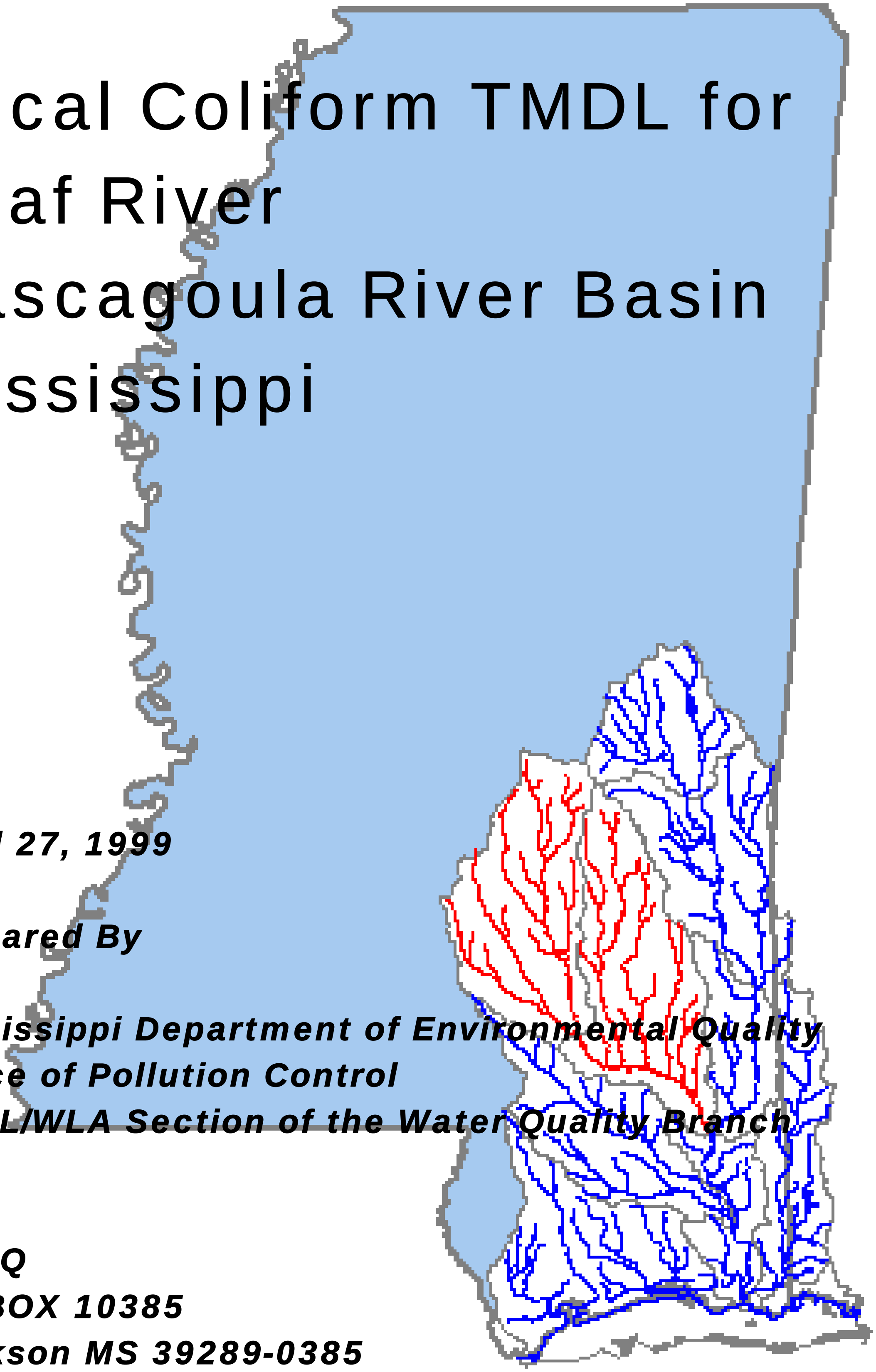

Fecal Coliform TMDL for Leaf River Pascagoula River Basin Mississippi

April 27, 1999

Prepared By

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FOREWORD

This report has been prepared in accordance with the schedule contained within the federal consent decree dated December 22, 1998. The report contains one or more Total Maximum Daily Loads (TMDLs) for waterbody segments found on Mississippi's 1996 Section 303(d) List of Impaired Waterbodies. Because of the accelerated schedule required by the consent decree, many of these TMDLs have been prepared out of sequence with the State's rotating basin approach. The segments addressed are comprised of monitored segments that have data indicating impairment. The implementation of the TMDLs contained herein will be prioritized within Mississippi's rotating basin approach.

The amount and quality of the data on which this report is based are limited. As additional information becomes available, the TMDLs may be updated. Such additional information may include water quality and quantity data, changes in pollutant loadings, or changes in landuse within the watershed. In some cases, additional water quality data may indicate that no impairment exists.

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MONITORED SEGMENT IDENTIFICATION

Name:	Leaf River
Waterbody ID#:	MS086M
Location:	Near Hattiesburg: From Hattiesburg (Hwy 42 & Hwy 11) to confluence of Tallahala Creek
County:	Forrest and Perry Counties, Mississippi
USGS HUC Code:	03170005
NRCS Watershed:	010
Length:	21.5 miles
Use Impairment:	Contact Recreation
Cause Noted:	Pathogens (Fecal Coliform)
Priority Rank:	33
NPDES Permits:	There are 17 NPDES Permits issued for facilities that discharge fecal coliform in the watershed (Table 3.1).
Pollutant Standard:	Geometric mean of 200 per 100 ml, Less than 10% of the samples may exceed 400 per 100 ml.
Waste Load Allocation:	4.59E+12 counts per 30 day critical period (The TMDL requires all dischargers to meet water quality standards for disinfection.)
Load Allocation:	3.82E+13 counts per 30 day critical period
Margin of Safety:	Implicit modeling assumptions - The model was run for an 11 year time span.
Total Maximum Daily Load (TMDL):	4.28E+13 counts per 30 day critical period The TMDL is a combination of the direct input of fecal coliform from NPDES permitted dischargers and nonpoint sources due to cows with access to streams, failing septic tanks, and land surface fecal coliform application rates.

MONITORED SEGMENT IDENTIFICATION

Name:	Leaf River
Waterbody ID#:	MS090M1
Location:	Near New Augusta: From confluence with Tallahala Creek to confluence with Thompsons Creek
County:	Perry and George Counties, Mississippi
USGS HUC Code:	03170005
NRCS Watershed:	050
Length:	18.5 miles
Use Impairment:	Secondary Contact Recreation
Cause Noted:	Pathogens (Fecal Coliform)
Priority Rank:	45
NPDES Permits:	There are 21 NPDES Permits issued for facilities that discharge fecal coliform in the watershed (Table 3.1).
Pollutant Standard:	May through October - Geometric mean of 200 per 100 ml, Less than 10% of the samples may exceed 400 per 100 ml. November through April - Geometric mean of 2000 per 100 ml, Less than 10% of the samples may exceed 4000 per 100 ml.
Waste Load Allocation:	4.77E+12 counts per 30 day critical period (The TMDL requires all dischargers to meet water quality standards for disinfection.)
Load Allocation:	3.91E+13 counts per 30 day critical period
Margin of Safety:	Implicit modeling assumptions - The model was run for an 11 year time span.
Total Maximum Daily Load (TMDL):	4.39E+13 counts per 30 day critical period The TMDL is a combination of the direct input of fecal coliform from NPDES permitted dischargers and nonpoint sources due to cows with access to streams, failing septic tanks, and land surface fecal coliform application rates.

MONITORED SEGMENT IDENTIFICATION

Name:	Leaf River
Waterbody ID#:	MS094M1
Location:	Near McLain: From confluence with Thompsons Creek to mouth of Leaf River at Merrill
County:	George County, Mississippi
USGS HUC Code:	03170005
NRCS Watershed:	090
Length:	29.5 miles
Use Impairment:	Secondary Contact Recreation
Cause Noted:	Pathogens (Fecal Coliform)
Priority Rank:	111
NPDES Permits:	There are 25 NPDES Permits issued for facilities that discharge fecal coliform in the watershed (Table 3.1).
Pollutant Standard:	May through October - Geometric mean of 200 per 100 ml, Less than 10% of the samples may exceed 400 per 100 ml. November through April - Geometric mean of 2000 per 100 ml, Less than 10% of the samples may exceed 4000 per 100 ml.
Waste Load Allocation:	7.86E+12 counts per 30 day critical period (The TMDL requires all dischargers to meet water quality standards for disinfection.
Load Allocation:	4.63E+13 counts per 30 day critical period
Margin of Safety:	Implicit modeling assumptions - The model was run for an 11 year time span.
Total Maximum Daily Load (TMDL):	5.42E+13 counts per 30 day critical period The TMDL is a combination of the direct input of fecal coliform from NPDES permitted dischargers and nonpoint sources due to cows with access to streams, failing septic tanks, and land surface fecal coliform application rates.

EXECUTIVE SUMMARY

Three segments of Leaf River have been placed on the Mississippi 1998 Section 303(d) List of Waterbodies as impaired due to fecal coliform bacteria. The applicable state standard specifies that the maximum allowable fecal coliform count shall not exceed a geometric mean of 200 per 100ml, nor shall more than 10% of the samples examined during any month exceed a colony count of 400 per 100ml. A review of the available monitoring data for the watershed indicates that there is a violation of the standard for the impaired waterbody.

The Leaf River flows approximately 150 miles in a south-eastern direction from its headwaters in southeast Scott County to its confluence with the Pascagoula River in George County. This TMDL has been developed for the three segments of Leaf River found on the 1998 303(d) List. The BASINS Nonpoint Source Model (NPSM) was selected as the modeling framework for performing the TMDL allocations. The weather data used were collected at Leakesville and Meridian. The hydrologic period used for this TMDL was 1985 through 1995.

Fecal coliform loadings from nonpoint sources in the watershed were calculated based upon wildlife populations; numbers of cattle, hogs, and chickens; information on livestock and manure management practices for the Pascagoula Basin; and urban development. The estimated fecal coliform production and accumulation rates due to nonpoint sources for the watershed were incorporated into the model. Also represented in the model were the nonpoint sources such as failing septic systems and cattle which have direct access to tributaries of the Leaf River. There are 25 NPDES permitted dischargers located in the watershed and included as point sources in the model. Under the existing loading conditions, output from the model indicates violation of the fecal coliform standard in the waterbody. After applying a loading scenario with the model, there were no violations of the standard according to the model.

The loading scenario involves a cooperative effort between all fecal coliform contributors in the Leaf River Watershed. Fecal coliform contributors include both point and nonpoint sources. First, all NPDES facilities will be required to treat their discharge so that the fecal coliform concentrations do not exceed water quality standards at the end of the pipe. Careful monitoring of all permitted facilities in the Leaf River Watershed should be continued to ensure that compliance with permit limits is consistently attained. Second, a 88% reduction in nonpoint source contributions may be required. Best management practices are a vital part of achieving this goal.

The model accounted for seasonal variations in hydrology, climatic conditions, and watershed activities. The use of the continuous simulation model allowed for consideration of the seasonal aspects of rainfall and temperature patterns within the watershed. Calculation of the fecal coliform accumulation parameters and source contributions on a monthly basis accounted for seasonal variations in watershed activities such as livestock grazing and land application of manure.

1.0 INTRODUCTION

1.1 Background

The identification of waterbodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those waterbodies are required by Section 303(d) of the Clean Water Act and the Environmental Protection Agency=s (EPA) Water Quality Planning and Management Regulations (40 CFR part 130). The TMDL process is designed to restore and maintain the quality of those impaired waterbodies through the establishment of pollutant specific allowable loads. The pollutant of concern for this TMDL is fecal coliform. Fecal coliform bacteria are used as indicator organisms. They are readily identifiable and indicate the possible presence of other pathogenic organisms in the waterbody. The TMDL process can be used to establish water quality based controls to reduce pollution from both point and nonpoint sources, and it can be used to restore and maintain the quality of water resources.

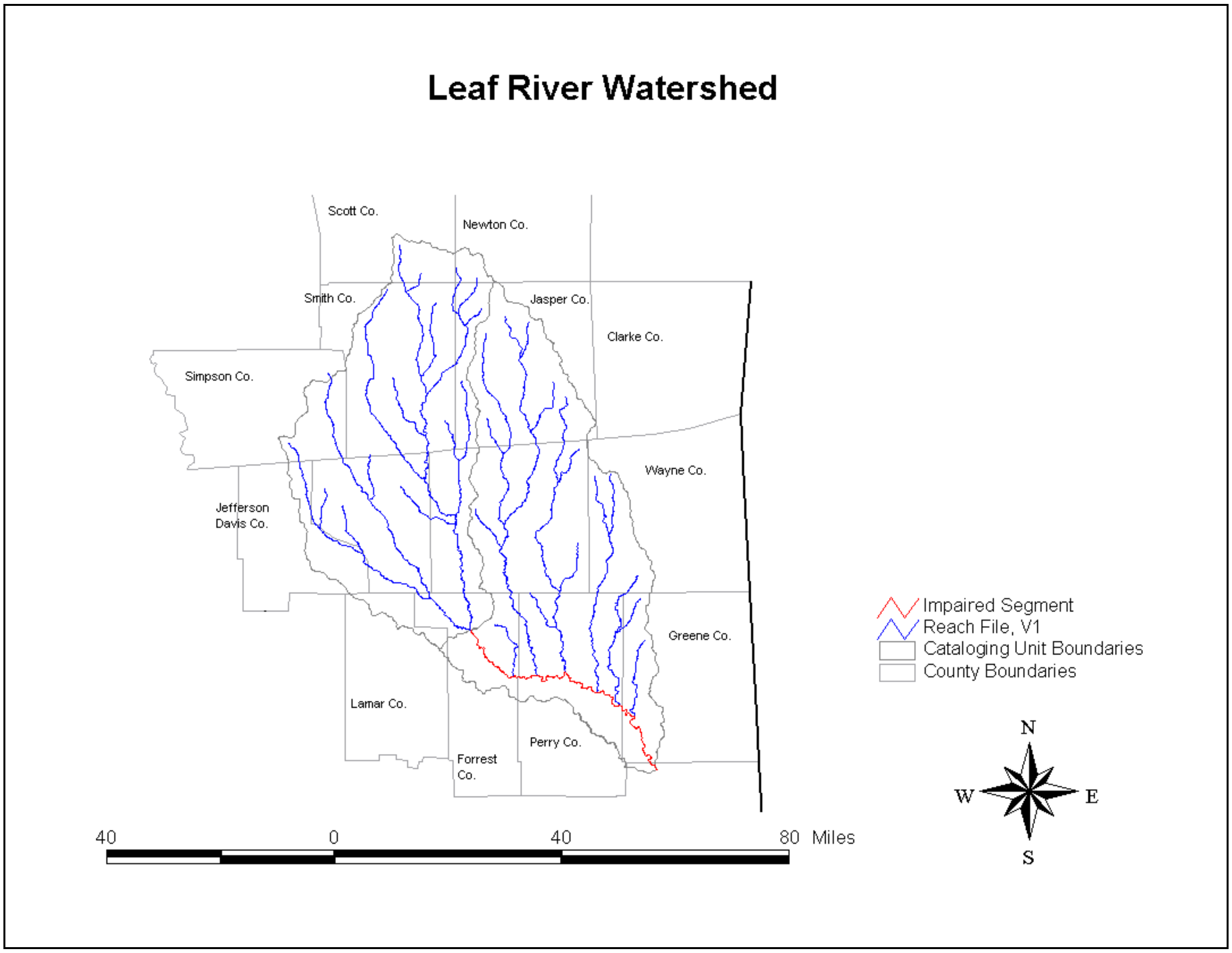
The Mississippi Department of Environmental Quality (MDEQ) has identified three segments of the Leaf River as being impaired by fecal coliform bacteria for a total length of 69.5 miles as reported in the 1998 Section 303(d) List of Waterbodies. The impaired segments begin near Hattiesburg and extend to the mouth of the Leaf River at the confluence with the Pascagoula River. The Leaf River segment MS086M is ranked 33rd, MS090M1 is ranked 45th, and MS094M1 is ranked 111th on the 1998 Section 303(d) List of Waterbodies. The monitored sections are shown in Figure 1.1a.

The impaired segments of Leaf River lie within the Pascagoula River Basin Hydrologic Unit Code (HUC) 03170005 in southeastern Mississippi. The Leaf River Watershed, HUCs 03170004 and 03170005, is in Covington and Jones Counties and portions of Clarke, Forrest, George, Greene, Jasper, Lamar, Newton, Perry, Scott, Simpson, Smith, and Wayne Counties. HUC 03170005 also includes a portion of the DeSoto National Forest. The Leaf River Watershed includes Hattiesburg, and several small urban areas including McLain, New Augusta, and Petal. Forest is the dominant landuse within the watershed. The land area of the Leaf River Watershed is approximately 2.27 million acres. The land distribution is shown in Table 1.1 and Figure 1.1b.

Table 1.1 Land Distribution in Acres for the Leaf River Watershed

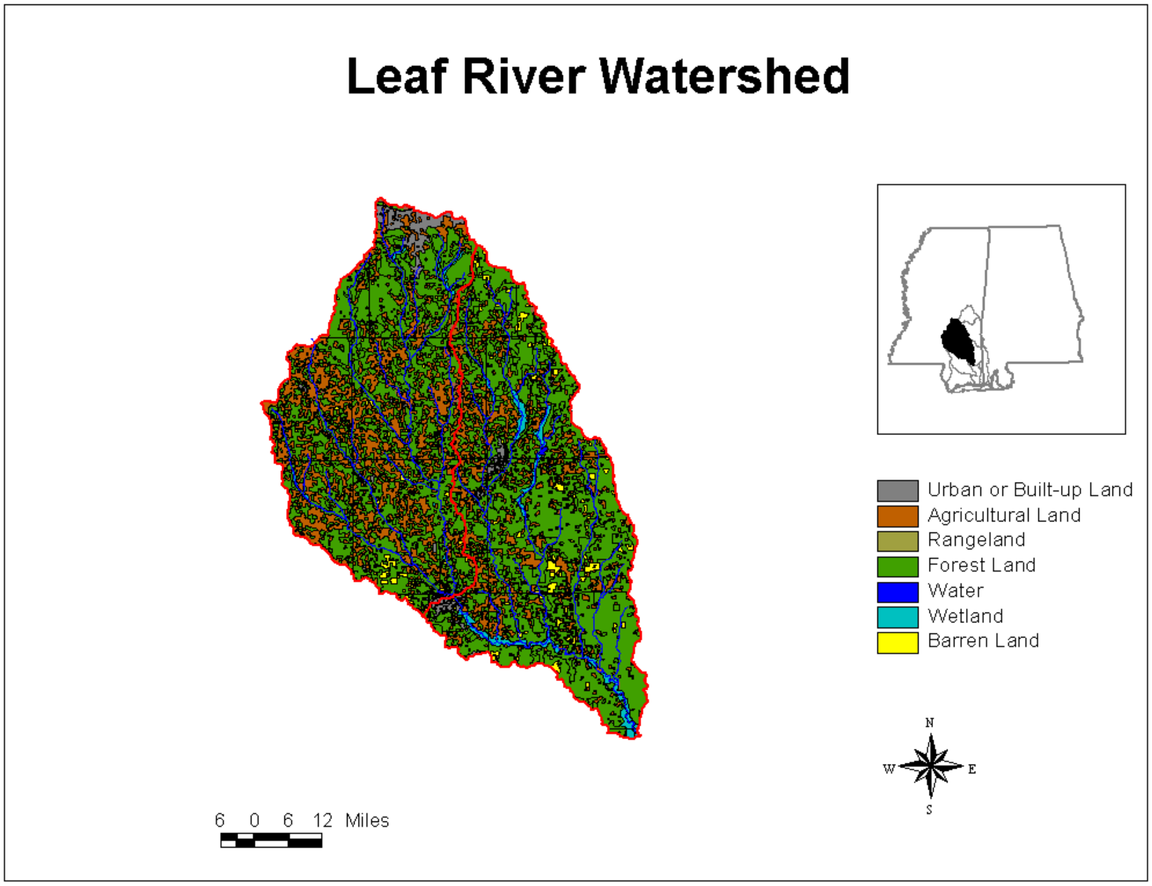
	Urban	Forest	Cropland	Pasture	Barren	Wetlands	Total
Area (Acres)	26,050	1,563,197	57,097	503,812	10,085	109,024	2,269,264
% Area	1.2%	68.9%	2.5%	22.2%	0.4%	4.8%	

Figure 1.1a Leaf River Watershed Impaired Segments



The drainage area, or watershed, has been divided into 64 subwatersheds based on the major tributaries and topography. Bowie Creek (MS084M), Okatoma Creek (MS080O2M) and Tallahala Creek (MS089M2) are impaired major tributaries within the Leaf River watershed. These waterbodies have been modeled separately and input into the Leaf model as point sources. Another major tributary of the Leaf River, Bogue Homo, while not impaired, was also modeled separately and input into the Leaf model as a point source. The remaining area of the watershed was divided into 37 separate subwatersheds. Figure 1.1c shows the subwatersheds with a three digit Reach File 1 segment identification number. Each subwatershed is assigned a corresponding identification number, which is a combination of the eight digit HUC and the three digit Reach File 1 segment identification number. The most downstream impaired waterbody, MS094M1is made up of segments, using HUC and Reach File 1 identification numbers, 03170005001, 03170005003, and 03170005007 and is impacted by all of HUC 03170004 and HUC 03170005. MS090M1 is made up of segments 03170005011 and 03170005019; and MS086M is made up of segments 03170005031 and 03170005033.

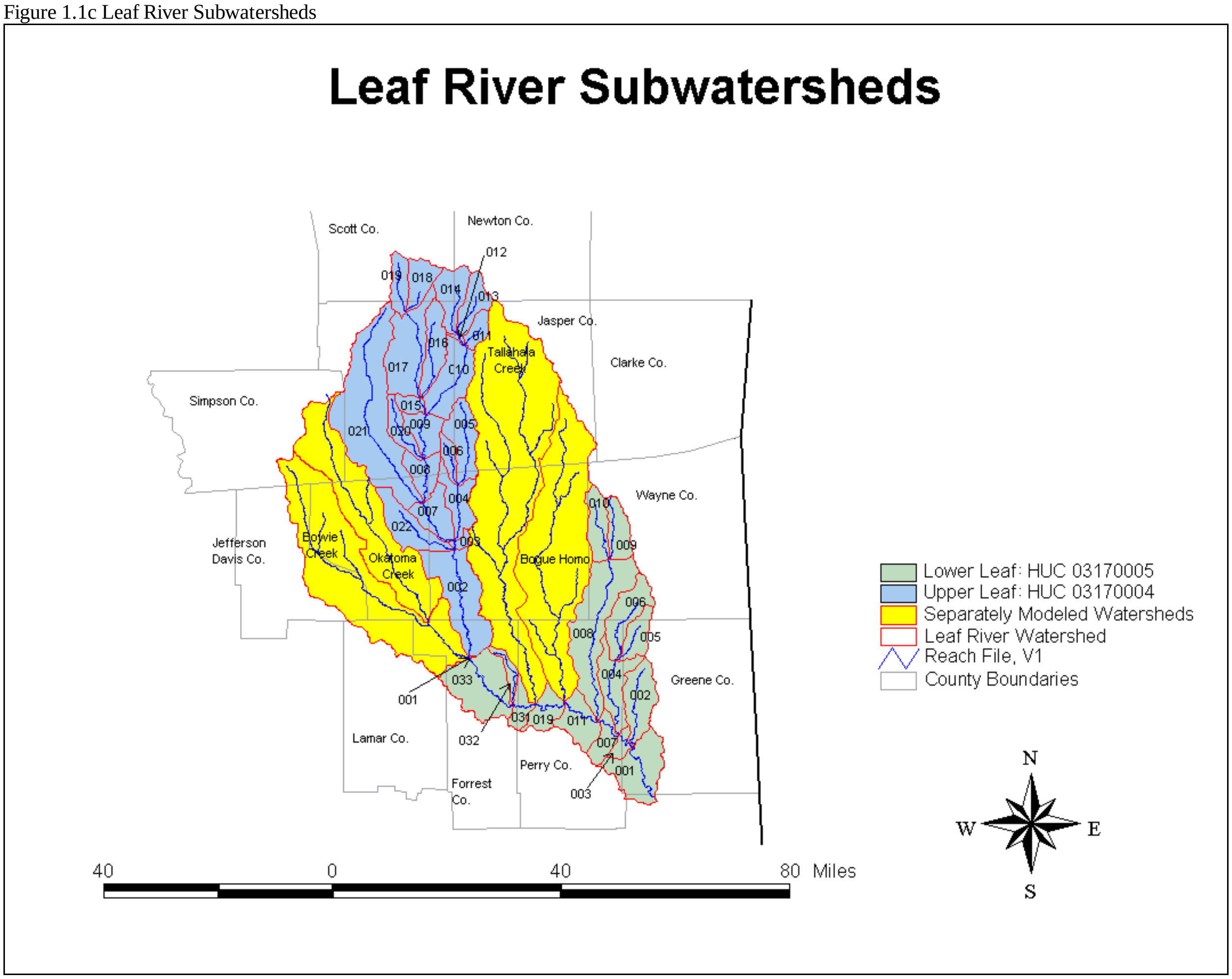
Figure 1.1b Leaf River Watershed Landuse



1.2 Applicable Water Body Segment Use

Designated beneficial uses and water quality standards are established by the *State of Mississippi Water Quality Criteria for Intrastate, Interstate and Coastal Waters* regulations. The designated uses for Leaf River segment MS086M as defined by the regulations are Contact Recreation and Fish and Wildlife Support. The designated uses for Leaf River segments MS090M1 and MS094M1 as defined by the regulations are Aquatic Life Support and Secondary Contact Recreation. Secondary Contact Recreation is defined as incidental contact with the water, including wading and occasional swimming.

Figure 1.1c Leaf River Subwatersheds



1.3 Applicable Waterbody Segment Standard

The water quality standard applicable to Contact Recreation and the pollutant of concern is defined in the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters.* The standard states that the fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10 percent of the samples examined during any month exceed a colony count of 400 per 100 ml. The water quality standard applicable to Secondary Contact Recreation and the pollutant of concern is defined in the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. The standard states that from May through October the fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10 percent of the samples examined during any month exceed a colony count of 400 per 100 ml, and that from November through April the fecal coliform colony counts shall not exceed a geometric mean of 2000 per 100 ml, nor shall more than 10 percent of the samples examined during any month exceed a colony count of 4000 per 100 ml. This water quality standard will be used as targeted endpoints to evaluate impairments and establish this TMDL.

2.0 TMDL ENDPOINT AND WATER QUALITY ASSESSMENT

2.1 Selection of a TMDL Endpoint and Critical Condition

One of the major components of a TMDL is the establishment of instream numeric endpoints, which are used to evaluate the attainment of acceptable water quality. Instream numeric endpoints, therefore, represent the water quality goals that are to be achieved by implementing the load and waste load reductions specified in the TMDL. The endpoints allow for a comparison between observed instream conditions and conditions that are expected to restore designated uses. The instream fecal coliform target for this TMDL is a 30-day geometric mean of 200 counts per 100 ml.

Because fecal coliform may be attributed to both nonpoint and point sources, the critical condition used for the modeling and evaluation of stream response was represented by a multi-year period. Critical conditions for waters impaired by nonpoint sources generally occur during periods of wet-weather and high surface runoff. But, critical conditions for point source dominated systems generally occur during low-flow, low-dilution conditions. The 1985-1995 period represents both low flow conditions as well as wet-weather conditions and encompasses a range of wet and dry seasons. Therefore, the 11-year period was selected as representing critical conditions associated with all potential sources of fecal coliform bacteria within the watershed.

2.2 Discussion of Instream Water Quality

Water quality data available for the monitored segment of Leaf River show that the stream is frequently impaired by high levels of fecal coliform bacteria. There are 6 ambient stations located within the impaired waterbody segments operated by MDEQ which collected fecal coliform monitoring data during the 11 year modeling period. Monitoring for flow and fecal coliform was performed on a monthly basis at six of these stations. The data indicate that high instream fecal coliform concentrations occurred during both periods of high flow and dry, low-flow conditions.

2.2.1 Inventory of Available Water Quality Monitoring Data

The State=s 1998 Section 305(b) Water Quality Assessment Report was reviewed to assess water quality conditions and data available for the watershed. According to the report, Leaf River, MS086M, is not supporting the use of secondary contact recreation; Leaf River, MS090M1, is not supporting the use of secondary contact recreation; and Leaf River, MS094M1, is partially supporting the use of secondary contact recreation. These conclusions were based on instantaneous data collected at six stations. An inventory of these six stations is shown in Table 2.2a.

Table 2.2a MDEQ Water Quality Stations

Station ID	Location	# of Samples	Monitoring Frequency	Period of Record Examined	Waterbody ID
2473260	near Palmer at Sims Bridge	21	monthly	10/1991 - 6/1993	MS086M
2474560	at Hwy 29 near New Augusta	21	monthly	10/1991 - 6/1993	MS090M1
2474680	at Wingate Bridge near Beaumont	21	monthly	10/1991 - 6/1993	MS090M1
2474740	at Beaumont	21	monthly	10/1991 - 6/1993	MS090M1
2475000	near McLain at old Hwy 98	21	monthly	10/1991 - 6/1993	MS094M1
2475082	at Merrill	21	monthly	10/1991 - 6/1993	MS094M1

2.2.2 Analysis of Instream Water Quality Monitoring Data

Statistical summaries of the water quality data are presented in Table 2.2.2. The summer standard percent exceedance is the number of summer samples that exceeded the summer instantaneous limit of 400 counts/100 ml divided by the total number of summer samples. The winter standard percent exceedance is the number of winter samples that exceeded the winter instantaneous limit of 4000 counts/100 ml divided by the total number of winter samples. The percent exceedance does not represent the amount of time that the water quality is in exceedance. In the case of station 2473260, which is located in a contact recreation waterbody, the year round instantaneous limit is 400 counts/100 ml. Therefore, the winter analysis is not valid for this station.

Table 2.2b. Statistical Summary of Water Quality Data

Station ID	Min	Max	Mean	Median	Summer Standard Exceedances		Winter Standard Exceedances	
					Number	Percent	Number	Percent
2473260	19	5600	1161	350	10	48%	na	na
2474560	20	5000	963	340	4	44%	1	8%
2474680	110	28000	3267	640	5	63%	0	0%
2474740	90	19000	2039	475	5	63%	1	8%
2475000	20	2400	559	340	3	38%	0	0%
2475082	50	2400	655	390	4	50%	0	0%

3.0 SOURCE ASSESSMENT

The TMDL evaluation summarized in this report examined all known potential sources of fecal coliform in the Leaf River Watershed. The source assessment was used as the basis of development for the model and ultimate analysis of the TMDL allocation options. The sources were analyzed according to the 37 separate subwatersheds. The subwatershed delineations were based primarily on an analysis of the Reach File 3 (RF3) stream network and the digital elevation model of the watershed. In evaluation of the sources, loads are characterized by the best available information, monitoring data, literature values, and local management activities. This section documents the available information and interpretation for the analysis. The representation of the following sources in the model is discussed in Section 4.0, Modeling Procedure: Linking the Sources to the Endpoint.

3.1 Assessment of Point Sources

Point sources of fecal coliform bacteria have their greatest potential impact on water quality during periods of low flow. Thus, a careful evaluation of point sources that discharge fecal coliform bacteria was necessary in order to quantify the degree of impairment present during the low flow, critical condition period. The 25 point sources in the Leaf River Watershed serve a variety of activities including residential subdivisions, schools, recreational areas, and other businesses. The majority of the 25 wastewater treatment plants serve residential subdivisions.

Once the permitted dischargers were located, the effluent from each source was characterized based on all available monitoring data including permit limits, discharge monitoring reports, and information on treatment types. Discharge monitoring reports (DMRs) were the best data source for characterizing effluent because they report measurements of flow and fecal coliform present in effluent samples. Of the facilities for which they were available, the DMRs for the past five years, 1993 through 1998, were analyzed. When data were available, the fecal coliform concentrations used in the model were calculated by taking an average of fecal coliform concentrations reported in the discharge monitoring reports. When data were not available, the fecal coliform concentrations used in the model were determined using permit limits or best professional judgement. If evidence of insufficient treatment existed, best professional judgement was used to estimate a fecal coliform loading rate in the model. The permit limits of each facility included in the model are given in Table 3.1.

3.2 Assessment of Nonpoint Sources

There are many potential nonpoint sources of fecal coliform bacteria for Leaf River, including:

$ Failing septic systems
$ Wildlife
$ Land application of hog and cattle manure
$ Land application of poultry litter
$ Cattle contributions directly deposited instream
$ Grazing animals
$ Urban development

The 1.17 million acre drainage area included in the model contains many different landuse types, including urban, forest, cropland, pasture, barren, and wetlands. The landuse information is based on data collected by the State of Mississippi=s Automated Information System (MARIS), 1997. This data set is based on Landsat Thematic Mapper digital images taken between 1992 and 1993. The MARIS data are classified on a modified Anderson level one and two system with additional level two wetland classifications. However, for modeling purposes the landuse categories were grouped into the landuses of urban, forest, cropland, pasture, barren, and wetlands. The contributions of each of these land types to the fecal coliform loading of Leaf River was considered on a subwatershed basis. Table 3.2 shows the landuse distribution within each subwatershed in number of acres.

Table 3.1. Inventory of Point Source Dischargers

NPDES #	Facility Name	Receiving Waterbody	Sub-watershed	Permit Limits	
				Summer	Winter
MS0031542	Hattiesburg Regional Airport	tributary of Leaf River	3170004002	200	200
MS0031259	Moselle Elementary School	Leaf River	3170004002	200	200
MS0046302	Southern Hens Incorporated	Leaf River	3170004002	200	200
MS0038792	Lakewood Estates S/D	Big Creek	3170004004	200	200
MS0027685	Bay Springs POTW	Etehomo Creek	3170004005	200	2000
MS0037672	Polk's Meat Products	Roaring Creek	3170004005	200	200
MS0020401	USDA Marathon Lake Rec Area	Ichusa Creek	3170004016	200	200
MS0025038	Taylorsville POTW	Fisher Creek	3170004020	200	5300
MS0038521	Prospect Trailer Park	Bear Branch	3170005002	200	200
MS0024996	MS/Camp Shelby - Act Sludge	Weldy Creek	3170005007	200	200
MS0024686	Richton POTW	Thompson Creek	3170005008	200	14800
MS0037478	Prospect Processing Plant	Bear Creek	3170005009	200	200
MS0020869	Beaumont POTW	Carter Creek	3170005011	200	7300
MS0038636	Perry Central School	Coleman Creek	3170005011	200	200
MS0039373	Big Oak Trailer Park	Leaf River	3170005011	200	200
MS0047503	Hood Industries Incorporated	Leaf River	3170005011	200	2000
MS0031771	Petal Sherwood Forest	Reese Creek	3170005032	200	200
MS0030201	North Forrest Attendance Ctr	tributary of Leaf River	3170005033	200	200
MS0053449	Deerfield Estates Utility	Leaf River	3170005033	200	200
MS0029131	Glendale Utility Lagoon	Leaf River	3170005033	200	200
MS0030601	Happy Acres Packing Co. Inc.	Leaf River	3170005033	200	200
MS0020303	Hattiesburg - South Lagoon	Leaf River	3170005033	200	23750
MS0042994	Trailwood Subdivision	Lott's Creek	3170005033	200	200
MS0043516	Dixie Attendance Center	Myers Creek	3170005033	200	200
MS0051233	Homestead Subdivision	Priests Creek	3170005033	200	200

Table 3.2. Landuse Distribution in Number of Acres

Subwatershed	Urban	Forest	Cropland	Pasture	Barren	Wetlands	Total
03170004001	106	10	0	8	50	14	189
03170004002	1,255	39,605	2,300	19,247	309	11,854	74,569
03170004003	0	2,233	98	1,061	0	844	4,237
03170004004	38	16,146	918	8,099	37	1,923	27,161
03170004005	206	23,902	977	10,232	83	212	35,612
03170004006	0	7,124	412	2,948	6	15	10,505
03170004007	0	11,986	853	7,645	69	6,173	26,725
03170004008	238	11,830	785	4,042	148	3,976	21,019
03170004009	0	13,731	747	5,386	20	4,010	23,894
03170004010	47	27,918	1,228	9,876	60	6,458	45,586
03170004011	0	6,950	713	2,220	40	2,018	11,941
03170004012	0	755	97	205	3	783	1,844
03170004013	0	12,346	434	3,894	31	5,453	22,157
03170004014	0	17,666	2,129	4,235	48	4,913	28,992
03170004015	0	5,282	169	2,270	7	1,340	9,067
03170004016	0	24,692	381	6,092	20	222	31,406
03170004017	36	43,272	884	9,970	92	6,791	61,046
03170004018	273	16,396	275	3,511	17	789	21,261
03170004019	240	14,405	213	3,045	64	121	18,087
03170004020	0	10,951	682	5,506	63	360	17,562
03170004021	65	116,970	3,958	33,569	175	1,204	155,941
03170004022	0	24,256	2,074	11,455	56	143	37,984
03170005001	537	31,753	24	6,011	444	12,560	51,329
03170005002	0	28,664	14	9,214	0	39	37,932
03170005003	419	5,036	0	1,732	22	1,075	8,284
03170005004	0	28,540	126	7,514	10	101	36,290
03170005005	0	14,075	0	5,657	6	0	19,739
03170005006	0	28,934	0	6,316	8	0	35,257
03170005007	186	11,335	0	2,866	129	2,121	16,637
03170005008	255	78,531	666	14,028	468	1,501	95,449
03170005009	0	17,901	639	5,286	15	78	23,918
03170005010	0	17,712	649	5,387	95	132	23,975
03170005011	859	19,832	106	3,572	362	4,031	28,763
03170005019	302	13,257	724	2,078	524	3,009	19,894
03170005031	155	8,469	638	2,226	219	1,958	13,665
03170005032	0	5,576	1,042	2,825	66	168	9,677
03170005033	6,786	34,644	2,446	10,888	1,640	7,018	63,423
All Watersheds	**12,003**	**792,685**	**27,401**	**240,116**	**5,406**	**93,407**	**1,171,017**

The nonpoint fecal coliform contribution from each landuse was estimated using the latest information available. Population and agricultural census data were extracted from the MARIS landuse data for Mississippi. MDEQ contacted several agencies to refine the assumptions made in determining the fecal coliform loading. The Mississippi Department of Wildlife, Fisheries, and Parks provided information of wildlife density in the Leaf River Watershed. The Mississippi State Department of Health was contacted regarding the failure rate of septic tank systems in this portion of the state. Mississippi State University researchers provided information on manure application practices and loading rates for hog farms and cattle operations. The Natural Resources Conservation Service also gave MDEQ information on manure treatment practices and land application of manure.

3.2.1 Failing Septic Systems

Septic systems have a potential to deliver fecal coliform bacteria loads to surface waters due to malfunctions, failures, and direct pipe discharges. Properly operating septic systems treat wastewater and dispose of the water through a series of underground field lines. The water is applied through these lines into a rock substrate, thence into underground absorption. The systems can fail when the field lines are broken, or the underground substrate is clogged or flooded. A failing septic system's discharge can reach the surface, where it becomes available for wash-off into the stream. Another potential problem is a direct bypass from the system to a stream.

Another consideration is the use of individual onsite wastewater treatment plants. These treatment systems are in wide use in Mississippi. They can adequately treat wastewater when properly maintained. However, these systems may not receive the maintenance needed for proper, long-term operation. These systems require some disinfection to properly operate. When this expense is ignored, the water does not receive adequate disinfection prior to release.

3.2.2 Wildlife

Wildlife present in the Leaf River Watershed contribute to fecal coliform bacteria on the land surface. In the Leaf River model, all wildlife was accounted for by considering contributions from deer. Estimates of deer population were designed to account for the deer combined with all of the other wildlife present in the area. It was assumed that the wildlife population remained constant throughout the year, and that wildlife were present on all land classified as pastureland, cropland, and forest. It was also assumed that the wildlife and the manure produced by the wildlife were evenly distributed throughout these land types.

3.2.3 Land Application of Hog and Cattle Manure

In the Pascagoula Basin, processed manure from confined hog and dairy cattle operations is collected in lagoons and routinely applied to pastureland during April through October. This manure is a potential contributor of bacteria to receiving waterbodies due to runoff produced during a rain event. Hog farms in the Pascagoula Basin operate by either keeping the animals confined by or allowing hogs to graze in a small pasture or pen. For this model, it was assumed that all of the hog manure produced by either farming method was applied evenly to the available pastureland. Application rates of hog manure to pastureland from confined operations varied monthly according to management practices currently used in this area.

The dairy farms that are currently operating in the Leaf River Watershed only confine the animals for a limited time during the day. The model assumed a confinement time of four hours per day, during which time the cattle are milked and fed. During all other times, dairy cattle are allowed to graze on pasturelands. The manure collected during confinement is applied to the available pastureland in the watershed. Like the hog farms, application rates of dairy cow manure to pastureland vary monthly according to management practices currently used in this area and permit regulations.

3.2.4 Grazing Beef and Dairy Cattle

Grazing cattle deposit manure and, therefore, fecal coliform bacteria on pastureland, where it is available for wash-off and delivery to receiving waterbodies. Beef cattle have access to pastureland for grazing all of the time. However, dairy cattle spend four hours per day confined in milking barns, and the remainder of their time grazing on pastureland. Manure produced by grazing beef and dairy cows is directly deposited onto pastureland.

3.2.5 Land Application of Poultry Litter

There is a considerable number of chickens produced in the Leaf River Watershed as estimated by the 1997 Census of Agriculture. In this area, poultry farming operations use houses in which chickens are confined all of the time. The manure produced by the chickens is collected in litter on the floor of the chicken houses. This litter is routinely applied as a fertilizer to pastureland in the watershed. Application rates of the litter vary monthly.

Two kinds of chickens are raised on farms in the Pascagoula Basin, broilers and layers. For the broiler chickens, the amount of growth time from when the chicken is born to when it is sold off the farm is approximately 48 days or 1.6 months. Layer chickens remain on farms for 10 months or longer. More than 93% of the chickens raised in this area are broilers. For the model, a weighted average of growth time was determined to account for both types of chickens. An average growth time of 52 days, or 1/7 of a year, was used. To determine the number of chickens on farms on any given day, the yearly population of chickens sold was divided by 7.

3.2.6 Cattle Contributions Directly Deposited Instream

Cattle often have direct access to flowing and intermittent streams which run through fenced pastureland. These small streams are tributaries of larger streams. Fecal coliform bacteria deposited in these streams by grazing cattle are considered a direct input of bacteria to the stream. Due to the general topography in the Leaf River Watershed, it was assumed that all land slopes in the watershed are such that cattle are able to access the intermittent streams in all pastures. In order to determine the amount of bacteria introduced into streams from cattle, it was assumed that all grazing cattle spent five percent of their time standing in the streams. Thus, the model assumes that five percent of the manure produced by grazing beef and dairy cows is deposited directly in the stream.

3.2.7 Urban Development

Urban areas include land classified as urban and barren. Even though only 1.2% of the Leaf River Watershed is urban and barren, the contribution of the urban areas to fecal coliform loading in Leaf River was considered. The Leaf River Watershed includes Hattiesburg, and several small urban areas including McLain, New Augusta, and Petal. Fecal coliform contributions from urban areas may come from storm water runoff through stormwater sewers (e.g. residential, commercial, industrial, road transportation), illicit discharges of sanitary wastes, and runoff contribution from improper disposal of waste materials.

4.0 MODELING PROCEDURE: LINKING THE SOURCES TO THE ENDPOINT

Establishing the relationship between the instream water quality target and the source loadings is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired source load reductions. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses to flow and loading conditions. In this section, the selection of the modeling tools, setup, and model application are discussed.

4.1 Modeling Framework Selection

The BASINS model platform and the NPSM model were used to predict the significance of fecal coliform sources to fecal coliform levels in the Leaf River Watershed. BASINS is a multipurpose environmental analysis system for use in performing watershed and water quality-based studies. A geographic information system (GIS) provides the integrating framework for BASINS and allows for the display and analysis of a wide variety of landscape information such as landuses, monitoring stations, point source discharges, and stream descriptions. The NPSM model simulates nonpoint source runoff from selected watersheds, as well as the transport and flow of the pollutants through stream reaches. A key reason for using BASINS as the modeling framework is its ability to integrate both point and nonpoint sources in the simulation, as well as its ability to assess instream water quality response.

4.2 Model Setup

The Leaf River TMDL model includes the impaired sections of the river. Bowie Creek (MS084M), Okatoma Creek (MS080O2M), Tallahala Creek (MS089M2), and Bogue Homo, major tributaries of Leaf River, were modeled separately and added to the Leaf River model. These point source inputs allow the model to assess Bowie Creek, Okatoma Creek, Tallahala Creek, and Bogue Homo's contribution to the hydrology and fecal coliform loading in the lower reaches of Leaf River. These point source inputs of Bowie Creek, Okatoma Creek, Tallahala Creek, and Bogue Homo were added to the model with both the modeled existing loading conditions and after the loading scenario was modeled. Table 4.2 gives the fecal coliform load reduction scenarios for these inputs. Thus, all upstream contributors of bacteria are accounted for in the model. The remaining watershed was divided into 37 subwatersheds in an effort to isolate the major stream reaches in the Leaf River Watershed. This subdivision allowed the relative contribution of point and nonpoint sources to be addressed within each subwatershed.

Table 4.2 Loading Scenarios for Separately Modeled Tributaries of the Leaf River (percent reduction)

	NPDES Permitted Facilities	Cattle Access	Failing Septic Tanks
Bowie Creek	meet water quality standards	75%	50%
Okatoma Creek	meet water quality standards	75%	50%
Tallahala Creek	meet water quality standards	90%	50%
***Bogue Homo**	meet water quality standards	90%	50%

*****A separate TMDL report was not done for this tributary

4.3 Source Representation

Both point and nonpoint sources were represented in the model. Due to die-off rates and overland transportation assumptions, the fecal coliform loadings from point and nonpoint sources must be addressed separately. A fecal coliform spreadsheet was developed for quantifying point and nonpoint sources of bacteria for the Leaf River model. This spreadsheet calculates the model inputs for fecal coliform loading due to point and nonpoint sources using assumptions about land management, septic systems, farming practices, and permitted point source contributions. Each of the potential bacteria sources is covered in the fecal coliform spreadsheet.

The discharge from point sources was added as a direct input into the appropriate reach of the waterbody. There are 25 NPDES permitted facilities in the watershed which discharge fecal coliform bacteria. Fecal coliform loading rates for point sources are input to the model as flow in cubic feet per second and fecal coliform contribution in counts per hour.

The nonpoint sources are represented in the model with two different methods. The first of these methods is a direct fecal coliform loading to Leaf River. Other sources are represented as an application rate to the land in the Leaf River Watershed. For these sources, fecal coliform accumulation rates in counts per acre per day were calculated for each subwatershed on a monthly basis and input to the model for each landuse. Fecal coliform contributions from forests and wetlands were considered to be equal. Urban and barren areas were also considered to produce equal loads. The fecal coliform accumulation rate for pastureland is the sum of accumulation rates due to litter application, wildlife, processed manure, and grazing animals. For cropland in this area it is only due to wildlife. Accumulation rates for pastureland are calculated on a monthly basis to account for seasonal variations in manure and litter application.

4.3.1 Failing Septic Systems

Discharges from failing septic systems were quantified based on several factors including the estimated population served by the septic systems, an average daily discharge of 100 gallons per person per day, and a septic system effluent fecal coliform concentration of 10,000 counts per 100 ml.

4.3.2 Wildlife

Based on information provided by the Mississippi Department of Wildlife, Fisheries, and Parks, the deer population throughout the Leaf River Watershed was estimated to be 30 to 45 animals per square mile. For the model, the upper limit of 45 deer per square mile was used to account for the deer and all other wildlife contributing to fecal coliform accumulation in the area. The wildlife contribution in counts per acre per day is calculated by multiplying a loading rate by the number of animals. The loading rate used in the model was estimated to be 5.00E+08 counts per day per animal. The per acre loading rate applied to the landuses is 3.52E+07 counts/acre/day.

4.3.3 Land Application of Hog and Cattle Manure

The fecal coliform spreadsheet was used to estimate the amount of waste and the concentration of fecal coliform bacteria contained in hog and dairy cattle manure produced by confined animal feeding operations. The livestock count per county is based upon the 1997 Census of Agriculture data. The county livestock count is used to estimate the number of livestock on a subwatershed scale. This is calculated by multiplying the county livestock figures with the area of the county within the subwatershed boundaries. This estimate is made with the assumption that the livestock are uniformly distributed throughout the county. A fecal coliform production rate in counts per day per animals was multiplied by the number of confined animals to quantify the amount of bacteria produced. The manure produced by these operations is collected in lagoons and applied evenly to all pastureland. Manure application rates to pastureland vary on a monthly basis. This monthly variation is incorporated into the model by using monthly loading rates.

4.3.4 Grazing Beef and Dairy Cattle

It is assumed that the manure produced by grazing beef and dairy cattle is evenly spread on pastureland throughout the year. The fecal coliform content of manure produced by grazing cattle is estimated by multiplying the number of grazing cattle by a fecal coliform production of 5.40E+09 counts per day per animal (Metcalf and Eddy, 1991). The resulting fecal coliform loads are in the units of counts per acre per day.

4.3.5 Land Application of Poultry Litter

The fecal coliform spreadsheet estimates the concentration of bacteria which accumulates in the dry litter where poultry waste is collected. This is done by multiplying the daily number of chickens on farms by a fecal coliform production rate in counts per day per animal given in Metcalf & Eddy, 1991. The model assumed a watershed area normalized chicken population. The chicken population was determined from the 1997 Census of Agriculture Data for the number of chickens sold from each county per year. Litter application to pastureland varies monthly, and is modeled with a monthly loading rate.

4.3.6 Cattle Contributions Deposited Directly Instream

The contribution of fecal coliform from cattle to a stream is represented as a direct input into the stream by the model. In order to estimate the point source loading produced by grazing beef and dairy cattle with access to streams, it is assumed that three percent of the number of grazing cattle in each subwatershed are standing in a stream at any given time. When cattle are standing in a stream, their fecal coliform production is estimated as flow in cubic feet per second and a concentration in counts per hour. The fecal coliform concentration is calculated using the number of cows in the stream and a bacteria production rate of 5.40E+09 counts per animal per day (Metcalf and Eddy, 1991).

4.3.7 Urban Development

The MARIS landuse data divide urban land into several categories. For the Leaf River Watershed, the urban land is divided into three different categories, high density, low density, and transportation. For the model, fecal coliform buildup rates for each category were determined by using literature values from Horner, 1992. The literature value accounts for all of the potential fecal coliform sources in each urban category. It is assumed that 16% of all urban land is high density, 45% is low density, and 39% is transportation. The fecal coliform production rate for each of these subdivisions of urban land is 1.54E+07 for high density, 1.03E+07 for low density, and 2.00E+05 for transportation. In the model, fecal coliform loading rates on urban land are input as counts per acre per day.

4.4 Stream Characteristics

The stream characteristics given below describe the three impaired sections of Leaf River. The channel geometry and lengths for Leaf River are based on data available within the BASINS modeling system. The 7Q10 flow is was determined from USGS data. The characteristics of the modeled impaired sections of Leaf River are as follows.

MS086M:
- Length 21.5 miles
- Average Depth 2.69 ft
- Average Width 220.09 ft
- Mean Flow 2808.90 cubic ft per second
- Mean Velocity 1.89 ft per second
- 7Q10 Flow 386.80 cubic ft per second
- Slope 0.00016 ft per ft

MS090M1:
- Length 18.5 miles
- Average Depth 2.41 ft
- Average Width 201.29 ft
- Mean Flow 4445.42 cubic ft per second
- Mean Velocity 2.24 ft per second
- 7Q10 Flow 488.48 cubic ft per second
- Slope 0.00027 ft per ft

MS094M1:
- Length 29.5 miles
- Average Depth 2.57 ft
- Average Width 224.19 ft
- Mean Flow 5385.35 cubic ft per second
- Mean Velocity 2.40 ft per second
- 7Q10 Flow 592.56 cubic ft per second
- Slope 0.00023 ft per ft

4.5 Selection of Representative Modeling Period

The model was run for 12 years, from January 1, 1984 through December 31, 1995. The first year of data were used to stabilize the model. Results from the model were evaluated for the time period from January 1, 1985, until December 31, 1995. Because the 11-year time span is used, a margin of safety (MOS) is implicitly applied. Seasonality and critical conditions are accounted for during the extended time frame of the simulation.

The critical condition for fecal coliform impairment from nonpoint source contributors occurs after a heavy rainfall which is preceded by several days of dry weather. The dry weather allows a build up of fecal coliform bacteria which is then washed off the ground by a heavy rainfall. By using the 11-year time period, many such occurrences are captured in the model results. Critical conditions for point sources, which occur during low flow and low dilution conditions, are simulated as well.

4.6 Model Calibration Process

First, the model was calibrated for hydraulics. A total of seven USGS gages within the Leaf River Watershed were used to calibrate the model hydraulically. The data from these gages, 02471100, 02471250, 02472000, 02473000, 02474560, 02474600, 02475000, were compared to the hydraulic output from the corresponding waterbody segment within the model. A sample of these results is included in Appendix A, Graphs A-1 through A-3.

The water quality data available are such that water quality calibration was difficult. As described in section 2.2 the water quality data available are instantaneous samples collected approximately every two months. The data available are not sufficient for calibration purposes. Instead, MDEQ contacted researchers and agricultural experts to quantify representative pathogen loads entering the stream.

4.7 Existing Loadings

Appendix A includes four graphs of the model results showing the instream fecal coliform concentrations for the most downstream impaired reach and the most upstream impaired reach. Graph A-4 shows the modeled fecal coliform levels in the stream during the 11-year modeling period for the most downstream reach. The graph shows a 30-day geometric mean of the data. The straight line at 200 counts per 100 ml indicates the water quality standard for the stream. Graph A-6 shows the modeled fecal coliform levels in the stream during the 11-year modeling period for the most upstream impaired reach.

Graph A-5 shows the 30-day geometric mean of the fecal coliform levels after a reduction scenario has been modeled for the most downstream reach. Graph A-7 shows the 30-day geometric mean of the fecal coliform levels after a reduction scenario has been modeled for the most upstream impaired reach. The scale matches the previous graphs for comparison purposes. The graphs indicate that there are no violations of the water quality standard after the reduction scenario was applied.

5.0 ALLOCATION

The allocation for this TMDL involves a wasteload allocation for point sources and a load allocation for nonpoint sources necessary for attainment of water quality standards. Point source contributions enter the stream directly in the appropriate reach. The nonpoint fecal coliform sources used in the model have two different transportation methods. Cows in the stream and failing septic tanks were modeled as direct inputs to the stream. The other nonpoint source contributions were applied to land area on a counts per day per acre basis. The fecal coliform bacteria applied to land is subject to a die-off rate and an absorption rate before it enters the stream. The TMDL was calculated based on modeling estimates which are referenced in Appendix A.

5.1 Wasteload Allocations

The contribution of point sources was considered on a subwatershed basis for the model. Within each subwatershed, the modeled contribution of each discharger was based on the facility's discharge monitoring data and other records of past performance. As part of this TMDL, all wastewater treatment facilities will be required to meet water quality standards at the end of their pipe. Table 5.1 lists the point source contributions, on a subwatershed basis, along with their existing load, allocated load, and percent reduction. Several of the subwatersheds do not contain any permitted point sources, and are not included in the table. The final wasteload allocation on the summary page also accounts for the load from 50% of the failing septic tanks which are assumed to directly bypass to the stream.

Table 5.1. Wasteload Allocations

Subwatershed	Existing Flow (cfs)	Existing Load (counts/hr)	Allocated Flow (cfs)	Allocated Load (counts/hr)	Percent Reduction
3170004002	1.39	5.40E+07	1.39	5.40E+07	0%
3170004004	0.21	6.30E+07	0.21	4.28E+07	32%
3170004005	0.26	2.83E+07	0.26	2.68E+07	6%
3170004016	0.24	1.89E+06	0.24	1.89E+06	0%
3170004020	0.31	1.25E+08	0.31	6.23E+07	50%
3170004021	0.16	3.15E+07	0.16	3.15E+07	0%
3170005002	0.01	9.45E+05	0.01	9.45E+05	0%
3170005007	15.50	3.15E+09	15.50	3.15E+09	0%
3170005008	0.34	3.44E+07	0.34	3.44E+07	0%
3170005009	0.02	3.15E+06	0.02	3.15E+06	0%
3170005011	0.52	2.35E+08	0.52	1.05E+08	55%
3170005019	0.98	9.45E+05	0.98	9.45E+05	0%
3170005032	0.16	1.57E+08	0.16	3.15E+07	80%
3170005033	13.10	1.65E+10	13.10	2.66E+09	84%

5.2 Load Allocations

Reductions in the load allocation for this TMDL involve two different types of nonpoint sources: cattle access to streams and septic tanks. Contributions from both of these sources are input into the model in a manner similar to point source input, with a flow and fecal coliform concentration in counts per hour. Table 5.2a lists the nonpoint source contributions due to cattle access to streams, on a subwatershed basis, along with their existing load, allocated load, and percent reduction. Table 5.2b gives the same parameters for contributions due to septic tank failure.

Nonpoint fecal coliform loadings due to cattle grazing; land application of manure produced by confined dairy cattle, hogs, and poultry; wildlife; and urban development are also included in the load allocation. Currently, no reduction is assumed for these contributors in the model for Leaf River to achieve water quality standards. The model estimated the fecal coliform bacteria count per 30 days entering Leaf River for each impaired segment due to runoff during the 30-day critical period. These values are given in section 5.4 Calculation of the TMDL.

The scenario chosen for the load allocation in the Leaf River Watershed assumes a 88% reduction in total nonpoint source contributions. The scenario used in this analysis assumes a 90% reduction in the loading from cattle access to the stream and a 50% reduction in the loading from leaking septic tanks to make up the overall nonpoint source reduction. This scenario could be achieved by supporting BMP projects that promote fencing around streams in pastures, and by supporting education projects that encourage homeowners to properly maintain their septic tanks by routinely pumping them out, repairing broken field lines, and disinfecting the effluent from small individual onsite treatment plants.

5.3 Incorporation of a Margin of Safety

The two types of MOS development are to implicitly incorporate the MOS using conservative model assumptions or to explicitly specify a portion of the total TMDL as the MOS. The MOS selected for this model is implicit. The primary component of the MOS is provided by running the model for eleven years with no violations of the water quality standard. Ensuring compliance with the standard throughout all of the critical condition periods represented during the 11 years is a conservative practice. Another component of the MOS is the conservative assumption that in the model all of the fecal coliform bacteria discharged from failing septic tanks reaches the stream, while it is likely that only a portion of the bacteria will reach the stream due to filtration and die off during transport.

Table 5.2a. Fecal Coliform Loading Rates for Nonpoint Source Contribution of Cattle Access to Streams

Subwatershed	Existing Flow (cfs)	Existing Load (counts/hr)	Allocated Flow (cfs)	Allocated Load (counts/hr)	Percent Reduction
03170004001	1.71E-06	4.50E+07	1.71E-07	4.50E+06	90%
03170004002	1.56E-03	4.11E+10	1.56E-04	4.11E+09	90%
03170004003	1.07E-04	2.82E+09	1.07E-05	2.82E+08	90%
03170004004	6.76E-04	1.78E+10	6.76E-05	1.78E+09	90%
03170004005	5.96E-04	1.57E+10	5.96E-05	1.57E+09	90%
03170004006	2.26E-04	5.96E+09	2.26E-05	5.96E+08	90%
03170004007	7.43E-04	1.96E+10	7.43E-05	1.96E+09	90%
03170004008	5.42E-04	1.43E+10	5.42E-05	1.43E+09	90%
03170004009	5.26E-04	1.39E+10	5.26E-05	1.39E+09	90%
03170004010	8.64E-04	2.28E+10	8.64E-05	2.28E+09	90%
03170004011	1.72E-04	4.54E+09	1.72E-05	4.54E+08	90%
03170004012	2.92E-05	7.70E+08	2.92E-06	7.70E+07	90%
03170004013	4.43E-04	1.17E+10	4.43E-05	1.17E+09	90%
03170004014	7.24E-04	1.91E+10	7.24E-05	1.91E+09	90%
03170004015	2.00E-04	5.27E+09	2.00E-05	5.27E+08	90%
03170004016	6.95E-04	1.83E+10	6.95E-05	1.83E+09	90%
03170004017	1.36E-03	3.58E+10	1.36E-04	3.58E+09	90%
03170004018	5.87E-04	1.55E+10	5.87E-05	1.55E+09	90%
03170004019	4.97E-04	1.31E+10	4.97E-05	1.31E+09	90%
03170004020	3.87E-04	1.02E+10	3.87E-05	1.02E+09	90%
03170004021	3.66E-03	9.65E+10	3.66E-04	9.65E+09	90%
03170004022	1.24E-03	3.26E+10	1.24E-04	3.26E+09	90%
03170005001	4.42E-04	1.17E+10	4.42E-05	1.17E+09	90%
03170005002	3.21E-04	8.46E+09	3.21E-05	8.46E+08	90%
03170005003	6.14E-05	1.62E+09	6.14E-06	1.62E+08	90%
03170005004	2.34E-04	6.18E+09	2.34E-05	6.18E+08	90%
03170005005	1.78E-04	4.68E+09	1.78E-05	4.68E+08	90%
03170005006	3.58E-04	9.43E+09	3.58E-05	9.43E+08	90%
03170005007	1.01E-04	2.65E+09	1.01E-05	2.65E+08	90%
03170005008	9.65E-04	2.54E+10	9.65E-05	2.54E+09	90%
03170005009	2.99E-04	7.88E+09	2.99E-05	7.88E+08	90%
03170005010	3.10E-04	8.17E+09	3.10E-05	8.17E+08	90%
03170005011	1.74E-04	4.58E+09	1.74E-05	4.58E+08	90%
03170005019	1.22E-04	3.20E+09	1.22E-05	3.20E+08	90%
03170005031	8.95E-05	2.36E+09	8.95E-06	2.36E+08	90%
03170005032	7.52E-05	1.98E+09	7.52E-06	1.98E+08	90%
03170005033	5.14E-04	1.35E+10	5.14E-05	1.35E+09	90%
Total	**2.01E-02**	**5.29E+11**	**2.01E-03**	**5.29E+10**	**90%**

Table 5.2b. Fecal Coliform Loading Rates for Failing Septic Tanks (50% LA and 50% WLA)

Subwatershed	Existing Flow (cfs)	Existing Load (counts/hr)	Allocated Flow (cfs)	Allocated Load (counts/hr)	Percent Reduction
03170004001	4.56E-04	4.64E+06	2.28E-04	2.32E+06	50%
03170004002	1.80E-01	1.83E+09	9.01E-02	9.17E+08	50%
03170004003	1.02E-02	1.04E+08	5.12E-03	5.21E+07	50%
03170004004	6.56E-02	6.68E+08	3.28E-02	3.34E+08	50%
03170004005	8.61E-02	8.76E+08	4.30E-02	4.38E+08	50%
03170004006	2.54E-02	2.58E+08	1.27E-02	1.29E+08	50%
03170004007	6.46E-02	6.57E+08	3.23E-02	3.29E+08	50%
03170004008	5.08E-02	5.17E+08	2.54E-02	2.58E+08	50%
03170004009	5.77E-02	5.87E+08	2.89E-02	2.94E+08	50%
03170004010	6.31E-02	6.42E+08	3.16E-02	3.21E+08	50%
03170004011	1.65E-02	1.68E+08	8.27E-03	8.41E+07	50%
03170004012	2.55E-03	2.60E+07	1.28E-03	1.30E+07	50%
03170004013	3.07E-02	3.12E+08	1.53E-02	1.56E+08	50%
03170004014	4.02E-02	4.09E+08	2.01E-02	2.04E+08	50%
03170004015	1.26E-02	1.28E+08	6.28E-03	6.39E+07	50%
03170004016	4.35E-02	4.43E+08	2.17E-02	2.21E+08	50%
03170004017	8.45E-02	8.60E+08	4.23E-02	4.30E+08	50%
03170004018	2.94E-02	3.00E+08	1.47E-02	1.50E+08	50%
03170004019	2.40E-02	2.44E+08	1.20E-02	1.22E+08	50%
03170004020	2.33E-02	2.37E+08	1.16E-02	1.18E+08	50%
03170004021	2.07E-01	2.10E+09	1.03E-01	1.05E+09	50%
03170004022	5.04E-02	5.13E+08	2.52E-02	2.56E+08	50%
03170005001	6.81E-02	6.93E+08	3.40E-02	3.46E+08	50%
03170005002	5.03E-02	5.12E+08	2.52E-02	2.56E+08	50%
03170005003	1.10E-02	1.12E+08	5.49E-03	5.59E+07	50%
03170005004	4.81E-02	4.90E+08	2.41E-02	2.45E+08	50%
03170005005	2.62E-02	2.66E+08	1.31E-02	1.33E+08	50%
03170005006	4.15E-02	4.22E+08	2.07E-02	2.11E+08	50%
03170005007	1.96E-02	1.99E+08	9.79E-03	9.96E+07	50%
03170005008	1.12E-01	1.14E+09	5.61E-02	5.71E+08	50%
03170005009	2.81E-02	2.86E+08	1.41E-02	1.43E+08	50%
03170005010	2.82E-02	2.87E+08	1.41E-02	1.43E+08	50%
03170005011	3.38E-02	3.44E+08	1.69E-02	1.72E+08	50%
03170005019	2.34E-02	2.38E+08	1.17E-02	1.19E+08	50%
03170005031	1.61E-02	1.64E+08	8.04E-03	8.18E+07	50%
03170005032	1.14E-02	1.16E+08	5.69E-03	5.79E+07	50%
03170005033	1.66E-01	1.69E+09	8.30E-02	8.45E+08	50%
Total	**1.85E+00**	**1.88E+10**	**9.26E-01**	**9.42E+09**	**50%**

5.4 Calculation of the TMDL

The TMDL was calculated based on the following equation:

TMDL = WLA + LA + MOS

The TMDL was calculated based on the 30-day critical period for the Leaf River Watershed according to the model. Each of the loading rates has been converted to the 30-day equivalent. The wasteload allocation incorporates the fecal coliform contribution from identified NPDES Permitted facilities and 50% of the contribution from failing septic tanks. The load allocation includes the fecal coliform contributions from surface runoff, cows in the stream, and 50% of the contribution from failing septic tanks. The margin of safety for this TMDL is derived from the conservative loading assumptions used in setting up the model and are implicit. Table 5.4 gives the TMDLs for all monitored segments.

WLA = NPDES Permitted Facilites + **2** of the Septic Tank Failures

LA = Surface Runoff + Cows in the Stream + **2** of the Septic Tank Failures

MOS = implicit

TMDL = WLA + LA + MOS

Table 5.4. TMDL Summary for Monitored Segments (counts/30 days)

	MS086M	**MS090M1**	**MS094M1**
NPDES Permits	2.10E+12	2.17E+12	4.47E+12
1/2 Failing Septic Tanks	2.49E+12	2.60E+12	3.39E+12
WLA	**4.59E+12**	**4.77E+12**	**7.86E+12**
Surface Runoff	4.41E+12	4.59E+12	4.86E+12
Cows in Stream	3.13E+13	3.19E+13	3.81E+13
1/2 Failing Septic Tanks	2.49E+12	2.60E+12	3.39E+12
LA	**3.82E+13**	**3.91E+13**	**4.63E+13**
TMDL = WLA + LA	**4.28E+13**	**4.39E+13**	**5.42E+13**

5.5 Seasonality

For two impaired segments of the Leaf River, fecal coliform limits vary according to the seasons due to their designation for the use of secondary contact recreation. One segment, however, is designated for the use of contact recreation. For this use, the pollutant standard is constant throughout the year. The water quality standard applicable to the use Contact Recreation and the pollutant of concern states that fecal coliform [colony counts] shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10 % of the samples examined during any month exceed [a colony count of] 400 per 100 ml. The water quality standard applicable to the use Secondary Contact Recreation and the pollutant of concern, for the months May through October, is the same as the standard for Contact Recreation. However, for the months of November through April, the standard states that fecal coliform shall not exceed a geometric mean of 2000 per 100 ml, nor shall more than 10% of the samples examined during any month exceed 4000 per 100 ml.

Because the model was established for an 11-year time span, it took into account all of the seasons within the calendar years from 1985 to 1995. The extended time period allowed the simulation of many different atmospheric conditions such as rainy and dry periods and high and low temperatures. It also allowed seasonal critical conditions to be simulated.

6.0 CONCLUSION

The fecal coliform reduction scenario used in this TMDL included requiring all NPDES Permitted dischargers of fecal coliform to meet water standards for disinfection, along with reducing the assumed fecal load from nonpoint sources by 88%.

The TMDL will not impact existing or future NPDES Permits as long as the effluent is disinfected to meet water quality standards for fecal coliform bacteria. MDEQ will not approve any NPDES Permit application that does not plan to meet water quality standards for disinfection. Education projects that teach best management practices should be used as a tool for reducing nonpoint source contributions. These projects may be funded by CWA Section 319 Nonpoint Source (NPS) Grants.

6.1 Future Monitoring

MDEQ has adopted the Basin Approach to Water Quality Management, a plan that divides Mississippi=s major drainage basins into five groups. During each yearlong cycle, MDEQ resources for water quality monitoring will be focused on one of the basin groups. During the next monitoring phase in the Pascagoula Basin, Leaf River may receive additional monitoring to identify any change in water quality.

6.2 Public Participation

This TMDL will be published for a 30-day public notice. During this time, the public will be notified by publication in the statewide newspaper and a newspaper in the area of the watershed. The public will be given an opportunity to review the TMDL and submit comments. At the end of the 30-day period, MDEQ will determine the level of interest in the TMDL and make a decision on the necessity of holding a public hearing.

If a public hearing is deemed appropriate, the public will be given a 30-day notice of the hearing to be held at a location near the watershed. That public hearing would be an official hearing of the Mississippi Commission on Environmental Quality, and would be transcribed.

All comments received during the public notice period and at any public hearings become a part of the record of this TMDL. All comments will be considered in the ultimate approval of this TMDL by the Commission on Environmental Quality and for submission of this TMDL to EPA Region IV for final approval.

DEFINITIONS

Ambient stations: a network of fixed monitoring stations established for systematic water quality sampling at regular intervals, and for uniform parametric coverage over a long-term period.

Assimilative capacity: the capacity of a body of water or soil-plant system to receive wastewater effluents or sludge without violating the provisions of the State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters and Water Quality regulations.

Background: the condition of waters in the absence of man-induced alterations based on the best scientific information available to MDEQ. The establishment of natural background for an altered waterbody may be based upon a similar, unaltered or least impaired, waterbody or on historical pre-alteration data.

Calibrated model: a model in which reaction rates and inputs are significantly based on actual measurements using data from surveys on the receiving waterbody.

Critical Condition: hydrologic and atmospheric conditions in which the pollutants causing impairment of a waterbody have their greatest potential for adverse effects.

Daily discharge: the "discharge of a pollutant" measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. For pollutants with limitations expressed in units of mass, the "daily discharge" is calculated as the total mass of the pollutant discharged over the day. For pollutants with limitations expressed in other units of measurement, the "daily average" is calculated as the average.

Designated Use: use specified in water quality standards for each waterbody or segment regardless of actual attainment.

Discharge monitoring report: report of effluent characteristics submitted by a NPDES Permitted facility.

Effluent standards and limitations: all State or Federal effluent standards and limitations on quantities, rates, and concentrations of chemical, physical, biological, and other constituents to which a waste or wastewater discharge may be subject under the Federal Act or the State law. This includes, but is not limited to, effluent limitations, standards of performance, toxic effluent standards and prohibitions, pretreatment standards, and schedules of compliance.

Effluent: treated wastewater flowing out of the treatment facilities.

Fecal coliform bacteria: a group of bacteria that normally live within the intestines of mammals, including humans. Fecal coliform bacteria are used as an indicator of the presence of pathogenic organisms in natural water.

Geometric mean: the *n*th root of the product of *n* numbers. A 30-day geometric mean is the 30^{th} root of the product of 30 numbers.

Impaired Waterbody: any waterbody that does not attain water quality standards due to an individual pollutant, multiple pollutants, pollution, or an unknown cause of impairment.

Land Surface Runoff: water that flows into the receiving stream after application by rainfall or irrigation. It is a transport method for nonpoint source pollution from the land surface to the receiving stream.

Load allocation (LA): the portion of a receiving water's loading capacity attributed to or assigned to nonpoint sources (NPS) or background sources of a pollutant. The load allocation is the value assigned to the summation of all cattle and land applied fecal coliform that enter a receiving waterbody. It also contains a portion of the contribution from septic tanks.

Loading: the total amount of pollutants entering a stream from one or multiple sources.

Nonpoint Source: pollution that is in runoff from the land. Rainfall, snowmelt, and other water that does not evaporate become surface runoff and either drains into surface waters or soaks into the soil and finds its way into groundwater. This surface water may contain pollutants that come from land use activities such as agriculture; construction; silviculture; surface mining; disposal of wastewater; hydrologic modifications; and urban development.

NPDES permit: an individual or general permit issued by the Mississippi Environmental Quality Permit Board pursuant to regulations adopted by the Mississippi Commission on Environmental Quality under Mississippi Code Annotated (as amended) '' 49-17-17 and 49-17-29 for discharges into State waters.

Point Source: pollution loads discharged at a specific location from pipes, outfalls, and conveyance channels from either wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving stream.

Pollution: contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the State, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive, or other substance, or leak into any waters of the State, unless in compliance with a valid permit issued by the Permit Board.

Publicly Owned Treatment Works (POTW): a waste treatment facility owned and/or operated by a public body or a privately owned treatment works which accepts discharges which would otherwise be subject to Federal Pretreatment Requirements.

Regression Coefficient: an expression of the functional relationship between two correlated variables that is often empirically determined from data, and is used to predict values of one variable when given values of the other variable.

Scientific Notation (Exponential Notation): mathematical method in which very large numbers or very small numbers are expressed in a more concise form. The notation is based on powers of ten. Numbers in scientific notation are expressed as the following: *4.16 x 10^(+b)* and *4.16 x 10^(-b) [same as 4.16E4 or4.16E-4].* In this case, *b* is always a positive, real number. The *10^(+b)* tells us that the decimal point is *b* places to the right of where it is shown. The *10^(-b)* tells us that the decimal point is *b* places to the left of where it is shown.

For example: $2.7X10^{4}$ = 2.7E+4 =27000 and $2.7X10^{-4}$ = 2.7E-4=0.00027.

Sigma (S): shorthand way to express taking the sum of a series of numbers. For example, the sum or total of three amounts 24, 123, 16, ($\mathbf{d_l}$, $\mathbf{d_2}$, $\mathbf{d_3}$) respectively could be shown as:

$$\sum_{i=1}^{3} d_i = d_1+d_2+d_3 = 24 + 123 + 16 = 163$$

Total Maximum Daily Load or TMDL: the calculated maximum permissible pollutant loading to a waterbody at which water quality standards can be maintained.

Waste: sewage, industrial wastes, oil field wastes, and all other liquid, gaseous, solid, radioactive, or other substances which may pollute or tend to pollute any waters of the State.

Wasteload allocation (WLA): the portion of a receiving water's loading capacity attributed to or assigned to point sources of a pollutant. It also contains a portion of the contribution from septic tanks

Water Quality Standards: the criteria and requirements set forth in *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters.* Water quality standards are standards composed of designated present and future most beneficial uses (classification of waters), the numerical and narrative criteria applied to the specific water uses or classification, and the Mississippi antidegradation policy.

Water quality criteria: elements of State water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports the present and future most beneficial uses.

ABBREVIATIONS

7Q10......................... Seven-Day Average Low Stream Flow With a Ten-Year Occurrence Period

BASINS................................Better Assessment Science Integrating Point and Nonpoint Sources

BMP .... Best Management Practice

DMR ....Discharge Monitoring Report

EPA... Environmental Protection Agency

GIS .... Geographic Information System

HUC..Hydrologic Unit Code

LA .... Load Allocation

MARIS .... State of Mississippi Automated Information System

MDEQ.. Mississippi Department of Environmental Quality

MOS.. Margin of Safety

NRCS .... National Resource Conservation Service

NPDES... National Pollution Discharge Elimination System

NPSM..Nonpoint Source Model

USGS .... United States Geological Survey

WLA..Waste Load Allocation

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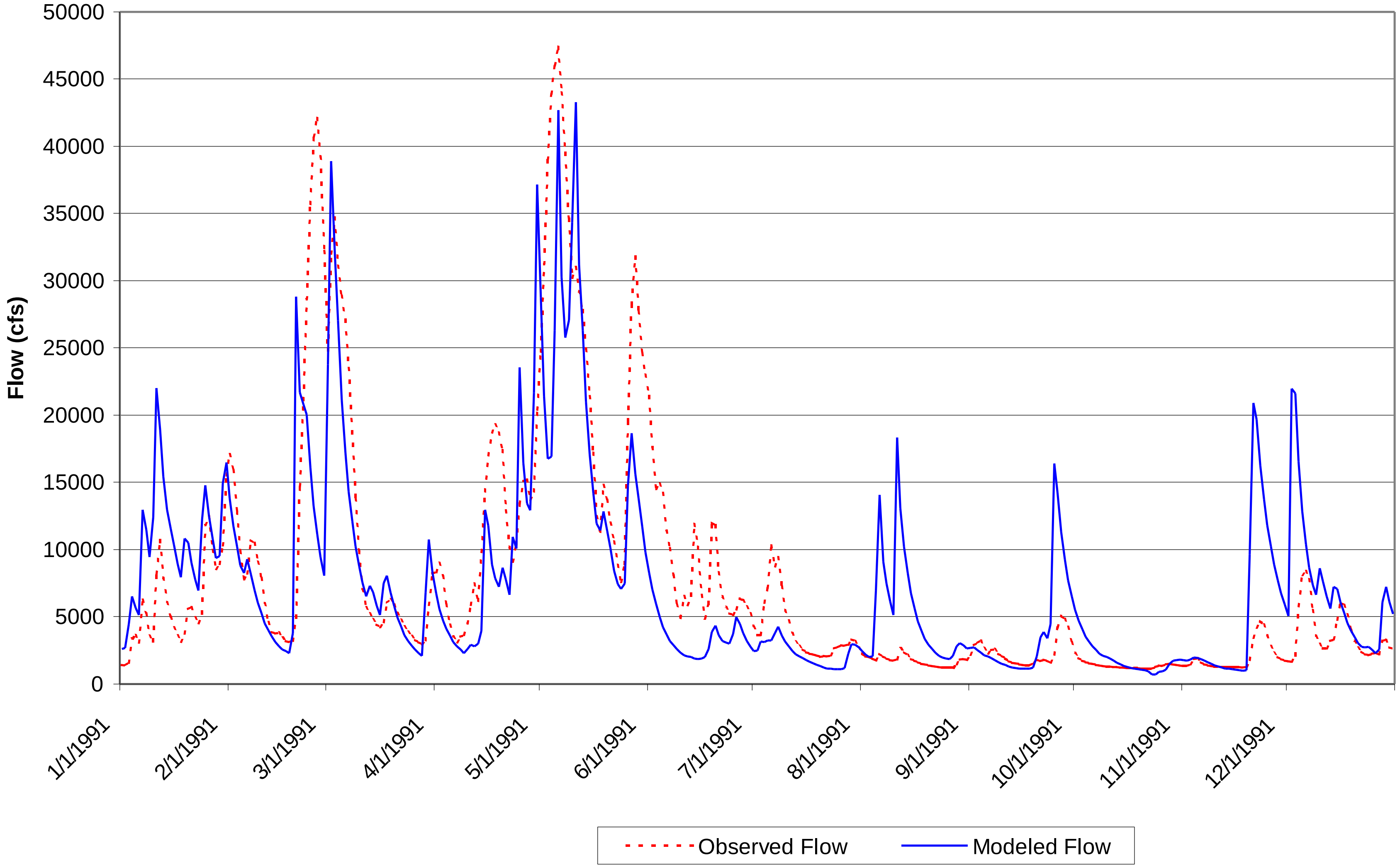
APPENDIX A

This appendix contains printouts of the various model run results. Graphs A-1 though A-3 show the modeled flow, in cfs, through reach 03170005001 compared to the USGS gage readings from Leaf River near McLain, gage 02475000. The graphs show data from selected years of the modeled period, 01/01/91-12/31/91, 01/01/92-12/31/92, and 01/01/93-12/31/93. The second set of graphs show the 30-day geometric mean for fecal coliform concentrations in counts per 100 ml in two of the impaired sections of Leaf River, the most downstream impaired reach, 03170005001, and the most upstream impaired reach, 03170005033. The graphs represent an 11-year time period, from 01/01/85, to 12/31/95. The graphs contain a reference line at 200 counts per 100 ml. Graph A-4 represents the existing fecal coliform loading in Leaf River, reach 03170005001. Graph A-5 represents the conditions in Leaf River, reach 03170005001, after the reduction scenario has been applied. Graph A-6 represents the existing fecal coliform loading in Leaf River, reach 03170005033. Graph A-7 represents the conditions in Leaf River, reach 03170005033, after the reduction scenario has been applied. Graphs A-4 through A-7 are shown with the same scale for comparison purposes.

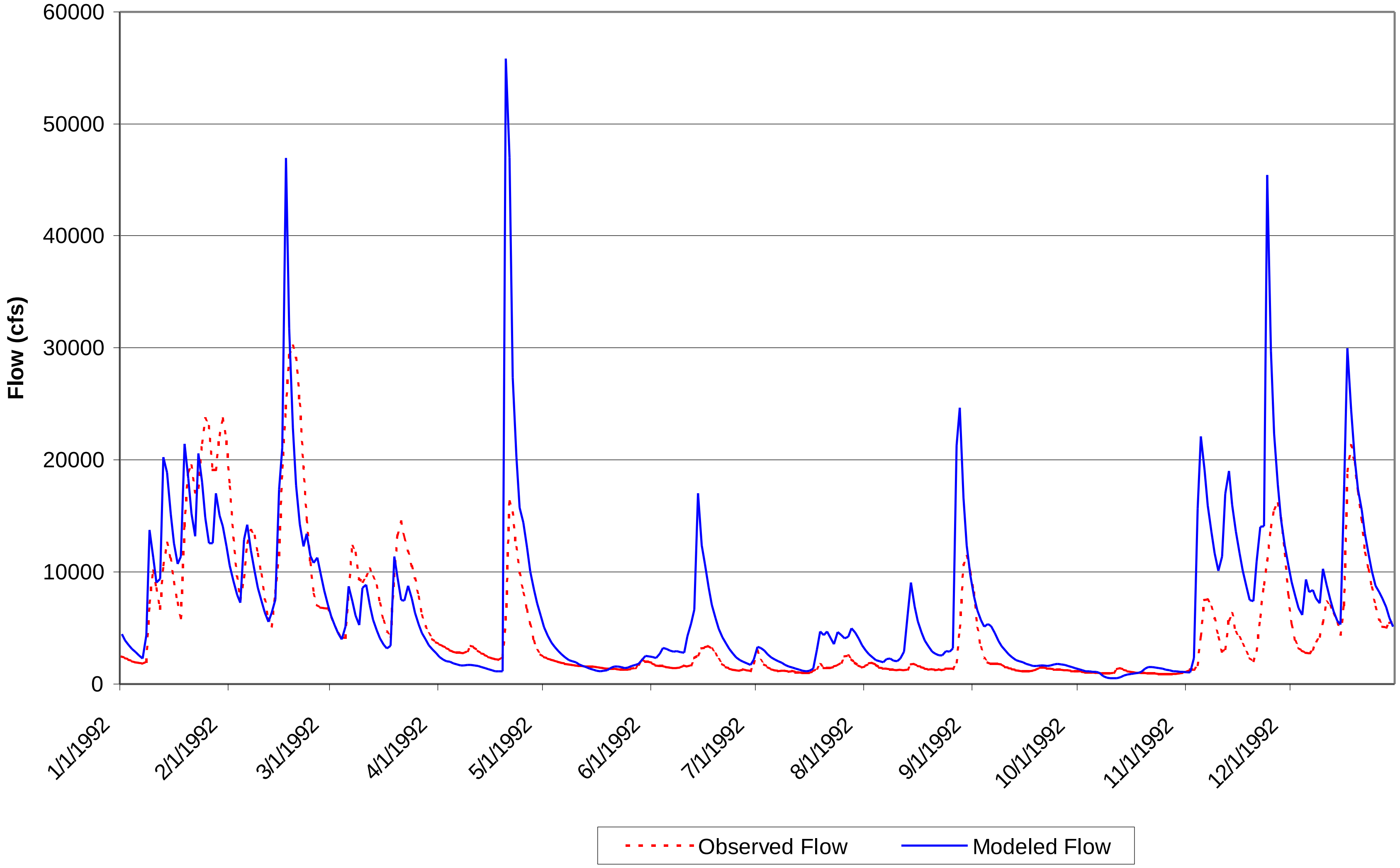
The TMDL calculated in this report represents the maximum fecal coliform load that can be assimilated by the waterbody segment during the critical 30-day period that will maintain water quality standards. The calculation of this TMDL is based on the critical hydrologic flow condition that occurred during the modeled time span. The graph showing the 30-day geometric mean of instream fecal coliform concentrations representing the allocated loading scenario (Graph A-5) was used to identify the critical condition. The TMDL calculation includes the sum of the loads from all identified point and nonpoint sources applied or discharged within the modeled watershed.

An individual TMDL calculation was prepared for each waterbody segment and drainage area included in this report. The numerical values for the wasteload allocation (point sources) and load allocation (nonpoint sources) for each waterbody segment or drainage area can be found on the waterbody segment identification pages at the beginning of this report.

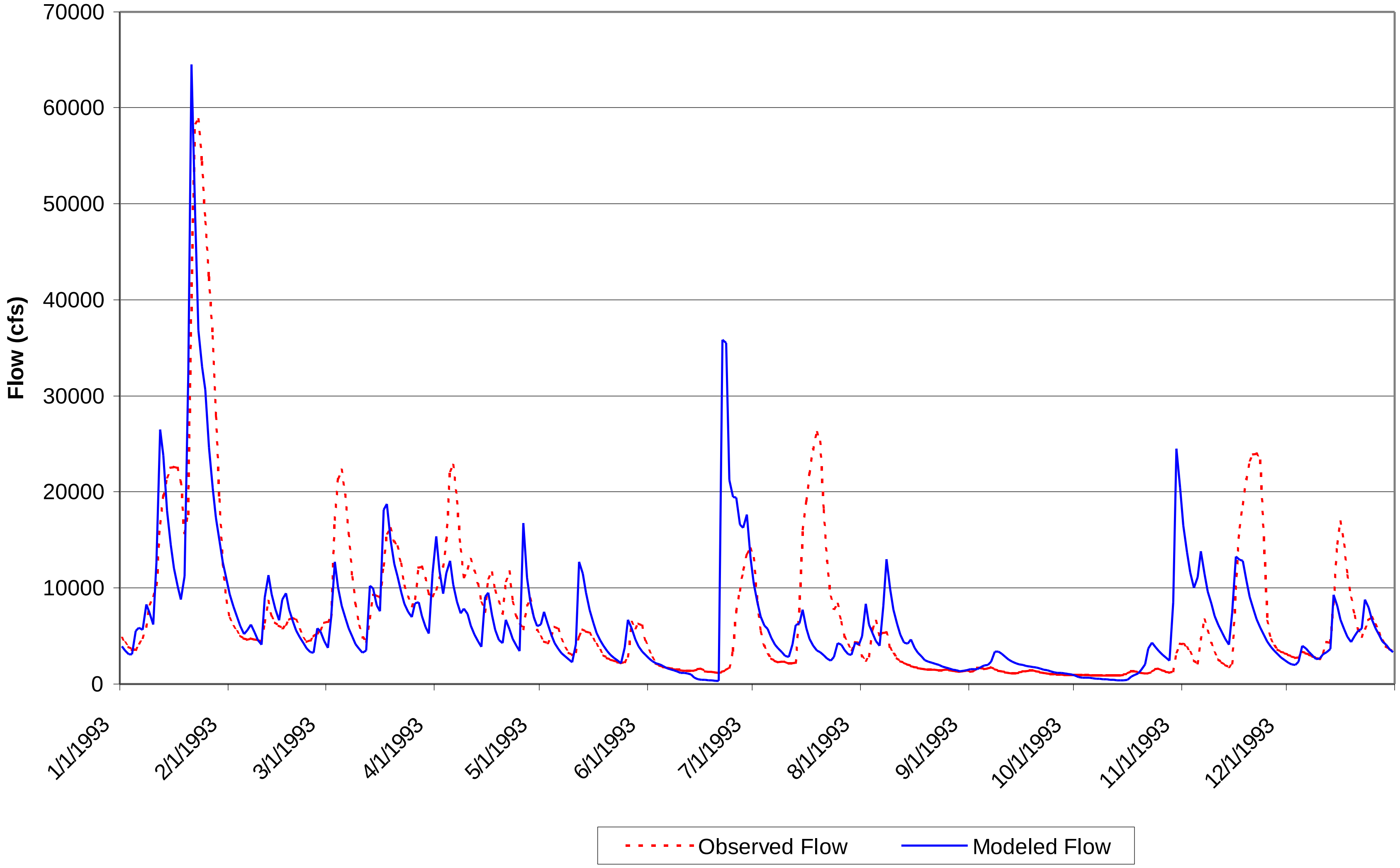
Graph A-1 Daily Flow Comparison between USGS Gage 02475000 and Reach 03170005001 for 01/01/91 - 12/31/91

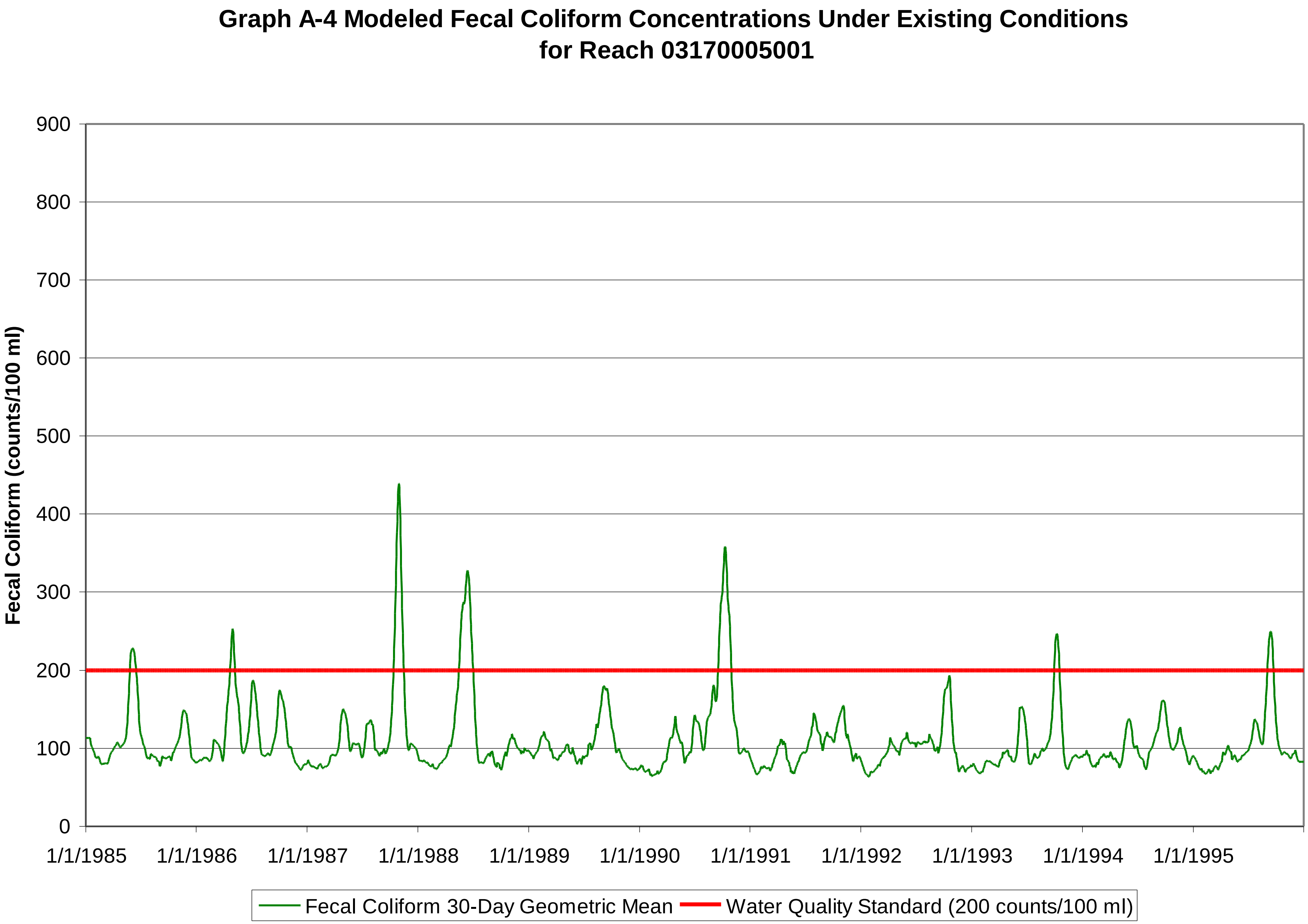


Graph A-2 Daily Flow Comparison between USGS Gage 02475000 and Reach 03170005001 for 01/01/92 - 12/31/92

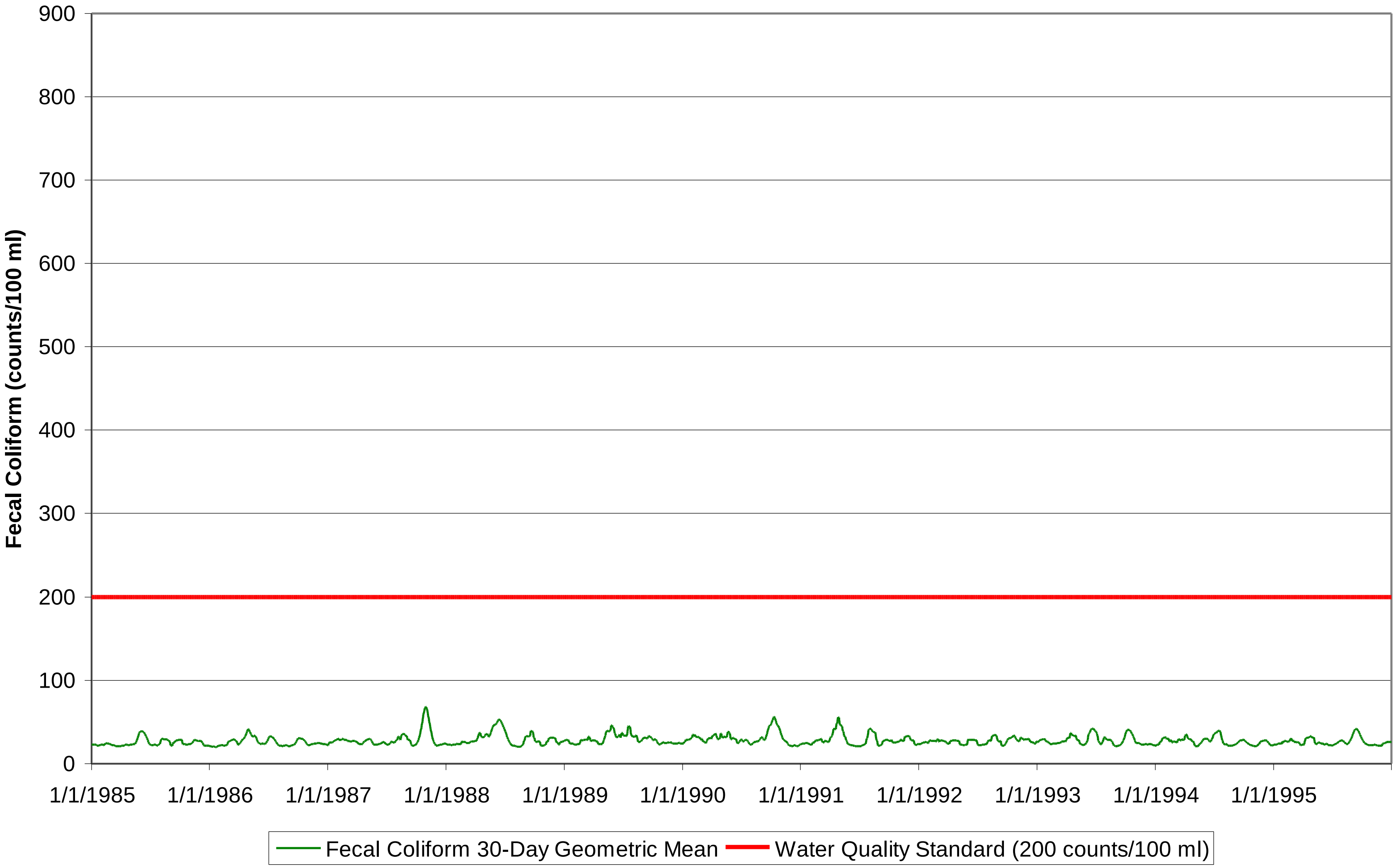


Graph A-3 Daily Flow Comparison between USGS Gage 02475000 and Reach 03170005001 for 01/01/93 - 12/31/93




Graph A-4 Modeled Fecal Coliform Concentrations Under Existing Conditions
for Reach 03170005001
Fecal Coliform (counts/100 ml)
900
800
700
600
500
400
300
200
100
0
1/1/1985
1/1/1986
1/1/1987
1/1/1988
1/1/1989
1/1/1990
1/1/1991
1/1/1992
1/1/1993
1/1/1994
1/1/1995
Fecal Coliform 30-Day Geometric Mean
Water Quality Standard (200 counts/100 ml)

Graph A-5 Modeled Fecal Coliform Concentrations After Application of Reduction Scenario for Reach 03170005001



Graph A-6 Modeled Fecal Coliform Concentrations Under Existing Conditions for Reach 03170005033