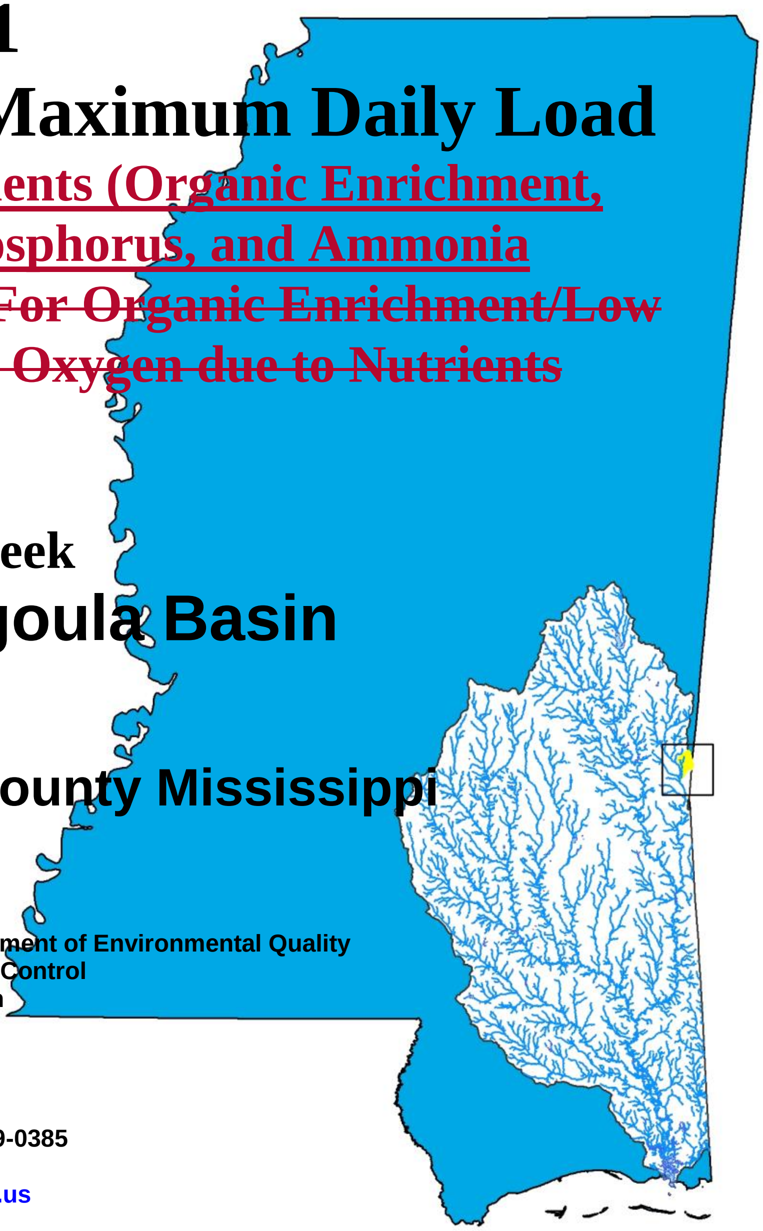
~~PROPOSED~~
FINAL~~DRAFT~~
REPORT

# Phase 1
# Total Maximum Daily Load
## For Nutrients (Organic Enrichment, Total Phosphorus, and Ammonia Toxicity)~~For Organic Enrichment/Low Dissolved Oxygen due to Nutrients~~



## Cedar Creek
# Pascagoula Basin

## Clarke County Mississippi

**Prepared By**


**Mississippi Department of Environmental Quality**
**Office of Pollution Control**
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# FOREWORD

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

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

**Conversion Factors**

| To convert from | To | Multiply by | To convert from | To | Multiply by |
|---|---|---|---|---|---|
| mile$^2$ | acre | 640.000 | acre | ft$^2$ | 43560.00 |
| km$^2$ | acre | 247.100 | days | seconds | 86400.00 |
| m$^3$ | ft$^3$ | 35.300 | meters | feet | 3.28 |
| ft$^3$ | gallons | 7.480 | ft$^3$ | gallons | 7.48 |
| ft$^3$ | liters | 28.300 | hectares | acres | 2.47 |
| cfs | gal/min | 448.800 | miles | meters | 1609.30 |
| cfs | MGD | 0.646 | tonnes | tons | 1.10 |
| m$^3$ | gallons | 264.200 | µg/l * cfs | gm/day | 2.45 |
| m$^3$ | liters | 1000.000 | µg/l * MGD | gm/day | 3.79 |

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

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# TMDL INFORMATION PAGE

**i. Listing Information**

| Name | ID | County | HUC | Cause | Mon/Eval |
|---|---|---|---|---|---|
| **Cedar Creek** | MS068CE | Clarke | 03170002 | Nutrients | Evaluated |
| Near Threadville from Headwaters to Mouth at Buc~~k~~atunna Creek | | | | | |

**ii. Water Quality Standard**

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

**iii. NPDES Facilities**

There are no NPDES permits in the Cedar Creek Watershed.

**iv. Phase 1 Total Maximum Daily Load for TBODu**

| WLA (lbs/day) | LA (lbs/day) | MOS | TMDL (lbs/day) |
|---|---|---|---|
| ***0.0** | **26.3** | **Implicit** | **26.3** |

*This TMDL will not exclude future NPDES permits in the Cedar Creek Watershed. Requests for permits in this water body will be evaluated to accommodate a load that does not to violate the TMDL of 26.3 lbs/day of TBODu. Nutrient monitoring will be required for any future NPDES permit.

# EXECUTIVE SUMMARY

This TMDL has been developed for a segment of Cedar Creek that has been placed on the Mississippi 2002 Section 303(d) List of Water Bodies as an evaluated water body segment. The segment of Cedar Creek is listed due to nutrients and sediment. Sediment will be addressed in a separate TMDL report. Mississippi currently does not have standards for allowable nutrient concentrations, so a TMDL for specific nutrient species will not be developed. However, because elevated levels of nutrients may cause low levels of dissolved oxygen, this TMDL will be developed for dissolved oxygen. The dissolved oxygen TMDL addresses the potential impact of elevated nutrients in the water body. The applicable state standard specifies that the dissolved oxygen concentrations shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l. Ammonia nitrogen levels will ~~also~~ be evaluated in this TMDL using criteria established for ammonia nitrogen toxicity. Additionally this TMDL will estimate the total phosphorus load in the stream. This TMDL has been developed as a phase 1 TMDL so that when more data are available and nutrient water quality standards are developed phase 2 could address nitrogen and/or phosphorus loads as needed.~~TMDL so that specific nutrient species may be evaluated when more data are available and nutrient water quality standards are developed.~~

The Cedar Creek Watershed is located in southeastern Mississippi in HUC 03170002. Cedar Creek, Photo 1, begins near the town ~~on~~ of Shiloh in Clarke County near the Mississippi and Alabama state line. The river flows for approximately 9 miles in a southern direction, from its headwaters to its confluence with Buckatunna Creek. The location of the watershed is shown in Figure 1.

**Photo 1. Cedar Creek at Hwy 511**

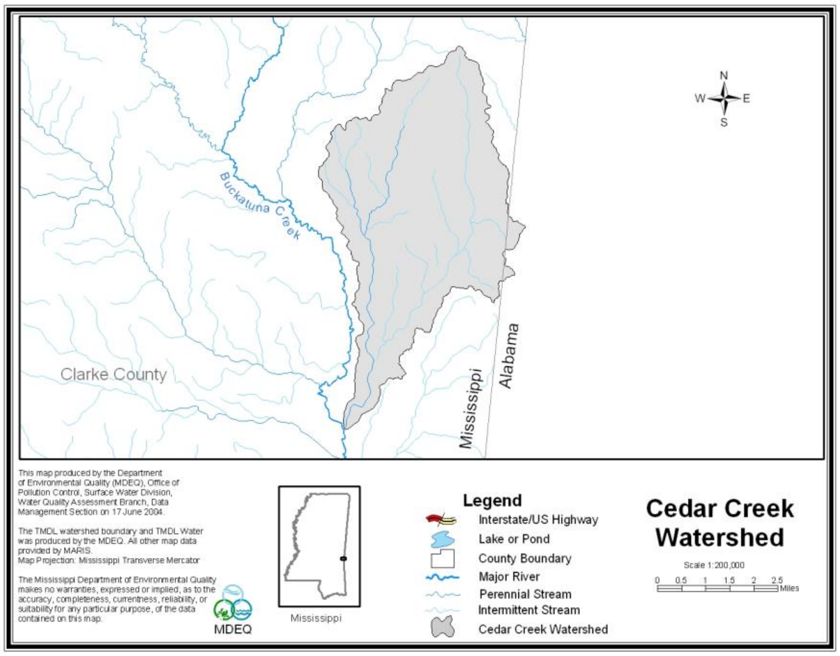


**Figure 1. Cedar Creek Watershed**

The predictive models used to calculate this TMDL are based primarily on assumptions described in MDEQ Regulations. A modified Streeter-Phelps dissolved oxygen sag model was selected as the modeling framework for developing the TMDL allocations for this study. A mass-balance approach was used to ensure that the instream concentration of ammonia nitrogen ($NH_3$-N) did not exceed the water quality criteria. The critical modeling period was determined to occur during the hot, dry summer period.

Based on preliminary data from Mississippi's Benthic Index of Stream Quality (M-BISQ) study, the water body system may be slightly impaired. Thus, TMDL development is needed. The TMDL for organic enrichment/low dissolved oxygen due to nutrients was quantified in terms of total ultimate biochemical oxygen demand (TBODu). The model used in developing this TMDL included only non-point sources of TBODu in the Cedar Creek Watershed. TBODu loading from non-point sources in the watershed was accounted for by using an estimated background concentration of TBODu in the water body. There are currently no NPDES Permitted discharges located in the watershed. However, this TMDL does not exclude NPDES permits in the future. The model results showed that the DO levels in Cedar Creek are above water quality standards and levels of $NH_3$-N are well below toxicity levels and that the total phosphorus levels are from nonpoint sources. ~~Thus, there is additional assimilative capacity in the water body.~~ There are ~~no~~ nonpoint source nutrient reductions recommended ~~from the current loading required~~ by this TMDL.

# INTRODUCTION

## 1.1 Background

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

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

The surveys asked for the presence of agriculture, urban areas, or forestry in the watershed. MDEQ interpreted potential pollutants present on these land uses and listed several broad potential pollutant categories based on the survey results. Every watershed, for which agriculture was checked, was listed for several pollutants, including sediment, pesticides, organic enrichment/low dissolved oxygen, and nutrients. Cedar Creek was listed for pesticides, nutrients, and siltation based on the survey results. TMDLs for Cedar Creek must be developed for these pollutants even though there is little data available.

To further complicate the situation, nutrients were listed as an impairment even though there are no state criteria in Mississippi for nutrients. These criteria are currently being developed by the Mississippi Nutrient Task Force (NTF) in agreement with EPA Region 4. MDEQ has a work plan for nutrient criteria development approved by EPA and is on schedule according to the approved plan in development of nutrient criteria (MDEQ, 2004). Data have been collected for wadeable streams to be used to calculate the criteria.

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

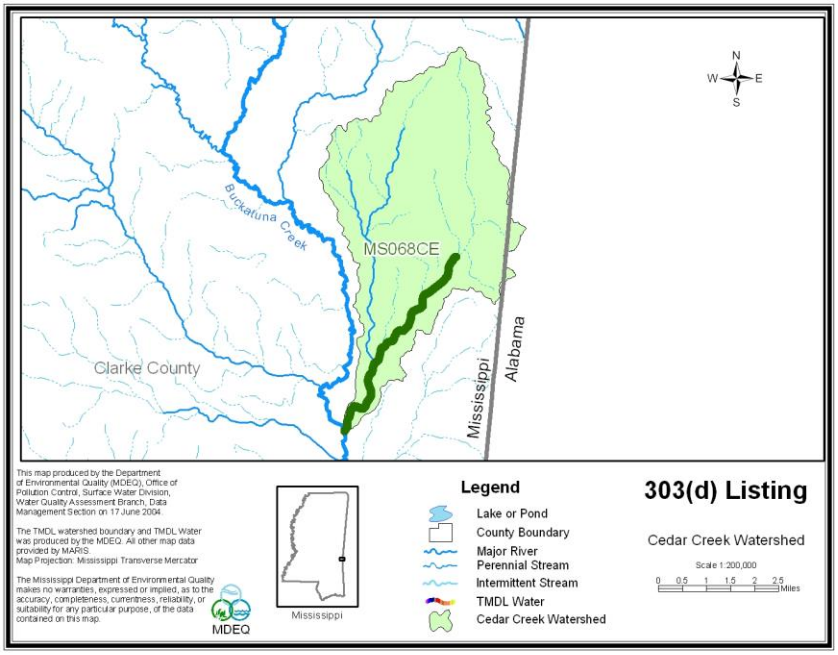


**Figure 2. Cedar Creek 303(d) Listed Segment**

## 1.2 Applicable Water Body Segment Use

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

## 1.3 Applicable Water Body Segment Standard

The water quality standard applicable to the use of the water body and the pollutant of concern is defined in the *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters* (MDEQ, 2002). The applicable standard specifies that the dissolved oxygen (DO) concentrations shall be maintained at a daily average of not less than 5.0 mg/l with an instantaneous minimum of not less than 4.0 mg/l. The daily average water quality standard will be used to evaluate impairment and establish this TMDL.

The water quality standard for ammonia nitrogen toxicity is also included in this TMDL. Ammonia nitrogen concentrations can be evaluated using the criteria given in *1999 Update of Ambient Water Quality Criteria for Ammonia* (EPA-822-R-99-014). The maximum allowable instream ammonia nitrogen ($NH_3$-N) concentration at a pH of 7.0 and stream temperature of 26°C is 2.82 mg/l.

Mississippi's NTF is currently in the process of developing numeric criteria for nutrients. The current standards only contain a narrative criteria that can be applied to nutrients which states that *"Waters shall be free from materials attributable to municipal, industrial, agricultural, or other discharges producing color, odor, taste, total suspended or dissolved solids, sediment, turbidity, or other conditions in such degree as to create a nuisance, render the waters injurious to public health, recreation or to aquatic life and wildlife or adversely affect the palatability of fish, aesthetic quality, or impair the waters for any designated use."*

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In the *1999 Protocol for Developing Nutrient TMDLs*, EPA suggests several methods for the development of numeric criteria for nutrients (EPA, 1999). In accordance with the 1999 Protocol, *"The target value for the chosen indicator can be based on: comparison to similar but unimpaired waters; user surveys; empirical data summarized in classification systems; literature values; or best professional judgment"*. MDEQ believes the most economical and scientifically defensible method for use in Mississippi is a comparison between similar but unimpaired waters within the same region.

## 1.4 Selection of a Critical Condition

The critical condition represents the hydrologic and atmospheric conditions in which the pollutants causing impairment of a water body have their greatest potential for adverse effects. Low DO due to elevated nutrient levels typically occurs during seasonal low-flow, high-temperature periods during the late summer and early fall. Elevated oxygen demand and ammonia nitrogen is of primary concern during low-flow periods because the effects of minimum dilution and high temperatures combine to produce the worst-case potential effect on water quality (USEPA, 1997). The flow at critical conditions is typically defined as the 7Q10 flow, which is the lowest flow for seven consecutive days expected during a 10-year period. The low flow condition for Cedar Creek was determined based on information given in *Techniques for Estimating 7-Day, 10-Year Low-Flow Characteristics on Streams in Mississippi* (Telis, 1992).

## 1.5 Selection of a TMDL Endpoint

One of the major components of a TMDL is the establishment of instream numeric endpoints, which are used to evaluate the attainment of acceptable water quality. Instream numeric endpoints, therefore, represent the water quality goals that are to be achieved by meeting the load and wasteload allocations specified in the TMDL. The endpoints allow for a comparison between observed instream conditions and conditions that are expected to restore or maintain designated uses. The instream DO target for this TMDL is a daily average of not less than 5.0 mg/l. The instream target for ammonia nitrogen is a concentration less than 2.82 mg/l. The instantaneous minimum portion of the DO standard was considered when establishing the instream target for this TMDL. However, it was determined that using the daily average standard with the conservative modeling assumptions would protect the instantaneous minimum standard. The daily average choice is supported by the use of the existing modeling tools in a desktop modeling exercise such as this. More specific modeling and calibration are needed in order to obtain diurnal oxygen levels with any expectation of accuracy. Therefore, based on the limited data available and the relative simplicity of the model, the daily average target is appropriate.

The TMDL for ~~DO~~ nutrients will be quantified in terms of organic enrichment. Organic enrichment is measured in terms of total ultimate biochemical oxygen demand (TBODu). TBODu represents the oxygen consumed by microorganisms while stabilizing or degrading carbonaceous and nitrogenous compounds under aerobic conditions over an extended time period. The carbonaceous compounds are referred to as CBODu, and the nitrogenous compounds are referred to as NBODu. TBODu is equal to the sum of NBODu and CBODu, Equation 1.

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

# WATER BODY ASSESSMENT

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

## 2.1 Discussion of Instream Water Quality Data

There are very little monitoring data available for Cedar Creek (See Table 1). MDEQ collected two grab samples in 1997 from a monitoring station located on Cedar Creek, 02477895 and gathered one sample during the IBI sample in 2003. This station is located near Threadville downstream from the Hwy 511 Bridge. MDEQ has also conducted biological sampling at a site on Cedar Creek. Based on preliminary results, the biology may be slightly impaired. However, the biologicalse data have not been finalized or fully assessed. Thus, these data are considered preliminary. Also, a stressor identification report, which would identify particular pollutants causing the biological impairment in the water body, has not been developed.

**Table 1. Total Phosphorus Data for Cedar Creek**

| Date | Time | Total Phosphorus (mg/l) |
|---|---|---|
| 9/18/1997 | 9:45 | 0.04 |
| 12/11/1997 | 12:31 | 0.01 |
| 2/5/2003 | 08:10 | 0.02 |

~~Additional biological monitoring and data assessment are planned for Cedar Creek in the future.~~

## 2.2 Assessment of Point Sources

There are currently no point sources located within this watershed.

## 2.3 Assessment of Non-Point Sources

Non-point loading of nutrients and organic material in a water body results from the transport of the pollutants into receiving waters by overland surface runoff and groundwater infiltration. Phosphorous is typically seen as the limiting nutrient in most freshwater environments. Therefore, this TMDL will only address total phosphorus. Phosphorus is primarily transported by runoff when it has been sorbed by eroding sediment. Phosphorous may not be immediately released from sediment and can sometimes reenter the water column from deposited sediment. Most non-point sources of phosphorous will have build up and then wash off during rain events. Table 2 presents typical nutrient loading ranges for various land uses.

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Table 2. 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 |


| 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 |
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| 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)

Non-point pollution sources of concern are storm drainage from disturbed areas and runoff from agricultural areas. Overland surface runoff and groundwater infiltration results in the transport of TBODu into receiving waters.

The drainage area of Cedar Creek is approximately 11,156 acres. The watershed contains many different landuse types, including forest, pasture, water, and wetlands. The landuse information given below is based on data collected by the State of Mississippi's Automated Resource Information System (MARIS) 1997. This data set is based on Landsat Thematic Mapper digital images taken between 1992 and 1993. Forest is the dominant landuse within the watershed. The landuse distribution is shown in Table 1 3 and Figure 3. Note that this landuse distribution is for the watershed area within the state of Mississippi only. Landuse data was not available for the small portion of this watershed, approximately 150 acres that are located in Alabama.

**Table 13. Landuse Distribution, Cedar Creek Watershed**

| | Urban | Forest | Cropland | Pasture | Disturbed | Water | Wetlands |
|---|---|---|---|---|---|---|---|
| Area (acres) | 0 | 8,751 | 0 | 1,217 | 653 | 4 | 531 |
| Percentage | 0% | 78% | 0% | 11% | 6% | 0% | 5% |

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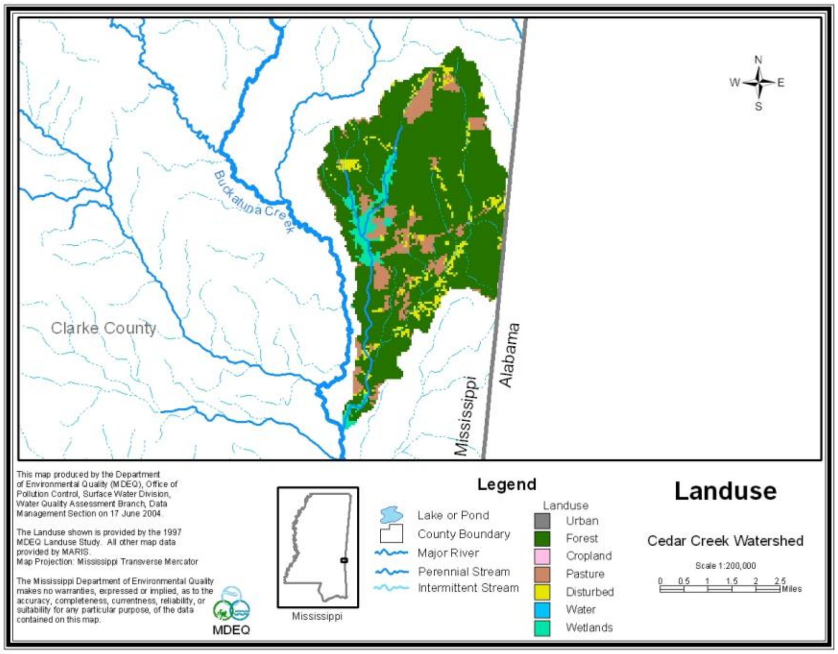



**Figure 3. Landuse Distribution for the Cedar Creek Watershed**

# MODELING PROCEDURE: LINKING THE SOURCES TO THE ENDPOINT

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

## 3.1 Modeling Framework Selection

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

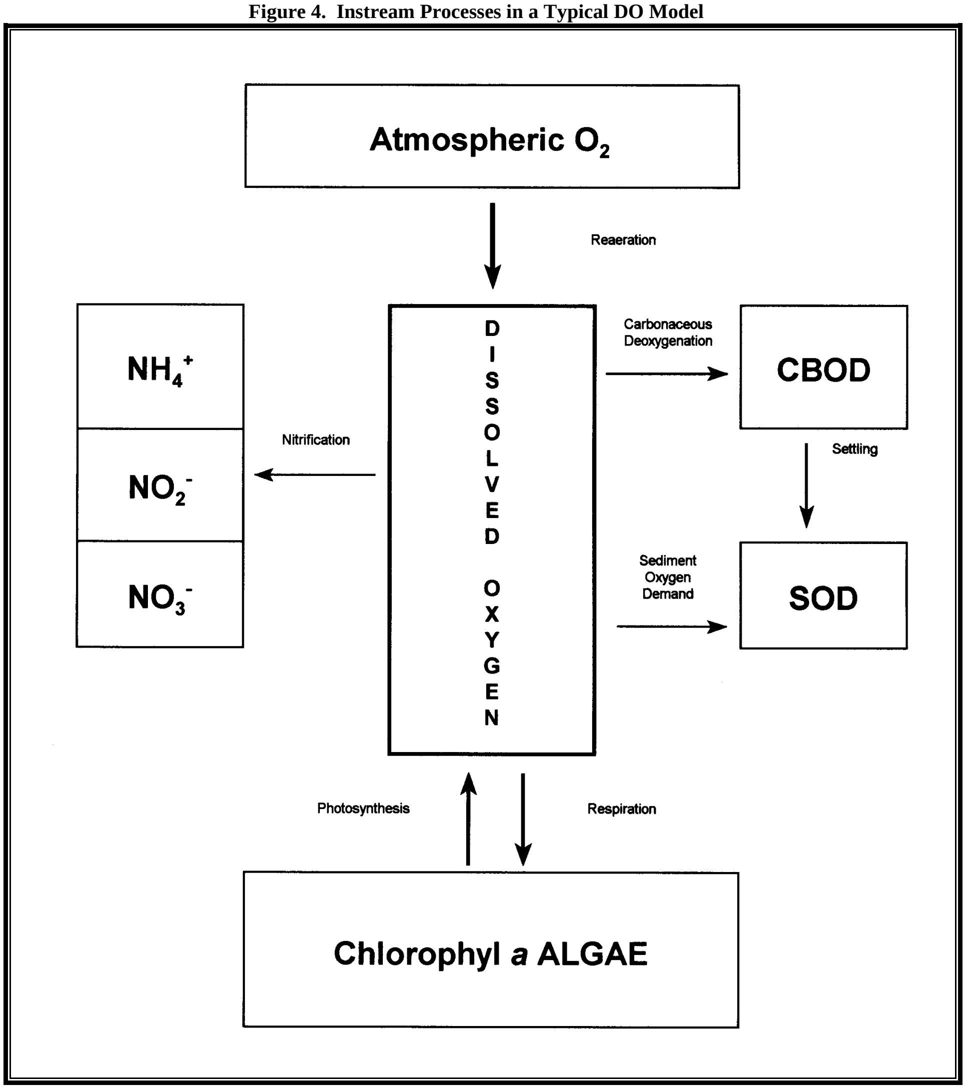
STREAM is a steady-state, daily average computer model that utilizes a modified Streeter-Phelps DO sag equation. Instream processes simulated by the model include CBODu decay, nitrification, reaeration, sediment oxygen demand, and respiration and photosynthesis of algae. Figure 4 shows how these processes are related in a typical DO model. Reaction rates for the instream processes are input by the user and corrected for temperature by the model. The model output includes water quality conditions in each computational element for DO, CBODu, and $NH_3$-N concentrations. The hydrological processes simulated by the model include stream velocity and flow from point sources and spatially distributed inputs.

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

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

C is the escape coefficient, U is the reach velocity in mile/day, and S is the average reach slope in ft/mile. The value of the escape coefficient is assumed to be 0.11 for stream reaches with flows less than 10 cfs. Reach velocities were calculated using an equation based on slope. Slopes for Cedar Creek range from 10 to 30 ft/mile.

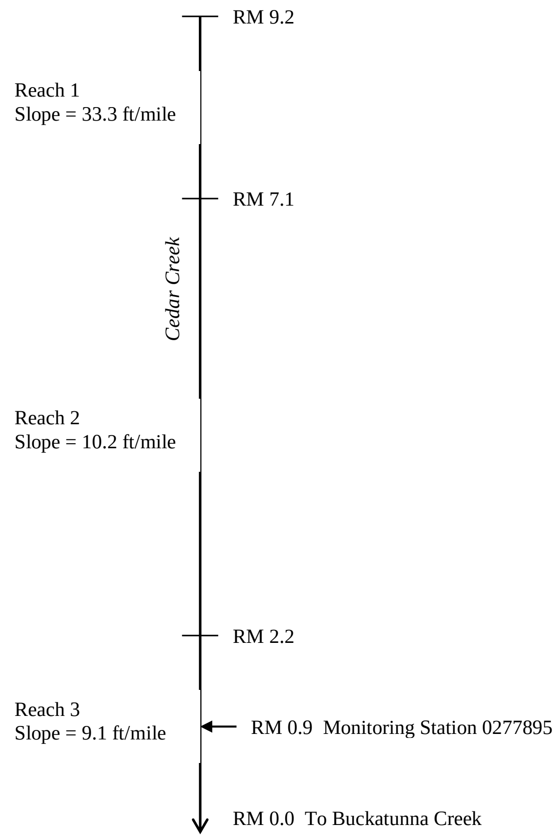
**Figure 4. Instream Processes in a Typical DO Model**




## 3.2 Model Setup

The model for Cedar Creek was developed beginning with its headwaters to its confluence with Buckatunna Creek. A diagram showing the model setup for Cedar Creek is shown in Figure 5. Arrows represent the direction of flow. The numbers on the figure represent approximate river miles (RM). River miles are assigned to water bodies, beginning with zero at the mouth.

**Figure 5. Cedar Creek Model Setup (Note: Not to Scale)**




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

The STREAM model was setup to simulate flow and temperature conditions, which were determined to be the critical condition for this TMDL. In accordance with MDEQ regulations, the temperature was set to 26°C for flows less than 50 cfs. The headwater instream DO was assumed to be 85% of saturation at the stream temperature. Rates for CBODu decay range from 0.6 to 0.3 $day^{-1}$ base *e*, based on the instream CBODu concentrations. The instream CBODu decay rate is also dependent on temperature, according to Equation 3.

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

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

The flow in Cedar Creek was modeled at 7Q10 condition based on data available from the USGS (Telis, 1992). Cedar Creek does not have a flow gage, so the flow was estimated using a drainage area ratio. Drainage area ratios represent the estimated 7Q10 flow per square mile of drainage area.

## 3.3 Source Representation

Only non-point sources were represented in the model. There are currently no NPDES permitted point sources located in the Cedar Creek Watershed. Spatially distributed loads, which represent non-point sources of flow, CBODu, and ammonia nitrogen were distributed evenly into each computational element of the modeled water body. In order to convert the ammonia nitrogen ($NH_3$-N) loads to an oxygen demand, a factor of 4.57 pounds of oxygen per pound of ammonia nitrogen ($NH_3$-N) oxidized to nitrate nitrogen ($NO_3$-N) was used. Using this factor is a conservative modeling assumption because it assumes that all of the ammonia is converted to nitrate through nitrification. The oxygen demand caused by nitrification of ammonia is equal to the NBODu load. The sum of CBODu and NBODu is equal to the load of TBODu.

Direct measurements of non-point concentrations of CBODu and $NH_3$-N were not available for the Cedar Creek Watershed. Because there were are no data available, the concentrations of CBODu and $NH_3$-N were estimated based on *Empirical Stream Model Assumptions for Conventional Pollutants and Conventional Water Quality Models* (MDEQ, 1994). According to these regulations, the concentrations assumed are CBODu = 2.0 mg/l and $NH_3$-N is 0.1 mg/l.

Non-point source flows were included in the model to account for water entering due to groundwater infiltration, overland flow, and small, unmeasured tributaries. These flows were estimated based on USGS data for the 7Q10 flow condition in the Cedar Creek Watershed. For USGS data, the drainage area ratio for the watershed is 0.01 cfs/square mile. The drainage area ratio represents the amount of flow per square mile of drainage area entering the creek during 7Q10 flow conditions. The drainage area ratio was multiplied by the drainage area of Cedar Creek to determine the amount of non-point source flow entering each reach. The drainage area ratio for Cedar Creek is 0.01 cfs/square mile. The drainage area of Cedar Creek is approximately 17 square miles. Thus, a 7Q10 flow of 0.17 cfs for the watershed was used in the model. The flows were then multiplied by the concentrations of CBODu and $NH_3$-N to calculate the non-point source loads, Table 24. The non-point source loads were assumed to be distributed evenly throughout the modeled reaches.

**Table ~~2~~4. Non-Point Source Loads Input into the Model**

| Reach | Flow (cfs) | $CBOD_u$ (mg/L) | CBODu (lbs/day) | $NH_3$-N (mg/l) | NBODu (lbs/day) | TBODu (lbs/day) |
|---|---|---|---|---|---|---|
| Reach 1 (RM 9.2 – 7.1) | 0.04 | 2 | 0.43 | 0.1 | 0.10 | 0.53 |
| Reach 2 (RM 7.1 – 2.2) | 0.09 | 2 | 0.97 | 0.1 | 0.22 | 1.19 |
| Reach 3 (RM 2.2 – 0.0) | 0.04 | 2 | 0.43 | 0.1 | 0.10 | 0.53 |
| | **0.17** | | **1.83** | | **0.42** | **2.25** |

## 3.4 Model Results

Once the model setup was complete, the model was used to predict water quality conditions in Cedar Creek. The model was first run under baseline conditions. Under baseline conditions, the non-point source loads were set at low-flow conditions, Table ~~2~~3. Thus, baseline model runs reflect the current condition of the water body at low-flow. Baseline model runs showed that the water quality standard for dissolved oxygen was not violated at any point in Cedar Creek. The model was then run using a trial-and-error process to determine the maximum TBODu loads which would not violate water quality standards for DO. These model runs are called maximum load scenarios.

### 3.4.1 Baseline Model Results

The baseline model results are shown in Figures 6 and 7. The figure shows the modeled daily average DO with the estimated non-point source loads. The figure shows the daily average instream DO concentrations, beginning with river mile 9.2 and ending with river mile 0.0 in Cedar Creek. As shown, the model predicts that the DO stays near saturation level, well above the standard of 5.0 mg/l. Baseline model output for ammonia nitrogen is shown in Figure 7. The ammonia nitrogen is also well below the water quality standard of 2.82 mg/l $NH_3$-N.

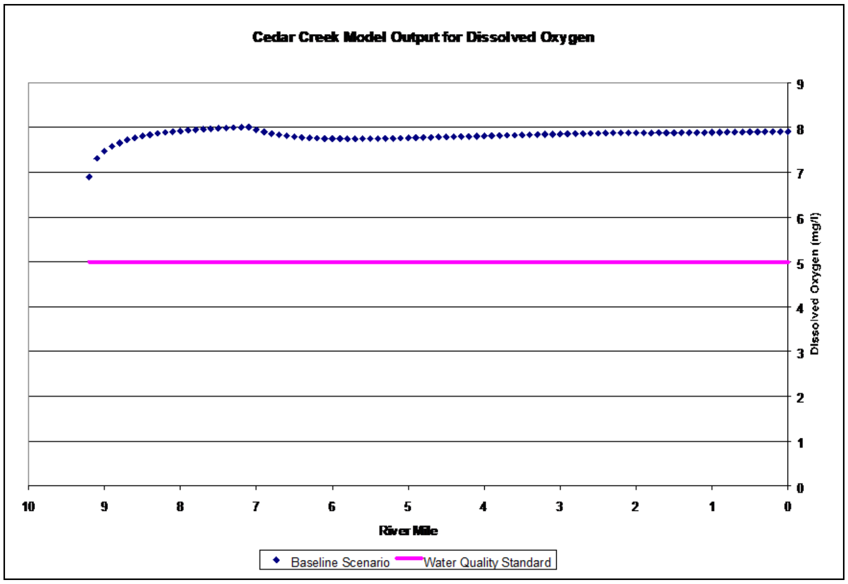



**Figure 6. Baseline Model Output for DO in Cedar Creek**

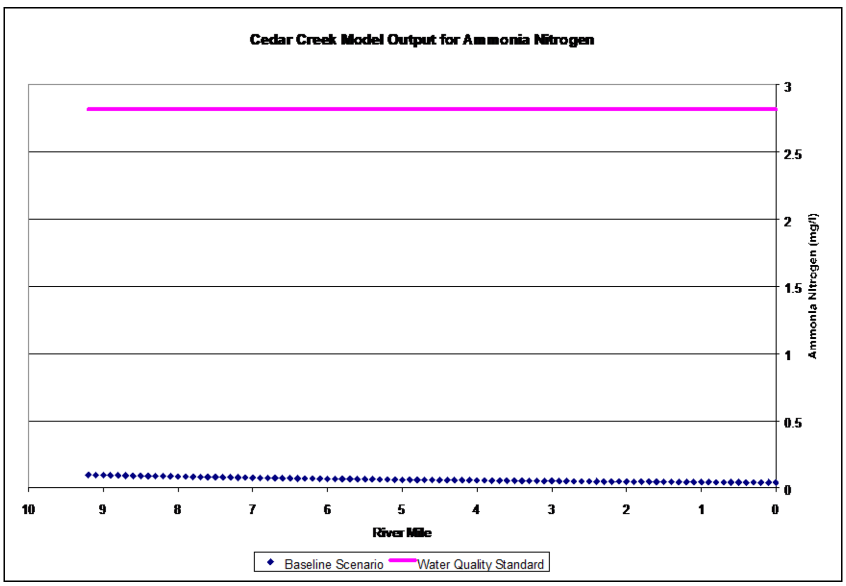



**Figure 7. Baseline Model Output for $NH_3$-N in Cedar Creek**

### 3.4.2 Maximum Load Scenario

The graph of the baseline model output shows that the predicted DO does not fall below the DO standard in Cedar Creek during critical conditions. Thus, reductions from the baseline loads of TBODu are not necessary. Calculating maximum allowable load of TBODu involved increasing the loads and running the model using a trial-and-error process until the modeled DO was just above 5.0 mg/l. The baseline non-point source loads were increased by a factor of 11.4 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 8.

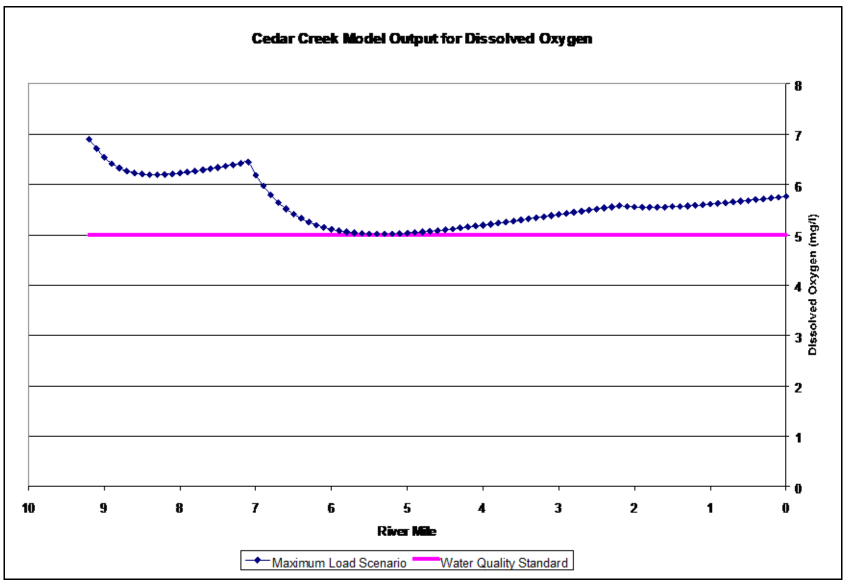



**Figure 8. Model Output for DO in Cedar Creek with Maximum Load**

## 3.5 Evaluation of Ammonia Toxicity

Ammonia must not only be considered due to its effect on dissolved oxygen in the receiving water, but also its toxicity potential. Ammonia nitrogen concentrations can be evaluated using the criteria given in 1999 Update of Ambient Water Quality Criteria for Ammonia (EPA-822-R-99-014). The maximum allowable instream ammonia nitrogen ($NH_3$-N) concentration at a pH of 7.0 and stream temperature of 26°C is 2.82 mg/l. Based on the model results from the maximum load scenario, Figure 9, this standard was not exceeded in Cedar Creek.

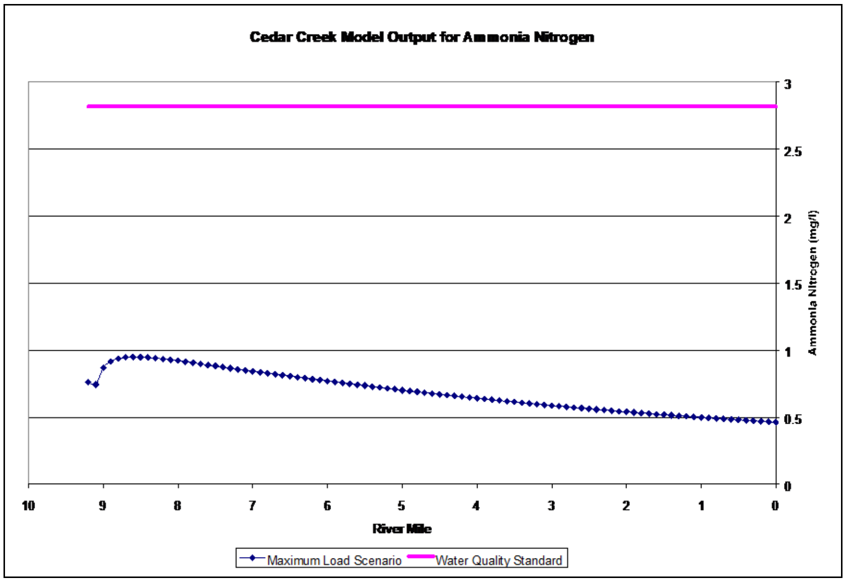



**Figure 9. Model Output for Ammonia Nitrogen in Cedar Creek with Maximum Loads**

## 3.6 Total Phosphorus Estimates

For Cedar Creek total phosphorus should be the limiting nutrient. Therefore, the nutrient estimates within this TMDL are focusing on total phosphorus. The range of the total phosphorus concentrations measured for the least-disturbed wadeable streams for all seasons in the same bioregion is 0.07 to 0.11 mg/l. Streams that are not least disturbed in this bioregion have an estimated average total phosphorus concentration of 0.22 mg/l. Cedar Creek only has 3 data points which average 0.023 mg/l., however, these data are insufficient to draw any meaningful conclusion. To convert the total phosphorus concentration to a total phosphorus load, the average annual flow for Cedar Creek was estimated based on USGS monitoring data. The annual average flow for Buckatunna Creek near Denham (02477990) is 734 cfs, with a drainage area of 492 square miles. To estimate the amount of flow in Cedar Creek, a drainage area ratio was calculated (734 cfs/492 square miles = 1.49 cfs/square mile). The ratio was then multiplied by the drainage area of the modeled segment, 11.5 square miles (1.49 cfs/square mile * 11.5 square miles = 17.1 cfs). Thus, the annual average flow in Cedar Creek is estimated as 17.1 cfs (11.0 MGD). The existing TP load was then calculated, using Equation 5 as shown below, to be 2.11 lbs/day. This load, which is entirely from non-point sources, was calculated using only the three data points available for Cedar Creek. Since, three data points is inadequate to properly access the water quality and any possible nutrient impairment in Cedar Creek this TMDL recommends a 50 to 68% reduction in nonpoint source nutrient loads for this stream based on the average values for this bioregion.

Therefore, based on the average values for this bioregion, this TMDL recommends a 50% to 68% reduction in nonpoint source nutrient loads for this stream.

**TP Load (lb/day) = Flow(MGD) *8.34 (conversion factor)* TP Concentration (mg/L) (Eq. 5)**

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# ALLOCATION

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

Nutrients were listed based on anecdotal information, not data that could be compared to a criterion. Therefore, without the "mark on the wall" to make a comparison, it is impossible to establish any TMDL limits at this time. MDEQ is making progress on this however with the Nutrient Task Force's work. In agreement with EPA Region 4, MDEQ is continuing work on a six year plan to establish criteria for nutrients in wadeable streams, non-wadeable rivers, lakes, and estuaries. Data collection efforts are well underway at this time.

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

## 4.1 Wasteload Allocation

There are currently no NPDES permits issued for the Cedar Creek Watershed. Thus, the WLA is equal to zero. Although this wasteload allocation is based on the current condition of Cedar Creek, it is not intended to prevent the issuance of permits for future facilities. This is because the model results show that Cedar Creek has additional assimilative capacity for organic material. Future permits will be considered on a case-by-case basis as long as they are within the maximum allowable load given in this TMDL. Nutrient monitoring will be required in all NPDES permits considered for discharge into Cedar Creek.

## 4.2 Load Allocation

The non-point source loads are included in the load allocation. The TBODu concentrations of these loads were determined by using an assumed CBODu concentration of 2.0 mg/L and an $NH_3$-N concentration of 0.1 mg/l. This TMDL does not require a reduction of the BOD load allocation. This TMDL does does not require recommend a 50% to 68% reduction of the total phosphorus load allocation.

In Table 3 5 the load allocation is shown for each reach included in the model. The load allocation consists of the estimated loads at the 7Q10 flow multiplied by a factor of 11.4.

**Table ~~3~~5. Load Allocation**

| Reach | CBODu (lbs/day) | NBODu (lbs/day) | TBODu (lbs/day) |
|---|---|---|---|
| Reach 1 (RM 9.2 – 7.1) | 4.9 | 1.1 | 6.0 |
| Reach 2 (RM 7.1 – 2.2) | 11.4 | 2.6 | 14.0 |
| Reach 3 (RM 2.2 – 0.0) | 5.1 | 1.2 | 6.3 |
| | **21.4** | **4.9** | **26.3** |

## 4.3 Incorporation of a Margin of Safety

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

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.

## 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~~5~~.

**TMDL = WLA + LA + MOS** **(Equation 6~~5~~)**

Where WLA is the wasteload allocation, LA is the load allocation, and MOS is the margin of safety. All units are in lbs/day of TBODu. The phase 1 TMDL for TBODu was calculated based on the maximum allowable loading of the pollutants in Cedar Creek. The TMDL calculations are shown in Table ~~4~~6. As shown in the table, TBODu is the sum of CBODu and NBODu. The load allocation includes the non-point sources of TBODu and $NH_3$-N from surface runoff and groundwater infiltration. The wasteload allocation in this TMDL is zero because there are currently no NPDES facilities. However, NPDES permits may be allowed in the future as long as the load does not violate the TMDL. The implicit margin of safety for this TMDL is derived from the conservative assumptions used in setting up the model.

**Table ~~4~~6. Phase 1 TMDL for TBODu in the Cedar Creek Watershed**

| | WLA (lbs/day) | LA (lbs/day) | MOS | TMDL (lbs/day) |
|---|---|---|---|---|
| CBODu | 0.0 | 21.4 | Implicit | 21.4 |
| NBODu | 0.0 | 4.9 | Implicit | 4.9 |
| **TBODu** | **0.0** | **26.3** | | **26.3** |

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

## 4.6 Reasonable Assurance

This component of the TMDL development does not apply to this TMDL Report. There are no point sources (WLA) requesting a reduction based on promised LA components and reductions.

# CONCLUSION

This Phase 1 TMDL is based on a desktop model using MDEQ's regulatory assumptions and literature values in place of actual field data. The model results indicate that Cedar 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 Cedar Creek. This report has been developed as a Phase 1 TMDL so that specific nutrient species may be evaluated when more data are available and water quality standards are developed for nutrients.

This TMDL recommends quarterly nutrient monitoring for any future NPDES permits issued to discharge into Cedar Creek to develop information for the Nutrient Task Force development of criteria and a phase 2 TMDL. Additionally, it is recommended that the Cedar Creek watershed be considered a priority for stream bank and riparian buffer zone restoration and any nutrient reduction BMPs, especially for agricultural activities. The implementation of these BMP activities should reduce the nutrient load entering Cedar Creek. This will provide improved habitat for the support of aquatic life in the water body and will result in the attainment of the applicable water quality standards.
This report has been developed as a Phase 1 TMDL so that specific nutrient species may be evaluated when more data are available and water quality standards are developed for nutrients.

## 5.1 Future Monitoring

Additional monitoring needed for model refinement may be prioritized by the local stakeholders, MDEQ, and EPA. MDEQ has adopted the Basin Approach to Water Quality Management, a plan that divides Mississippi's major drainage basins into five groups. During each year-long cycle, MDEQ's resources for water quality monitoring will be focused on one of the basin groups. During the next monitoring phase in the Pascagoula River Basin, the Cedar Creek Watershed may receive additional monitoring to identify any change in water quality.

## 5.2 Public Participation

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

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

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# DEFINITIONS

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

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

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

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

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

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

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

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

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

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

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

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

**Conventional Lagoon**: An un-aerated, relatively shallow body of water contained in an earthen basin of controlled shape and designed for the purpose of treating water.

**Critical Condition**: Hydrologic and atmospheric conditions in which the pollutants causing impairment of a water body have their greatest potential for adverse effects.

**Daily Discharge**: The "discharge of a pollutant" measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. For pollutants with limitations expressed in units of mass, the "daily discharge" is calculated as the total mass of the pollutant discharged over the day. For pollutants with limitations expressed in other units of measurement, the "daily average" is calculated as the average.

**Designated Use**: Use specified in water quality standards for each water body or segment regardless of actual attainment.

**Discharge Monitoring Report**: Report of effluent characteristics submitted by a NPDES Permitted facility.

**Dissolved Oxygen**: The amount of oxygen dissolved in water. It also refers to a measure of the amount of oxygen that is available for biochemical activity in a water body. The maximum concentration of dissolved oxygen in a water body depends on temperature, atmospheric pressure, and dissolved solids.

**Dissolved Oxygen Deficit**: The saturation dissolved oxygen concentration minus the actual dissolved oxygen concentration.

**DO Sag**: Longitudinal variation of dissolved oxygen representing the oxygen depletion and recovery following a waste load discharge into a receiving water.

**Effluent Standards and Limitations**: All State or Federal effluent standards and limitations on quantities, rates, and concentrations of chemical, physical, biological, and other constituents to which a waste or wastewater discharge may be subject under the Federal Act or the State law. This includes, but is not limited to, effluent limitations, standards of performance, toxic effluent standards and prohibitions, pretreatment standards, and schedules of compliance.

**Effluent**: Treated wastewater flowing out of the treatment facilities.

**First Order Kinetics**: Describes a reaction in which the rate of transformation of a pollutant is proportional to the amount of that pollutant in the environmental system.

**Groundwater**: Subsurface water in the zone of saturation. Groundwater infiltration describes the rate and amount of movement of water from a saturated formation.

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

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

**Load Allocation (LA)**: The portion of receiving water's loading capacity attributed to or assigned to non-point sources (NPS) or background sources of a pollutant

**Loading**: The total amount of pollutants entering a stream from one or multiple sources.

**Mass Balance**: An equation that accounts for the flux of mass going into a defined area and the flux of mass leaving a defined area, the flux in must equal the flux out.

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

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

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

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

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

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

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

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

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

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

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

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

**Storm Runoff**: Rainfall that does not evaporate or infiltrate the ground because of impervious land surfaces or a soil infiltration rate than rainfall intensity, but instead flows into adjacent land or water bodies or is routed into a drain or sewer system.

**Streeter-Phelps DO Sag Equation**: An equation which uses a mass balance approach to determine the DO concentration in a water body downstream of a point source discharge. The equation assumes that the stream flow is constant and that CBODu exertion is the only source of DO deficit while reaeration is the only sink of DO deficit.

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

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

**Total Maximum Daily Load or TMDL**: The calculated maximum permissible pollutant loading to a water body at which water quality standards can be maintained.

**Waste**: Sewage, industrial wastes, oil field wastes, and all other liquid, gaseous, solid, radioactive, or other substances which may pollute or tend to pollute any waters of the State.

**Wasteload Allocation (WLA)**: The portion of a receiving water's loading capacity attributed to or assigned to point sources of a pollutant.

**Water Quality Standards**: The criteria and requirements set forth in *State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters*. Water quality standards are standards composed of designated present and future most beneficial uses (classification of waters), the numerical and narrative criteria applied to the specific water uses or classification, and the Mississippi antidegradation policy.

**Water Quality Criteria**: Elements of State water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports the present and future most beneficial uses.

**Waters of the State**: All waters within the jurisdiction of this State, including all streams, lakes, ponds, wetlands, impounding reservoirs, marshes, watercourses, waterways, wells, springs, irrigation systems, drainage systems, and all other bodies or accumulations of water, surface and underground, natural or artificial, situated wholly or partly within or bordering upon the State, and such coastal waters as are within the jurisdiction of the State, except lakes, ponds, or other surface waters which are wholly landlocked and privately owned, and which are not regulated under the Federal Clean Water Act (33 U.S.C.1251 et seq.).

**Watershed**: The area of land draining into a stream at a given location.

# ABBREVIATIONS

7Q10 .......................... Seven-Day Average Low Stream Flow with a Ten-Year Occurrence Period

BMP .......................... Best Management Practice

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

CBODu .......................... Carbonaceous Ultimate Biochemical Oxygen Demand

CWA .......................... Clean Water Act

DMR .......................... Discharge Monitoring Report

DO .......................... Dissolved Oxygen

EPA .......................... Environmental Protection Agency

GIS .......................... Geographic Information System

HUC .......................... Hydrologic Unit Code

LA .......................... Load Allocation

MARIS .......................... Mississippi Automated Resource Information System

MDEQ .......................... Mississippi Department of Environmental Quality

MGD .......................... Million Gallons per Day

MOS .......................... Margin of Safety

NBODu .......................... Nitrogenous Ultimate Biochemical Oxygen Demand

$NH_3$ .......................... Total Ammonia

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

$NO_2$+ $NO_3$ .......................... Nitrite Plus Nitrate

NPDES .......................... National Pollution Discharge Elimination System

POTW .......................... Public Owned Treatment Works

RBA .......................... Rapid Biological Assessment

TBODu........................................................................Total Ultimate Biochemical Oxygen Demand

TKN ........................................................................................................Total Kjeldahl Nitrogen

TN .....................................................................................................................Total Nitrogen

TOC............................................................................................................ Total Organic Carbon

TP.............................................................................................................. Total Phosphorous

USGS ...................................................................................... United States Geological Survey

WLA ........................................................................................................ Waste Load Allocation