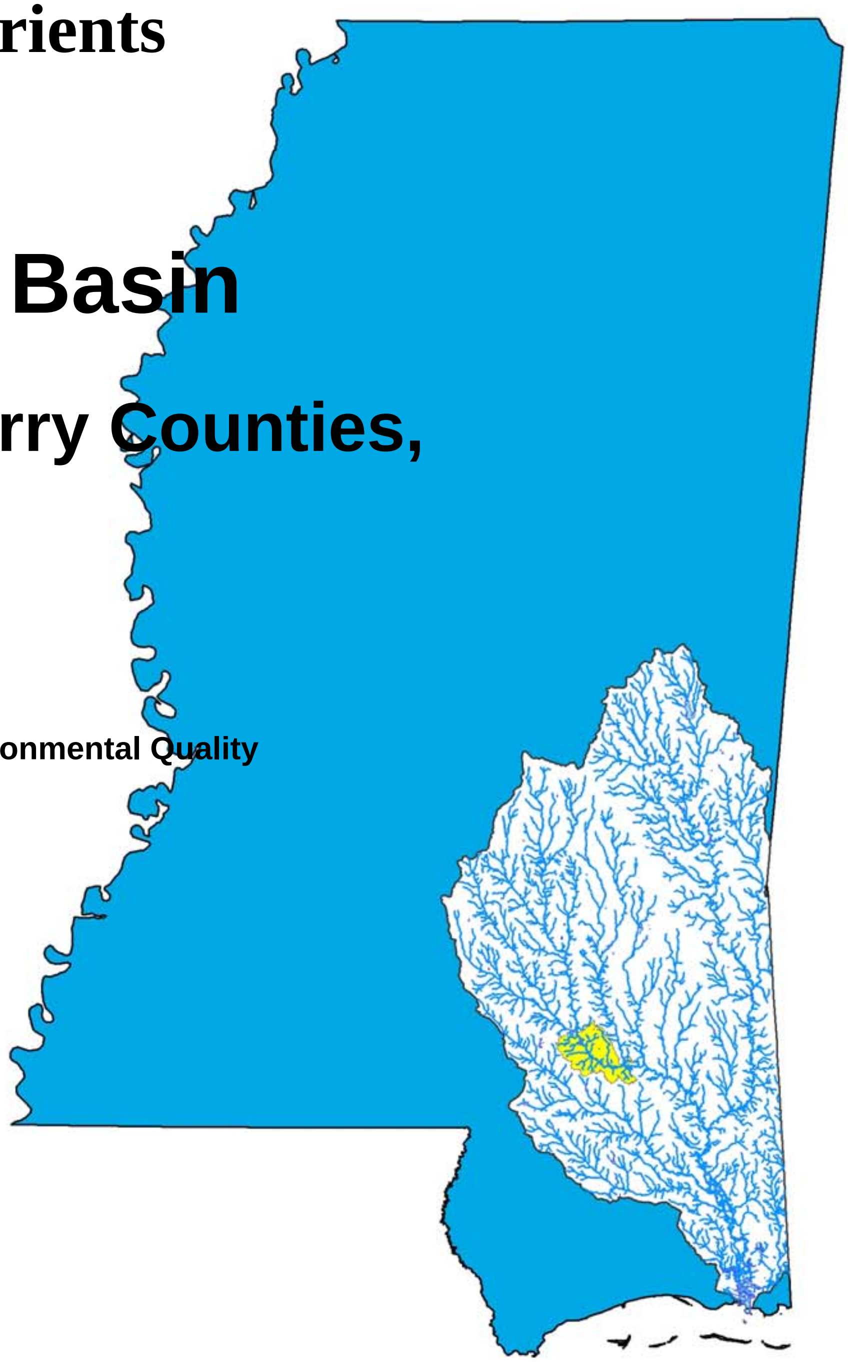
FINAL REPORT
June 2005
ID: 405063003

Phase 1
Total Maximum Daily Load
Biological Impairment Due to Organic Enrichment/Low Dissolved Oxygen and Nutrients

The Leaf River
Pascagoula Basin

Forrest and Perry Counties, Mississippi



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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 Water bodies. 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.

Conversion Factors

To convert from	To	Multiply by	To convert from	To	Multiply by
$mile^2$	acre	640	acre	ft^2	43560
km^2	acre	247.1	days	seconds	86400
m^3	ft^3	35.3	meters	feet	3.28
ft^3	gallons	7.48	ft^3	gallons	7.48
ft^3	liters	28.3	hectares	acres	2.47
cfs	gal/min	448.8	miles	meters	1609.3
cfs	MGD	0.646	tonnes	tons	1.1
m^3	gallons	264.2	µg/l * cfs	gm/day	2.45
m^3	liters	1000	µg/l * MGD	gm/day	3.79

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	:	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

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i. Listing Information

Name	ID	Counties	HUC	Cause	Mon/Eval
Leaf River	MS086E	Forrest and Perry	03170005	Biological Impairment due to Nutrients and Organic Enrichment/Low DO	Monitored
Near Camp Shelby from Confluence with Bowie River to Confluence with Tallahala Creek					

ii. Water Quality Standard

Parameter	Beneficial use	Water Quality Criteria
Dissolved Oxygen	Aquatic Life Support	DO concentrations shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l
Nutrients	Aquatic Life Support	Waters shall be free from materials attributable to municipal, industrial, agricultural, or other dischargers producing color, odor, taste, total suspended solids, or other conditions in such degree as to create a nuisance, render the waters injurious to public health, recreation, or to aquatic life and wildlife, or adversely affect the palatability of fish, aesthetic quality, or impair the waters for any designated uses.

iii. NPDES Facilities

NPDES ID	Facility Name	Permitted Discharge (MGD)	Receiving Water
MS0020303	Hattiesburg, South	20.0	Leaf River
MS0024996	Mississippi Army National Guard, Camp Shelby, Activated Sludge	10.0	Weldy Creek thence Leaf River
MS0042994	5 R Development Corporation, Trailwood Subdivision	0.160	Lott's Creek
MS0053449	Deerfield Estates	0.070	Unnamed Creek thence Leaf River
MS0051233	Homestead SD	0.080	Unnamed tributary of Priests Creek
MS0048178	Big K, Hwy 11	0.005	Unnamed tributary of Priests Creek
MS0043516	Dixie Attendance Center	0.015	Myers Creek
MS0031771	Sherwood Forest Subdivision	0.200	Reese Creek

iv. Phase 1 Total Maximum Daily Load for TBODu

WLA (lbs/day)	LA (lbs/day)	MOS	TMDL (lbs/day)
10,926	**7,142**	**Implicit**	**18,068**

v. Total Estimated Maximum Daily Load for TP*

WLA lbs/day	LA lbs/day	MOS lbs/day	TMDL lbs/day
934.0*	**545.6 to 1391.0***	**Implicit**	**1479.6 to 2325.0***

* Due to the lack of nutrient water quality criteria these Phase 1 TMDL allocations are estimates based on literature assumptions and projected targets. The State of Mississippi is in the process of developing numeric nutrient criteria in accordance with an EPA approved work plan for nutrient criteria development. This TMDL recommends quarterly monitoring of nutrients for NPDES facilities. MDEQ's calculations of the annual average load indicate that the majority of the estimated nutrient load is from non-point sources. Therefore, the State will focus on striving to attain the goal set by the LA portion of the TMDL.

EXECUTIVE SUMMARY

This TMDL has been developed for a segment of the Leaf River that has been placed on the Mississippi 2004 Section 303(d) List of Water Bodies due to Biological Impairment. A Stressor Identification Report which indicates the potential stressors to the water body has been developed. Based on the available information, it was determined that the biological impairment is most likely due to nutrients, organic enrichment/low dissolved oxygen, and sediment. Sediment will be addressed in a separate TMDL report. The applicable state standard specifies that the dissolved oxygen concentrations shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l. Ammonia nitrogen levels will also be evaluated in this TMDL using criteria established for ammonia nitrogen toxicity. Additionally, this TMDL will provide an estimate of the total phosphorous (TP) load in the stream and a preliminary breakdown of the TP load between point and non-point sources. Currently, Mississippi does not have numeric water quality standards for allowable nutrient concentrations. MDEQ currently has a Nutrient Task Force (NTF) working on the development of numeric criteria for nutrients.

For TMDL development, TP was used as the nutrient of concern because phosphorus is typically the limiting nutrient in most rivers and streams (Thomann and Mueller, 1987). A preliminary analysis of the total phosphorus data measured for non-impaired wadeable streams in the East Bioregion was completed to find a range of appropriate TP loading. The range selected in the East Bioregion is 0.07 to 0.11 mg/L of total phosphorus. MDEQ is presenting this range as a preliminary value for TMDL development which is subject to revision after the development of nutrient criteria, when the work of the NTF is complete. This TMDL has been developed as a Phase 1 TMDL so nutrients may be further evaluated when more data are available and nutrient criteria are developed.

The Leaf River Watershed is located in southeastern Mississippi in HUCs 03170004 and 03170005. The headwaters of the Leaf River begin south of Forest, MS in Scott County. The river flows for approximately 150 miles in a southern direction to its confluence with the Pascagoula River in George County.

Photo 1. Leaf River near Hattiesburg

This 303(d) listed segment of the Leaf River begins near Hattiesburg, MS at the confluence with the Bowie River. The segment flows for approximately 22 miles to the confluence with Tallahala Creek. Photo 1 shows the Leaf River near Hattiesburg. The location of the watershed is shown in Figure 1.

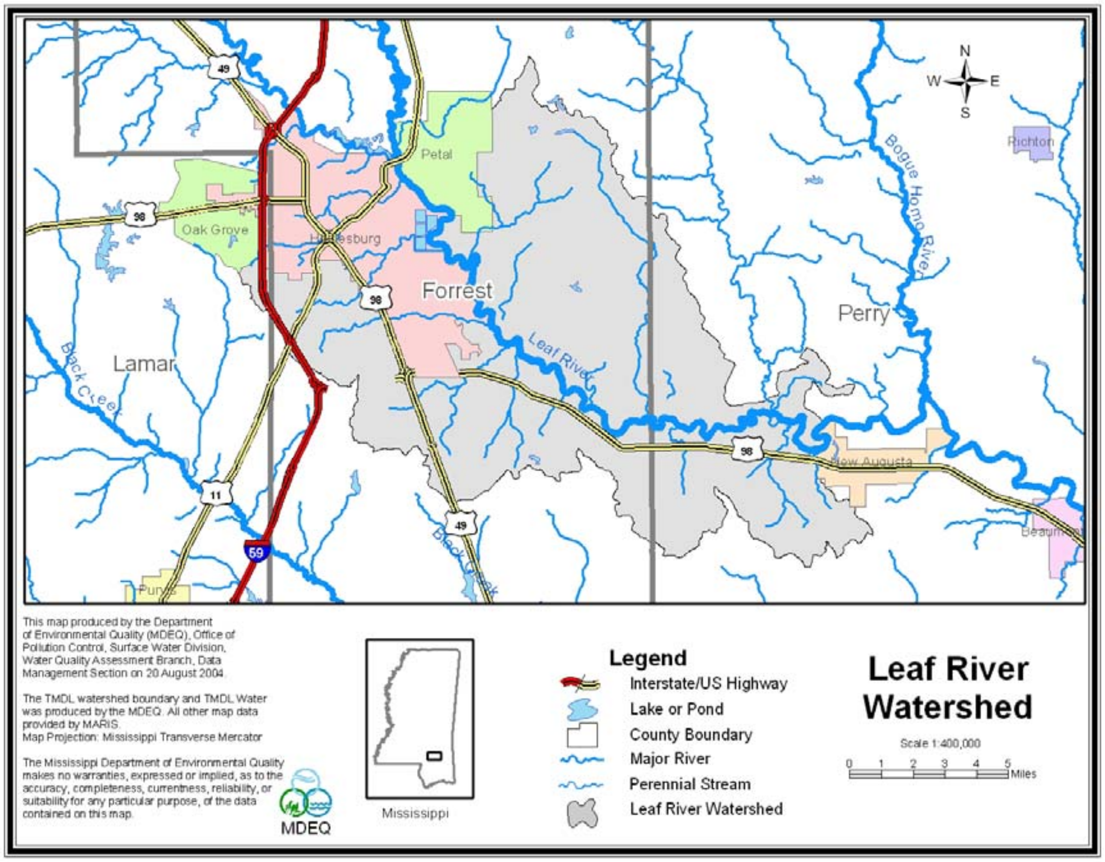


Figure 1. Leaf River Watershed

The predictive model used to calculate the dissolved oxygen TMDL is based primarily on assumptions described in MDEQ Regulations. A modified Streeter-Phelps dissolved oxygen sag model was selected as the modeling framework for developing the TMDL allocations for this study. The critical modeling period was determined to occur during the hot, dry summer period. A mass-balance approach was used to ensure that the instream concentration of ammonia nitrogen (NH_3-N) did not exceed the water quality criteria. MDEQ also used the mass balance approach to estimate total phosphorous contributions from point and non-point sources.

The TMDL for organic enrichment was quantified in terms of total ultimate biochemical oxygen demand (TBODu). The model used in developing this TMDL included both point and non-point sources of TBODu in the Leaf River Watershed. TBODu loading from background and non-point sources in the watershed was accounted for by using an estimated concentration of TBODu and flows based on 7Q10 conditions. There are several NPDES Permitted discharges located in the watershed that are included as point sources in the model.

According to the model, the current load in the water body does not exceed the assimilative capacity of the Leaf River for organic material and ammonia nitrogen. However, some reductions in the current loading of organic material are recommended in this TMDL report in order to meet technology based limits and permit modifications requested by NPDES permitted facilities. These modifications represent a 30% reduction from current permitted loads. The WLA is based on the permitted load to the Leaf River after these reductions have been implemented. Although the reduction cannot be quantified at this time, the WLA included in this report is also expected to reduce nutrient loads discharged to the Leaf River. This WLA, however, will not limit expansion of existing facilities or construction of new facilities in the Leaf River watershed because modeling shows there is additional assimilative capacity in the water body. Future NPDES permits in this section of the Leaf River will be analyzed on a case-by-case basis.

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. This TMDL has been developed for the 303(d) listed segment shown in Figure 2.

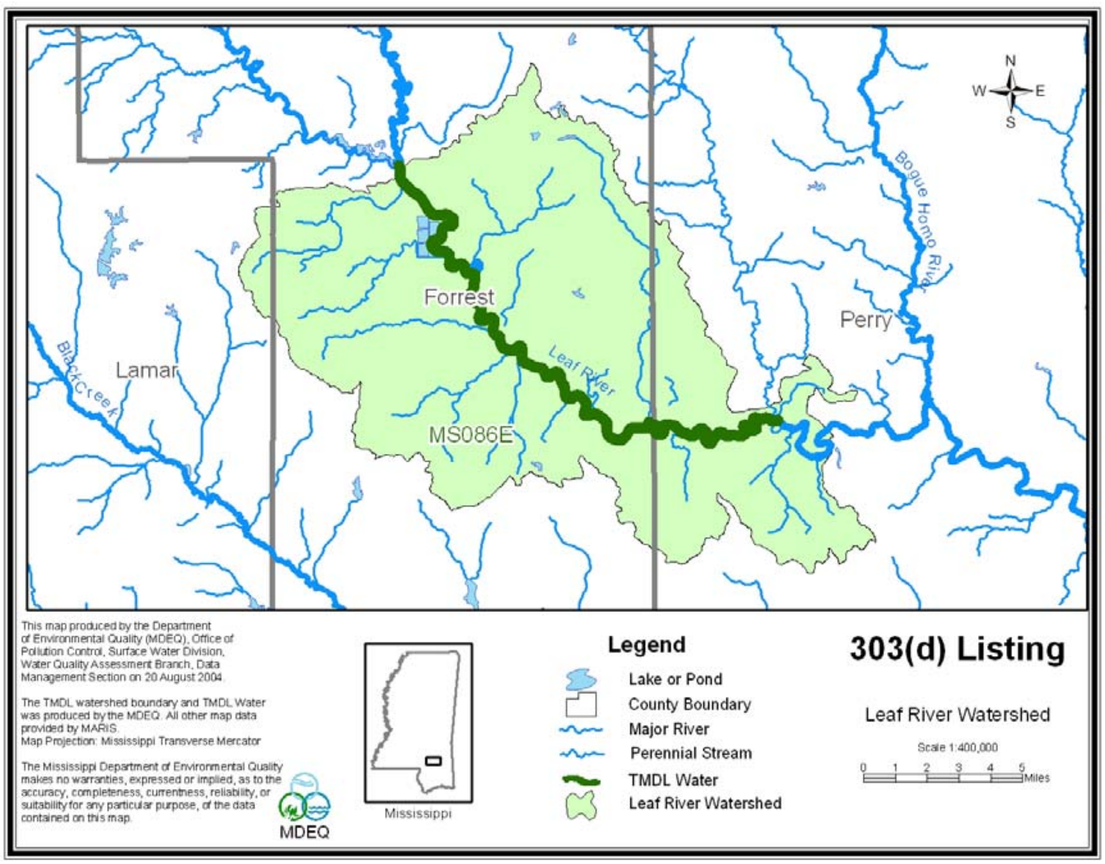


Figure 2. Leaf River 303(d) Listed Segment

1.2 Stressor Identification

The impaired segment of the Leaf River was listed due to failure to meet minimum water quality criteria for biological use support based on biological sampling conducted in 2001 (MDEQ, 2003). Additional sampling conducted in 2003 under different weather conditions indicated that the water body was below the threshold for impairment. Because of the 2001 sampling results, a detailed assessment of the watershed and potential pollutant sources, called a stressor identification report, was developed. The purpose of a stressor identification report is to identify the stressors and their sources most likely causing degradation of instream biological conditions. The report indicated that nutrients, organic enrichment/low dissolved oxygen, and sediment were the most likely stressors (MDEQ, 2004). Sediment will be addressed in a separate TMDL report.

There are no state criteria in Mississippi for nutrients. These criteria are currently being developed by the Mississippi Nutrient Task Force in agreement with EPA Region 4. MDEQ proposed a work plan for nutrient criteria development that has been approved by EPA and is on schedule according to the approved plan in development of nutrient criteria (MDEQ, 2004). Data have been collected for wadeable streams to be used to calculate the criteria. For this TMDL, MDEQ chose total phosphorus as the limiting nutrient. Preliminary analysis of the data reveals that an annual concentration range of 0.07 to 0.11 mg/l is an applicable target for total phosphorus for water bodies located in the East Bioregion. However, MDEQ is presenting this range as a preliminary target value for TMDL development which is subject to revision after the development of nutrient criteria, when the work of the NTF is complete.

1.3 Applicable Water Body Segment Use

The water use classifications are established by the State of Mississippi in the document *Water Quality Criteria for Intrastate, Interstate and Coastal Waters*. The designated beneficial use for the listed segment of the Leaf River is fish and wildlife support.

1.4 Applicable Water Body 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* (MDEQ, 2002). The applicable standard specifies that the dissolved oxygen (DO) concentrations shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l. The daily average water quality standard will be used to evaluate impairments and establish the TBODu TMDL.

The water quality standard for ammonia nitrogen toxicity is also included in this TMDL. Ammonia nitrogen concentrations can be evaluated using the criteria given in 1999 Update of Ambient Water Quality Criteria for Ammonia (EPA-822-R-99-014). The maximum allowable instream ammonia nitrogen (NH_3-N) concentration at a pH of 7.0 and stream temperature of 26°C is 2.82 mg/l.

Mississippi's NTF is currently developing numeric criteria for nutrients. The current standards only contain a narrative criteria that can be applied to nutrients which states that "Waters shall be free from materials attributable to municipal, industrial, agricultural, or other discharges producing color, odor, taste, total suspended or dissolved solids, sediment, turbidity, or other conditions in such degree as to create a nuisance, render the waters injurious to public health, recreation or to aquatic life and wildlife or adversely affect the palatability of fish, aesthetic quality, or impair the waters for any designated use (MDEQ, 2002)."

In the 1999 Protocol for Developing Nutrient TMDLs, EPA suggests several methods for the development of numeric criteria for nutrients (USEPA, 1999). In accordance with the 1999 Protocol, "The target value for the chosen indicator can be based on: comparison to similar but unimpaired waters; user surveys; empirical data summarized in classification systems; literature values; or best professional judgment." MDEQ believes the most economical and scientifically defensible method for use in Mississippi is a comparison between similar but unimpaired waters within the same region. This method is dependent on adequate data which are being collected in accordance with the EPA approved plan. The initial phase of the data collection process for wadeable streams has been completed. Preliminary analysis of the available data reveals that an annual concentration range of 0.07 to 0.11 mg/l is an applicable TMDL target for total phosphorus for water bodies located in the East Bioregion. However, MDEQ is presenting this as a preliminary target value for TMDL development which will be subject to revision after the development of nutrient criteria, when the work of the NTF is complete.

1.5 Selection of a Critical Condition

Low DO typically occurs during seasonal low-flow, high-temperature periods during the late summer and early fall. Elevated oxygen demand is of primary concern during low-flow periods because the effects of minimum dilution and high temperatures combine to produce the worst-case potential effect on water quality (USEPA, 1997). The flow at critical conditions is typically defined as the 7Q10 flow, which is the lowest flow for seven consecutive days expected during a 10-year period. The low flow condition for Leaf River was determined based on *Techniques for Estimating 7-Day, 10-Year Low-Flow Characteristics on Streams in Mississippi* (Telis, 1992).

1.6 Selection of a TMDL Endpoint

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 meeting the load and wasteload allocations specified in the TMDL. The endpoints allow for a comparison between observed instream conditions and conditions that are expected to restore designated uses. The instream DO target for this TMDL is a daily average of not less than 5.0 mg/l. The instantaneous minimum portion of the DO standard was considered when establishing the instream target for this TMDL. However, it was determined that using the daily average standard with the conservative modeling assumptions would protect the instantaneous minimum standard. The daily average choice is supported by the use of the existing modeling tools in a desktop modeling exercise such as this. More specific modeling and calibration is needed in order to obtain diurnal oxygen levels with any expectation of accuracy. Therefore, based on the limited data available and the relative simplicity of the model, the daily average target is sufficient.

The maximum impact of oxidation of organic material is generally not at the location of the sources, but at some distance downstream, where the maximum DO deficit occurs. The DO deficit is defined as the difference between the DO concentration at 100% saturation and the actual DO. The point of maximum DO deficit, also called the DO sag, will be used to define the endpoint required for this TMDL. The endpoint for this TMDL will be based on a daily average of not less than 5.0 mg/l at the DO sag during critical conditions.

The TMDL for DO will be quantified in terms of organic enrichment. Organic enrichment is measured in terms of total ultimate biochemical oxygen demand (TBODu). TBODu represents the oxygen consumed by microorganisms while stabilizing or degrading carbonaceous and nitrogenous compounds under aerobic conditions over an extended time period. The carbonaceous compounds are referred to as CBODu, and the nitrogenous compounds are referred to as NBODu. TBODu is equal to the sum of NBODu and CBODu, Equation 1.

$$\textbf{TBODu} = \textbf{CBODu} + \textbf{NBODu} \qquad \textbf{(Equation 1)}$$

The TMDL for nutrients will be quantified in terms of an annual average concentration range for TP. TP was used as the nutrient of concern because phosphorus is typically the limiting nutrient in most rivers and streams (Thomann and Mueller, 1987). A preliminary analysis of the total phosphorus data measured for non-impaired wadeable streams in the East Bioregion was completed to transform the narrative criteria for nutrients into a preliminary numeric range for use in TMDL development. Streams were classified as non-impaired based on biological sampling which was conducted as part of Mississippi's Benthix Index of Stream Quality (MBISQ) project. A non-impaired wadeable stream is one which supports the designated aquatic life use which is defined by the State of Mississippi's *Water Quality Criteria for Intrastate, Interstate and Coastal Waters* (MDEQ, 2002) and one which also satisfies all other conditions of the narrative criteria. The annual concentration range for this TMDL and all other wadeable streams which are located in the East Bioregion is 0.07 to 0.11 mg/L of total phosphorus. These values may be subject to revision as the nutrient criteria development process continues.

WATER BODY ASSESSMENT

This TMDL Report includes an analysis of available water quality data and the identification of all known potential pollutant sources in the Leaf River Watershed. The potential point and non-point pollutant sources were characterized by the best available information, monitoring data, and literature values.

2.1 Discussion of Instream Water Quality Data

There are several sources of data available for this 303(d) listed segment of the Leaf River. The most recent available data were collected by MDEQ at the Leaf River near Palmer at Sims Bridge (02473260). This station is located several miles below the confluence of Bowie River with Leaf River, Figure 3. The location on a USGS flow monitoring station (2473000) is also shown on the figure. Data collected from station 02473260 from January 1997 through December 2001 are available. The data for dissolved oxygen, ammonia nitrogen, and other nutrient parameters are given in Table 1. Note that none of the values show violations of water quality standards for dissolved oxygen. However, the data reflect single DO measurements collected during the morning and afternoon hours when DO levels are expected to be highest. The samples do not reflect the diurnal DO variations that naturally occur in water bodies.

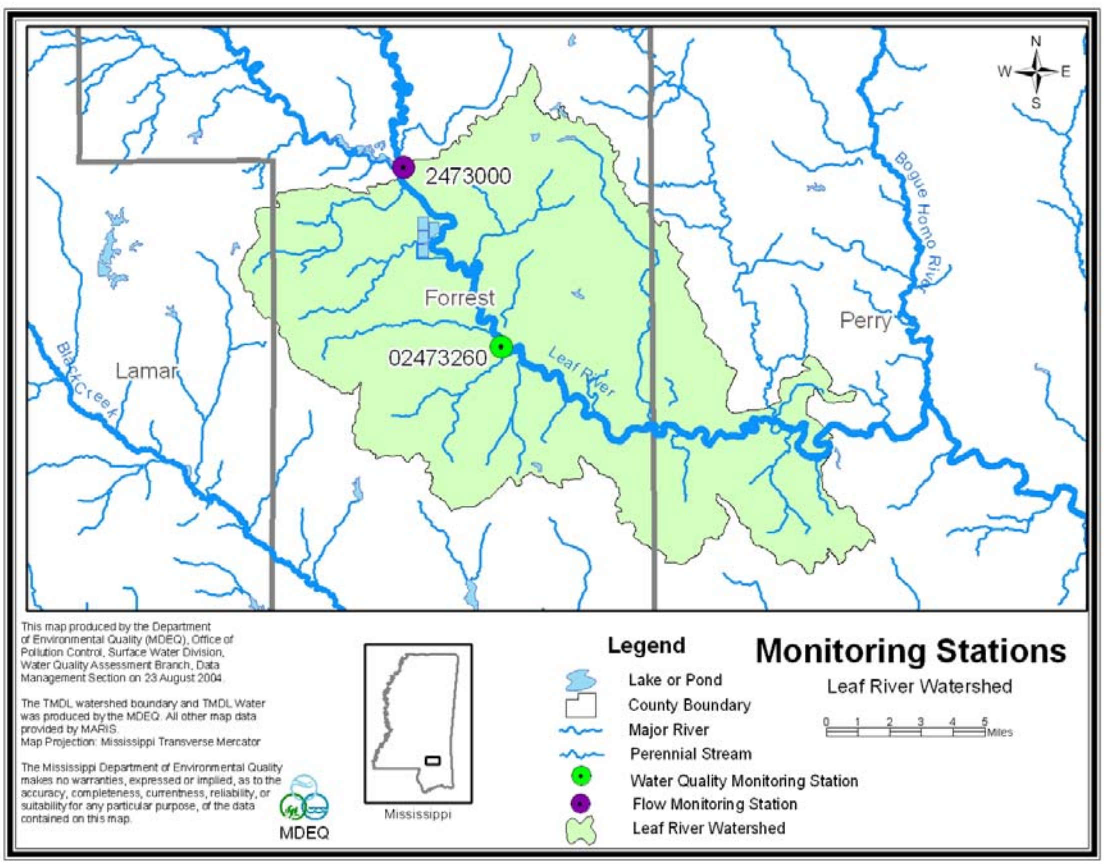


Figure 3. Leaf River Monitoring Stations

Table 1. Water Quality Data Collected at the Leaf River near Palmer (02473260)

Sample Date	Time	Dissolved Oxygen (mg/l)	Ammonia Nitrogen (mg/l)	Nitrite + Nitrate (mg/l)	Total Kjeldahl Nitrogen (mg/l)	Total Phosphorous (mg/l)
22-Jan-97	8:21	11.4	0.25	0.42	0.79	0.09
18-Feb-97	8:24	10.6	0.12	0.23	0.31	0.08
19-Mar-97	8:35	8.6	0.16	0.22	0.78	0.11
10-Apr-97	8:49	8.2	0.18	0.22	0.58	0.1
15-May-97	8:34	7.3	0.17	0.39	0.39	0.04
17-Jun-97	8:27	7.3	0.17	0.34	0.7	0.07
10-Jul-97	10:05	6.8	0.17	0.43	0.37	0.1
19-Aug-97	10:36	7.3	0.72	0.51	0.68	0.12
26-Aug-97	13:00	8.8	0.17	0.49	0.68	0.11
24-Sep-97	10:25	8.6	0.1	0.59	0.43	0.09
13-Oct-97	10:22	7	0.26	0.6	0.6	0.13
19-Nov-97	10:44	10.5	0.22	0.55	0.59	0.06
11-Dec-97	10:44	7.4	0.28	0.19	0.62	0.08
16-Dec-97	9:37	9.7	0.26	0.45	0.82	0.08
20-Jan-98	10:25	11.1	0.28	0.28	0.87	0.12
18-Feb-98	9:58	9.5	0.1	0.23	1.13	0.12
23-Mar-98	10:38	9.6	0.36	0.2	0.65	0.11
8-Apr-98	8:34	8	0.17	0.33	0.6	0.06
18-Jun-98	9:01	6.9	0.1	0.59	0.21	0.15
23-Jul-98	8:48	6.5	0.11	0.45	0.43	0.06
27-Aug-98	11:04	6.8	0.1	0.63	0.61	0.12
16-Sep-98	10:55	6.8	0.27	0.71	0.82	0.08
28-Oct-98	8:48	10	0.24	0.94	0.73	0.36
9-Nov-98	12:20	9.4	0.19	1.18	0.29	0.1
3-Dec-98	11:58	8.4	0.12	0.88	0.31	0.09
25-Jan-99	8:55	9.34	0.44	0.49	1.95	0.39
24-Feb-99	8:25	11.43	0.31	0.49	0.67	0.12
15-Mar-99	8:50	9.87	0.31	0.2	0.94	0.19
1-Apr-99	8:55	9.18	0.2	0.38	0.2	0.06
11-May-99	9:00	7.08	0.16	0.48	0.46	0.17
8-Jun-99	10:23	7.45	0.14	0.45	0.57	0.17
22-Jul-99	9:15	5.6	0.49	0.44	0.61	0.11
4-Aug-99	1:35	6.12	0.26	0.47	0.26	0.06
16-Sep-99	1:40	6.41	0.46	0.58	1.57	0.16
28-Oct-99	11:00	8.6	0.29	0.58	0.67	0.22

Sample Date	Time	Dissolved Oxygen (mg/l)	Ammonia Nitrogen (mg/l)	Nitrite + Nitrate (mg/l)	Total Kjeldahl Nitrogen (mg/l)	Total Phosphorous (mg/l)
23-Nov-99	12:20	9.39	0.29	0.65	0.29	0.14
13-Dec-99	12:58	9.71	0.22	0.46	0.58	0.14
19-Jan-00	8:23	8.78	0.26	0.55	0.59	0.1
23-Feb-00	8:45	8.88	0.33	0.49	0.59	0.15
11-Apr-00	10:40	8.42	0.21	0.32	0.8	0.13
8-May-00	9:00	7	0.29	0.37	0.31	0.11
26-May-00	8:33	6.2	0.27	0.42	0.94	1.16
16-Jun-00	11:15	6.13	0.36	0.29	0.74	0.14
17-Jul-00	10:35	5.27	0.37	0.19	0.82	0.18
12-Oct-00	8:53	7.2	0.32	0.4	0.55	0.2
12-Dec-00	8:52	9.77	0.36	0.54	0.74	0.2
11-Apr-01	9:15	13.58	0.21	0.31	0.68	0.12
9-May-01	9:30	7.53	0.1	0.48	0.79	0.14
12-Jun-01	10:20	7.27	0.22	0.17	1.07	0.17
12-Jul-01	9:45	5.9	0.12	0.38	0.6	0.16
20-Sep-01	9:54	6.98	0.1	0.45	0.55	0.12
4-Oct-01	10:43	8.24	0.1	0.61	0.29	0.12
8-Nov-01	13:03	10.37	0.1	0.54	0.46	0.13
6-Dec-01	13:22	9.69	0.1	0.22	0.78	0.08

2.2 Assessment of Point Sources

An important step in assessing pollutant sources in the Leaf River watershed is locating the NPDES permitted sources. There are 7 facilities permitted to discharge organic material into this segment of the Leaf River or its tributaries, Table 2. These facilities serve a variety of activities in the watershed, including municipalities, industries, and other businesses. The locations of the facilities are shown in Figure 4. Photo 2 shows the Hattiesburg South POTW discharge location.

Photo 2. Hattiesburg South POTW

It should be noted that the Camp Shelby facility has requested a change in their permitted location and discharge. The existing facility is an activated sludge plant that discharges to Weldy Creek, a tributary of the Leaf River, with a permitted flow of 10 MGD. Weldy Creek is a small tributary of the Leaf River. Removing the NPDES discharge from Weldy Creek will improve water quality in this tributary. Since the time of its original construction during WWII, the wastewater treatment needs for Camp Shelby have changed. The permit holder has asked for a change in their permit location to go directly into the Leaf River with a flow of 1.0 MGD. Wastewater at this discharge location would be treated with a new aerated lagoon. Improvements to the wastewater collection system to reduce inflow and infiltration in the system are also planned. This request has been considered in the TMDL report. Since this change would represent a reduction of load of organic material discharged in the Leaf River Watershed, approval of the request is recommended by this TMDL.

Table 2. NPDES Permitted Facilities Treatment Types

Name	NPDES Permit	Treatment Type
Hattiesburg, South	MS0020303	Aerated lagoon
Mississippi Army National Guard, Camp Shelby, Activated Sludge	MS0024996	Activated sludge (current) Aerated lagoon (proposed)
5 R Development Corporation, Trailwood Subdivision	MS0042994	Aerated lagoon
Deerfield Estates	MS0053449	Conventional lagoon
Homestead SD	MS0051233	Activated sludge
Big K, Hwy 11	MS0048178	Aerated lagoon
Dixie Attendance Center	MS0043516	Conventional lagoon
Sherwood Forest Subdivision	MS0031771	Conventional lagoon

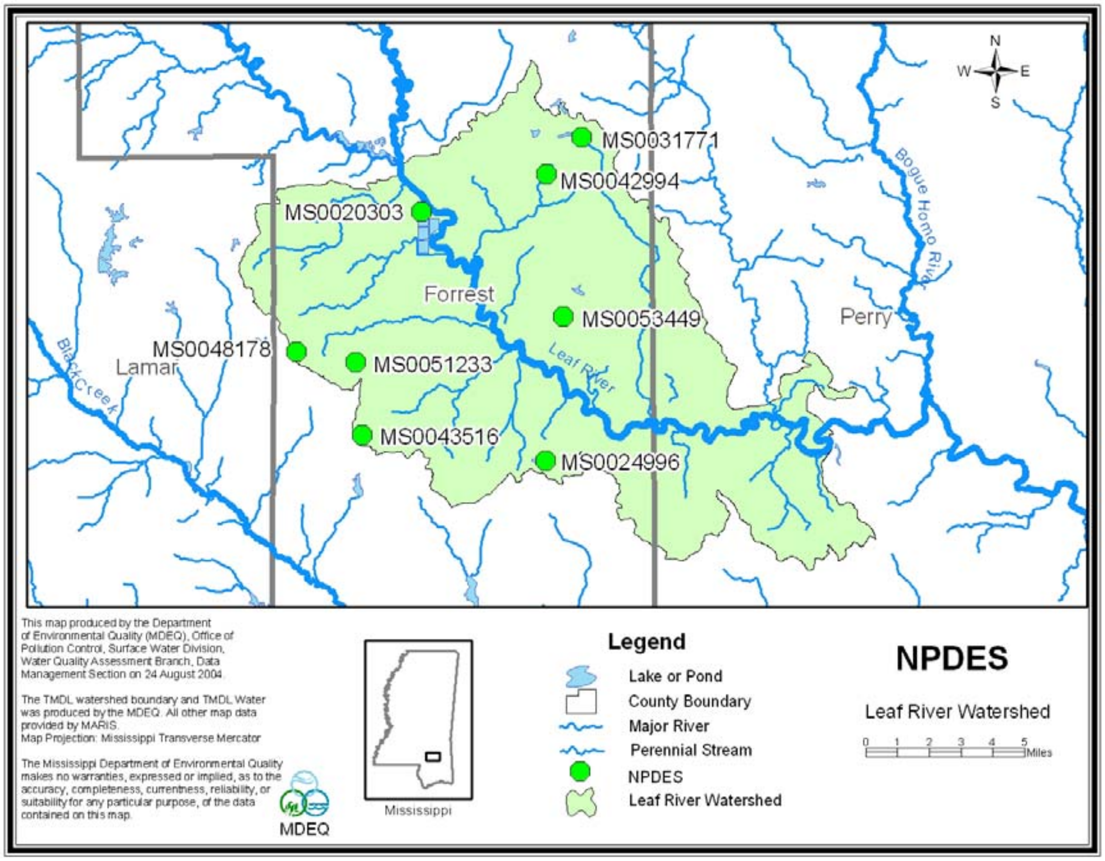


Figure 4. Point Source Location Map for the Leaf River Watershed

The effluent from each facility was characterized based on all available data including information on each facility's wastewater treatment system, permit limits, and discharge monitoring reports. The permit limits as well as the average flows and BOD_5 concentrations, as reported in available discharge monitoring reports (DMRs) for recent years are given in Table 3. Ammonia nitrogen permit limits and monitoring are not required for most of the facilities. Most of the facilities, including the Hattiesburg South POTW and Camp Shelby, are discharging well below their maximum permitted levels. Big K, Hwy 11 has reported values that exceed their permit limits. However, only 1 measurement was available for this facility. More data from this facility is needed to assess whether it is routinely violating its permit limits.

Table 3. Identified NPDES Permitted Facilities

Name	NPDES Permit	Permitted Discharge (MGD)	Actual Average Discharge (MGD)	Permitted Average BOD_5 (mg/L)	Actual Average BOD_5 (mg/L)	Actual Average CBODu (lbs/day)
Hattiesburg, South	MS0020303	20.000	10.970	45	23.68	3,249.7
Mississippi Army National Guard, Camp Shelby, Activated Sludge	MS0024996	10.000	1.070	10	3.63	74.5
5 R Development Corporation, Trailwood Subdivision	MS0042994	0.160	No data	30	No data	No data
Deerfield Estates	MS0053449	0.070	No discharge	30	No discharge	No discharge
Homestead SD	MS0051233	0.080	No discharge	30	No discharge	No discharge
Big K, Hwy 11	MS0048178	0.005	0.007*	30	59.50*	5.2
Dixie Attendance Center	MS0043516	0.015	No discharge	30	No discharge	No discharge
Sherwood Forest Subdivision	MS0031771	0.200	0.160	30	29.08	59.6

*based on one measurement only

2.3 Assessment of Non-Point Sources

Non-point loading of nutrients and organic material in a water body results from the transport of the pollutants into receiving waters by overland surface runoff and groundwater infiltration. Phosphorus is typically seen as the limiting nutrient in most rivers and streams (Thomann and Mueller, 1987). Therefore, this TMDL will address total phosphorus. Phosphorus is primarily transported by runoff when it has been sorbed by eroding sediment. Phosphorous may not be immediately released from sediment and can sometimes reenter the water column from deposited sediment. Most non-point sources of phosphorous will build up and then wash off during rain events. Table 4 presents typical nutrient loading ranges for various land uses.

Table 4. Nutrient Loadings for Various Land Uses

Landuse	Total Phosphorus [lb/acre-y]			Total Nitrogen [lb/acre-y]		
	Minimum	Maximum	Median	Minimum	Maximum	Median
Roadway	0.53	1.34	0.98	1.2	3.1	2.1
Commercial	0.61	0.81	0.71	1.4	7.8	4.6
Single Family-Low Density	0.41	0.57	0.49	2.9	4.2	3.6
Single Family-High Density	0.48	0.68	0.58	3.6	5.0	5.2
Multifamily Residential	0.53	0.72	0.62	4.2	5.9	5.0
Forest	0.09	0.12	0.10	1.0	2.5	1.8
Grass	0.01	0.22	0.12	1.1	6.3	3.7
Pasture	0.01	0.22	0.12	1.1	6.3	3.7

Source: Horner et al., 1994 in Protocol for Developing Nutrient TMDLs (USEPA 1999)

Non-point pollution sources of concern are drainage from the City of Hattiesburg and runoff from agricultural areas. Non-point loading of TBODu in a water body results from the transport of the pollutants into receiving waters by overland surface runoff and groundwater infiltration.

Landuse activities within the drainage basin, such as agriculture and urbanization contribute to non-point source loading.

The drainage area of this section of the Leaf River is approximately 99,149 acres (155 square miles). The watershed contains many different landuse types, including urban, forest, cropland, pasture, water, and wetlands. The landuse information given below is based on data collected by the State of Mississippi's Automated Resource Information System (MARIS) 1997. This data set is based on Landsat Thematic Mapper digital images taken between 1992 and 1993. Forest is the dominant landuse within this watershed. The landuse distribution is shown in Table 5 and Figure 5.

Table 5. Landuse Distribution, Leaf River Watershed

	Urban	Forest	Cropland	Pasture	Scrub/Barren	Water	Wetlands
Area (acres)	7,556	42,777	4,344	16,958	14,218	2,975	10,321
Percentage	8%	43%	4%	17%	14%	3%	10%

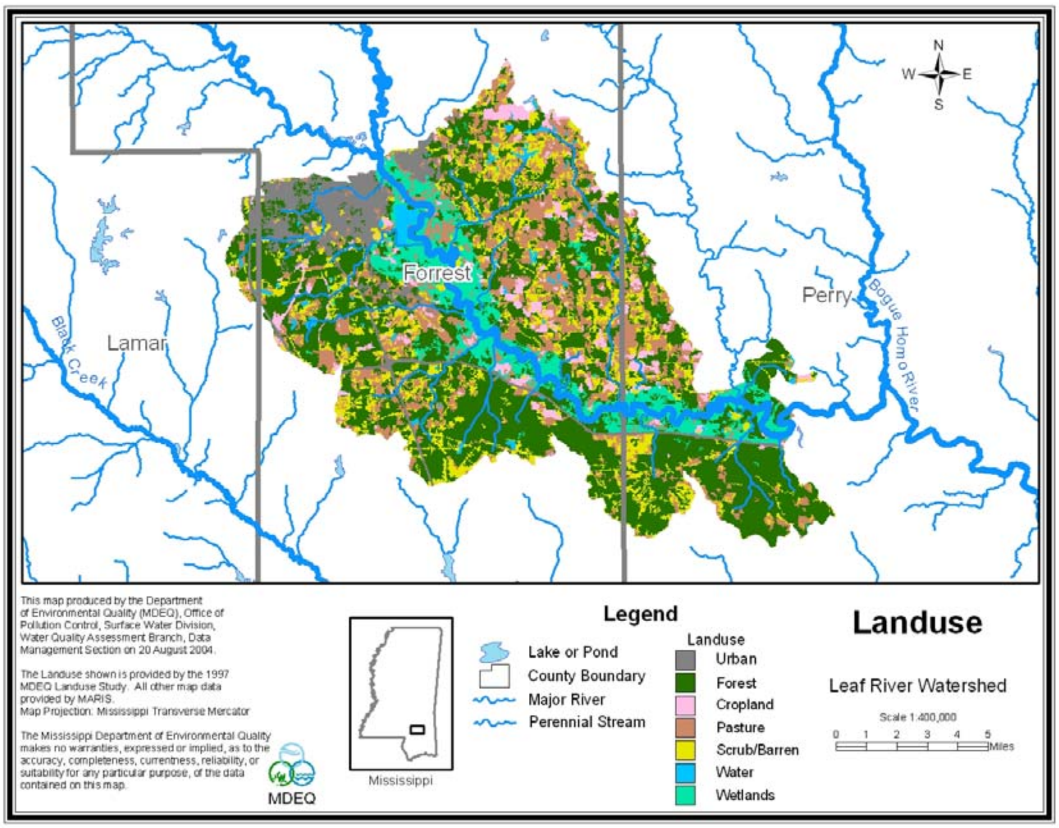


Figure 5. Landuse Distribution for the Leaf River Watershed

MODELING PROCEDURE: LINKING THE SOURCES TO THE ENDPOINT

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. The link can be established through a range of techniques, from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. 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.

3.1 Modeling Framework Selection

A mathematical model, STeady Riverine Environmental Assessment Model (STREAM), for DO distribution in freshwater streams was used for developing the TMDL. STREAM is an updated version of the AWFWUL1 model, which had been used by MDEQ for many years. The use of AWFWUL1 is promulgated in the *Wastewater Regulations for National Pollutant Discharge Elimination System (NPDES) Permits, Underground Injection Control (UIC) Permits, State Permits, Water Quality Based Effluent Limitations and Water Quality Certification* (MDEQ, 1994). This model has been approved by EPA and has been used extensively at MDEQ. A key reason for using the STREAM model in TMDL development is its ability to assess instream water quality conditions in response to point and non-point source loadings.

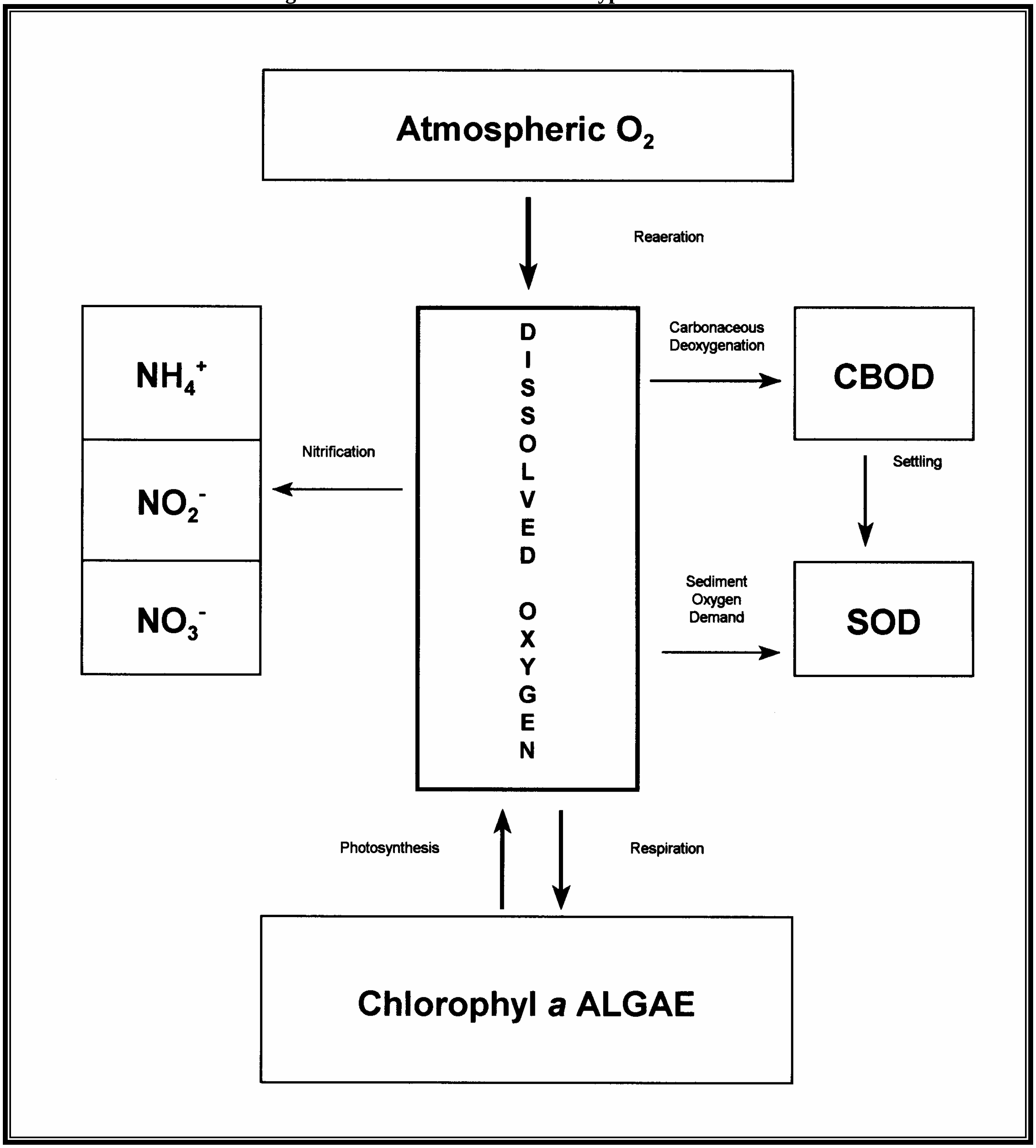
STREAM is a steady-state, daily average computer model that utilizes a modified Streeter-Phelps DO sag equation. Instream processes simulated by the model include CBODu decay, nitrification, reaeration, sediment oxygen demand, and respiration and photosynthesis of algae. Figure 6 shows how these processes are related in a typical DO model. Reaction rates for the instream processes are input by the user and corrected for temperature by the model. The model output includes water quality conditions in each computational element for DO, CBODu, and NH_3-N concentrations. The hydrological processes simulated by the model include stream velocity and flow from point sources and spatially distributed inputs.

The model was set up to calculate reaeration within each reach using the Tsivoglou formulation. The Tsivoglou formulation calculates the reaeration rate, K_a (day^{-1} base *e*), within each reach according to Equation 2.

$$K_a = C*S*U \qquad \textbf{(Equation 2)}$$

C is the escape coefficient, U is the reach velocity in mile/day, and S is the average reach slope in ft/mile. The value of the escape coefficient is assumed to be 0.0597 for streams with flows greater than 10 cfs. Reach velocities were calculated using an equation based on slope. The slope of each reach was estimated from USGS quad maps and input into the model in units of feet/mile. Slopes for the Leaf River typically range from 1 to 4 ft/mile.

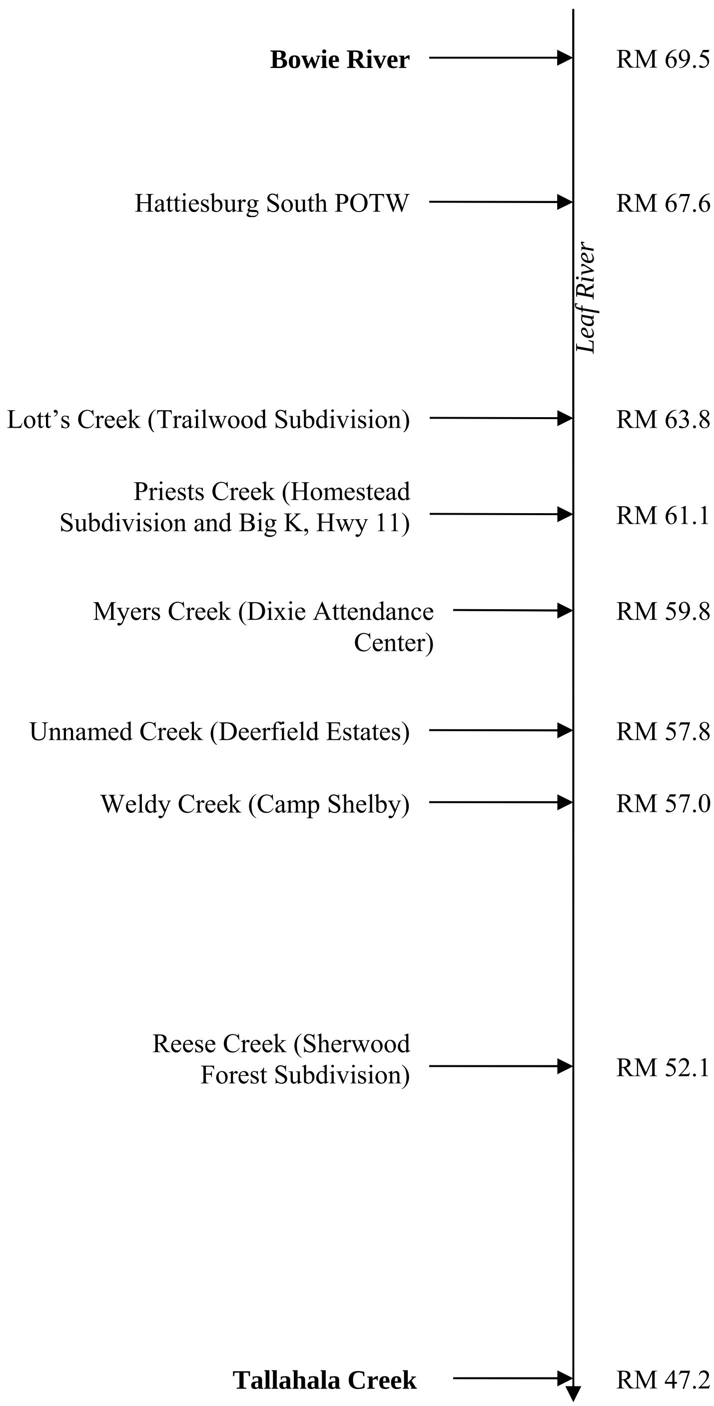
Figure 6. Instream Processes in a Typical DO Model



3.2 Model Setup

The model for this TMDL includes the 303(d) listed segment of the Leaf River, beginning at the confluence of the Bowie River and ending at the confluence with Tallahala Creek. A diagram showing the model setup is shown in Figure 7. The locations of the confluence of point sources and significant tributaries are shown. Point sources were modeled as direct inputs into the Leaf River. Arrows represent the direction of flow in each segment. The numbers on the figure represent approximate river miles (RM). River miles are assigned to water bodies, beginning with zero at the mouth.

Figure 7. Leaf River Model Setup (Note: Not to Scale)



The water body was divided into reaches for modeling purposes. Reach divisions were made at locations where there is a significant change in hydrological and water quality characteristics, such as the confluence of a point source or tributary. Within each reach, the modeled segments were divided into computational elements of 0.1 mile. The simulated hydrological and water quality characteristics were calculated and output by the model for each computational element.

The STREAM model was setup to simulate flow and temperature conditions, which were determined to be the critical condition for this TMDL. In accordance with MDEQ regulations, the temperature was 30°C because the flow is greater than 300 cfs. The headwater instream DO was assumed to be 85% of saturation at the stream temperature. The nitrogenous deoxygenation rate, K_n and the instream CBODu decay rate, K_d at 20°C were input as 0.3 day^{-1} (base e) as specified in MDEQ regulations. The model adjusts the K_d rate based on temperature, according to Equation 3.

$$\mathbf{K_{d(T)} = K_{d(20°C)}(1.047)^{T-20}} \qquad \textbf{(Equation 3)}$$

Where K_d is the CBODu decay rate and T is the assumed instream temperature. The assumptions regarding the instream temperatures, background DO saturation, and CBODu decay rate are required by the *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). Also based on MDEQ Regulations, the rates for photosynthesis, respiration, and sediment oxygen demand were set to zero because data for these model parameters are not available.

The flow in the Leaf River system was modeled at 7Q10 condition based on data available from the USGS (Telis, 1992). There is a flow gauging station located on the Leaf River just downstream of the confluence of the Bowie River. This station is the Leaf River at Hattiesburg, 2473000. The 7Q10 flow at this station is 347 cfs with a drainage area of 1,748 square miles.

3.3 Source Representation

Both point and non-point sources were represented in the model. The loads from NPDES permitted sources were added as direct inputs into the appropriate reach of the Leaf River as a flow in MGD and concentration of $CBOD_5$ and ammonia nitrogen in mg/L. Spatially distributed loads, which represent non-point sources of flow, $CBOD_5$, and ammonia nitrogen were distributed evenly into each computational element of the modeled water body.

Organic material discharged to a stream from an NPDES permitted point source is typically quantified as 5-day biochemical oxygen demand (BOD_5). BOD_5 is a measure of the oxidation of carbonaceous and nitrogenous material over a 5-day incubation period. However, oxidation of nitrogenous material, called nitrification, usually does not take place within the 5-day period because the bacteria that are responsible for nitrification are normally not present in large numbers and have slow reproduction rates (Metcalf and Eddy, 1991). Thus, BOD_5 is generally considered equal to $CBOD_5$. Because permits for point source facilities are written in terms of BOD_5 while TMDLs are typically developed using CBODu, a ratio between the two terms is needed, Equation 4.

$$\textbf{CBODu} = \textbf{CBOD}_5 * \textbf{Ratio} \qquad \textbf{(Equation 4)}$$

The CBODu to $CBOD_5$ ratios are given in *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). These values are recommended for use by MDEQ regulations when actual field data are not available. The value of the ratio depends on the treatment type of wastewater. For secondary treatment systems (conventional and aerated lagoons), this ratio is 1.5. A CBODu to $CBOD_5$ ratio of 1.5 is appropriate for all of the facilities in Leaf River Watershed, with the exception of Homestead Subdivision (MS0051233) and the present system at Camp Shelby (MS0024996). A ratio of 2.3 was used for these facilities. MDEQ regulations specify that a ratio of 2.3 should be used for advanced treatment (activated sludge).

In order to convert the ammonia nitrogen (NH_3-N) loads to an oxygen demand, a factor of 4.57 pounds of oxygen per pound of ammonia nitrogen (NH_3-N) oxidized to nitrate nitrogen (NO_3-N) was used. Using this factor is a conservative modeling assumption because it assumes that all of the ammonia is converted to nitrate through nitrification. The oxygen demand caused by nitrification of ammonia is equal to the NBODu load. The sum of CBODu and NBODu is equal to the point source load of TBODu. The maximum permitted loads of TBODu from each of the existing point sources are given in Table 6. Because the facilities do not have permit limits for NH_3-N an assumed value of 2.0 mg/L was used to calculate the NBODu load for most of the facilities.

Table 6. Point Sources, Maximum Permitted Loads

Facility	Flow (MGD)	$CBOD_5$ (mg/l)	NH_3-N (mg/L)	$CBOD_u$:$CBOD_5$ Ratio	CBODu (lbs/day)	NH_3-N (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
Hattiesburg, South	20.000	45	2	1.5	11,259	334	1,525	12,784
Mississippi Army National Guard, Camp Shelby, Activated Sludge	10.000	10	2	2.3	1,918	167	762	2,681
5 R Development Corporation, Trailwood Subdivision	0.160	30	2	1.5	60	3	12	72
Deerfield Estates	0.070	30	2	1.5	26	1	5	32
Homestead SD	0.080	30	2	2.3	46	1	6	52
Big K, Hwy 11	0.005	30	2	1.5	2	0.1	0.4	2
Dixie Attendance Center	0.015	30	2	1.5	6	0.3	1	7
Sherwood Forest Subdivision	0.200	30	2	1.5	75	3	15	90
					13,392	**509**	**2,326**	**15,720**

Direct measurements of background concentrations of CBODu and NH_3-N were not available for the Leaf River. Because there were no data available, the background concentrations of CBODu and NH_3-N were estimated based on *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). According to these regulations, the background concentrations used in modeling are CBODu = 2.0 mg/L and NH_3-N = 0.1 mg/l. The background concentrations were used to establish the headwater conditions for the Leaf River. They were also used as estimates the CBODu and NH_3-N levels of water entering the water bodies through non-point source flow and tributaries.

Non-point source flows were included in the model to account for the background flow and water entering due to groundwater infiltration, overland flow, and small, unmeasured tributaries. These flows were estimated based on USGS data. The background flow is equal to the 7Q10 flow at the most upstream point of the model, 347 cfs. According to Tellis (1992) the unit 7Q10 (7Q10 flow per square mile of drainage area) for the drainage area of the Leaf River south of Hattiesburg is 0.06 cfs/square mile. The unit 7Q10 was multiplied by the drainage area of the modeled segment of the Leaf River (approximately 155 square miles) to estimate the amount of non-point source flow. It was assumed that the flows were evenly distributed throughout the river. The flows were multiplied by the background concentrations of CBODu and NH_3-N to calculate the non-point source loads going into each reach of the Leaf River, Table 7.

Table 7. Non-Point Source Loads Input into the Model

	Flow (cfs)	$CBOD_u$ (mg/L)	CBODu (lbs/day)	NH_3-N (mg/l)	NBODu (lbs/day)	TBODu (lbs/day)
Background Flow	374	2	6,048	0.1	1,103	7,150
RM 69.5 – RM 67.6	0.79	2	13	0.1	2	15
RM 67.6 – RM 66.7	0.38	2	6	0.1	1	7
RM 66.7 –RM 63.8	1.21	2	20	0.1	3	23
RM 63.8 – RM 61.1	1.13	2	18	0.1	3	21
RM 61.1 – RM 59.8	0.54	2	9	0.1	1	10
RM 59.8 – RM 57.8	0.83	2	13	0.1	2	15
RM 57.8 – RM 57.0	0.33	2	5	0.1	1	6
RM 57.0 – RM 55.3	0.71	2	11	0.1	2	13
RM 55.3 – RM 52.1	1.33	2	22	0.1	3	25
RM 52.1 – RM 51.3	0.33	2	5	0.1	1	6
RM 51.3 – RM 47.2	1.71	2	28	0.1	4	32
			6,198		**1,126**	**7,323**

3.4 Model Calibration

The model used to develop the TMDL was not calibrated due to lack of instream monitoring data collected during critical conditions. However, comparison of the data shows that the predicted daily average dissolved oxygen and ammonia nitrogen levels are in the same range as the more recently collected data from 1999 through 2001 at monitoring station 02473260. This station is located at river mile 60.5. The points on Figures 8 and 9 represent the average measured value, while the bars represent the minimum and maximum value measured. The predicted DO and NH_3-N are in the low range of the measured values. Note that the model predictions in Figures 8 and 9 represent the point source dischargers at their actual discharge level based on DMR data.

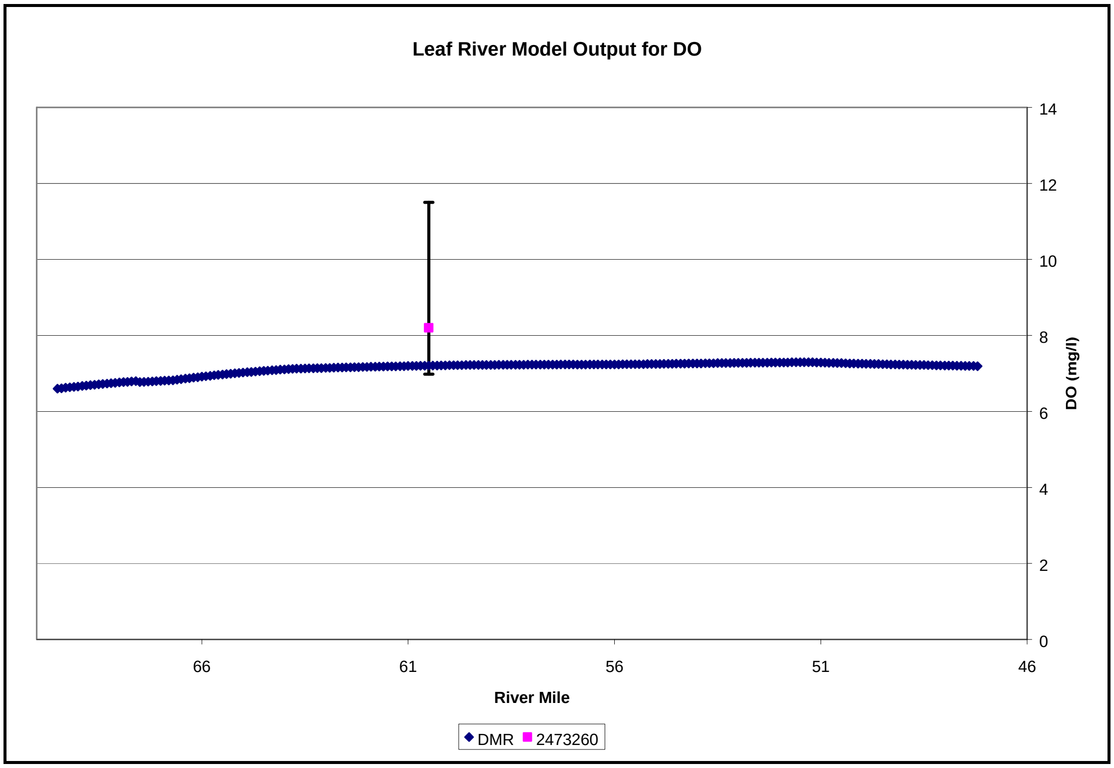


Figure 8. Modeled vs Measured DO

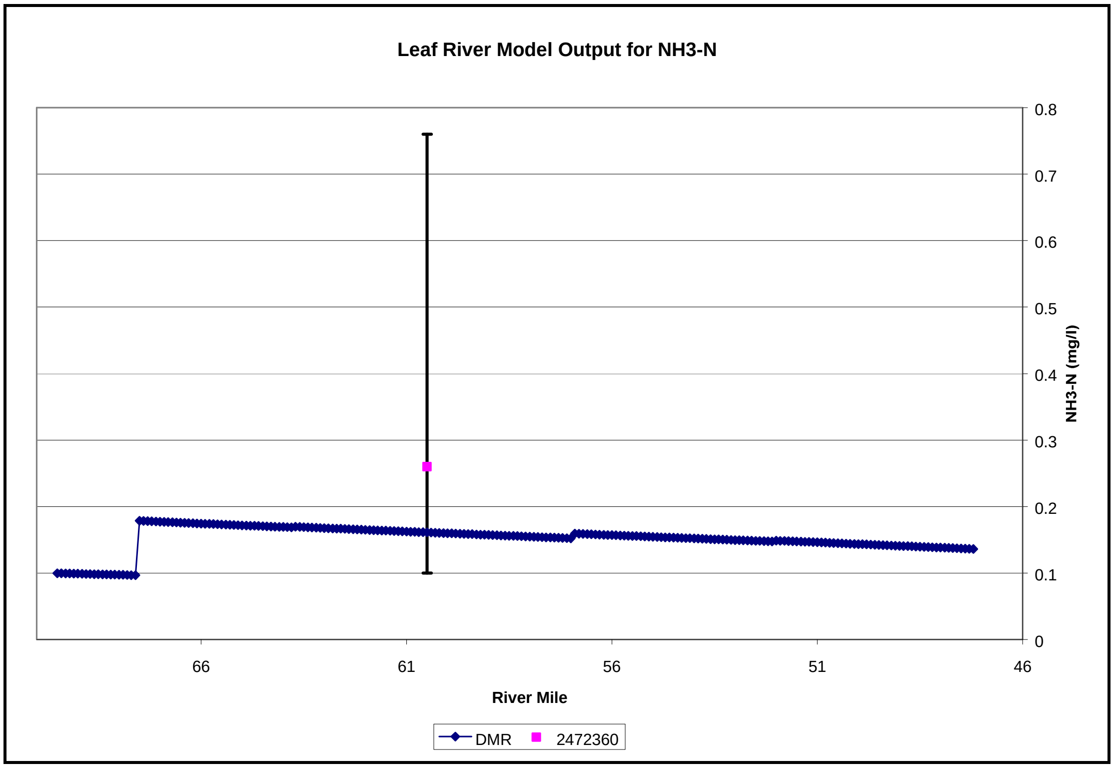


Figure 9. Modeled vs Measured NH_3-N

3.5 Model Results

Once the model setup was complete, the model was used to predict water quality conditions in the Leaf River. The model was first run under baseline conditions. Under baseline conditions, the loads from NPDES permitted point sources were set at their current location and maximum permit limits, Table 6. The model was run again to reflect some improvements in the NPDES sources. The second set of model results is called the maximum load scenario.

3.5.1 Baseline Model Runs

The baseline model results are shown in Figures 10 and 11. Figure 10 shows the modeled daily average DO with the NPDES permits at their maximum allowable loads. The figure shows the daily average instream DO concentrations, beginning with river mile 69.5 and ending with river mile 47.2 of the Leaf River. As shown, the model does not predict that the DO goes below the standard of 5.0 mg/l.

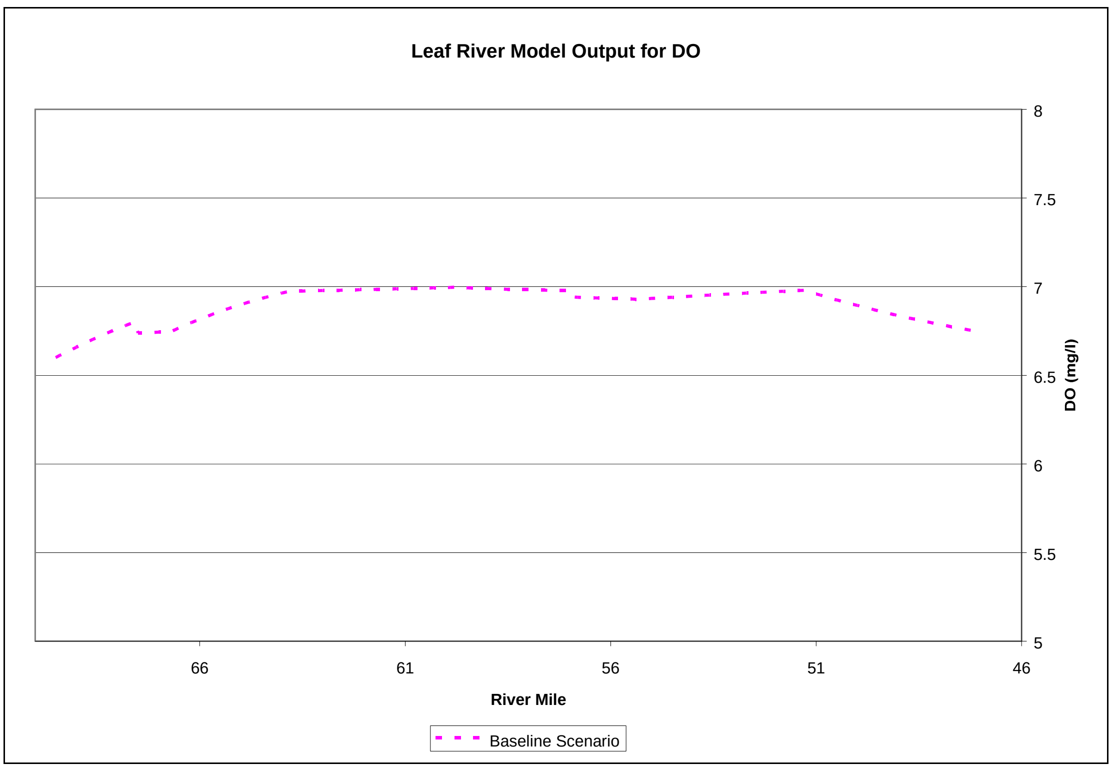


Figure 10. Model Output for the Leaf River for DO, Baseline Scenario

Figure 11 shows the modeled concentration of CBODu in the Leaf River. There are no water quality standards for CBODu concentration. However, model output shows increases of CBODu below the outfalls of the Hattiesburg South POTW and Camp Shelby.

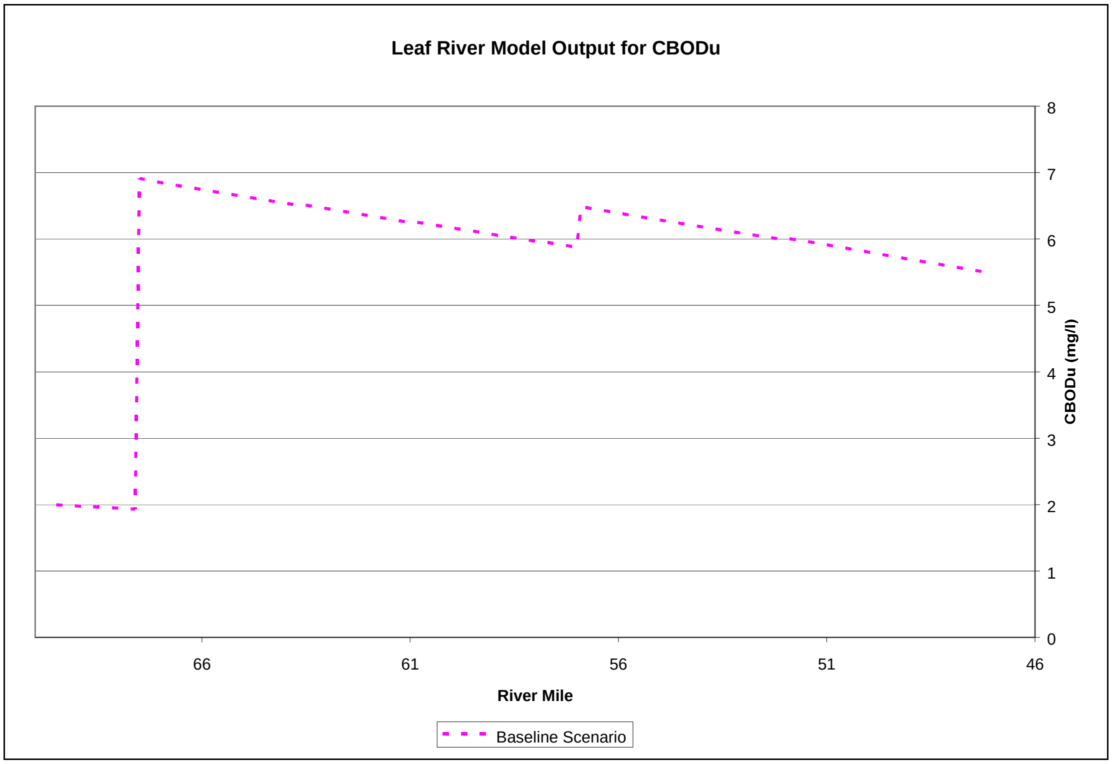


Figure 11. Model Output for the Leaf River for CBODu, Baseline Scenario

3.5.2 Maximum Load Scenario

The graphs of baseline model output show that the predicted DO does not fall below the daily average DO standard in the Leaf River during the simulated critical conditions. However, due to the biological impairment, this TMDL recommends that some improvements be made to the two largest NPDES dischargers, Hattiesburg South POTW and Camp Shelby. Hattiesburg South's permit limit for BOD_5 will be reduced from 45 to 35 mg/l in order to meet a technology based effluent limit. Camp Shelby's permitted discharge flow will be reduced from 10 MGD to 1 MGD, the outfall location will be moved, and a new wastewater treatment system will be constructed. The reduced loading is the maximum load scenario recommended in this TMDL. The overall TBODu load will be reduced 30% from current maximum permitted loads.

Figure 12 shows the modeled instream DO concentrations in the Leaf River after application of the selected maximum load scenario at critical conditions. The figure also shows the results from the baseline scenario for comparison. As shown, the DO in the Leaf River stays well above 5.0 mg/l and increases slightly with the maximum load scenario. Figure 13 shows the modeled CBODu in the Leaf River under the maximum load scenario, and compared to the baseline scenario. As shown, the concentration has decreased under the maximum load scenario. The model results for the maximum load scenario show that the water body has remaining assimilative capacity beyond the current loading. Thus, this TMDL does not limit future growth in this area.

The TBODu loads included in the maximum load scenario are given in Table 8. Note that the load from Camp Shelby was calculated using a CBODu to CBOD5 ratio of 1.5. This ratio is used for wastewater treated with an aerated lagoon. The new Camp Shelby facility is expected to close their current activated sludge treatment process and construct an aerated lagoon system. The overall percent reductions in Table 9 are based on a reduction from the maximum permitted loads. The selected load reduction scenario was used to develop the waste load allocation in this TMDL.

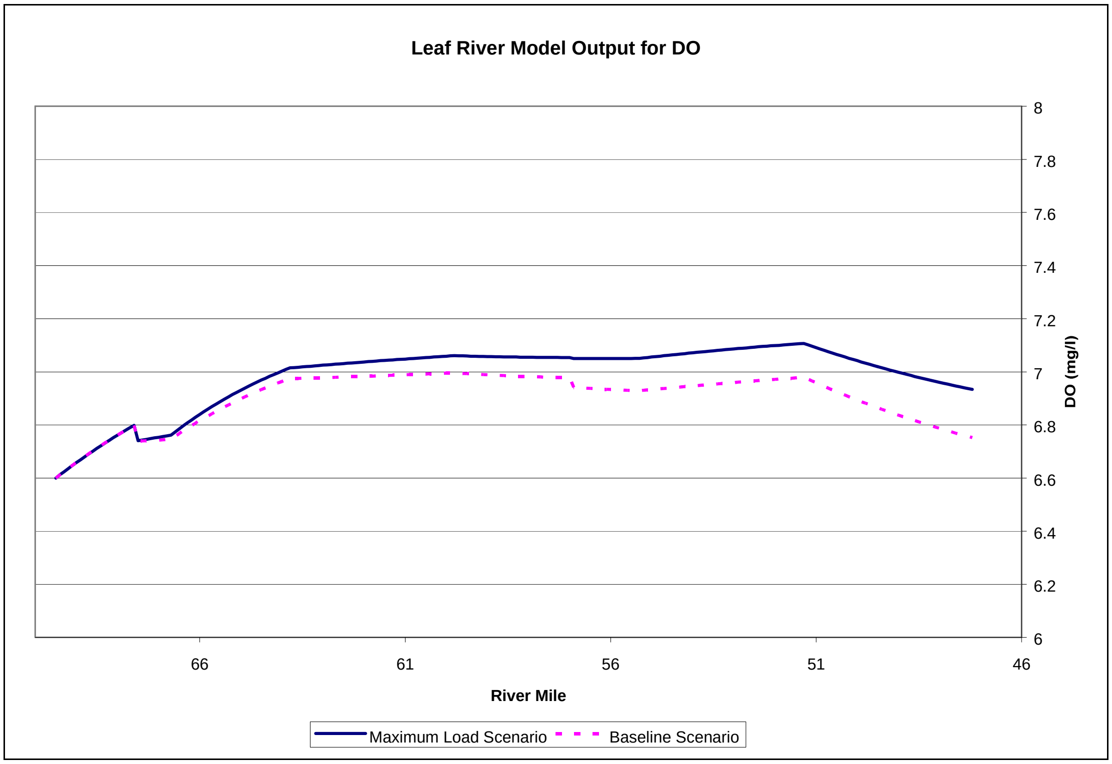


Figure 12. Model Output for the Leaf River for DO, Maximum Load Scenario

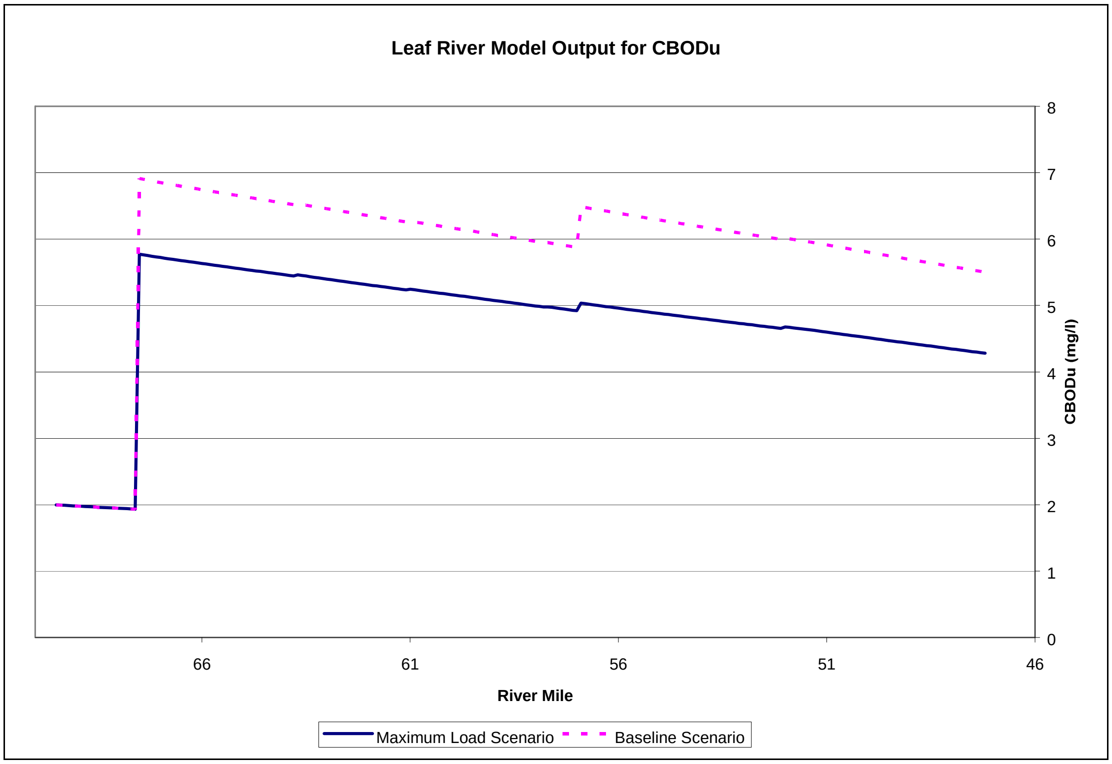


Figure 13. Model Output for the Leaf River for CBODu, Maximum Load Scenario

Table 8. Maximum Load Scenario

Facility	Flow (MGD)	$CBOD_5$ (mg/l)	NH_3-N (mg/L)	$CBOD_u$:$CBOD_5$ Ratio	CBODu (lbs/day)	NH_3-N (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
Hattiesburg, South	20.000	35	2	1.5	8,757	334	1,525	10,282
Mississippi Army National Guard, Camp Shelby	1.000	25	2	1.5	313	17	76	389
5 R Development Corporation, Trailwood Subdivision	0.160	30	2	1.5	60	3	12	72
Deerfield Estates	0.070	30	2	1.5	26	1	5	32
Homestead SD	0.080	30	2	2.3	46	1	6	52
Big K, Hwy 11	0.005	30	2	1.5	2	0.1	0.4	2
Dixie Attendance Center	0.015	30	2	1.5	6	0.3	1	7
Sherwood Forest Subdivision	0.200	30	2	1.5	75	3	15	90
					9,285	**359**	**1,641**	**10,926**

Table 9. Maximum Load Scenario, Percent Reductions

Facility	Percent Reduction from Current Permit Limits
Hattiesburg, South	20%
Mississippi Army National Guard, Camp Shelby, Activated Sludge	85%
5 R Development Corporation, Trailwood Subdivision	0%
Deerfield Estates	0%
Homestead SD	0%
Big K, Hwy 11	0%
Dixie Attendance Center	0%
Sherwood Forest Subdivision	0%
	30%

3.6 Evaluation of Ammonia Toxicity

Ammonia must not only be considered due to its effect on dissolved oxygen in the receiving water, but also its toxicity potential. Ammonia nitrogen concentrations can be evaluated using the criteria given in 1999 Update of Ambient Water Quality Criteria for Ammonia (EPA-822-R-99-014). The maximum allowable instream ammonia nitrogen (NH_3-N) concentration at a pH of 7.0 and stream temperature of 30°C is 2.18 mg/l. Based on the model results, Figure 14, the NH_3-N concentration increases slightly below the Hattiesburg South POTW and Camp Shelby. However, the concentration is well below the water quality standard under the current NH_3-N loads.

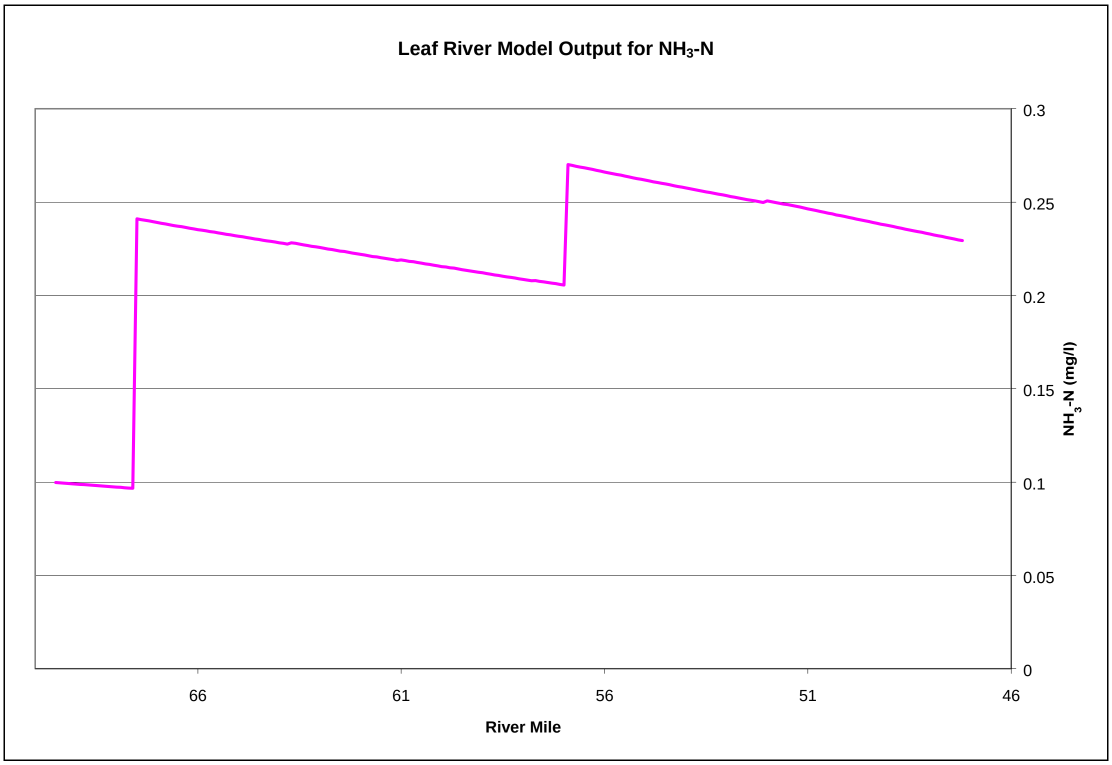


Figure 14. Model Output for Ammonia Nitrogen in the Leaf River

3.7 Total Phosphorus Estimates

The primary data available for the Leaf River were collected as part of the M-BISQ project and historical ambient chemical monitoring. The chemical data available for the Leaf River was collected at station 02473260 near Palmer from January 1997 through December 2001. This data is presented in Section 2.1. The impaired segment of the Leaf River failed to meet minimum water quality criteria for biological use support based on biological sampling conducted in 2001 (MDEQ, 2003). Additional sampling conducted in 2003 under different weather conditions indicated that the preliminary water body IBI score was below the threshold for impairment. As a result of the 2001 sampling, the water body was listed for biological impairment and a Stressor Identification Report was prepared by MDEQ in 2004. The stressor identification process determined that the biological impairment in the Leaf River was most likely due to organic enrichment/low dissolved oxygen, nutrients, and sediment. Sediment will be addressed in another TMDL.

The chemical data in Section 2.1 was used to calculate the annual average total phosphorus concentrations for the Leaf River, which are shown in Table 10. The annual average total phosphorus concentration for 1997 through 2001 is 0.15 mg/l. This average is below the median total phosphorus concentration of 0.22 mg/l for sites in the East Bioregion which have impaired biology and high nutrient concentrations. However, this average value is above the range of 0.07 to 0.11 mg/l of total phosphorus measured for non-impaired wadeable streams located in the East Bioregion.

Table 10. Average Annual Total Phosphorus Loads

Year	Samples Collected	Annual Average TP mg/l
1997	14	0.090
1998	11	0.125
1999	12	0.161
2000	9	0.263
2001	8	0.13
All		**0.15**

The mass balance approach was used only to get an initial estimate of the relative contribution of point and non-point loads. To convert the annual average total phosphorus concentration to a total phosphorus load, the average annual flow for the Leaf River was estimated based on USGS monitoring data. The annual average flow for the Leaf River at Hattiesburg (02473000) is 2696 cfs with a drainage area of 1748 square miles. This flow monitoring station is located on the Leaf River upstream of the impaired segment. To estimate the amount of flow in the Leaf River within the segment, a drainage area ratio was calculated (2696 cfs/1748 square miles = 1.54 cfs/square mile). The ratio was then multiplied by the drainage area of the modeled segment, 2542 square miles (1.54 cfs/square mile * 2542 square miles = 3921 cfs). Thus, the annual average flow in the Leaf River is estimated as 3921 cfs (2534 MGD).

The existing TP load was then estimated, using Equation 5 as shown below, to be 3251 lbs/day. The existing total phosphorous load consists of both point and non-point components. Since many treatment facilities in Mississippi do not have permit limits for phosphorous, nor are they currently required to report effluent phosphorous concentrations, MDEQ used an estimated effluent concentration based on literature values for different treatment types. Table 11 shows the median effluent phosphorus concentrations for four conventional treatment processes. The appropriate concentration for each of the facilities was then used in Equation 5 to estimate the total phosphorus load from point sources.

TP Load (lb/day) = Flow(MGD) *8.34 (conversion factor)* TP Concentration (mg/L) (Eq. 5)

Table 11. Median Phosphorous Concentrations in Wastewater Effluents

	Treatment Type			
	Primary	**Trickling Filter**	**Activated Sludge**	**Stabilization Pond**
No. of plants sampled	55	244	244	149
Total P (mg/L)	6.6 ± 0.66	6.9 ± 0.28	5.8 ± 0.29	5.2 ± 0.45

Source: After Ketchum, 1982 in EPA 823-B-97-002 (USEPA, 1997)

Table 12. NPDES Permitted Facilities Treatment Types with Phosphorus Estimates

Facility Name	NPDES	Treatment Type	Permitted Discharge (MGD)	TP concentration estimate (mg/l)	TP Load estimate (lbs/day)
Hattiesburg, South	MS0020303	Aerated lagoon	20.000	5.2	867.4
Mississippi Army National Guard, Camp Shelby, Activated Sludge	MS0024996	Aerated lagoon (proposed)	1.000	5.2	43.3
5 R Development Corporation, Trailwood Subdivision	MS0042994	Aerated lagoon	0.160	5.2	6.9
Deerfield Estates	MS0053449	Conventional lagoon	0.070	5.8	3.0
Homestead SD	MS0051233	Activated sludge	0.080	5.2	3.9
Big K, Hwy 11	MS0048178	Aerated lagoon	0.005	5.2	0.2
Dixie Attendance Center	MS0043516	Conventional lagoon	0.015	5.2	0.7
Sherwood Forest Subdivision	MS0031771	Conventional lagoon	0.200	5.2	8.7
Total			21.53		934

The average TP point source load is estimated to be 934 pounds per day. The annual average total load based on the average total phosphorus concentration of 0.15 mg/L and an annual average flow of 2534 MGD is 3170.5 pounds per day. The point source load is 29.5% of the total load. Therefore, 70.5% of the annual average total load is from non-point sources.

The annual total phosphorus concentration range for this TMDL is 0.07 to 0.11 mg/L based on total phosphorus concentrations measured for non-impaired wadeable streams in the East Bioregion. The existing annual average concentration for the Leaf River is 0.15 mg/L based on data collected between 1997 and 2001. In order to meet the range for non-impaired wadeable streams in the East Bioregion, a 27 to 53% reduction of the estimated instream total phosphorus concentration is recommended for the Leaf River.

ALLOCATION

The allocation for this TMDL involves a wasteload allocation for point sources and a load allocation for non-point sources necessary for attainment of water quality standards in the Leaf River.

The nutrient portion of this TMDL is addressed through the calculation of an annual average concentration and an initial estimate of the target total phosphorus concentrations. In agreement with EPA Region 4, MDEQ is continuing work on a six year plan to establish criteria for nutrients in wadeable streams, non-wadeable rivers, lakes, and estuaries. The target for this TMDL is only preliminary and will be subject to revision as the work of the NTF continues. When water quality standards and additional information become available, a Phase 2 TMDL may be developed for the Leaf River that includes a modified nutrient target and reduction scenario.

4.1 Wasteload Allocation

Federal regulations require that effluent limits developed to protect water quality criteria are consistent with the assumptions and requirements of any available wasteload allocation for the discharge prepared by the state and approved by EPA. Due to economic and environmental considerations in the watershed, MDEQ will stage the implementation of this TMDL. This TMDL recommends a 5-year compliance schedule be included in the NPDES permits affected by the TMDL. The compliance schedule should require each facility to meet current permit limits during the first four years of the permit. Prior to the end of the fifth year of the permit, the compliance schedule will require each facility to meet limits as determined by the state necessary to meet whatever applicable water quality standards that are in place at that time.

The NPDES Permitted facilities that discharge BOD_5 and ammonia nitrogen in the modeled segment of the Leaf River or tributaries of the Leaf River are included in the wasteload allocation, Table 13. An overall reduction of 30% of the permitted TBODu load is recommended by this TMDL. The reduction for the Hattiesburg South POTW is based on a technology based limit for the wastewater treatment process that this facility uses. The TMDL also recommends approval of Camp Shelby's request for modification and relocation of their discharge point from Weldy Creek to the Leaf River. This change will also involve closing their current activated sludge facility which discharges into a small tributary. Also, the construction of a new aerated lagoon treatment system is recommended. This change is recommended because it will improve Camp Shelby's ability to discharge well-treated wastewater. It will reduce the permitted flow from 10 MGD to 1.0 MGD and the permitted TBODu load by 85%. Also, it will remove the wastewater discharge from Weldy Creek.

Table 13. Wasteload Allocation

Facility	CBODu (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
Hattiesburg, South	8,757	1,525	10,282
Mississippi Army National Guard, Camp Shelby, Activated Sludge	313	76	389
5 R Development Corporation, Trailwood Subdivision	60	12	72
Deerfield Estates	26	5	32
Homestead SD	46	6	52
Big K, Hwy 11	2	0.4	2
Dixie Attendance Center	6	1	7
Sherwood Forest Subdivision	75	15	90
	9,285	**1,641**	**10,926**

Table 14. Wasteload Allocation TP*

Facility	Existing Estimated TP Point Source Concentration (mg/l)	Permitted Discharge (MGD))	Existing Estimated TP Point Source Load (lbs/day)	Allocated Average TP Point Source Load (lbs/day)	Percent Reduction
Hattiesburg, South	5.2	20.000	867.4	867.4	0
Mississippi Army National Guard, Camp Shelby, Activated Sludge	5.2	1.000	43.3	43.3	0
5 R Development Corporation, Trailwood Subdivision	5.2	0.160	6.9	6.9	0
Deerfield Estates	5.8	0.070	3.0	3.0	0
Homestead SD	5.2	0.080	3.9	3.9	0
Big K, Hwy 11	5.2	0.005	0.2	0.2	0
Dixie Attendance Center	5.2	0.015	0.7	0.7	
Sherwood Forest Subdivision	5.2	0.200	8.7	8.7	0
		21.53	934	934*	0

* Due to the lack of nutrient water quality criteria these Phase 1 TMDL allocations are estimates based on literature assumptions and projected targets. The State of Mississippi is in the process of developing numeric nutrient criteria in accordance with an EPA approved work plan for nutrient criteria development. This TMDL recommends quarterly monitoring of nutrients for NPDES facilities. MDEQ's calculations of the annual average load indicate that the majority of the estimated nutrient load is from non-point sources. Therefore, the State will focus on striving to attain the goal set by the LA portion of the TMDL.

The estimated load of total phosphorus from point sources shown in Table 14 is 29.5% of the estimated existing average annual load of total phosphorus in the Leaf River, as described in Section 3.7. Because this estimate is based on literature values this TMDL recommends quarterly nutrient monitoring for all facilities, except Big K, Hwy 11 and the Dixie Attendance Center.

Although this wasteload allocation is based on the permit limits of facilities present in the Leaf River watershed, it is not intended to prevent the issuance of permits for future facilities. This is because the model results show that the Leaf River has additional assimilative capacity for organic material. Future permits will be considered on a case-by-case basis.

4.2 Load Allocation

The headwater and spatially distributed loads are included in the load allocation. The TBODu concentrations of these loads were determined by using an assumed $CBOD_u$ concentration of 2.0 mg/L and an NH_3-N concentration of 0.1 mg/l. These concentrations should be assumed when reliable field data are not available, according to *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). This TMDL does not require a reduction of the load allocation for organic enrichment, but does recommend reduction of the nonpoint source contribution of total phosphorus. In Table 15, the load allocation is shown as background (the flow at the most upstream point in the model) and non-point source (the spatially distributed flow entering each reach in the model).

Table 15. Load Allocation

	Flow (cfs)	$CBOD_u$ (mg/L)	CBODu (lbs/day)	NH_3-N (mg/L)	NBODu (lbs/day)	TBODu (lbs/day)
Background	374.0	2	6,048	0.1	921	6,969
Non-Point Source	9.3	2	150	0.1	23	173
	383.3		**6,198**		**944**	**7,142**

Based on initial estimates in Section 3.7, approximately 70.5% of the total phosphorus load in this watershed comes from non-point sources. Therefore, best management practices (BMPs) should be encouraged in the watershed to reduce potential total phosphorus loads from non-point sources. The Leaf River watershed should be considered a priority for riparian buffer zone restoration and any nutrient reduction BMPs. For land disturbing activities related to silviculture, construction, and agriculture, it is recommended that practices, as outlined in "Mississippi's BMPs: Best Management Practices for Forestry in Mississippi" (MFC, 2000), "Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater" (MDEQ, et. al, 1994), and "Field Office Technical Guide" (NRCS, 2000), be followed, respectively. Table 16 shows the load allocation for Total Phosphorus based on the estimates given in Section 3.7.

Table 16. Load Allocation for Estimated Total Phosphorus

Existing Estimated TP Nonpoint Source Load (lbs/day)	Allocated Average TP Nonpoint Source Load (lbs/day)	Percent Reduction
2236.5	545.6 to 1391.0	38% to 76%

4.3 Incorporation of a Margin of Safety

The margin of safety is a required component of a TMDL and accounts for the uncertainty about the relationship between pollutant loads and the quality of the receiving water body. The two types of MOS development are to implicitly incorporate the MOS using conservative model assumptions or to explicitly specify a portion of the total TMDL as the MOS. The MOS selected for this model is implicit.

Conservative assumptions which place a higher demand of DO on the water body than may actually be present are considered part of the margin of safety. The assumption that all of the ammonia nitrogen present in the water body is oxidized to nitrate nitrogen, for example, is a conservative assumption. In addition, the TMDL is based on the critical condition of the water body represented by the low-flow, high-temperature condition. Modeling the water body at this flow provides protection during the worst-case scenario.

The total phosphorus allocations incorporate an implicit margin of safety in the estimation of the allocations using annual average flow estimates and literature values for loading based on facility type. The estimation of the preliminary target also includes implicitly conservative assumptions in the use of only the non-impaired streams for target development.

4.4 Seasonality

Seasonal variation may be addressed in the TMDL by using seasonal water quality standards or developing model scenarios to reflect seasonal variations in temperature and other parameters. Mississippi's water quality standards for dissolved oxygen, however, do not vary according to the seasons. This model was set up to simulate dissolved oxygen during the critical condition period, the low-flow, high-temperature period that typically occurs during the summer season. Since the critical condition represents the worst-case scenario, the TMDL developed for critical conditions is protective of the water body at all times. Thus, this TMDL will ensure attainment of water quality standards for each season.

4.5 Calculation of the TMDL

The TMDLs were calculated based on Equation 6.

$$\textbf{TMDL} = \textbf{WLA} + \textbf{LA} + \textbf{MOS} \qquad \textbf{(Equation 6)}$$

Where WLA is the wasteload allocation, LA is the load allocation, and MOS is the margin of safety. All units are in lbs/day of TBODu. The phase 1 TMDL for TBODu was calculated based on the current loading of pollutant in the Leaf River, according to the model. The TMDL calculations are shown in Tables 17 and 18. As shown in Table 17, TBODu is the sum of CBODu and NBODu. The wasteload allocations incorporate the CBODu and NH_3-N contributions from identified NPDES Permitted facilities. The load allocations include the background and non-point sources of TBODu and NH_3-N from surface runoff and groundwater infiltration. The implicit margin of safety for this TMDL is derived from the conservative assumptions used in setting up the model.

Table 17. Phase 1 TMDL for TBODu in the Leaf River Watershed

	WLA (lbs/day)	LA (lbs/day)	MOS	TMDL (lbs/day)
CBODu	9,285	6,198	Implicit	15,483
NBODu	1,641	944	Implicit	2,585
TBODu	**10,926**	**7,142**		**18,068**

Table 18. Phase 1, TMDL for TP* in the Leaf River Watershed

	WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
TP	**934.0***	**545.6 to 1391.0***	**Implicit**	**1479.6 to 2325.0***

* Due to the lack of nutrient water quality criteria these Phase 1 TMDL allocations are estimates based on literature assumptions and projected targets. The State of Mississippi is in the process of developing numeric nutrient criteria in accordance with an EPA approved work plan for nutrient criteria development. This TMDL recommends quarterly monitoring of nutrients for NPDES facilities. MDEQ's calculations of the annual average load indicate that the majority of the estimated nutrient load is from non-point sources. Therefore, the State will focus on striving to attain the goal set by the LA portion of the TMDL.

The TMDL presented in this report represents the current load of a pollutant allowed in the water body. Although it has been developed for critical conditions in the water body, the allowable load is not tied to any particular combination of point and non-point source loads. The LA given in the TMDL applies to all non-point sources, and does not assign loads to specific sources. Also, the WLA does not dictate a specific distribution of the loads among individual point sources.

It is noted that a sediment TMDL is also being developed for segment MS086E of the Leaf River. In this TMDL, BMPs, as outlined in "Mississippi's BMPs: Best Management Practices for Forestry in Mississippi" (MFC, 2000), "Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater" (MDEQ, et. al, 1994), and "Field Office Technical Guide" (NRCS, 2000), would be the most effective means of reducing the sediment load from a majority of potential upland sources. While these BMPs address the issue of sediment control, it is believed that these BMP's will also help alleviate any non-point source runoff that would contribute to organic enrichment and nutrient loading in the Leaf River. The adoption of numeric nutrient criteria will be reflected in the Phase 2 TMDL that will be completed using data based allocations in lieu of the literature based allocations included in this TMDL. MDEQ's calculations of the annual average load indicate that the majority of the estimated nutrient load is from non-point sources. Therefore, the State will focus on striving to attain the goal set by the LA portion of the TMDL.

4.6. 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 LA components and reductions.

MDEQ has adopted the Basin Approach to Water Quality Management, a plan that divides Mississippi's major drainage basins into five groups. Each TMDL is evaluated through the Basin Team for prioritization and targeting of implementation activities.

CONCLUSION

Monitoring data indicate that this segment was biologically impaired in 2001. A second biological sample in 2003 was found to be above the impairment threshold, indicating that the water body was not impaired. Weather and rainfall amounts may be a significant contributor to the impairment seen during dry conditions in 2001 and subsequent recovery in 2003. MDEQ believes the reductions applied to the two largest wastewater treatment facilities in this watershed will positively impact the Leaf River by reducing nutrients and organic load.

This Phase 1 TMDL is based on a desktop model using MDEQ's regulatory assumptions and literature values in place of actual field data. The model results indicate that the Leaf River is meeting the water quality standard for dissolved oxygen at the present loading of TBODu. The TMDL recommends some improvements to the existing facilities. However, this TMDL does not limit the issuance of new NPDES permits in the watershed as long as new facilities meet technology based limits and do not cause impairment in the Leaf River. Nutrients were addressed through an estimate of a preliminary total phosphorus concentration target range. This TMDL has been developed as a Phase 1 TMDL so that TBOD and/or nutrients may be further evaluated when more data are available or when numeric water quality standards are finalized for nutrients.

In lieu of state water quality standards for nitrogen and phosphorus, MDEQ developed this estimated TMDL for total phosphorus based on various assumptions. The TMDL recommends a 27 to 53% reduction of the nutrient concentrations in the Leaf River to meet the preliminary range of 0.07 to 0.11 mg/l. Because 70.5% of the existing total phosphorus load is estimated to be due to non-point sources, the State will focus on striving to attain the goal set by the LA portion of the TMDL. This TMDL recommends quarterly nutrient monitoring for the facilities shown in Table 19. Additionally, it is recommended that the Leaf River watershed be considered as a priority watershed for riparian buffer zone restoration and any nutrient reduction BMPs. The implementation of these BMP activities should reduce the nutrient load entering the Leaf River. This will provide improved water quality for the support of aquatic life in the water body and will result in the attainment of the applicable water quality standards.

Table 19. Facilities Recommended for Quarterly Nutrient Monitoring

Name	NPDES Permit
Hattiesburg, South	MS0020303
Mississippi Army National Guard, Camp Shelby, Activated Sludge	MS0024996
5 R Development Corporation, Trailwood Subdivision	MS0042994
Deerfield Estates	MS0053449
Homestead SD	MS0051233
Sherwood Forest Subdivision	MS0031771

5.1 Additional Monitoring

MDEQ has conducted monitoring activities in the Bowie River several miles above its confluence with the Leaf River. This monitoring took place in September 2004. It involved sampling for water chemistry parameters, including dissolved oxygen and nutrient concentrations, at several locations. The effort also included a time-of-travel study in the Bowie

River. Although this study did not involve data collection in the Leaf River, the results may be useful in estimating the contribution of organic material and nutrients from the Bowie River when laboratory data become available.

Additional monitoring needed for model refinement may be prioritized by the local stakeholders, MDEQ, and EPA. 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's resources for water quality monitoring will be focused on one of the basin groups. During the next monitoring phase in the Pascagoula Basin, the Leaf River Watershed may receive additional monitoring to identify any change in water quality.

5.2 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 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.

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DEFINITIONS

5-Day Biochemical Oxygen Demand: Also called BOD_5, the amount of oxygen consumed by microorganisms while stabilizing or degrading carbonaceous or nitrogenous compounds under aerobic conditions over a period of 5 days.

Activated Sludge: A secondary wastewater treatment process that removes organic matter by mixing air and recycled sludge bacteria with sewage to promote decomposition

Aerated Lagoon: A relatively deep body of water contained in an earthen basin of controlled shape which is equipped with a mechanical source of oxygen and is designed for the purpose of treating wastewater.

Ammonia: Inorganic form of nitrogen (NH_3); product of hydrolysis of organic nitrogen and denitrification. Ammonia is preferentially used by phytoplankton over nitrate for uptake of inorganic nitrogen.

Ammonia Nitrogen: The measured ammonia concentration reported in terms of equivalent ammonia concentration; also called total ammonia as nitrogen (NH_3-N)

Ammonia Toxicity: Under specific conditions of temperature and pH, the unionized component of ammonia can be toxic to aquatic life. The unionized component of ammonia increases with pH and temperature.

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

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

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

Biological Impairment: Condition in which at least one biological assemblages (e.g. , fish, macroinvertebrates, or algae) indicates less than full support with moderate to severe modification of biological community noted.

Carbonaceous Biochemical Oxygen Demand: Also called CBODu, the amount of oxygen consumed by microorganisms while stabilizing or degrading carbonaceous compounds under aerobic conditions over an extended time period.

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.

Conventional Lagoon: An un-aerated, relatively shallow body of water contained in an earthen basin of controlled shape and designed for the purpose of treating water.

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

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

Discharge Monitoring Report: Report of effluent characteristics submitted by a NPDES Permitted facility.

Dissolved Oxygen: The amount of oxygen dissolved in water. It also refers to a measure of the amount of oxygen that is available for biochemical activity in a water body. The maximum concentration of dissolved oxygen in a water body depends on temperature, atmospheric pressure, and dissolved solids.

Dissolved Oxygen Deficit: The saturation dissolved oxygen concentration minus the actual dissolved oxygen concentration.

DO Sag: Longitudinal variation of dissolved oxygen representing the oxygen depletion and recovery following a waste load discharge into a receiving water.

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

Effluent: Treated wastewater flowing out of the treatment facilities.

First Order Kinetics: Describes a reaction in which the rate of transformation of a pollutant is proportional to the amount of that pollutant in the environmental system.

Groundwater: Subsurface water in the zone of saturation. Groundwater infiltration describes the rate and amount of movement of water from a saturated formation.

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 non-point source pollution from the land surface to the receiving stream.

Load Allocation (LA): The portion of receiving water's loading capacity attributed to or assigned to non-point sources (NPS) or background sources of a pollutant

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

Mass Balance: An equation that accounts for the flux of mass going into a defined area and the flux of mass leaving a defined area, the flux in must equal the flux out.

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

Nitrification: The oxidation of ammonium salts to nitrites via *Nitrosomonas* bacteria and the further oxidation of nitrite to nitrate via *Nitrobacter* bacteria.

Nitrogenous Biochemical Oxygen Demand: Also called NBODu, the amount of oxygen consumed by microorganisms while stabilizing or degrading nitrogenous compounds under aerobic conditions over an extended time period.

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

Photosynthesis: The biochemical synthesis of carbohydrate based organic compounds from water and carbon dioxide using light energy in the presence of chlorophyll.

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

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

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

Reaeration: The net flux of oxygen occurring from the atmosphere to a body of water across the water surface.

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

Respiration: The biochemical process by means of which cellular fuels are oxidized with the aid of oxygen to permit the release of energy required to sustain life. During respiration, oxygen is consumed and carbon dioxide is released.

Sediment Oxygen Demand: The solids discharged to a receiving water are partly organics, which upon settling to the bottom decompose aerobically, removing oxygen from the surrounding water column.

Storm Runoff: Rainfall that does not evaporate or infiltrate the ground because of impervious land surfaces or a soil infiltration rate than rainfall intensity, but instead flows into adjacent land or water bodies or is routed into a drain or sewer system.

Streeter-Phelps DO Sag Equation: An equation which uses a mass balance approach to determine the DO concentration in a water body downstream of a point source discharge. The equation assumes that the stream flow is constant and that CBODu exertion is the only source of DO deficit while reaeration is the only sink of DO deficit.

Technology based effluent limitation (TBEL): A minimum waste treatment requirement, established by the Department, based on treatment technology. The minimum treatment requirements may be set at levels more stringent than that which is necessary to meet water quality standards of the receiving water body.

Total Ultimate Biochemical Oxygen Demand: Also called TBODu, the amount of oxygen consumed by microorganisms while stabilizing or degrading carbonaceous or nitrogenous compounds under aerobic conditions over an extended time period.

Total Kjeldahl Nitrogen: Also called TKN, organic nitrogen plus ammonia nitrogen.

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

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

Wasteload Allocation (WLA): The portion of a receiving water's loading capacity attributed to or assigned to point sources of a pollutant.

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

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

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: The area of land draining into a stream at a given location.

ABBREVIATIONS

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

BMP .... Best Management Practice

$CBOD_5$ .... 5-Day Carbonaceous Biochemical Oxygen Demand

CBODu .... Carbonaceous Ultimate Biochemical Oxygen Demand

CWA .... Clean Water Act

DMR .... Discharge Monitoring Report

DO .... Dissolved Oxygen

EPA .... Environmental Protection Agency

GIS .... Geographic Information System

HUC .... Hydrologic Unit Code

LA .... Load Allocation

MARIS .... Mississippi Automated Resource Information System

MDEQ .... Mississippi Department of Environmental Quality

MGD .... Million Gallons per Day

MOS .... Margin of Safety

NBODu .... Nitrogenous Ultimate Biochemical Oxygen Demand

NH_3 .... Total Ammonia

NH_3-N .... Total Ammonia as Nitrogen

NO_2+ NO_3 .... Nitrite Plus Nitrate

NPDES .... National Pollution Discharge Elimination System

NTF .... Nutrient Task Force

POTW .... Public Owned Treatment Works

RBA .... Rapid Biological Assessment

TBODu...Total Ultimate Biochemical Oxygen Demand

TKN .... Total Kjeldahl Nitrogen

TN ....Total Nitrogen

TOC... Total Organic Carbon

TP .... Total Phosphorous

USGS .... United States Geological Survey

WLA .... Waste Load Allocation