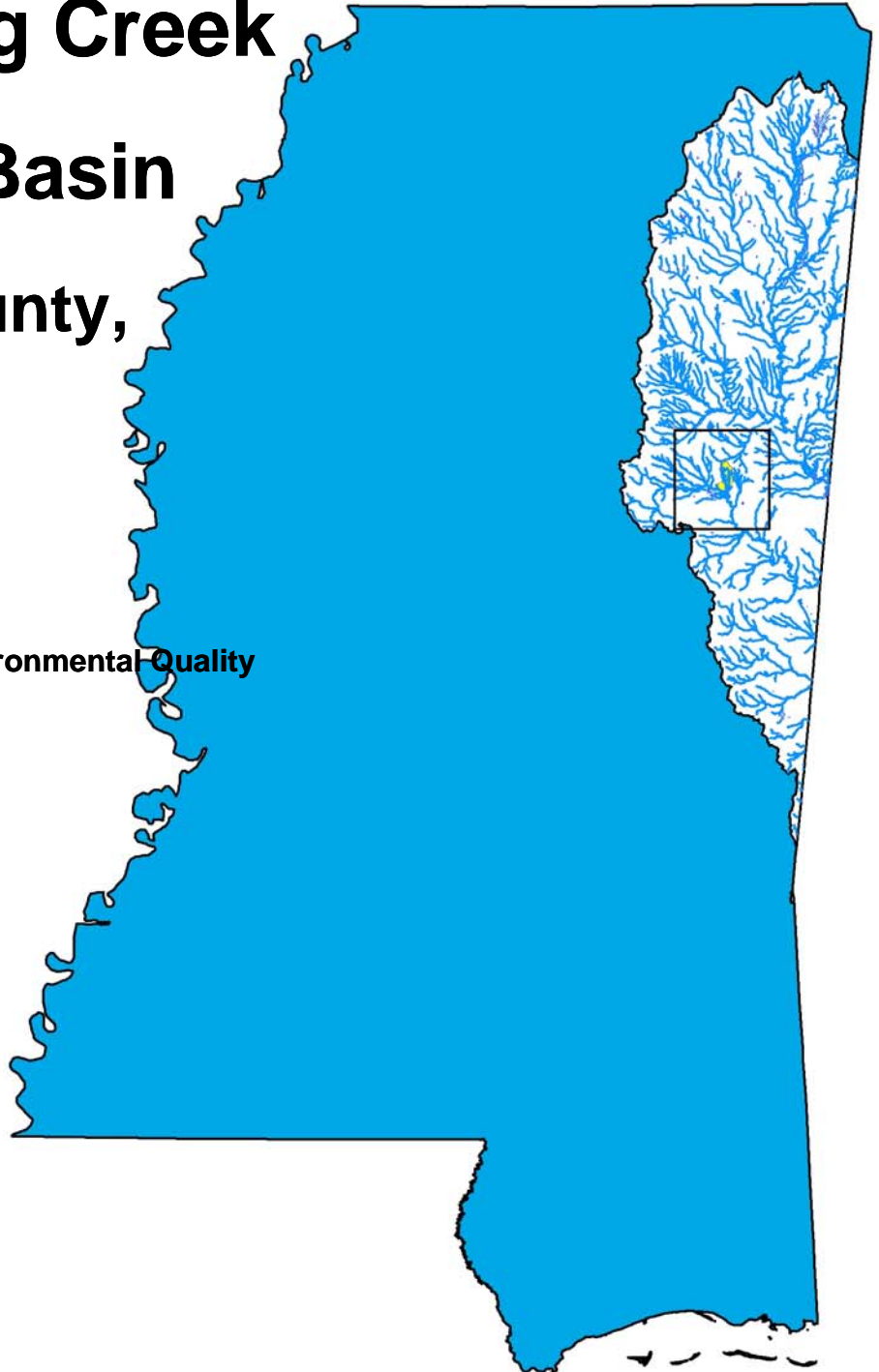


FINAL REPORT
August 2006
ID: 806080904

Fecal Coliform TMDL for Browning Creek

Tombigbee Basin

Oktibbeha County, 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 water body 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 is 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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TMDL INFORMATION PAGE

Listing Information

Name	ID	County	HUC	Cause	Mon/Eval
Browning Creek ¹	MSTB038R00_010	Oktibbeha	03160108	Pathogens	Monitored
Near Oktoc from headwaters to confluence with Noxubee River					

¹ Listed in 2004 Based on Water Quality Data

Water Quality Standard

Parameter	Beneficial use	Water Quality Criteria
Pathogens	Secondary Contact	<p>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% of the time.</p> <p>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% of the time.</p>

NPDES Facilities

NPDES ID	Facility Name	Receiving Water
MS0052892	Browning Creek Development	Tributary of Browning Creek
MS0038601	Oktibbeha County Schools, Moor High School	Browning Creek

Browning Creek

Season	WLA (counts per 30 days)	LA (counts per 30 days)	MOS (counts per 30 days)	Total TMDL (counts per 30 days)
Summer	2.54E+10	1.44E+12	1.62+11	1.62E+12
Winter	2.54E+10	6.22E+12	6.93E+11	6.93E+12

EXECUTIVE SUMMARY

A fecal coliform TMDL has been developed for Browning Creek watershed in Oktibbeha County, Mississippi. Two of the four data sets collected at this location indicated impairment due to pathogens. Therefore, this water body segment, MSTB038R00_010 was added to the Mississippi 2004 Section 303(d) List of Impaired Water Bodies. All 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 for monitoring and TMDL development.

Browning Creek flows in a southerly direction from its headwaters near Oktoc and Chapel Hill roads to its confluence with the Noxubee River in Noxubee County. This TMDL has been developed for Browning Creek from the headwaters to the confluence with the Noxubee River. Due to data limitations, complex dynamic modeling was inappropriate for performing the TMDL allocations for this study, as were load duration curves. Therefore, a mass balance approach was used to develop the TMDL for the three water body segments.

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 watershed. Browning Creek Development (MS0052892) and Oktibbeha County Schools, Moor High School (MS0038601) are the only NPDES permitted facilities that discharge to Browning Creek. Since the current loading exceeds the assimilative capacity of Browning Creek, a permit limit for fecal coliform is recommended for the Moor High School facility. This TMDL will recommend that Moor High School begin disinfection to meet a standard of 200 for fecal coliform in the next permitting cycle. Monitoring of this facility should continue to ensure that compliance with permit limits is consistently attained. Nonpoint sources of fecal coliform include wildlife and livestock. Also considered were the nonpoint sources such as failing septic systems, leaking sewer lines, sewer bypasses, and other direct inputs to Browning Creek.

The seasonal variations in hydrology, climatic conditions, and watershed activities are represented through the use of seasonal average flows and seasonal monitoring. The critical period for Browning Creek was determined to be in the summer due to the fact that violations of both portions of the standard occurred but no violations occurred in the winter seasons.

The TMDL for Browning Creek was calculated using a mass balance procedure. In order to account for uncertainty in the mass balance procedure an explicit 10% margin of safety (MOS) was used. The estimated reduction of fecal coliform is 38%.

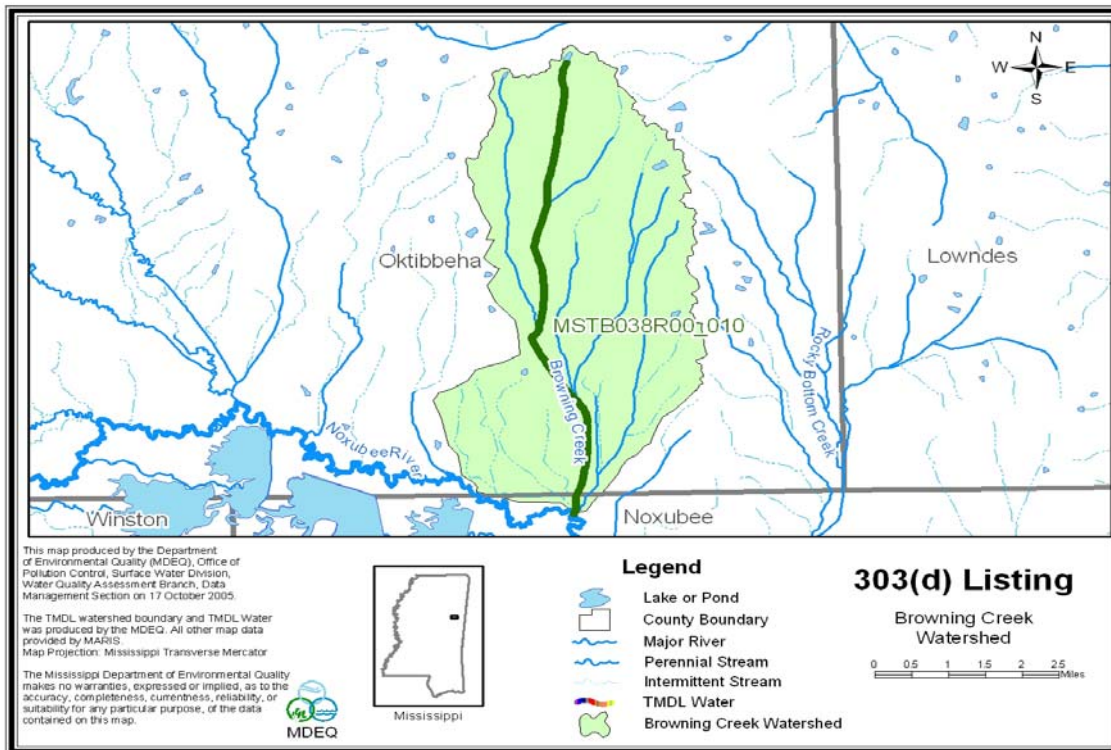
INTRODUCTION

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 pathogens as indicated by fecal coliform. Fecal coliform bacteria are used as indicator organisms because they are readily identifiable and indicate the possible presence of other pathogenic organisms in the water body. 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.

Browning Creek is a 7.53 mile segment that flows in a southerly direction from its headwaters near Oktoc and Chapel Hill roads to its confluence with the Noxubee River. The 303(d) segment for Browning Creek is shown in Figure 1.

Figure 1. Browning Creek 303(d) segment

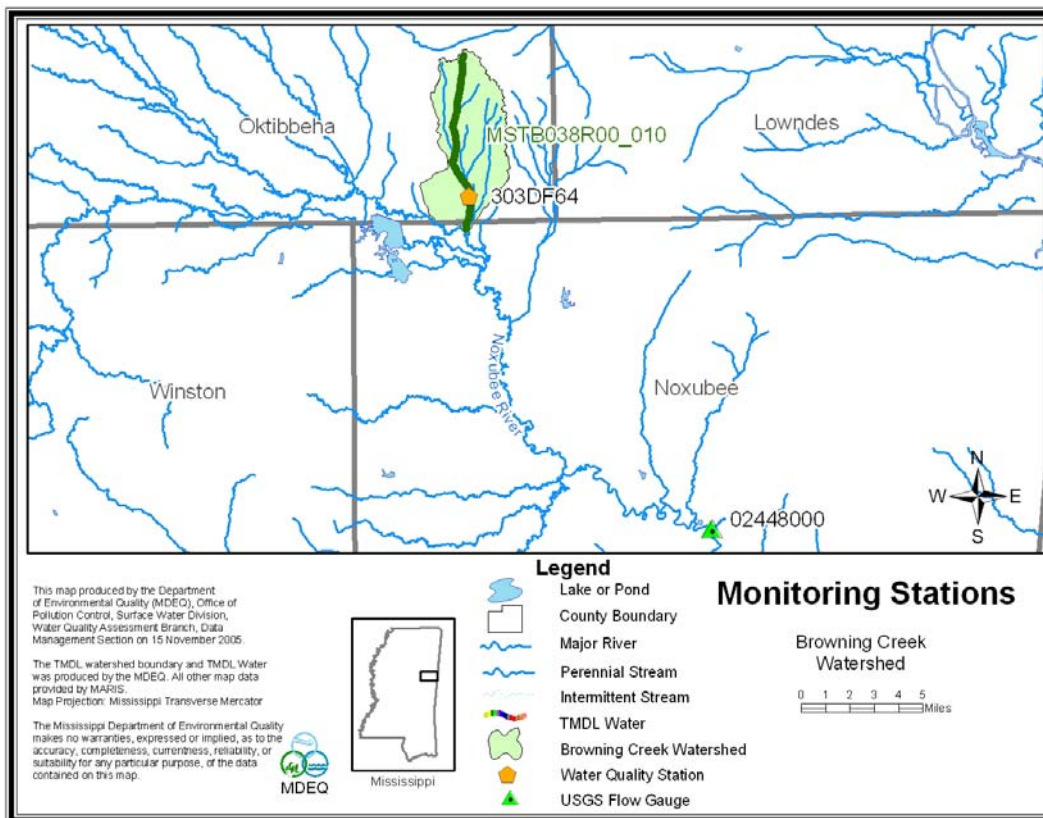


FECAL COLIFORM TMDL FOR BROWNING CREEK

Browning Creek was originally listed in the Mississippi 2004 Section 303(d) List of Impaired Water Bodies for pathogens. Two of the four data sets collected at this location indicated impairment due to pathogens. All available data are listed in Section 2.2.

This TMDL was developed using a mass balance method. This method is an applicable method for TMDL development when water quality data are collected in a manner consistent with water quality standards, that is at least 5 samples collected within a 30 day period. The mass balance method requires water quality data and flow data. The water body segment along with the location of the water quality stations and flow gage are shown in Figure 2. The TMDL for Browning Creek was developed using the mass balance method with water quality data from the fecal coliform sampling stations. The flow for Browning Creek was determined based on the flow measured at USGS gage 02448000 on the Noxubee River at Highway 45 near Macon, MS.

Figure 2. Water Body Segments with Water Quality Stations and Flow Gage



Browning Creek is in Hydrologic Unit Code (HUC) 03160108 in northeast Mississippi. The watershed is approximately 11,443 acres. The majority of the land area within the watershed is rural in nature.

1.2 Applicable Water Body Segments Use

The water use classification for the water body segment, as established by the State of

Mississippi in the 2002 *Water Quality Criteria for Intrastate, Interstate and Coastal Waters*, is Fish and Wildlife Support. The designated beneficial use for the water body segment is 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 Water Body Segments Standard

The water quality standard applicable to the water body based on the identified use 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 fecal coliform colony counts 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.

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 fecal coliform standard 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. In accordance with EPA guidance, MDEQ collects fecal samples during dry weather periods to establish steady state conditions. EPA Publication *Ambient Water Quality Criteria for Bacteria* (EPA440/5-84-002).

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 laboratory analysis method used to measure fecal coliform levels in the water. The membrane filtration (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 of the sample.

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 the summer and 2000 in the 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 water quality 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 the summer and 4000 counts per 100 ml in the 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 the stream will be considered impaired. This can be used not only to assess actual water quality data, but also computer generated daily average 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 daily values.

2.1.3 Discussion of Combining the Tests

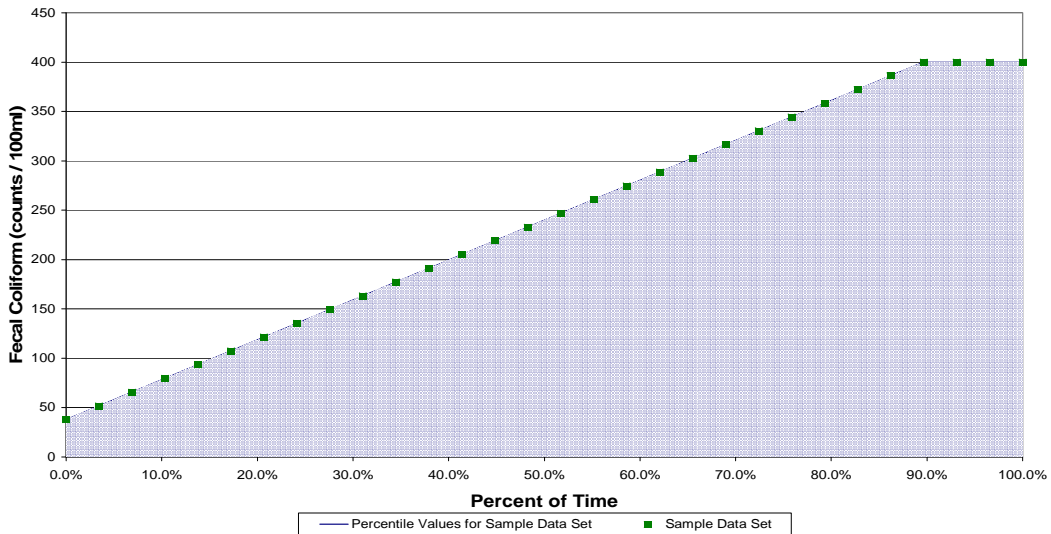
MDEQ determined a theoretical maximum allowable load data set that meets both portions of the water quality standard and is indicative of possible water quality conditions. This theoretical maximum allowable load data set is shown in Table 1. The theoretical maximum allowable load data set, or capacity, 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 capacity data set was then plotted, generating a theoretical maximum capacity set curve. This curve can be seen in Figure 3. The integral of the theoretical maximum allowable load data set curve is used for mass balance TMDL calculations. By multiplying the integral of the theoretical capacity curve by the flow in a given water body, the mass balance TMDL is 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 capacity data set 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 Capacity 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 Capacity Data Set 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 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 were collected in each 30-day period, at station 64 in segment MSTB038R00_010 during two summer seasons and two winter seasons in 2001, 2002, and 2003. Samples were taken in accordance with EPA Publication *Ambient Water Quality Criteria for Bacteria* (EPA440/5-84-002).

2.2.1 Inventory of Available Water Quality Monitoring Data

The data collected at Station 64 on Browning Creek is provided in Tables 2 through 5 below.

Table 2. Fecal Coliform Data reported in Browning Creek, Station 64, Winter 2001

Date	Time	Fecal Coliform (counts/100ml)	Geometric Mean	Geometric Mean Violation	90th Percentile	90th Percentile Violation
12/04/01	10:45	700	255.5	No	736	No
12/06/01	11:00	760				
12/10/01	10:45	195				
12/12/01	10:25	50				
12/21/01	10:25	210				

FECAL COLIFORM TMDL FOR BROWNING CREEK

Table 3. Fecal Coliform Data reported in Browning Creek, Station 64, Summer 2002

Date	Time	Fecal Coliform (counts/100ml)	Geometric Mean	Geometric Mean Violation	90 th Percentile	90 th Percentile Violation
5/07/02	10:55	420	367.9	Yes, Geometric Mean is greater than 200	1240	Yes, 90 th percentile is greater than 400
5/9/02	10:45	980				
5/14/02	10:35	35				
5/21/02	10:35	140				
5/23/02	11:00	820				
5/29/02	11:300	1500				

Table 4. Fecal Coliform Data reported in Browning Creek, Station 64, Winter 2003

Date	Time	Fecal Coliform (counts/100ml)	Geometric Mean	Geometric Mean Violation	90 th Percentile	90 th Percentile Violation
03/13/03	10:30	205	157.5	No, geometric mean is less than 2000	498	No, 90 th percentile is less than 4000
03/14/03	10:52	520				
03/21/03	11:10	300				
03/25/03	11:25	62				
03/27/03	11:13	285				
04/01/03	10:54	27				

Table 5. Fecal Coliform Data reported in Browning Creek, Station 64, Summer 2003

Date	Time	Fecal Coliform (counts/100ml)	Geometric Mean	Geometric Mean Violation	90 th Percentile	90 th Percentile Violation
07/29/03	9:30	195	237.8	Yes, geometric mean is greater than 200	774	Yes, 90 th percentile is greater than 400
08/11/03	9:35	145				
08/14/03	9:33	1160				
08/18/03	9:20	160				
08/22/03	9:30	145				

2.2.2 Analysis of Instream Water Quality Monitoring Data

For Browning Creek, the data collected at station 64 during the summer periods of 2002, and 2003 indicate a violation of the geometric mean portion of the standard and the percent of time in exceedence. A graphical representation of the data for Browning Creek can be seen in Figures 4

FECAL COLIFORM TMDL FOR BROWNING CREEK

and 5 below. For the summer periods a line has been added to the graphs 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 are greater than 400 more than 10% of the time. The critical period for this TMDL was determined to be in the summer, due to the fact that violations of both portions of the standard occurred but no violations occurred in the winter seasons.

Figure 4. 10% Test Curve for Station 64, Summer 2002

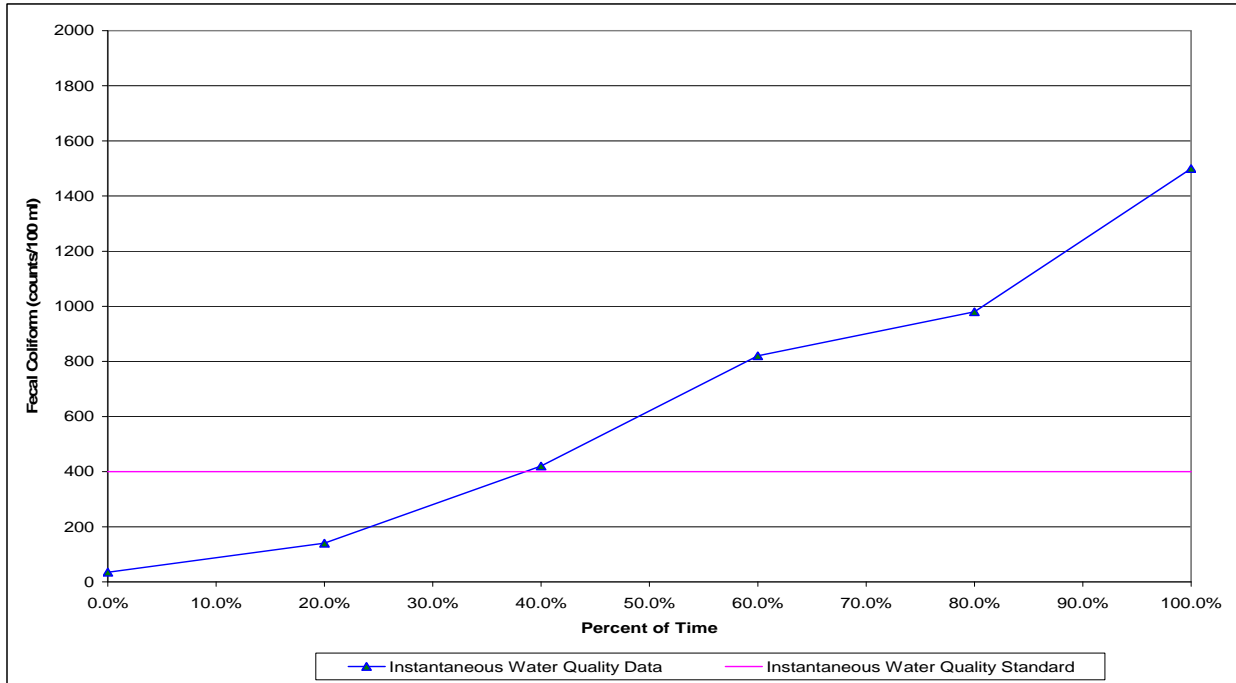
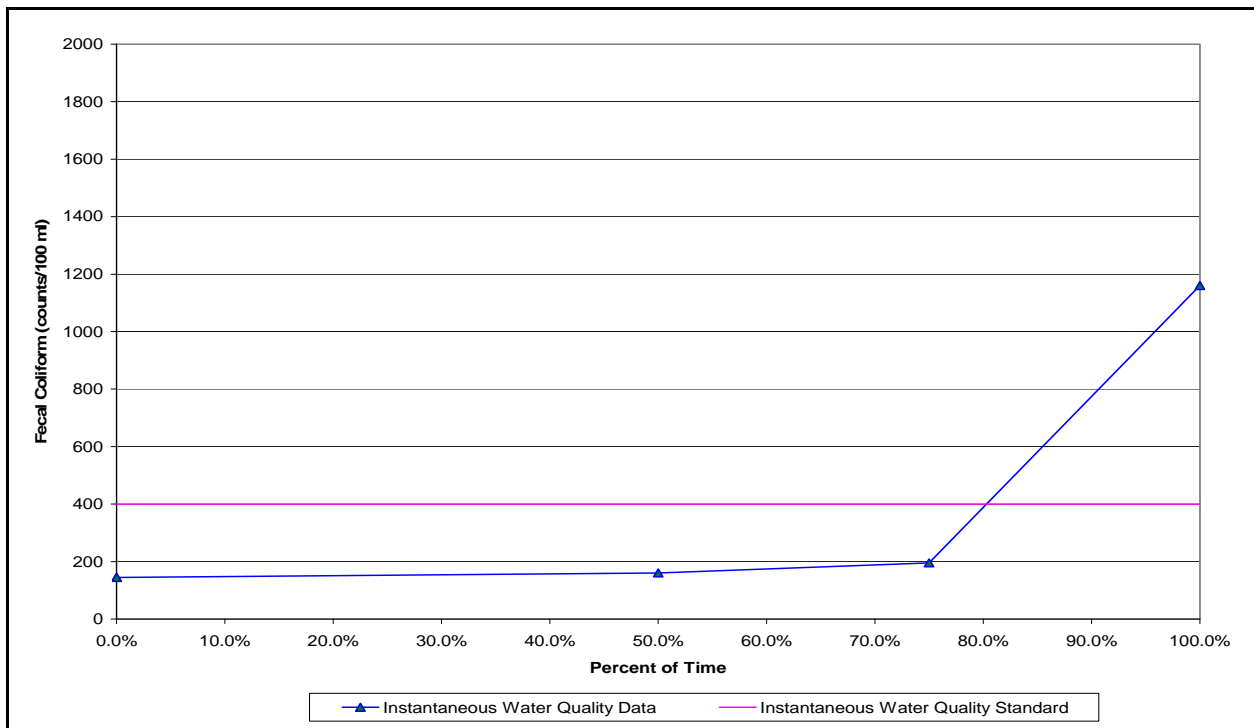


Figure 5. 10% Test Curve for Station 64, Summer 2003



SOURCE ASSESSMENT

The TMDL evaluation summarized in this report examined all known potential fecal coliform sources in the 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.

The Browning Creek watershed contains two permitted point sources. These are Browning Creek Development (NPDES Permit #MS0052892) and Oktibbeha County Schools, Moor High School (NPDES Permit #MS0038601). The effluent from the point sources was characterized based on all available monitoring data including permit limits, discharge monitoring reports, and information on treatment type. The receiving water body and the flow for Browning Creek are shown in Table 6.

Table 6. Inventory of Point Source Dischargers

NPDES ID	Facility Name	Receiving Water	Design Flow (MGD)
MS0052892	Browning Creek Development	Unnamed tributary of Browning Creek	0.1
MS0038601	Oktibbeha County Schools, Moor High School	Browning Creek	0.012

3.2 Assessment of Nonpoint Sources

There are many potential nonpoint sources of fecal coliform bacteria in the watershed, including:

- ◆ Failing septic systems
- ◆ Confined Animal Feeding Operations
- ◆ Wildlife
- ◆ Grazing animals
- ◆ Sewer Bypasses
- ◆ Other Direct Inputs

The 46.3 square kilometer (11,440 acres) drainage area, of Browning Creek contains many different landuse types, including forest, cropland, pasture, scrub/barren, water, and wetlands. The landuse distribution for the watershed is provided in Table 7 and displayed in Figure 6

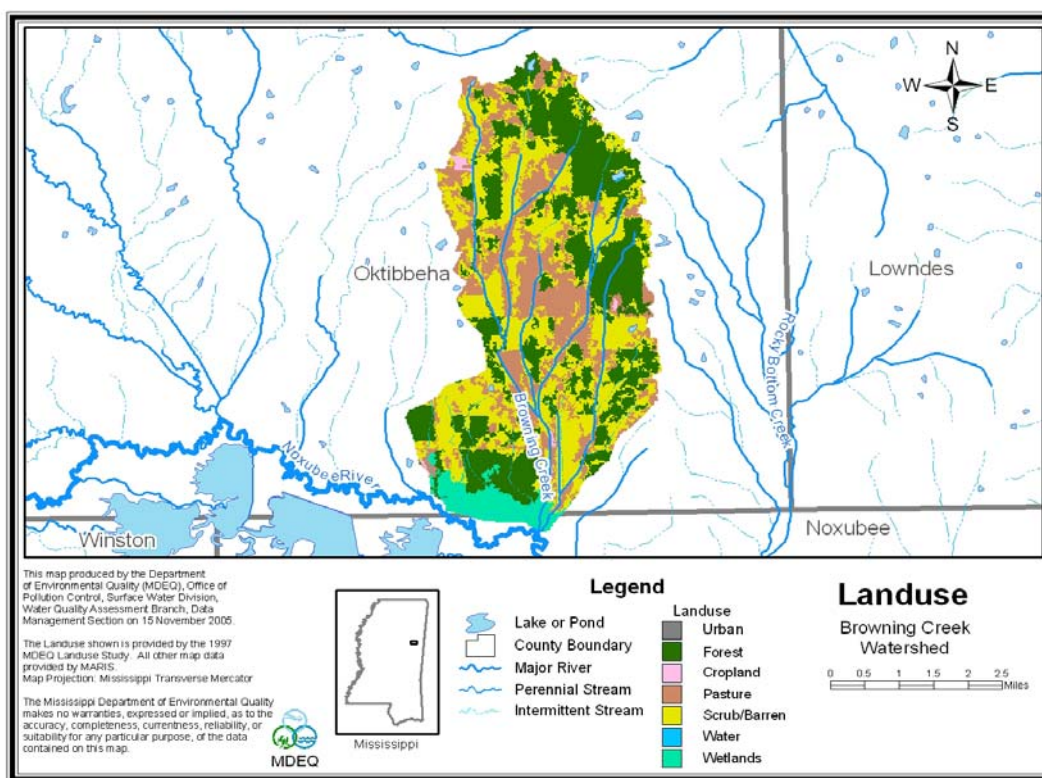
FECAL COLIFORM TMDL FOR BROWNING CREEK

below. The land use 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 land uses of urban, forest, cropland, pasture, scrub/barren, water, and wetlands.

Table 7. Landuse Distribution

	Urban	Forest	Cropland	Pasture	Scrub/Barren	Wetland	Water	Total
Area (acres)	0	3,806	53	2,637	4,386	540	18	11,440
% Area	0%	33%	0.5%	23%	38%	5%	.1%	100%

Figure 6. Landuse in Browning Creek Watershed



To refine the information concerning nonpoint sources of fecal coliform bacteria, MDEQ contacted the Natural Resources Conservation Service. The NRCS gave MDEQ information on area practices which may impact the nonpoint source loading of fecal coliform. The 2002 Census of Agriculture produced by the National Agriculture Statistics Service was used to estimate agricultural animal populations in the watershed.

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. The watershed contains several facilities that operate onsite wastewater treatment plants. These facilities are permitted with no discharge to surrounding areas, but they may be a significant nonpoint source of fecal coliform during rainfall events.

All septic systems may have an impact on nonpoint source fecal coliform impairment in the Tombigbee 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.

Some counties in Mississippi manage the problem of onsite treatment systems through the use of a wastewater ordinance. A wastewater ordinance requires that the wastewater treatment and disposal system used be certified as sufficient. It also ensures that electricity, water, or natural gas will not be made available without written approval from the county Health Department or the Mississippi Department of Environmental Quality. Currently, Oktibbeha County does not have a wastewater ordinance. The lack of a wastewater ordinance could allow some of the rural areas to have only modest wastewater treatment, if any treatment, before discharge.

3.2.2 Confined Animal Feeding Operations

In the Browning Creek watershed there is at least one Confined Animal Feeding Operation (CAFO), Bill Cook Swine Facility. The facility is located about 14 kilometers (8.7 miles) south of Starkville in Oktibbeha County. The facility operates a non-discharging waste treatment operation as required by the Mississippi General Permit for Confined Feeding Operations. Waste from the swine operation is flushed or drained to a primary anaerobic lagoon. The wastewater is then removed from the lagoons and land applied using irrigation systems, as needed to maintain the proper functionality of the lagoons. Approximately 53 acres are available for wastewater application. The solids are also removed from the lagoon and land applied then disked as needed. There are no direct surface water discharges from this facility, all wastewater and waste is land applied.

3.2.3 Beef and Dairy Cattle

Grazing cattle deposit manure on pastureland where it is available for wash-off and delivery to receiving water bodies. Beef cattle have access to pastureland for grazing all of the time. For dairy cattle, the dry cattle and heifers have access to pastureland for grazing all of the time. Manure produced by grazing beef and dairy cows is directly deposited onto pastureland and is available for wash off.

Small 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.

Oktibbeha County has a small number of cattle farms, in which most of the farms have less than 200 head of cattle. According to the 2002 Census of Agriculture there were only 6 farms with greater than 200 head of cattle. These cattle are primarily beef cattle, heifers, steers, and bulls. There are very few dairy cattle within the watershed.

3.2.4 Sewer Bypasses

The only sewered area in the Browning Creek watershed is within the Browning Creek Development. This residential development began construction in 2000. As such, the infrastructure is in good operational condition. With proper operation and maintenance, sewer bypasses should be kept to a minimum and are not expected to contribute to fecal coliform loading.

3.2.5 Other Direct Inputs

Other direct inputs of fecal coliform bacteria to water bodies in the watershed include illicit discharges, human recreation, and access of both domestic and wild animals to the stream.

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 water body 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 Browning Creek. This method of analysis was selected because data limitations precluded the use of more complex methods. Therefore, the mass balance approach is suitable for this TMDL.

4.2 Calculation of Allowable 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:

$$\text{Load}(\text{counts per 30 days}) = \text{Theoretical 30 day Capacity} \left(\frac{\text{day} \cdot \text{counts}}{100 \text{ ml}} \right) \times \text{Flow (cfs)} * \text{Conversion Factor}$$

$$\text{when Conversion Factor} = \left(\frac{28316.8 \text{ ml}}{\text{ft}^3} \right) \times \left(\frac{100 \text{ ml}}{100 \text{ ml}} \right) \times \left(\frac{60 \text{ s}}{1 \text{ min}} \right) \times \left(\frac{60 \text{ min}}{1 \text{ hr}} \right) \times \left(\frac{24 \text{ hr}}{1 \text{ day}} \right)$$

$$= 2.45E + 07 \left(\frac{100 \text{ ml} \cdot \text{s}}{\text{ft}^3 \cdot \text{day}} \right)$$

The theoretical 30 day capacity is calculated by taking the integral of the theoretical capacity curve, Figure 4.

$$\int_0^{26.91} [13.47x + 37.82] / dx + \int_{26.91}^{30} 400/dx = \mathbf{7129.4} \text{ (day * counts/100 ml)}$$

USGS flow gage 02448000 was used to estimate the flow Browning Creek. The average summer discharge at the flow gage was calculated by averaging the USGS monthly mean stream

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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 for Browning Creek was then estimated based on the average summer discharge at this station (02448000) which is on the Noxubee River at Macon, MS and shown in Table 8. To estimate the flow for each water body segment MDEQ utilized a drainage area ratio. The average summer discharge for Browning Creek was determined to be 9.32 cfs. This method was also used to calculate the average winter discharge. The average winter discharge was determined to be 39.7 cfs as shown below.

Table 8. Average Flows for Noxubee River at Macon

Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Summer					993	366	432	199	219	193			400
Winter	1,878	2,336	2,398	2,054							439	1128	1,705

$$\text{Avg Seasonal Discharge (cfs)} = \left\{ \frac{[02448000 \text{ Avg Seasonal Discharge (cfs)}]}{[02448000 \text{ Drainage Area (acres)}]} \right\} * [\text{Water Body Drainage Area (acres)}]$$

$$\text{MSTB038R00_010 Avg Summer Discharge (cfs)} = \left\{ \frac{[400.3 \text{ (cfs)}]}{[768 \text{ (sq. miles)}]} \right\} * [17.88 \text{ (sq. miles)}] = 9.3 \text{ cfs}$$

$$\text{MSTB038R00_010 Avg Winter Discharge (cfs)} = \left\{ \frac{[1705.5 \text{ (cfs)}]}{[768 \text{ (sq. miles)}]} \right\} * [17.88 \text{ (sq. miles)}] = 39.7 \text{ cfs}$$

4.3 Calculation of Existing Load

For the calculation of the existing load, the daily stream flow 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, Summer 2002

Date	Time	Fecal Coliform (counts/100 ml)	Flow (cfs)	Existing Load (counts per 30days)
5/07/02	10:55	420	4.7	2.54 E+12
5/9/02	10:45	980	4.3	
5/14/02	10:35	140	3.3	
5/21/02	10:35	35	10.1	
5/23/02	11:00	820	4.4	
5/29/02	11:30	1500	3.0	

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Table 10. Existing Load, Summer 2003

Date	Time	Fecal Coliform (counts/100 ml)	Flow (cfs)	Existing Load (counts per 30days)
7/29/03	9:30	195	3.4	2.63E+12
8/11/03	9:35	145	12.8	
8/14/03	9:33	1160	16.5	
8/18/03	9:20	160	8.0	
8/22/03	9:20	145	8.8	

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 watershed. The point sources in Browning Creek and the allocated load is shown in Table 11. Table 11 also shows the limits of Browning Creek Development (MS0052892). The first value is the average fecal coliform concentration that the facility may 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 is still allowable. Moor High School currently has no permit limit for fecal coliform. Therefore, this TMDL recommends the permit for Oktibbeha County Schools, Moor High School be modified to include fecal coliform limits of 200/400. Since Browning Creek Development currently has a low fecal coliform limit no permit modification is necessary. This TMDL was developed using the new limits.

Table 11. Wasteload Allocations for Segment MSTB038R00_010

NPDES ID	Summer Permit Limit Average/Maximum (counts/100ml)	Winter Permit Limit Average/Maximum (counts/100ml)	Average Summer Allocated Load (counts/30days)	Average Winter Allocated Load (counts/30days)	Permit Modification Necessary
MS0052892	200/400	200/400	2.27E+10	2.27E+10	No
MS0038601	200/400*	200/400*	2.73E+9	2.73E+9	Yes
*Proposed Permit Limits					

5.2 Load Allocations

The load allocation for the Browning Creek is calculated using the water quality criteria and the estimated critical flow. The load allocation is assumed to represent nonpoint sources as described in section 3.2. In calculating the LA component, the total TMDL for the water body is reduced by a 10% MOS. For this TMDL, the summer load is based on a fecal coliform concentration for 30 days determined by the integral of the theoretical maximum allowable load curve and the average summer flow. The resulting winter LA was estimated using the average winter flow and the integral of the theoretical maximum allowable load curve. The resulting load allocations are shown below in Table 12.

Table 12. Load Allocations

Name	ID	Summer LA (counts per 30 days)	Winter LA (counts per 30 days)
Browning Creek	MSTB038R00_010	1.44E+12	6.22E+12

$$\text{Load Allocation} = [0.9 * 7129.4(\text{day} * \text{counts}/100\text{ml}) * \text{Flow}(\text{cfs}) * 2.45\text{E}+07[(100\text{ml} * \text{s})/(\text{ft}^3 * \text{day})] - \text{WLA}]$$

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. An explicit 10% margin of safety was used for this TMDL. The margin of safety is calculated below for Browning Creek using the average seasonal flows and theoretical maximum allowable load data set curve. The results of the calculations are shown in Table 13.

Table 13. Margin of Safety

Name	ID	Summer MOS (counts per 30 days)	Winter MOS (counts per 30 days)
Browning Creek	MSTB098R00_010	1.62E+11	6.93E+11

$$\text{MOS} = 0.1 * 7129.4(\text{day} * \text{counts}/100\text{ml}) * \text{Flow}(\text{cfs}) * 2.45\text{E}+07[(100\text{ml} * \text{s})/(\text{ft}^3 * \text{day})]$$

5.4 Calculation of the TMDL

The TMDL for Browning Creek is calculated based on the following equation:

$$\text{TMDL} = \text{WLA} + \text{LA} + \text{MOS}$$

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

WLA = NPDES Permitted Facilities

LA = Surface Runoff + Other Direct Inputs

MOS = 10% explicit

The summer TMDL for Browning Creek was calculated based on the average summer flow of the watershed, and a fecal coliform concentration for 30 days determined by the integral of the theoretical maximum allowable load data set curve. 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 integral of the theoretical maximum allowable load data set curve. The

necessary percent reductions are shown below in Table 14.

Table 14. Estimated Fecal Coliform Reductions

Name	ID	Summer % Reduction	Winter % Reduction
Browning Creek	MSTB038R00_010	38%	None Necessary

Summer

$$\text{TMDL} = 7129.4(\text{day} \cdot \text{counts}/100\text{ml}) * 9.3(\text{cfs}) * 2.45\text{E}+07[(100\text{ml} \cdot \text{s})/(\text{ft}^3 \cdot \text{day})]$$

$$\text{TMDL} = 1.62\text{E}+12 \text{ (counts per 30 days)}$$

Winter

$$\text{TMDL} = 7129.4(\text{day} \cdot \text{counts}/100\text{ml}) * 39.7(\text{cfs}) * 2.45\text{E}+07[(100\text{ml} \cdot \text{s})/(\text{ft}^3 \cdot \text{day})]$$

$$\text{TMDL} = 6.93\text{E}+12 \text{ (counts per 30 days)}$$

Table 15. TMDL Summary for Browning Creek – MSTB038R00_010 (counts per 30 days)

	Summer	Winter
WLA	2.54E+10	2.54E+10
LA	1.44E+12	6.22E+12
MOS	1.62E+11	6.93E+11
TMDL = WLA + LA +MOS	1.62E+12	6.93E+12

5.5 Seasonality

For many streams in the state, fecal coliform limits vary according to the seasons. Browning Creek is designated for the use of secondary contact. For this use, the fecal coliform standard is seasonal.

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 is no WLA reduction request based on promised LA 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 100ml target at the end of their discharge pipe.

CONCLUSION

The TMDL will not impact future NPDES Permits as long as the effluent is disinfected to meet water quality standards for fecal coliform. The TMDL recommends Oktibbeha County Schools, Moor High School meet fecal coliform limits of 200/400.

Education projects that teach best management practices should be used as a tool for reducing other nonpoint source contributions. These projects may be funded by CWA Section 319 Nonpoint Source (NPS) Grants.

MDEQ will continue to evaluate the point sources through the Environmental Compliance and Enforcement Division (ECED). Also, additional fecal coliform monitoring data for Browning Creek may be collected during the next monitoring phase in the Tombigbee Basin.

Additionally, MDEQ will continue its cooperation with state, county and city officials to encourage the adoption of local building standards. These standards should address design and installation of individual on-site wastewater treatment systems to insure proper operation and maintenance.

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 year long cycle, MDEQ resources for water quality monitoring will be focused on one of the basin groups. During the next monitoring phase in the Tombigbee River Basin, Browning 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. The public will be given an opportunity to review the TMDL and submit comments. MDEQ also distributes all TMDLs at the beginning of the public notice to those members of the public who have requested to be included on a TMDL mailing list. TMDL mailing list members may request to receive the TMDL reports through either, email or the postal service. Anyone wishing to become a member of the TMDL mailing list should contact Greg Jackson at (601) 961-5098 or Greg_Jackson@deq.state.ms.us.

All comments should be directed to Greg Jackson at Greg_Jackson@deq.state.ms.us or Greg Jackson, MDEQ, PO Box 10385, Jackson, MS 39289. All comments received during the public notice period and at any public hearings become a part of the record of this TMDL and will be considered in the submission of this TMDL to EPA Region 4 for final approval.

At the end of the 30-day period, MDEQ will determine the level of interest in the TMDL and

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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.

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 water body 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 segments 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 n th 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 quantity 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 function 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: $4.16 \times 10^{(+b)}$ and $4.16 \times 10^{(-b)}$ [same as $4.16E4$ or $4.16E-4$]. 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:

$$\begin{matrix} 3 \\ \Sigma d_i = d_1 + d_2 + d_3 = 24 + 123 + 16 = 163 \\ i=1 \end{matrix}$$

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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 from (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 particular 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 antidegradation 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

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
MDEQ.....	Mississippi Department of Environmental Quality
MOS.....	Margin of Safety
MRLC.....	Multi-Resolution Land Characterization
NLCD.....	National Land Cover Data
NRCS	National Resource Conservation Service
NPDES.....	National Pollution Discharge Elimination System
UNT	Unnamed Tributary
USGS	United States Geological Survey
WLA	Waste Load Allocation

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