PROPOSED REPORT
November 2004

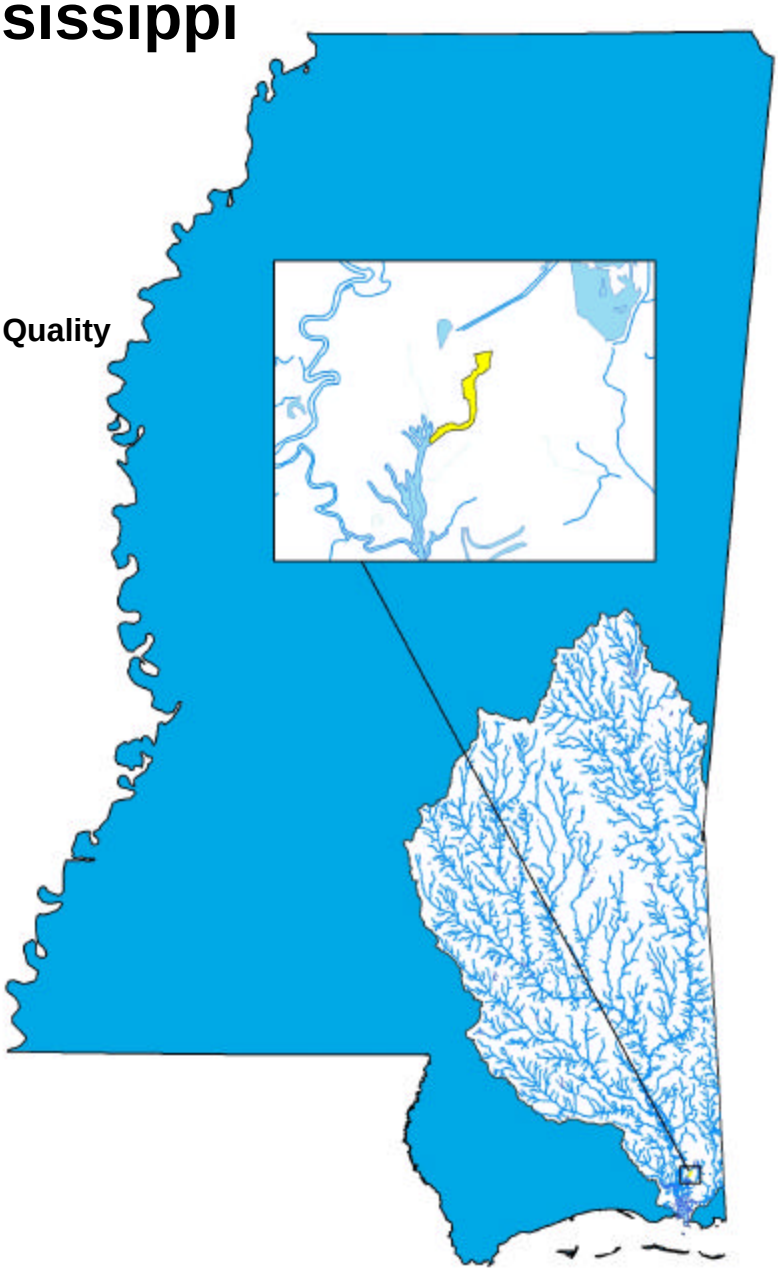
Total Maximum Daily Load

For Biological Impairment due to Organic Enrichment/Low DO

Unnamed Tributary to Clark Bayou

Pascagoula River Basin

Jackson County, Mississippi



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MISSISSIPPI DEPARTMENT OF
ENVIRONMENTAL QUALITY

FOREWORD

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

The amount and quality of the data on which this report is based 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.

Prefixes for fractions and multiples of SI units

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

Conversion Factors

To convert from	To	Multiply by	To convert from	To	Multiply by
$mile^2$	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

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TABLES

TMDL INFORMATION PAGE

i. Listing Information

Name	ID	County	HUC	Cause	Mon/Eval
Unnamed tributary to Clark Bayou	MS096E2	Jackson	03170006	Biological Impairment	E
Near Colltown: From Headwaters to Clark Bayou					

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

iii. Total Maximum Daily Load for TBODu

LA (lbs/day)	WLA[1] (lbs/day)	MOS	TMDL (lbs/day TBODu)
0.76	0.0	Implicit	0.76

[1]If a facility wants to obtain a permit for the unnamed tributary to Clark Bayou, this water body will be reevaluated to accommodate a loading so as not to violate the TMDL of 0.76 lbs/ day of TBODu.

EXECUTIVE SUMMARY

An unnamed tributary to Clark Bayou located in the Pascagoula River basin in Jackson County near Colltown has been placed on the Mississippi 2002 Section 303(d) List of Waterbodies as an evaluated water body segment for biological impairment. This TMDL will be prepared for biological impairment due to organic enrichment/low dissolved oxygen. The applicable state standard specifies that the Dissolved Oxygen (DO) concentration 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. Because elevated levels of nutrients may also cause low levels of dissolved oxygen, the TMDL developed for dissolved oxygen also addresses the potential impact of elevated nutrients in the unnamed tributary to Clark Bayou.

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 (CBODu) decay rate. A mass-balance approach was used to ensure that the instream concentration of ammonia nitrogen (NH_3-N) did not exceed the water quality criteria 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).

The model used in developing this TMDL included only nonpoint sources of total ultimate biochemical oxygen demand (TBODu) in the unnamed tributary to Clark Bayou Watershed. There are no NPDES permitted dischargers located in the watershed. The location of the watershed is shown in Figure 1. TBODu loading from nonpoint sources in the watershed was accounted for by using an estimated background concentration of TBODu in the stream. The load allocations developed for TBODu are less than the maximum assimilative capacity of the unnamed tributary to Clark Bayou, as indicated by predictive modeling. Thus, there is assimilative capacity for additional TBODu loading in this water body segment.

It is noted that MDEQ currently does not have recent data to determine if there is any impairment in the unnamed tributary to Clark Bayou. The limited data available was collected at a volunteer monitoring station from 1995 to 1997. According to the most recent data available (March 1997), the water body is stable. Although, MDEQ does not know if there is any impairment in the water body, 0.76 lbs/day of TBODu has been determined to be the maximum loading.

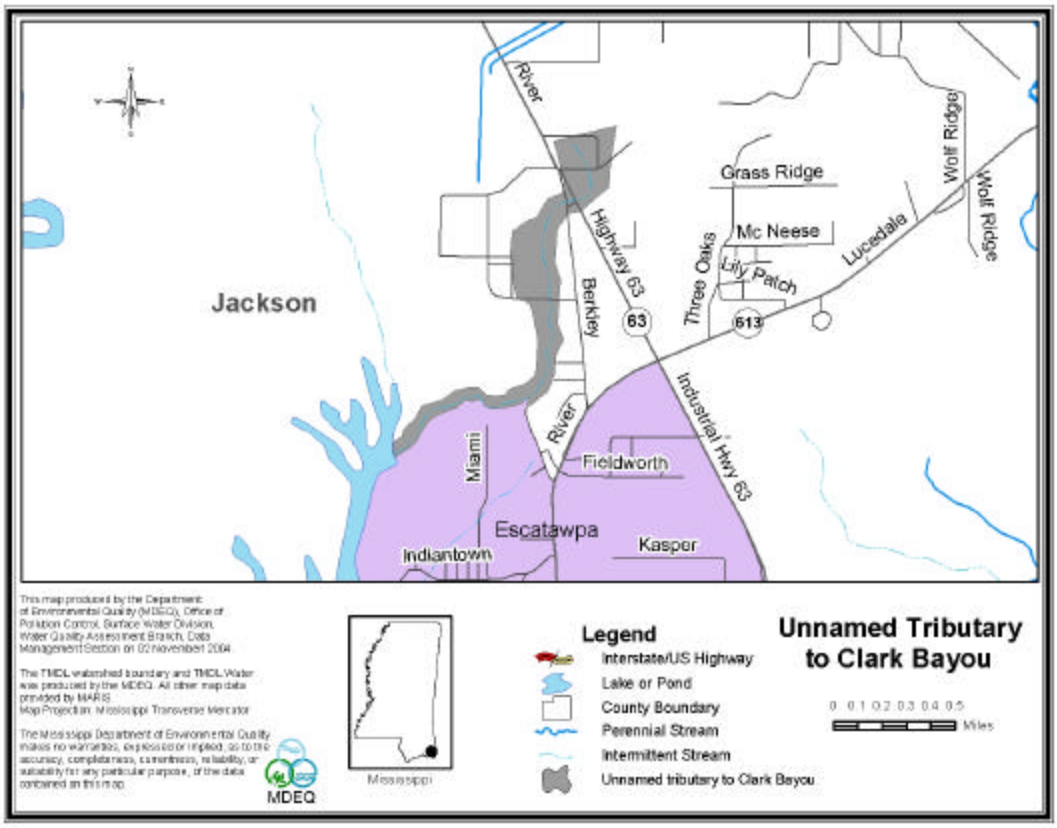


Figure 1. Unnamed Tributary to Clark Bayou Watershed

INTRODUCTION

1.1 Background

The identification of water bodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those water bodies are required by Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR part 130). The TMDL process is designed to restore and maintain the quality of those impaired water bodies through the establishment of pollutant specific allowable loads. The impairment is caused by reduced levels of dissolved oxygen (DO) in the bayou due to enrichment with nutrients and oxidation of organic material. Thus, this TMDL has been developed for biological impairment due to organic enrichment. This TMDL was developed for the 303(d) listed segment and watershed shown in Figure 2.

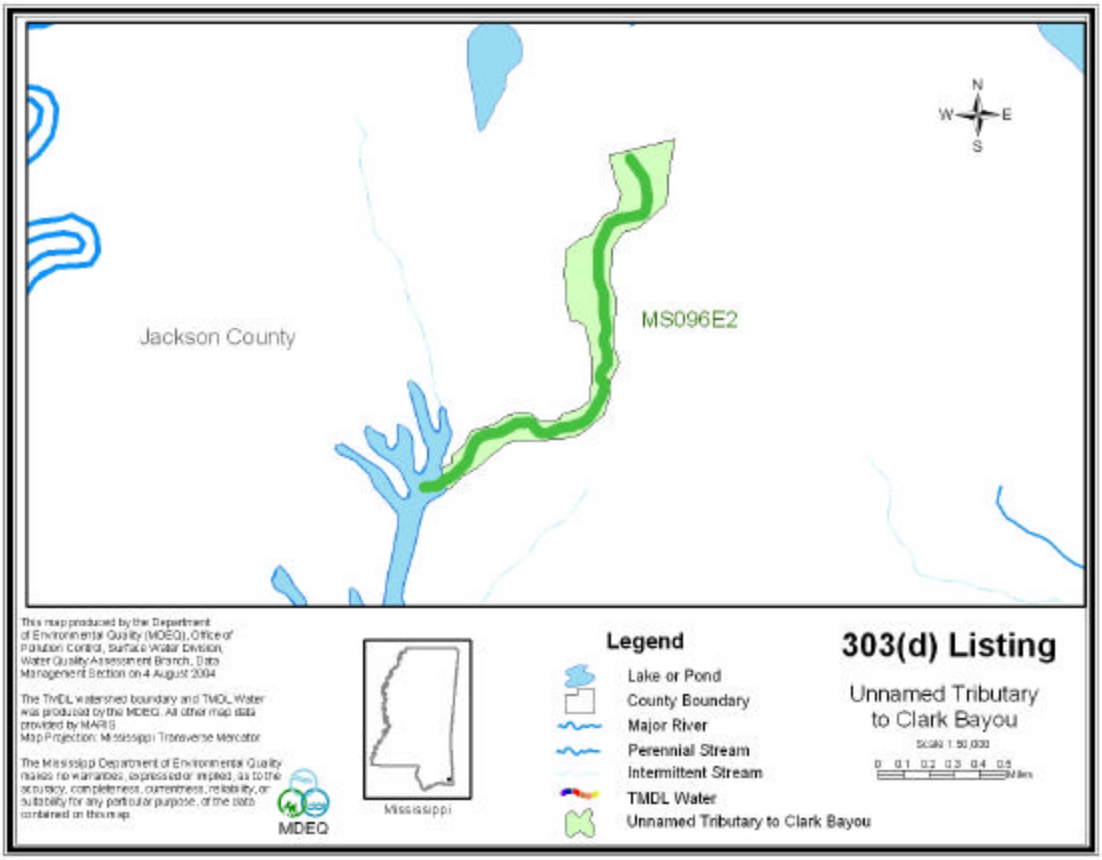


Figure 2. Unnamed Tributary to Clark Bayou Watershed 303(d) Listed Segment and Drainage Area

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.

TBODu = CBODu + NBODu **(Equation 1)**

1.2 Applicable Waterbody Segment Use

The water use classification for the listed segment of the unnamed tributary to Clark Bayou, as established by the State of Mississippi in the *Water Quality Criteria for Intrastate, Interstate and Coastal Waters* regulation, is Fish and Wildlife Support. The designated beneficial use for the unnamed tributary to Clark Bayou is Aquatic Life Support.

1.3 Applicable Waterbody 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*. The applicable standard specifies that the DO concentrations shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l. The 5.0 mg/l water quality standard will be used as targeted endpoints to evaluate and establish this TMDL.

1.4 Selection of a TMDL Endpoint and Critical Condition

One of the major components of a TMDL is the establishment of instream numeric endpoints, which are used to evaluate the attainment of acceptable water quality. Instream numeric endpoints, therefore, represent the water quality goals that are to be achieved by 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 is sufficiently protective of the instantaneous minimum standard.

Low DO typically occurs during seasonal low-flow periods of 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 low-flow, high-temperature period is referred to as the critical condition. The maximum impact of oxidation of organic material is generally not at the location of the point source discharge, but at some distance downstream, where the maximum DO deficit occurs. The DO deficit is defined as the difference between the DO concentration at 100% saturation and the actual DO. The endpoint for this TMDL will be based on a daily average of not less than 5.0 mg/l DO within the 303(d) listed segment during critical conditions in the unnamed tributary to Clark Bayou.

WATERBODY ASSESSMENT

This TMDL Report includes an analysis of available water quality data and the identification of all known potential pollutant sources in the unnamed tributary to Clark Bayou watershed. The potential nonpoint pollutant sources were characterized by the best available information and literature values. This section documents the available information for the unnamed tributary to Clark Bayou.

2.1 Discussion of Instream Water Quality Data

The State's Section 305(b) Water Quality Assessment Reports were reviewed to assess water quality conditions and data available for the watershed. Limited water quality data are available for the unnamed tributary to Clark Bayou. According to the 1998 report, the unnamed tributary to Clark Bayou is not supporting for the use of aquatic life support. These conclusions were based on volunteer monitoring data collected at station V/MB003V10-CB1. This monitoring station was part of MDEQ's Adopt-A-Stream program and was located near Colltown. The data from this station are given in Table 1. The data were collected between January 1995 and March 1997.

Table 1. Water Quality Data for Unnamed Tributary to Clark Bayou, MDEQ Station V/MB003V10-CB1

Sample Month	Sample Year	Water Temperature ºC	Dissolved Oxygen (mg/L)	Macroinvertebrate Data
January	1995	14.4	8.00	Good
February	1995	13.3	-	-
March	1995	19.4	7.50	-
April	1995	22	4.80	-
June	1995	25	2.00	-
July	1995	30	2.75	Fair
October	1995	27	3.20	-
November	1995	13	6.20	Good
December	1995	6	9.30	-
January	1996	17	7.30	-
April	1996	18	7.90	Good
May	1996	27	8.35	-
August	1996	32	5.9	-
October	1996	23.5	6.4	Good
March	1997	20	6.7	Excellent

Assessments of these data are no longer possible because the 2002 CALM requirements are not met. This TMDL was completed based on the historical evaluated listings of this segment based on limited data. It is noted that in 1998, the evaluated causes (siltation, organic enrichment/low DO, and other habitat alterations) were replaced with biological impairment (BI). Based on the limited data available, it has been determined that organic enrichment/ low DO was the cause of impairment in the stream.

The DO data given in Table 1 were further analyzed to determine when excursions of the DO standard are most likely to occur. An analysis of this type will determine the environmental conditions and pollutant sources that have the largest impact on the water body. Because the DO data given in these tables are instantaneous measurements, they were compared to the instantaneous portion of the standard. Figure 3 shows a plot of the measured DO compared to the water temperature. The points on the figure represent all of the data that were collected at station V/MB003V10-CB1. The line on the figure is at 4.0 mg/l DO, the instantaneous portion of the standard. As shown in the figure, all of the DO excursions occur during warmer periods, when water temperatures are greater than 20°C.

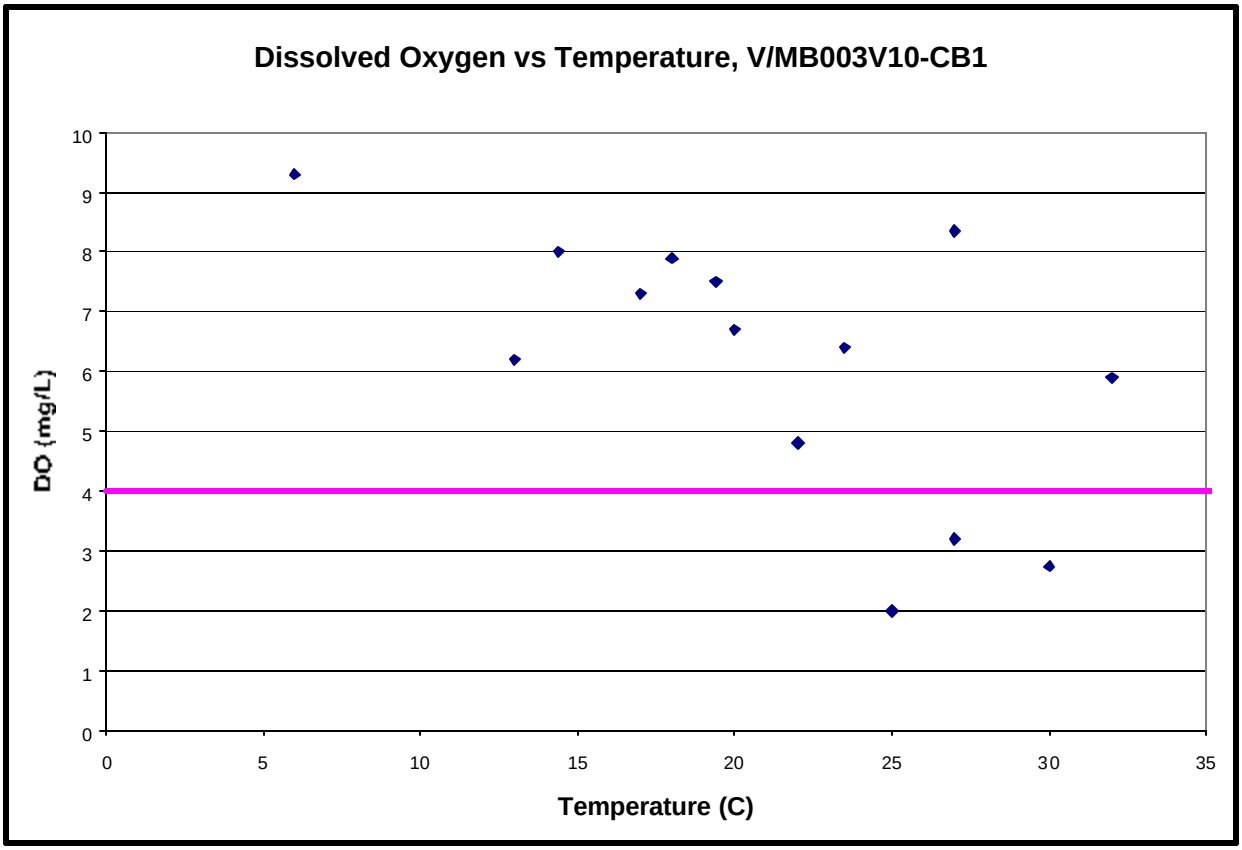


Figure 3. DO Data Compared to Temperature Data

The DO measurements were also compared to the month in which they were collected in order to look for seasonal trends, Figure 4. This figure shows that majority of the DO excursions occur during the months of May through October. These months are the summer months in Mississippi, in which temperatures are elevated and lower flows are expected.

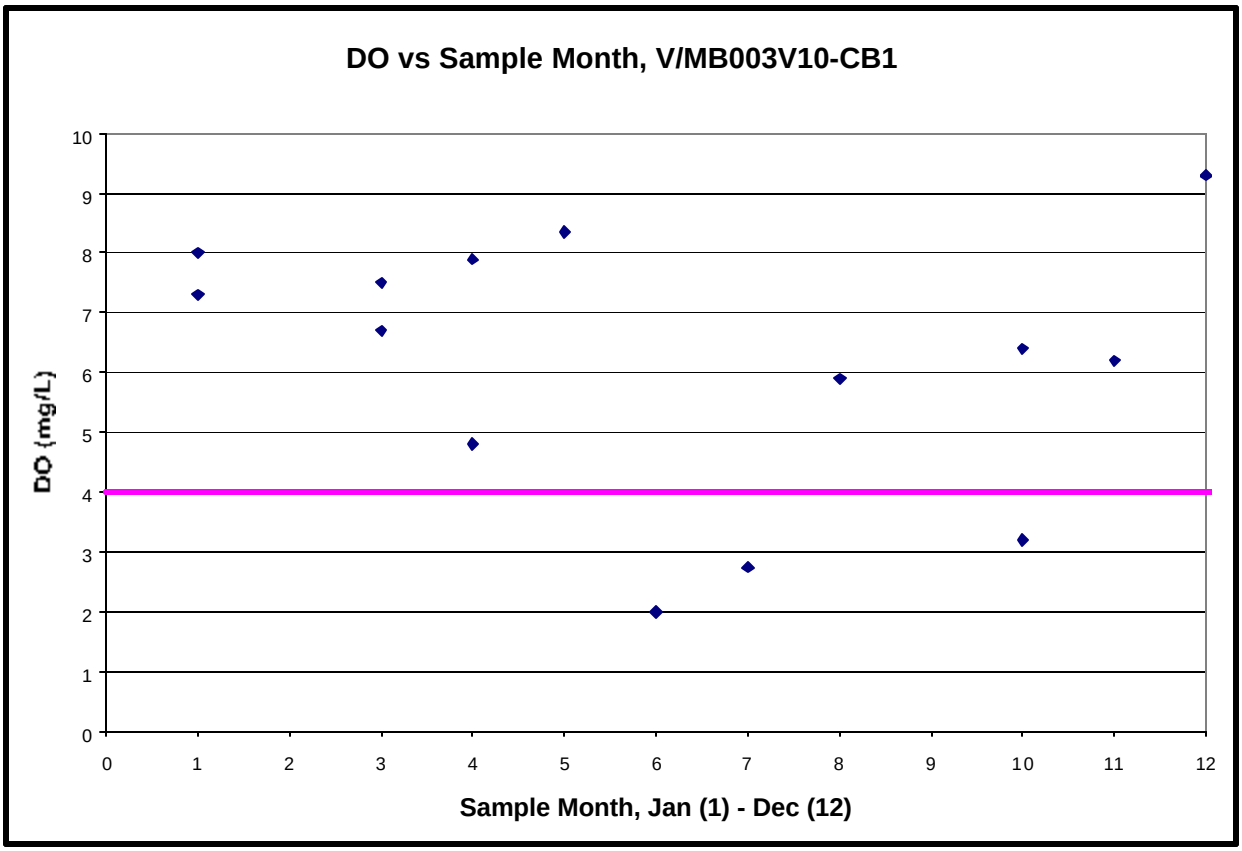


Figure 4. DO Data Compared to Sample Month

2.2 Assessment of Point Sources

There are no point source dischargers in this watershed.

2.3 Assessment of Nonpoint Sources

The 147-acre drainage area of the unnamed tributary to Clark Bayou contains several different landuse types, including urban, forest, pasture, disturbed, water, and wetlands. The landuse information 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. Wetlands, forest and pasture are the dominant landuse within this watershed. The landuse distribution within the unnamed tributary to Clark Bayou Watershed is shown in Table 2 and Figure 5.

Table 2. Landuse Distribution

	Urban	Forest	Pasture	Disturbed	Wetlands	Water	Total
Area (acres)	8.23	35.8	35.3	21.6	36.5	10.0	147.43
% Area	6%	24%	24%	15%	25%	7%	100%

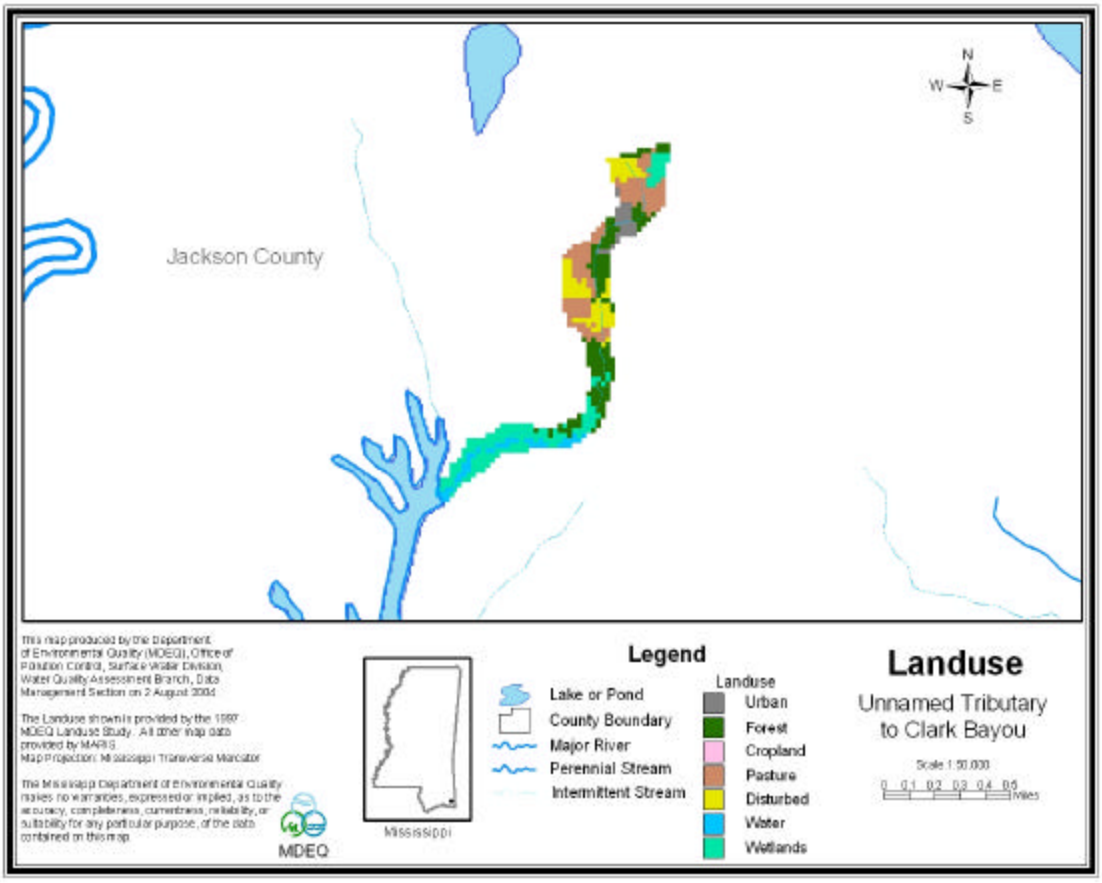


Figure 5. Landuse Distribution Map for Unnamed Tributary to Clark Bayou Watershed

Nonpoint loading of TBODu in a water body results primarily from the transport of the pollutants into receiving waters by overland surface runoff, groundwater infiltration, atmospheric deposition, and natural weathering of rocks and soil. Sources of organic material which could deplete DO levels during this time period would include discharges from failing septic systems, which have their maximum impact during low-flow conditions since dilution would be at a minimum, intermittent sources such as pollutants carried to the water body during rainfall and runoff events, and particularly the presence of wetlands. Because wetlands are a significant landuse in the watershed, DO violations may have occurred during the "die-out" stage of the algae. When large amounts of algae die, aerobic bacteria must utilize massive amounts of dissolved oxygen during decomposition, which consequently causes DO levels to drop. Because the limited monitoring data available does not discuss wetland conditions of the area, it is not known whether the wetlands are the cause of impairment in the 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, named STREAM, previously known as AWFWUL1, for DO distribution in freshwater streams was used for developing the TMDL. This model has been approved by EPA and has been used extensively by 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 nonpoint source loadings.

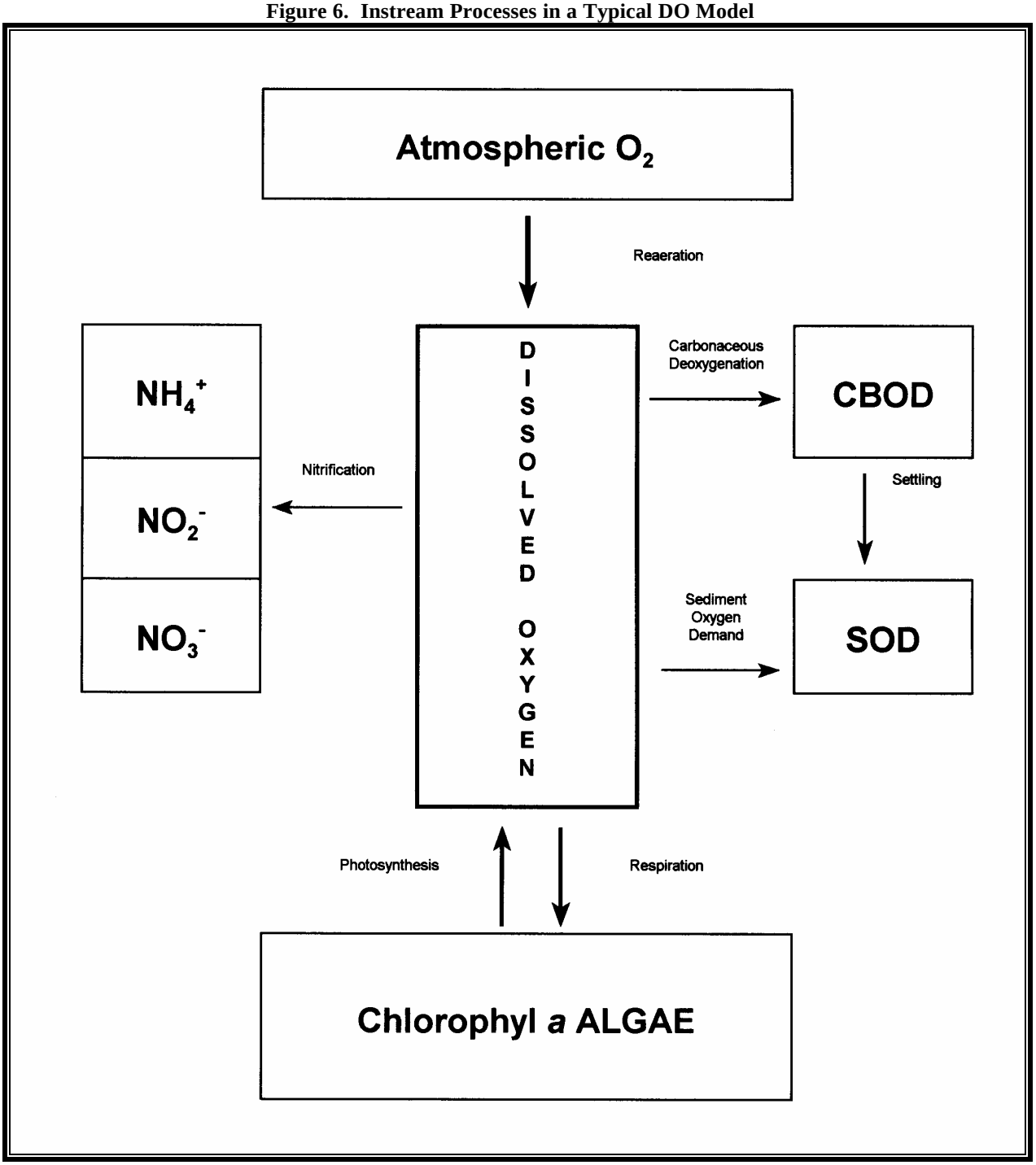
The model is a steady-state, daily average computer model that utilizes a modified Streeter-Phelps DO sag equation. Instream processes simulated by the model include CBODu decay, nitrification, reaeration, sediment oxygen demand, and respiration and photosynthesis of algae. Figure 6 shows how these processes 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 due to the small size of the water body. The Tsivoglou formula calculates reaeration (Ka) within each reach according to Equation 2.

$$Ka = CSU \qquad \textbf{(Equation 2)}$$

S is the slope in ft/mile, U is the reach velocity in mile/day, and C is the escape coefficient, which is 0.11 for reaches with flow less than 10 cfs and 0.0597 for reaches with flow greater than 10 cfs and less than 280 cfs. The slope of each reach was estimated from USGS quad maps and input into the model in units of feet/mile.

Figure 6. Instream Processes in a Typical DO Model

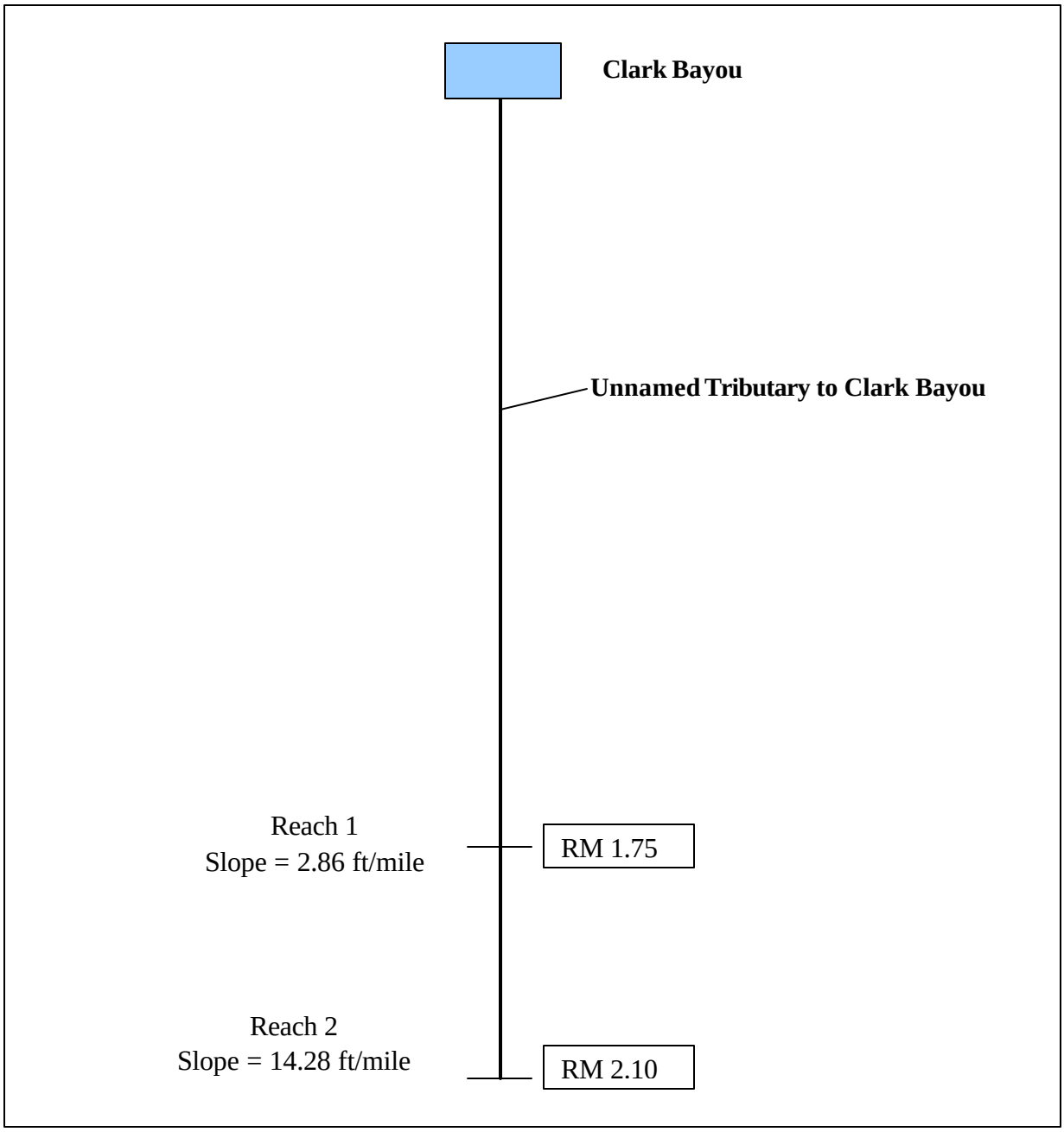


3.2 Model Setup

The modeled water body was divided into reaches for input into the STREAM model. Reach divisions were made at any major change in the hydrology of the water body such as the significant change in slope. The watershed was modeled according to the diagram shown in Figure 7. The numbers on the figure represent river miles (RM). River miles are assigned to water bodies, beginning with zero at the mouth. The slope of each reach was estimated from USGS quad maps and input into the model in units of feet/mile. Within each reach, the modeled

segments were divided into computational elements of 0.1 mile. The hydrological and water quality characteristics are calculated and output by the model for each computational element.

Figure 7. Unnamed Tributary to Clark Bayou Model Setup (Note: Figure not to Scale)



The model was setup to simulate low-flow, high-temperature conditions, which was determined to be the critical condition for this TMDL. 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 is dependent on temperature, according to Equation 3.

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

Where Kd 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). According to the requirements in this document, the SOD, photosynthesis, and respiration rates were set to zero due to lack of field measurements of these parameters.

3.3 Source Representation

Only nonpoint sources were represented in the model. Spatially distributed loads, which represent nonpoint sources of flow, CBODu, and ammonia nitrogen were distributed evenly into each computational element of the unnamed tributary to Clark Bayou.

Direct measurements of nonpoint source loads of CBODu and NH_3-N were not available for the unnamed tributary to Clark Bayou Watershed. The background contributions of CBODu and total ammonia as nitrogen (NH_3–N) were estimated based on *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). According to these regulations, the background concentrations used in modeling are CBODu = 2.0 mg/l and NH_3-N = 0.1 mg/l.

Due to the lack of data, the nonpoint source flows in the unnamed tributary to Clark Bayou were also estimated. For the unnamed tributary to Clark Bayou watershed, the 7Q10 flow was calculated accordingly.

7Q10 Flow (cfs) = Drainage Area of unnamed tributary to Clark Bayou (square miles)*Unit 7Q10 (cfs/square miles)

7Q10 Flow in the unnamed tributary to Clark Bayou = 0.23 (square miles) * 0.1 (cfs/square miles) = **0.023 cfs**

The unit 7Q10 was determined from a map included in *Techniques for Estimating 7-Day, 10-Year Low Flow Characteristics for Ungaged Sites on Streams in Mississippi* (Telis, 1992).

After determining the 7Q10 flow of the unnamed tributary to Clark Bayou Watershed, the amount of water draining into each modeled reach during low-flow conditions was estimated. The estimated flows were multiplied by the background concentrations of CBODu and NH_3-N to calculate the nonpoint source loads in the model. The nonpoint source loads as input into the model are given in Table 3. It was assumed that the nonpoint source loads were evenly distributed within each reach.

Table 3. Nonpoint Source Loads as Input into the Model

Reach	Flow (cfs)	CBODu (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
1	0.019	0.20	0.05	0.25
2	0.004	0.04	0.01	0.05
Total	**0.023**	**0.24**	**0.06**	**0.30**

3.4 Model Calibration

The model used to develop the unnamed tributary to Clark Bayou TMDL was not calibrated due to the lack of instream monitoring data collected during critical conditions. If additional data are collected in the unnamed tributary to Clark Bayou during the critical condition period, these data will be used to calibrate the model. If the calibrated model is significantly different, a Phase 2 TMDL will be developed to reflect the updated model results.

3.5 Model Results

The model was used to predict water quality conditions in the unnamed tributary to Clark Bayou. The model was first run under baseline conditions. Under baseline conditions, nonpoint source loads were modeled according to the loads given in Table 3. Thus, baseline model runs reflect the current condition of the unnamed tributary to Clark Bayou without any reduction of the estimated TBODu loads. 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.

3.5.1 Baseline Model Runs

The model results from the baseline model run are shown in Figure 8. Figure 8 shows the daily average instream DO concentrations in the unnamed tributary to Clark Bayou under existing summer conditions, beginning with rivermile 2.10 and ending with rivermile 0.0 (at the confluence with Clark Bayou). The red line represents the DO standard of 5.0 mg/l.

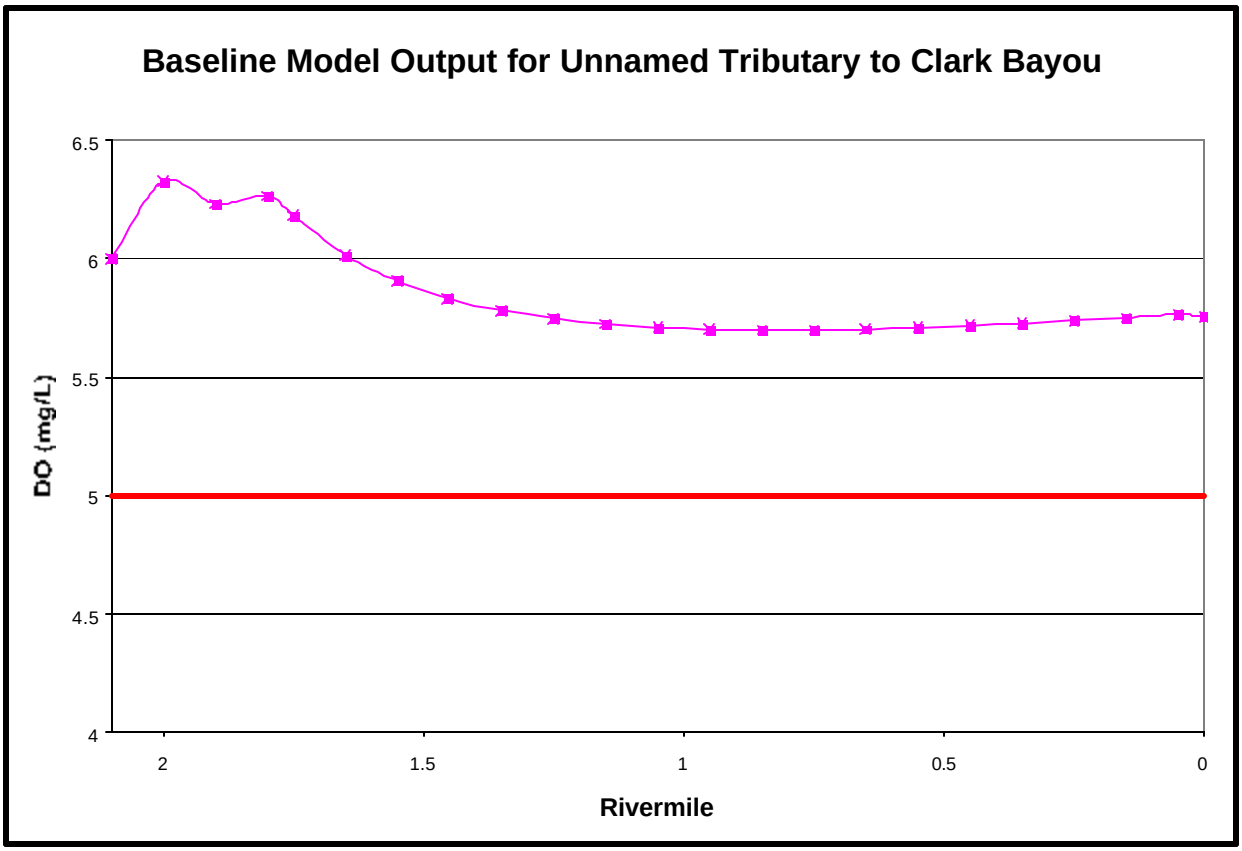


Figure 8. Baseline Model Output for Unnamed Tributary to Clark Bayou

3.5.2 Maximum Load Scenarios

The graph of the baseline model output shows that the predicted DO does not fall below the DO standard in the unnamed tributary to Clark Bayou during critical conditions. Thus, reductions from the baseline loads of TBODu are not necessary.

Calculating the TMDL involved increasing the nonpoint loads and running the model using a trial-and-error process until the modeled DO was just above 5.0 mg/l. The model run included increasing the nonpoint source loads by a factor of 2.5, which resulted in a TMDL of 0.76 lbs/day of TBODu.

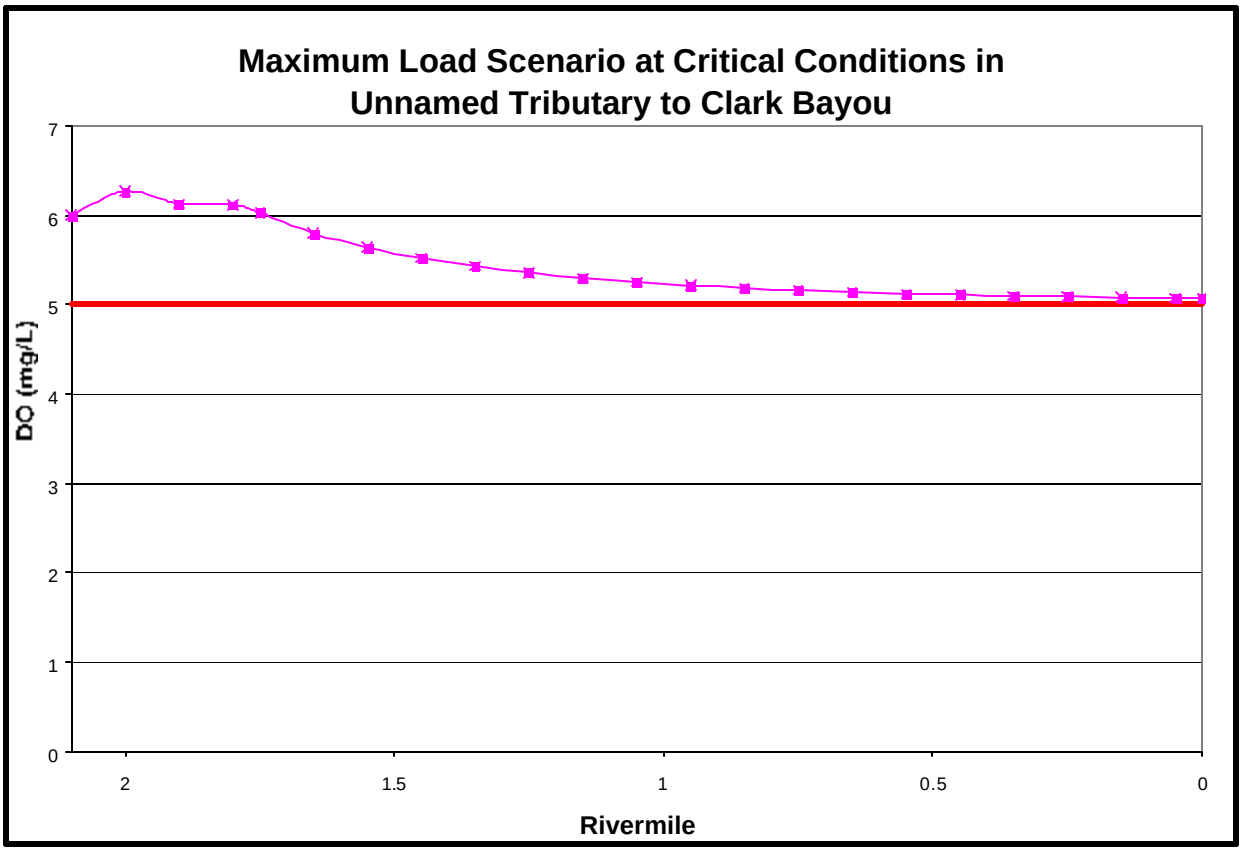


Figure 9. Model Output for Unnamed Tributary to Clark Bayou after Application of Maximum Load Scenario

Table 4. Maximum Load Scenario at Critical Conditions (Nonpoint sources only)

Reach	Flow (cfs)	CBODu (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
1	0.019	0.51	0.12	0.63
2	0.004	0.11	0.02	0.13
Total	**0.023**	**0.62**	**0.14**	**0.76**

3.6 Evaluation of Ammonia Toxicity

Ammonia must not only be considered due to its effect on dissolved oxygen in the receiving water, but also its toxicity potential. Ammonia nitrogen concentrations can be evaluated using the criteria given in 1999 Update of Ambient Water Quality Criteria for Ammonia (EPA-822-R-99-014). The maximum allowable instream ammonia nitrogen (NH_3-N) concentration at a pH of 7.0 and stream temperature of 26°C is 2.82 mg/l. Based on the model results, this criteria was not exceeded in the unnamed tributary to Clark Bayou under the current NH_3-N loads.

ALLOCATION

The allocation for this TMDL involves a load allocation for nonpoint sources necessary for attainment of water quality standards in segment MS096E2.

4.1 Load Allocation

The headwater and spatially distributed loads are included in the load allocation. The TBODu concentrations of these loads were determined by using an assumed $CBOD_5$ concentration of 1.33 mg/l and an NH_3-N concentration of 0.1 mg/l. These concentrations should be assumed when reliable field data are not available, according to *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). The spatially distributed flows were calculated for the unnamed tributary to Clark Bayou Watershed based on the 7Q10 flow for the watershed and the watershed size. The load allocations were calculated to determine the CBODu and NBODu loads in lbs/day. The LA in Table 5 consists of the estimated loads multiplied by a factor of 2.5.

Table 5. Load Allocations

Reach	Flow (cfs)	CBODu (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
1	0.019	0.51	0.12	0.63
2	0.004	0.11	0.02	0.13
Total	**0.023**	**0.62**	**0.14**	**0.76**

4.2 Seasonality

Seasonal variation may be addressed in the TMDL by using seasonal water quality standards or developing model runs 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. The unnamed tributary to Clark Bayou TMDL 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.

4.3 Incorporation of a Margin of Safety

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

Conservative assumptions, which place a higher demand of DO on the water body than may actually be present, are considered part of the margin of safety. The assumption that all of the ammonia nitrogen present in the water body is oxidized to nitrate nitrogen, for example, is a conservative assumption. In addition, the TMDL is based on the critical condition of the water

body, which is represented by the low flow. The low flow for the unnamed tributary to Clark Bayou is very small. Therefore, modeling the water body at this flow provides protection in the worst-case scenario.

4.4 Calculation of the TMDL

The TMDL was calculated based on Equation 5.

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

Where WLA is the wasteload allocation, LA is the load allocation, and MOS is the margin of safety. All units are in lbs/day of TBODu. The TMDL for TBODu was calculated based on the maximum allowable loading of the pollutants in unnamed tributary to Clark Bayou to the model. The TMDL calculations are shown in Table 6. As shown in the table, TBODu is the sum of CBODu and NBODu. The wasteload allocation incorporated into this TMDL is zero because there are no NPDES facilities. The implicit margin of safety for this TMDL is derived from the conservative assumptions used in setting up the model.

Table 6. TMDL for TBODu, for Critical Conditions in Unnamed Tributary to Clark Bayou

	LA (lbs/day)	WLA* (lbs/day)	MOS	TMDL (lbs/day)
CBODu	0.14	0.0	Implicit	**0.14**
NBODu	0.62	0.0	Implicit	**0.62**
TBODu	**0.76**	**0.0**	**Implicit**	**0.76**

* If a facility wants to obtain a permit for the unnamed tributary to Clark Bayou, this water body will be reevaluated to accommodate a loading so as not to violate the TMDL of 0.76 lbs/ day of TBODu.

CONCLUSION

MDEQ currently does not have sufficient data to determine if there is any impairment in the unnamed tributary to Clark Bayou. The DO violations shown at station V/MB003V10-CB1 occurred in 1995. Nonetheless, the data available from 1996 through 1997 indicate the DO level was better than water quality standards. Additionally, the 1996 and 1997 data regarding macro invertebrates indicate that the biology for the water body was good or excellent for those years, respectively. Although, MDEQ does not know if there is any impairment in the water body, 0.76 lbs/day of TBODu has been determined to be the maximum loading. Currently, the entire load has been allocated towards nonpoint sources; however, if a facility wants to obtain a permit to discharge into the unnamed tributary to Clark Bayou, the water body will be reevaluated at that time to allow discharging without violating the TMDL of 0.76 lbs/day of TBODu.

5.1 Future Monitoring

MDEQ has adopted the Basin Approach to Water Quality Management, a plan that divides Mississippi's major drainage basins into five groups. During each year-long cycle, MDEQ's resources for water quality monitoring will be focused on one of the basin groups. During the next monitoring phase in the Pascagoula River Basin, the unnamed tributary to Clark Bayou may receive additional monitoring to identify any change in water quality. The additional monitoring may allow confirmation of the assumptions used in the model used for calculating the TMDL. If the additional data show that the assumptions used were not accurate, the model as well as the TMDL will be updated as a Phase 2 Report.

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 and a newspaper in the area of the watershed. The public will be given an opportunity to review the TMDL and submit comments. MDEQ also distributes all TMDLs prior to the beginning of the public notice to those members of the public who have requested to be included on a TMDL email list. Anyone wishing to be included on the TMDL email list should contact Greg Jackson at (601) 961-5098 or Greg_Jackson@deq.state.ms.us. 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 meeting. All written comments received during the public notice period and at any public meeting become a part of the record of this TMDL. All comments will be considered in the ultimate completion of this TMDL for submission of this TMDL to EPA Region 4 for final approval.

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DEFINITIONS

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

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

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

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

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

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

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

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

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

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

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

Calibrated Model: A model in which reaction rates and inputs are significantly based on actual measurements using data from surveys on the receiving waterbody.

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 waterbody 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 waterbody 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 waterbody 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 Waterbody: Any waterbody that does not attain water quality standards due to an individual pollutant, multiple pollutants, pollution, or an unknown cause of impairment.

Land Surface Runoff: Water that flows into the receiving stream after application by rainfall or irrigation. It is a transport method for nonpoint source pollution from the land surface to the receiving stream.

Load Allocation (LA): The portion of a receiving water's loading capacity attributed to or assigned to nonpoint 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.

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

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

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

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

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

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

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

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

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

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

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

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

Storm Runoff: Rainfall that does not evaporate or infiltrate the ground because of impervious land surfaces or a soil infiltration rate than rainfall intensity, but instead flows into adjacent land or waterbodies 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 waterbody downstream of a point source discharge. The equation assumes that the stream flow is constant and that CBODu exertion is the only source of DO deficit while reaeration is the only sink of DO deficit.

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

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

Total Maximum Daily Load or TMDL: The calculated maximum permissible pollutant loading to a waterbody 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

BASINS .....Better Assessment Science Integrating Point and Nonpoint Sources

BMP .....Best Management Practice

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

CBODu.....Carbonaceous Ultimate Biochemical Oxygen Demand

CWA .....Clean Water Act

DMR.....Discharge Monitoring Report

DO .....Dissolved Oxygen

EPA .....Environmental Protection Agency

GIS ..... Geographic Information System

HUC .....Hydrologic Unit Code

LA .....Load Allocation

MARIS .....Mississippi Automated Resource Information System

MDEQ.....Mississippi Department of Environmental Quality

MGD .....Million Gallons per Day

MOS.....Margin of Safety

NBODu .....Nitrogenous Ultimate Biochemical Oxygen Demand

NH_3..... Total Ammonia

NH_3-N .....Total Ammonia as Nitrogen

NO_2+ NO_3..... Nitrite Plus Nitrate

NPDES .....National Pollution Discharge Elimination System

RBA .....Rapid Biological Assessment

$TBOD_5$ .....5-Day Total Biochemical Oxygen Demand

TBODu.....Total Ultimate Biochemical Oxygen Demand

TKN ..... Total Kjeldahl Nitrogen

TN .....Total Nitrogen

TOC.....Total Organic Carbon

TP .....Total Phosphorous

USGS .....United States Geological Survey

WLA.....Waste Load Allocation

WWTP ..... Wastewater Treatment Plant