Fecal Coliform TMDL for Big Creek
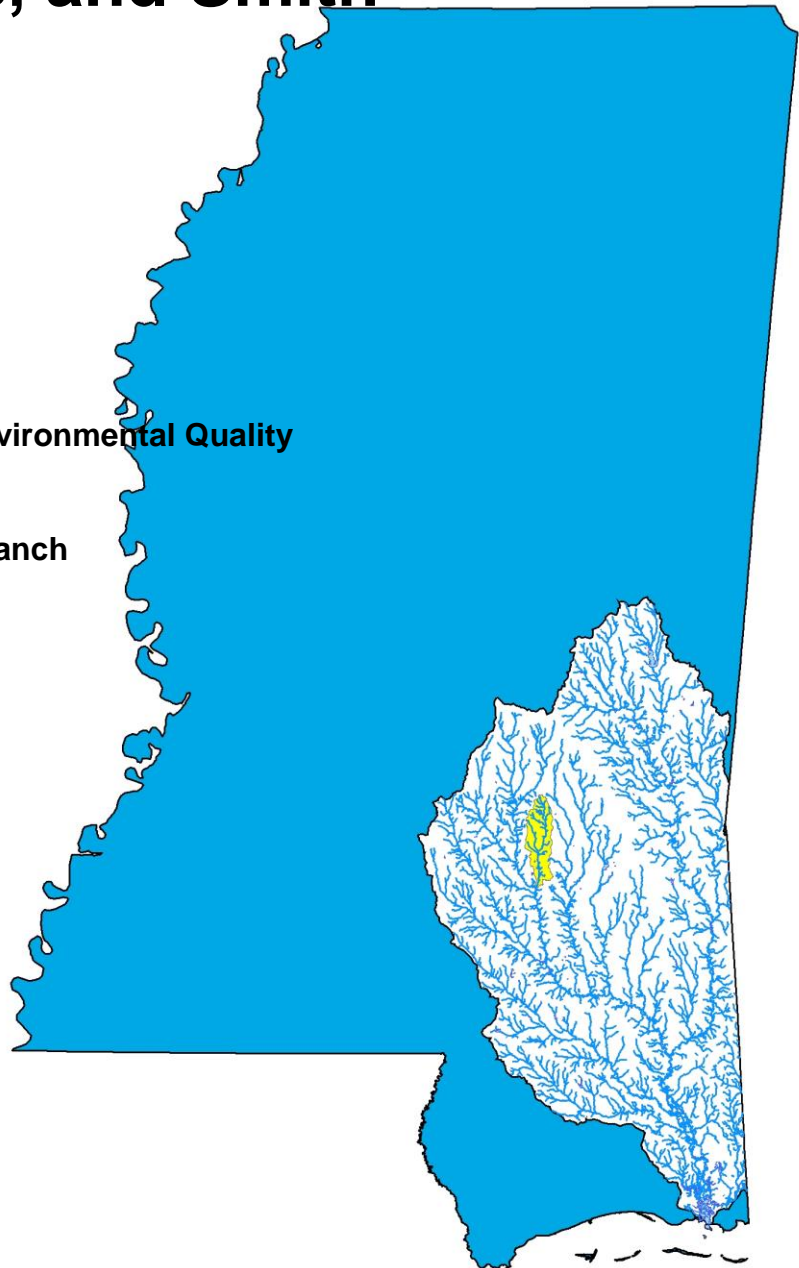
Pascagoula River Basin

Jasper, Jones, and Smith Counties, Mississippi

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 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.

Prefixes for fractions and multiples of SI units

Fraction	Prefix	Symbol	Multiple	Prefix	Symbol
10^{-1}	deci	d	10	deka	da
10^{-2}	centi	c	10^2	hecto	h
10^{-3}	milli	m	10^3	kilo	k
10^{-6}	micro	μ	10^6	mega	M
10^{-9}	nano	n	10^9	giga	G
10^{-12}	pico	p	10^{12}	tera	T
10^{-15}	femto	f	10^{15}	peta	P
10^{-18}	atto	a	10^{18}	exa	E

Conversion Factors

To convert from	To	Multiply by	To Convert from	To	Multiply by
Acres	Sq. miles	0.00156	Days	Seconds	86400
Cubic feet	Cu. Meter	0.02832	Feet	Meters	0.3048
Cubic feet	Gallons	7.4805	Gallons	Cu feet	0.13368
Cubic feet	Liters	28.316	Hectares	Acres	2.4711
cfs	Gal/min	448.83	Miles	Meters	1609.34
cfs	MGD	0.64632	Mg/l	ppm	1
Cubic meters	Gallons	264.173	μg/l * cfs	Gm/day	2.45

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FIGURES

TABLES

TMDL INFORMATION PAGE

Listing Information

Name	ID	County	HUC	Cause	Mon/Eval
Big Creek	MS077E	Jones	03170004	Pathogens	Evaluated
Near Soso from confluence with Ettehoma Creek and Mill Creek to mouth at Leaf River					

Water Quality Standard

Parameter	Beneficial use	Water Quality Criteria
Fecal Coliform	Secondary Contact	**May - October**: Fecal coliform colony counts not to exceed a geometric mean of 200 per 100ml based on a minimum of 5 samples taken over a 30-day period with no less than 12 hours between individual samples, nor shall the samples examined during a 30-day period exceed 400 per 100ml more than 10 percent of the time. **November – April**: Fecal coliform colony counts shall not exceed a geometric mean of 2000 per 100 ml based on a minimum of 5 samples taken over a 30-day period with no less than 12 hours between individual samples, nor shall the samples examined during a 30-day period exceed 4000 per 100 ml more than 10 percent of the time.

NPDES Facilities

NPDES ID	Facility Name	Receiving Water
MS0027685	Bay Springs POTW	Ettehoma Creek
MS0037672	Polk's Meat Products Inc.	Roaring Creek
MS0051381	SoSo Quick Stop	Spring Creek

Total Maximum Daily Load for Segment MS077E

Season	WLA (counts per 30 days)	LA (counts per 30 days)	MOS (counts per 30 days)	Total TMDL (counts per day)	TMDL Percent Reduction
Summer	9.45E+10	1.24E+13	1.39E+12	1.39E+13	88
Winter	9.13E+11	4.32E+13	4.90E+12	4.90E+13	0

EXECUTIVE SUMMARY

A pathogen TMDL has been developed for one evaluated water body segment of Big Creek, MS077E, on the Mississippi 2002 Section 303(d) List of Water Bodies. The segment was originally listed based on anecdotal information, but impairment has been verified through recent monitoring. These recent monitoring data were assessed based on the 2002 *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. MDEQ selected fecal coliform as an indicator organism for pathogenic bacteria.

Big Creek, Figure 1, flows in a southeasterly direction from its headwaters near Bay Springs, MS in Jasper County to the Leaf River in Jones County near Oak Bowery. Big Creek is a tributary of the Leaf River in the Pascagoula River Basin. This TMDL has been developed for one segment of Big Creek. Due to data limitations, complex dynamic modeling was inappropriate for performing the TMDL allocations for this study, as were load duration curves. A mass balance approach was used to develop the TMDL for segment MS077E.

Although fecal coliform loadings from point and nonpoint sources in the watershed were not explicitly represented with a model, a source assessment was conducted for the Big Creek Watershed. Nonpoint sources considered include wildlife, livestock, and urban development. Also considered were the nonpoint sources such as failing septic systems and other direct inputs to Big Creek.

Figure 1. Location of the Big Creek Watershed
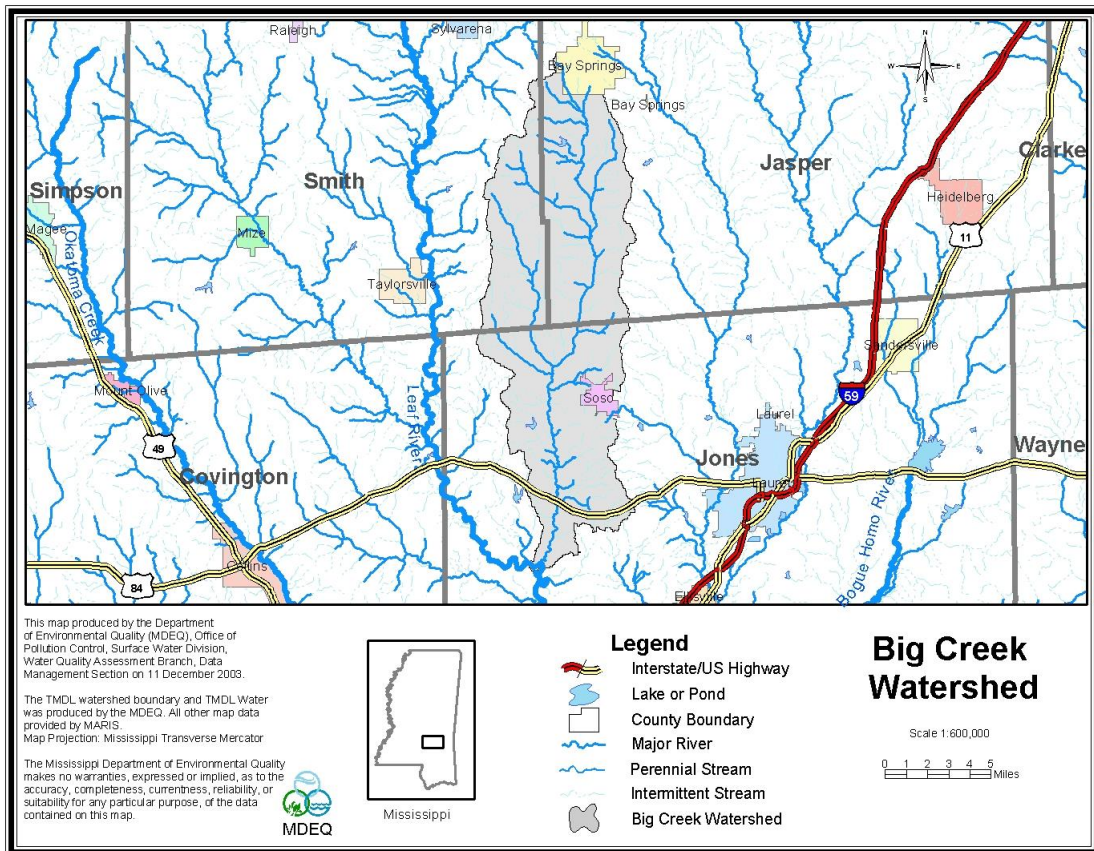
There are 3 NPDES Permitted discharges included as point sources in the waste load allocation (WLA). The permitted facilities currently have requirements in their NPDES Permits that require disinfection to meet water quality standards for pathogens at the end of pipe. Therefore, no changes are required for those existing NPDES permits. Monitoring of the permitted facilities in the Big Creek Watershed should continue to ensure that compliance with permit limits is consistently attained.

The seasonal variations in hydrology, climatic conditions, and watershed activities are represented through the use of a seasonal TMDL based on seasonal average flows and seasonal monitoring. The critical period was determined to be the summer season. An explicit 10 percent margin of safety (MOS) was used in the mass balance method to account for uncertainty.

Water quality data indicate violations of the fecal coliform standard in the waterbody. The estimated summer reduction of fecal coliform bacteria for segment MS077E is 84%.

INTRODUCTION

1.1 Background

The identification of water bodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those water bodies 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 water bodies 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 nonpoint sources, maintain permit requirements for point sources, and restore and maintain the quality of water resources.

A TMDL has been developed for segment MS077E of Big Creek. This segment was listed on the evaluated section of the Mississippi 2002 Section 303(d) List of Waterbodies for pathogen impairment. Segment MS077E was originally listed based on anecdotal information. However, this segment had data collected in 2002 and 2003 that indicated impairment. The data are listed in Tables 3 through 7 in Section 2.2. The segment is shown in Figure 2.

Figure 2. Big Creek Watershed Segment
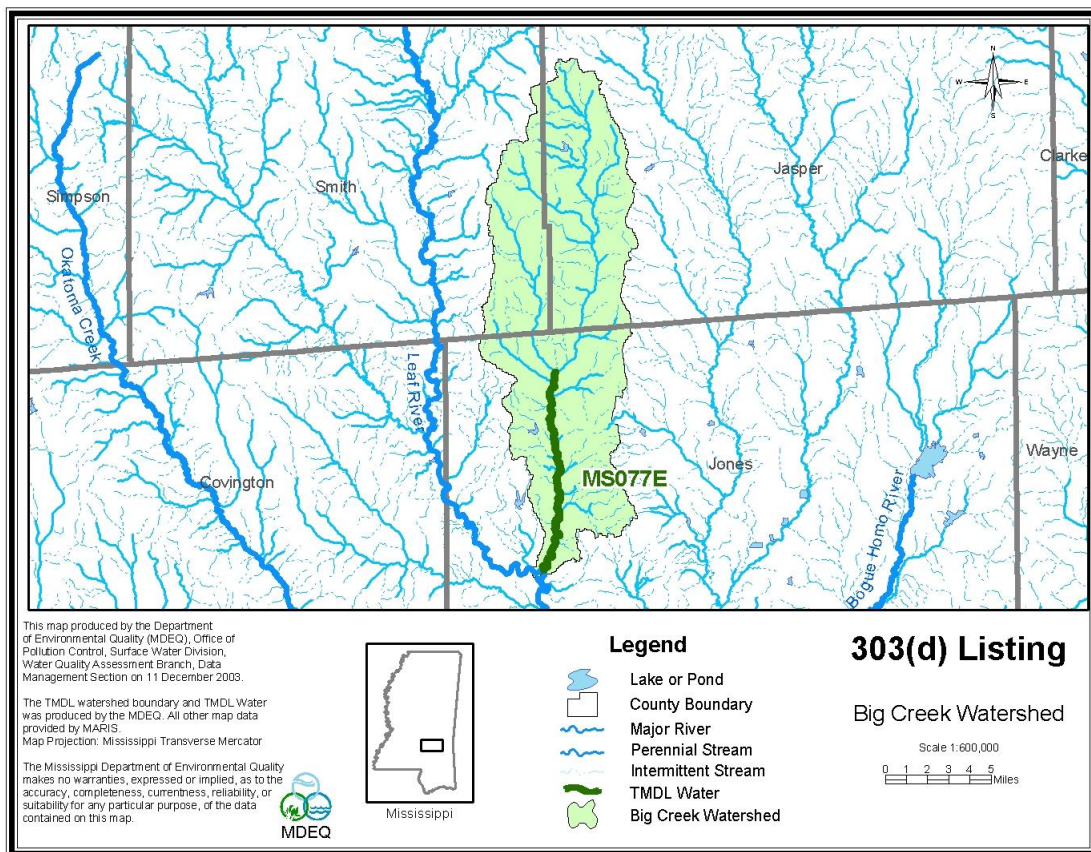
The mass balance method is used when the water quality data are collected in a manner consistent with the water quality standards, that is at least 5 samples collected within a 30 day period. The water body segment along with the location of the water quality gage and flow gage are shown in Figure 3. The TMDL for segment MS077E was developed using the mass balance method with water quality data from station 15 and flow data from the station 02472000.

Figure 3. Big Creek Segment with Water Quality and Flow Gages
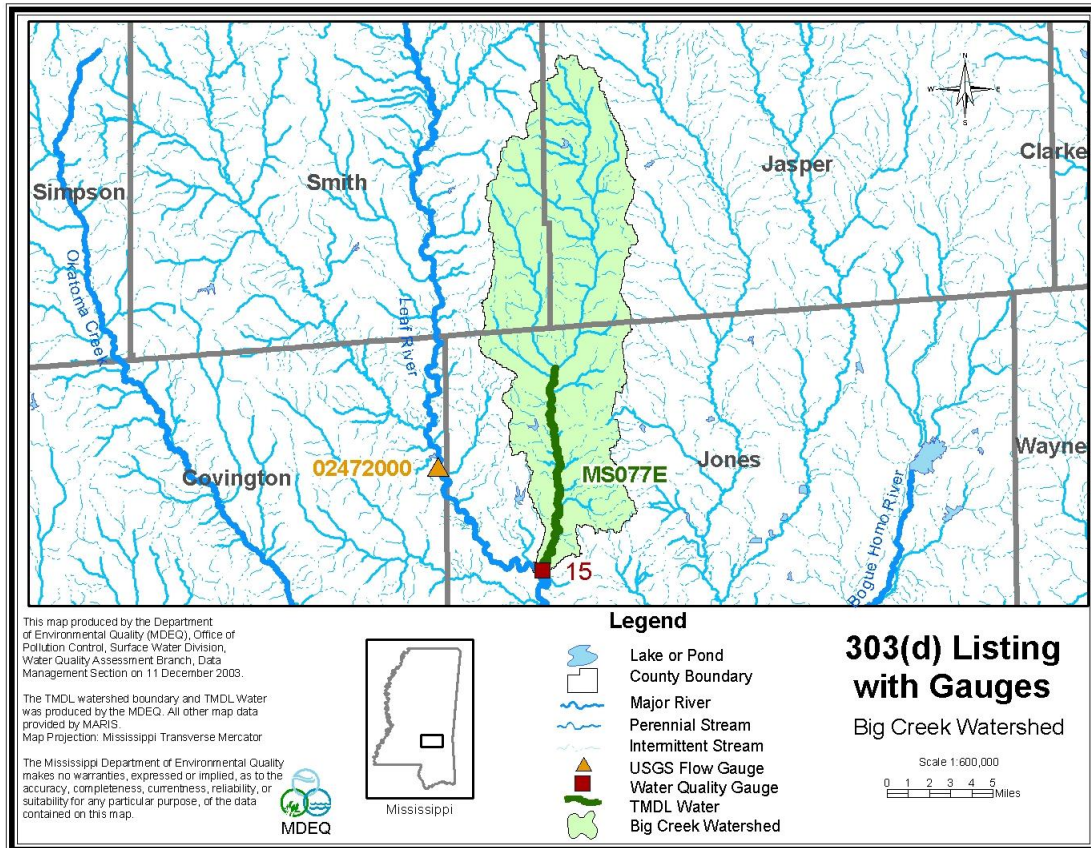
The Big Creek segment is in Hydrologic Unit Code (HUC) 03170004 in southeast Mississippi. The watershed is approximately 78,000 acres. The watershed is primarily rural, but includes some small municipalities. Forest is the dominant landuse within the watershed.

1.2 Applicable Waterbody Segment Use

The water use classification for the listed segment of Big Creek, as established by the State of Mississippi in the *Water Quality Criteria for Intrastate, Interstate and Coastal Waters* regulation, is Fish and Wildlife Support. The designated beneficial uses for Big Creek are Secondary Contact and Aquatic Life Support. Secondary Contact is defined as incidental contact with the water during activities such as wading, fishing and boating, that are not likely to result in full body immersion.

1.3 Applicable Waterbody Segment Standard

The water quality standard applicable to the use of the water body and the pollutant of concern is defined in the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* (2002). The standard for fecal coliform is different for summer and winter for a secondary contact use, where summer is defined as the months of May through October and winter is defined as the months of November through April. For the summer months the fecal coliform colony counts shall not exceed a geometric mean of 200 per 100 ml, based on a minimum of 5 samples taken over a 30-day period with no less than 12 hours between individual samples, nor shall the samples examined during a 30-day period exceed 400 per 100 ml more than 10% of the time. For the winter months, the maximum allowable level of fecal coliform shall not exceed a geometric mean of 2000 colonies per 100 ml, based on a minimum of 5 samples taken over a 30-day period with no less than 12 hours between individual samples, nor shall the samples examined during a 30-day period exceed 4000 per 100 ml more than 10% of the time. The water quality standard was used to assess the data to determine impairment in the water body.

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. Recently, MDEQ established a revision to the fecal coliform standard that allows for a statistical review of any fecal coliform data set. There are two tests, the geometric mean test and the 10% test, that the data set must pass to show acceptable water quality.

The geometric mean test states that for the summer the fecal coliform colony count shall not exceed a geometric mean of 200 per 100 ml based on a minimum of 5 samples taken over a 30-day period with no less than 12 hours between individual samples and for the winter the fecal coliform colony count shall not exceed a geometric mean of 2000 per 100 ml based on a minimum of 5 samples taken over a 30-day period with no less than 12 hours between individual samples. The 10% test states that for the summer the samples examined during a 30-day period shall not exceed a count of 400 per 100 ml more than 10% of the time and for the winter the samples examined during a 30-day period shall not exceed a count of 4000 per 100 ml more than 10% of the time.

2.1.1 Discussion of the Geometric Mean Test

The level of fecal coliform found in a natural water body varies greatly depending on several independent factors such as temperature, flow, or distance from the source. This variability is accentuated by the standard test used to measure fecal coliform levels in the water. The membrane filtration or MF method uses a direct count of bacteria colonies on a nutrient medium to estimate the fecal level. The fecal coliform colony count per 100 ml is determined using an equation that incorporates the dilution and volume to the sample filtered.

The geometric mean test is used to dampen the impact of the large numbers when there are smaller numbers in the data set. The geometric mean is calculated by multiplying all of the data values together and taking the root of that number based on the number of samples in the data set.

$$G = \sqrt[n]{s1 * s2 * s3 * s4 * s5 * sn}$$

The water quality standard requires a minimum of 5 samples be used to determine the geometric mean. MDEQ routinely gathers 6 samples within a 30-day period in case there is a problem with one of the samples. It is conceivable that there would be more samples available in an intensive survey, but typically each data set will contain 6 samples therefore, n would equal 6. For the data set to indicate no impairment, the result must be less than or equal to 200 in summer and 2000 in winter.

2.1.2 Discussion of the 10% Test

The 10% test looks at the data set as representing the 30 days for 100% of the time. The data points are sorted from the lowest to the highest and each value then represents a point on the curve from 0% to 100% or from day 1 to day 30. The lowest value becomes the 1st data point and the highest data point becomes the nth data point. The standard requires that 90% of the time, the counts of fecal coliform in the stream be less than or equal to 400 counts per 100 ml in summer and 4000 counts per 100 ml in winter.

By calculating a concentration of fecal coliform for every percentile point based on the data set, it is possible to determine a curve that represents the percentile ranking of the data set. Once the 90th percentile of the data set has been determined, it may be compared to the standard of 400 counts per 100 ml. If the 90th percentile of the data is greater than 400 then the stream will be considered impaired. This can be used not only to assess actual water quality data, but also computer generated model results. Actual water quality data will typically have 5 or 6 values in the data set, and computer generated model results would have 30 values.

2.1.3 Discussion of Combining the Tests

MDEQ determined a theoretical maximum allowable load data set that meets both portions of the water quality standard and is indicative of possible water quality conditions. This theoretical maximum allowable load data set is shown in Table 1. The theoretical maximum allowable load data set was constructed to represent the maximum amount of fecal coliform per day that will still meet both portions of the water quality standard. The theoretical maximum allowable load data set was then plotted, generating a theoretical maximum allowable load curve. This curve can be seen in Figure 3. The integral of the theoretical maximum allowable load curve is used for mass balance TMDL calculations. By multiplying the integral of the theoretical maximum allowable load curve by the flow in a given water body, the mass balance TMDL can be calculated.

When actual data are collected from a water body, and the data are plotted in a similar way, an existing load can be calculated based on the integral of the existing load curve and the flow in the water body. This existing load can be compared to the TMDL calculated using the theoretical maximum allowable load curve to determine the percent reduction of fecal coliform necessary for the water body to meet both portions of the water quality standard, the geometric mean test and the 10% test.

Table 1. Theoretical Maximum Allowable Load Data Set

Fecal Coliform (counts/100ml)	Percentile Ranking
37.82	0.0%
51.75	3.4%
65.68	6.9%
79.61	10.3%
93.54	13.8%
107.47	17.2%
121.4	20.7%
135.33	24.1%
149.26	27.6%
163.19	31.0%
177.12	34.5%
191.05	37.9%
204.98	41.4%
218.91	44.8%
232.84	48.3%
246.77	51.7%
260.7	55.2%
274.63	58.6%
288.56	62.1%
302.49	65.5%
316.42	69.0%
330.35	72.4%
344.28	75.9%
358.21	79.3%
372.14	82.8%
386.07	86.2%
400	89.7%
400	93.1%
400	96.6%
400	100.0%

Figure 3. Theoretical Maximum Allowable Load Curve
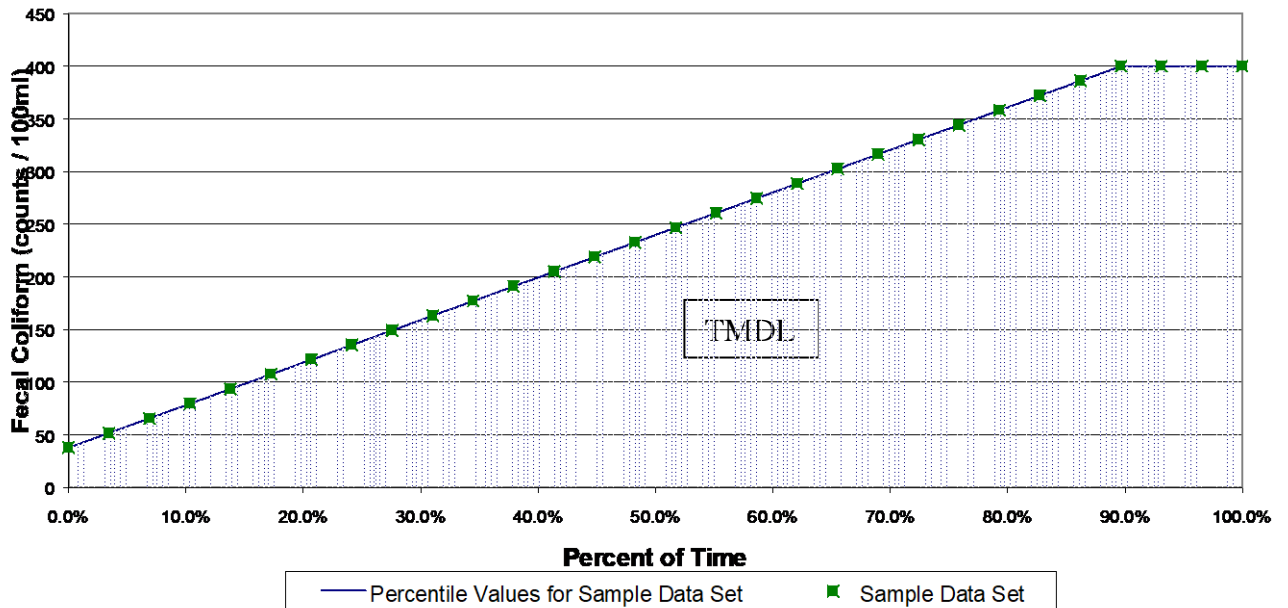
2.1.4 Discussion of the Targeted Endpoint

While the endpoint of a TMDL calculation is similar to a standard for a pollutant, the endpoint is not the standard. For a mass balance TMDL, the endpoint selected is both portions of the standard, that is the geometric mean test and the 10% test. Meeting the geometric mean test and applying the 10% test to the data sets applies both parts of the standard when applied to an actual data set or when considering a computer generated data set. It is therefore appropriate to select both portions of the standard as the targeted endpoint for the mass balance TMDL.

2.1.5 Discussion of the Critical Condition for Fecal Coliform

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 periods of low-flow, low-dilution conditions. Therefore a careful examination of the data is needed to determine the critical 30-day period to be used for the TMDL.

2.2 Discussion of Instream Water Quality

Monitoring was performed in a manner consistent with the water quality standards, at least 5 samples in a 30-day period, at station 15 in segment MS077E during three summer seasons and two winter seasons in 2002 and 2003.

2.2.1 Inventory of Available Water Quality Monitoring Data

The data collected at station 15 is provided in Tables 2 through 6.

Table 2. Fecal Coliform Data reported in Big Creek, Station 15
February and March, 2002, Winter Season

Date and Time	Fecal Coliform (counts/100ml)	Geometric Mean	Geometric Mean Violation	90th Percentile	90th Percentile Violation
2/25/02 10:40	104				
2/28/02 12:05	190		No, geometric mean is less than 2000		No, 90th percentile is less than 4000
3/6/02 11:45	85	198.3		695	
3/8/02 11:45	140				
3/11/02 11:30	230				
3/14/02 11:35	1160				

Table 3. Fecal Coliform Data reported in Big Creek, Station 15
May, 2002, Summer Season

Date and Time	Fecal Coliform (counts/100ml)	Geometric Mean	Geometric Mean Violation	90th Percentile	90th Percentile Violation
5/6/02 11:45	800				
5/8/02 11:40	640				
5/10/02 11:25	480	591.4	Yes, geometric mean is greater than 200	830	Yes, 90th percentile is greater than 400
5/17/02 11:15	460				
5/20/02 11:35	860				
5/23/02 11:30	440				

Table 4. Fecal Coliform Data reported in Big Creek, Station 15
August and September, 2002, Summer Season

Date and Time	Fecal Coliform (counts/100ml)	Geometric Mean	Geometric Mean Violation	90th Percentile	90th Percentile Violation
8/19/02 12:00	1000				
8/21/02 11:55	*740				
8/28/02 11:45	580	420.9	Yes, geometric mean is greater than 200	870	Yes, 90th percentile is greater than 400
8/30/02 11:55	120				
9/3/02 11:40	300				
9/5/02 11:35	>360				

Table 5. Fecal Coliform Data reported in Big Creek, Station 15
March and April, 2003, Winter Season

Date and Time	Fecal Coliform (counts/100ml)	Geometric Mean	Geometric Mean Violation	90th Percentile	90th Percentile Violation
3/24/03 11:55	180				
3/26/03 10:45	120				
3/31/03 11:55	320	415.3	No, geometric mean is less than 2000	1700	No, 90th percentile is less than 4000
4/2/03 11:45	330				
4/14/03 11:50	900				
4/16/03 12:25	2500				

Table 6. Fecal Coliform Data reported in Big Creek, Station 15
July and August, 2003, Summer Season

Date and Time	Fecal Coliform (counts/100ml)	Geometric Mean	Geometric Mean Violation	90th Percentile	90th Percentile Violation
7/28/03 11:50	183				
7/30/03 12:00	>600				
8/1/03 11:45	3300	676.3	Yes, geometric mean is greater than 200	4650	Yes, 90th percentile is greater than 400
8/11/03 12:05	100				
8/15/03 11:30	>6000				
8/18/03 12:00	440				

2.2.2 Analysis of Instream Water Quality Monitoring Data

For segment MS077E, the data collected at station 15 during the three summer season monitoring periods indicate violation of the geometric mean portion of the standard and the percent of time in exceedence portion of the standard. A graphical representation can be seen in Figures 6, 7, and 8 below. A line has been added to the graph representing 400 counts/100 ml and showing that this occurs less than 90% of the time, meaning that the counts of fecal coliform in the stream is greater than 400 more than 10% of the time. However, the data collected during the two winter monitoring periods indicated no violations of either portion of the standard. Since the violations occurred during the summer seasons, it is considered the critical period for Big Creek.

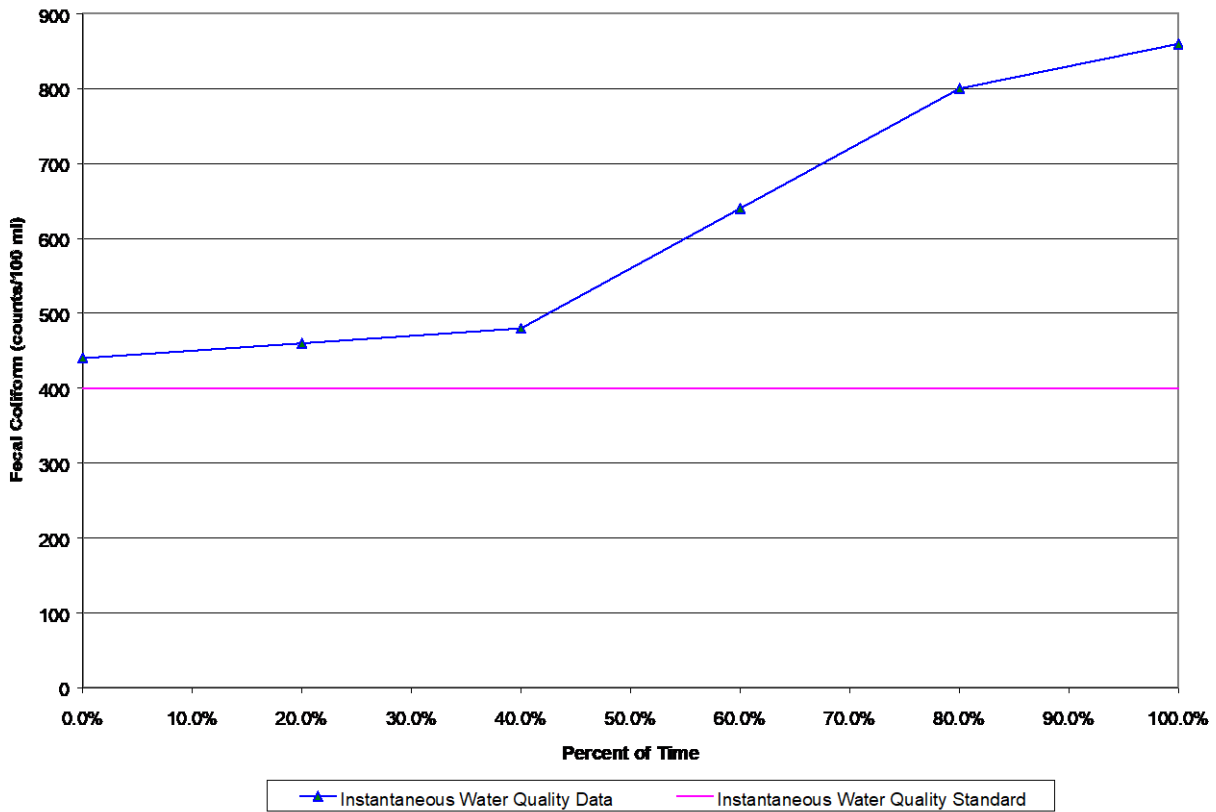**Figure 5. Existing Load Curve for Station 15, May 2002**

Figure 6. Existing Load Curve for Station 15, August and September 2002
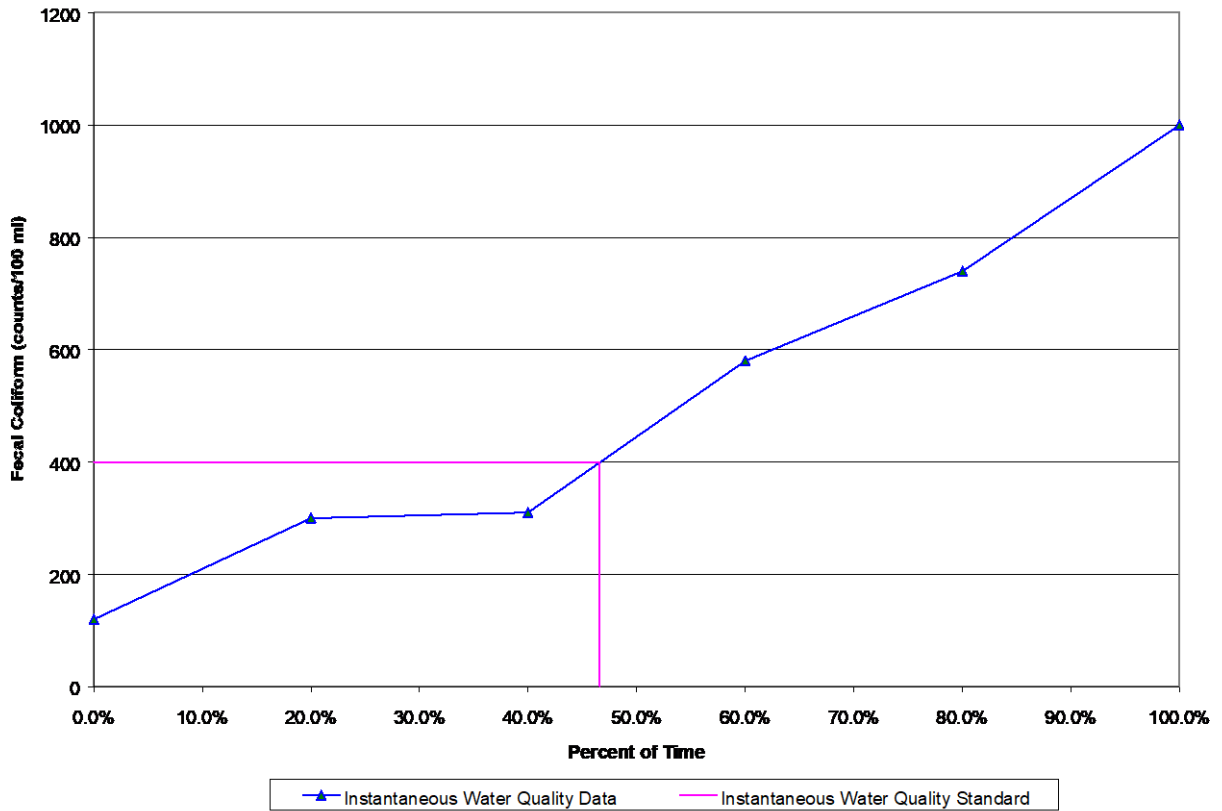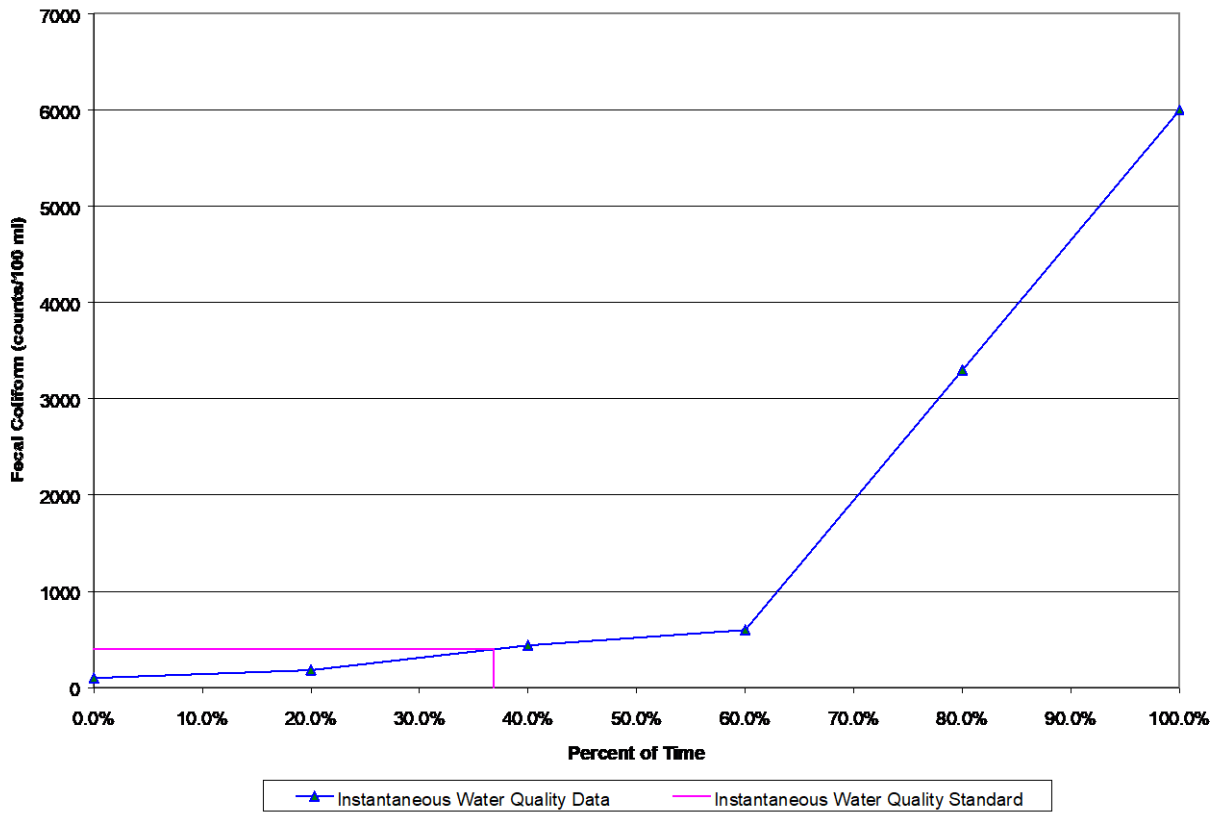
Figure 7. Existing Load Curve for Station 15, July and August 2003

SOURCE ASSESSMENT

The TMDL evaluation summarized in this report examined all known potential fecal coliform sources in the Big Creek Watershed. In evaluation of the sources, loads were 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.

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

Once the permitted dischargers were located, the effluent 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 effluents because they report measurements of flow and fecal coliform present in effluent samples. If evidence of insufficient treatment existed or when data were not available, professional judgement was used to estimate a fecal coliform loading rate for the calculations. The facilities are shown in Table 7.

Table 7. Inventory of Point Source Dischargers

NPDES ID	Facility Name	Receiving Water	Design Flow (MGD)
MS0027685	Bay Springs POTW	Ettehoma Creek	0.4
MS0037672	Polk's Meat Products Inc.	Roaring Creek	0.015
MS0051381	SoSo Quick Stop	Spring Creek	0.001

3.2 Assessment of Nonpoint Sources

There are many potential nonpoint sources of fecal coliform bacteria for Big Creek, including:

♦ Failing septic systems
♦ Wildlife
♦ Land application of hog and cattle manure
♦ Grazing animals
♦ Land application of poultry litter
♦ Other Direct Inputs
♦ Urban development

The 78,000 acre drainage area of Big Creek contains many different landuse types, including urban, forest, cropland, pasture, and wetlands. The landuse distribution for the watershed is provided in Table 8 and displayed in Figure 8. The landuse information for the watershed is based on the State of Mississippi's Automated Resource Information System (MARIS), 1997. This data set is based 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. The landuse categories were grouped into the landuses of urban, forest, cropland, pasture, barren, and wetlands.

Table 8. Landuse Distribution (acres)

	Urban	Forest	Agriculture	Barren	Wetland	Water	Total
Area (acres)	236	38,168	25,159	131	13,633	716	78,043
% Area	0%	49%	32%	0%	18%	1%	100%

Figure 8. Landuse Distribution Map for the Big Creek Watershed
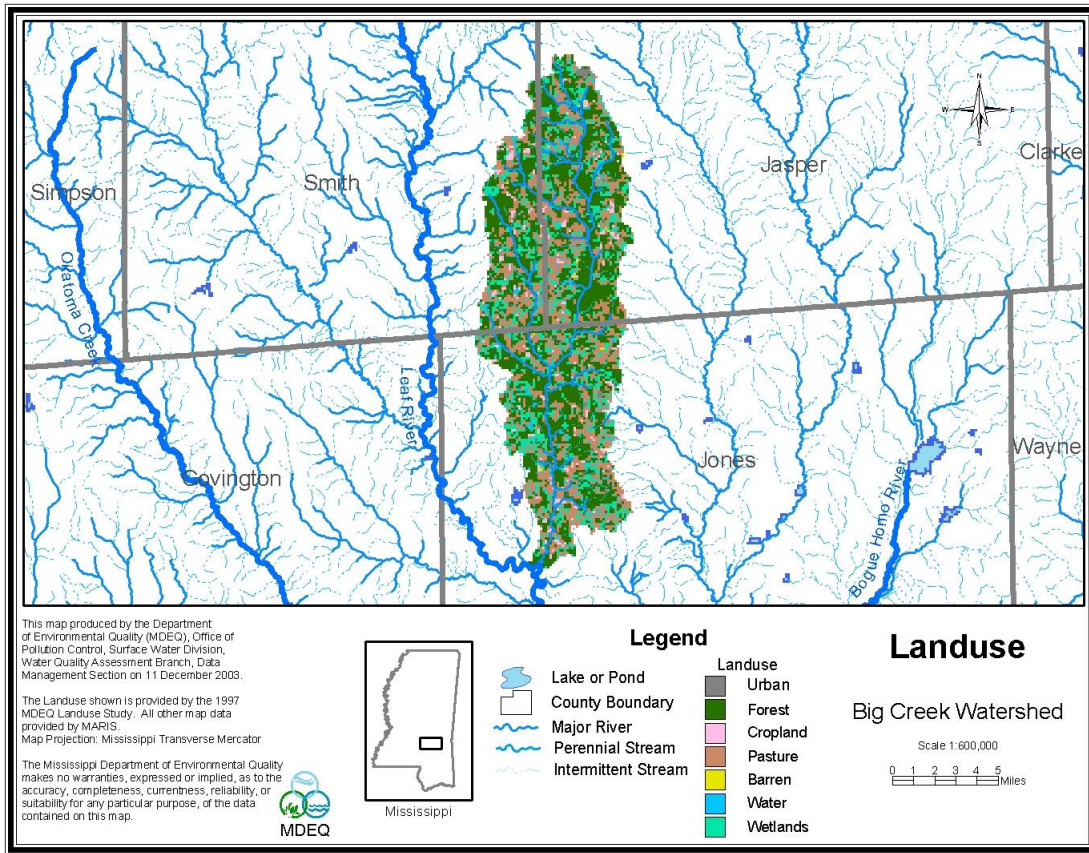
The MARIS landuse data for Mississippi was utilized by the Watershed Characterization System (WCS) to extract landuse sizes, populations, and agriculture census data. MDEQ contacted several agencies to refine the assumptions made in determining the fecal coliform loading. The Mississippi Department of Wildlife, Fisheries, and Parks provided information of wildlife density in the Magees Creek 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, poultry farms, and beef and dairy operations.   The Natural Resources Conservation Service gave MDEQ information on agricultural 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 when 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. In an effort to keep the water off the land, pipes are occasionally placed from the septic tank or the field lines directly to the creek.

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 sort of disinfection to properly operate. When this expense is ignored, the water does not receive adequate disinfection prior to release.

Septic systems have an impact on nonpoint source fecal coliform impairment in the Pascagoula River Basin. The best management practices needed to reduce this pollutant load need to prioritize eliminating septic tank failures and improving maintenance and proper use of individual onsite treatment systems.

3.2.2 Wildlife

Wildlife present in the Big Creek Watershed contributes to fecal coliform bacteria on the land surface. 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 manure produced by the wildlife was evenly distributed throughout these land types.

3.2.3 Beef and Dairy Cattle

Large dairy farms, over 200 head, typically confine the milking herd at all times. Smaller dairy farms confine the lactating cattle for a limited time during the day for milking and feeding. The manure collected during confinement is applied to the available pastureland in the watershed. Application rates of dairy cow manure to pastureland vary monthly according to management practices currently used in this area.

Grazing cattle deposit manure on pastureland where it is available for wash-off and delivery to receiving water bodies. Beef cattle are assumed to have access to pastureland for grazing all of the time. For dairy cattle, the dry cattle and heifers are assumed to have access to pastureland for grazing all of the time. The small dairy farms, less than 200 head, in the Pascagoula River Basin confine the lactating cattle for a limited time during the day. During all other times, the lactating cattle at small dairies are assumed to have access to pastureland for grazing. The milking herd is assumed to make up approximately 80% of the total herd. Manure produced by grazing beef and dairy cows is directly deposited onto pastureland and is available for wash off.

The manure produced by confined dairy cows is collected in lagoons and spray applied to available

pastureland in the watershed. Large dairy farms, more than 200 head, typically confine the milking herd at all times. Smaller dairy farms confine the lactating cattle for a limited time during the day for milking and feeding. Application rates of dairy cow manure to pastureland vary monthly according to management practices currently used in this area.

3.2.4 Land Application of Poultry Litter

Predominantly, two kinds of chickens are raised on farms in the Pascagoula River 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. Broiler chickens are confined in poultry houses all of the time. Typically, the dry waste accumulated in the poultry houses is "de-caked" between flocks unless a disease situation warrants clean-out before the change of flocks. During "de-caking", approximately the top two inches of litter is removed. The majority of the litter is used as a fertilizer on hay and row crops and may be used in areas of the state other than the location of the poultry houses. The litter is applied in the spring, summer, and early fall and rates are determined by a phosphorous index.

Layer chickens are confined at all times and remain on farms for ten months or longer. Large scale layer operations collect the chicken waste in a lagoon and periodically spray apply the waste to corn fields. The application rates vary monthly from the spring through the early fall.

3.2.5 Other Direct Inputs

Due to the general topography in the Pascagoula River Watershed, it was assumed that land slopes in the watershed are such that unconfined animals are able to access the intermittent streams in the watershed. This direct input of cattle manure represents animal access to streams (domestic and wild), illicit discharges of fecal coliform bacteria, human recreation, and leaking sewer collection lines.

3.2.6 Urban Development

Urban areas include land classified as urban and barren. Even though only a small percentage of the watershed is classified as urban, the contribution of the urban areas to fecal coliform loading in the Big Creek Watershed was considered. Fecal coliform contributions from urban areas may come from storm water runoff, failing sewer pipes, and runoff contribution from improper disposal of materials such as litter.

MASS BALANCE PROCEDURE

Establishing the relationship between the instream water quality target and the source loading 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

A mass balance approach was used to calculate the TMDL for segment MS077E. This method of analysis was selected because data limitations precluded the use of more complex methods. The mass balance approach is suitable for this TMDL

4.2 Calculation of Load

The mass balance approach utilizes the conservation of mass principle. Loads can be calculated by multiplying the fecal coliform concentration in the water body for a 30-day period by the flow. The principle of the conservation of mass allows for the addition and subtraction of those loads to determine the appropriate numbers necessary for the TMDL. The loads can be calculated using the following relationship:

Load (counts/30days) = [**Concentration for 30 days** (30 days*counts/ 100 ml)] * [**Flow** (cfs)] * (Conversion Factor)

$$\text{where (Conversion Factor)} = [(28316.8 \text{ ml}/1 \text{ ft}^3)*(1 \ (100 \text{ ml})/100 \ (1 \text{ ml}))*(60 \text{ s}/1 \text{ min})*$$
$$(60 \text{ min}/1 \text{ hour})*(24 \text{ hour}/1 \text{ day})*(30 \text{ days}/1 \ (30 \text{ days})/30 \text{ days}]$$
$$= 2.45 \text{ E}+07 \ ((100 \text{ ml} * \text{s})/(\text{ft}^3 *30 \text{ days}*30\text{days}))$$

For the calculation of this TMDL, the concentration for 30 days used was the integral of the theoretical maximum allowable load curve as shown in Section 2.1.3. This value is 7129.4 (30days*counts/100 ml). USGS flow gage 02472000 was used to estimate the flow for segment MS077E. The average summer discharge at the flow gage was calculated by averaging the USGS monthly mean stream flows for the summer period (May through October) for the period of record of the gage. The average winter discharge at the flow gage was calculated accordingly. The average summer flow was estimated to be 79.7 cfs based on the average summer discharge at station 02472000 on the Leaf River near Collins, Mississippi. (Telis). This method was also used to calculate the average winter discharge.

Avg Seasonal Discharge (cfs)={[**02472000 Avg Seasonal Discharge** (cfs)]/[**02472000 Drainage Area** (acres)]}*[**MS077E Drainage Area** (acres)]

Avg Summer Discharge (cfs) = {[**486** (cfs)]/[**475,518** (acres)]}*[**78,043** (acres)]

Avg Summer Discharge (cfs) = **79.7** cfs

4.3 Calculation of Existing Load

For the calculation of the existing load, the daily streamflow was multiplied by the fecal coliform concentration for the dates the water quality samples were taken to get a daily load. The integral of this daily load over 30 days was then multiplied by the conversion factor to get the existing load.

Table 9. Existing Load
May, 2002

Date and Time	Fecal Coliform (counts/100ml)	Flow (cfs)	Existing Load (counts/30days
5/6/02 11:45	800	40	
5/8/02 11:40	640	36	
5/10/02 11:25	480	33	
5/17/02 11:15	460	29	1.52E+13
5/20/02 11:35	860	34	
5/23/02 11:30	440	28	

Table 10. Existing Load
August and September, 2002

Date and Time	Fecal Coliform (counts/100ml)	Flow (cfs)	Existing Load (counts/30days
8/19/02 12:00	1000	26	
8/21/02 11:55	740	27	
8/28/02 11:45	580	22	
8/30/02 11:55	120	21	8.52E+12
9/3/02 11:40	300	18	
9/5/02 11:35	360	17	

Table 11. Existing Load
July and August, 2003

Date and Time	Fecal Coliform (counts/100ml)	Flow (cfs)	Existing Load (counts/30days
7/28/03 11:50	183	65	
7/30/03 12:00	600	60	
8/1/03 11:45	3300	71	
8/11/03 12:05	100	98	1.19E+14
8/15/03 11:30	6000	210	
8/18/03 12:00	440	67	

ALLOCATION

The allocation for this TMDL includes a wasteload allocation (WLA) for point sources, a load allocation (LA) for nonpoint sources, and a margin of safety (MOS).

5.1 Wasteload Allocations

The wasteload allocation is based on the existing point sources in the Big Creek Watershed. The point sources in segment MS077E and their allocated load are shown in Table 12. Table 12 also shows the current permit limits of the NPDES permitted dischargers in the watershed. The first value is the average fecal coliform concentration that the facility my discharge and the second is the maximum fecal coliform concentration that the facility may discharge. While the allocated loads included in the TMDL calculation are based upon the permit limit of the average allowable concentration, the maximum portion of the permit limit is still allowable and does not indicate any permit modification is necessary. The point sources that are recommended for permit modification to include fecal coliform limits and disinfection are also indicated in Table 12.

Table 12. Wasteload Allocations for Segment MS077E

NPDES ID	Summer Permit Limit Average/Maximum (counts/100ml)	Winter Permit Limit Average/Maximum (counts/100ml)	Summer Allocated Load (counts/30days)	Winter Allocated Load (counts/30days)	Permit Modification Necessary
MS0027685	200 / 400	2000 / 4000	9.09E+10	9.09E+11	No
MS0037672	200 / 400	200 / 400	3.41E+09	3.41E+09	No
MS0051381	200 / 400	200 / 400	2.27E+08	2.27E+08	No
Total			9.45E+10	9.13E+11	

5.2 Load Allocations

The load allocation for segment MS077E is calculated using the water quality criteria and the estimated critical flow. In calculating the LA component, the total TMDL for the water body is reduced by a 10 percent MOS. For this TMDL, the summer load is based on a fecal coliform concentration for 30 days determined by the area under a curve that meets both portions of the standards for a 30 sample data set and the average summer flow of 79.7 cfs. The resulting summer LA is estimated to be 1.24E+13 counts/30 days. The resulting winter LA is estimated to be 4.32E+13 counts/30 days using the average winter flow.

Summer

LA = 0.9*7129.4(30 days*counts/100ml)* 79.7(cfs) * 2.45E+07[(100ml*s)/(ft^3 *30 days*30 days)] – 9.45E+10(counts for 30 days)
LA = 1.24E+13 (counts for 30 days)

<u>Winter</u>

LA = 0.9*7129.4(30 days*counts/100ml)* 280.7(cfs) * 2.45E+07[(100ml*s)/(ft^3 *30 days*30
      days)] – 9.13E+11(counts for 30 days)
LA = 4.32E+13 (counts for 30 days)

5.3 Incorporation of a Margin of Safety (MOS)

The two types of MOS development are to implicitly incorporate the MOS using conservative assumptions or to explicitly specify a portion of the total TMDL as the MOS. For segment MS077E, reducing the TMDL by 10 percent explicitly specifies the MOS. Assuming the average summer flow, the resulting load attributed to the MOS for the summer is 1.39E+12 counts/30 days.

<u>Summer</u>

MOS = 0.1*7129.4(30 days*counts/100ml)* 79.7(cfs) * 2.45E+07[(100ml*s)/(ft^3*30 days*30
      days)]
MOS = 1.39E+12 (counts for 30 days)

<u>Winter</u>

MOS = 0.1*7129.4(30 days*counts/100ml)* 280.7(cfs) * 2.45E+07[(100ml*s)/(ft^3*30 days*30
      days)]
MOS = 4.90E+12 (counts for 30 days)

5.4 Calculation of the TMDL

The TMDL for segment MS077E is calculated based on the following equation:

$$TMDL = WLA + LA + MOS$$

where WLA is the Waste Load Allocation, LA is the Load Allocation, and MOS is the Margin of Safety.

WLA = NPDES Permitted Facilities

LA = Surface Runoff + Other Direct Inputs

MOS = explicit

The summer TMDL for segment MS077E was calculated based on the average summer flow of the watershed, and a fecal coliform concentration for 30 days determined by the area under a curve that meets both portions of the standards for a 30-sample data set. The resulting summer percent reduction of fecal coliform to segment MS077E is 88% based on the existing load for July and August, 2003. The winter TMDL was calculated based on the average winter flow of the watershed, and a fecal coliform concentration for 30 days determined by the area under a curve that meets both portions of the standards for a 30-sample data set.

Summer

TMDL = 7129.4(30 days*counts/100ml)* 79.7(cfs) * 2.45E+07[(100ml*s)/(ft^3*30 days*30
     days)]
TMDL = 1.39E+13 (counts for 30 days)

Winter

TMDL = 7129.425(30 days*counts/100ml)* 280.7(cfs) * 2.45E+07[(100ml*s)/(ft^3*30 days*30
     days)]
TMDL = 4.90E+13 (counts for 30 days)

Table 13. TMDL Summary for Segment MS077E (counts/30 days)

	Summer	Winter
WLA	9.45E+10	9.13E+11
LA	1.24E+13	4.32E+13
MOS	1.39E+12	4.90E+12
TMDL = WLA + LA +MOS	**1.39E+13**	**4.90E+13**

5.5 Seasonality

For many streams in the state, fecal coliform limits vary according to the seasons. This stream is designated for the use of secondary contact. For this use, the fecal coliform standard is seasonal. The criteria for the most critical season, which is the summer for Big Creek, was used as the target for this TMDL.

MDEQ used the average summer flow for calculating the summer TMDL and the average winter flow for calculating the winter TMDL; therefore, the season differences are incorporated in the seasonal average flow values.

5.6 Reasonable Assurance

This component of TMDL development does not apply to this TMDL Report. There are no point sources (WLA) requesting a reduction based on promised Load Allocation components and reductions. This TMDL will recommend that all point sources discharge treated and disinfected effluent that will be below the 200 colony counts per 100-ml. target at the end of their discharge pipe.

CONCLUSION

The fecal coliform reduction scenario used in this TMDL included requiring all NPDES Permitted dischargers of bacteria to meet water standards for fecal coliform at the end of their discharge pipe. 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. 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 River Basin, Big Creek may receive additional monitoring to identify any change in water quality. MDEQ produced guidance for future Section 319 project funding will encourage NPS restoration projects that attempt to address TMDL related issues within Section 303(d)/TMDL watersheds in Mississippi.

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. MDEQ also distributes all TMDLs prior to the beginning of the public notice to those members of the public who have requested to be included on a TMDL email list. Anyone wishing to be included on the TMDL email list should contact Greg Jackson at (601) 961-5098 or Greg_Jackson@deq.state.ms.us. 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 meeting. All written comments received during the public notice period and at any public meeting become a part of the record of this TMDL. All comments will be considered in the ultimate completion of this TMDL for submission of this TMDL to EPA Region 4 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 natural body of water to receive wastewaters or toxic materials without deleterious effects and without damage to aquatic life or humans who use the water.

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 water body may be based upon a similar, unaltered or least impaired, water body 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 water body.

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 24-hour period that reasonably represents the 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 discharge is calculated as the average measurement of the pollutant over the day.

Designated Uses: (1) those uses specified in the water quality standards for each water body or segment whether or not they are being attained. (2) those water uses identified in state water quality standards which must be achieved and maintained as required under the Clean Water Act. Uses can include public water supply, recreation, etc.

Discharge monitoring report (DMR): the EPA uniform national form, including any subsequent additions, revisions, or modifications for the reporting of self-monitoring results by permittees.

Effluent: wastewater – treated or untreated – that flows out of a treatment plant or industrial outfall. Generally refers to wastes discharged into surface waters.

Effluent limitation: (1) any restriction established by a State or the Administrator on quantities, rates, and concentrations of chemical, physical, biological, and other constituents which are discharged from point sources into navigable waters, the waters of the contiguous zone, or the ocean, including schedules of compliance. (2) restrictions established by a State or EPA on quantities, rates, and concentrations in wastewater discharges.

Effluent standard: any effluent standard or limitation, which may include a prohibition of any discharge, established or proposed to be established for any toxic pollutant under section 307(a) of the Act.

Fecal Coliform Bacteria: (1) those organisms associated with the intestines of warm-blooded animals that are commonly used to indicate the presence of fecal material and the potential presence of organisms capable of causing human disease. (2) bacteria found in the intestinal tracts of mammals. Their presence in water or sludge is an indicator of pollution and possible contamination by pathogens.

Geometric mean: the nth root of the production of n factors. A 30-day geometric mean is the 30th root of the product of 30 numbers.

Impaired Water Body: any water body 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 that is attributed either to one of its existing or

future nonpoint sources of pollution or to natural background sources. Load allocations are best estimates of the loading, which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible, natural and nonpoint source loads should be distinguished.

Loading: the introduction of waste into a waste management unit but not necessarily to complete capacity.

Mass Balance: a concept based on a fundamental law of physical science (conservation of mass) which says that matter can not be created or destroyed. It is used to calculate all input and output streams of a given substance in a system.

Model: a quantitative or mathematical representation or computer simulation which attempts to describe the characteristics or relationships of physical events.

National pollutant discharge elimination system (NPDES): the national program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements, under section 307, 402, 318, and 405 of the Clean Water Act.

Nonpoint Source: the pollution sources which generally are not controlled by establishing effluent limitations under section 301, 302, and 402 of the Clean Water Act. Nonpoint source pollutants are not traceable to a discrete identifiable origin, but generally result from land runoff, precipitation, drainage, or seepage.

Outfall: the point where an effluent is discharges into receiving waters

Point Source: a stationery location or fixed facility from which pollutants are discharges or emitted. Also, any single identifiable source of pollution, e.g., a pipe, ditch, ship, ore pit, factory smokestack.

Pollution: generally, the presence of matter or energy whose nature, location or quanitity produces undesired environmental effects. Under the Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical, biological, and radiological integrity of water.

Publicly Owned Treatment Works (POTW): the treatment works treating domestic sewage that is owned by a municipality or State.

Regression: a relationship of y and x in a finction of $y = f(x)$, where: y is the expected value of an independent random variable x. The parameters in the function $f(x)$ are determined by the method of least squares. When $f(x)$ is a linear function of x, the term linear regression is used.

Regression Coefficient: a quantity that describes the slope and intercept of a regression line.

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: $2.7 \times 10^4 = 2.7E+4 = 27000$ and $2.7 \times 10^{-4} = 2.7E-4 = 0.00027$.

Sigma (Σ): shorthand way to express taking the sum of a series of numbers. For example, the sum or total of three amounts 24, 123, 16, (d_1, d_2, 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: (1) the calculated maximum permissible pollutant loading introduced to a water body such that any additional loading will produce a violation of water quality standards. (2) the sum of the individual waste load allocations and load allocations. A margin of safety is included with the two types of allocations so that any additional loading, regardless of source, would not produce a violation of water quality standards.

Waste: (1) useless, unwanted or discarded material resulting form (agricultural, commercial, community and industrial) activities. Wastes include solids, liquids, and gases. (2) any liquid resulting from industrial, commercial, mining, or agricultural operations, or from community activities that is discarded or is being accumulated, stored, or physically, chemically, or biologically treated prior to being discarded or recycled.

Wasteload allocation (WLA): (1) the portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water quality based effluent limitation. (2) the portion of a receiving water's total maximum daily load that is allocated to one of its existing or future point source of pollution. (3) the maximum load of pollutants each discharger of waste is allowed to release into a particulat waterway. Discharge limits are usually required for each specific water quality criterion being, or expected to be, violated. The portion of a stream's total assimilative capacity assigned to an individual discharge.

Water Quality Standards: State-adopted and EPA-approved regulations mandated by the Clean Water Act and specified in 40 CFR 131 that describe the designated uses of a water body, the numeric and narrative water quality criteria designed to protect those uses, and an antidegredation statement to protect existing levels of water quality. Standards are designed to safeguard the public health and welfare, enhance the quality of water and serve the purposes of the Clean Water Act.

Water quality criteria: numeric water quality values and narrative statements which are derived to protect designated uses. Numeric criteria are scientifically-derived ambient concentrations developed by EPA or States for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal. Ambient waters that meet applicable water quality criteria are considered to support their designated uses.

Waters of the State: all waters within the jurisdiction of this State, including all streams, lakes, ponds, wetlands, impounding reservoirs, marshes, watercourses, waterways, wells, springs, irrigation systems, drainage systems, and all other bodies or accumulations of water, surface and underground, natural or artificial, situated wholly or partly within or bordering upon the State, and such coastal waters as are within the jurisdiction of the State, except lakes, ponds, or other surface waters which are wholly landlocked and privately owned, and which are not regulated under the Federal Clean Water Act (33 U.S.C.1251 et seq.).

Watershed: (1) the land area that drains (contributes runoff) into a stream. (2) the land area that drains into a stream; the watershed for a major river may encompass a number of smaller watersheds that ultimately combine at a common delivery point.

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

CWA ....Clean Water Act

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

RF3... Reach File 3

USACOE... United States Army Corps of Engineers

USGS .... United States Geological Survey

WLA ....Waste Load Allocation

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