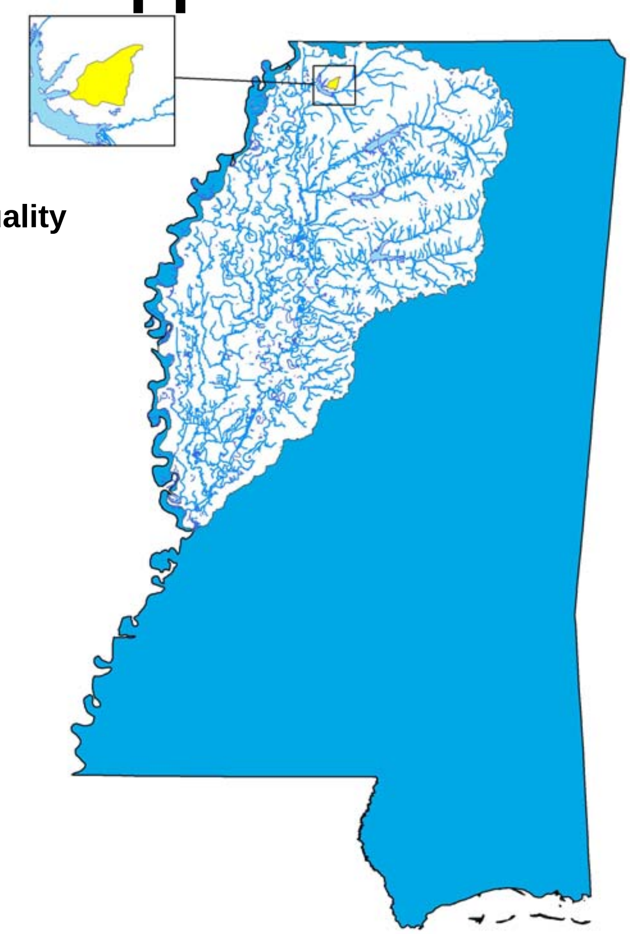
PROPOSED REPORT
April 2008

Total Maximum Daily Load
For
Nutrients and Organic Enrichment / Low Dissolved Oxygen
For
Cane Creek

Yazoo River Basin
DeSoto County, Mississippi



Prepared By

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

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

Mississippi Department of
Environmental Quality

FOREWORD

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

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

Conversion Factors

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

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

TABLE OF CONTENTS

FIGURES

TABLES

TMDL INFORMATION PAGE

Table 1. Listing Information

Name	ID	County	HUC	Impaired Use	Causes
Cane Creek	MS306E	DeSoto	08030204	Aquatic Life Support	Nutrients and Organic Enrichment / Low Dissolved Oxygen
Near Pleasant Hill from headwaters to Arkabutla Flood Pool					

Table 2. Water Quality Standards

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

Table 3. Total Maximum Daily Load for Cane Creek

	WLA lbs/day	LA lbs/day	MOS	TMDL lbs/day
TBODu	3.79	62.6	54.15	120.54
Total Nitrogen	0.68	57.6-115.9	Implicit	58.3-116.6
Total Phosphorous	0.28	3.88-16.38	Implicit	4.16-16.6

Table 4. Identified NPDES Permitted Facilities

Name	NPDES Permit	Permitted Discharge (MGD)	Receiving Water
Shadyview Trailer Park	MS0021822	0.006	Cane Creek

EXECUTIVE SUMMARY

This TMDL has been developed for Cane Creek which was placed on the Mississippi 1996 Section 303(d) List of Impaired Water Bodies due to evaluated causes of pesticides, siltation, nutrients, organic enrichment/low dissolved oxygen, and pathogens. Separate TMDLs will be done for the pesticides and siltation causes. This TMDL addresses organic enrichment/low DO and nutrients and will provide an estimate of the total nitrogen (TN) and total phosphorus (TP) in the stream.

Mississippi does not have numeric criteria in its water quality standards for allowable nutrient concentrations. MDEQ currently has a Nutrient Task Force (NTF) working on the development of criteria for nutrients. An annual concentration range of 0.56 to 1.12 mg/l is an applicable target for TN and 0.04 to 0.16 mg/l for TP for water bodies located in Ecoregion 74. MDEQ is presenting these ranges as preliminary target values for TMDL development which is subject to revision after the development of numeric nutrient criteria.

The Cane Creek Watershed is located in HUC 08030204. Cane Creek begins near Pleasant Hill and flows southwest from its headwaters to the Arkabutla Lake Flood Pool. The location of the watershed for the listed segment is shown in Figure 1.

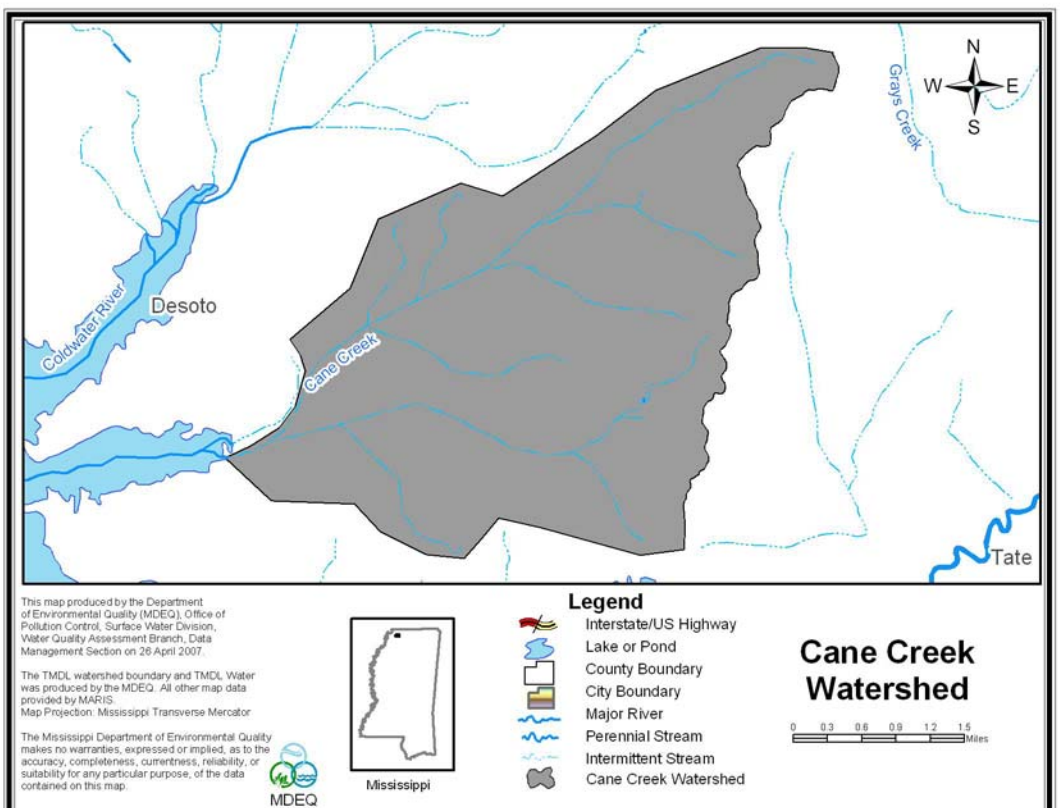


Figure 1. Cane Creek

The predictive model used to calculate the dissolved oxygen TMDL is based primarily on assumptions described in MDEQ Regulations. A modified Streeter-Phelps dissolved oxygen sag model was selected as the modeling framework for developing the TMDL allocations. The critical modeling period occurs during the hot, dry summer period. The TMDL for organic enrichment was quantified in terms of total ultimate biochemical oxygen demand (TBODu). The model used in developing this TMDL included both non-point and point sources of TBODu in the Cane Creek Watershed. TBODu loading from background and non-point sources in the watershed was accounted for by using an estimated concentration of TBODu and flows based on 7Q10 conditions. There is one NPDES permitted discharger located in the watershed that is included as a point source in the model.

According to the model, the current TBODu load in the water body does not exceed the assimilative capacity of Cane Creek for organic material. Therefore, no reductions in the current permitted loads of organic material are needed for this TMDL report in order to meet water quality limits.

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

INTRODUCTION

1.1 Background

The identification of water bodies not meeting their designated use and the development of total maximum daily loads (TMDLs) for those water bodies are required by Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR part 130). The TMDL process is designed to restore and maintain the quality of those impaired water bodies through the establishment of pollutant specific allowable loads. This TMDL has been developed for the 2006 §303(d) listed segment shown in Figure 2.

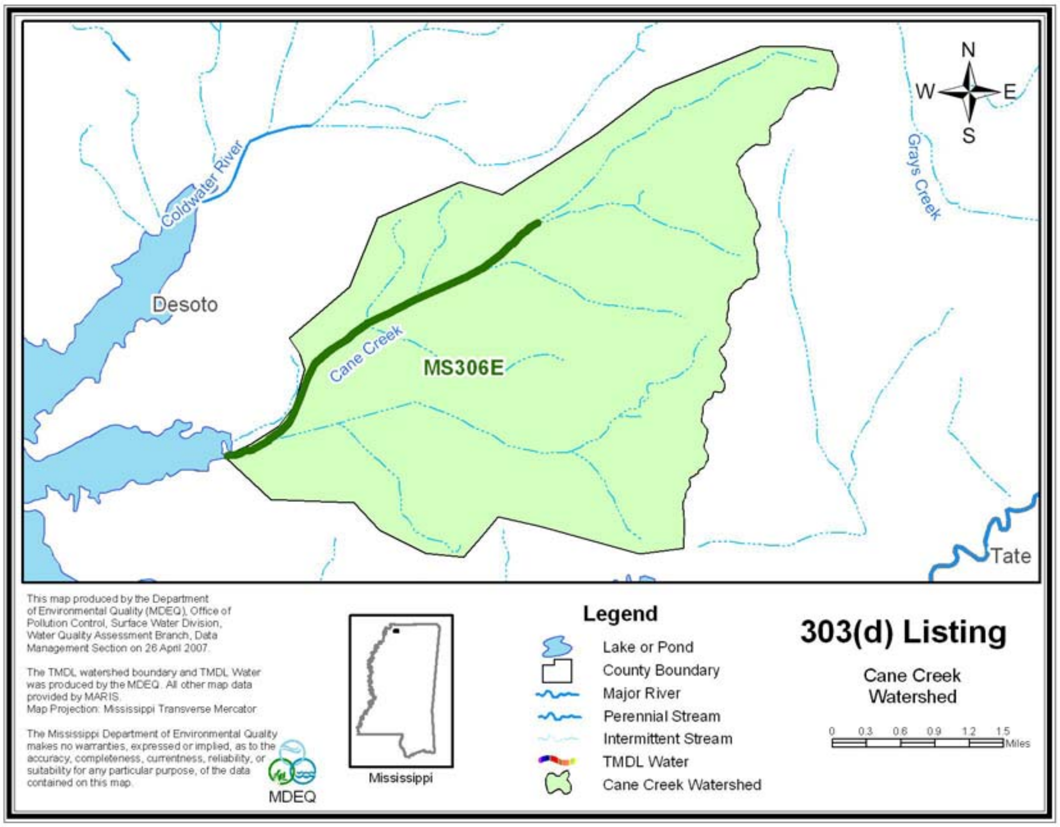


Figure 2. Cane Creek §303(d) Listed Segment

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, 2003). The designated beneficial use for the listed segment is fish and wildlife.

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, 2003).

Mississippi's current standards contain a narrative criteria that can be applied to nutrients which states "*Waters shall be free from materials attributable to municipal, industrial, agricultural, or other discharges producing color, odor, taste, total suspended or dissolved solids, sediment, turbidity, or other conditions in such degree as to create a nuisance, render the waters injurious to public health, recreation, or to aquatic life and wildlife, or adversely affect the palatability of fish, aesthetic quality, or impair the waters for any designated use* (MDEQ, 2002)." In the 1999 Protocol for Developing Nutrient TMDLs, EPA suggests several methods for the development of numeric criteria for nutrients (USEPA, 1999). In accordance with the 1999 Protocol, "The target value for the chosen indicator can be based on: comparison to similar but unimpaired waters; user surveys; empirical data summarized in classification systems; literature values; or professional judgment." MDEQ believes the most economical and scientifically defensible method for use in Mississippi is a comparison between similar but unimpaired waters within the same region. This method is dependent on adequate data which are being collected in accordance with the EPA approved plan. The initial phase of the data collection process for wadeable streams is complete.

1.4 Nutrient Target Development

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

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

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

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

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

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

1.5 Selection of a Critical Condition

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

1.6 Selection of a TMDL Endpoint

One of the major components of a TMDL is the establishment of instream numeric endpoints, which are used to evaluate the attainment of acceptable water quality. Instream numeric endpoints, therefore, represent the water quality goals that are to be achieved by meeting the load and wasteload allocations specified in the TMDL. The endpoints allow for a comparison between observed instream conditions and conditions that are expected to restore designated uses. The instream DO target for this TMDL is a daily average of not less than 5.0 mg/l. The instantaneous minimum portion of the DO standard was considered when establishing the instream target for this TMDL. However, it was determined that using the daily average standard with the conservative modeling assumptions would protect the instantaneous minimum standard. The daily average choice is supported by the use of the existing modeling tools in a desktop modeling exercise such as this. More specific modeling and calibration are needed in order to obtain accurate diurnal oxygen levels. Therefore, based on the limited data available and the relative simplicity of the model, the daily average target is appropriate.

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

carbonaceous compounds are referred to as CBODu, and the nitrogenous compounds are referred to as NBODu. TBODu is equal to the sum of NBODu and CBODu, Equation 1.

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

There are no state criteria in Mississippi for nutrients. These criteria are currently being developed by the Mississippi Nutrient Task Force in coordination with EPA Region 4. MDEQ proposed a work plan for nutrient criteria development that has been approved by EPA and is on schedule according to the approved plan in development of nutrient criteria (MDEQ, 2004). Data were collected for wadeable streams to calculate the nutrient criteria.

For this TMDL, MDEQ is presenting preliminary target ranges for TN and TP. An annual concentration range of 0.56 to 1.12 mg/l is an applicable target for TN and 0.04 to 0.16 mg/l for TP for water bodies located in Ecoregion 74. However, MDEQ is presenting these ranges as preliminary target values for TMDL development which is subject to revision after the development of nutrient criteria, when the work of the NTF is complete.

WATER BODY ASSESSMENT

2.1 Cane Creek Water Quality Data

Nutrient data for the Cane Creek watershed were gathered and reviewed. The data are given in Table 5. Data exist for the §303(d) listed segment based on monitoring at station YZ115. The location of the station is shown in Figure 3.

Table 5. Water Quality Data Collected at Cane Creek, Station # YZ115

Sample Date	Time	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Dissolved Oxygen (mg/L)
12-May-99	14:25	0.08	0.66	9.15
15-Mar-00	13:44	0.13	0.29	9.51
8-May-00	12:43	0.15	1.9	-
27-Nov-00	11:51	0.37	1.06	10.48
28-Feb-01	10:45	0.16	1.22	-
Average		**0.18**	**1.03**	

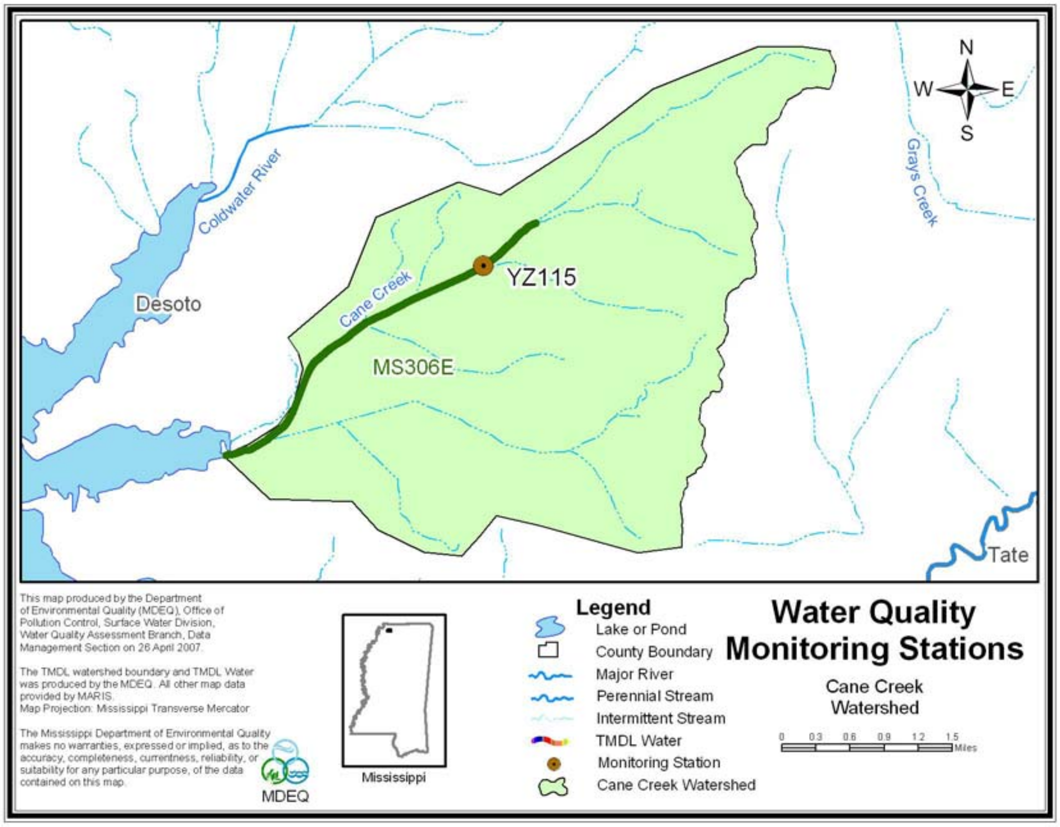


Figure 3. Cane Creek Water Quality Monitoring Stations

2.2 Assessment of Point Sources

An important step in assessing pollutant sources in the Cane Creek watershed is locating the NPDES permitted sources. There is one facility permitted to discharge organic material into the Cane Creek watershed, Table 6. The location of the facility is shown in Figure 4.

Table 6. NPDES Permitted Facilities Treatment Types

Name	NPDES Permit	Treatment Type
Shadyview Trailer Park	MS0021822	Aerated Tank

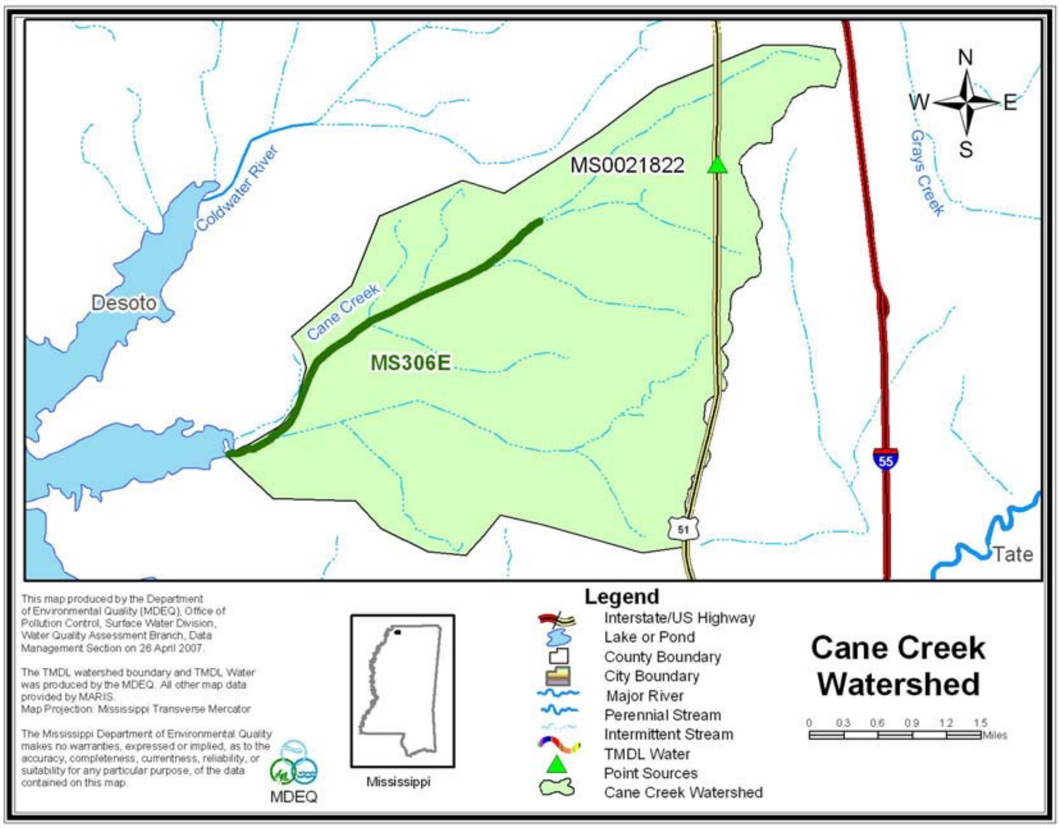


Figure 4. Cane Creek Point Source

The effluent from the facility was characterized based on all available data including information on its wastewater treatment system, permit limits, and discharge monitoring reports. The permit limits are given in Table 7.

Table 7. Identified NPDES Permitted Facilities

Name	NPDES Permit	Permitted Discharge (MGD)	Permitted Average BOD_5 (mg/l)
Shadyview Trailer Park	MS0021822	0.006	30

2.3 Assessment of Non-Point Sources

Non-point loading of nutrients and organic material in a water body results from the transport of the pollutants into receiving waters by overland surface runoff, groundwater infiltration, and atmospheric deposition. The two primary nutrients of concern are nitrogen and phosphorus. Total nitrogen is a combination of many forms of nitrogen found in the environment. Inorganic nitrogen can be transported in particulate and dissolved phases in surface runoff. Dissolved inorganic nitrogen can be transported in groundwater and may enter a stream from groundwater infiltration. Finally, atmospheric gaseous nitrogen may enter a stream from atmospheric deposition.

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

Watersheds with a large number of failing septic tanks may also deliver significant loadings of phosphorus to a stream. All domestic wastewater contains phosphorus which comes from humans and the use of phosphate containing detergents. Table 8 presents typical nutrient loading ranges for various land uses.

Table 8. 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 Cane Creek is approximately 8027.8 acres or 12.54 square miles. The watershed contains many different landuse types, including urban, forest, cropland, pasture, and wetlands. The landuse information given below is based on data collected by the Multi-Resolution Land Characteristics (MRLC) Consortium. This data set is the National Land Cover Database (NLCD) 2001 and is based on satellite imagery from 2001. Pasture is the dominant landuse within this watershed, although cropland is the dominant landuse surrounding the water body. The landuse distribution for the Cane Creek Watershed is shown in Table 9 and Figure 5.

Table 9. Landuse Distribution for the Cane Creek Watershed

In Acres	Urban	Forest	Cropland	Pasture	Scrub/Barren	Wetlands
Cane Creek	10.7	1071.3	2558.7	3760.2	467.3	159.6
Percentage	0.1%	13.3%	31.9%	46.8%	5.8%	2.0%

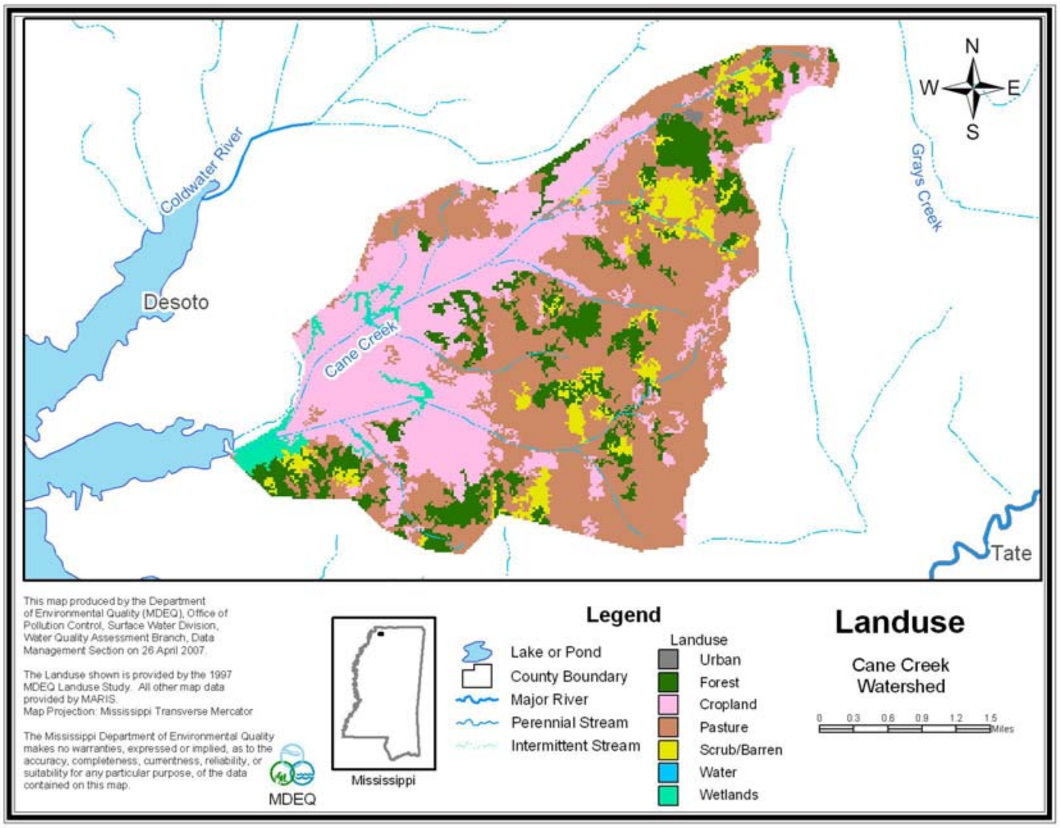


Figure 5. Cane Creek Watershed Landuse

MODELING PROCEDURE: LINKING THE SOURCES TO THE ENDPOINT

Establishing the relationship between the instream water quality target and the source loading is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired source load reductions. The link can be established through a range of techniques, from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain water body responses to flow and loading conditions. In this section, the selection of the modeling tools, setup, and model application are discussed.

3.1 Modeling Framework Selection

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

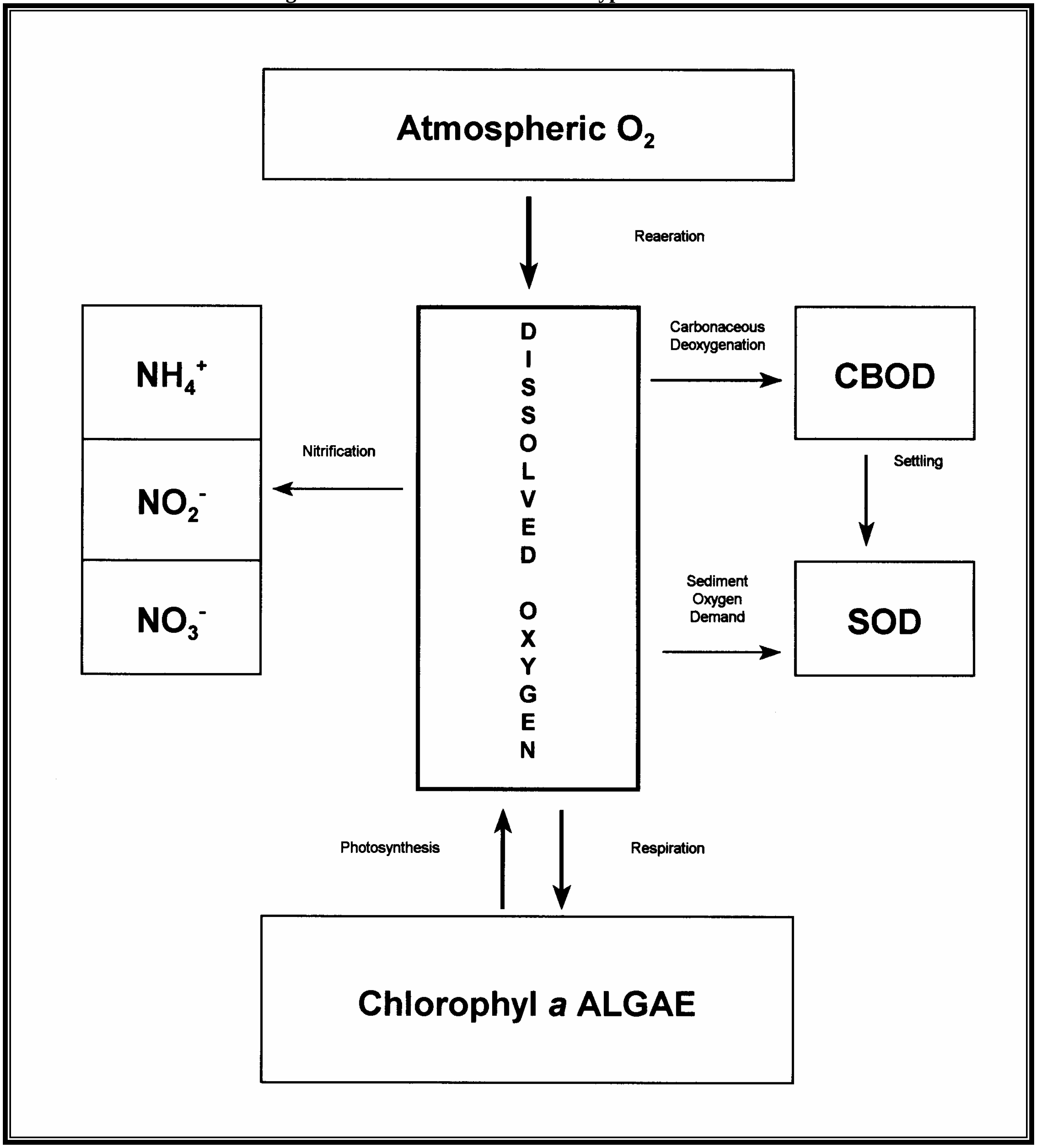
STREAM is a steady-state, daily average computer model that utilizes a modified Streeter-Phelps DO sag equation. Instream processes simulated by the model include CBODu decay, nitrification, reaeration, sediment oxygen demand, and respiration and photosynthesis of algae. Figure 6 shows how these processes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

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

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

C is the escape coefficient, U is the reach velocity in mile/day, and S is the average reach slope in ft/mile. The value of the escape coefficient is assumed to be 0.11 for streams with flows less than 10 cfs. Reach velocities were calculated using an equation based on slope. The slope of each reach was estimated electronically and input into the model in units of feet/mile.

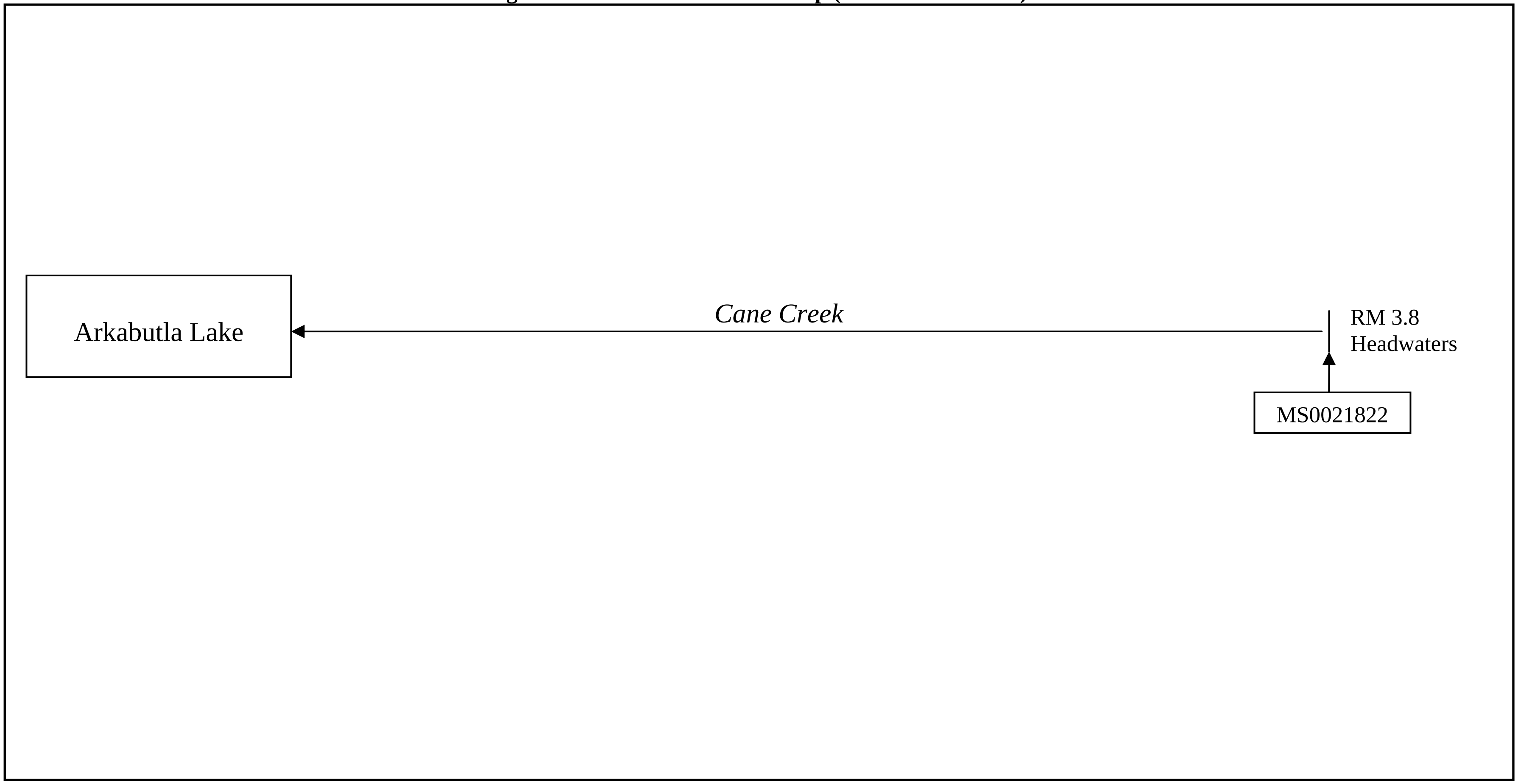
Figure 6. Instream Processes in a Typical DO Model



3.2 Model Setup

The model for this TMDL includes the §303(d) listed segment of Cane Creek, beginning at the headwaters and ending at the Arkabutla Flood Pool. A diagram showing the model setup is shown in Figure 7. The location of the confluence of the point source is shown. Arrows represent the direction of flow in each segment. The numbers on the figure represent approximate river miles (RM). River miles are assigned to water bodies, beginning with zero at the mouth.

Figure 7. Cane Creek Model Setup (Note: Not to Scale)



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

The STREAM model was setup to simulate flow and temperature conditions, which were determined to be the critical condition for this TMDL. MDEQ Regulations state that when the flow in a water body is less than 50 cfs, the temperature used in the model is 26°C. The headwater instream DO was assumed to be 85% of saturation at the stream temperature. The instream CBODu decay rate at K_d at 20°C was input as 0.3 day^{-1} (base e) as specified in MDEQ regulations. The model adjusts the K_d rate based on temperature, according to Equation 3.

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

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

Cane Creek has no USGS flow gages. The flow in the Cane Creek watershed was modeled at 7Q10 conditions based on data available from the USGS (Telis, 1991) with an estimated 7Q10 for the watershed of 0.63 cfs.

3.3 Source Representation

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

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

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

The CBODu to $CBOD_5$ ratios are given in *Empirical Stream Model Assumptions for*

Conventional Pollutants and Conventional Water Quality Models (MDEQ, 1994). These values are recommended for use by MDEQ regulations when actual field data are not available. The value of the ratio depends on the treatment type of wastewater. For activated sludge treatment systems this ratio is 2.3.

In order to convert the ammonia nitrogen (NH_3-N) loads to an oxygen demand, a factor of 4.57 pounds of oxygen per pound of ammonia nitrogen (NH_3-N) oxidized to nitrate nitrogen (NO_3-N) was used. Using this factor is a conservative modeling assumption because it assumes that all of the ammonia is converted to nitrate through nitrification. The oxygen demand caused by nitrification of ammonia is equal to the NBODu load. The sum of CBODu and NBODu is equal to the point source load of TBODu. The maximum permitted loads of TBODu from the existing point source is given in Table 10.

Table 10. Point Sources, Maximum Permitted Loads

NPDES	Flow (MGD)	$CBOD_5$ (mg/l)	NH_3-N (mg/l)	$CBOD_u$: $CBOD_5$ Ratio	CBODu (lbs/day)	NH_3-N (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
MS0021822	0.006	30	2	2.3	3.45	0.097	0.44	3.89

Direct measurements of background concentrations of CBODu were not available for Cane Creek. Because there were no data available, the background concentrations of CBODu and NH_3-N were estimated based on *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). According to these regulations, the background concentration used in modeling for BOD_5 is 1.33 mg/l and for NH_3-N is 0.1 mg/l. These concentrations were also used as estimates for the CBODu and NH_3-N levels of water entering the water bodies through non-point source flow and tributaries.

Non-point source flows were included in the model to account for water entering due to groundwater infiltration, overland flow, and small, unmeasured tributaries. These flows were estimated based on USGS data for the 7Q10 flow condition in the Cane Creek watershed. The non-point source loads were assumed to be distributed evenly on a river mile basis throughout the modeled reaches as shown in Table 11.

Table 11. Non-Point Source Loads Input into the Model

	Flow (cfs)	$CBOD_5$ (mg/l)	CBODu (lbs/day)	NH_3-N (mg/l)	NBODu (lbs/day)	TBODu (lbs/day)
Cane Creek background load	0.01	1.33	0.11	0.1	0.03	0.14
Cane Creek non-point source	0.63	1.33	6.77	0.1	1.55	8.32
Total	**0.64**		**6.88**		**1.58**	**8.46**

3.4 Model Calibration

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

3.5 Model Results

Once the model setup was complete, the model was used to predict water quality conditions in

Cane Creek. The model was first run under regulatory load conditions. Under regulatory load conditions, the load from the NPDES permitted point source was set at its current location and maximum permit limits, Table 10.

3.5.1 Regulatory Load Scenario

The regulatory load scenario model results are shown in Figure 8. Figure 8 shows the modeled daily average DO with the NPDES permit at its maximum allowable loads and with estimated non-point source loads. The figure shows the daily average instream DO concentrations, beginning with the headwaters at river mile 3.8 and ending at river mile 0.0 at the Arkabutla Lake Flood Pool. As shown in the figure, the model does not predict that the DO goes below the standard of 5.0 mg/l using the maximum allowable loads.

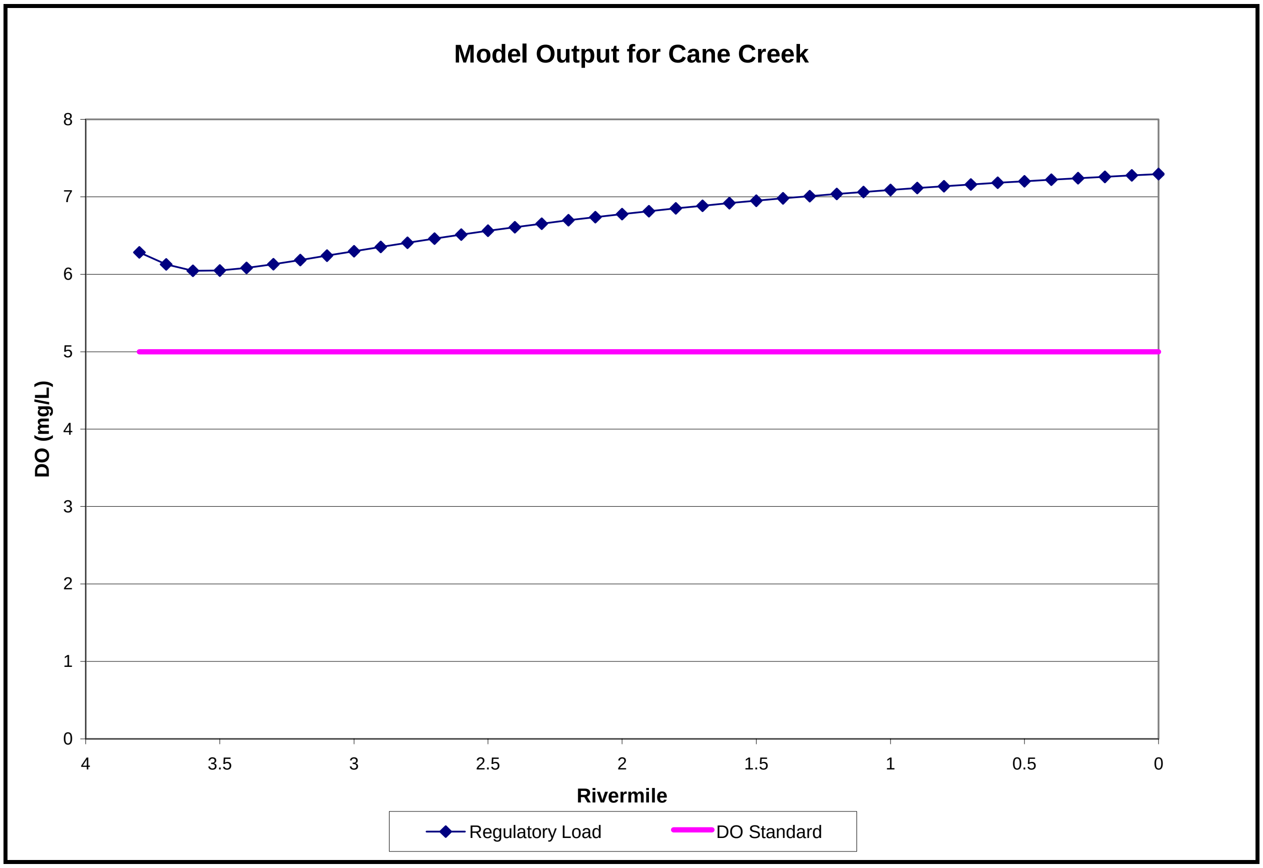


Figure 8. Model Output for DO in Cane Creek, Regulatory Load Scenario

3.5.2 Maximum Load Scenario

The graph of the regulatory load scenario output shows that the predicted DO does not fall below the DO standard in Cane Creek during critical conditions. Thus, reductions from the loads of TBODu are not necessary. Calculating the maximum allowable load of TBODu involved increasing the non-point source loads only and running the model using a trial-and-error process until the modeled DO was just above 5.0 mg/l. The non-point source loads were increased by a factor of 7.5 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 10.

Figure 10 shows the modeled instream DO concentrations in Cane Creek after application of the selected maximum load scenario at critical conditions. The model results for the maximum load scenario show that the water body does have additional assimilative capacity.

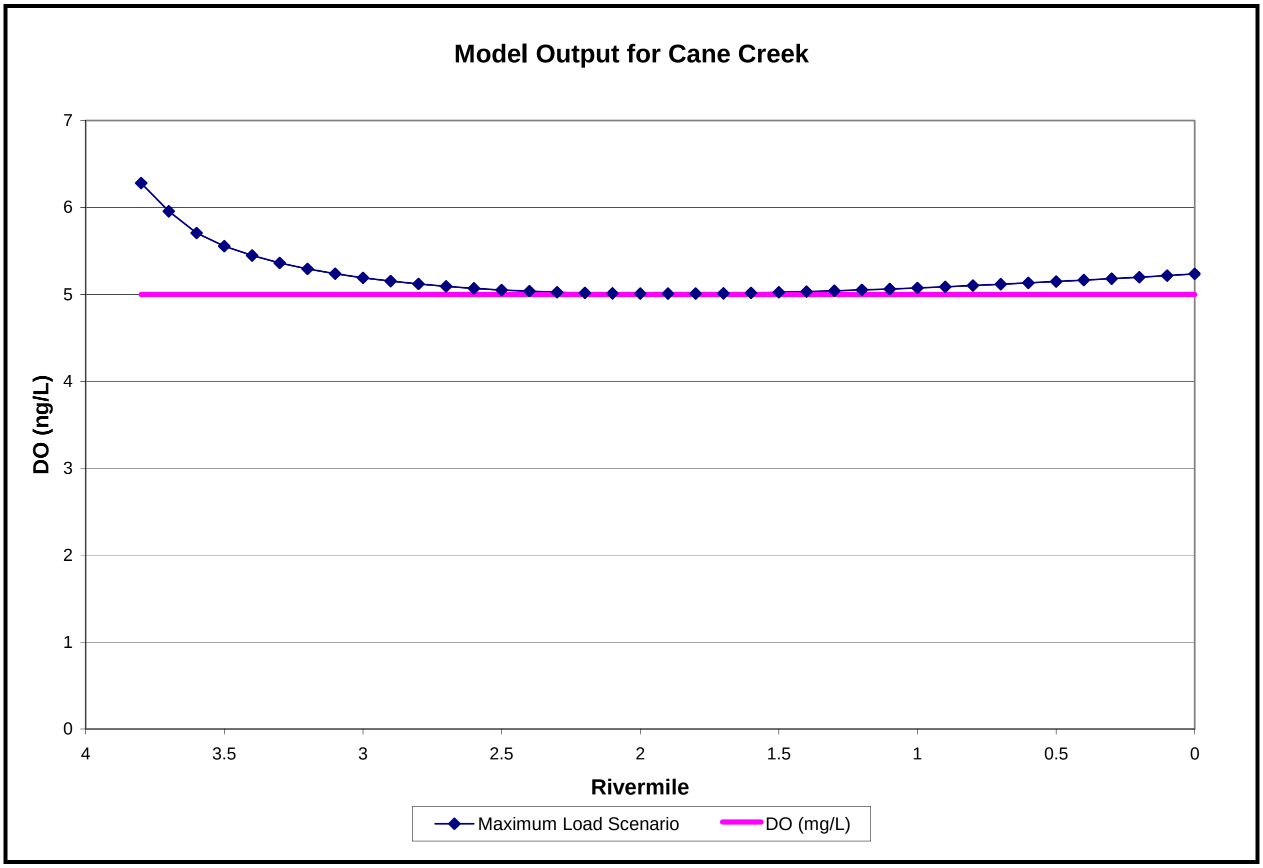


Figure 9. Model Output for Cane Creek for DO, Maximum Load Scenario

3.6 Estimated Existing Load for Total Nitrogen

The estimated existing total nitrogen concentration is based on the median total nitrogen concentrations measured in wadeable streams in Ecoregion 74 with impaired biology and elevated nutrients, which is 1.71 mg/l. The average of the available Cane Creek data for TN is 1.03 mg/l. However, due to the limited amount of data, the targeted reductions will be based on the estimated total nitrogen level for impaired streams in Ecoregion 74.

To convert the estimated existing total nitrogen concentration to a total nitrogen load, the average annual flow for Cane Creek was estimated based on USGS monitoring station 07277700 on Hickahala Creek near Senatobia, Mississippi. The annual average flow for Hickahala Creek near Senatobia, Mississippi is 187.4 cfs, with a drainage area of 121 square miles. To estimate the amount of flow in Cane Creek, a drainage area ratio for the 07277700 gage watershed was calculated (187.4 cfs / 121 square miles = 1.54 cfs/square mile). The ratio was then multiplied

by the drainage area in square miles of the impaired segment. Thus, the annual average flow in Cane Creek is estimated as 19.3 cfs. The existing TN load was then calculated, using Equation 5 and the results are shown in Table 12.

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

Table 12. Estimated Existing Total Nitrogen Load for Cane Creek

Stream	Area (sq miles)	Average Annual Flow (cfs)	TN (mg/L)	TN (lbs/day)
Cane Creek	12.5	19.3	1.71	178.0

Table 13. NPDES Permitted Facilities Treatment Types with Nitrogen Estimates

Facility Name	NPDES	Treatment Type	Permitted Discharge (MGD)	TN concentration estimate (mg/l)	TN Load estimate (lbs/day)
Shadyview Trailer Park	MS0021822	Aerated Tank	0.006	13.6	0.68
		Total	**0.006**		**0.68**

The TN point source load is estimated to be 0.68 lbs/day, Table 13. The annual average total load based on the estimated total nitrogen concentration of 1.71 mg/l and an annual average flow of 19.3 cfs is 178.0 lbs/day. The point source load is 0.40% of the total load. Therefore, 99.6% of the estimated existing TN load is from non-point sources.

3.7 Estimated Existing Load for Total Phosphorous

The estimated existing total phosphorous concentration is based on the median total phosphorous concentrations measured in wadeable streams in Ecoregion 74 with impaired biology and elevated nutrients, which is 0.16 mg/l. The average of the available Cane Creek data for TP is also 0.18 mg/l.

To convert the estimated existing total phosphorus concentration to a total phosphorus load, the average annual flow for Cane Creek was estimated based on USGS monitoring station 07277700 on Hickahala Creek near Senatobia, Mississippi. As previously described, the annual average flow in Cane Creek is estimated as 19.3 cfs. The existing TP load was then calculated, using Equation 5 and the results are shown in Table 14.

Table 14. Estimated Existing Total Phosphorous Load for Cane Creek

Stream	Area (sq miles)	Average Annual Flow (cfs)	TP (mg/L)	TP (lbs/day)
Cane Creek	12.5	19.3	0.16	16.7

Table 15. 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)
Shadyview Trailer Park	MS0021822	Aerated Tank	0.006	5.8	0.28
		Total	**0.006**		**0.28**

The TP point source load is estimated to be 0.28 lbs/day, Table 15. The annual average total load based on the estimated total phosphorus concentration of 0.18 mg/l and an annual average flow of 19.3 cfs is 16.7 lbs/day. The point source load is 1.7% of the total load. Therefore, 98.3% of the estimated existing TP load is from non-point sources.

ALLOCATION

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

4.1 Wasteload Allocation

There is currently one NPDES permit issued for the Cane Creek watershed. Although this wasteload allocation is based on the current condition of Cane Creek, it is not intended to prevent the issuance of permits for future facilities. This is because the model results show that Cane Creek has additional assimilative capacity for organic material. Future permits will be considered in accordance with Mississippi's *Wastewater Regulations for National Pollutant Discharge Elimination System (NPDES) Permits, Underground Injection Control (UIC) Permits, State Permits, Water Quality Based Effluent Limitations and Water Quality Certification*.

The NPDES permitted facility is included in the wasteload allocation, Table 16. Table 17 gives the estimated load of TN from the point source which is 0.4% of the total existing load as described in Section 3.6. Table 17 also gives the estimated load of TP from the point source which is 1.7% of the total existing load as described in Section 3.7. Because the nutrient estimates are based on literature values, this TMDL recommends nutrient monitoring for this facility.

Table 16. Wasteload Allocation

Facility Name	CBODu (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
Shadyview Trailer Park	3.35	0.44	3.79
Total	**3.35**	**0.44**	**3.79**

Table 17. Nutrient Wasteload Allocation

Facility Name	Existing Estimated TN Point Source Load (lbs/day)	Allocated Average TN Point Source Load (lbs/day)	Existing Estimated TP Point Source Load (lbs/day)	Allocated Average TP Point Source Load (lbs/day)	Percent Reduction
Shadyview Trailer Park	0.68	0.68	0.28	0.28	0

4.2 Load Allocation

The headwater and spatially distributed loads are included in the load allocation. The TBODu concentrations of these loads were determined by using an assumed BOD_u concentration of 1.33 mg/l and an NH_3-N concentration of 0.1 mg/l. This TMDL does not require a reduction of the load allocation. In Table 18, the load allocation is shown as the non-point sources (the spatially distributed flow entering each reach in the model).

Table 18. Load Allocation, Maximum Scenario

	CBODu (lbs/day)	NBODu (lbs/day)	TBODu (lbs/day)
Background	0.11	0.03	0.14
Non-Point Source	50.82	11.64	62.46
	50.93	**11.67**	**62.60**

Based on initial estimates in Sections 3.6 and 3.7, most of the TN and TP loads in this watershed come from non-point sources. Therefore, best management practices (BMPs) should be encouraged in the watershed to reduce potential nutrient loads from non-point sources The watershed should be considered a priority for riparian buffer zone restoration and any nutrient reduction BMPs. For land disturbing activities related to silviculture, construction, and agriculture, it is recommended that practices, as outlined in “Mississippi’s BMPs: Best Management Practices for Forestry in Mississippi” (MFC, 2000), “Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater” (MDEQ, et. al, 1994), and “Field Office Technical Guide” (NRCS, 2000), be followed, respectively. Table 19 shows the load allocation for TN and TP.

Table 19. Load Allocation for Estimated TN and TP

Nutrient	Estimated Nutrient Nonpoint Source Load (lbs/day)	Allocated Nutrient Nonpoint Source Load (lbs/day)
TN	177.3	58.3 – 116.6
TP	16.4	4.16 – 16.6

4.3 Incorporation of a Margin of Safety

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

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

The explicit MOS for this report is the difference between the non-point loads calculated in the maximum load scenario and the regulatory load scenario non-point loads. The regulatory load scenario non-point source loads represent an approximation of the loads currently going into Cane Creek at the critical conditions. The maximum non-point source loads are the maximum TBODu loads with a 7.5 increase that allow maintenance of water quality standards. MDEQ has set the explicit MOS as the difference in these loads. The calculated MOS is in Table 20.

Table 20. Calculation of Explicit MOS

	Maximum Non-Point Load	Regulatory Non-Point Load	Margin of Safety
CBODu (lbs/day)	50.83	6.77	44.06
NBODu (lbs/day)	11.64	1.55	10.09
TBODu (lbs/day)	**62.47**	**8.32**	**54.15**

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.

TMDL = WLA + LA + MOS **(Eq. 6)**

The TMDL for TBODu was calculated based on the current loading of pollutant in Cane Creek, according to the model. The TMDL calculations are shown in Tables 21 and 22. As shown in Table 21, the TBODu is the sum of CBODu and NBODu. The wasteload allocations incorporate the CBODu contributions from identified NPDES Permitted facilities. The load allocations include the background and non-point sources of TBODu from surface runoff and groundwater infiltration. The implicit margin of safety for this TMDL is derived from the conservative assumptions used in setting up the model, while the explicit margin of safety is calculated based on the maximum loads scenario explained in Section 3.5.2.

Equation 5 was used to calculate the TMDL for TP and TN. The target concentration ranges, presented in Section 1.7, were used with the average flow for the watershed to determine the TMDLs. The TMDLs, given in Table 22, were then compared to the estimated existing load for the ecoregion, presented in Sections 3.6 and 3.7. The estimated existing TP concentration indicates needed reductions of 0.60% to 75.0%. The TMDL for TP is 4.16-16.6 lbs/day. The estimated existing total nitrogen concentration indicates needed reductions of 34.5% to 67.2%. The TMDL for TN is 58.3-116.6 lbs/day.

Table 21. TMDL for TBODu in the Cane Creek Watershed

	WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
CBODu	3.35	50.93	44.06	98.34
NBODu	0.44	11.67	10.09	22.20
TBODu	**3.79**	**62.6**	**54.15**	**120.54**

Table 22. TMDL for Nutrients in the Cane Creek Watershed

	WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
TN	**0.68**	**57.6-115.9**	Implicit	**58.3-116.6**
TP	**0.28**	**3.88-16.38**	Implicit	**4.16-16.6**

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

CONCLUSION

This TMDL is based on a desktop model using MDEQ's regulatory assumptions and literature values in place of actual field data. The model results indicate that Cane 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 Cane Creek. Nutrients were addressed through an estimate of a preliminary total phosphorous concentration target range and a preliminary total nitrogen concentration target range. Based on the estimated existing and target total phosphorous concentrations, this TMDL recommends a 0.6% to75.0% reduction of the phosphorous loads entering these streams to meet the preliminary target range of 0.04 to 0.16 mg/l. Based on the estimated existing and target total nitrogen concentrations, this TMDL recommends a 34.5% to 67.2% reduction of the nitrogen loads entering these streams to meet the preliminary target range of 0.56 to 1.12 mg/l. Because only 0.4% of the existing TN load and 1.7% of the TP load are estimated to be due to point sources, this TMDL does not recommend percent reductions from the NPDES permit. It is recommended that the Cane 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 creeks. This will provide improved water quality for the support of aquatic life in the water bodies and will result in the attainment of the applicable water quality standards.

5.1 Public Participation

This TMDL will be published for a 30-day public notice. During this time, the public will be notified by publication in the statewide newspaper. The public will be given an opportunity to review the TMDLs and submit comments. MDEQ also distributes all TMDLs at the beginning of the public notice to those members of the public who have requested to be included on a TMDL mailing list. Anyone wishing to become a member of the TMDL mailing list should contact Kay Whittington at Kay_Whittington@deq.state.ms.us.

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

REFERENCES

Davis and Cornwell. 1998. *Introduction to Environmental Engineering.* McGraw-Hill.

MDEQ. 2006. *Stressor Identification Report for Cane Creek*. Office of Pollution Control.

MDEQ. 2004. *Mississippi's Plan for Nutrient Criteria Development*. Office of Pollution Control.

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. 2003. *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. 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.

Thomann and Mueller. 1987. *Principles of Surface Water Quality Modeling and Control*.
New York: Harper Collins.

USEPA. 2000. *Stressor Identification Guidance Document*. EPA/822/B-00/025. Office of Water, Washington, DC.

USEPA. 1999. *Protocol for Developing Nutrient TMDLs*. EPA 841-B-99-007. Office of Water (4503F), United States Environmental Protection Agency, Washington D.C. 135 pp.