

Phase 1

Total Maximum Daily Load

For Organic Enrichment/Low Dissolved Oxygen and Nutrients

Stout Creek

North Independent Basin

Marshall County Mississippi

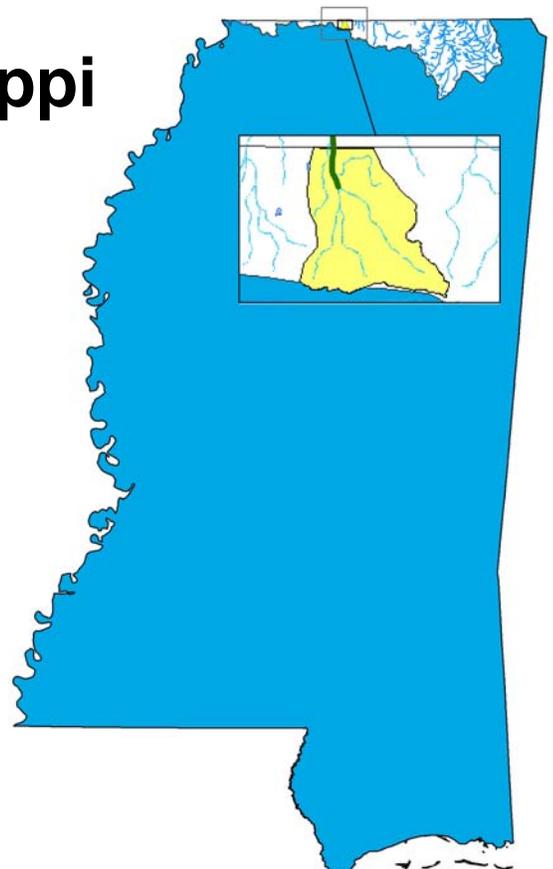
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FOREWORD

This report has been prepared in accordance with the schedule contained within the federal consent decree dated December 22, 1998. The report contains one or more Total Maximum Daily Loads (TMDLs) for water body segments found on Mississippi's 1996 Section 303(d) List of Impaired Water bodies. Because of the accelerated schedule required by the consent decree, many of these TMDLs have been prepared out of sequence with the State's rotating basin approach. The implementation of the TMDLs contained herein will be prioritized within Mississippi's rotating basin approach.

The amount and quality of the data on which this report is based are limited. As additional information becomes available, the TMDLs may be updated. Such additional information may include water quality and quantity data, changes in pollutant loadings, or changes in landuse within the watershed. In some cases, additional water quality data may indicate that no impairment exists.

Conversion Factors

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

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

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TMDL INFORMATION PAGE

i. Listing Information

Name	ID	County	HUC	Cause	Mon/Eval
Stout Creek	MS215E	Marshall	08010210	Organic Enrichment/Low DO and Nutrients	Evaluated
Near Mt. Pleasant from Headwaters to Tennessee Line					

ii. Water Quality Standard

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

iii. NPDES Facilities

NPDES	Facility Name	Flow (MGD)	Receiving Water
MS0034631	Marshall County Schools, HW Byers HS	0.021	Unnamed Tributary to Stout

iv. Phase 1 Total Maximum Daily Load for TBODu

WLA (lbs/day)	Baseline LA (lbs/day)	MOS	TMDL (lbs/day)
9.34*	12.83	20.56	42.73

*This TMDL will not exclude future NPDES permits in the Stout Creek Watershed. Requests for permits in this water body will be evaluated to accommodate a load that does not violate the TMDL of 42.73 lbs/day of TBODu.

v. Total Estimated Maximum Daily Load for TP*

WLA lbs/day	LA lbs/day	MOS lbs/day	TMDL lbs/day
0.91*	1.57 to 9.09*	Implicit	2.48 to 9.93 *

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

EXECUTIVE SUMMARY

This TMDL has been developed for a segment of Stout Creek placed on the Mississippi 2004 Section 303(d) List of Water Bodies as an evaluated water body segment. This segment of Stout Creek is listed due to nutrients, organic enrichment, pesticides and sediment. Pesticides and sediment will be addressed in separate TMDL reports. The applicable state standard specifies that the dissolved oxygen concentrations shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l. Ammonia nitrogen levels will also be evaluated in this TMDL using criteria established for ammonia nitrogen toxicity.

Additionally, this TMDL will provide an estimate of the total phosphorous (TP) in the stream and a preliminary breakdown of the TP load between point and non-point sources. Mississippi does not have water quality standards for allowable nutrient concentrations. MDEQ currently has a Nutrient Task Force (NTF) working on the development of criteria for nutrients. For TMDL development, TP was used as the nutrient of concern because phosphorus is typically the limiting nutrient in non-point source dominated rivers and streams (Thomann and Mueller, 1987). Preliminary analysis of the data reveals that an annual concentration range of 0.04 to 0.16 mg/l is an applicable target for total phosphorus for water bodies which are located in Ecoregion 74. MDEQ is presenting this range as a preliminary target value for TMDL development which is subject to revision for the development of nutrient criteria, when the work of the NTF is complete. This TMDL has been developed as a Phase 1 TMDL so nutrients may be further evaluated when more data are available and nutrient criteria are developed.

The Stout Creek Watershed is located in northern Mississippi in HUC 08010208. Stout Creek begins in Marshall County near the Mississippi and Tennessee line. The river flows for approximately 8 miles in a northern direction from its headwaters to its confluence with Grissum Creek in Tennessee. There are approximately 4 miles of this creek located within Mississippi. The location of the Mississippi portion of the watershed is shown in Figure 1.

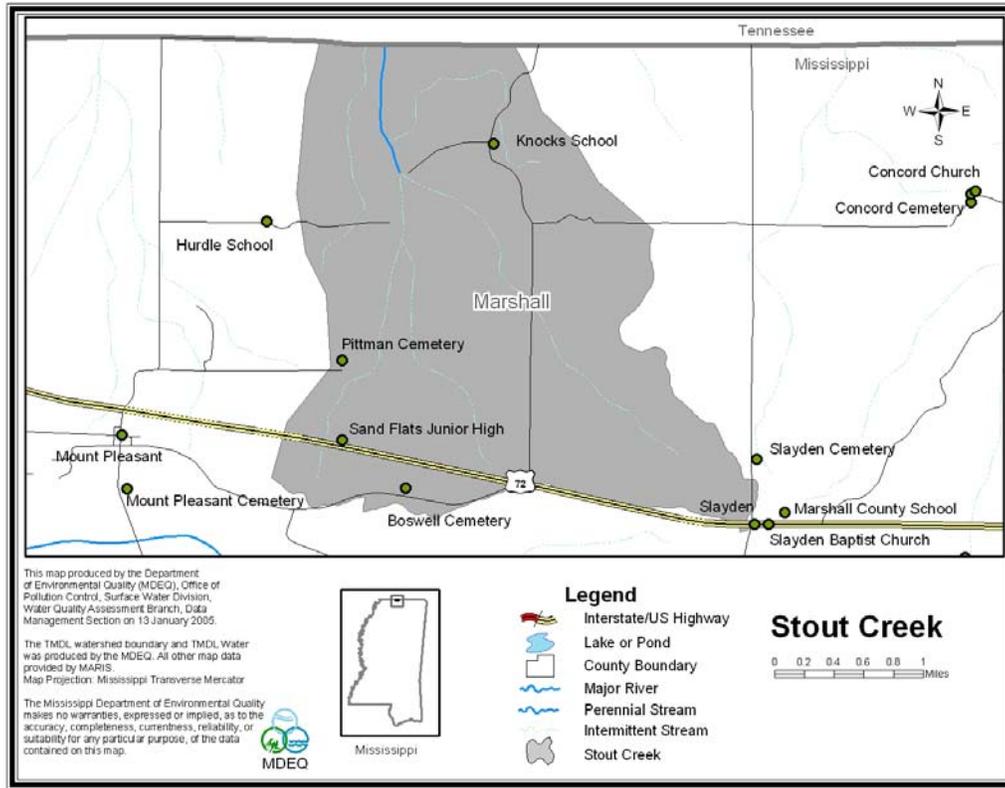


Figure 1. Stout Creek Watershed

The predictive model used to calculate this TMDL is based primarily on assumptions described in MDEQ Regulations. A modified Streeter-Phelps DO sag model was selected as the modeling framework for performing the TMDL allocations for this study. The model was developed to account for critical conditions in stream temperature, dissolved oxygen saturation, and carbonaceous biochemical oxygen demand (CBOD_u) decay rate. A mass-balance approach was used to ensure that the instream concentration of ammonia nitrogen (NH₃-N) did not exceed the water quality criteria for toxicity. The critical modeling period was determined to be during low-flow, high-temperature conditions that occur during the summer (May – October) period. This flow condition is typically represented as the 7-day, 10-year low flow (7Q10 flow). The 7Q10 flow value was estimated using the ungaged sites on an ungaged stream method described in *Techniques for Estimating 7-Day, 10-Year Low Flow Characteristics for Ungaged Sites on Streams in Mississippi* (Telis, 1992).

According to the model, the current load in the water body does not exceed the assimilative capacity of Stout Creek for organic material and ammonia nitrogen. Additionally, mass balance calculations showed that the potential phosphorus levels are predominantly from non-point sources. Therefore, no reductions in the current loading of organic material are needed for this TMDL report in order to meet water quality limits.

INTRODUCTION

1.1 Background

Stout Creek was originally placed on the 303(d) List 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. Stout Creek was listed for nutrients, organic enrichment/low dissolved oxygen, pesticides, and sediment/siltation based on the survey results. Because of a federal court consent decree required for the state of Mississippi, TMDLs for Stout Creek must be developed for these pollutants even though there are no data available.

The identification of water bodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those water bodies are required by Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR part 130). The TMDL process is designed to restore and maintain the quality of those impaired water bodies through the establishment of pollutant specific allowable loads. This TMDL has been developed for the 303(d) listed segment shown in Figure 2.

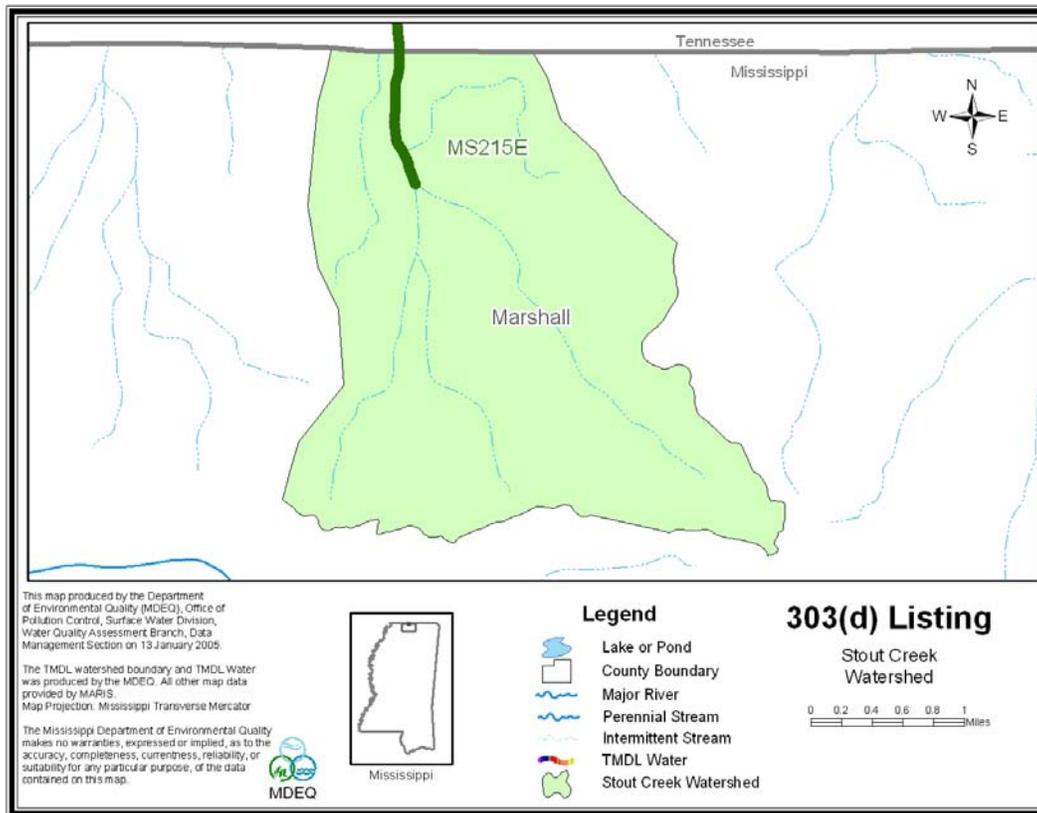


Figure 2. Stout Creek 303(d) Listed Segment

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 Stout Creek 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. This water quality standard will be used as a targeted endpoint to evaluate impairment and establish this TMDL.

The water quality standard for ammonia nitrogen toxicity is also included in this TMDL. Ammonia nitrogen concentrations can be evaluated using the criteria given in *1999 Update of Ambient Water Quality Criteria for Ammonia* (EPA-822-R-99-014). The maximum allowable instream ammonia nitrogen ($\text{NH}_3\text{-N}$) concentration at a pH of 7.0 and stream temperature of 26°C is 2.82 mg/l.

Mississippi's NTF is currently developing numeric criteria for nutrients. The current standards only contain a narrative criteria that can be applied to nutrients which states that "Waters shall be

free from materials attributable to municipal, industrial, agricultural, or other discharges producing color, odor, taste, total suspended or dissolved solids, sediment, turbidity, or other conditions in such degree as to create a nuisance, render the waters injurious to public health, recreation or to aquatic life and wildlife or adversely affect the palatability of fish, aesthetic quality, or impair the waters for any designated use (MDEQ, 2002).”

In the 1999 Protocol for Developing Nutrient TMDLs, EPA suggests several methods for the development of numeric criteria for nutrients (USEPA, 1999). In accordance with the 1999 Protocol, “The target value for the chosen indicator can be based on: comparison to similar but unimpaired waters; user surveys; empirical data summarized in classification systems; literature values; or best professional judgment.” MDEQ believes the most economical and scientifically defensible method for use in Mississippi is a comparison between similar but unimpaired waters within the same region. This method is dependent on adequate data which are being collected in accordance with the EPA approved plan. The initial phase of the data collection process for Wadeable streams has been completed. Preliminary analysis of the available data reveals that an annual concentration range of 0.04 to 0.16 mg/l is an applicable TMDL target for total phosphorus for water bodies located in Ecoregion 74. However, MDEQ is presenting this as a preliminary target value for TMDL development which will be subject to revision after the development of nutrient criteria, when the work of the NTF is complete.

1.4 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 Stout Creek 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 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.

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

WATER BODY ASSESSMENT

This TMDL Report includes an analysis of available water quality data and the identification of all known potential pollutant sources in Stout Creek. The pollutant sources were characterized by the best available information, monitoring data, and literature values.

2.1 Discussion of Instream Water Quality Data

There are no data available for Stout Creek.

2.2 Assessment of Point Sources

An important step in assessing pollutant sources in the Stout Creek watershed is locating the NPDES permitted sources. There is one facility permitted to discharge organic material into the Stout Creek Watershed, Table 1. The location of the facility is shown in Figure 3.

Table 1. NPDES Permitted Facilities Treatment Types

Name	NPDES Permit	Treatment Type
Marshall County Schools, HW Byers HS	MS0034631	Aerated lagoon

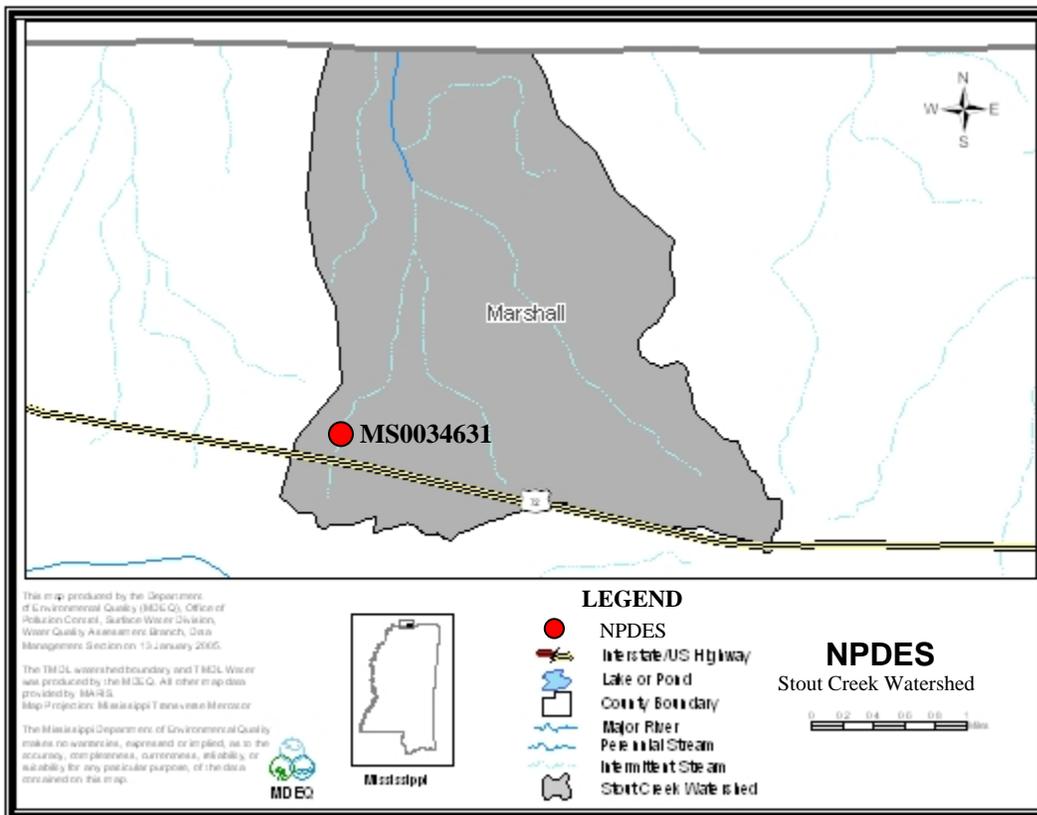


Figure 3. Point Source Location Map for the Stout Creek Watershed

The effluent from this facility was characterized based on all available data including information on its wastewater treatment system and permit limits. No discharge monitoring reports were available. Therefore, modeling was done utilizing only the permit limits. The flow and BOD₅ load are given in Table 2.

Table 2. Identified NPDES Permitted Facilities

Name	NPDES Permit	Permitted Discharge (MGD)	Permitted Average BOD ₅ (mg/L)	Permitted Average CBODu (lbs/day)
Marshall County Schools, HW Byers HS	MS0034631	0.021	30	7.76

2.3 Assessment of Non-Point Sources

Non-point loading of nutrients and organic material in a water body results from the transport of the pollutants into receiving waters by overland surface runoff and groundwater infiltration. Phosphorus is typically seen as the limiting nutrient in non-point source dominated rivers and streams (Thomann and Mueller, 1987). Therefore, this TMDL will address total phosphorus. Phosphorus is primarily transported by runoff when it has been sorbed by eroding sediment. Phosphorous may not be immediately released from sediment and can sometimes reenter the water column from deposited sediment. Most non-point sources of phosphorous will build up and then wash off during rain events. Table 3 presents typical nutrient loading ranges for various land uses.

Table 3. 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 Stout Creek is approximately 4,407 acres (6.89 square miles) in MS. The watershed contains different landuse types, including forest, cropland, pasture, and scrub/barren. 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. Cropland and pasture are the dominant landuses within the watershed. The landuse distribution is shown in Table 4 and Figure 4. Note that this landuse distribution is for the watershed area within the state of Mississippi only.

Table 4. Landuse Distribution, Stout Creek Watershed

	Unknown	Forest	Cropland	Pasture	Scrub/Barren
Area (acres)	17.7	526.6	1426.3	1611.2	825.2
Percentage	0.4%	11.9%	32.4%	36.6%	18.7%

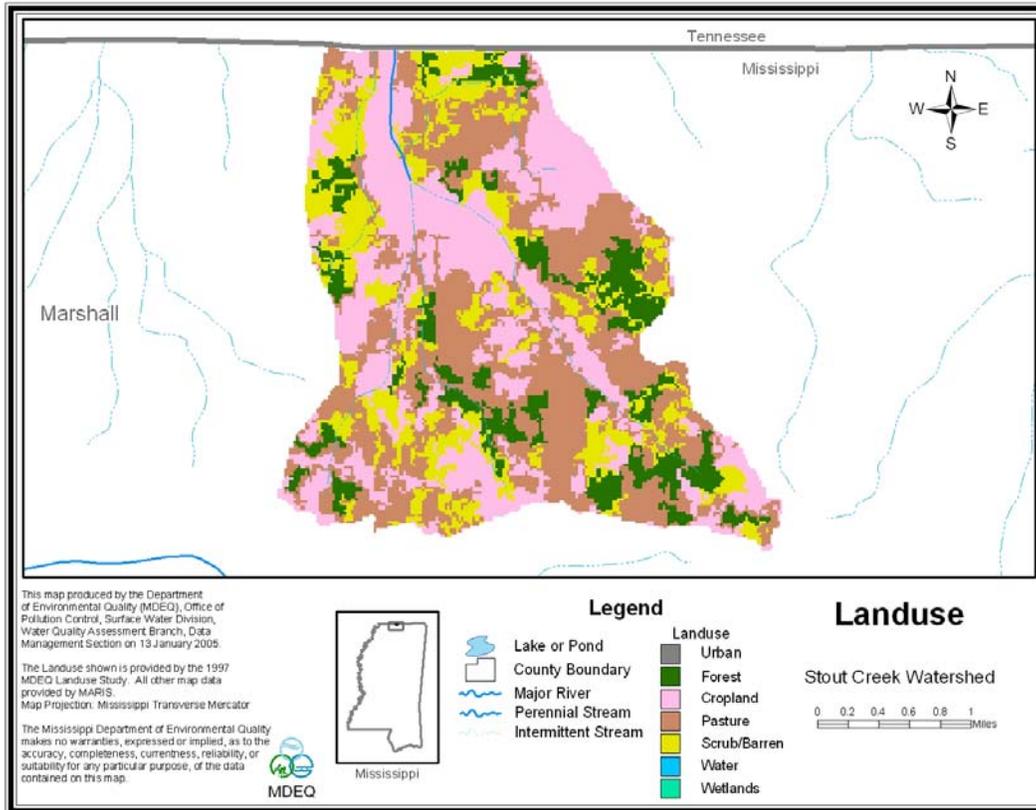


Figure 4. Landuse Distribution for the Stout Creek Watershed

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 AFWWUL1 model, which had been used by MDEQ for many years. The use of AFWWUL1 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.

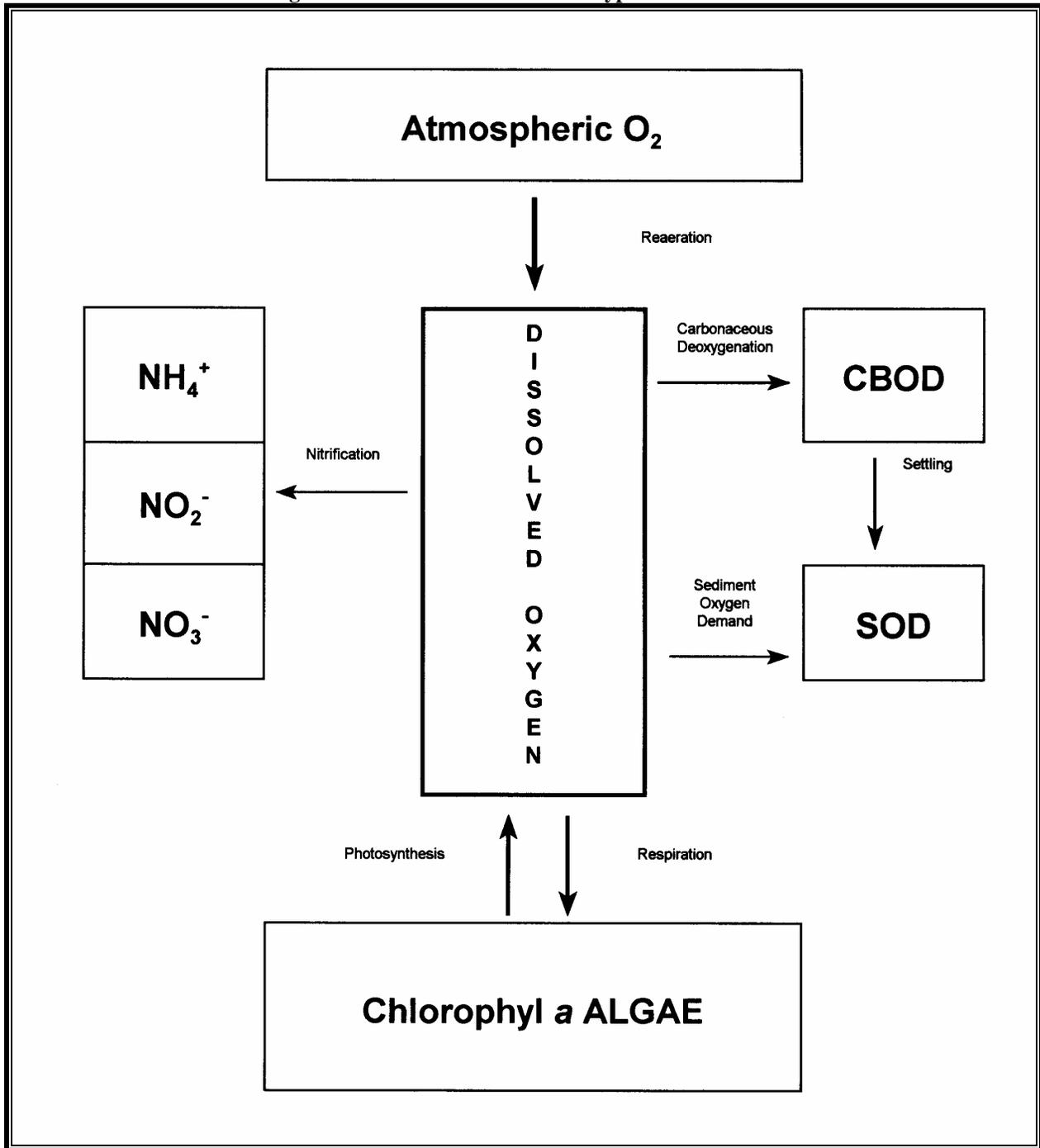
STREAM is a steady-state, daily average computer model that utilizes a modified Streeter-Phelps DO sag equation. Instream processes simulated by the model include CBOD_u decay, nitrification, reaeration, sediment oxygen demand, and respiration and photosynthesis of algae. Figure 5 shows how these processes 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, CBOD_u, and NH₃-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.

$$K_a = C * S * U \quad \text{(Equation 2)}$$

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 0.11 for stream reaches with flows less than 10 cfs. Reach velocities were calculated using an equation based on slope.

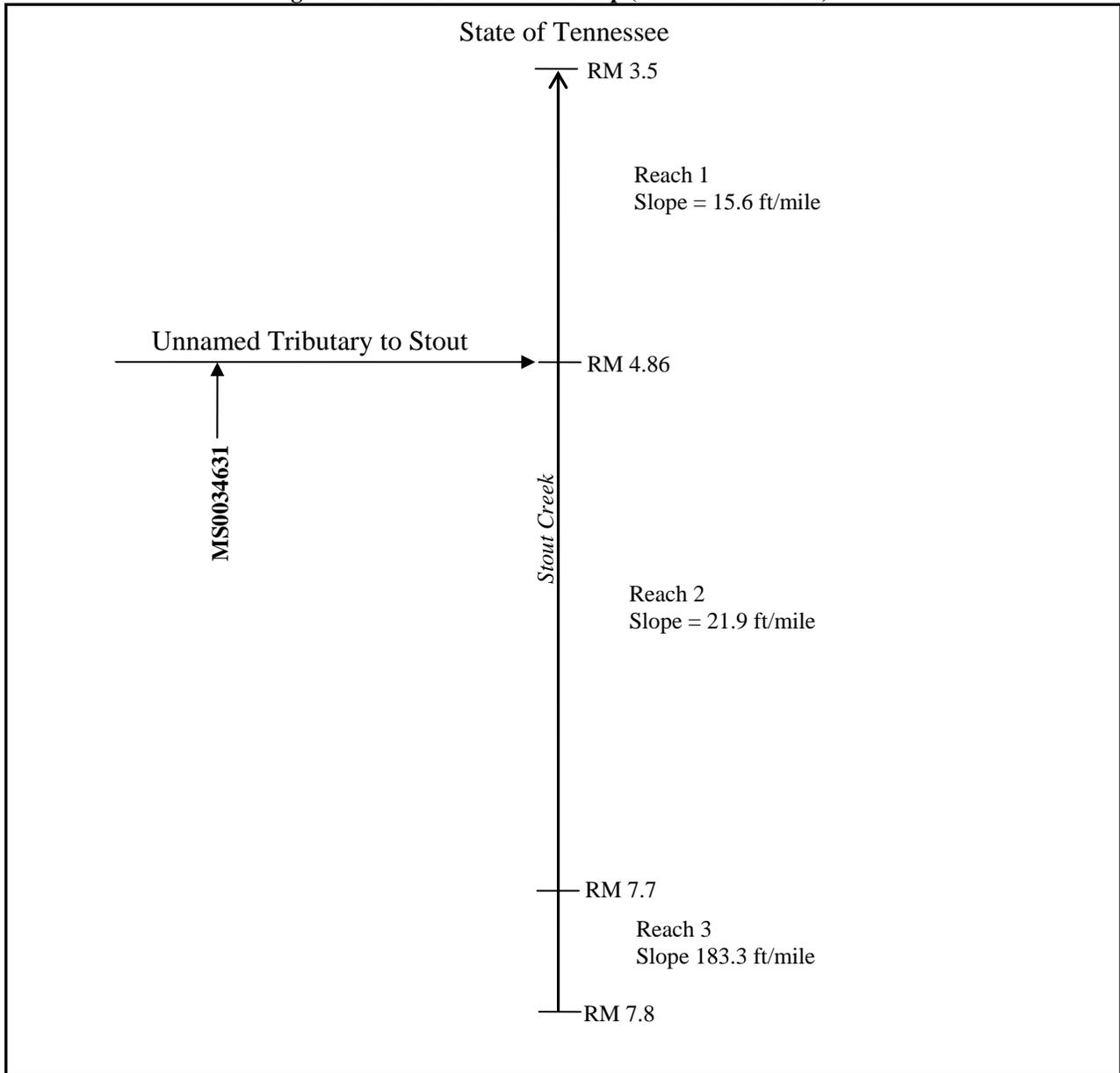
Figure 5. Instream Processes in a Typical DO Model



3.2 Model Setup

The model for Stout Creek was developed beginning with its headwaters to the Tennessee State Line. A diagram showing the model setup for Stout Creek is shown in Figure 6. 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 6. Stout Creek 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 26°C for flows less than 50 cfs. The headwater instream DO was assumed to be 85% of saturation at the stream temperature. Rates for CBOD_u decay range from 0.6 to 0.3 day⁻¹ base *e*, based on the instream CBOD_u concentrations. The instream CBOD_u decay rate is also dependent on temperature, according to Equation 3.

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

Where K_d is the CBOD_u decay rate and T is the assumed instream temperature. The assumptions regarding the instream temperatures, background DO saturation, and CBOD_u 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 Stout Creek was modeled at 7Q10 conditions based on data available from the USGS (Telis, 1992). Stout Creek does not have a flow gage, so the flow was estimated using a drainage area ratio. Drainage area ratios represent the estimated 7Q10 flow per square mile of drainage area.

3.3 Source Representation

Both point and non-point sources were represented in the model. There is currently one NPDES permitted point source located in the Stout Creek Watershed. The loads from the NPDES permitted source were added as direct input into the appropriate reach of Stout Creek. Spatially distributed loads, which represent non-point sources of flow, CBOD_u, 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 (BOD₅). BOD₅ 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, BOD₅ is generally considered equal to CBOD₅. Because permits for point source facilities are written in terms of BOD₅ while TMDLs are typically developed using CBOD_u, a ratio between the two terms is needed, Equation 4.

$$\text{CBOD}_u = \text{CBOD}_5 * \text{Ratio} \quad \text{(Equation 4)}$$

The CBOD_u to CBOD₅ ratios are given in *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). These values are recommended for use by MDEQ regulations when actual field data are not available. The value of the ratio depends on the treatment type of wastewater. For secondary treatment systems (conventional and aerated lagoons), this ratio is 1.5.

In order to convert the ammonia nitrogen (NH₃-N) loads to an oxygen demand, a factor of 4.57 pounds of oxygen per pound of ammonia nitrogen (NH₃-N) oxidized to nitrate nitrogen (NO₃-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 NBOD_u load. The sum of CBOD_u and NBOD_u is equal

to the point source load of TBOD_u. The maximum permitted load of TBOD_u from the existing point source is given in Table 5. Because the facility does not have a permit limit for NH₃-N, an assumed value of 2.0 mg/L was used to calculate the NBOD_u load for this facility.

Table 5. Point Sources, Maximum Permitted Loads

Facility	Flow (MGD)	CBOD ₅ (mg/l)	NH ₃ -N (mg/L)	CBOD _u :CBOD ₅ Ratio	CBOD _u (lbs/day)	NH ₃ -N (lbs/day)	NBOD _u (lbs/day)	TBOD _u (lbs/day)
Marshall County Schools, HW Byers HS	0.021	30	2	1.5	7.76	0.35	1.58	9.34
					7.76	0.35	1.58	9.34

Direct measurements of non-point concentrations of CBOD_u and NH₃-N were not available for the Stout Creek Watershed. Because there were no data available, the concentrations of CBOD_u and NH₃-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 CBOD_u = 2.0 mg/l and NH₃-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 7Q10 flow condition in the Stout Creek Watershed. According to USGS, the drainage area ratio for the watershed is 0.1 cfs/square mile. The drainage area ratio represents the amount of flow per square mile of drainage area entering the creek during 7Q10 flow conditions. The drainage area ratio was multiplied by the drainage area of Stout Creek to determine the amount of non-point source flow entering each reach. The drainage area of Stout Creek within Mississippi is approximately 6.89 square miles. Thus, a 7Q10 flow of 0.689 cfs for the watershed was used in the model. The flows were then multiplied by the concentrations of CBOD_u and NH₃-N to calculate the non-point source loads, Table 6. The non-point source loads were assumed to be distributed evenly throughout the modeled reaches.

Table 6. Non-Point Source Loads Input into the Model

Reach	Flow (cfs)	CBOD _u (mg/L)	CBOD _u (lbs/day)	NH ₃ -N (mg/l)	NBOD _u (lbs/day)	TBOD _u (lbs/day)
Reach 1 (RM 3.52 – 4.86)	0.215	2	3.48	0.1	0.53	4.01
Reach 2 (RM 4.86 – 7.70)	0.456	2	7.37	0.1	1.12	8.49
Reach 3 (RM 7.70 – 7.80)	0.018	2	0.29	0.1	0.04	0.33
	0.689		11.14		1.69	12.83

3.4 Model Results

Once the model setup was complete, the model was used to predict water quality conditions in Stout Creek. The model was first run under baseline conditions. Under baseline conditions, the point sources were set at the permit limits and non-point source loads were set at low-flow conditions. Thus, baseline model runs reflect the current condition of the water body at low-

flow. Baseline model runs showed that the water quality standard for dissolved oxygen was not violated at any point in Stout Creek. The model was then run using a trial-and-error process to determine the maximum TBODu loads which would not violate water quality standards for DO. These model runs are called maximum load scenarios.

3.4.1 Baseline Model Results

The baseline model results are shown in Figures 7 and 8. The figure shows the modeled daily average DO with the estimated non-point source loads. The figure shows the daily average instream DO concentrations, beginning with river mile 7.8 and ending with river mile 3.5 in Stout Creek. As shown, the model predicts that the DO stays near saturation level, well above the standard of 5.0 mg/l. Baseline model output for ammonia nitrogen is shown in Figure 7. The ammonia nitrogen is also well below the water quality standard of 2.82 mg/l NH₃-N.

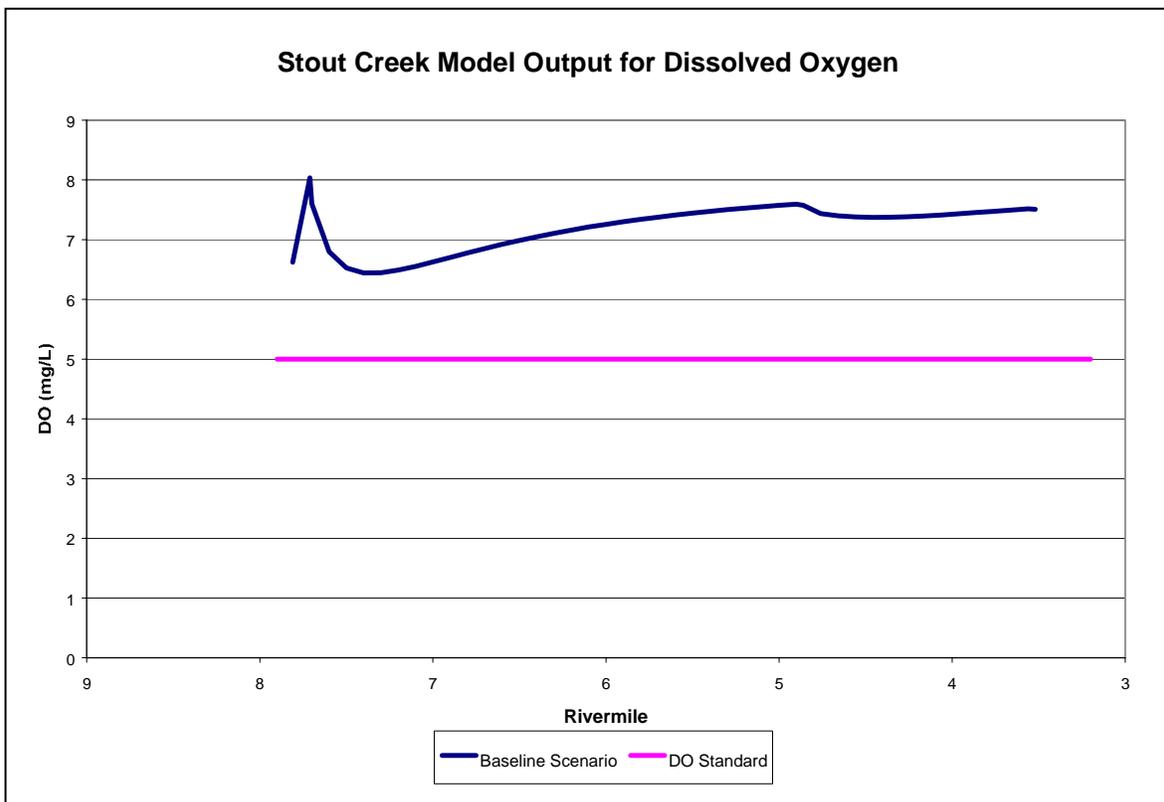


Figure 7. Baseline Model Output for DO in Stout Creek

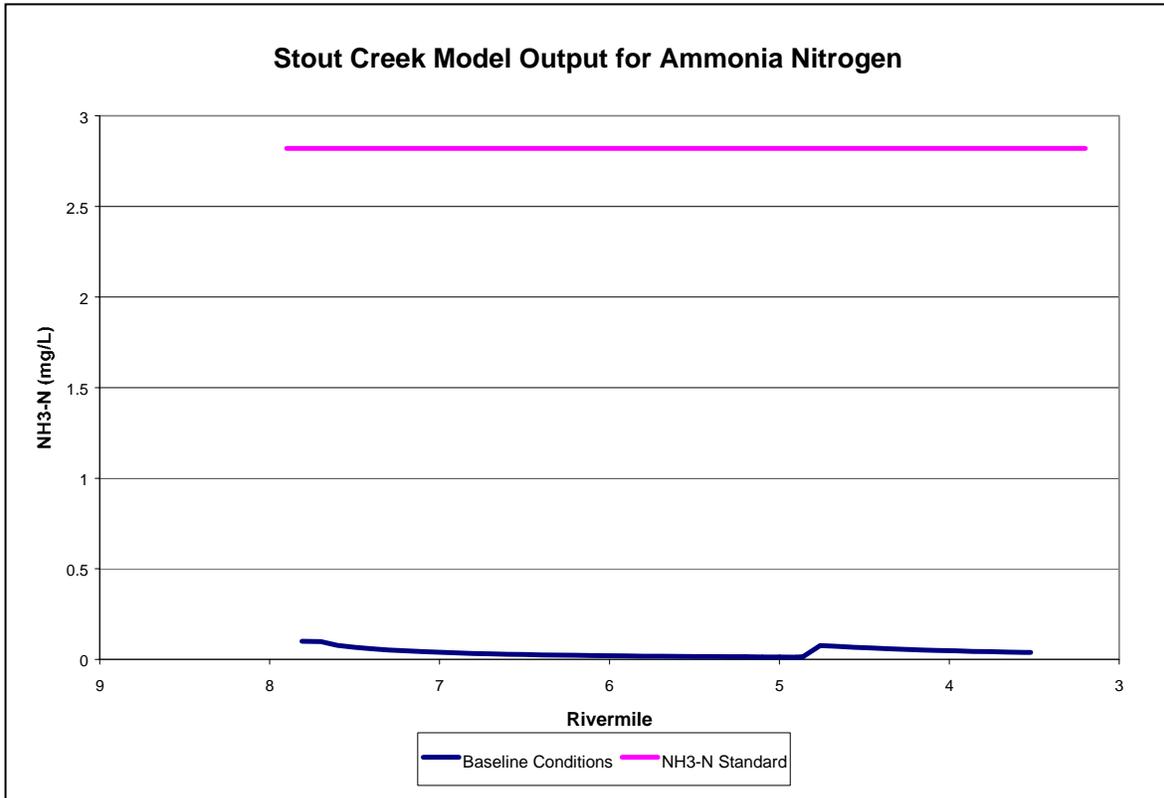


Figure 8. Baseline Model Output for NH₃-N in Stout Creek

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 Stout Creek during critical conditions. Thus, reductions from the baseline loads of TBOD_u are not necessary. Calculating maximum allowable load of TBOD_u 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 2.6 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 9.

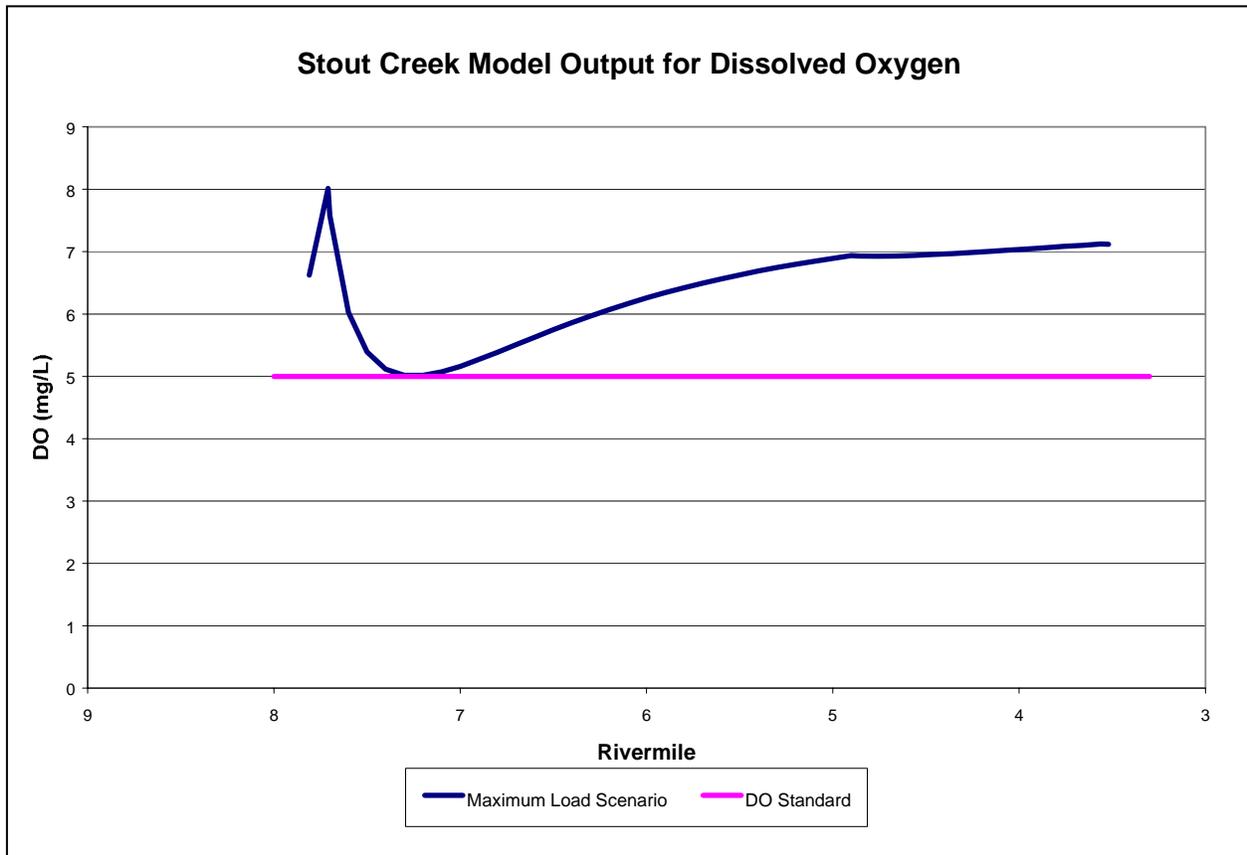


Figure 9. Model Output for DO in Stout Creek with Maximum Load

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 ($\text{NH}_3\text{-N}$) concentration at a pH of 7.0 and stream temperature of 26°C is 2.82 mg/l. Based on the model results from the maximum load scenario, Figure 10, this standard was not exceeded in Stout Creek.

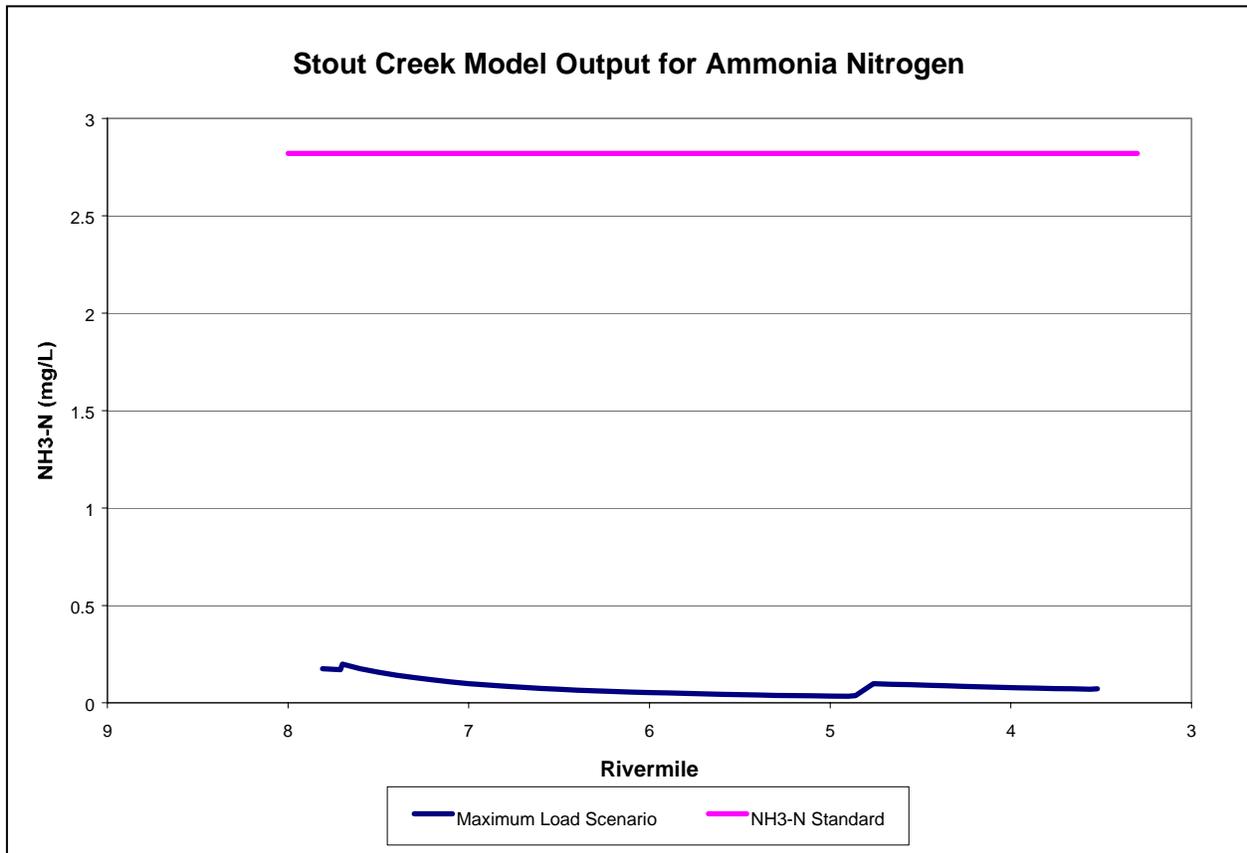


Figure 10. Model Output for Ammonia Nitrogen in Stout Creek with Maximum Load

3.6 Total Phosphorus Estimates

Due to the lack of total phosphorus data available for Stout Creek, the estimated existing total phosphorus concentration is based on the median total phosphorus concentrations measured in wadeable streams in Ecoregion 74 with impaired biology and elevated nutrients. For wadeable streams in Ecoregion 74, the estimated existing total phosphorus concentration from sites with impaired biology and elevated nutrients is 0.21 mg/l.

A mass balance approach was used only to get an initial estimate of the difference between point and non-point loads. To convert the estimated existing total phosphorous concentration to a total phosphorous load, the average annual flow for Stout Creek was estimated based on USGS monitoring data from Nonconnah Creek because a flow gage with an average annual flow was not available for the Stout Creek. The annual average flow for Nonconnah Creek near Germantown, Tennessee (07032200) is 113.9 cfs, with a drainage area of 68.20 square miles. To estimate the amount of flow in Stout Creek within the segment, a drainage area ratio was calculated ($113.9 \text{ cfs} / 68.2 \text{ square miles} = 1.67 \text{ cfs/square mile}$). The ratio was then multiplied by the drainage area of the modeled segment, 6.89 square miles ($1.67 \text{ cfs/square mile} * 6.89 \text{ square miles} = 11.5 \text{ cfs}$). Thus, the annual average flow in Stout Creek is estimated as 11.5 cfs (7.44 MGD).

The existing TP load was then calculated, using Equation 5 as shown below, to be 13.0 lbs/day. The existing total phosphorous load consists of both point and non-point components. Since

many treatment facilities in Mississippi do not have permit limits for phosphorous, nor are they currently required to report effluent phosphorous concentrations, MDEQ used an estimated effluent concentration based on literature values for different treatment types. Table 7 shows the median effluent phosphorus concentrations for four conventional treatment processes. The appropriate concentration the facility was then used in Equation 5 to estimate the total phosphorus load from point sources as shown in Table 8.

$$\text{TP Load (lb/day)} = \text{Flow (MGD)} * 8.34 \text{ (conversion factor)} * \text{TP Concentration (mg/L)} \quad (\text{Eq. 5})$$

Table 7. Median Phosphorous Concentrations in Wastewater Effluents

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

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

Table 8. 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)
Marshall County Schools, HW Byers HS	MS0034631	Aerated Lagoon	0.021	5.2	0.91
		Total	0.021		0.91

The average TP point source load is estimated to be 0.91 lbs/day. The annual average instream load based on the estimated existing total phosphorus concentration of 0.21 mg/L and an annual average flow of 7.44 MGD is 13.0 lbs/day. The point source load is 7% of the total load. Therefore, 93% of the estimated existing total load is from non-point sources.

The target annual total phosphorus concentration for this TMDL is 0.04 to 0.16 mg/L based on total phosphorus concentrations measured for non-impaired wadeable streams in Ecoregion 74. The existing concentration was assumed to be 0.21 mg/L based on total phosphorus concentrations measured for wadeable streams in Ecoregion 74 with impaired biology and elevated nutrients. This indicates that an estimated percent reduction of 24 to 81% of estimated instream total phosphorus is needed in Stout Creek to meet the target concentration for non-impaired wadeable streams in Ecoregion 74.

ALLOCATION

The allocation for this TMDL involves an allocation for point and non-point sources necessary for attainment of water quality standards in the Stout Creek. The allocations are given in terms of TBODu for this phase 1 TMDL. When water quality standards and additional information become available, future TMDLs may be developed for Stout Creek that address specific nutrient species.

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

4.1 Wasteload Allocation

There is currently one NPDES permit issued for the Stout Creek Watershed. Although this wasteload allocation is based on the current condition of Stout Creek, it is not intended to prevent the issuance of permits for future facilities. This is because the model results show that Stout Creek has additional assimilative capacity for organic material. Future permits will be considered on a case-by-case basis as long as they are within the maximum allowable load given in this TMDL. This TMDL recommends quarterly monitoring of nutrients for the NPDES facility. Tables 9 and 10 show the wasteload allocation for Stout Creek.

Table 9. Waste Load Allocation

Facility	Flow (MGD)	CBOD ₅ (mg/l)	NH ₃ -N (mg/L)	CBOD _u : CBOD ₅ Ratio	CBOD _u (lbs/day)	NH ₃ -N (lbs/day)	NBOD _u (lbs/day)	TBOD _u (lbs/day)
Marshall County Schools, HW Byers HS	0.021	30	2	1.5	7.76	0.35	1.58	9.34
					7.76	0.35	1.58	9.34

Table 10. TP Wasteload Allocation*

Facility	Existing Estimated TP Point Source Concentration (mg/l)	Permitted Discharge (MGD)	Existing Estimated TP Point Source Load (lbs/day)	Allocated Average TP Point Source Load (lbs/day)	Percent Reduction
Marshall County Schools, HW Byers HS	5.2	0.021	0.91	0.91	0
Total		0.021	0.91	0.91*	0

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

4.2 Load Allocation

The non-point source loads are included in the load allocation. The TBODu concentrations of these loads were determined by using an assumed CBODu concentration of 2.0 mg/L and an NH₃-N concentration of 0.1 mg/l. This TMDL does not require a reduction of the load allocation. In Table 11, 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 2.6.

Table 11. Load Allocation

Reach	CBODu (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
Reach 1 (RM 7.81 – 7.70)	9.04	1.38	10.42
Reach 2 (RM 7.70 – 4.86)	19.17	2.92	22.09
Reach 3 (RM 4.86 – 3.52)	0.76	0.12	0.88
	28.97	4.42	33.39

Based on initial estimates in Section 3.6, approximately 93% of the total phosphorus load in this watershed comes from non-point sources. Therefore, best management practices (BMPs) should be encouraged in the watershed to reduce potential total phosphorus loads from non-point sources. The Stout Creek 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 12 shows the load allocation for Total Phosphorus based on the estimates given in Section 3.6.

Table 12. Load Allocation for Estimated Total Phosphorus

Existing Estimated TP Nonpoint Source Load (lbs/day)	Allocated Average TP Nonpoint Source Load (lbs/day)	Percent Reduction
12.12	1.57 to 9.02*	26 to 87%

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 Stout Creek at the critical conditions. The maximum non-point source loads are the maximum TBODu loads with a 2.6 increase that allow maintenance of water quality standards. MDEQ has set the MOS as the difference in these loads. Table 13 shows the calculated MOS.

Table 13. Calculation of Explicit MOS

	Maximum Non-Point Load	Baseline Non-Point Load	Margin of Safety
CBODu (lbs/day)	28.97	11.14	17.83
NBODu (lbs/day)	4.42	1.69	2.73
TBODu (lbs/day)	33.39	12.83	20.56

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 6.

$$\text{TMDL} = \text{WLA} + \text{LA} + \text{MOS} \quad \text{(Equation 6)}$$

Where WLA is the wasteload allocation, LA is the load allocation (baseline LA for this report), 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 Stout Creek, according to the model. The TMDL calculations are shown in Tables 14 and 15. As shown in Table 14, TBODu is the sum of CBODu and NBODu. The wasteload allocations incorporate the CBODu and NH₃-N contributions from identified NPDES Permitted facilities. The load allocations include the background and non-point sources of TBODu and NH₃-N from surface runoff and groundwater infiltration. The implicit and explicit margin of safety for this TMDL are derived from the conservative assumptions used in setting up the model.

Table 14. Phase 1 TMDL for TBODu in the Stout Creek Watershed

	WLA (lbs/day)	Baseline LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
CBODu	7.76	11.14	17.83	36.73
NBODu	1.58	1.69	2.73	6.00
TBODu	9.34	12.83	20.56	42.73

Table 15. Phase 1, TMDL for TP* in Stout Creek Watershed

	WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
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TP	0.91*	1.57 to 9.02*	Implicit	2.48 to 9.93*
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* Due to the lack of nutrient water quality criteria these Phase 1 TMDL allocations are estimates based on literature assumptions and projected targets. The State of Mississippi is in the process of developing numeric nutrient criteria in accordance with an EPA approved work plan for nutrient criteria development. This TMDL recommends quarterly monitoring of nutrients for NPDES facility. MDEQ's calculations of the annual average load indicate that the majority of the estimated nutrient load is from non-point sources. Therefore, the State will focus on striving to attain the goal set by the LA portion of the TMDL.

The TMDL presented in this report represents the 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 Stout Creek 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 Stout Creek. Nutrients were addressed through an estimate of a preliminary total phosphorous concentration target range. 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.

Based on the estimated existing and target total phosphorus concentrations, this TMDL recommends a 24 to 81% reduction of the nutrient loads entering Stout Creek to meet the preliminary target range of 0.04 to 0.16 mg/l. Because, 93% of the existing total phosphorus load is estimated to be due to non-point sources, this recommended percent reduction should not impact current or future NPDES permits. However, it is recommended that the facility in this watershed perform quarterly monitoring. It is also recommended that the Stout Creek 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 Stout Creek. This will provide improved water quality for the support of aquatic life in the water body and will result in the attainment of the applicable water quality standards.

5.1 Additional 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 North Independent Basin, the Stout Creek Watershed may receive additional monitoring to identify any change in water quality.

5.2 Public Participation

This TMDL will be published for a 30-day public notice. During this time, the public will be notified by publication in the statewide newspaper. The public will be given an opportunity to review the TMDL and submit comments. MDEQ also distributes all TMDLs at the beginning of the public notice to those members of the public who have requested to be included on a TMDL mailing list. TMDL mailing list members may request to receive the TMDL reports through either, email or the postal service. Anyone wishing to become a member of the TMDL mailing list should contact Greg Jackson at (601) 961-5098 or Greg_Jackson@deq.state.ms.us.

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

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

make a decision on the necessity of holding a public hearing. If a public hearing is deemed appropriate, the public will be given a 30-day notice of the hearing to be held at a location near the watershed. That public hearing would be an official hearing of the Mississippi Commission on Environmental Quality, and would be transcribed.

REFERENCES

- MDEQ. 2003. Development and Application of the Mississippi Benthic Index of Stream Quality (M-BISQ). June 30, 2003. Prepared by Tetra Tech, Inc., Owings Mills, MD, for the Mississippi Department of Environmental Quality, Office of Pollution Control, Jackson, MS. *(for further information on this document, contact Randy Reed [601-961-5158])*
- MDEQ. 2002. *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. Office of Pollution Control.
- MDEQ. 1998. *Mississippi List of Water bodies, Pursuant to Section 303(d) of the Clean Water Act*. Office of Pollution Control.
- MDEQ. 1998. *Mississippi 1998 Water Quality Assessment, Pursuant to Section 305(b) of the Clean Water Act*. Office of Pollution Control.
- MDEQ. 1994. *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*. Office of Pollution Control.
- Metcalf and Eddy, Inc. 1991. *Wastewater Engineering: Treatment, Disposal, and Reuse 3rd ed.* New York: McGraw-Hill.
- Telis, Pamela A. 1992. *Techniques for Estimating 7-Day, 10-Year Low Flow Characteristics for Ungaged Sites on Streams in Mississippi*. U.S. Geological Survey, Water Resources Investigations Report 91-4130.
- USEPA. 1997. *Technical Guidance Manual for Developing Total Maximum Daily Loads, Book 2: Streams and Rivers, Part 1: Biochemical Oxygen Demand/Dissolved Oxygen and Nutrients/Eutrophication*. United States Environmental Protection Agency, Office of Water, Washington, D.C. EPA 823-B-97-002.

DEFINITIONS

5-Day Biochemical Oxygen Demand: Also called BOD₅, 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 (NH₃); 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 (NH₃-N)

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

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

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

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

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

Carbonaceous Biochemical Oxygen Demand: Also called CBOD_u, 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 NBOD_u, 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 CBOD_u exertion is the only source of DO deficit while reaeration is the only sink of DO deficit.

Total Ultimate Biochemical Oxygen Demand: Also called TBOD_u, 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
CBOD _u	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
NBOD _u	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

TBOD_u.....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