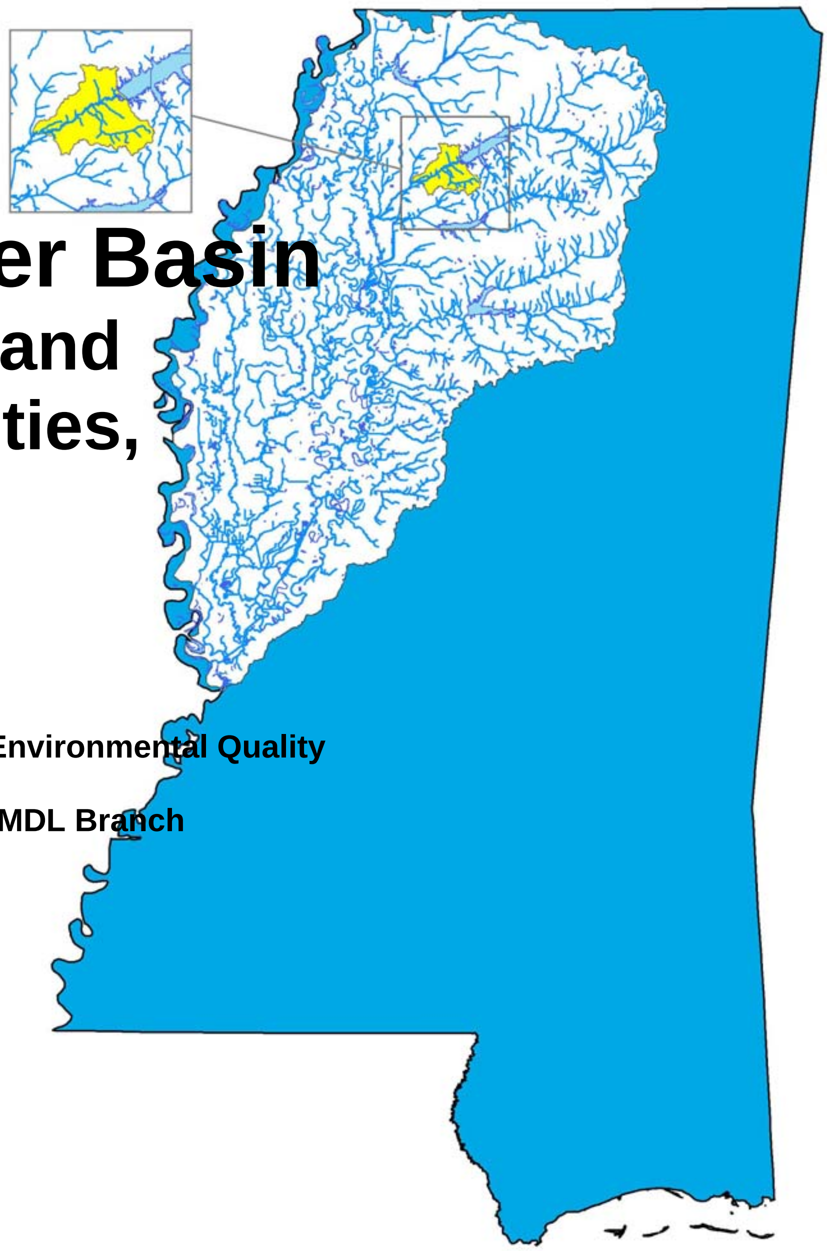
PROPOSED REPORT
April 2008

Total Maximum Daily Load
For Nutrients and Organic Enrichment / Low Dissolved Oxygen In the Little Tallahatchie River



Yazoo River Basin
Tallahatchie and Panola Counties, Mississippi

Prepared By

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FOREWORD

This report has been prepared in accordance with the schedule contained within the federal consent decree dated December 22, 1998. The report contains one or more Total Maximum Daily Loads (TMDLs) for 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	µ	10^6	mega	M
10^{-9}	nano	n	10^9	giga	G
10^{-12}	pico	p	10^{12}	tera	T
10^{-15}	femto	f	10^{15}	peta	P
10^{-18}	atto	a	10^{18}	exa	E

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Table 1. Listing Information

Name	ID	County	HUC	Impaired Use	Causes
Little Tallahatchie River	MS261E	Panola	08030201	Aquatic Life Support	Nutrients and Organic Enrichment / Low Dissolved Oxygen
Near Sardis from Lower Sardis Lake to confluence with Mciver Canal					

Table 2. Water Quality Standards

Parameter	Beneficial use	Water Quality Criteria
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.
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

Table 3. Total Maximum Daily Load for the Little Tallahatchie River

	WLA lbs/day	LA lbs/day	MOS	TMDL lbs/day
TBODu	1350.8	259.4	Implicit	**1610.2**
Total Nitrogen	328.7	7,994.2 – 14,272.9	Implicit	**8,322.9 – 14,601.6**
Total Phosphorous	142.5	587.6 –1,901.7	Implicit	**730.1 – 2,044.2**

Table 4. Identified NPDES Permitted Facilities

Name	NPDES Permit	Permitted Discharge (MGD)	Receiving Water
Batesville POTW	MS0024627	2.1	Little Tallahatchie River
Brewer Trailer Park LLC	MS0048852	0.0076	UNT of Little Tallahatchie River
The Hickory's	MS0058351	0.005	UNT of Little Tallahatchie River
Pride Auto Sales Inc	MS0052604	0.001	Cole Creek
Sardis POTW	MS0046710	0.85	Little Tallahatchie River
Smith Mobile Home Park	MS0045969	0.0015	Deer Creek
US Army COE, Sardis Lower Lake	MS0043737	0.075	Sardis Lake Emergency Spillway Channel

EXECUTIVE SUMMARY

This TMDL has been developed for the Little Tallahatchie River which was placed on the Mississippi 1996 Section 303(d) List of Impaired Water Bodies due to evaluated causes of nutrients and organic enrichment/low dissolved oxygen. This TMDL addresses organic enrichment/low DO and nutrients and will provide an estimate of the total nitrogen (TN) and total phosphorus (TP) in the stream.

Mississippi does not have numeric criteria in its water quality standards for allowable nutrient concentrations. MDEQ currently has a Nutrient Task Force (NTF) working on the development of criteria for nutrients. Since the watershed is partially (28%) in Ecoregion 65 and partially (72%) in Ecoregion 74 a weighted area approach was used to determine the nutrient targets from the Ecoregion ranges. Based on the Ecoregion ranges and the given percentages, an annual concentration range of 0.57 to 1.0 mg/l is an applicable target for TN and 0.05 to 0.14 mg/l for TP for this water body. MDEQ is presenting these ranges as preliminary target values for TMDL development which is subject to revision after the development of numeric nutrient criteria.

The Little Tallahatchie River watershed is located in HUC 08030201. Segment MS261E of the Little Tallahatchie River begins at Lower Sardis Lake and flows southwest to the confluence with Mciver Canal. The location of the watershed for the listed segment is shown in Figure 1.

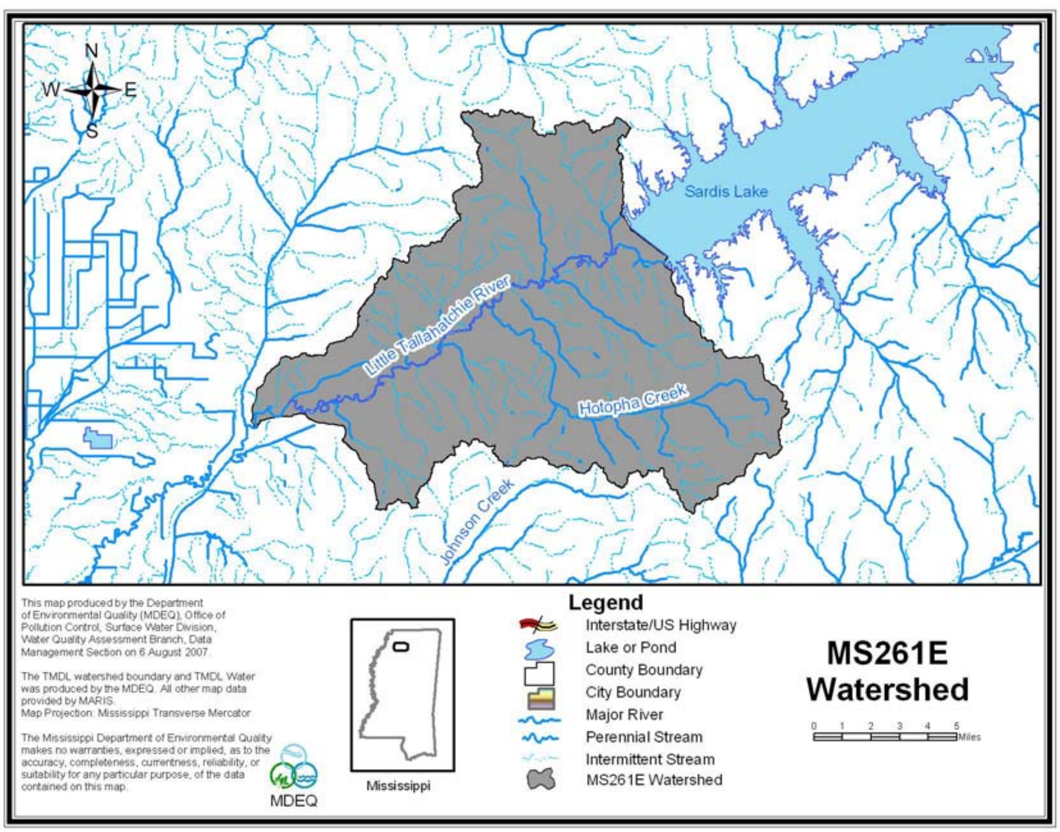


Figure 1. Little Tallahatchie River

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. The critical modeling period usually occurs during the hot, dry summer period. However, the critical low flow period for this segment of the Little Tallahatchie River occurs when the spillway of Sardis Lake is shut off periodically for inspections. Typically, these inspections are done every 5 years but may be done more frequently if a problem is suspected. 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 non-point and point sources of TBODu in the Little Tallahatchie 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 the critical flow conditions. There are seven NPDES permitted dischargers located in the watershed that are included as point sources in the model.

According to the model, the current TBODu load in the water body exceeds the assimilative capacity of the Little Tallahatchie River for organic material at the critical conditions. Therefore, Batesville POTW is presented as an option for a permit reduction in order to meet the assimilative capacity and protect water quality.

Mass balance calculations showed that the nutrient levels are predominantly from non-point sources. The estimated existing ecoregion concentrations indicate non-point source reductions of nutrients are needed.

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 2006 §303(d) listed segment shown in Figure 2.

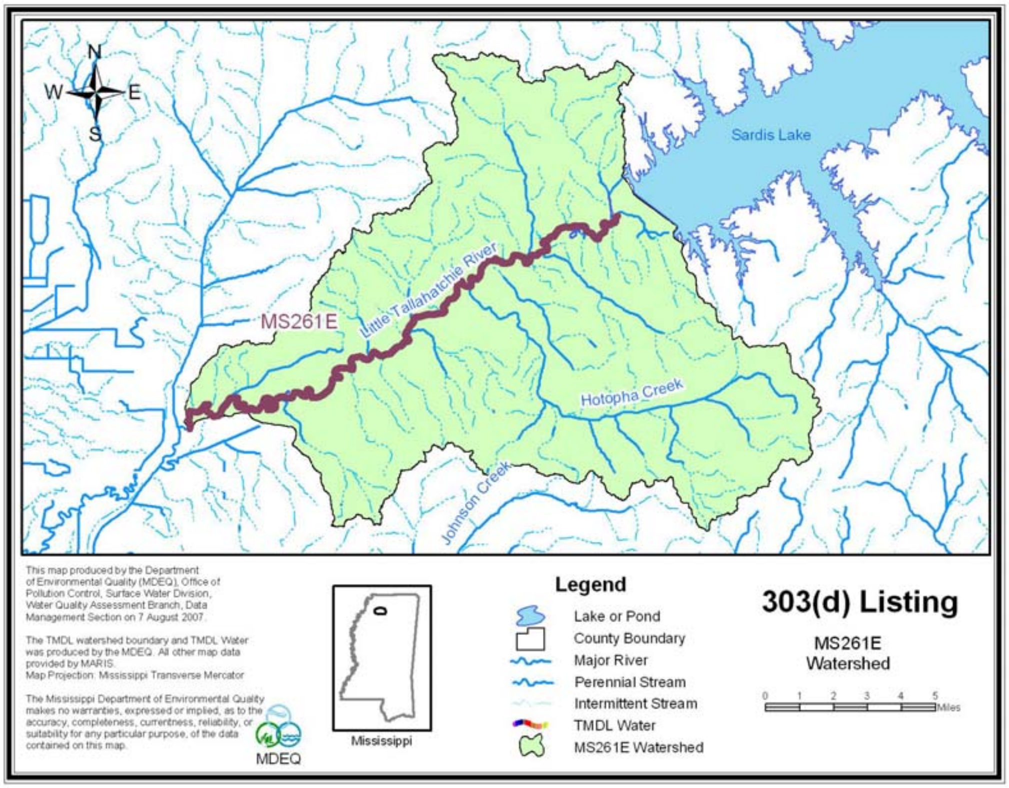


Figure 2. Little Tallahatchie River §303(d) Listed Segment

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, 2007). The designated beneficial use for the listed segment is fish and wildlife. A portion of the segment from Sardis Lake to Hwy. 51 is also listed for recreation.

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, 2007).

Mississippi's current standards contain a narrative criteria that can be applied to nutrients which states "*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 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 is complete.

1.4 Nutrient Target Development

Nutrient data were collected quarterly at 99 discrete sampling stations state wide where biological data already existed. These stations were identified and used to represent a range of stream reaches according to biological health status, geographic location (selected to account for ecoregion, bioregion, basin and geologic variability) and streams that potentially receive non-point source pollution from urban, agricultural, and silviculture lands as well as point source pollution from NPDES permitted facilities.

Nutrient concentration data were not normally distributed; therefore, data were log transformed for statistical analyses. Data were evaluated for distinct patterns of various data groupings (stratification) according to natural variability. Only stations that were characterized as "least disturbed" through a defined process in the M-BISQ process (M-BISQ 2003) or stations that resulted in a biological impairment rating of "fully attaining" were used to evaluate natural variability of the data set. Each of these two groups was evaluated separately ("least disturbed sites" and "fully attaining sites). Some stations were used in both sets, in other words, they were considered "least disturbed" and "fully attaining". The number of stations considered "least disturbed" was 30 of 99, and the number of stations considered "fully attaining" was 53 of 99.

Several analysis techniques were used to evaluate nutrient data. Graphical analyses were used as the primary evaluation tool. Specific analyses used included; scatter plots, box plots, Pearson's correlation, and general descriptive statistics.

In general, natural nutrient variability was not apparent based on box plot analyses according to the 4 stratification scenarios. Bioregions were selected as the stratification scheme to use for TMDLs in the Pascagoula Basin. However, this was not appropriate for some water bodies in smaller bioregions. Therefore, MDEQ now uses ecoregions as a stratification scheme for the water bodies in the remainder of the state.

In order to use the data set to determine possible nutrient thresholds, nutrient concentrations were evaluated as to their correlation with biological metrics. That thorough evaluation was completed prior to the Pascagoula River Basin TMDLs. The methodology and approach were verified. The same methodology was applied to the subsequent ecoregions.

For the preliminary target concentration range for each ecoregion, the 75th and 90th percentiles were derived from the mean nutrient value at each site found to be fully supporting of aquatic life support according to the M-BISQ scores. For the estimate of the existing concentrations the 50th percentile (median) was derived from the mean nutrient value at each site of sites that were not attaining and had nutrient concentrations greater than the target.

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. However, the critical low flow period for this segment of the Little Tallahatchie River occurs when the spillway of Sardis Lake is shut off periodically for inspections. Typically, these inspections are done every 5 years but may be done more frequently if a problem is suspected. Long term flow monitoring (1960 -1980) by the USGS at flow gage 07272500 on the Little Tallahatchie River at Sardis Dam indicated that the minimum or 7Q10 flow in this segment is 15 cfs. Recent communications with the Corps of Engineers indicated that they are in close agreement that the critical flow entering the headwaters of this segment is15 cfs. The additional non-point source flows downstream of Sardis Lake were 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 are needed in order to obtain accurate diurnal oxygen levels. Therefore, based on the limited data available and the relative simplicity of the model, the daily average target is appropriate.

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.

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

There are no state criteria in Mississippi for nutrients. These criteria are currently being developed by the Mississippi Nutrient Task Force in coordination 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 were collected for wadeable streams to calculate the nutrient criteria.

For this TMDL, MDEQ is presenting preliminary target ranges for TN and TP. Since the watershed is partially (28%) in Ecoregion 65 and partially (72%) in Ecoregion 74 a weighted area approach was used to determine the nutrient targets from the Ecoregion ranges. Based on the Ecoregion ranges and the given percentages, an annual concentration range of 0.57 to 1.0 mg/l is an applicable target for TN and 0.05 to 0.14 mg/l for TP for this water body. However, MDEQ is presenting these ranges as preliminary target values for TMDL development which is subject to revision after the development of nutrient criteria, when the work of the NTF is complete.

WATER BODY ASSESSMENT

2.1 Little Tallahatchie River Water Quality Data

There are no DO or nutrient monitoring data available for segment MS261E of the Little Tallahatchie River, which is an evaluated segment of a large river that is not subject to monitoring and analysis according to MDEQ's biological monitoring protocol.

2.2 Assessment of Point Sources

An important step in assessing pollutant sources in the Little Tallahatchie River watershed is locating the NPDES permitted sources. There are seven facilities permitted to discharge organic material into this portion of the Little Tallahatchie River watershed, Table 5. The locations of these facilities are shown in Figure 3.

Table 5. NPDES Permitted Facilities Treatment Types

Name	NPDES Permit	Treatment Type
Batesville POTW	MS0024627	Oxidation Ditch
Brewer Trailer Park LLC	MS0048852	Septic Tank w/ sand filter
The Hickory's	MS0058351	ATU
Pride Auto Sales Inc	MS0052604	Package Plant w/ sand filter
Sardis POTW	MS0046710	Conventional Lagoon
Smith Mobile Home Park	MS0045969	ATU
US Army COE, Sardis Lower Lake	MS0043737	Aerated Lagoon

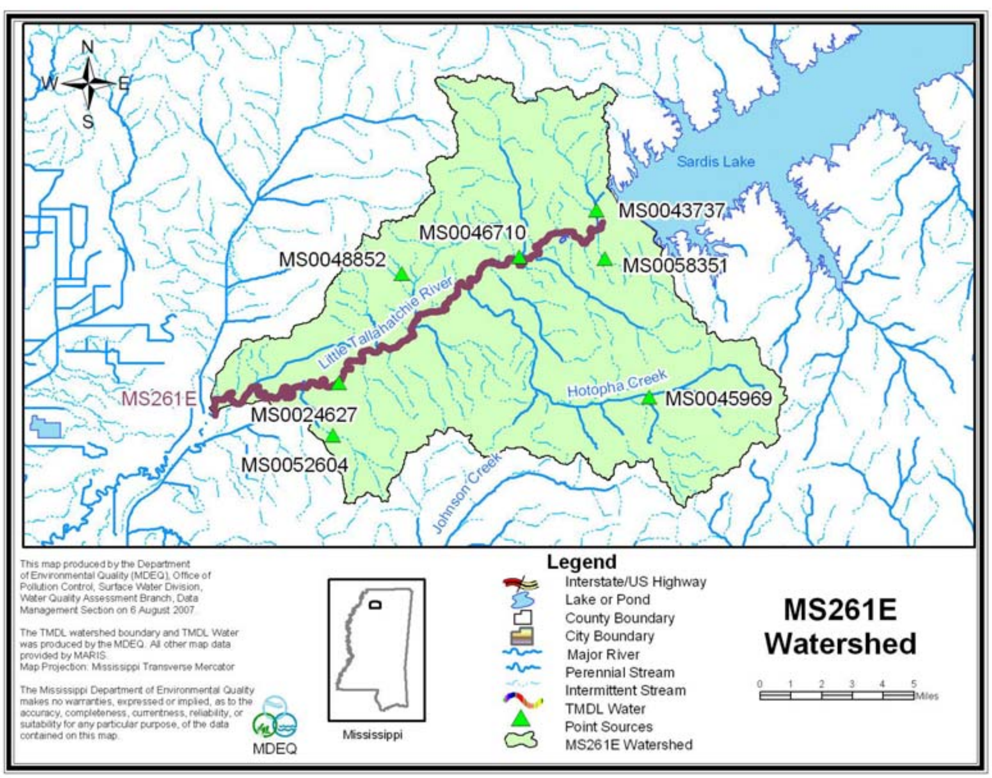


Figure 3 Little Tallahatchie River Point Sources

The effluent from the facilities was characterized based on all available data including information on their wastewater treatment system, permit limits, and discharge monitoring reports. The permit limits are given in Table 6.

Table 6. Identified NPDES Permitted Facilities

Name	NPDES Permit	Permitted Discharge (MGD)	Permitted Average BOD_5 (mg/l)
Batesville POTW	MS0024627	2.1	15
Brewer Trailer Park LLC	MS0048852	0.0076	30
The Hickory's	MS0058351	0.005	30
Pride Auto Sales Inc	MS0052604	0.001	30
Sardis POTW	MS0046710	0.85	45
Smith Mobile Home Park	MS0045969	0.0015	30
US Army COE, Sardis Lower Lake	MS0043737	0.075	30

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, groundwater infiltration, and atmospheric deposition. The two primary nutrients of concern are nitrogen and phosphorus. Total nitrogen is a combination of many forms of nitrogen found in the environment. Inorganic nitrogen can be transported in particulate and dissolved phases in surface runoff. Dissolved inorganic nitrogen can be transported in groundwater and may enter a stream from groundwater infiltration. Finally, atmospheric gaseous nitrogen may enter a stream from atmospheric deposition.

Unlike nitrogen, phosphorus is primarily transported in surface runoff when it has been sorbed by eroding sediment. Phosphorus may also be associated with fine-grained particulate matter in the atmosphere and can enter streams as a result of dry fallout and rainfall (USEPA, 1999). However, phosphorus is typically not readily available from the atmosphere or the natural water supply (Davis and Cornwell, 1988). As a result, phosphorus is typically the limiting nutrient in most non-point source dominated rivers and streams, with the exception of watersheds which are dominated by agriculture and have high concentrations of phosphorus contained in the surface runoff due to fertilizers and animal excrement or watersheds with naturally occurring soils which are rich in phosphorus (Thomann and Mueller, 1987).

Watersheds with a large number of failing septic tanks may also deliver significant loadings of phosphorus to a stream. All domestic wastewater contains phosphorus which comes from humans and the use of phosphate containing detergents. 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 of the Little Tallahatchie River is approximately 85,816.3 acres or 134.1 square miles. The watershed contains many different landuse types, including urban, forest, cropland, pasture, and wetlands. The land use information for the watershed is based on the State of Mississippi's Automated Resource Information System (MARIS), 1997. This data set is based Landsat Thematic Mapper digital images taken between 1992 and 1993. The MARIS data are classified on a modified Anderson level one and two system with additional level two wetland classifications. The land use categories were grouped into the land uses of urban, forest, cropland, pasture, disturbed, wetlands, and water. Pasture is the dominant landuse within this watershed, although cropland is the dominant landuse surrounding the water body. The landuse distribution for the Little Tallahatchie River Watershed is shown in Table 8 and Figure 4

Table 8. Landuse Distribution for the Little Tallahatchie River Watershed

In Acres	Urban	Forest	Cropland	Pasture	Scrub/Barren	Wetlands
Little Tallahatchie River	2,855	18,748	14,515	37,828	10,597	166
Percentage	3.3	21.9	16.9	44.1	12.4	0.2

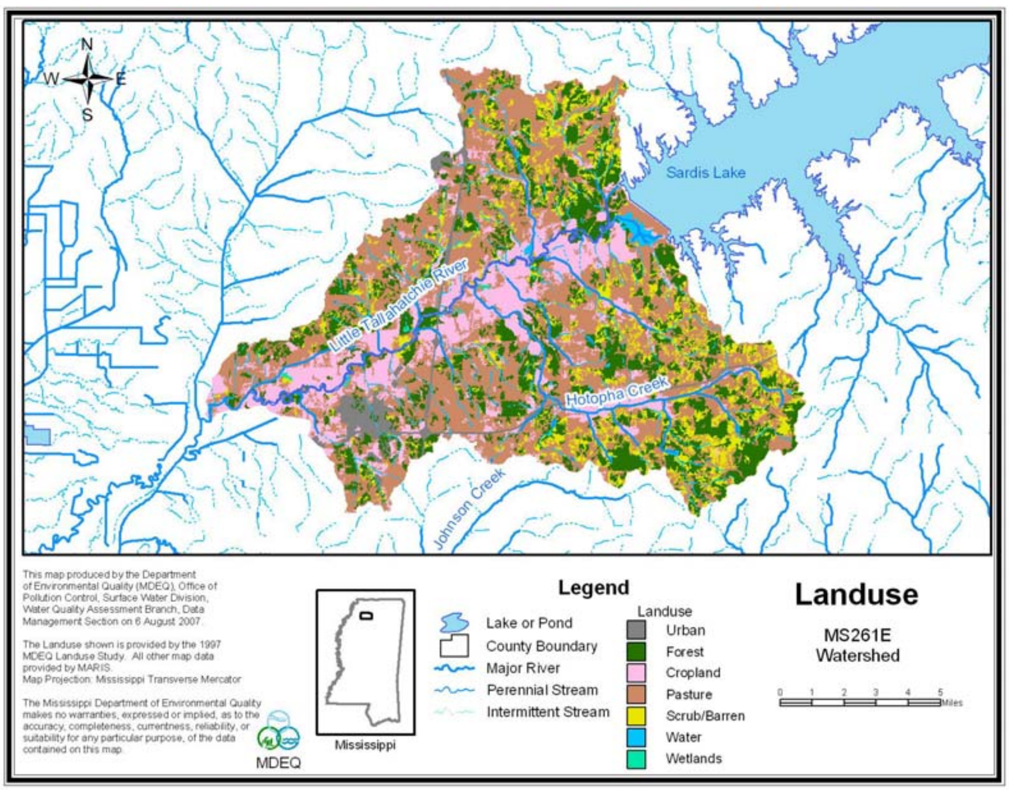


Figure 4. Little Tallahatchie River Watershed Landuse

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.

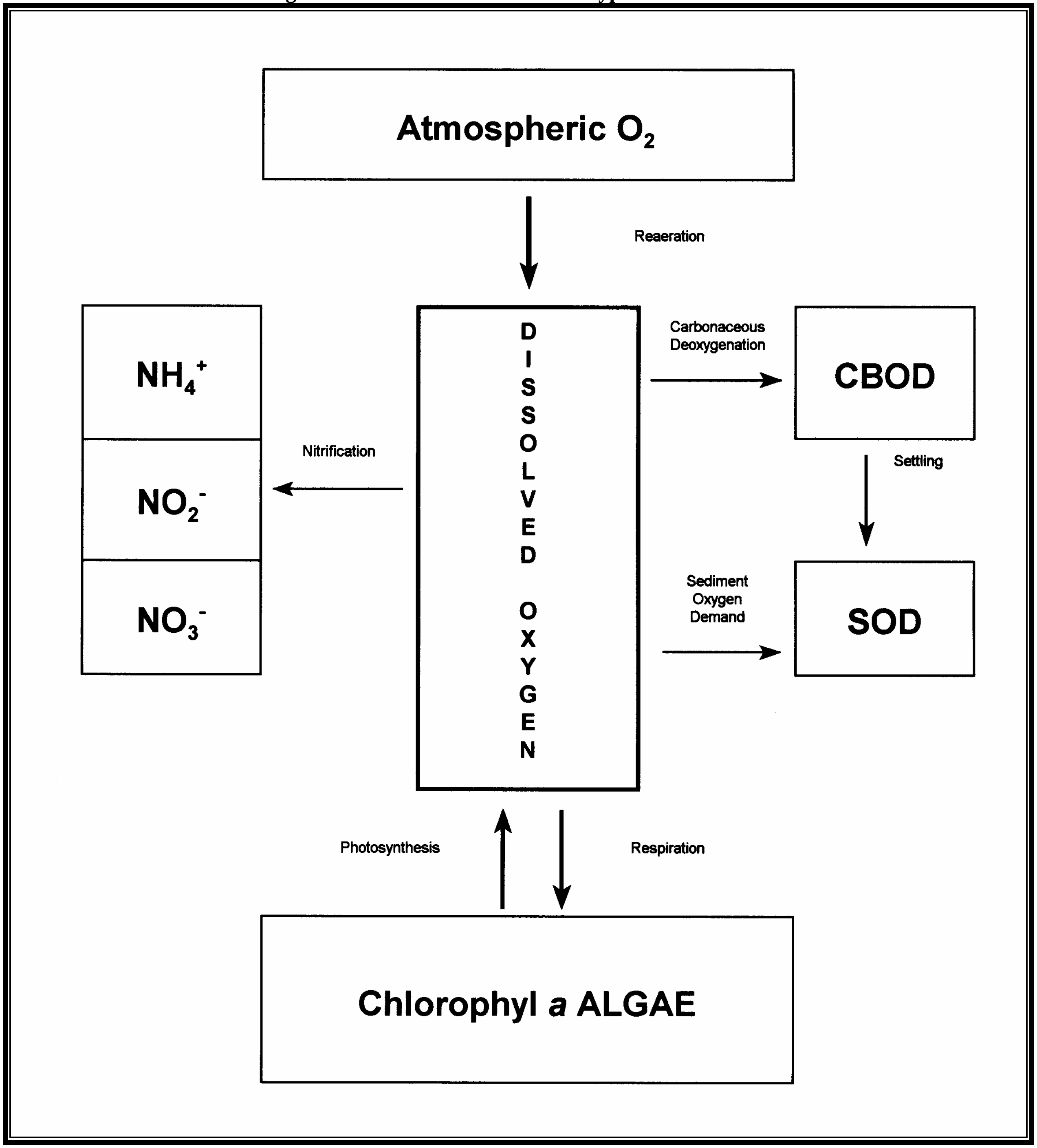
STREAM is a steady-state, daily average computer model that utilizes a modified Streeter-Phelps DO sag equation. Instream processes simulated by the model include CBODu decay, nitrification, reaeration, sediment oxygen demand, and respiration and photosynthesis of algae. Figure 6 shows how these processes 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.

$$\mathbf{K_a = C*S*U} \qquad \textbf{(Eq. 2)}$$

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 0.11 for streams with flows less than 10 cfs and 0.0597 for stream flows equal to or greater than 10 cfs. Reach velocities were calculated using an equation based on slope. The slope of each reach was estimated electronically and input into the model in units of feet/mile.

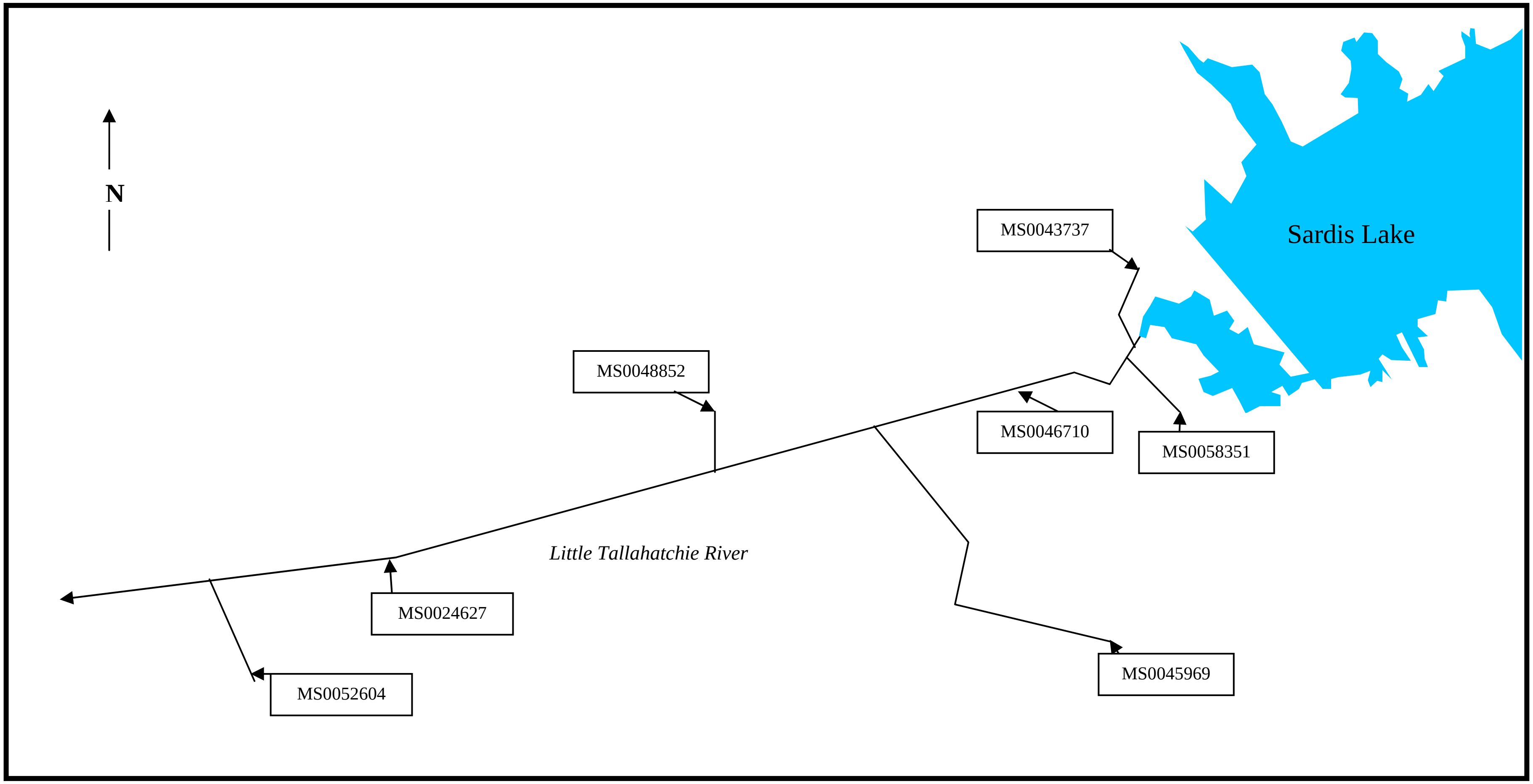
Figure 5. Instream Processes in a Typical DO Model



3.2 Model Setup

The model for this TMDL includes the §303(d) listed segment of the Little Tallahatchie River, beginning at the spillway of Sardis Lake and several minor tributaries. A diagram showing the model setup is shown in Figure 6.

Figure 6. Little Tallahatchie 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. MDEQ Regulations state that when the flow in a water body is less than 50 cfs, the temperature used in the model is 26°C. The headwater instream DO was assumed to be 85% of saturation at the stream temperature. The instream CBODu decay rate at K_d at 20°C was 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.

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

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.

This segment of the Little Tallahatchie River currently has no USGS flow gages. The flow in the Little Tallahatchie River watershed was modeled at critical conditions based on data available from USGS flow gage 07272500 on the Little Tallahatchie River at Sardis Dam which operated from 1960 to 1980 , USGS (Telis, 1991), and personal communications with the US Army Corps of Engineers.

3.3 Source Representation

Both point and non-point sources were represented in the model. The loads from the NPDES permitted point sources was added as a direct input into the appropriate reaches 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.

$$\mathbf{CBODu = CBOD_5 * Ratio} \qquad \textbf{(Eq. 4)}$$

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 wastewater treatment type.

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 the existing point sources is given in Table 9.

Table 9. Point Sources, Maximum Permitted Loads

NPDES	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)
MS0024627	2.1	15	5	2.3	604.7	87.63	400.5	1005.2
MS0048852	0.0076	30	2*	1.5	2.9	0.13	0.6	3.4
MS0058351	0.005	30	2*	2.3	2.9	0.08	0.4	3.3
MS0052604	0.001	30	2*	1.5	0.4	0.02	0.1	0.5
MS0046710	0.85	45	2*	1.5	478.9	14.19	64.8	543.7
MS0045969	0.0015	30	2*	2.3	0.9	0.03	0.1	1.0
MS0043737	0.075	30	2*	1.5	28.2	1.25	5.7	33.9

*Assumed Value

Direct measurements of background concentrations of CBODu were not available for the Little Tallahatchie 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 concentration used in modeling for BOD_5 is 1.33 mg/l and for NH_3-N is 0.1 mg/l. These concentrations were also used as estimates for 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 water entering due to groundwater infiltration, overland flow, and small, unmeasured tributaries. These flows were estimated based on USGS data for the 7Q10 flow condition in the Little Tallahatchie River watershed. The non-point source loads were assumed to be distributed evenly on a river mile basis throughout the modeled reaches as shown in Table 10.

Table 10. Non-Point Source Loads Input into the Model

	Flow (cfs)	$CBOD_5$ (mg/l)	CBODu (lbs/day)	NH_3-N (mg/l)	NBODu (lbs/day)	TBODu (lbs/day)
Little Tallahatchie River background load	15	1.33	161.3	0.1	37.0	198.3
Little Tallahatchie River non-point source load	4.6	1.33	49.7	0.1	11.4	61.1
Total			**211.0**		**48.4**	**259.4**

3.4 Model Calibration

The model used to develop the Little Tallahatchie River TMDL was not calibrated due to lack of instream monitoring data collected during critical conditions. Future monitoring is essential to improve the accuracy of the model and the results.

3.5 Model Results

Once the model setup was complete, the model was used to predict water quality conditions in the Little Tallahatchie River. The model was first run under regulatory load conditions. Under regulatory load conditions, the loads from the NPDES permitted point sources were based on their current location and maximum permit limits, Table 10.

3.5.1 Regulatory Load Scenario

The regulatory load scenario model results are shown in Figure 7. Figure 7 shows the modeled daily average DO with the NPDES permitted facilities at their current maximum allowable loads and with estimated non-point source loads. The figure shows the daily average instream DO concentrations, beginning at the Sardis spillway at river mile 21.2 and ending at river mile 0.0 at the confluence with McIvor Canal. As shown in the figure, the model predicts that the DO goes below the standard of 5.0 mg/l using the maximum allowable loads, thus reductions are needed.

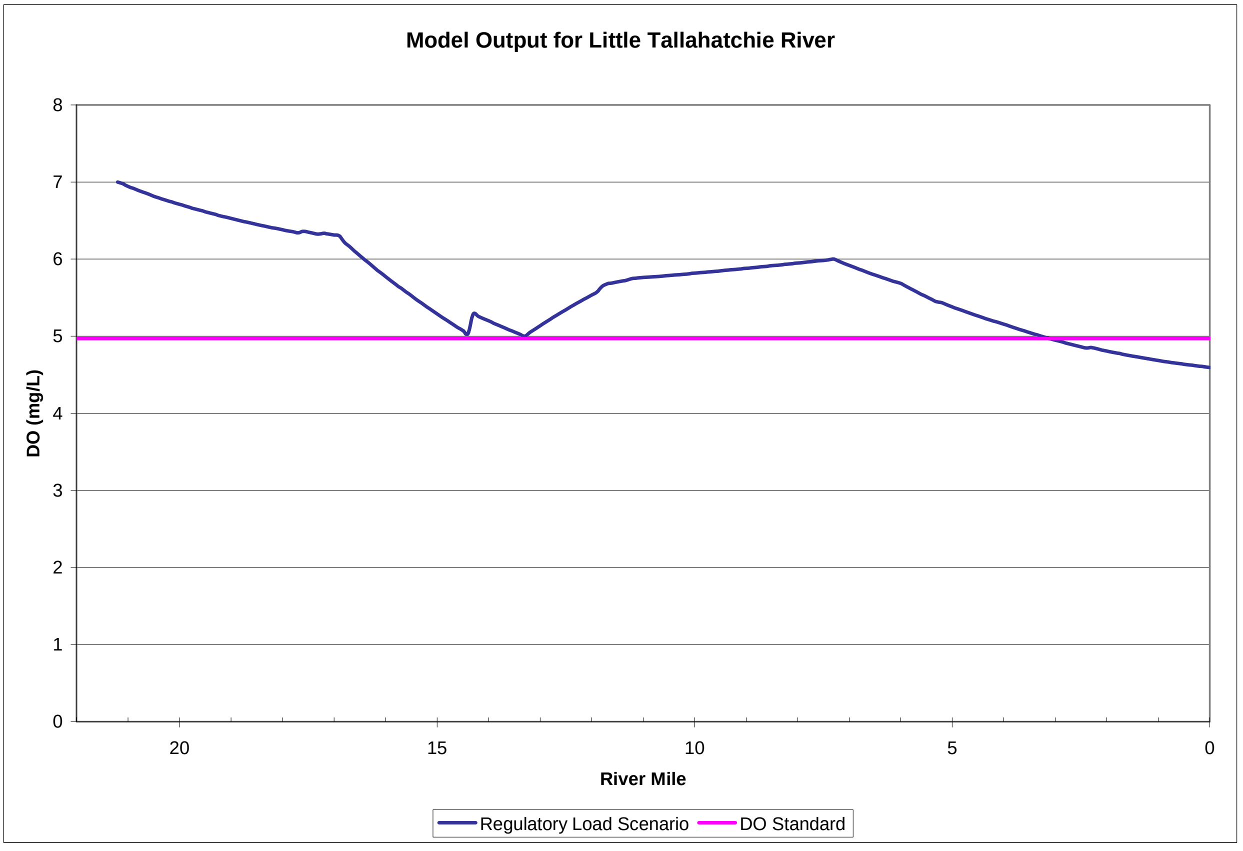


Figure 7. Model Output for DO in the Little Tallahatchie River, Regulatory Load Scenario

3.5.2 Maximum Load Scenario

The graph of the regulatory load scenario output shows that the predicted DO falls below the DO standard in the Little Tallahatchie River during critical conditions. Thus, reductions of the loads of TBODu are necessary. Calculating the maximum allowable load of TBODu involved decreasing the model loads until the modeled DO was just above 5.0 mg/l. The non-point source loads in this model were already set at background conditions based on MDEQ regulations so no reductions were necessary. The modeled sag is the result of Batesville POTW. Thus, the permitted limits of Batesville POTW were reduced until the minimum modeled DO was 5 mg/L. The decreased loads were then used to develop the allowable maximum daily load for this report. The model output for DO with the permit reduction for Batesville POTW is shown in Figure 8.

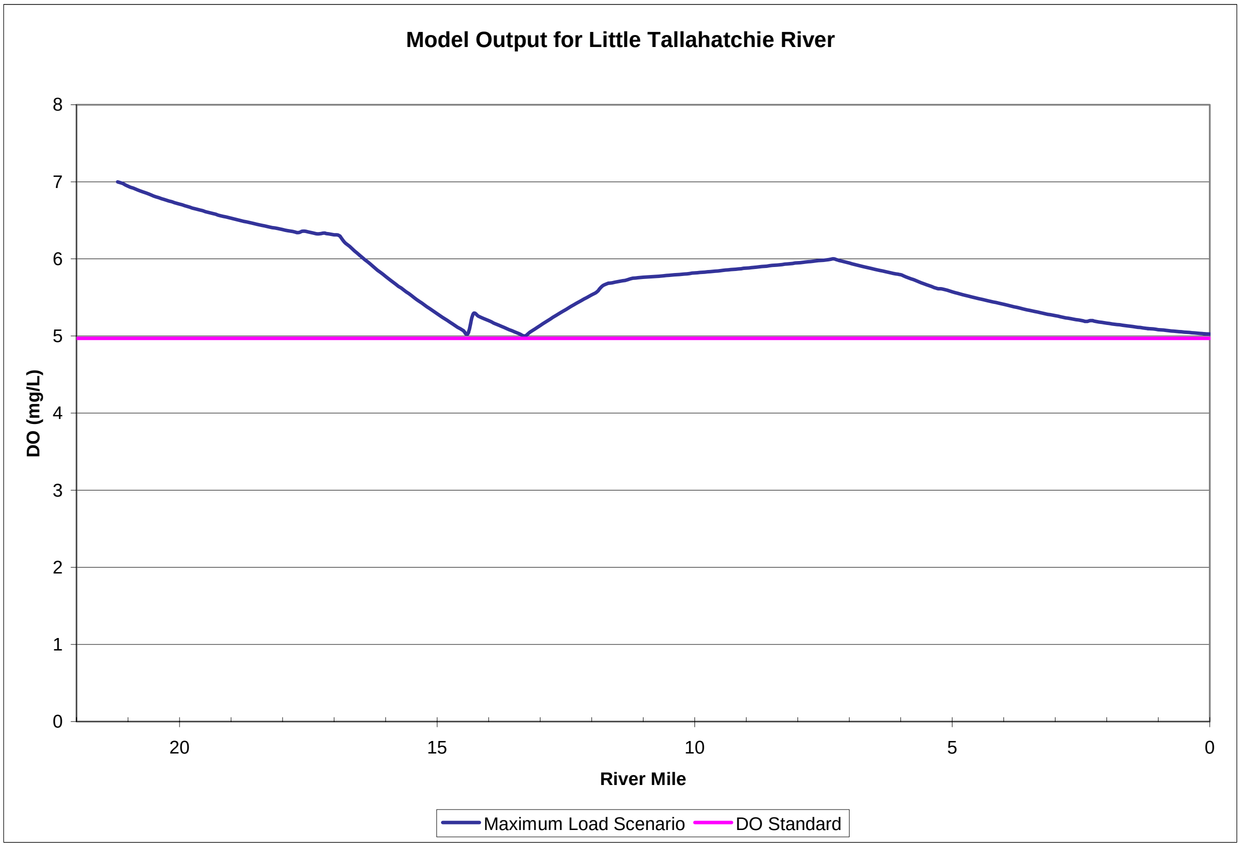


Figure 8. Model Output for the Little Tallahatchie River for DO, Maximum Load Scenario

3.6 Estimated Existing Load for Total Nitrogen

The estimated existing total nitrogen concentration is based on the area weighted median total nitrogen concentrations measured in wadeable streams in Ecoregion 74 and Ecoregion 65 with impaired biology and elevated nutrients, which is 1.62 mg/l.

To convert the estimated existing total nitrogen concentration to a total nitrogen load, the average annual flow for the Little Tallahatchie River needed to be determined. Based on the US Army Corps of Engineers, *Master Water Control Manual Yazoo Basin Lakes With Standing Instructions* the average annual flow for Sardis Lake is 2,491 cfs with a drainage area of 1,545 square miles. To calculate the flow in the segment the annual average flow for Sardis Lake was divided by the drainage area to compute the flow per square mile. (2,491 cfs/1,545 sq. miles = 1.61 cfs/sq. mile). The annual average flow in the segment was then computed by taking the initial 2,491 cfs and adding the computed flow in the segment based on the drainage area ratio (134.1 sq. miles * 1.61 cfs/sq. mile = 216 cfs) resulting in an annual average flow of 2,707 cfs. The existing TN load was then calculated, using Equation 5 and the results are shown in Table 11.

Nutrient Load (lb/day) = Flow (cfs) * 5.394 (conversion factor)* Nutrient Concentration (mg/L) (Eq. 5)

Table 11. Estimated Existing Total Nitrogen Load for the Little Tallahatchie River

Stream	Average Annual Flow (cfs)	TN (mg/L)	TN (lbs/day)
Little Tallahatchie River	2,707	1.62	23,654.5

Table 12. NPDES Permitted Facilities Treatment Types with Nitrogen Estimates

Facility Name	NPDES	Treatment Type	Permitted Discharge (cfs)	TN concentration estimate (mg/l)	TN Load estimate (lbs/day)
Batesville POTW	MS0024627	Oxidation Ditch	3.249	13.6	238.32
Brewer Trailer Park LLC	MS0048852	Septic Tank w/ sand filter	0.012	11.5	0.73
The Hickory's	MS0058351	ATU	0.008	13.6	0.57
Pride Auto Sales Inc	MS0052604	Package Plant w/ sand filter	0.002	11.5	0.10
Sardis POTW	MS0046710	Conventional Lagoon	1.315	11.5	81.57
Smith Mobile Home Park	MS0045969	ATU	0.002	13.6	0.17
US Army COE, Sardis Lower Lake	MS0043737	Aerated Lagoon	0.116	11.5	7.20
		Total	**4.704**		**328.7**

The TN point source load is estimated to be 328.7 lbs/day, Table 12. The annual average total load based on the estimated total nitrogen concentration of 1.62 mg/l and an annual average flow of 2,707 cfs is 23,654.5 lbs/day. The point source load is 1.4% of the total load. Therefore, 98.6% of the estimated existing TN load is from non-point sources.

3.7 Estimated Existing Load for Total Phosphorous

The estimated existing total phosphorous concentration is based on the area weighted median total phosphorous concentrations measured in wadeable streams in Ecoregion 74 and Ecoregion 65 with impaired biology and elevated nutrients, which is 0.17 mg/l.

To convert the estimated existing total phosphorus concentration to a total phosphorus load, the average annual flow in this segment was computed to be 2,707 cfs. The existing TP load was then calculated, using Equation 5 and the results are shown in Table 13.

Table 13. Estimated Existing Total Phosphorous Load for the Little Tallahatchie River

Stream	Average Annual Flow (cfs)	TP (mg/L)	TP (lbs/day)
Little Tallahatchie River	2,707	0.17	2,482.3

Table 14. NPDES Permitted Facilities Treatment Types with Phosphorus Estimates

Facility Name	NPDES	Treatment Type	Permitted Discharge (cfs)	TP concentration estimate (mg/l)	TP Load estimate (lbs/day)
Batesville POTW	MS0024627	Oxidation Ditch	3.249	5.8	101.64
Brewer Trailer Park LLC	MS0048852	Septic Tank w/ sand filter	0.012	5.2	0.33
The Hickory's	MS0058351	ATU	0.008	5.8	0.24
Pride Auto Sales Inc	MS0052604	Package Plant w/ sand filter	0.002	5.2	0.04
Sardis POTW	MS0046710	Conventional Lagoon	1.315	5.2	36.88
Smith Mobile Home Park	MS0045969	ATU	0.002	5.8	0.07
US Army COE, Sardis Lower Lake	MS0043737	Aerated Lagoon	0.116	5.2	3.25
		Total	**4.704**		**142.5**

The TP point source load is estimated to be 142.5 lbs/day, Table 14. The annual average total load based on the estimated total phosphorus concentration of 0.17 mg/l and an annual average flow of 2,707 cfs is 2,482.3 lbs/day. The point source load is 5.7% of the total load. Therefore, 94.3% of the estimated existing TP load is from non-point sources.

ALLOCATION

The allocation for this TMDL involves a wasteload allocation and a load allocation for non-point sources necessary for attainment of water quality standards in the Little Tallahatchie River. The nutrient portion of this TMDL is addressed through initial estimates of the existing and target TN and TP concentrations.

4.1 Wasteload Allocation

There are currently seven NPDES permits issued for this portion of the Little Tallahatchie River watershed. Although this wasteload allocation is based on the current condition of the Little Tallahatchie River, it is not intended to prevent the issuance of permits for future facilities. Future permits will be considered in accordance with Mississippi's *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*.

The NPDES permitted facilities included in the wasteload allocation are shown in Table 15. One option to meet water quality standards is a permit reduction is necessary for Batesville POTW, as shown in Figure 8. Since Batesville POTW currently has limits of 15-5-6 (BOD, NH_3-N, DO) there is some flexibility as to the allocations between NH_3-N and BOD. Possible scenarios which meet water quality standards are 15-2-6, 13-3-6, 11-4-6, and 9-5-6. The selection of the appropriate set of permit limits should be decided by the permitting engineer and the facility. Each scenario will limit the TBODu to 765.0 lbs/day and will result in the attainment of water quality standards in the Little Tallahatchie River. Table 16 gives the estimated load of TN from the point sources which are 1.4% of the total existing load as described in Section 3.6. Table 16 also gives the estimated load of TP from the point sources which are 5.7% of the total existing load as described in Section 3.7. Because the nutrient estimates are based on literature values, this TMDL recommends quarterly nutrient monitoring for Batesville POTW and Sardis POTW.

Table 15. Wasteload Allocation

Facility Name	CBODu (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
Batesville POTW	362.8 – 604.7*	160.2 – 400.5*	765.0
Brewer Trailer Park LLC	2.9	0.6	3.4
The Hickory's	2.9	0.4	3.3
Pride Auto Sales Inc	0.4	0.1	0.5
Sardis POTW	478.9	64.8	543.7
Smith Mobile Home Park	0.9	0.1	1.0
US Army COE, Sardis Lower Lake	28.2	5.7	33.9
Total	**877.0 – 1118.9***	**231.9 – 472.2***	**1350.8**

* Dependent upon the distribution of the BOD and NH_3-N permit limits for Batesville POTW

Table 16. Nutrient Wasteload Allocation

Facility Name	Existing Estimated TN Point Source Load (lbs/day)	Allocated Average TN Point Source Load (lbs/day)	Existing Estimated TP Point Source Load (lbs/day)	Allocated Average TP Point Source Load (lbs/day)	Percent Reduction
Batesville POTW	238.32	238.32	101.64	101.64	0
Brewer Trailer Park LLC	0.73	0.73	0.33	0.33	0
The Hickory's	0.57	0.57	0.24	0.24	0
Pride Auto Sales Inc	0.10	0.10	0.04	0.04	0
Sardis POTW	81.57	81.57	36.88	36.88	0
Smith Mobile Home Park	0.17	0.17	0.07	0.07	0
US Army COE, Sardis Lower Lake	7.20	7.20	3.25	3.25	0
Total	**328.7**	**328.7**	**142.5**	**142.5**	

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 BOD_u concentration of 1.33 mg/l and an NH_3-N concentration of 0.1 mg/l. This TMDL does not require a reduction of the load allocation. In Table 17, the load allocation is shown as the non-point sources (the spatially distributed flow entering each reach in the model).

Table 17. Load Allocation, Maximum Scenario

	CBODu (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
Background	161.3	37	198.3
Non-Point Source	49.7	11.4	61.1
	211.0	**48.4**	**259.4**

Based on initial estimates in Sections 3.6 and 3.7, most of the TN and TP loads in this watershed come from non-point sources. Therefore, best management practices (BMPs) should be encouraged in the watershed to reduce potential nutrient loads from non-point sources The 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 18 shows the load allocation for TN and TP.

Table 18. Load Allocation for Estimated TN and TP

Nutrient	Estimated Nutrient Nonpoint Source Load (lbs/day)	Allocated Nutrient Nonpoint Source Load (lbs/day)
TN	23,325.8	7,994.2 – 14,272.9
TP	2,339.8	587.6 –1,901.7

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 for this TMDL 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 when Sardis spillway is closed for inspections. Modeling the water body at this flow provides protection during the worst-case scenario.

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, which occurs when the spillway at Sardis Lake is shut down for inspections. 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 6.

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

The TMDL for TBODu was calculated based on the current loading of pollutant in the Little Tallahatchie River, according to the model. The TMDL calculations are shown in Tables 19 and 20. As shown in Table 19, the TBODu is the sum of CBODu and NBODu. The wasteload allocations incorporate the CBODu contributions from identified NPDES Permitted facilities. The load allocations include the background and non-point sources of TBODu 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.

Equation 5 was used to calculate the TMDL for TP and TN. The target concentration ranges, presented in Section 1.7, were used with the average flow for the watershed to determine the TMDLs. The TMDLs, given in Table 20, were then compared to the estimated existing load for the ecoregion, presented in Sections 3.6 and 3.7. The estimated existing TP concentration indicates needed reductions of 17.6% to 70.6%. The TMDL for TP is 730.1 – 2,044.2 lbs/day. The estimated existing total nitrogen concentration indicates needed reductions of 38.3% to 64.8%. The TMDL for TN is 8,322.9 – 14,601.6 lbs/day.

Table 19. TMDL for TBODu in the Little Tallahatchie River Watershed

	WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
CBODu	877.0 – 1118.9*	211	Implicit	1088.0-1329.9*
NBODu	231.9 – 472.2*	48.4	Implicit	280.3 – 520.6*
TBODu	**1350.8**	**259.4**	**Implicit**	**1610.2**

* Dependent upon the distribution of the BOD and NH_3-N permit limits for Batesville POTW

Table 20. TMDL for Nutrients in the Little Tallahatchie River Watershed

	WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
TN	328.7	7,994.2 – 14,272.9	Implicit	**8,322.9 – 14,601.6**
TP	142.5	587.6 –1,901.7	Implicit	**730.1 – 2,044.2**

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.

CONCLUSION

This 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 Little Tallahatchie River is not meeting water quality standards for dissolved oxygen at the present loading of TBODu. Therefore, a permit reduction is recommended for Batesville POTW. However, this TMDL does not limit the issuance of new permits in the watershed as long as new facilities do not cause impairment in the Little Tallahatchie River. Nutrients were addressed through an estimate of a preliminary total phosphorous concentration target range and a preliminary total nitrogen concentration target range. Based on the estimated existing and target total phosphorous concentrations, this TMDL recommends a 17.6% to 70.6% reduction of the phosphorous loads entering these streams to meet the preliminary target range of 0.05 to 0.14 mg/l. Based on the estimated existing and target total nitrogen concentrations, this TMDL recommends a 38.3% to 64.8% reduction of the nitrogen loads entering these streams to meet the preliminary target range of 0.57 to 1.00 mg/l. Because only 1.4% of the existing TN load and 5.7% of the TP load are estimated to be due to point sources, this TMDL does not recommend nutrient limits or reductions from the NPDES permits. It is recommended that the Little Tallahatchie 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 creeks. This will provide improved water quality for the support of aquatic life in the water bodies and will result in the attainment of the applicable water quality standards.

5.1 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 TMDLs 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. Anyone wishing to become a member of the TMDL mailing list should contact Kay Whittington at Kay_Whittington@deq.state.ms.us.

All comments should be directed to Kay Whittington at Kay_Whittington@deq.state.ms.us or Kay Whittington, 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.

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