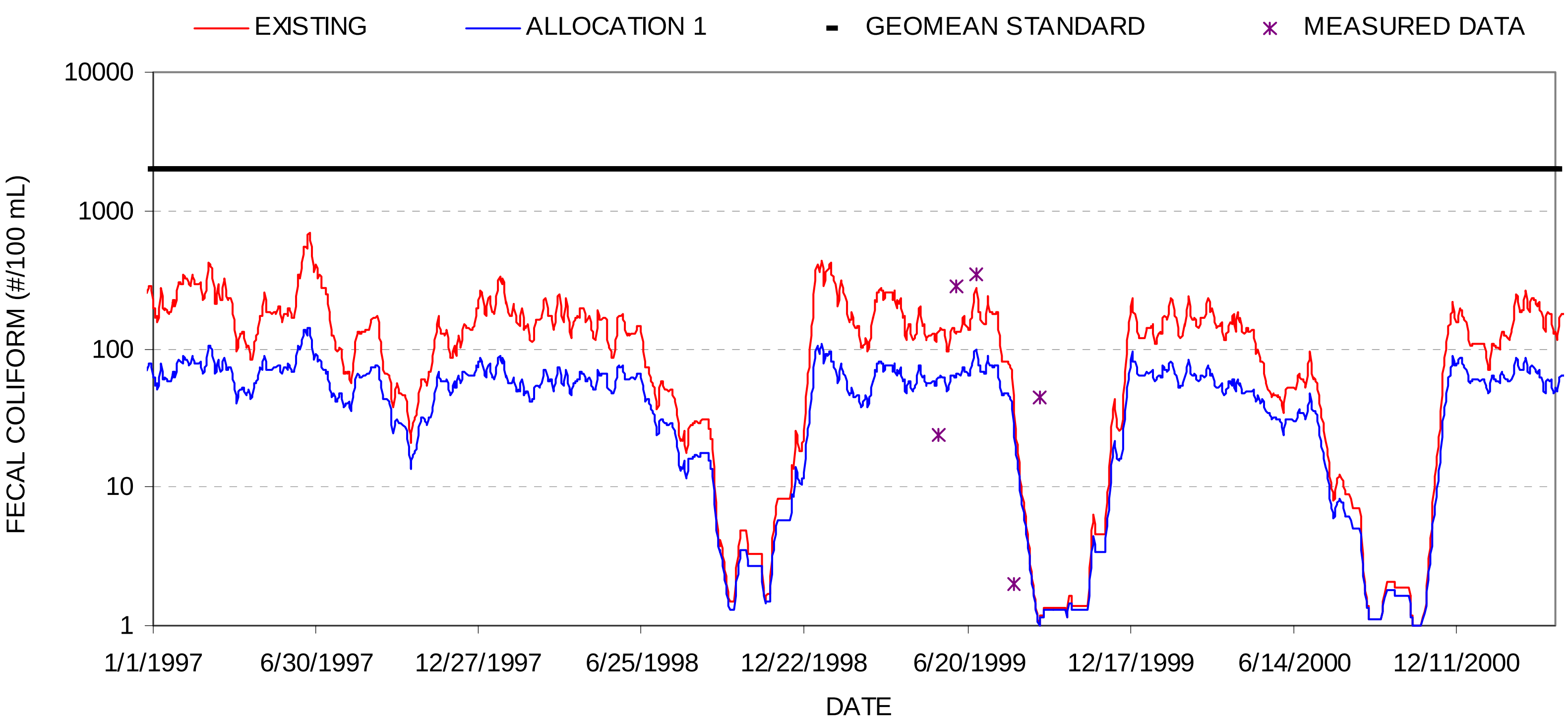
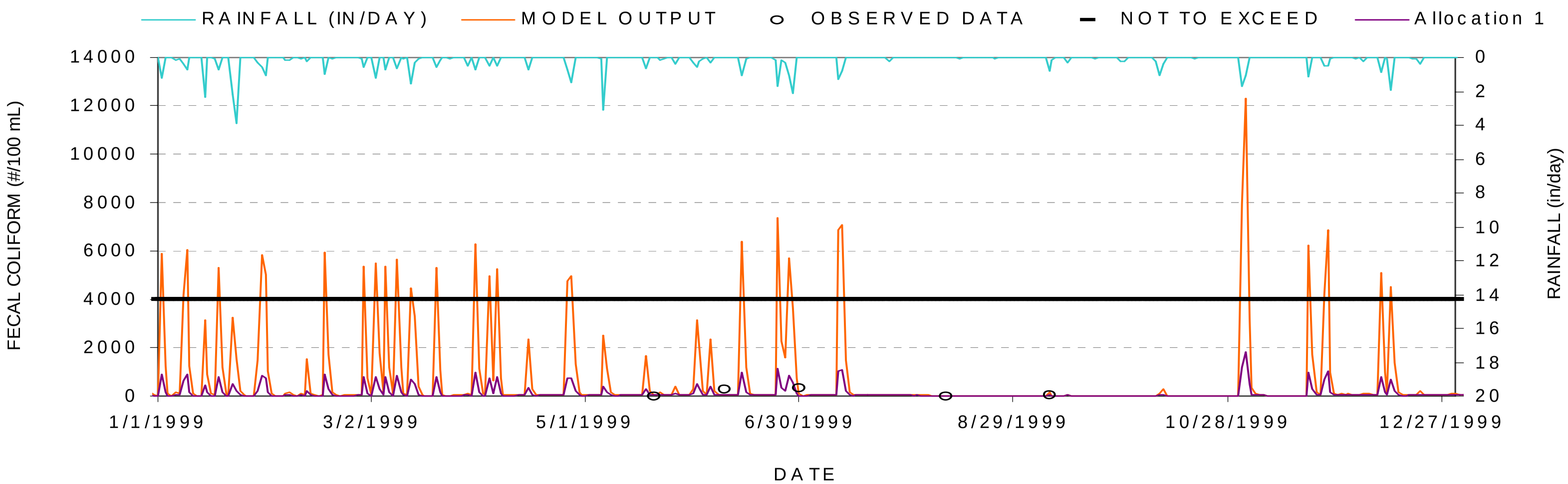


Figure 9-16 MFBN-002: Muddy Fork at Lawrence Co. Rd. 236; Geometric Mean Calculations



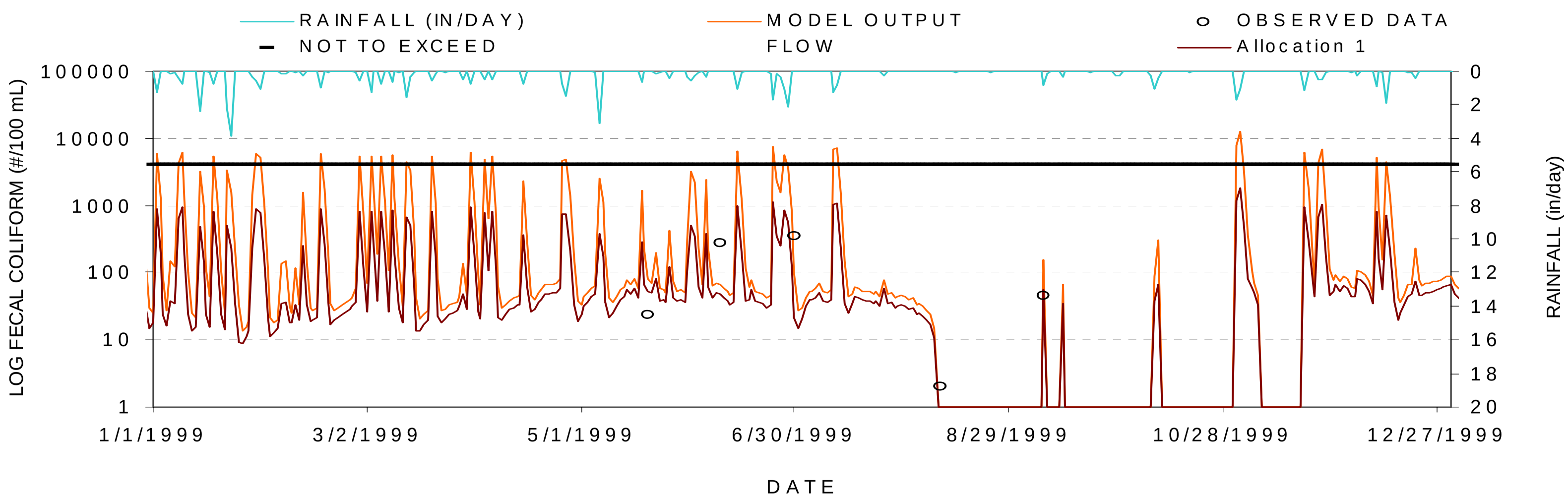


Figure 9-17 MFBN-002: Muddy Fork at Lawrence Co. Rd. 236; 1999 Calibration and Allocation

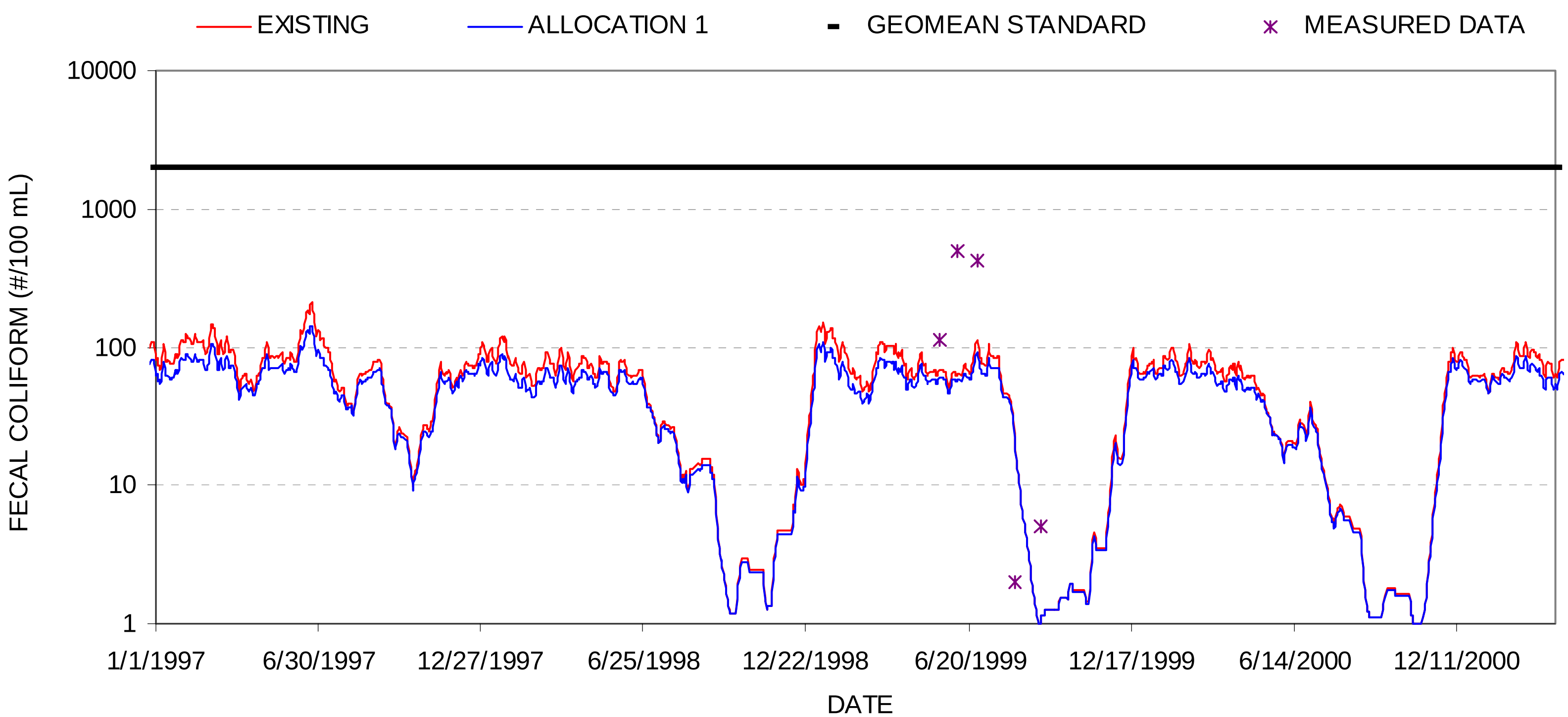


Figure 9-18 MFBN-003: Muddy Fork Upstream of Borden Creek: Geometric Mean Calculations

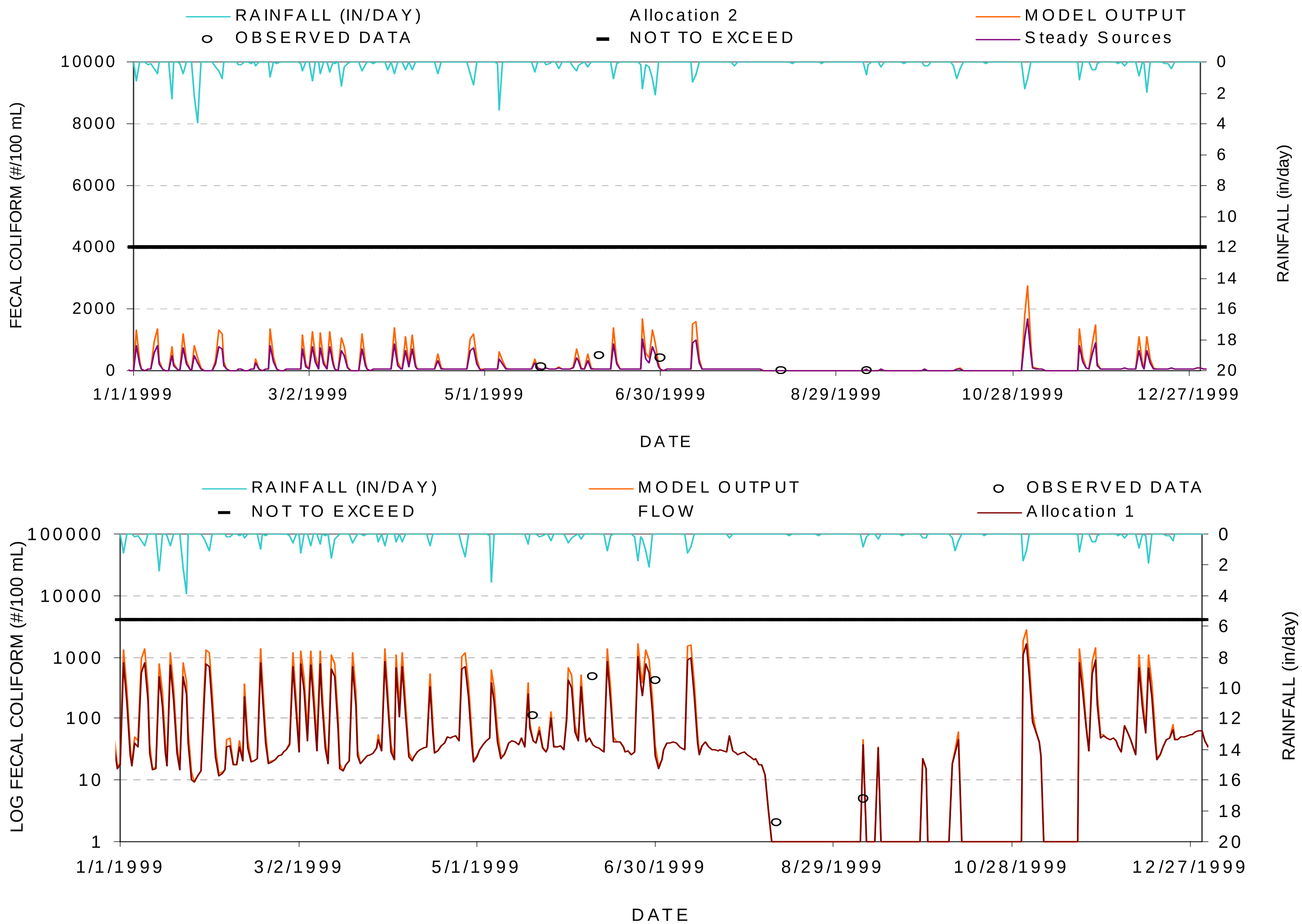


Figure 9-19 MFBN-003: Muddy Fork Upstream of Borden Creek; 1999 Calibration and Allocation

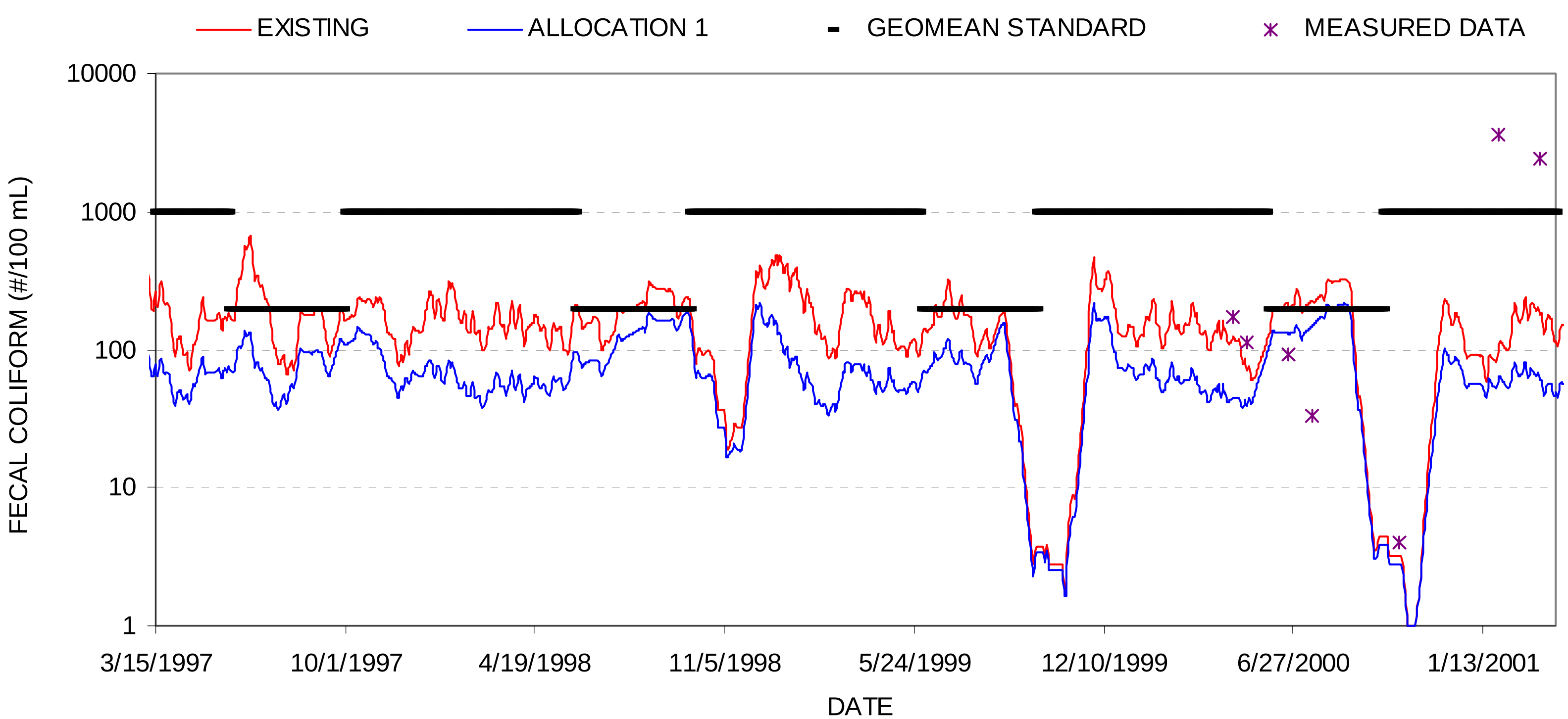


Figure 9-20 MFBN-004: Muddy Fork at Crow Branch; 1999 Geometric Mean Calculations

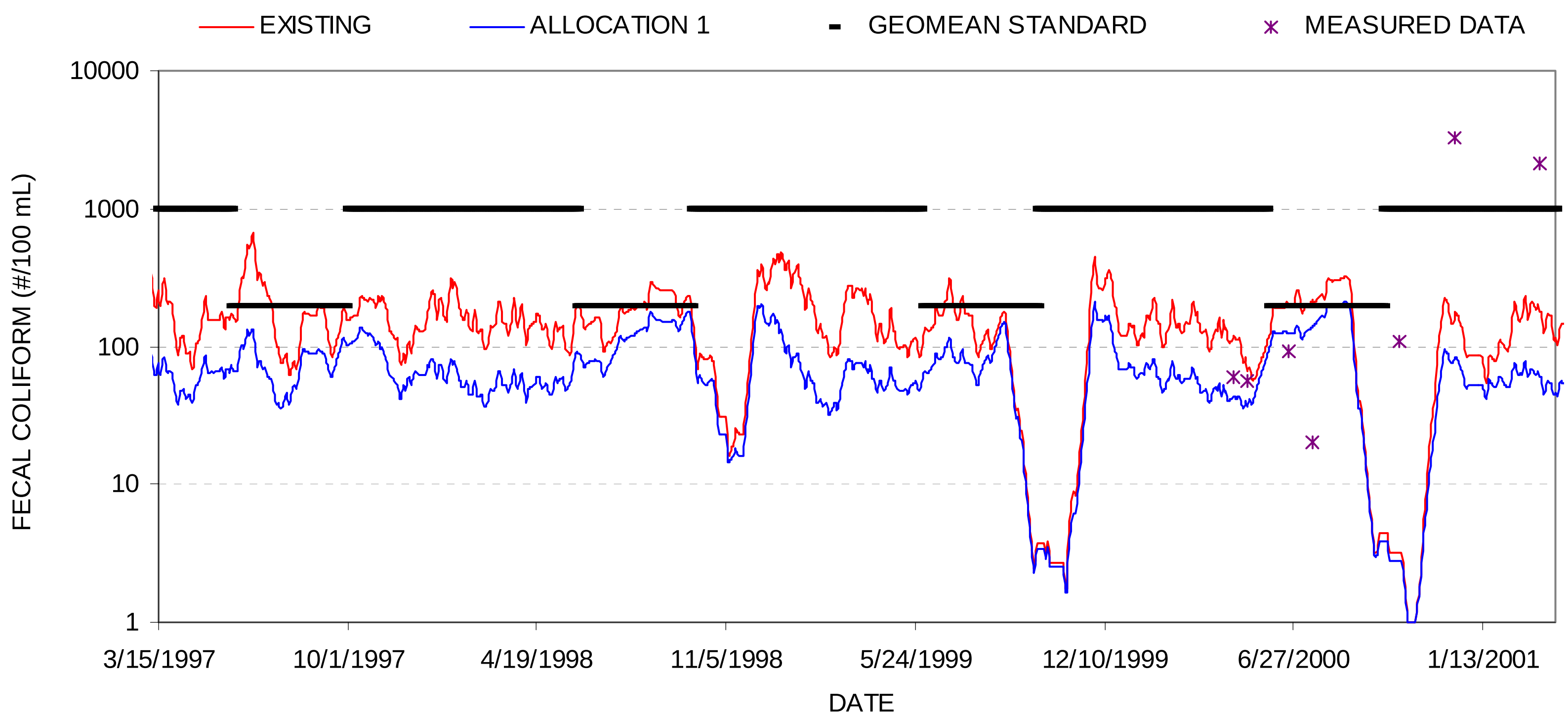
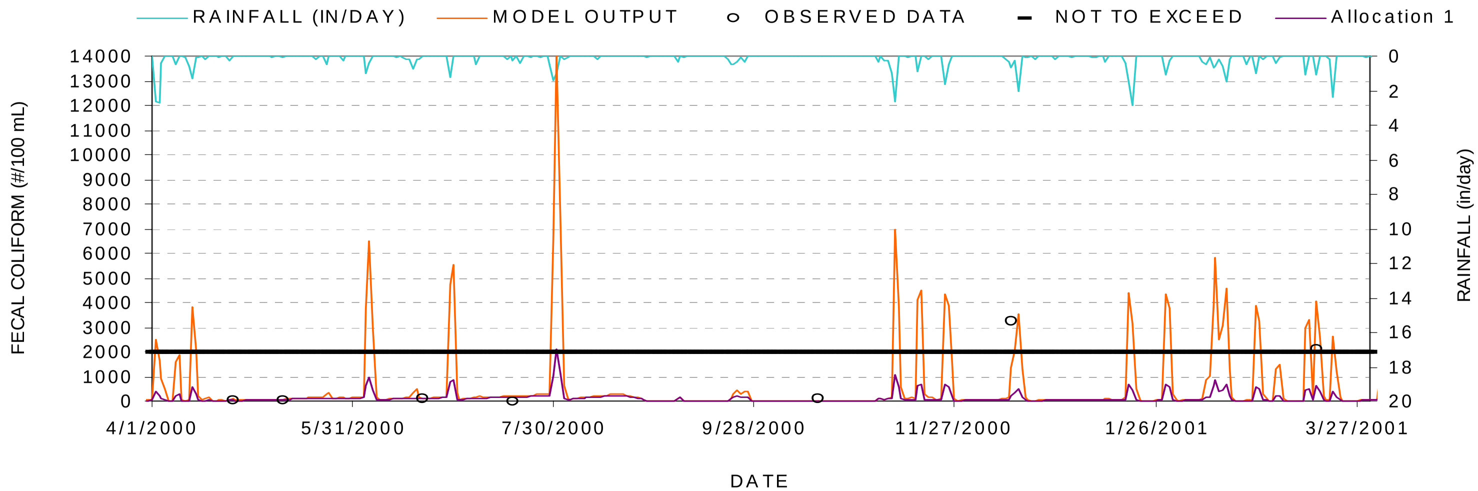


Figure 9-21 BGNL-032: Big Nance Creek next to Lawrence County Rd. 150; Geometric Mean Calculations



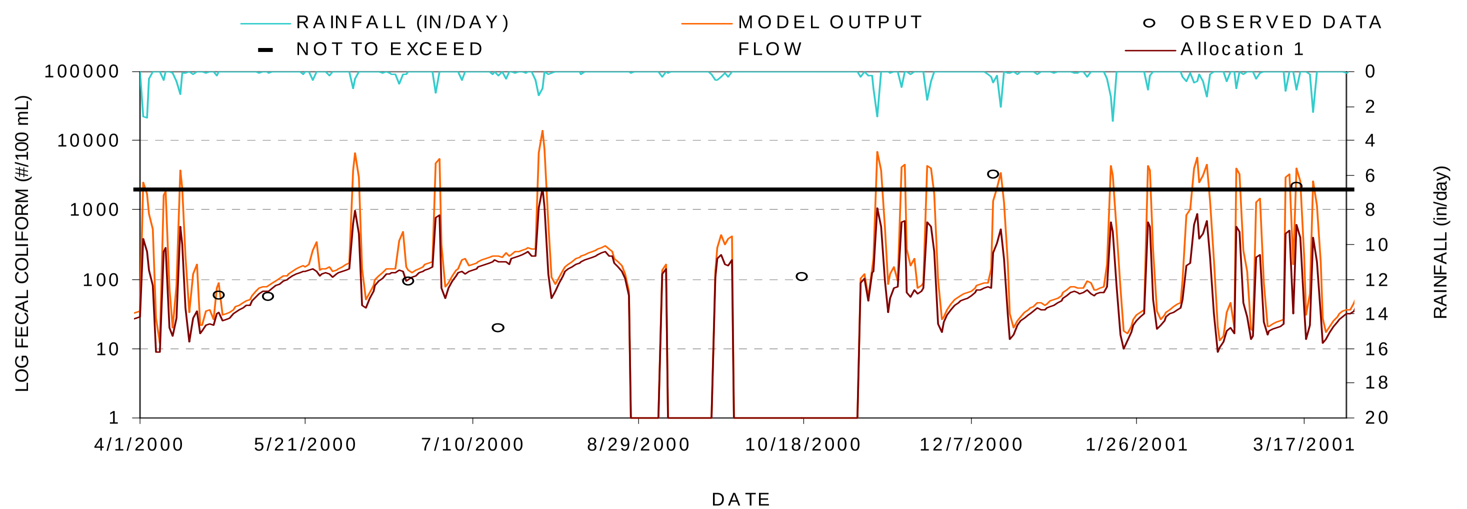


Figure 9-22 BGNL-032: Big Nance Creek next to Lawrence County Rd. 150; 2000 Calibration and Allocation

Figure 9-23 BGNL-033 (BNC-B): Big Nance Creek at Lawrence Co. Rd. 151; 2000 Calibration and Allocation

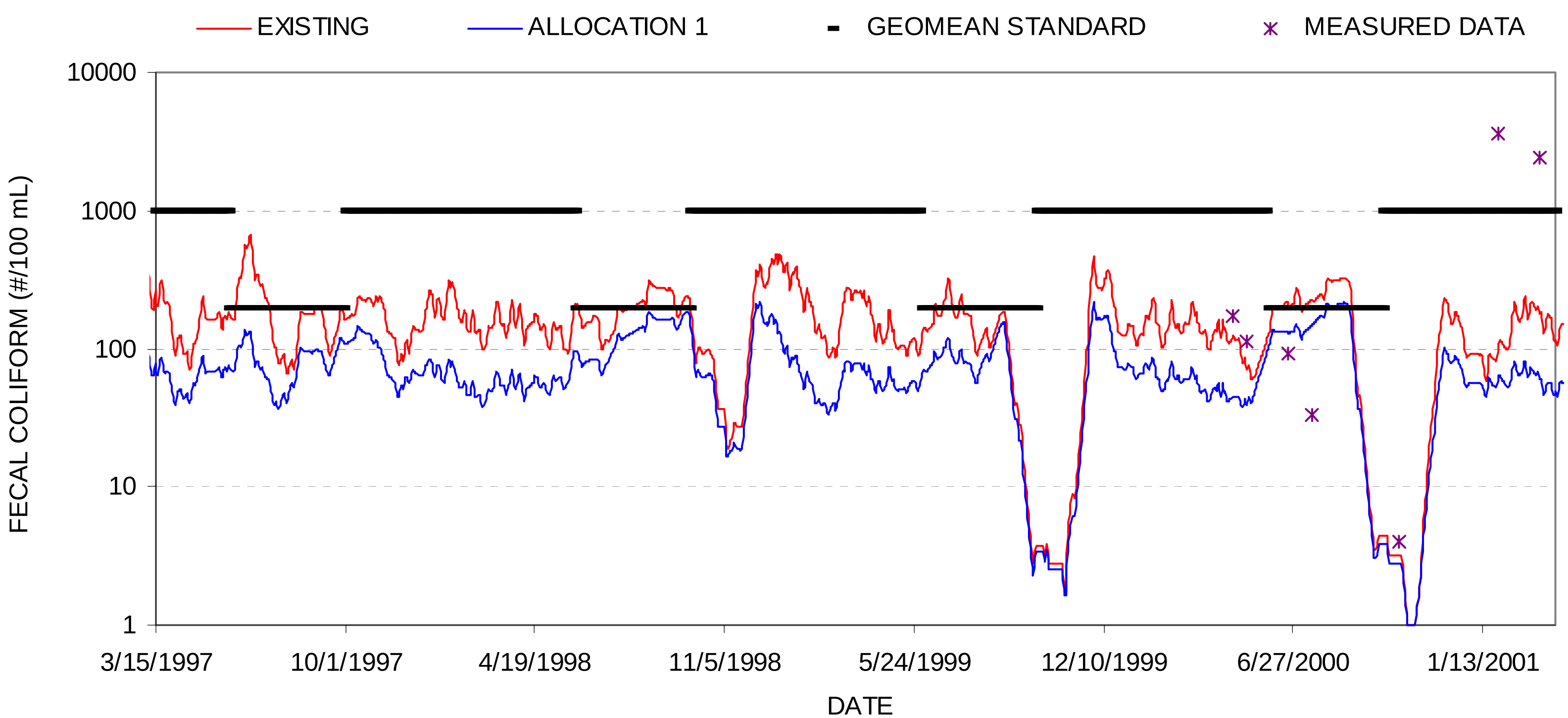


Figure 9-24 BGNL-035: Harmony Road Bridge; Geometric Mean Calculations

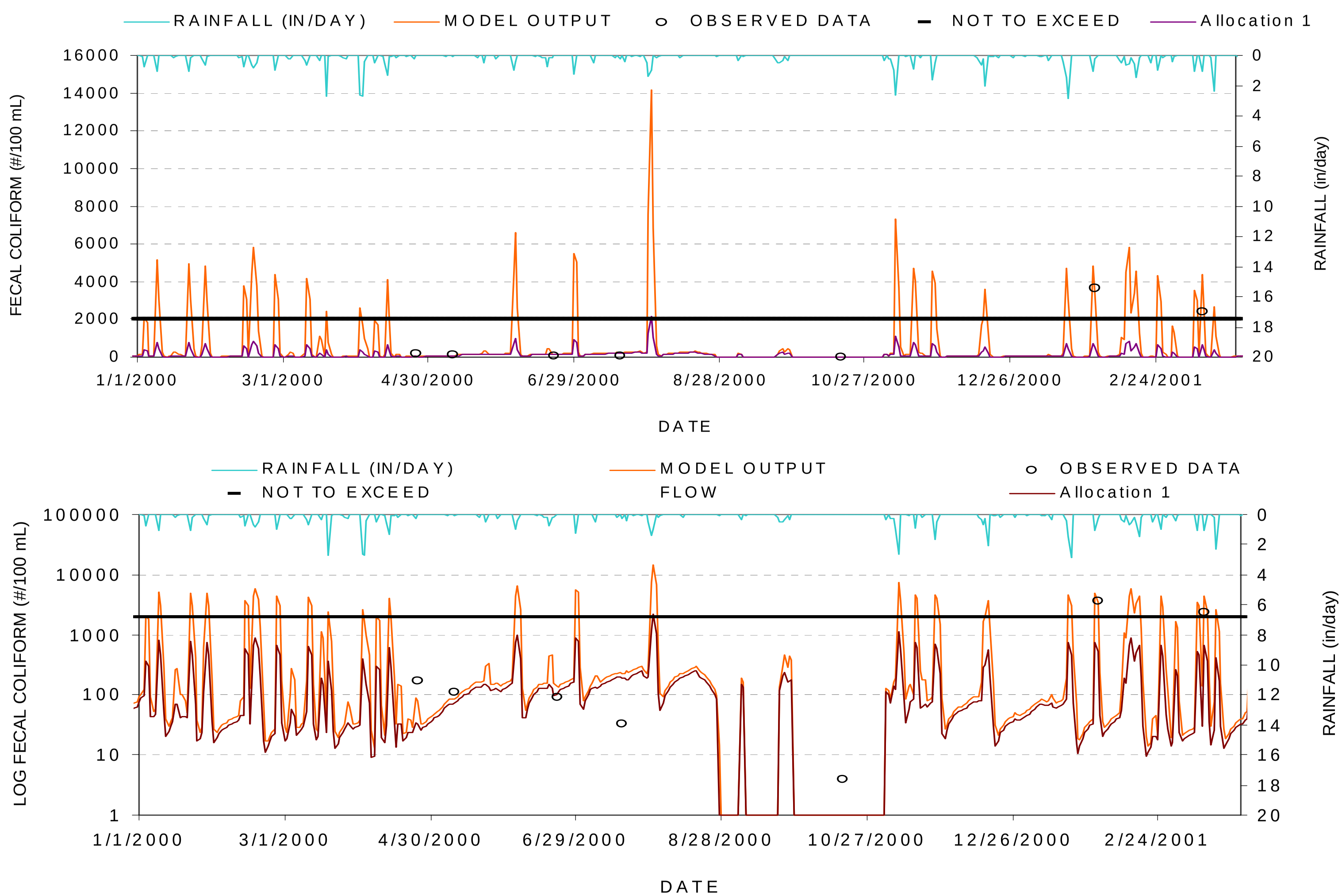


Figure 9-25 BGNL-035: Harmony Road Bridge; 2000 Calibration and Allocation

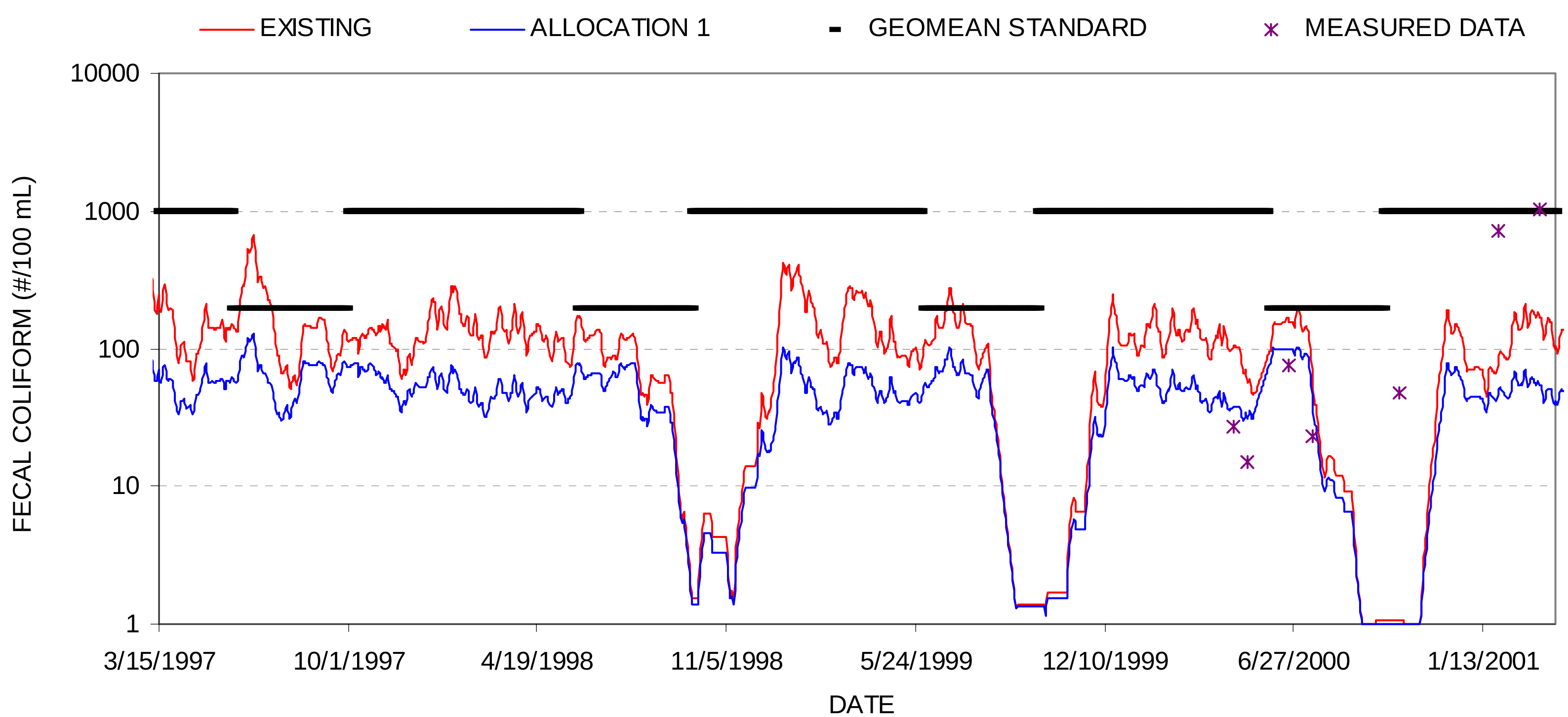


Figure 9-26 BGNL-037: Big Nance Creek near Red Bank; Geometric Mean Calculations

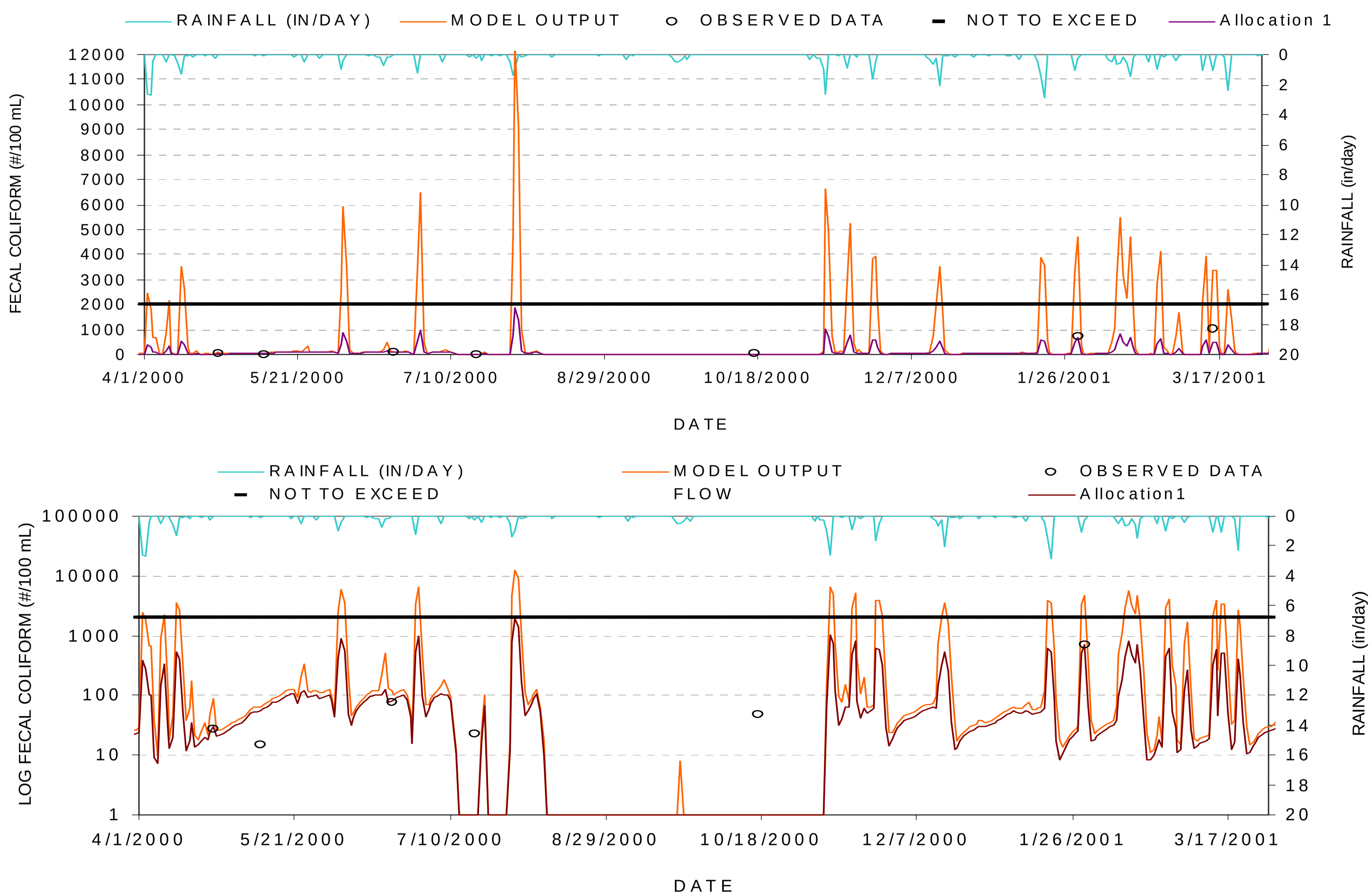


Figure 9-27 BGNL-037: Big Nance Creek near Red Bank; 2000 Calibration and Allocation

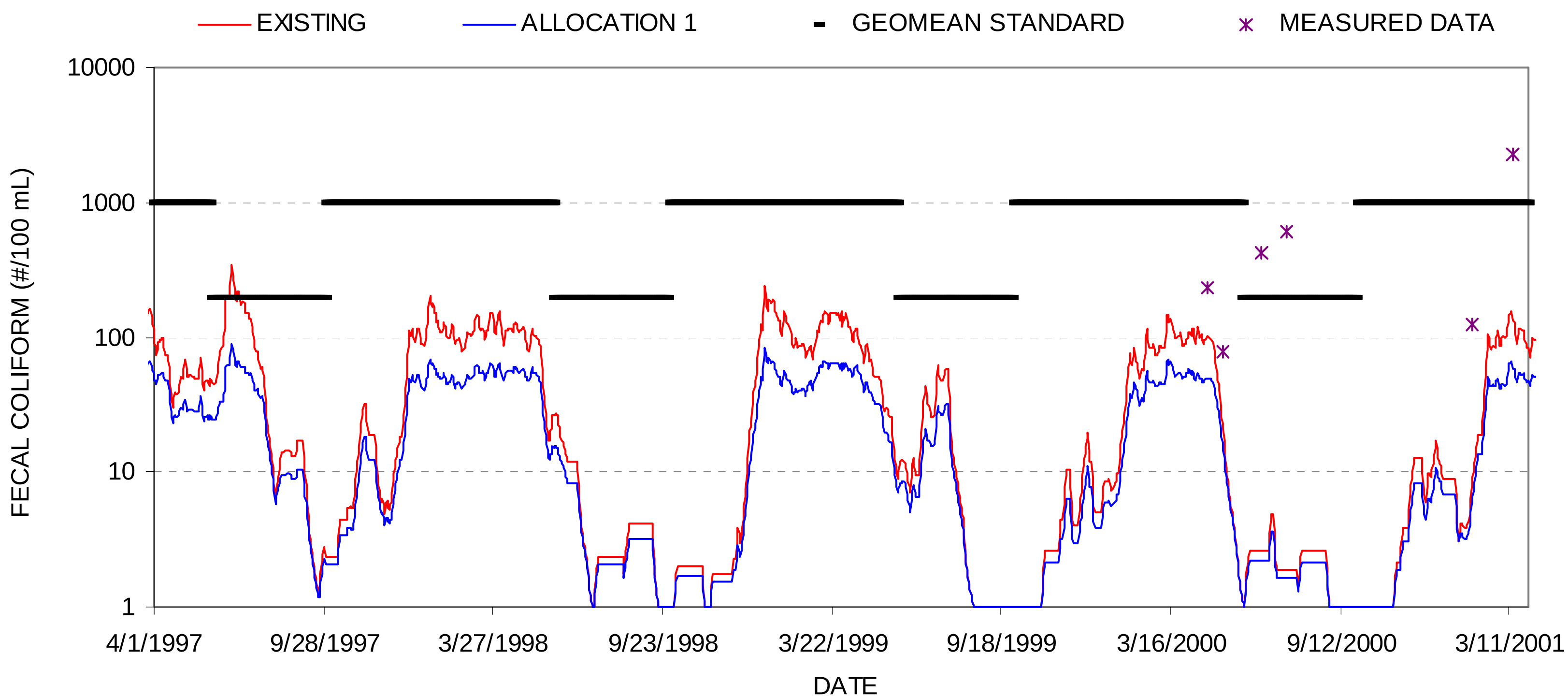


Figure 9-28 CRCL-001: Crooked Creek at Lawrence Co. Rd. 150; Geometric Mean Calculations

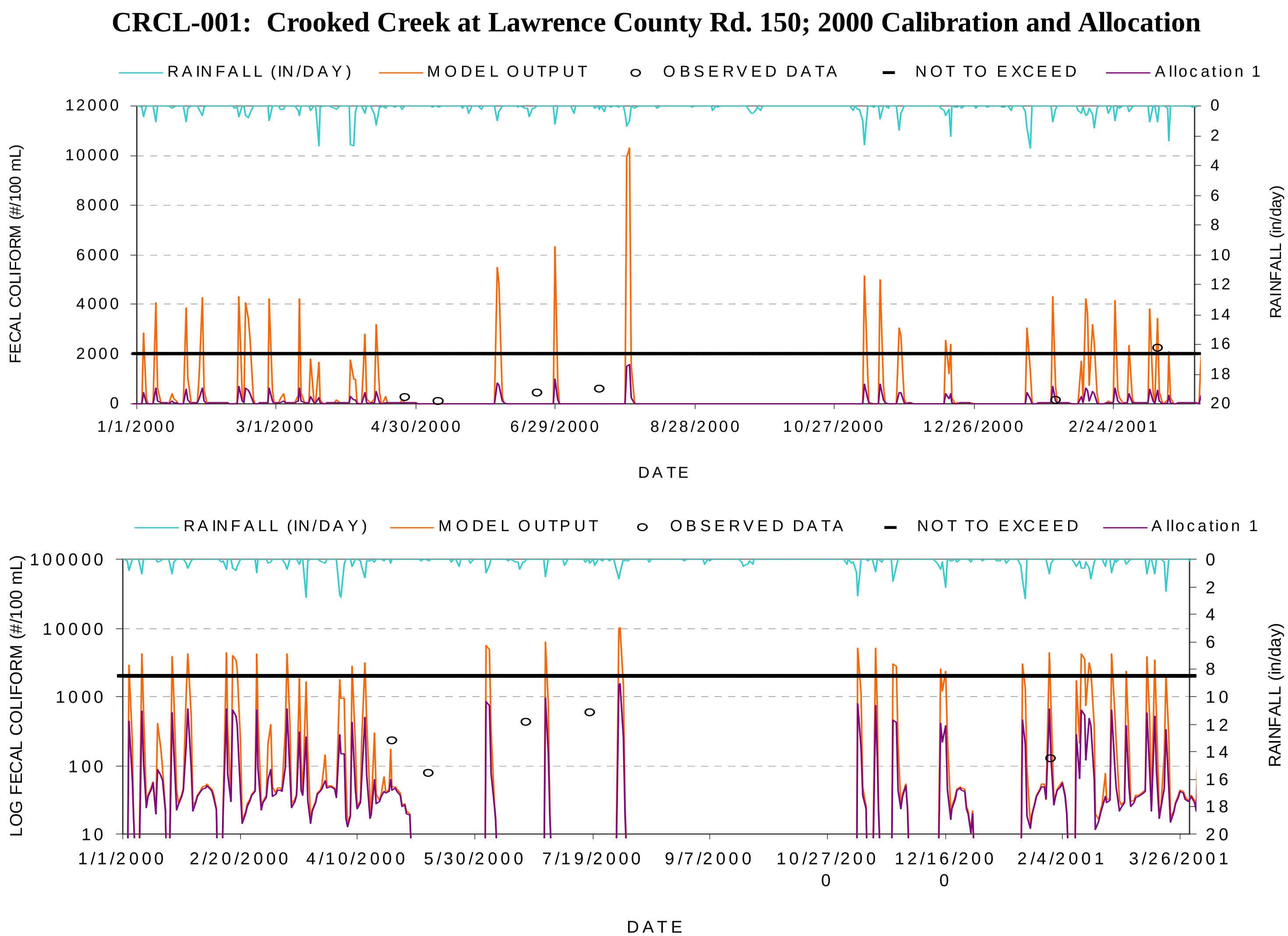


Figure 9-29 CRCL-001: Crooked Creek at Lawrence Co. Rd. 150; Geometric Mean Calculations

Appendix 9.5 - TMDL Allocation Results

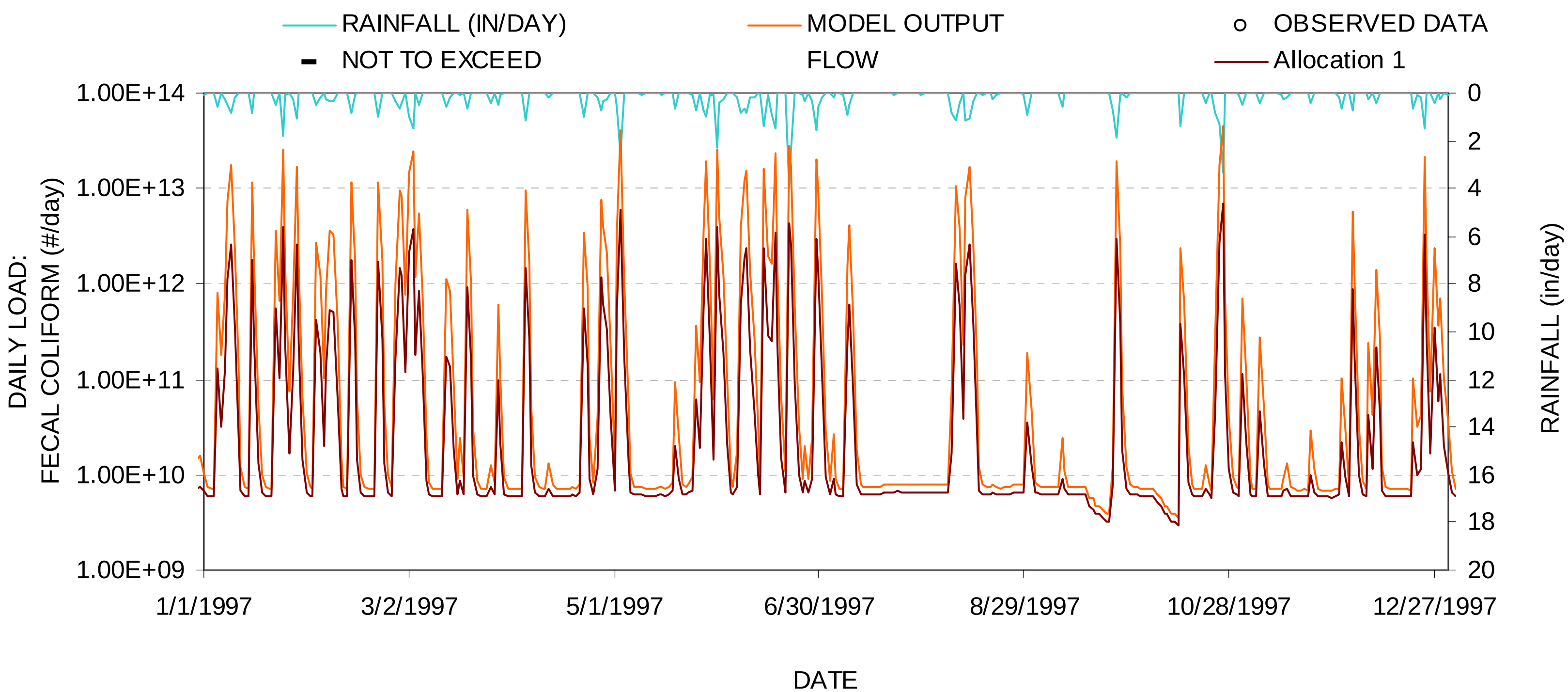


Figure 9-30 TMDL Allocation versus Existing Conditions