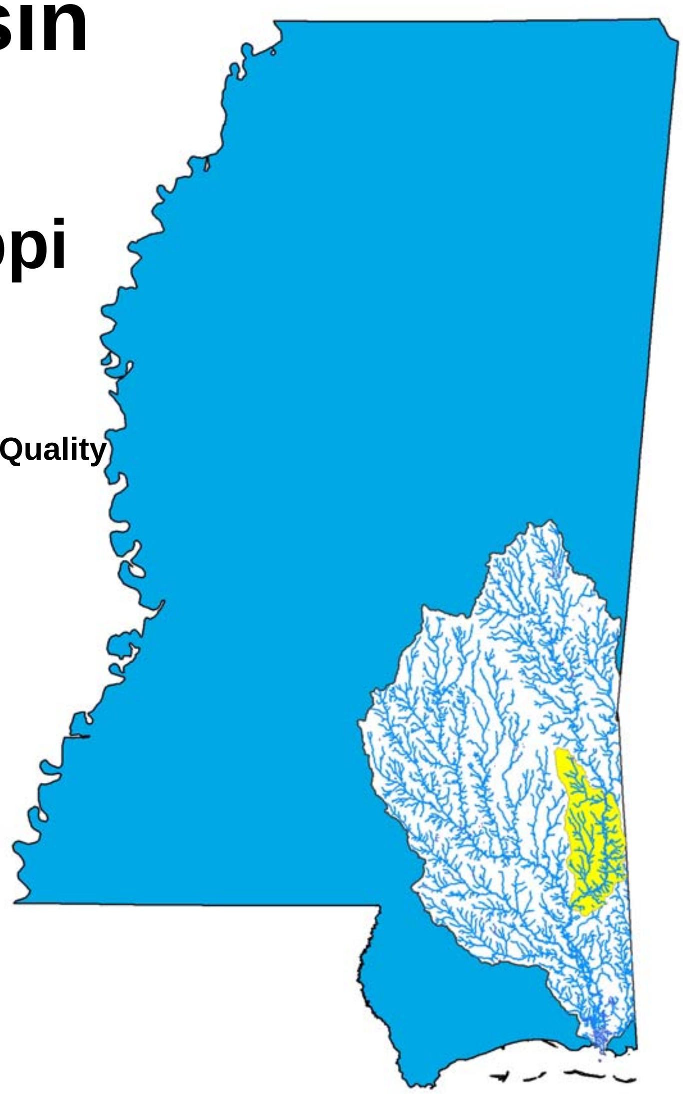
FINAL REPORT
June 2005
ID: 405063008

Phase 1
Total Maximum Daily Load
For Nutrients (Organic Enrichment, Total Phosphorus, and Ammonia Toxicity)

Chickasawhay River
Pascagoula Basin

Greene and Wayne Counties, Mississippi



Prepared By

Mississippi Department of Environmental Quality
Office of Pollution Control
TMDL/WLA Branch

MDEQ
PO Box 10385
Jackson, MS 39289-0385
(601) 961-5171
Hwww.deq.state.ms.us

Mississippi Department of
Environmental Quality

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	640.000	acre	ft^2	43560.00
km^2	acre	247.100	days	seconds	86400.00
m^3	ft^3	35.300	meters	feet	3.28
ft^3	gallons	7.480	ft^3	gallons	7.48
ft^3	liters	28.300	hectares	acres	2.47
cfs	gal/min	448.800	miles	meters	1609.30
cfs	MGD	0.646	tonnes	tons	1.10
m^3	gallons	264.200	µg/l * cfs	gm/day	2.45
m^3	liters	1000.000	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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TMDL INFORMATION PAGE

i. Listing Information

Name	ID	County	HUC	Cause	Mon/Eval
Chickasawhay River	MSLCHKRE1	Wayne, Greene	03170003	Nutrients	Evaluated
From confluence with Bucatunna Creek to confluence with Leaf River					

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 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.

iii. NPDES Facilities

NPDES ID	Facility Name	Permitted Discharge (MGD)	Receiving Water
MS0020664	Leakesville POTW	0.15	Martin Creek
MS0042935	Greene County School District	0.0275	Unnamed Tributary
MS0050750	South MS Correctional Facility	0.45	Martin Creek
MS0035211	Stateline POTW	0.15	Unnamed Tributary
MS0038784	Bucatunna Elementary	0.0075	Unnamed Tributary

iv. Phase 1 Total Maximum Daily Load for TBODu

WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
242.01	**3357.47**	**19933.75**	**23533.23**

EXECUTIVE SUMMARY

This TMDL has been developed for a segment of the Chickasawhay River placed on the Mississippi 2002 Section 303(d) List of Water Bodies as an evaluated water body segment. The segment of the Chickasawhay River is listed due to nutrients and sediment. Sediment will be addressed in a separate TMDL report. Mississippi currently does not have standards for allowable nutrient concentrations, however, because elevated levels of nutrients may cause low levels of dissolved oxygen, this TMDL also addresses nutrients. 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 be evaluated in this TMDL using criteria established for ammonia nitrogen toxicity. Additionally this TMDL will estimate the total phosphorus load in the stream and a preliminary breakpoint between point and nonpoint sources. This TMDL has been developed as a phase 1 TMDL so that when more data are available and nutrient water quality standards are developed phase 2 could address nitrogen and/or phosphorus loads as needed.

The §303(d) listed Chickasawhay River watershed is located in southeastern Mississippi in HUC 03170003. The §303(d) listed segment, Photo 1, begins near the town of Buckatunna in Wayne County near the Mississippi and Alabama state line, and flows for approximately 50 miles from the confluence with Bucatunna Creek to the mouth at the Leaf River. The location of the watershed is shown in Figure 1.

Photo 1. The Chickasawhay River near Buckatunna

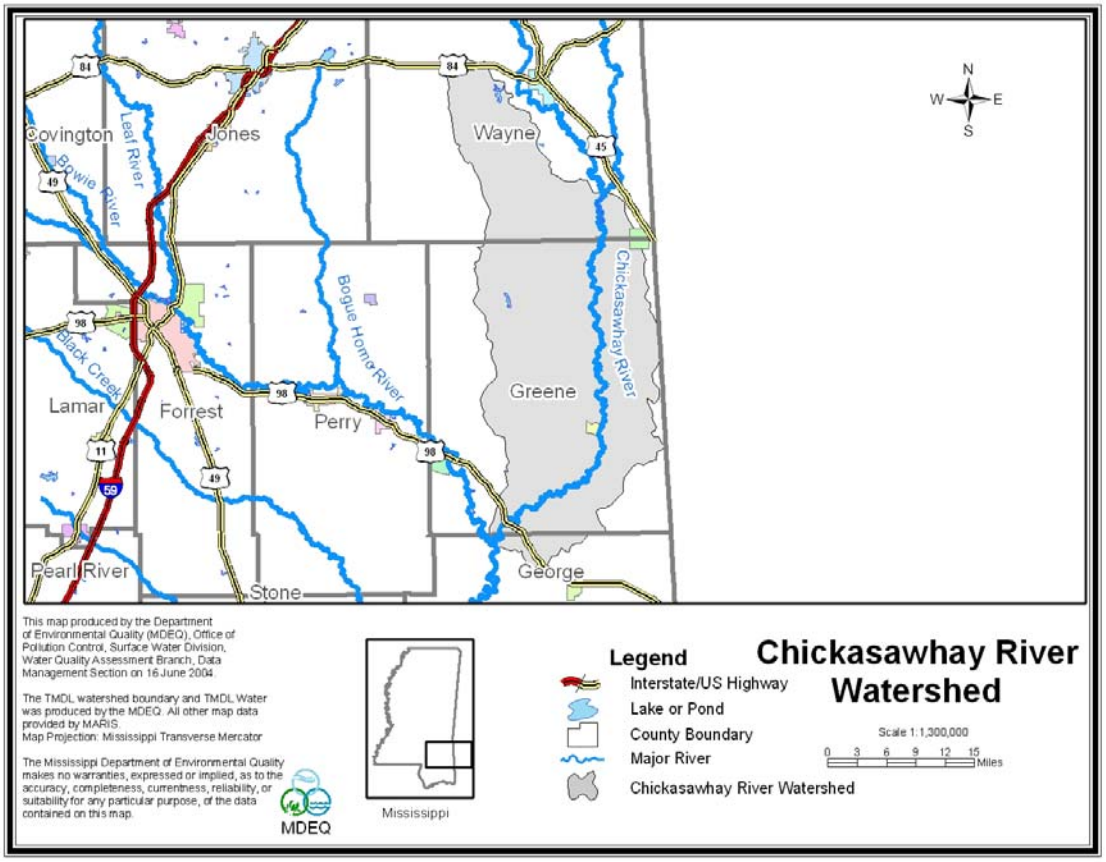


Figure 1. The Chickasawhay River Watershed

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. 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 the total phosphorus contributions from point and nonpoint sources. The critical modeling period was determined to occur during the hot, dry summer period.

The TMDL for organic enrichment/low dissolved oxygen due to nutrients was quantified in terms of total ultimate biochemical oxygen demand (TBODu). The model used in developing this TMDL included point and non-point sources of TBODu in the Chickasawhay River Watershed. TBODu loading from non-point sources in the watershed was accounted for by using an estimated background concentration of TBODu in the water body. There are currently five NPDES Permitted discharges located in the watershed. The model results showed that the DO levels in the Chickasawhay River are above water quality standards, mass balance calculations showed that the levels of NH_3-N are well below toxicity levels and that the total phosphorus levels are predominantly from nonpoint sources. Thus, there is additional assimilative capacity in the water body. There are no reductions from the current loading required by this TMDL.

INTRODUCTION

1.1 Background

The Chickasawhay River was originally placed on the §303(d) List was based on anecdotal information. Mississippi conducted a survey of district conservationists (DC) in 1988 and 1989 to find candidate watersheds for future §319 funding opportunities. MDEQ requested each DC identify the watersheds of concern in their county based on available information including land use. Numerous DCs responded to the survey and MDEQ created Mississippi's §319 list based on these surveys.

In 1992, MDEQ compiled a §303(d) List based, in part, on the §319 List of watersheds of concern. Therefore, water bodies were included on the §303(d) List based on speculation and not water quality monitoring. MDEQ uses the term "evaluated" to describe these water bodies that were placed on the §303(d) List without monitoring data. At the time, MDEQ considered the evaluated listings from the §319 survey as a placeholder for future monitoring to determine if there was actually impairment in the watershed.

The surveys asked for the presence of agriculture, urban areas, or forestry in the watershed. MDEQ interpreted potential pollutants present on these land uses and listed several broad potential pollutant categories based on the survey results. Every watershed, for which agriculture was checked, was listed for several pollutants, including sediment, pesticides, organic enrichment/low dissolved oxygen, and nutrients. The Chickasawhay River was listed for pesticides, nutrients, and siltation based on the survey results. Due to EPA's Federal Court Consent Decree, TMDLs for the Chickasawhay River must be developed for these pollutants even though there are little data available.

To further complicate the situation, nutrients were listed as an impairment even though there are no state criteria in Mississippi for nutrients. These criteria are currently being developed by the Mississippi Nutrient Task Force (NTF) in agreement with EPA Region 4. MDEQ has a work plan for nutrient criteria development 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. However, data have not yet been collected for non-wadeable streams like the Chickasawhay River.

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 §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.

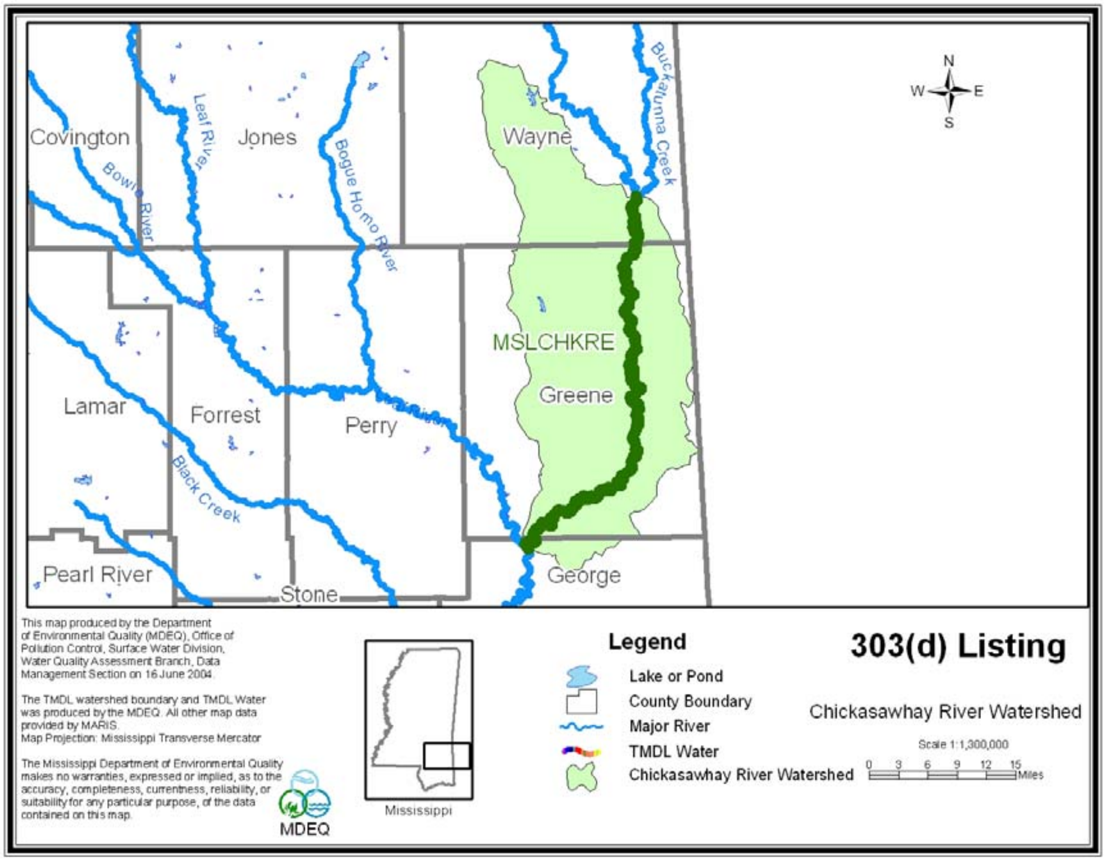


Figure 2. The Chickasawhay River §303(d) Listed Segment

1.2 Applicable Water Body Segment Use

The water use classifications are established by the State of Mississippi in the document *State of Mississippi Water Quality Criteria for Intrastate, Interstate and Coastal Waters* (MDEQ, 2002). The designated beneficial use for the Chickasawhay River is fish and wildlife support.

1.3 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 impairment and establish this TMDL.

The water quality standard for ammonia nitrogen toxicity is 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 28°C is 2.48 mg/l.

Mississippi's NTF is currently in the process of 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."

In the *1999 Protocol for Developing Nutrient TMDLs,* EPA suggests several methods for the development of numeric criteria for nutrients (EPA, 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, but are not yet available for non-wadeable streams.

1.4 Selection of a Critical Condition

The critical condition represents the hydrologic and atmospheric conditions in which the pollutants causing impairment of a water body have their greatest potential for adverse effects. Low DO due to elevated nutrient levels typically occurs during seasonal low-flow, high-temperature periods during the late summer and early fall. Elevated oxygen demand and ammonia nitrogen 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 the Chickasawhay River was determined based on information given in *Techniques for Estimating 7-Day, 10-Year Low-Flow Characteristics on Streams in Mississippi* (Telis, 1992).

1.5 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 or maintain designated uses. The instream DO target for this TMDL is a daily average of not less than 5.0 mg/l. The instream target for ammonia nitrogen is a concentration less than 2.82 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 are 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 appropriate.

The TMDL for nutrients 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.

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

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 Chickasawhay River. The pollutant sources were characterized by the best available information, monitoring data, and literature values.

2.1 Discussion of Instream Water Quality Data

The State's 2002 Section 305(b) Water Quality Assessment Report was reviewed to assess water quality conditions and data available for the watershed. There are data available at three stations for this section of the Chickasawhay River. The stations are 02478500, 02478999, and 02477630. The data for each station are listed in Tables 1, 2, and 3. Table 4 gives details of the locations associated with the stations. Figure 3 illustrates the station locations.

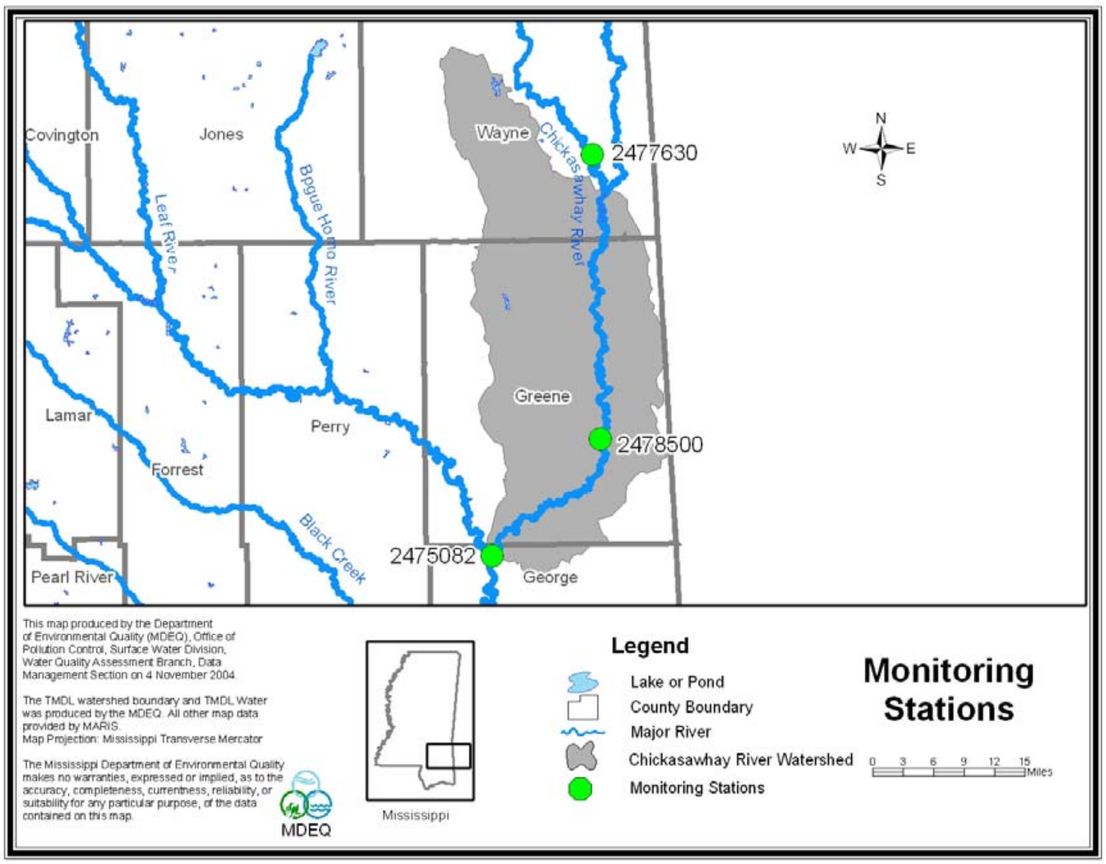


Figure 3. Monitoring Stations for Chickasawhay River (MSLCHKRE1)

Table 1. Chickasawhay River at Station 02478500

Date	Time	Temperature	DO mg/L	NH3-N mg/L	Total Kjeldahl (mg/l as N)	Nitrate-Nitrite (mg/l as N)	Total Phosphorous (mg/L)
12/17/1996	8:41	13.1	10.2	0.10	0.43	0.21	0.04
1/15/1997	8:22	5.8	11.8	0.11	0.64	0.20	0.04
2/12/1997	8:33	8.8	10.6	0.12	1.20	0.20	0.20
3/18/1997	8:45	15.7	9.1	0.23	0.79	0.11	0.11
4/9/1997	8:41	18.4	8.2	0.10	0.50	0.16	0.05
5/17/1997	8:42	21.6	8.1	0.14	0.30	0.2	0.13
6/16/1997	8:17	27.6	6.8	0.12	0.51	0.23	0.06
7/9/1997	8:43	28.3	6.6	0.14	0.30	0.24	0.08
8/13/1997	8:32	29.6	6.4	0.13	0.52	0.20	0.07
9/23/1997	8:45	28.1	6.7	0.13	0.37	0.19	0.06
10/7/1997	9:09	24.4	7.9	0.17	0.10	0.22	0.06
11/24/1997	10:07	13.2	9.2	0.10	1.01	0.16	0.22
12/10/1997	8:30	11.3	11.6	0.10	0.46	0.18	0.03
1/14/1998	8:45	12.5	9.1	0.19	1.01	0.03	0.01
2/11/1998	9:43	11.2	11.7	0.22	0.47	0.16	0.07
3/19/1998	9:05	15.3	9.2	0.35	0.64	0.15	0.09
4/8/1998	11:37	19.4	8.2	0.13	0.42	0.14	0.04
6/16/1998	10:44	30.1	7.1	0.10	0.37	0.24	0.06
7/23/1998	11:13	29.4	7.1	0.10	0.48	0.27	0.03
8/18/1998	12:00	30.4	7.5	0.13	0.38	0.28	0.20
8/18/1998	12:04	30.4	7.5	0.10	0.44	0.29	0.07
9/9/1998	8:58	28.5	7.2	0.10	0.31	0.14	0.01
10/22/1998	11:13	21.4	8.4	0.19	0.63	0.17	0.02
11/5/1998	8:58	17.6	9.2	0.10	0.11	0.18	0.03
12/7/1998	8:21	20.7	7.8	0.10	0.28	0.16	0.03
1/21/1999	9:02	15.1	10.1	0.13	0.24	0.21	0.03
2/1/1999	8:55	16.6	7.6	0.30	0.62	0.09	0.07
3/11/1999	8:46	15.3	9.9	0.34	0.76	0.15	0.17
3/30/1999	8:39	15.8	9.2	0.10	0.59	0.14	0.09
5/4/1999	9:50	22.7	8.4	0.13	0.54	0.19	0.11
6/8/1999	8:50	29.1	7.8	0.10	0.34	0.16	0.16
6/30/1999	10:02	27.9	6.6	0.38	0.60	0.23	0.40
8/3/1999	11:15	32.3	7.0	0.35	0.35	0.16	0.01
9/1/1999	10:00	28.3	6.7	0.68	0.61	0.32	0.50
10/19/1999	12:30	23.2	7.1	0.10	0.76	0.16	0.12
11/22/1999	10:55	17.4	8.5	0.75	0.75	0.09	0.08
12/9/1999	9:30	11.7		0.15	0.36	0.11	0.04
1/6/2000	9:50	12.4	9.3	0.27	1.04	0.25	0.14
2/15/2000	11:10	16.5	9.6	0.15	0.34	0.18	0.07
4/10/2000	10:50	17.3	8.2	0.13	0.70	0.07	0.12
5/10/2000	9:28	26.2	7.6	0.17	0.41	0.25	0.03
6/14/2000	9:39	28.0	8.5	0.12	0.41	0.03	0.06
7/13/2000	10:20	31.7	7.2	0.16	0.12	0.03	0.05
9/27/2000	10:18	21.3	7.4	0.21	0.28	0.14	0.10
10/16/2000	10:07	18.6	8.1	0.13	0.35	0.37	0.10
11/9/2000	12:15	23.6	10.6	0.16	0.52	0.13	0.02
12/18/2000	10:48			0.13	0.87	0.41	0.04
4/5/2001	10:37	18.9	8.9	0.20	0.52	0.17	0.07
5/14/2001	10:50	25.1	7.7	0.21	0.42	0.21	0.08
6/13/2001	10:45	24.4	7.1	0.10	1.00	0.12	0.12

7/16/2001	10:37	29.1	6.7	0.10	0.30	0.21	0.03
9/13/2001	11:27	26.3	6.6	0.10	1.00	0.16	0.10
10/3/2001	11:56	21.7	8.2	0.10	0.12	0.30	0.06
11/6/2001	10:40	16.8	9.6	0.10	0.29	0.23	0.05
11/29/2001	10:43	18.9	9.1	0.11	0.40	0.14	0.04

Table 2. Chickasawhay River at Station 02478999

Date	Time	Temperature	DO mg/L	NH3-N mg/L	Total Kjeldahl (mg/l as N)	Nitrate-Nitrite (mg/l as N)	Total Phosphorous (mg/L)
8/14/1997	11:30	30.5	7.0	0.12	0.43	0.14	0.08
8/18/1998	11:01	29.2	7.3	0.12	0.36	0.24	0.05
9/29/1999	11:10	25.5	7.4	0.36	0.49	0.08	0.04

Table 3. Chickasawhay River at Station 02477630

Date	Time	Temperature	DO mg/L	NH3-N mg/L	Total Kjeldahl (mg/l as N)	Nitrate-Nitrite (mg/l as N)	Total Phosphorous (mg/L)
11/20/1997	13:00	10.6	9.8	0.13	0.39	0.36	0.07
12/18/1997	11:45	8.2	10	0.17	0.44	0.33	0.06

Table 4. Location Descriptions for Chickasawhay River Monitoring Stations

Station Name	Station Location
02478500	Chickasawhay River at Highway 63: 0.1 mile SW of Leakesville
02478999	Chickasawhay River at Merrill:1 mile west of Merrill
02477630	Chickasawhay River near Buckatunna

2.2 Assessment of Point Sources

The first step in assessing pollutant sources in the Chickasawhay River watershed was locating the NPDES permitted sources. There are 5 sources permitted to discharge into this segment of the Chickasawhay River or its tributaries, Table 5. These facilities serve a variety of activities in the watershed, including municipalities, schools, and other businesses. The locations of the facilities are shown in Figure 4. The estimated effluent concentrations for total phosphorous are also shown in Table 5. Total phosphorous is not included in any of these facility's NPDES permits. Therefore, the total phosphorous concentration for the facilities was estimated based on literature values of an assumed concentration of 8.0 mg/l in effluent.

Table 5. 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)
Leakesville POTW	MS0020664	Conventional Lagoon	0.15	5.2	6.51
Greene County School District	MS0042935	Conventional Lagoon	0.0275	5.2	1.19
South MS Correctional Facility	MS0050750	Mechanical Treatment Plant with Tertiary Treatment	0.45	5.8	21.8
Stateline POTW	MS0035211	Three Cell Lagoon	0.15	5.2	6.51
Buckatunna Elementary	MS0038784	Aerated Lagoon	0.008	5.2	.347
Total			0.786		36.4

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 6. The sum of flows from the point sources is 0.786 MGD. Ammonia nitrogen permit limits and monitoring are not required for most of the facilities. As shown in the Table 6, most of the facilities are discharging well below their maximum permitted BOD levels.

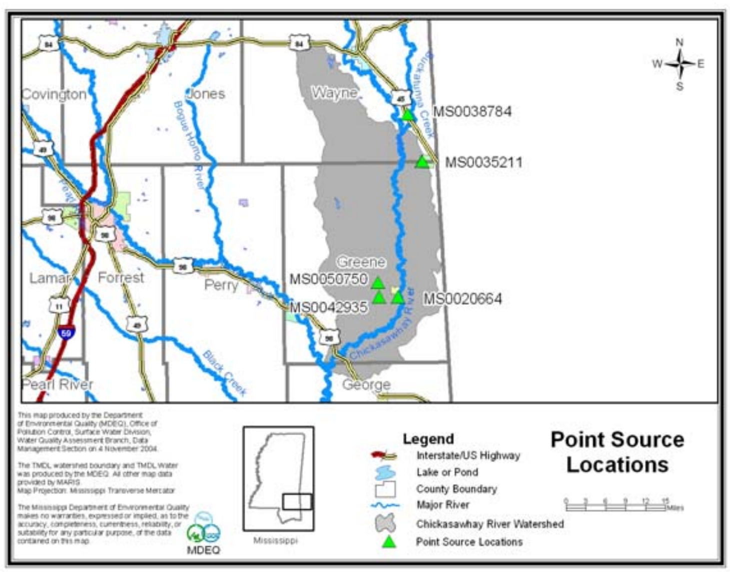


Figure 4. Chickasawhay River Point Sources

Table 6. Identified NPDES Permit Facilities

Facility Name	NPDES	Permitted Discharge (MGD)	Actual Average Discharge (MGD)	Permitted Average BOD_5 (mg/L)	Actual Average BOD_5 (mg/L)	Permitted CBODu (lbs/day)	Actual Average CBODu (lbs/day)
Leakesville POTW	MS0020664	0.15	0.1045	30	20	56.33	26.16
Greene County School District	MS0042935	0.0275	No discharge	30	No discharge	10.33	No discharge
South MS Correctional Facility	MS0050750	0.45	0.33	10	1.16	56.33	4.79
Stateline POTW	MS0035211	0.15	0.26	30	25.7	56.33	83.65
Buckatunna Elementary	MS0038784	0.008	0.0075	30	20	2.82	1.88

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. Phosphorous is typically seen as the limiting nutrient in most freshwater environments. Therefore, this TMDL will only 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 have build up and then wash off during rain events. Table 7 presents typical nutrient loading ranges for various land uses.

Table 7. 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)

The drainage area for the shown segment of the Chickasawhay River is approximately 424,989 acres. The watershed contains many different landuse types, including urban, forest, cropland, pasture, scrub/barren, 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 the watershed. The landuse distribution is shown in Table 8 and Figure 5.

Table 8. Landuse Distribution, the Chickasawhay River Watershed

	Urban	Forest	Cropland	Pasture	Scrub/Barren	Water	Wetlands
Area (acres)	1279.5	259362	147.6	86843.9	42714.2	2725.8	31916.5
Percentage	0.3%	61.0%	0.03%	20.4%	10.1%	0.6%	7.5%

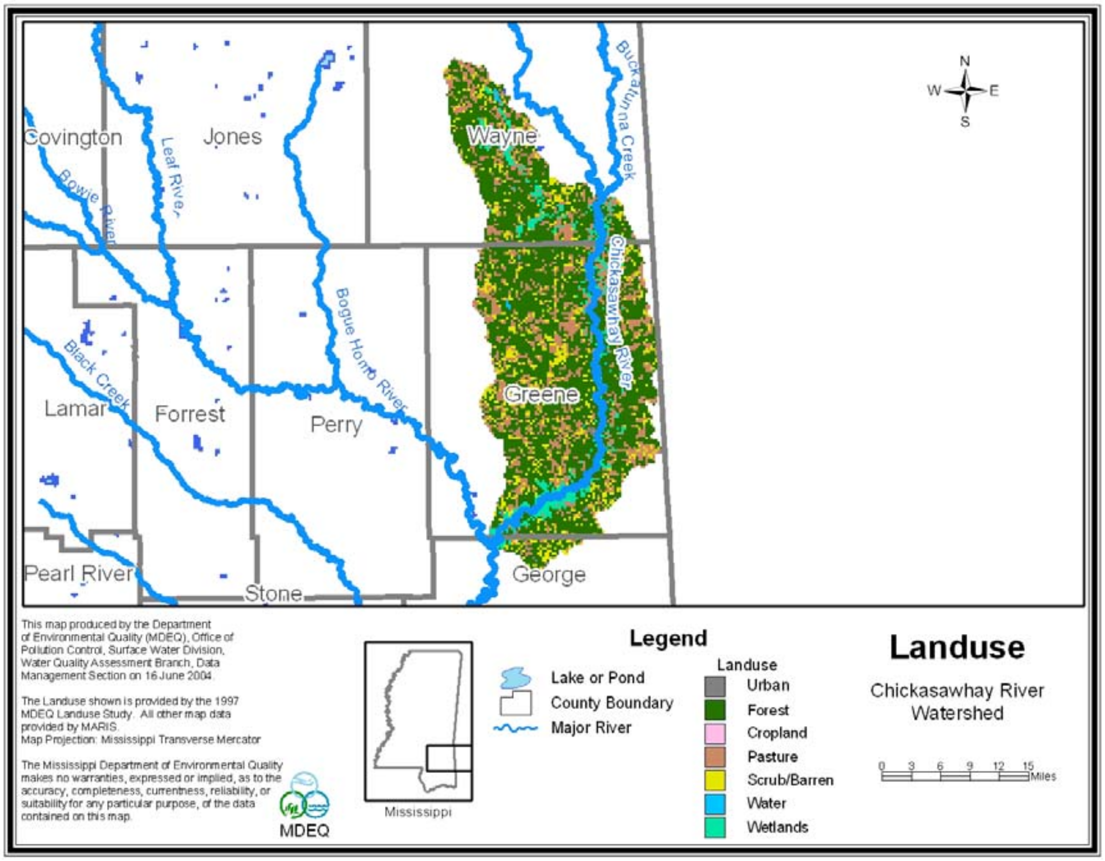


Figure 5. Landuse Distribution for the Chickasawhay River Watershed

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.

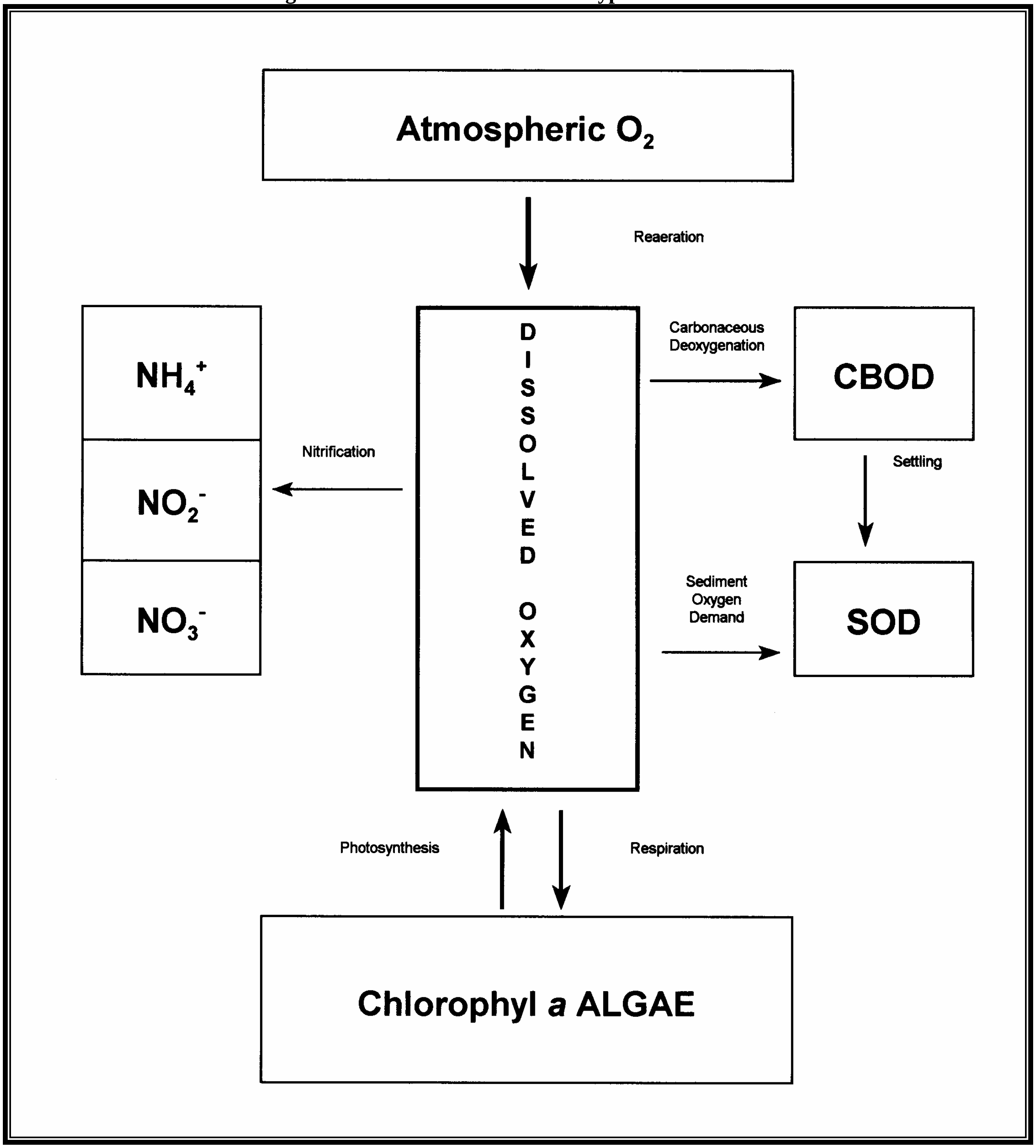
STREAM is a steady-state, daily average computer model that utilizes a modified Streeter-Phelps DO sag equation. Instream processes simulated by the model include CBODu decay, nitrification, reaeration, sediment oxygen demand, and respiration and photosynthesis of algae. Figure 4 shows how these processes 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 0.059 for stream reaches with flows greater than 10 cfs. Reach velocities were calculated using an equation based on the slopes.

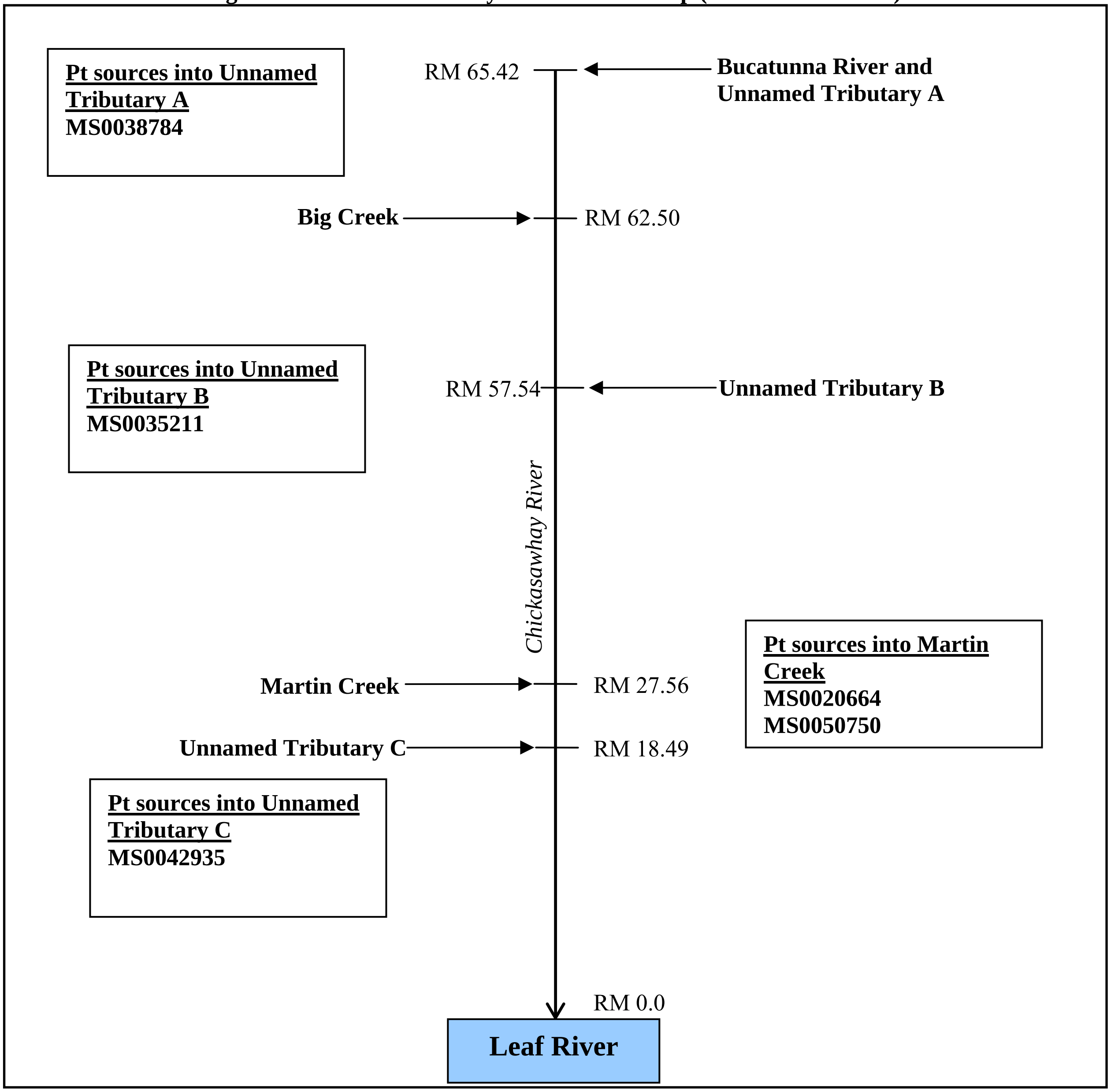
Figure 6. Instream Processes in a Typical DO Model



3.2 Model Setup

The model for the Chickasawhay River was developed beginning with the confluence with Bucatunna to its mouth at the Leaf River. A diagram showing the model setup for the Chickasawhay River is shown in Figure 7. Arrows represent the direction of flow. 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. The Chickasawhay River Model Setup (Note: Not to Scale)



The modeled water body was divided into reaches for modeling purposes. Reach divisions are made at locations where there is a significant change in hydrological and water quality characteristics, such as the confluence of a tributary. Within each reach, the modeled segments are divided into computational elements of 0.1 mile. The simulated hydrological and water quality characteristics are 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 set to 28°C for flows greater than 50 cfs but less than 300 cfs. The headwater instream DO was assumed to be 85% of saturation at the stream temperature. Rates for CBODu decay range from 0.6 to 0.3 day^{-1} base *e*, based on the instream CBODu concentrations. The instream CBODu decay rate is also dependent on temperature, according to Equation 3.

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

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 were not available.

The flow in the Chickasawhay River was modeled at 7Q10 conditions based on data available from the USGS (Telis, 1992). This segment of the Chickasawhay River has a flow gage at Waynesboro, MS (02477500) which is just above the modeled watershed and a flow gage at Leakesville, MS (02478500) which is very close to the mouth at the Leaf. Additionally, there are flow gages near the confluence of Bucatunna Creek and the Chickasawhay River (02478030) and near the confluence of Big Creek and the Chickasawhay River. Information about each gage is given in Table 8. The location of the gages is illustrated in Figure 8. It is noted that the flows from the gage on the Chickasawhay River at Waynesboro, MS and the gage on Bucatunna Creek at Buckatunna, MS were combined to estimate a headwaters flow at the beginning of this model. The flows from the gage on the Chickasawhay River at Leakesville and the gage on Big Creek near Leakesville were combined to estimate the flow at the end of this model.

Table 8. USGS Flow Gages

USGS Flow Gage	7Q10 (cfs)	Drainage Area (square miles)	Location
02477500	121	1650	Chickasawhay River at Waynesboro
02478500	246	2690	Chickasawhay River at Leakesville
02478030	34	601	Bucatunna Creek at Buckatunna, MS
02478700	8	152	Big Creek near Leakesville

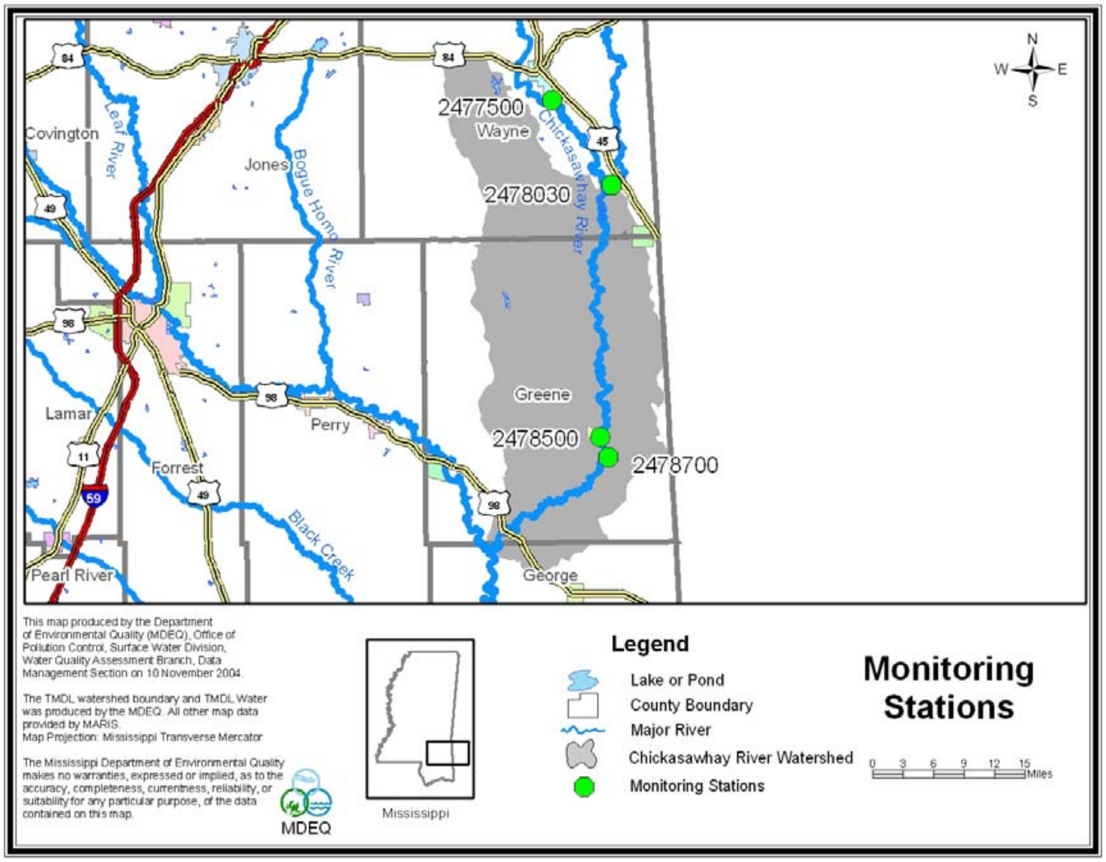


Figure 8. USGS Flow Gage Locations

3.3 Source Representation

Non-point sources and point sources were represented in the model. There are currently 5 NPDES permitted point sources located in the Chickasawhay River Watershed. Spatially distributed loads, which represent non-point sources of flow, CBODu, and ammonia nitrogen were distributed evenly into each computational element of the modeled water body. 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 load of TBODu.

Direct measurements of non-point concentrations of CBODu and NH_3-N were not available for the Chickasawhay River Watershed. Because there were no data available, the 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 concentrations assumed are CBODu = 2.0 mg/l and NH_3-N is 0.1 mg/l.

Non-point source flows were included in the model to account for water entering due to groundwater infiltration, overland flow, and small, unmeasured tributaries. These flows were estimated based on USGS data for the stations given in Table 8. The flows were then multiplied by the concentrations of CBODu and NH_3-N to calculate the non-point source loads, Table 9. For the nonpoint source loads, 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. The non-point source loads were assumed to be distributed evenly throughout the modeled reaches.

Table 9. Non-Point Source Loads Input into the Model

Reach	Flow (cfs)	CBOD5 (mg/L)	CBODu (lbs/day)	NH_3-N (mg/l)	NBODu (lbs/day)	TBODu (lbs/day)
Background flows	155	2	1667.06	0.1	381.88	2049.04
RM 62.50 – 57.54	7.6	2	81.74	0.1	18.72	100.56
RM 57.54 – 47.70	15.63	2	168.06	0.1	38.50	206.66
RM 47.70 – 35.29	19.72	2	212.05	0.1	48.57	260.72
RM 35.29 – 27.89	11.80	2	126.90	0.1	29.07	156.07
RM 27.89 – 27.56	0.48	2	5.16	0.1	1.18	6.44
RM 27.56 –18.49	14.40	2	154.91	0.1	35.49	190.50
RM 18.49 – 9.07	14.96	2	160.89	0.1	36.85	197.84
RM 9.07 – 4.28	7.61	2	81.81	0.1	18.74	100.65
RM 4.28 – 0.00	6.80	2	73.14	0.1	16.75	89.99
			2731.72		**625.75**	**3357.47**

3.4 Model Results

Once the model setup was complete, the model was used to predict water quality conditions in the Chickasawhay 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 second set of model results is called the maximum load scenario.

3.4.1 Baseline Model Results

The baseline model results are shown in Figure 9 and 10. Figure 9 shows the modeled daily average DO with the NPDES permit at its maximum allowable loads with the exception of Stateline POTW which had an actual average CBODu value that exceeded the maximum permit limit. The figure shows the daily average instream DO concentrations, beginning with river mile 65.42 and ending with river mile 0.0 at the mouth. As shown, the model does not predict that the DO goes below the standard of 5.0 mg/l. Figure 10 shows the modeled daily average NH3-N is well below the standard of 2.48 mg/L at its maximum allowable loads. Therefore, based on the modeled output at baseline conditions, a reduction in loads is not necessary.

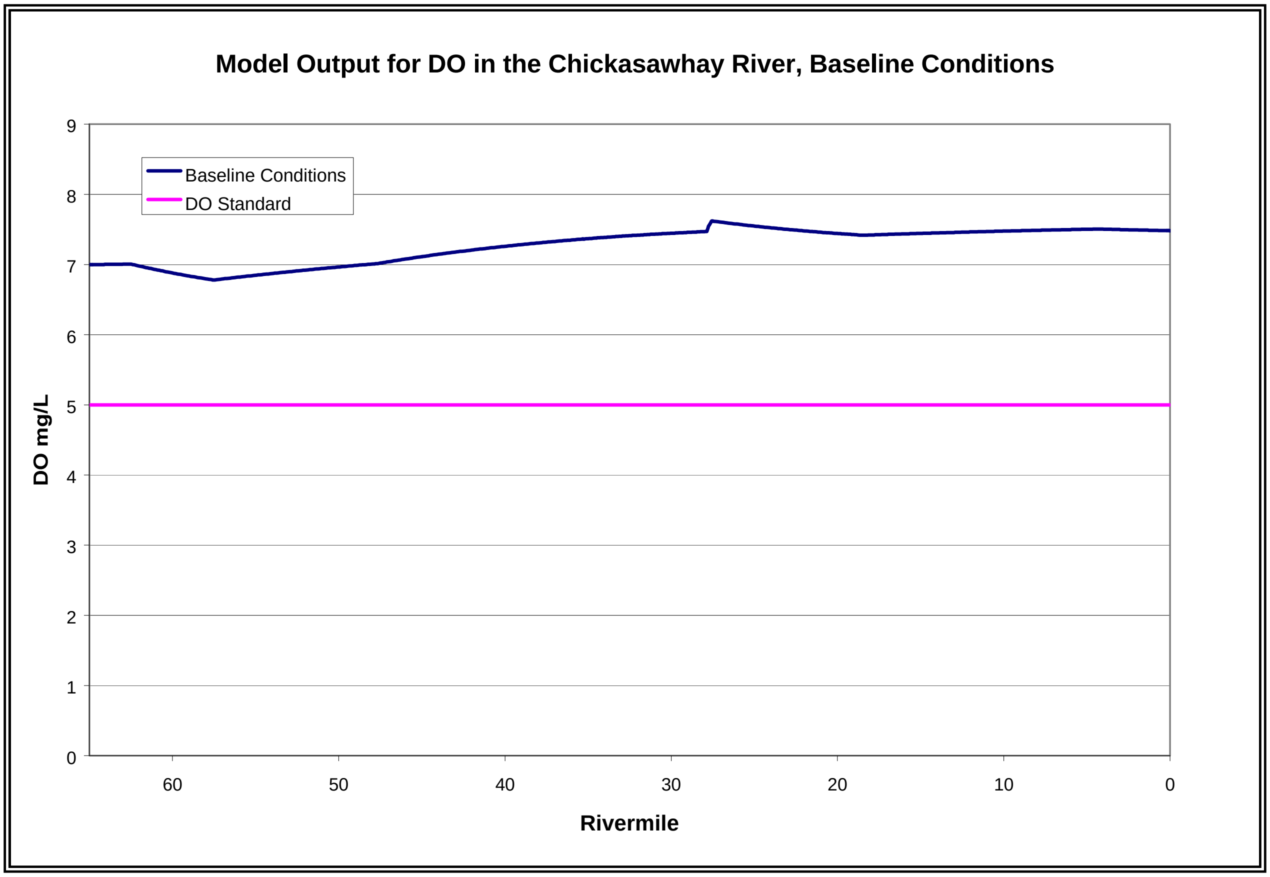


Figure 9. Baseline Model Output for DO in the Chickasawhay River

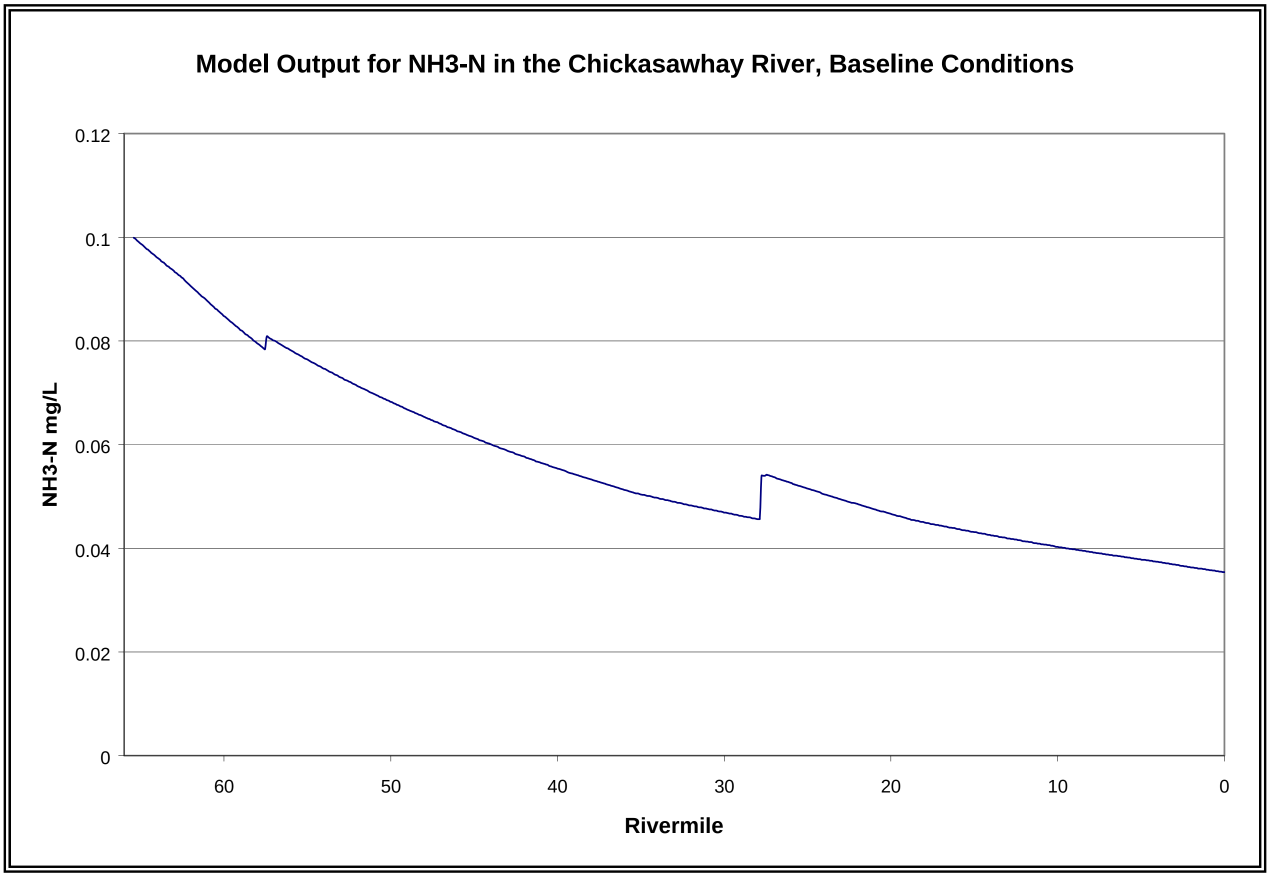


Figure 10. Baseline Model Output for NH_3-N in the Chickasawhay River

3.4.2 Maximum Load Scenario

The graph of the baseline model output shows that the predicted DO does not fall below the DO standard in the Chickasawhay River during critical conditions. Thus, reductions from the baseline loads of TBODu are not necessary. Calculating maximum allowable load of TBODu involved increasing the loads and running the model using a trial-and-error process until the modeled DO was just above 5.0 mg/l. The baseline non-point source loads were increased by a factor of 19.0 in this process. The increased loads were used to develop the allowable maximum daily load for this report. The model output for DO with the increased loads is shown in Figure 11.

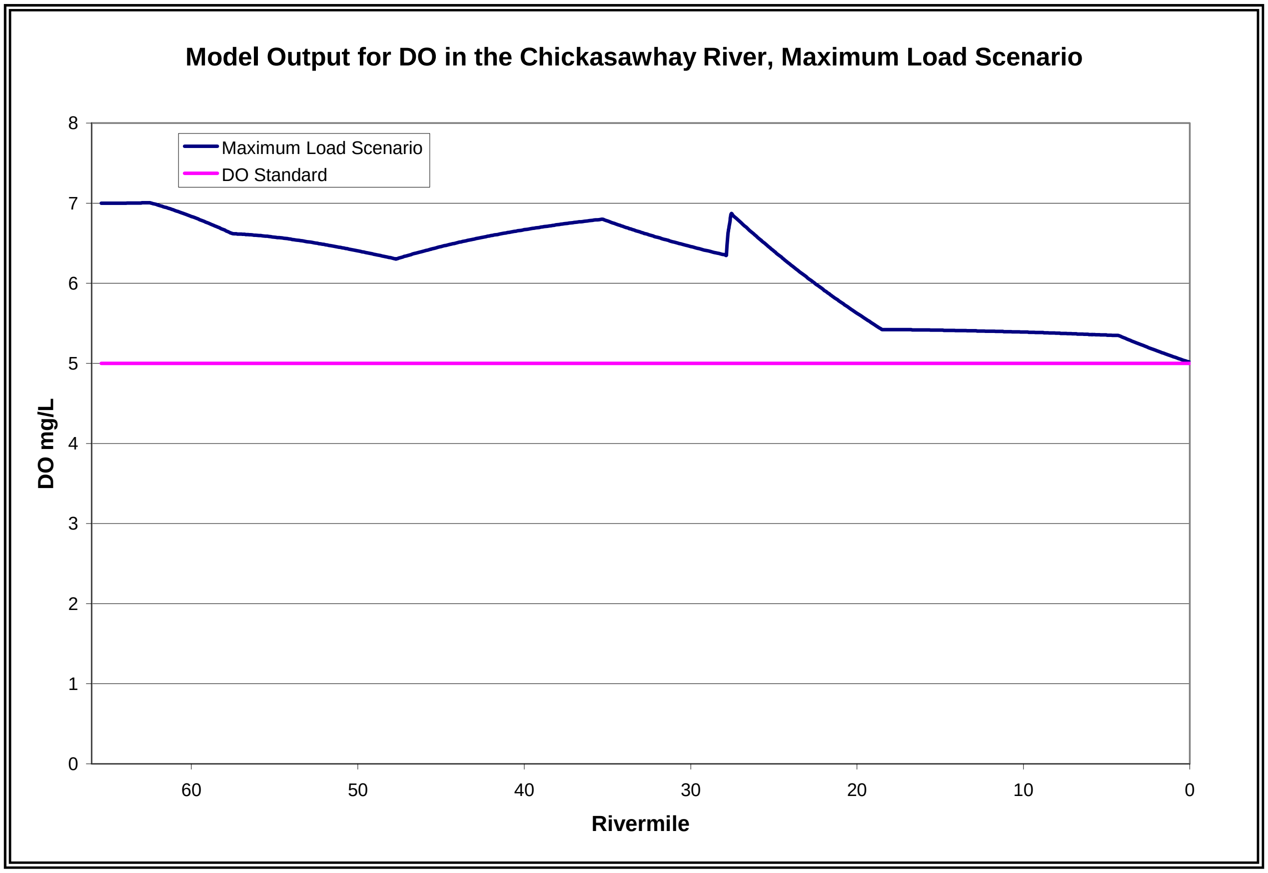


Figure 11. Model Output for DO in the Chickasawhay River with Maximum Load

3.5 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 28°C is 2.48 mg/l. Based on the model results from the maximum load scenario, Figure 12, this standard was not exceeded in the Chickasawhay River.

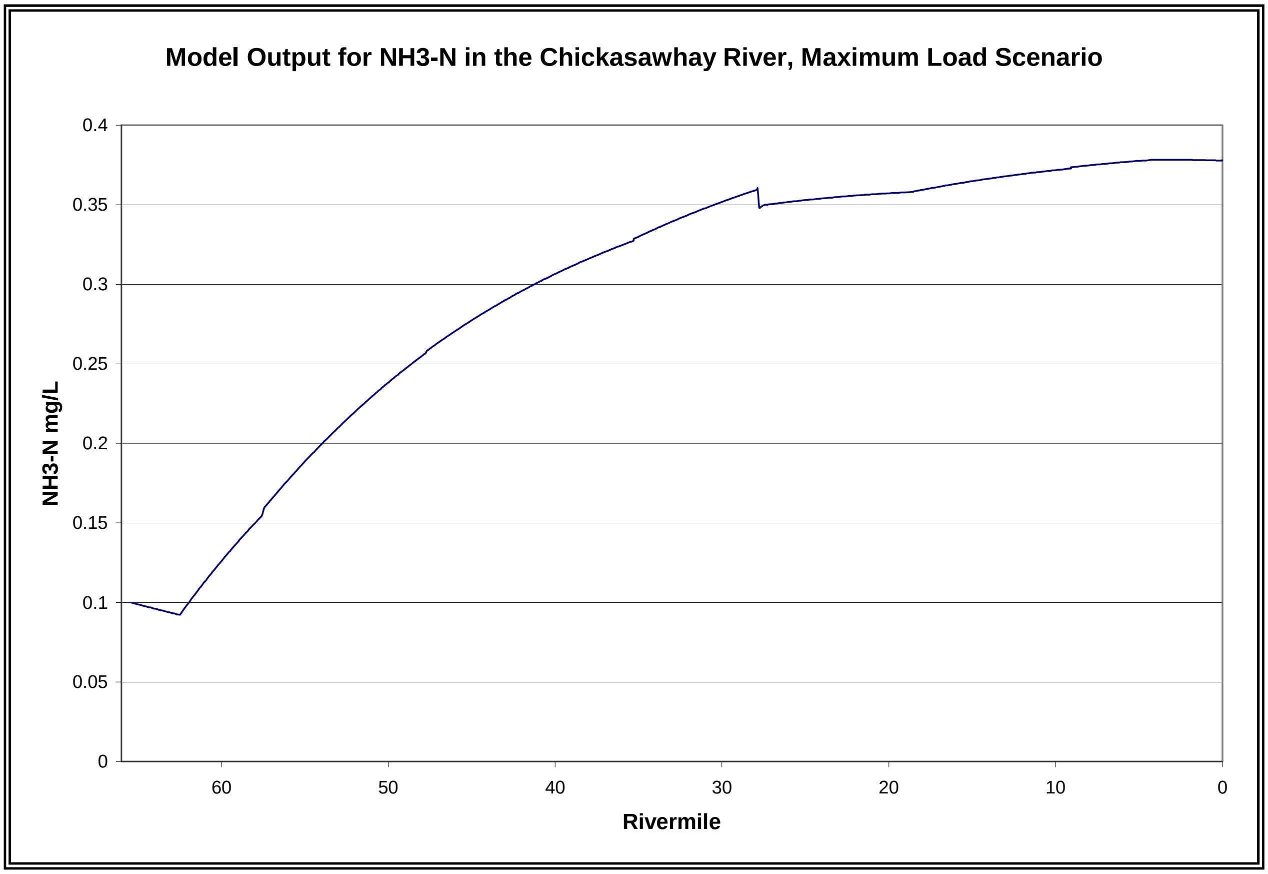


Figure 12. Model Output for Ammonia Nitrogen in the Chickasawhay River with Maximum Loads

3.6 Total Phosphorus Estimates

For the Chickasawhay River total phosphorus should be the limiting nutrient. Therefore, the nutrient estimates within this TMDL are focusing on total phosphorus. There are some data available in this stream as shown in Section 2.1. There were three stations where data were collected in this segment of the Chickasawhay River. Table 10 shows the average annual total phosphorus concentration in the stream. The annual average total phosphorus concentration is 0.088 mg/l. This average value is within the range of the total phosphorus concentrations measured for the least-disturbed wadeable streams for all seasons in the same bioregion, 0.07 to 0.11 mg/l. While there are not enough data to assess, nor is there a criterion to measure these results against, the concentration values appear to be inline with expected values.

Table 10 Average Annual Total Phosphorus Loads

Year	Samples Collected	Annual Average TP mg/l
1997	12	.093
1998	12	.055
1999	12	.148
2000	10	.073
2001	8	.069

The annual average flow in the Chickasawhay River is 2490 MGD. The annual average total phosphorus concentration is 0.088 mg/l. The estimated total phosphorus concentration from a lagoon system is 5.2 mg/l and from a mechanical treatment plant is 5.8 mg/l. The load of total phosphorus coming from point sources is estimated using the following equation.

$$TP = \sum flows * 8.34 conversion * [Effluent] mg/l$$

The maximum averaged TP point source load is estimated to be 36.4 pounds per day. The annual average total load based on data from 1997 to 2001 is 1819 pounds per day. The point source load on average is 2.0% of the total load.

ALLOCATION

The allocation for this TMDL involves a load allocation for point sources and non-point sources necessary for attainment of water quality standards in the Chickasawhay River. The allocations are given in terms of TBODu for this Phase 1 TMDL. Additionally this TMDL recommends monitoring at the Leakesville POTW and the South Mississippi Correctional Facility for nutrient loads (total phosphorus and total nitrogen). When water quality standards and additional information become available, a phase 2 TMDL may be developed for the Chickasawhay River that includes a nutrient target and reduction scenario.

Nutrients were listed based on anecdotal information, not data that could be compared to a criterion. Therefore, without the "mark on the wall" to make a comparison, it is impossible to establish any TMDL limits at this time. MDEQ is making progress on this however with the Nutrient Task Force's work. 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. Data collection efforts are well underway at this time.

MDEQ does not anticipate adverse downstream impacts from phosphorus loads based on the phosphorus data that are currently available for this water body. Since these water bodies flow into the West Pascagoula River, which was used as a reference condition for the Escatapwa River study, there does not appear to be any significant "far field" nutrient impacts in the River Basin. In addition, the River dissolved oxygen (DO) data indicate there were no severely depressed DO levels in morning samples or supersaturated DO levels in the afternoon samples. Therefore, it is reasonable to infer that there is no indication of severe diurnal DO sags occurring during the periods sampled by MDEQ. This assessment supports the contention that existing nutrient loadings are not likely causing severe impacts, but further study is necessary to ensure the current nutrient loads are not impairing the aquatic community.

4.1 Wasteload Allocation

There are currently five NPDES permits issued for this section of the Chickasawhay River. The facilities are shown in Table 11. Although this wasteload allocation is based on the current condition of the Chickasawhay River, it is not intended to prevent the issuance of permits for future facilities. This is because the model results show that the Chickasawhay River has additional assimilative capacity for organic material. Future permits will be considered on a case-by-case basis in accordance with Mississippi's Antidegradation Implementation Procedures. Also in considering new permits, the WLA will be assigned so that violations of the total maximum daily load established for this TMDL report do not occur.

Table 11. Waste Load Allocation

Facility	CBODu (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
Leakesville POTW	56.33	11.44	67.77
Greene County School District	10.33	2.1	12.43
South MS Correctional Facility	56.33	34.32	90.65
Stateline POTW	56.33	11.44	67.77
Buckatunna Elementary	2.82	0.57	3.39
	182.14	**59.87**	**242.01**

The estimated load of total phosphorus is 2.0% of the average annual load of total phosphorus in the river. Reductions at the point sources would not significantly reduce the total phosphorus in the environment. However, in order to gather information for the determination of nutrient impairment and potential TMDL implementation, this TMDL will recommend quarterly nutrient monitoring for the Leakesville POTW and the South Mississippi Correctional Facility WWTP. The Stateline POTW will be excluded from this quarterly monitoring because it is a facility that discharges very infrequently (twice a year).

4.2 Load Allocation

The BOD non-point source loads are included in the load allocation, Table 12. The TBODu concentrations of these loads were determined by using an assumed CBODu concentration of 2.0 mg/L and an NH_3-N concentration of 0.1 mg/l. This TMDL does not require a reduction of the BOD load allocation. In Table 12, the load allocation is shown for each reach included in the model. The load allocation consists of the estimated loads at the 7Q10 flow multiplied by a factor of 19.0.

Table 12. Maximum Scenario for Load Allocation

Reach	Flow (cfs)	$CBOD_u$ (mg/L)	CBODu (lbs/day)	NH_3-N (mg/l)	NBODu (lbs/day)	TBODu (lbs/day)
Background flows	155	2	1667.06	0.1	381.88	2048.9
RM 62.50 – 57.54	7.6	2	1553.05	0.1	77.85	100.50
RM 57.54 – 47.70	15.63	2	3193.14	0.1	160.06	206.60
RM 47.70 – 35.29	19.72	2	4028.89	0.1	201.95	260.60
RM 35.29 – 27.89	11.80	2	2411.08	0.1	120.86	156.0
RM 27.89 – 27.56	0.48	2	98.08	0.1	4.92	6.30
RM 27.56 –18.49	14.40	2	2943.27	0.1	147.53	190.40
RM 18.49 – 9.07	14.96	2	3056.85	0.1	153.23	197.70
RM 9.07 – 4.28	7.61	2	1554.38	0.1	77.92	100.60
RM 4.28 – 0.00	6.80	2	1389.57	0.1	69.65	89.90
			21895.37		**1395.85**	**23291.22**

Based on estimates in this report, well over 95% of the total phosphorus load in this watershed comes from nonpoint sources. Therefore, best management practices, BMPs should be encouraged in the watershed to reduce pollutant loads from nonpoint sources.

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 and explicit.

The explicit MOS for this report is the difference between the non-point loads calculated in the maximum load scenario and the baseline non-point loads. The baseline non-point source loads represent an approximation of the loads currently going into the Chickasawhay River at the critical conditions. The maximum non-point source loads are the maximum TBODu loads with a

19.0 increase that allow maintenance of water quality standards. MDEQ has set the MOS as the difference in these loads to account for the uncertainty in the desktop model that was used to develop this Phase 1 TMDL. Many assumptions based on regulations and literature values were used. The rate of sediment oxygen demand, for example, was set to zero due to lack of monitoring data. Sediment oxygen demand, however, can be a significant factor in the DO balance of a large water body. The STREAM model is a steady state, daily average model that assumes complete mixing throughout the water column. Due to the uncertainty in the model, MDEQ set a large, explicit MOS instead of increasing either the WLA or LA to express the maximum assimilative capacity determined for the water body. The calculated MOS is in Table 13.

Table 13. Calculation of Explicit MOS

	Maximum Non-Point Load	Baseline Non-Point Load	Margin of Safety
CBODu (lbs/day)	21895.37	2731.72	19163.65
NBODu (lbs/day)	1395.85	625.75	770.10
TBODu (lbs/day)	**23291.2**	**3357.47**	**19933.75**

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 TMDL was calculated based on Equation 5.

$$\mathbf{TMDL = WLA + LA + MOS} \qquad \textbf{(Equation 5)}$$

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 Chickasawhay River, according to the model. The TMDL calculations are shown in Table 14. As shown in the table, 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 explicit margin of safety for this TMDL is derived from the conservative assumptions used in setting up the model

Table 14. Phase 1 TMDL for TBODu in the Chickasawhay River Watershed

	WLA (lbs/day)	Base Line LA (lbs/day)	MOS	TMDL (lbs/day)
CBODu	134.57	2731.72	19163.65	22077.51
NBODu	47.67	625.75	770.10	1455.72
TBODu	**182.24**	**3357.47**	**19933.75**	**23533.23**

The TMDL presented in this report represents the maximum 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 loads. The LA given in the TMDL applies to all non-point sources and does not assign loads to specific sources.

4.6 Reasonable Assurance

This component of the 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.

CONCLUSION

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 Chickasawhay River is meeting the water quality standard for dissolved oxygen at the present loading of TBODu. Thus, this TMDL does not limit the issuance of new permits in the watershed as long as new facilities do not cause impairment in the Chickasawhay River. This report has been developed as a Phase 1 TMDL so that specific nutrient species may be evaluated when more data are available and water quality standards are developed for nutrients.

This TMDL recommends quarterly nutrient monitoring for the Leakesville POTW and the South Mississippi Correctional Facility WWTP to develop information for the Nutrient Task Force development of criteria and a phase 2 TMDL. Additionally, it is recommended that the Chickasawhay River watershed be considered a priority for stream bank and riparian buffer zone restoration and any nutrient reduction BMPs, especially for agricultural activities. The implementation of these BMP activities should reduce the nutrient load entering the Chickasawhay River. This will provide improved habitat for the support of aquatic life in the water body and will result in the attainment of the applicable water quality standards.

5.1 Future Monitoring

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 River Basin, the Chickasawhay River Watershed may receive additional monitoring to identify any change in water quality. Additionally, MDEQ is working with a Large River Task Force to develop the appropriate biological indicators for measurements in Mississippi. This river will be included in that development process.

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 received during the public notice period and at any public hearings become a part of the record of this TMDL. All comments will be considered in the submission of this TMDL to EPA Region 4 for final approval.

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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 assemblage (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.

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

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