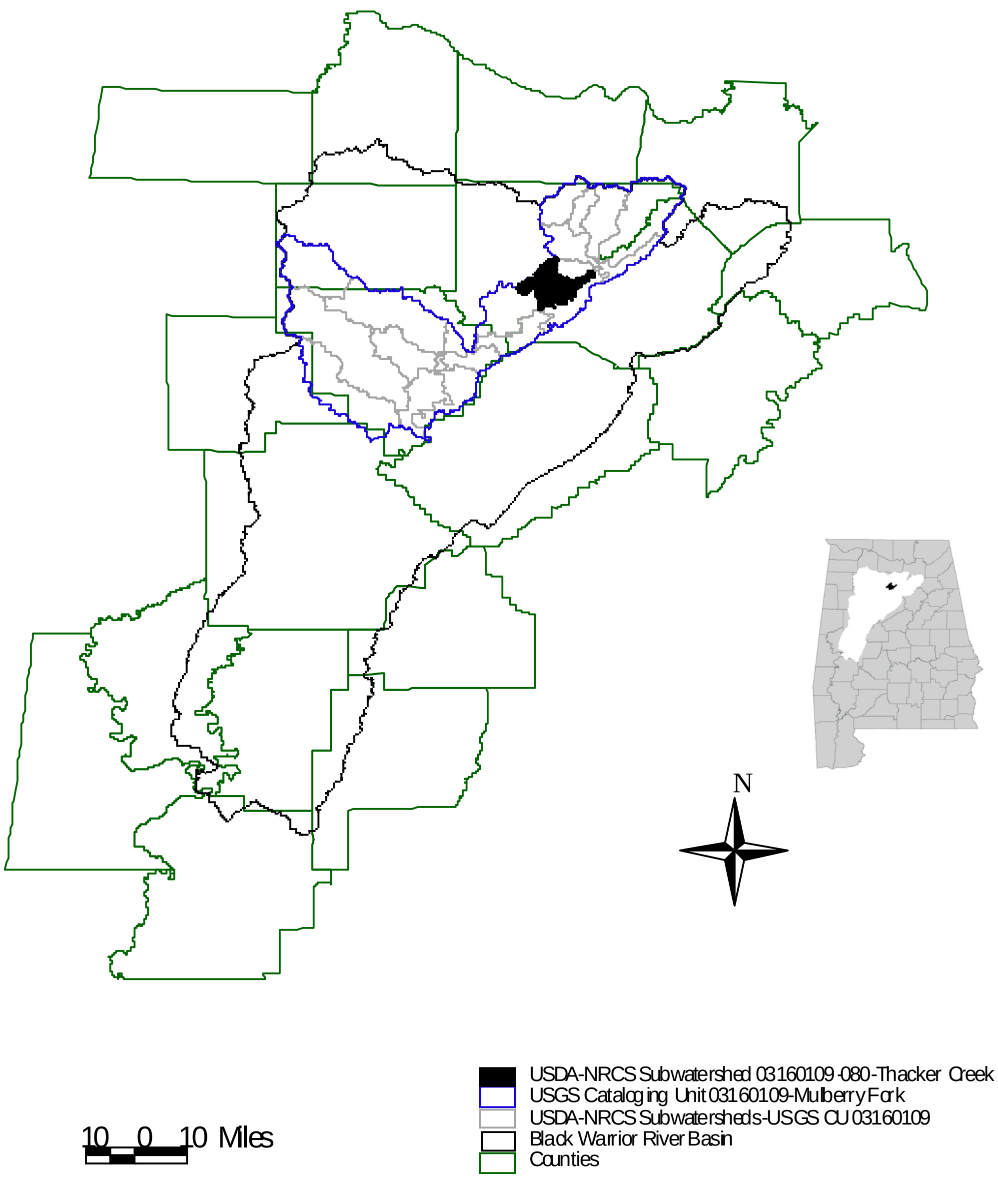
Alabama Department of Environmental Management

Final TMDL Development for

Thacker Creek AL/03160109-080-01
Low Dissolved Oxygen/Organic Loading
Ammonia as Nitrogen

Water Quality Branch
Water Division
February 2002

Thacker Creek Watershed in the Black Warrior Basin



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1.0 Executive Summary

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

The amount and quality of 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 land use within the watershed. In some cases, additional water quality data may indicate that no impairment exists.

Thacker Creek, a part of the Black Warrior basin, is located in Cullman County near Hanceville. It has been on the State of Alabama's §303(d) use impairment list since 1992 for organic enrichment/low dissolved oxygen (O.E./D.O.) and ammonia as nitrogen (NH_3-N). Its use classification is Fish and Wildlife.

Water quality data or information collected in 1992 identified dissolved oxygen impairments for Thacker Creek. The stream flows during periods of impairment were typically at, or below, the $7Q_{10}$ (the minimum 7-day average flow that occurs once in 10 years on average). Since the D.O. impairments were clearly driven by low flows and high temperatures, occurring during the summer months, a steady state modeling approach was adopted as appropriate for the TMDL analysis.

The following report addresses the results of the TMDL analysis for O.E./D.O and ammonia as nitrogen (NH_3-N). In accordance with ADEM water quality standards, the minimum dissolved oxygen concentration in a stream classified as Fish and Wildlife is 5.0 mg/l. In the absence of a numerical state water quality standard for ammonia as nitrogen, the EPA's ambient water quality chronic criterion for ammonia as nitrogen in a stream classified as Fish and Wildlife at a pH of 6.72 s.u. is 2.69 mg/l. For the purpose of this TMDL, a minimum dissolved oxygen level of 5.0 mg/l and an ammonia as nitrogen chronic toxicity criterion of 2.69 mg/l will be implemented allowing for an implicit margin of safety resulting from conservative assumptions used in the dissolved oxygen model.

A summary of the TMDL for the watershed is provided in the table presented on the next page. The pollutants shown in the table include ultimate carbonaceous biochemical oxygen demand ($CBOD_u$) and nitrogenous biochemical oxygen demand (NBOD), and ammonia as nitrogen (NH_3-N), which is a component of NBOD. $CBOD_u$ and NBOD are the principle causes for observed low dissolved oxygen concentrations. $CBOD_u$ is a measure of the total amount of oxygen required to degrade the carbonaceous portion of the organic matter present in the water. NBOD is the amount of oxygen utilized by bacteria as they convert ammonia to nitrate. Because organic nitrogen can be converted to ammonia, its potential oxygen demand is included in the NBOD component of the TMDL. The first table lists allowable pollutant loadings by source (point and non-point sources) for the summer season (May through November.

Table 1-1. Maximum Allowable Pollutant Loads by Source – Summer

Pollutant	Point Source Loads (lbs./day)	Non-point Source Loads (lbs./day)
$CBOD_u$	0	24.8
NBOD	0	26.7
Total	0	51.5
NH_3-N	0	0.7

2.0 Basis for §303(d) Listing

2.1 Introduction

Section 303(d) of the Clean Water Act (CWA) as amended by the Water Quality Act of 1987 and EPA's Water Quality Planning and Management Regulations [(Title 40 of the Code of Federal Regulations (CFR), Part 130)] require states to identify waterbodies which are not meeting water quality standards applicable to their designated use classifications. The identified waters are prioritized based on severity of pollution with respect to designated use classifications. Total maximum daily loads (TMDLs) for all pollutants causing violation of applicable water quality standards are established for each identified water. Such loads are established at levels necessary to implement the applicable water quality standards with seasonal variations and margins of safety. The TMDL process establishes the allowable loading of pollutants, or other quantifiable parameters for a waterbody, based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water-quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources (USEPA, 1991).

The State of Alabama has identified Thacker Creek as being impaired by organic loading (i.e., $CBOD_u$ and NBOD) and ammonia as nitrogen for a length of 9.5 miles, as reported on the 1992, 1994, 1996, 1998, and draft 2000 §303(d) list(s) of impaired waters. Thacker Creek is prioritized as "high" on the list(s). Thacker Creek is located in Cullman County and lies within the Thacker Creek watershed of the Black Warrior basin.

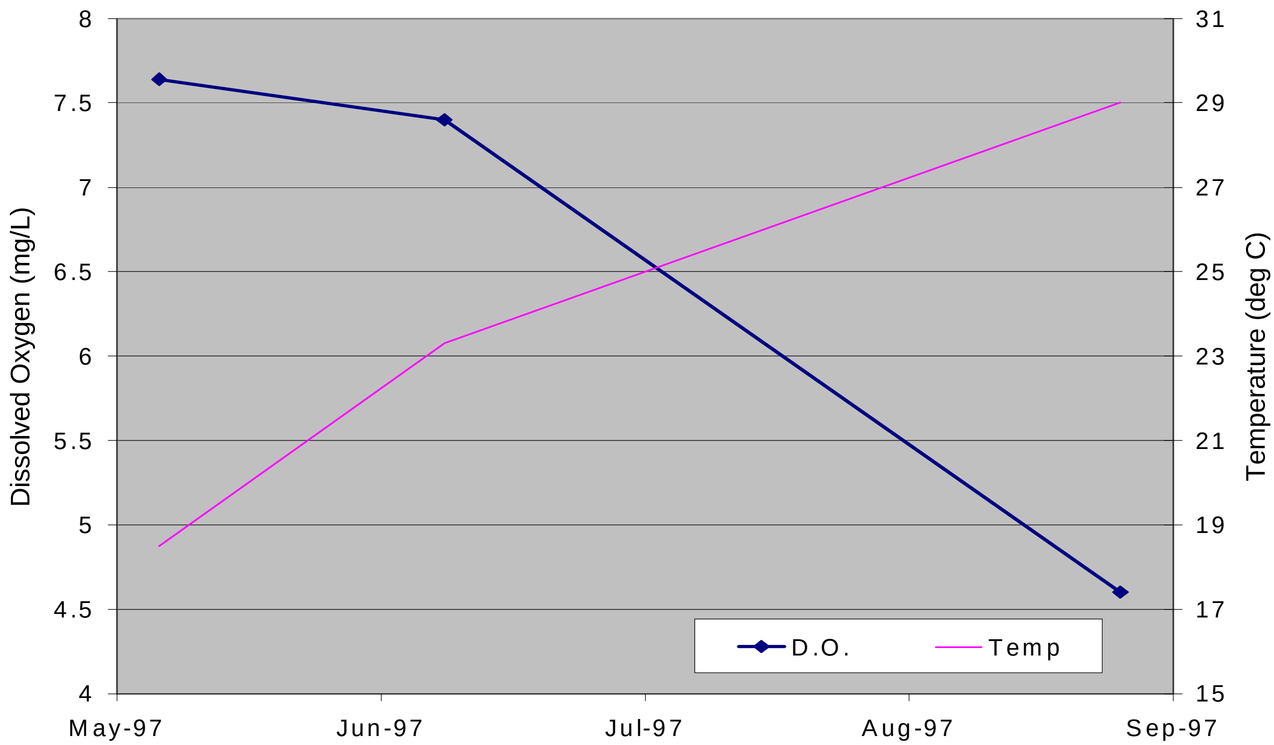
The TMDL developed for Thacker Creek illustrates the steps that can be taken to address a waterbody impaired by low dissolved oxygen levels and ammonia as nitrogen. The TMDL is consistent with a phased-approach: estimates are made of needed pollutant reductions, load reduction controls are implemented, and water quality is monitored for plan effectiveness. Flexibility is built into the plan so that load reduction targets and control actions can be reviewed if monitoring indicates continuing water quality problems.

2.2 Problem Definition

Thacker Creek is a small, headwater stream with a relatively small drainage area of 15.0 miles. Dry weather flows for the watershed are relatively low, or zero. Water quality data collected for the watershed during May 1997 thought August 1997, indicates that dissolved oxygen and ammonia as nitrogen impairments occurred primarily during the summer months (May through November). The percentage of the dissolved oxygen and ammonia as nitrogen data not meeting the minimum water quality standard are 22.2% and 0%, respectively. Generally, depressed in-stream D.O. concentrations may be caused by several sources including the decay of oxygen demanding waste from both point and non-point sources, algal respiration, sediment oxygen demand or other sources. It is believed based on available data that the low dissolved oxygen concentrations observed in this watershed are due to nonpoint source run off combined with persistent flow conditions at or below the $7Q_{10}$ and high temperatures, occurring during summer months, and are not the result of algal dynamics.

Figure 2.1 below illustrates the dissolved oxygen versus temperature data available for Thacker Creek.

Figure 2.1 Dissolved Oxygen vs. Temperature Data



Waterbody Impaired:	Thacker Creek from Mulberry Fork to its source
Water Quality Standard Violation:	Dissolved Oxygen/Ammonia as Nitrogen
Pollutant of Concern:	Organic Enrichment ($CBOD_u$/NBOD) and Ammonia as Nitrogen (NH_3-N)
Water Use Classification:	Fish and Wildlife

The impaired stream segment, Thacker Creek, is classified as Fish and Wildlife. Usage of waters in this classification is described in ADEM Admin. Code R. 335-6-10-.09(5)(a), (b), (c), and (d).

(a) Best usage of waters:

Fishing, propagation of fish, aquatic life, and wildlife, and any other usage except for swimming and water-contact sports or as a source of water supply for drinking or food processing purposes.

(b) Conditions related to best usage:

The waters will be suitable for fish, aquatic life and wildlife propagation. The quality of salt and estuarine waters to which this classification is assigned will also be suitable for the propagation of shrimp and crabs.

(c) Other usage of waters:

It is recognized that the waters may be used for incidental water contact and recreation during June through September, except that water contact is strongly discouraged in the vicinity of discharges or other conditions beyond the control of the Department or the Alabama Department of Public Health.

(d) Conditions related to other usage:

The waters, under proper sanitary supervision by the controlling health authorities, will meet accepted standards of water quality for outdoor swimming places and will be considered satisfactory for swimming and other whole body water-contact sports.

Low D.O./Organic Loading Criteria:

Alabama's water quality criteria document (ADEM Admin. Code R. 335-6-10-.09-(5)(e)(4.)) states that for a diversified warm water biota, including game fish, daily dissolved oxygen concentrations shall not be less than 5 mg/l at all times; except under extreme conditions due to natural causes, it may range between 5 mg/l and 4 mg/l, provided that the water quality is favorable in all other parameters. The normal seasonal and daily fluctuations shall be maintained above these levels. In no event shall the dissolved oxygen level be less than 4 mg/l due to discharges from existing hydroelectric generation impoundments. All new hydroelectric generation impoundments, including addition of new hydroelectric generation units to existing impoundments, shall be designed so that the discharge will contain at least 5 mg/l dissolved oxygen where practicable and technologically possible. The Environmental Protection Agency, in cooperation with the State of Alabama and parties responsible for impoundments, shall develop a program to improve the design of existing facilities.

Ammonia as Nitrogen Criteria

Alabama's water quality criteria document (ADEM Admin. Code R. 335-6-10) does not contain a numeric water quality standard for ammonia as nitrogen. However, in applying the following narrative standard found at ADEM Admin. Code R. 335-6-10-.06(c) the Department has relied upon the United States Environmental Protection Agency's (EPA) latest water quality criteria for ammonia.

> (c) State waters shall be free from substances attributable to sewage, industrial wastes or other wastes in concentrations or combinations which are toxic or harmful to human, animal or aquatic life to the extent commensurate with the designated usage of such waters.

The Municipal Branch and the Industrial Section of the Water Division of ADEM have adopted as policy EPA's ammonia criteria for purposes of developing permit limits in National Pollutant Discharge Elimination System (NPDES) permits. The EPA's *1998 Update of Ambient Water Quality Criteria for Ammonia*, EPA 822-R-98-008, provides the following equation for calculating Criteria Continuous Concentration (CCC) or the chronic criterion. This criterion is applied in streams with a designated use of Fish and Wildlife or higher.

$$CCC = \frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}},\ mg/l\ \ NH_3\text{-}N$$

This equation indicates that allowable in-stream ammonia concentration decreases as pH increases. For Thacker Creek, the maximum pH value measured was 6.72 s.u. which results in a CCC value of 2.69 mg/l NH_3-N.

Another consideration in establishing an allowable in-stream ammonia concentration is its effect on the stream's dissolved oxygen (D.O.) concentration due to ammonia being converted to nitrite and then to nitrate. Oxygen is consumed in the process. A water quality model that accounts for this process, known as nitrification, is used to ensure that D.O. concentrations remain above the applicable water quality standard. For Thacker Creek the D.O. standard is 5.0 mg/l.

3.0 Technical Basis for TMDL Development

3.1 Water Quality Target Identification

The minimum dissolved oxygen concentration in a stream classified as Fish and Wildlife is 5.0 mg/l. For the purpose of this TMDL, a minimum dissolved oxygen level of 5.0 mg/l will be implemented allowing for an implicit margin of safety resulting from conservative assumptions used in the dissolved oxygen model. The target $CBOD_u$ and NBOD concentrations are concentrations that, in concert with the nitrification of ammonia, will not deplete the dissolved oxygen concentration below this level as a result of the decaying process.

The EPA's ambient water quality chronic criterion for ammonia as nitrogen in stream classified as Fish and Wildlife at a pH 6.71 s.u. is 2.69 mg/l. For the purposes of establishing a TMDL for ammonia as nitrogen both the CCC value and the ammonia as nitrogen concentration predicted by the dissolved oxygen model is considered and the lower concentration controlled the allowable ammonia as nitrogen loading.

3.2 Source Assessment

3.2.1. General Sources of $CBOD_u$, NBOD, and NH_3-N

Both point and non-point sources may contribute $CBOD_u$ and NBOD, including the ammonia as nitrogen component, (i.e., organic loading) to a given waterbody. Potential sources of organic loading are numerous and often occur in combination. In rural areas, storm runoff from row crops, livestock pastures, animal waste application sites, and feedlots can transport significant loads of organic loading. Nationwide, poorly treated municipal sewage comprises a major source of organic compounds that are hydrolyzed to create additional organic loading. Urban storm water runoff, sanitary sewer overflows, and combined sewer overflows can be significant sources of organic loading.

All potential sources of organic loading in the watershed were identified based on an evaluation of current land use/cover information on watershed activities (e.g., agricultural management activities). The source assessment was used as the basis of development of the model and ultimate analysis of the TMDL allocations. The organic loading assessment within the watershed included both point and non-point sources.

3.2.2. Point Sources in the Thacker Creek Watershed

ADEM maintains a database of current NPDES permits and GIS files that locate each permitted outfall. This database includes municipal, semi-public/private, industrial, mining, industrial storm water, and concentrated animal feeding operations (CAFOs) permits. Table 3-1, below, shows the permitted point sources in the watershed that discharge into or upstream of the impaired segment. Included in Table 3-1 is the percent of the facility wastewater flow to the $7Q_{10}$. Table 3-2 contains the permit limitations for the significant point sources that were considered in the model development. As indicated in these tables there are no point sourses in the Thacker Creek water shed.

Table 3-1. Contributing Point Sources in the Waterbody Name Watershed.

NPDES Permit	Type of Facility (e.g., CAFO, Industrial, Municipal, Semi-Public/Private, Mining, Industrial Storm Water)	Facility Name	Significant Contributor (Yes/No) (% of $7Q_{10}$)
N/a	None		

Note: Storm water discharges listed in the above table were marked as not being significant contributors since the discharge would not occur during low flow conditions. Construction storm water discharges are not listed as these discharges do not occur during low flow and generally do not contribute directly to the organic loading.

Table 3-2. NPDES Permit Limits for Significant Contributing Point Sources

NPDES Permit	Facility Name	Permit Limtations - Summer							Permit Limtations - Winter						
		Flow (MGD)		BOD_5 (MG/L)		NH_3-N (MG/L)		DO (MG/L)	Flow (MGD)		BOD_5 (MG/L)				
		Max	Avg	Max	Avg	Max	Avg	Min	Max	Avg	Max	Avg	Max	Avg	Min
N/a															

Notes: n/a = not applicable. Flows listed for municipal and industrial permits are design flow and long term average flows, respectively. The flows listed for industrial permits may or may not be limited by the permit, but are included for the purpose of calculating the percent of the $7Q_{10}$.

3.2.3. Non-Point Sources in the Thacker Creek Watershed

Shown in Table 3-3, below, is a detailed summary of land usage in the Thacker Creek watershed. A land use map of the watershed is presented in Figure 3-1. The predominant land uses within the watershed are forest, pasture/hay, and row crops. Their respective percentages of the total watershed are 85.81%, 8.87%, and 3.07%.

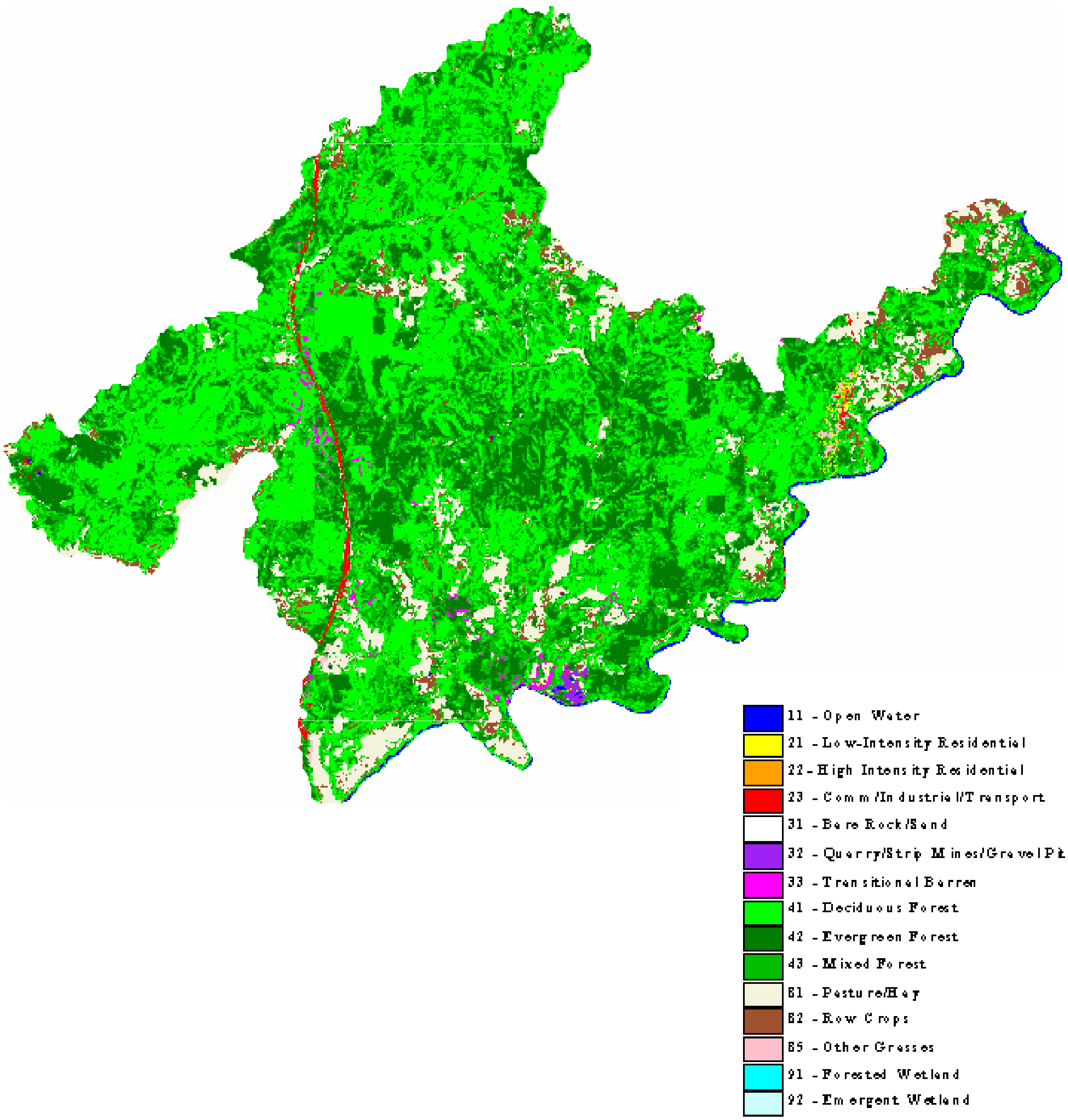
Table 3-3. Land Use in the Thacker Creek Watershed.

LAND USE	PERCENTAGE
Open Water	0.65
Low-Intensity Industrial Residential	0.12
Commercial/Industrial/Transport	0.62
Quarry/Strip Mine/Gravel Pits	0.14
Transitional Barren	0.48
Deciduous Forest	38.97
Evergreen Forest	19.48
Mixed Forest	27.36
Pasture/Hay	8.87
Row Crops	3.07
Other Grasses	0.22
Emergent Wetlands	0.02

The predominant land uses of forest, pasture/hay, and row crops make up 97.75% of the watershed. The other 2.25% of the land uses, except open water, was combined into one category (other) for modeling purposes. Each land use has the potential to contribute to the organic loading in the watershed due to organic material on the land surface that potentially can be washed off into the receiving waters of the watershed. Information on agricultural and management activities and watershed characteristics were obtained through coordination with the ADEM Mining and Non-Point Section, the Alabama Cooperative Extension System, and the USDA-Natural Resources Conservation Service (NRCS).

The major sources of organic enrichment from non-point sources within the Thacker Creek watershed are the forest, pasture/hay, and row crops land uses. Compared to other land uses organic enrichment from forested land is normally considered to be small. This is because forested land tends to serve as a filter of pollution originating within its drainage areas. However, organic loading can originate from forested areas due to the presence of wild animals such as deer, raccoons, turkeys, waterfowl, etc. Control of these sources is usually limited to land management best management practices (BMPs) and may be impracticable in most cases. In contrast to forested land, agricultural land can be a major source of organic loading. Runoff from pastures, animal operations, improper land application of animal wastes, and animals with access to streams are all mechanisms that can introduce organic loading to waterbodies.

Figure 3-1. Land Use Map for the Thacker Creek Watershed.



3.3 Loading Capacity – Linking Numeric Water Quality Targets and Pollutant Sources

EPA regulations define loading, or assimilative capacity, as the greatest amount of loading that a waterbody can receive without violating water quality standards (40 CFR Part 130.2(f)).

Alabama's water quality criteria document (ADEM Admin. Code R. 335-6-10-.09-(4)(e)(4.)) states that for a diversified warm water biota, including game fish, daily dissolved oxygen concentrations shall not be less than 5 mg/l at all times; except under extreme conditions due to natural causes, it may range between 5 mg/l and 4 mg/l, provided that the water quality is favorable in all other parameters. The normal seasonal and daily fluctuations shall be maintained above these levels.

The EPA's ambient water quality chronic criterion for ammonia as nitrogen in a stream classified as Fish and Wildlife at a pH of 6.72 s.u. is 2.69 mg/l. For the purposes of establishing a TMDL for ammonia as nitrogen both the CCC value and the ammonia as nitrogen concentration predicted by the dissolved oxygen model is considered and the lower concentration is used to compute allowable loading. For this TMDL the ammonia as nitrogen oxygen demand was the limiting factor.

Using the D.O. water quality criterion of 5.0 mg/l and the ammonia as nitrogen chronic criterion of 2.69 mg/l as the numerical targets, a TMDL model analysis was performed at critical conditions (i.e., summer) to determine the loading capacity for the watershed. This was accomplished through a series of simulations aimed at meeting the dissolved oxygen target limit by varying source contributions. The final acceptable simulation represented the TMDL (and loading capacity of the waterbody). If point sources were identified in the watershed, an additional model analysis was performed for the winter to determine the loading capacity during higher flow conditions.

In the TMDL model analysis, the pollutant concentrations from forestland were assumed to be at normal background concentrations. Specific values for background pollutant concentrations are as follows: 2 mg/l $CBOD_u$, 0.5 mg/l ammonia oxygen demand (NH_3OD_U), and 1 mg/l total organic nitrogen oxygen demand ($TONOD_u$). Pollutant concentrations for the other land uses in the watershed were assigned in proportion to measured concentrations and were set in the TMDL model at levels necessary to maintain dissolved oxygen concentrations greater than, or equal to, 5 mg/l. The model predictions for in-stream pollutant concentrations were then compared to actual field data. The model velocities and reaeration coefficients were adjusted in those cases where the field data indicated significant discrepancies from the model predictions.

3.4 Data Availability and Analysis

3.4.1. Watershed Characteristics

A. General Description: Thacker Creek, located in Cullman County, is a tributary to the Mulberry Fork. The Thacker Creek is a part of the Black Warrior River basin. Thacker Creek is a part of the USGS (United States Geological Survey) AL/03160109 cataloging unit and the NRCS (Natural Resources Conservation Service) 080 sub-watershed.

   Thacker Creek begins approximately 4 miles south east of Hanceville in Section 3, Township 3 W., and Range 12 S. It has a linear distance of 8.91 miles and a total drainage area of 15.0 square miles. Thacker Creek has a use classification of Fish & Wildlife (F&W).

B. Geological Description: The main rock type in the region is sand, conglomerate, shale, siltstone, and coal. There is a Pottsville Formation in the lower part of the region.

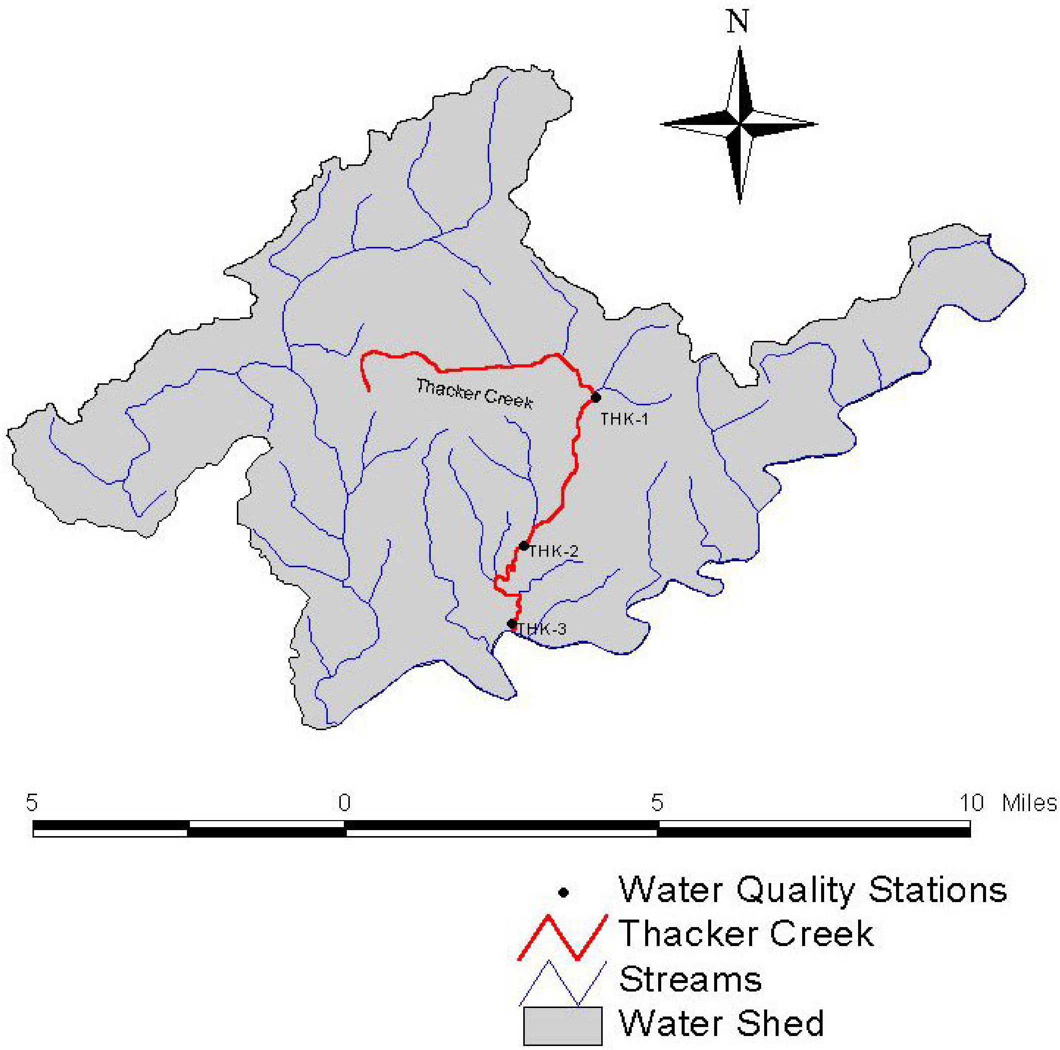
C. Eco-region Description: The Dissected Plateau is so strongly dissected that it no longer has a typical plateau appearance such as in 68a or d. The rugged, mostly forested region contains predominantly strongly sloping land, some steep-sided gorges and sandstone cliffs, and relief of 300-400 feet. The cool canyons and valleys often contain plant and animal species usually found further north. The Bankhead National Forest occupies a large portion of 68e, providing public recreation, wilderness, and forestry areas. Most of the region is drained by the Sipsey Fork of the Black Warrior River. The Sipsey Fork is a National Wild and Scenic River in its headwaters, and downstream is impounded to form Lewis Smith Lake, a hydroelectric generating reservoir, also popular for bass fishing.

D. Other Notable Characteristics: None.

3.4.2 Available Water Quality and Biological Data

Water Quality and biological data for the Thacker Creek is available for the period of May 1997 thought October 1997. Alabama Department of Environmental Management collected this data. Thacker Creek water quality stations are distributed across the stream. A complete listing of the available data can be found in the appendix of this report. A map indicating the location of sampling points relative to applicable point source discharges is presented in Figure 3-2. There is 1991 Alabama Clean Water Strategy Water Quality Assessment Report Data.

Figure 3-2. Map of Sampling Locations and Point Source Discharges for the Thacker Creek Watershed.



Station	Latitude	Longittude
THK-1	34.0012°	86.79989°
THK-2	33.97651°	86.81683°
THK-3		

3.4.3. Flow data

For the purpose of this TMDL, annual $7Q_{10}$ stream flows for the summer season and annual $7Q_2$ stream flows for the winter season are employed. These flows represent worst-case scenarios for seasonal model evaluations. The use of worst-case conditions, in turn, creates a margin of safety in the final results.

The $7Q_{10}$ flow represents the minimum 7-day flow that occurs, on average, over a 10-year recurrence interval. Likewise, the $7Q_2$ is the minimum 7-day flow that occurs, on average, over a 2-year period.

Both flows (i.e., $7Q_{10}$ and $7Q_2$) can be calculated for the model using gage data from the United States Geological Survey (USGS) or by using the Bingham Equation. The Bingham Equation can be found on page 3 of a publication from the Geological Survey of Alabama entitled, **Low-Flow Characteristics of Alabama Streams, Bulletin 117**.

The equations used to calculate the $7Q_{10}$ and $7Q_2$ flows based on continuous USGS gaging records for the stream and any associated tributaries are as follows:

$$7Q_{10}\ (\text{cfs}) = \frac{7Q_{10}\ @\ \text{USGS Station (cfs)}}{\text{Drainage Area}\ @\ \text{USGS Station}\ (\text{mi}^2)} * (\text{Watershed Drainage Area}\ (\text{mi}^2))$$

$$7Q_{2}\ (\text{cfs}) = \frac{7Q_{2}\ @\ \text{USGS Station (cfs)}}{\text{Drainage Area}\ @\ \text{USGS Station}\ (\text{mi}^2)} * (\text{Watershed Drainage Area}\ (\text{mi}^2))$$

The $7Q_{10}$ and $7Q_2$ flows can also be estimated using the Bingham Equation. Low flow estimates employing this equation are based on the stream's recession index (G, no units), the stream's drainage area (A, mi^2), and the mean annual precipitation (P, inches):

$$7Q_{10}\ (\text{cfs}) = 0.24\text{x}10^{-4}(G-30)^{1.07}(A)^{0.94}(P-30)^{1.51}$$
$$7Q_{2}\ (\text{cfs}) = 0.15\text{x}10^{-5}(G-30)^{1.35}(A)^{1.05}(P-30)^{1.64}$$

The method used to determine the $7Q_{10}$ flow for Thacker Creek was the Bingham Equation. The resulting $7Q_{10}$ flow is 0.35.

The calculated flows were distributed over Thacker Creek in the form of tributary flow or incremental inflow (identified on the modeled reach schematic as IF). The IF was distributed in proportion to the length of each segment.

3.5 Critical Conditions

Summer months (May – November) are generally considered critical conditions for dissolved oxygen in streams. This can be explained by the nature of storm events in the summer versus the winter. Periods of low precipitation allow for slower in-stream velocity, which increases the organic loading residence time and decreases stream re-aeration rates. This increased time permits more decay to occur which depletes the streams dissolved oxygen supply. Reaction rates for $CBOD_u$ and NBOD (i.e., organic loading) are temperature dependent and high summertime temperatures increase the decay process, which depletes the dissolved oxygen even further.

In winter, frequent low intensity rain events are more typical and do not allow for the build-up of organic loading on the land surface, resulting in a more uniform loading rate. Higher flows and lower temperatures create less residence time and lower decay rates. This pattern is evidenced in the output data of the model where the highest allowable loading achieved was for winter stream flows.

3.6 Margin of Safety (MOS)

There are two basic methods of incorporating the MOS (USEPA, 1991): 1) implicitly, using conservative model assumptions, or 2) explicitly by specifying a portion of the TMDL as the MOS.

The MOS is implicit in this TMDL process through the use of conservative model input parameters (**temperature, flow and D.O. concentrations**). Conservative temperature values are employed through the use of the highest average maximum temperature that would normally occur under critical stream flow conditions. The $7Q_{10}$ and $7Q_2$ stream flows employed for summer and winter, respectively, reflect the lowest flows that would normally occur under critical conditions. All point source discharges were assumed to be continuous at current NPDES permit limits. The D.O. concentration for incremental flow was set at 70% of the saturation concentration at the given temperature, which is 15% lower than the 85% normally assumed in a typical waste load allocation. Finally, the maximum pH value reported was used to determine the ammonia as nitrogen chronic criterion.

The following stream conditions also add to the MOS: 1) water depths are shallow, generally less than one foot, which exaggerates the effect of sediment oxygen demand (SOD); 2) water velocities are generally less than 0.5 fps or less, which intensifies the effect of SOD.

4.0 Water Quality Model Development

4.1 Water Quality Model Selection and Setup

Since the impairment noted by the available data occurred during periods of low flows, a steady-state modeling approach was adopted as appropriate to represent the relevant conditions in the impaired waterbody. The steady state TMDL spreadsheet water quality model (SWQM) developed by the ADEM was selected for the following reasons:

- It is a simplified approach without unnecessary complexity.
- It conforms to ADEM standard practices for developing wasteload allocations.
- It lends itself to being developed with limited data, which is the present situation for this waterbody.
- It has the ability to handle tributary inputs and both point and non-point source inputs.

The TMDL spreadsheet model also provides a complete spatial view of a stream, upstream to downstream, giving differences in stream behavior at various locations along the model reach. The model computes dissolved oxygen using a modified form of the Streeter-Phelps equation. The modified Streeter-Phelps equation takes into account the oxygen demand due to carbonaceous decay plus the oxygen demand generated from the nitrification process (ammonia decay). Each stream reach is divided into twenty elements, with each element assumed to be the functional equivalent of a completely mixed reactor.

The following assumptions were used in the spreadsheet TMDL model***:***

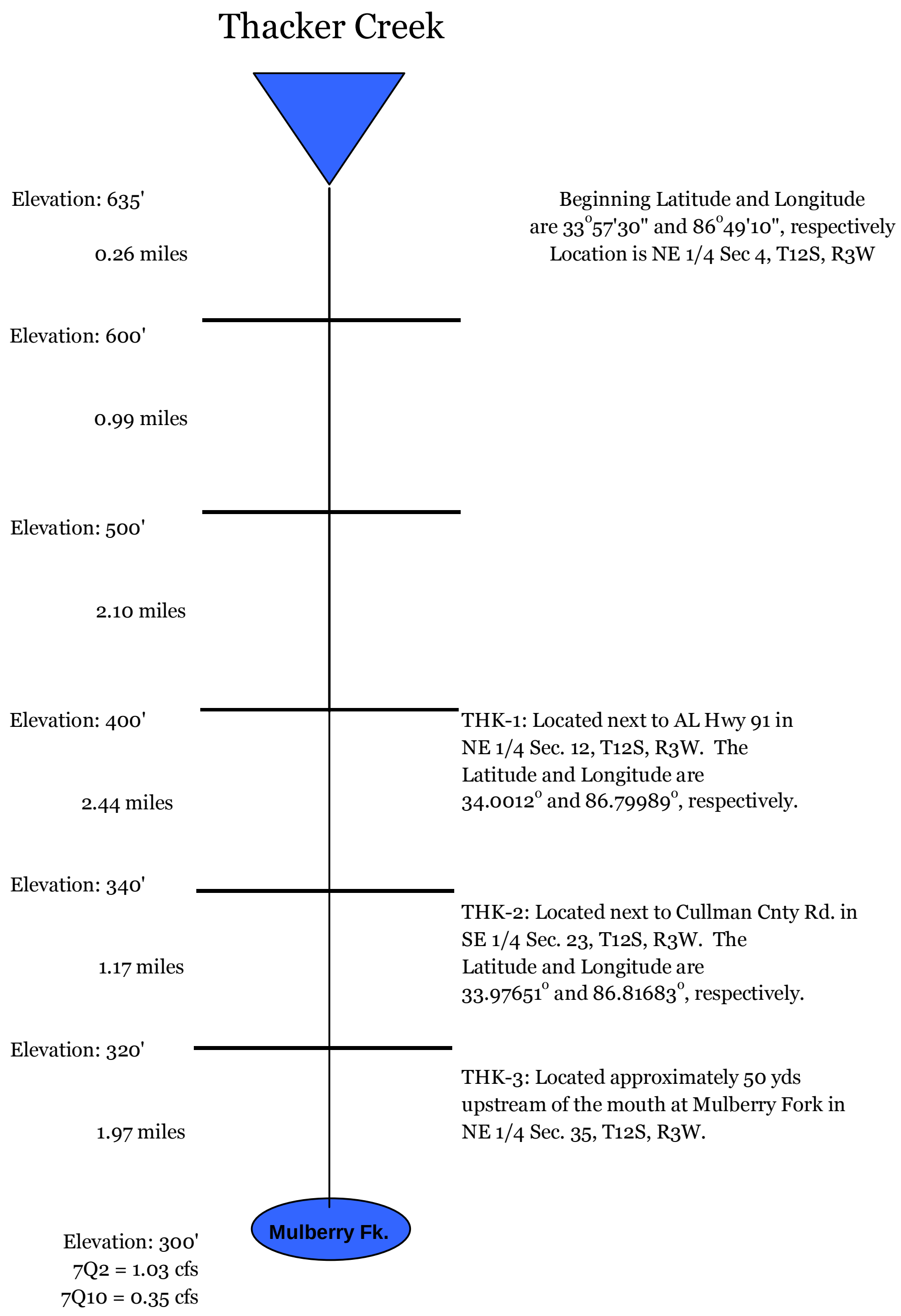
- D.O. concentrations for incremental flow were assumed @ 70% of the saturated value at the given temperature. **(MOS)**
- Incremental and tributary loading were apportioned to correlate with the land usage of the drainage basin.
- Ratios for $CBOD_U/NH_3OD_U$ and $CBOD_U/TONOD_U$ were calculated using water quality data for the waterbody. These ratios were assigned in the estimation of loading parameters for incremental flow and tributaries for all land uses, except forest and open water.
- $CBOD_5/BOD_5$ ratios used for point sources were 1.5.
- $CBOD_5/BOD_5$ ratios used for nonpoint sources were 1.5.
- NH_3OD_u is equal to 4.57 times the ammonia nitrogen concentration.
- $TONOD_u$ is equal to 4.57 times the organic nitrogen concentration.
- The ammonia as nitrogen concentration was determined at maximum reported pH.
- Background conditions were assumed for forest incremental flow.
  Background conditions are typically the following ranges: 2-3 mg/l $CBOD_u$, 0.2-1 mg/l NH_3ODu, 1-2 mg/l $TONOD_u$.

4.1.1. <u>SOD Representation</u>: Sediment oxygen demand (SOD) can be an important part of the oxygen demand budget in shallow streams. However, for shallow streams with steep slopes and rocky substrate, the SOD component is generally small. These hydrogeological conditions are representative of the Thacker Creek. It is believed, therefore, that the SOD for this stream is minimal. In the absence of available field SOD measurements for the waterbody, SOD data was obtained from EPA Region IV's SOD database. The EPA SOD database represents mixed land uses and varying degrees of point source activity. A SOD value of 0.05 gm-O_2 ft^2/day was chosen based on similar bottom characteristics of sand, conglomerate, shale, siltstone, and coal.

4.2 Water Quality Model Summary

The summer model reach consisted of 7 segments. The impaired portion of the summer model reach consists of segments 7. The length of the impaired portion is 8.91 miles. Total distance of the summer model reach is 8.91 miles. A schematic diagram of the model is presented in Figure 4-1. Assumed in-stream seasonal temperatures are based on historical model development. A guide for use of ADEM's TMDL water quality model can be found in the appendix. The guide also explains the theoretical basis for the physical/chemical mechanisms and principles that form the foundation of the model.

Figure 4-1. Schematic of the Modeled Reach.



4.2.1. Summer (May – November) Model

Summer Stream Flow Parameters

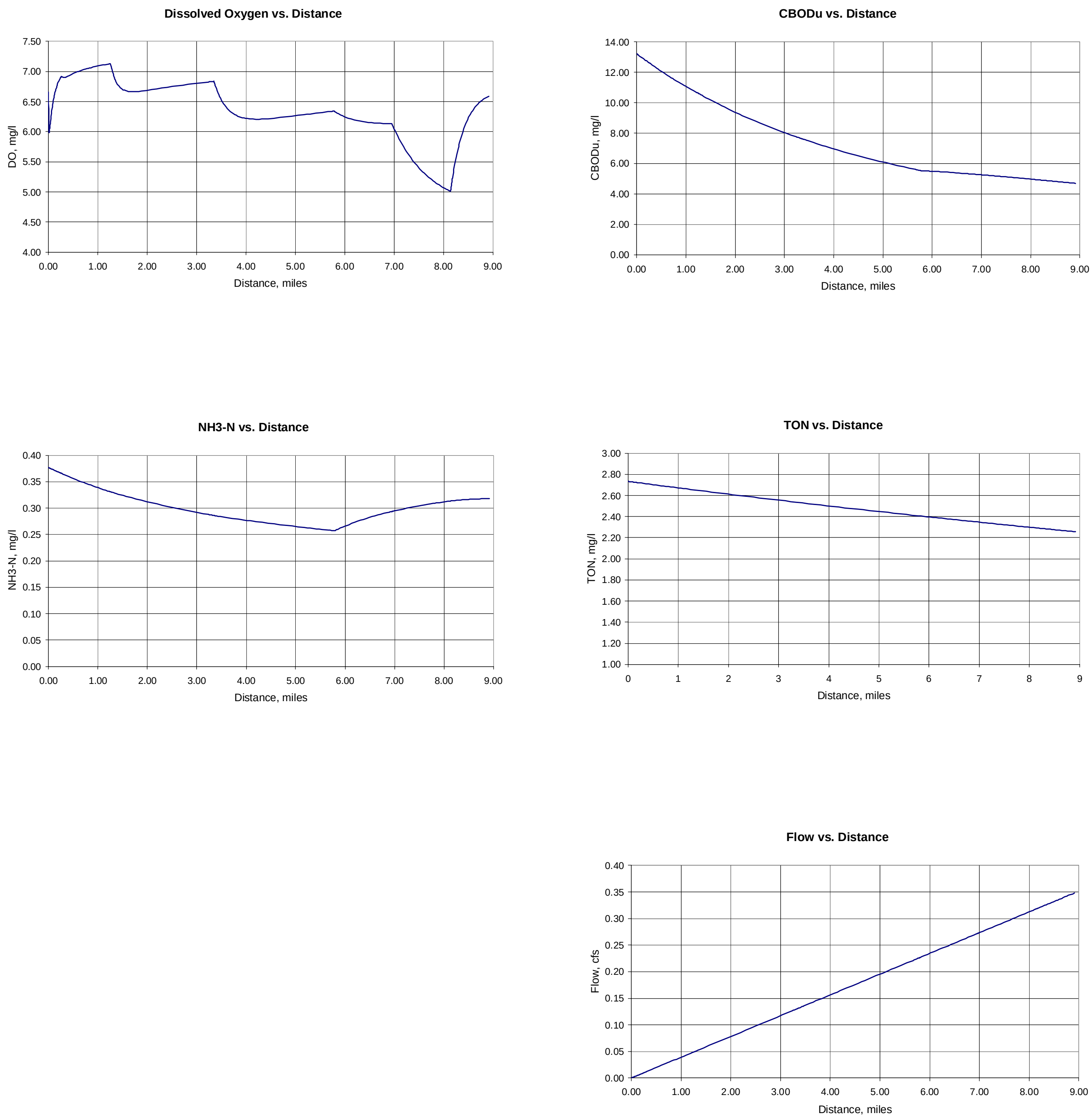
Description	Flow (cfs)	DO (mg/l)	$CBOD_U$ (mg/l)	NH_3N_U (mg/l)	TON_U (mg/l)	Temp (°C)
Headwaters	0.00	6.65	13.23	0.38	2.73	28
Conditions @ Lowest D.O.	0.32	5.01	4.93	0.31	2.29	28
Flow @ End of Model	0.35	6.59	4.70	0.32	2.26	28

Summer Incremental Flow Parameters

Sections	$CBOD_U$ (mg/l)	NH_3N_U (mg/l)	TON_U (mg/l)	DO (mg/l)	Total Flow (cfs)	Temp. (°C)
1	13.23	0.38	2.73	5.48	0.01	28
2	13.23	0.38	2.73	5.48	0.04	28
3	13.23	0.38	2.73	5.48	0.08	28
4	13.23	0.38	2.73	5.48	0.10	28
5	13.23	0.38	2.73	5.48	0.05	28
6	13.23	0.38	2.73	5.48	0.05	28
7	13.23	0.38	2.73	5.48	0.03	28

4.3 *Summer Models Predictions and Graphics*

Figure 4-2. Summer Model Predictions.



4.4 Reduction Analysis

Due to the fact that there is no point source on Thacker Creek and there is no flow data at the place or time of the low D.O. event there is no Calibrated or Reduction Model run. There is only a Summer TMDL.

4.5 Seasonal Variation

The regulations require that a TMDL be established with consideration of seasonal variations. Since impairments occurred only during the summer months and not during other times of the year, a seasonal variation in the TMDL was not necessary.

5.0 Conclusions

A summary of the TMDL is presented in Table 5-1.

Table 5-1. Summer TMDL Summary

	TMDL
	Summer
$CBOD_u$ Loading (lbs./day)	24.8
NBOD Loading (lbs./day)	26.7
Total Loading (lbs./day)	51.5
NH3-N (lbs./day)	0.7

6.0 TMDL Implementation

6.1 Non-Point Source Approach

Thacker Creek is impaired solely by nonpoint sources. For 303(d) listed waters impaired solely or primarily by nonpoint source (NPS) pollutants, necessary reductions will be sought during TMDL implementation using a phased approach. Voluntary, incentive-based mechanisms will be used to implement NPS management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the targeted impaired water. Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs. Local citizen-led and implemented management measures offer the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. Therefore, TMDL implementation activities will be coordinated through interaction with local entities in conjunction with Clean Water Partnership efforts.

The primary TMDL implementation mechanism used will employ concurrent education and outreach, training, technology transfer, and technical assistance with incentive-based pollutant management measures. The ADEM Office of Education and Outreach (OEO) will assist in the implementation of TMDLs in cooperation with public and private stakeholders. Planning and oversight will be provided by or coordinated with the Alabama Department of Environmental Management's (ADEM) Section 319 nonpoint source grant program in conjunction with other local, state, and federal resource management and protection programs and authorities. The CWA Section 319 grant program may provide limited funding to specifically ascertain NPS pollution sources and causes, identify and coordinate management programs and resources, present education and outreach opportunities, promote pollution prevention, and implement needed management measures to restore impaired waters.

Depending on the pollutant of concern, resources for corrective actions may be provided, as applicable, by the Alabama Cooperative Extension System (education and outreach); the USDA-Natural Resources Conservation Service (NRCS) (technical assistance) and Farm Services Agency (FSA) (federal cost-share funding); and the Alabama Soil and Water Conservation Committee (state agricultural cost share funding and management measure implementation assistance) through local Soil and Water Conservation Districts, or Resource Conservation and Development Councils (funding, project implementation, and coordination). Additional assistance from such agencies as the Alabama Department of Public Health (septic systems), Alabama Department of Agriculture and Industries (pesticides), and the Alabama Department of Industrial Relations and Dept of Interior - Office of Surface Mining (abandoned minelands), Natural Heritage Program and US Fish and Wildlife Service (threatened and endangered species), may also provide practical TMDL implementation delivery systems, programs, and information. Land use and urban sprawl issues will be addressed through the Nonpoint Source for Municipal

Officials (NEMO) education and outreach program. Memorandums of Agreements (MOAs) may be used as a tool to formally define roles and responsibilities.

Additional public/private assistance is available through the Alabama Clean Water Partnership (CWP) Program. The CWP program uses a local citizen-based environmental protection approach to coordinate efforts to restore and protect the state's resources in accordance with the goals of the Clean Water Act. Interaction with the state or river basin specific CWP will facilitate TMDL implementation by providing improved and timely communication and information exchange between community-based groups, units of government, industry, special interest groups, and individuals. The CWP can assist local entities to plan, develop, and coordinate restoration strategies that holistically meet multiple needs, eliminate duplication of efforts, and allow for effective and efficient use of available resources to restore the impaired waterbody or watershed.

Other mechanisms that are available and may be used during implementation of this TMDL include local regulations or ordinances related to zoning, land use, or storm water runoff controls. Local governments can provide funding assistance through general revenues, bond issuance, special taxes, utility fees, and impact fees. If applicable, reductions from point sources will be addressed by the NPDES permit program. The Alabama Water Pollution Control Act empowers ADEM to monitor water quality, issue permits, conduct inspections, and pursue enforcement of discharge activities and conditions that threaten water quality. In addition to traditional "end-of-pipe" discharges, the ADEM NPDES permit program addresses animal feeding operations and land application of animal wastes. For certain water quality improvement projects, the State Clean Water Revolving Fund (SRF) can provide low interest loans to local governments.

Long-term physical, chemical, and biological improvements in water quality will be used to measure TMDL implementation success. As may be indicated by further evaluation of stream water quality, the effectiveness of implemented management measures may necessitate revisions of this TMDL. The ADEM will continue to monitor water quality according to the rotational river basin monitoring schedule as allowed by resources. In addition, assessments may include local citizen-volunteer monitoring through the Alabama Water Watch Program and/or data collected by agencies, universities, or other entities using standardized monitoring and assessment methodologies. Core management measures will include, but not be limited to water quality improvements and designated use support, preserving and enhancing public health, enhancing ecosystems, pollution prevention and load reductions, implementation of NPS controls, and public awareness and attitude/behavior changes.

6.2 Point Source Approach

If applicable, reductions from point sources will be addressed by the NPDES permit program.

7.0 Follow Up Monitoring

ADEM has adopted a basin approach to water quality management; an approach that divides Alabama's fourteen major river basins into five groups. Each year, the ADEM water quality resources are concentrated in one of the basin groups. One goal is to continue to monitor §303(d) listed waters. This monitoring will occur in each basin according to the following schedule:

River Basin Group	Schedule
Cahaba / Black Warrior	2002
Tennessee	2003
Choctawhatchee / Chipola / Perdido-Escambia / Chattahoochee	2004
Tallapoosa / Alabama / Coosa	2005
Escatawpa / Upper Tombigbee / Lower Tombigbee / Mobile	2006

Monitoring will help further characterize water quality conditions resulting from the implementation of best management practices in the watershed. As Part of TMDL implementation Thacker Creek will be monitored during 2002. If so indicated by the data collection the TMDL will be revised, if necessary, to calculate the required reduction.

8.0 Public Participation

A thirty-day public notice will be provided for this TMDL. During this time, the availability of the TMDL will be public noticed, a copy of the TMDL will be provided as requested, and the public will be invited to provide comments on the TMDL.

Appendix 9.1
References

References

Adkins, J.B., Pearman, J.L.. 1994. Low-Flow and Flow-Duration Characteristics of Alabama Streams. Water-Resources Investigations Report 93-4186.

Bingham, R.H.. 1982. Low-Flow Characteristics of Alabama Streams. Geological Survey Water-Supply Paper 2083

United States Environmental Protection Agency. 1991. Guidance for Water Quality-Based Decisions: The TMDL Process, Office of Water, EPA 440/4-91-00

Alabama Department of Environmental Management. 1992. Alabama Clean Water Strategy Water Quality Assessment Report. Alabama Department of Environmental Management

Appendix 9.2
Water Quality Data

STATION	DATE	TIME	T/A °C	T/W °C	pH	DO	F. COLI.	COND.	TURB.	HARD	$CBOD_5$	TSS	TDS	ORTHO P	NH_3-N	NO_2+NO_3-N	TKN	PO_4-P	DEPTH	WIDTH	FLOW
THK-1	05/29/1997	13:40	19	17	7.84	9.12	520	63.5	7.3	32	1.8	1	62	<.005		0.284	0.23	0.036	1	12	
THK-2	05/29/1997	14:15	19	17.7	7.22	8.88	960	61.2	7.3	38	1.8	1	60	0.005		0.256	0.19	0.036	5	35	
THK-3	05/29/1997	15:00	21	18.5	7.24	7.64	1320	72.6	30	46	2	48	82	0.009		0.558	0.734	0.1		35	

STATION	DATE	TIME	T/A °C	T/W °C	pH	DO	F. COLI.	COND.	TURB.	HARD	$CBOD_5$	TSS	TDS	ORTHO P	NH_3-N	NO_2+NO_3-N	TKN	PO_4-P	DEPTH	WIDTH	FLOW
THK-1	06/25/1997	12:30	32	22.4	6.35		136	60.6	4.2	30	0.3	1	56	<.005		0.371	0.137	0.018	1	20	normal
THK-2	06/25/1997	13:15	25	23.6	6.34	8.5	440	57.5	6.1	34	0.3	1	54	0.005		0.349	0.249	0.018	4	25	normal
THK-3	06/25/1997	13:45	25	23.3	6.5	7.4	900	66.7	10.6	30	0.1	34	63	<.005		0.778	0.376	0.031	3	35	slow

STATION	DATE	TIME	T/A °C	T/W °C	pH	DO	F. COLI.	COND.	TURB.	HARD	$CBOD_5$	TSS	TDS	ORTHO P	NH_3-N	NO_2+NO_3-N	TKN	PO_4-P	DEPTH	WIDTH	FLOW
THK-1	07/22/1997	10:30	22	24	6.32	no data		89	96	48	2	28	97	0.013		0.375	0.686	0.097	1	15	fast
THK-2	07/22/1997	9:45		24.1	6.26	5.63		72	7.2	32	0.8	3	63	0.054		0.217	0.274	0.08	4	30	slow
THK-3	07/22/1997	11:25	22	22.8	6.25	no data		89	23	34	0.9	16	76	0.009		0.883	0.661	0.073			

STATION	DATE	TIME	T/A °C	T/W °C	pH	DO	F. COLI.	COND.	TURB.	HARD	$CBOD_5$	TSS	TDS	ORTHO P	NH_3-N	NO_2+NO_3-N	TKN	PO_4-P	DEPTH	WIDTH	FLOW
THK-1	08/28/1997	10:30	30	27	6.51	4.4	600			84	0.4	1	85	<.005		0.038	0.151	0.03	1	5	none
THK-2	08/28/1997	11:00	30	27	6.62	5.2	3400			56	0.4	1	64	<.005		0.153	0.193	0.031	2	15	none
THK-3	08/28/1997	12:00	30	29	6.71	4.6	27			46	0.4	<1	73	<.005		1.025	0.246	0.03	1	20	none

	Date	Time	Temp-Air	Temp-H_2O	DO	SpCond	Turb	Depth	pH	Flow	Weather
Station	MMDDYY	HHMM	°C	°C	mg/l	µmho/cm	NTUs	meters	Units	cfs	
Storet Code			00020	00010	00300	00095	82079	00068	00400	00060	(47501)
THK-1	10/07/97	1359	28	21.35	10.23	111	2.67	0.2	7.01		Cloudy (4)
THK-2	10/07/97	1344	29	18.98	6.27	117	1.82	0.6	6.39		Cloudy (4)
THK-3	10/07/97	1310	29	21.07	8.4	120	4.64	0.2	6.71		Cloudy (4)
THK-1	10/08/97	0747	18	17.76	7.96	126	1.47	0.2	6.66		P. Cloudy (3)
THK-2	10/08/97	0732	17	19.03	4.88	127	2.78	0.6	6.45		P. Cloudy (3)
THK-3	10/08/97	0715	17	18.17	6.74	128	3.81	0.3	6.53		P. Cloudy (3)
DUP-1(THK-1)	10/08/97	0748	18	17.76	7.93	126	1.55	0.2	6.66		P. Cloudy (3)
THK-1	10/08/97	1333	28	22.04	11.2	115	3.06	0.2	7.19	0.22	P. Cloudy (3)
THK-2	10/08/97	1322	26	19.22	4.2	134	6.15	0.7	6.49		P. Cloudy (3)
THK-3	10/08/97	1307	28	21.27	7.8	135	4.37	0.2	6.77	0.38	P. Cloudy (3)
THK-1	10/09/97	0745	16	17	6.2	113.5	3.14	0.2	6.78	0.183	Clear (1)
THK-2	10/09/97	0730	17	18	4.7	116.8	2.78	0.6	6.71		Clear (1)
THK-3	10/09/97	0705	16	17	6.2	126.7	3.73	0.3	6.89	0.296	Clear (1)
DUP-1(THK-1)	10/09/97	0745	16	17	6.3	114.8	3.61	0.2	6.81		Clear (1)

Stream Name / Location				County			State	Longitude	Latitude
TRIBURARY TO MULBERRY FORK				CULLMAN			AL	86^o 49' 06"	33^o 57' 49"

Time	AIR TEMP CENT	BOD 20C5DAY CAR MG/L		COD LOWLEVEL MG/L	DO MG/L	DO SATUR PERCENT	NH3+NH4- N TOTAL MG/L	NO2&NO3 N-TOTAL MG/L	ORG N N MG/L	PH SU	PHOS- TOT MG/L P	RESIDUE TOT NFLT MG/L	TOT KJEL N MG/L	UN-IONZD NH3-N MG/L	UN-IONZD NH3-NH3 MG/L	WATER TEMP CENT
1530	33				9.7	129.333				7.7						31
755	22	1.6		15	4.7	55.952	0.06	1.92	1.44	7.8	0.1	3	1.5	0.002	0.003	25
1010																
1600	30	1.9	63	23	10.5	140	0.04	1.86	1.56	8.5	0.08	15	1.6	0.009	0.01	31
750	22	2	61	22	4.3	52.439	0.02	2.35	1.68	8.4	0.12	7	1.7	0.003	0.003	26

Data from
Alabama Clean Water Strategy
Water Quality Assessment Report
December 1992

The samples were taken in 1991
Location: near the end of Cullman county road, SE ¼ Seac. 26, T12S, R3W

BLACK WARRIOR RIVER BASIN SAMPLING DATA

Station	Date	Time	H_2O Temp. (deg. C)	pH (S.U.)	D.O. (mg/l)	Cond.	$CBOD_5$ (mg/l)	NH_3-N (mg/l)	TKN (mg/l)	NO_2+NO_3-N (mg/l)	PO_4-P (mg/l)	T-PO_4 (mg/l)	bacteria org/100ml
Thacker Creek (F&W)	June 3	07:40	22.5	7.2	6.2	78	1.2	<0.03	0.12	0.05		0.01	180
	July 10	13:00	27.0	7.2	6.2	173	1.1	0.12	0.29	0.61		0.02	40
	August 9	09:40	26.0	7.1	**3.2**	136	4.2	0.01	0.29	0.37		0.00	180
	Sept 10	10:00	23.0	7.4	**3.2**	145	3.2	0.01	0.42	0.28		0.01	**2200**
	Oct 8	08:40	13.0	7.1	6.6	127	2.9	0.04	0.40	1.40		0.00	160

Appendix 9.3
Water Quality Model
Input and Output Files

SUMMER TMDL MODEL

9.5
Spreadsheet Water Quality Model (SWQM) User Guide