ADEM

Alabama Department of Environmental Management

Final TMDL Development for
Swan Creek / AL/06030002-390_01
Low Dissolved Oxygen/Organic Loading

Water Quality Branch
Water Division
February 2002

Swan Creek Watershed in the Tennessee River Basin

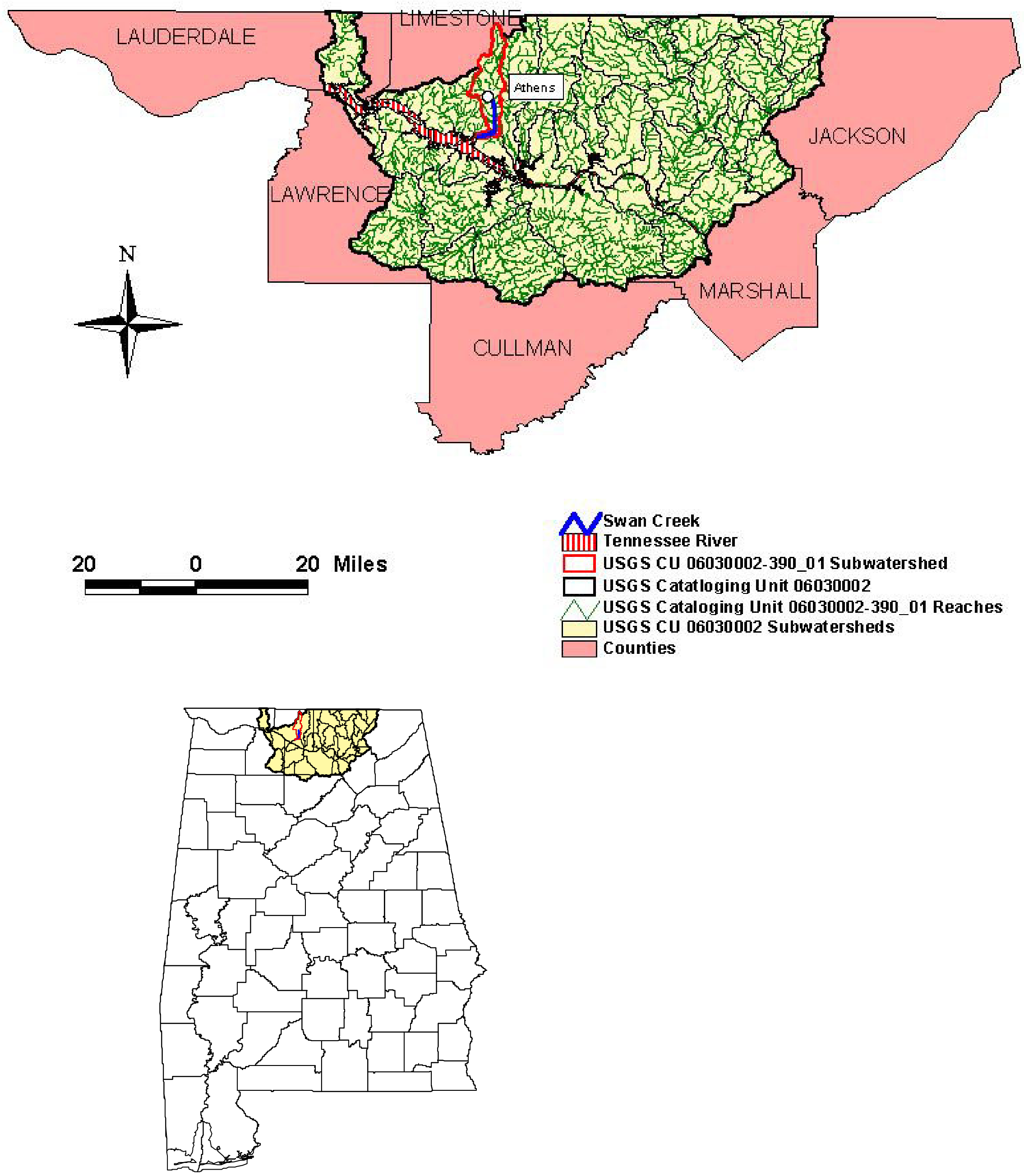


Table of Contents ***Page***

1. Executive Summary 4

2. Basis for §303(d) Listing 6

   2.1. Introduction 6
   2.2. Problem Definition 6

3. Technical Basis for TMDL Development 9

   3.1. Water Quality Target Identification 9
   3.2. Source Assessment 10
   3.3. Loading Capacity - Linking Water Quality Numeric Targets and Pollutant Sources 15
   3.4. Data Availability and Analysis 16
   3.5. Critical Conditions 20
   3.6. Margin of Safety 20

4. Water Quality Model Development 20

   4.1. Water Quality Model Selection and Setup 20
   4.2. Water Quality Model Summary 22
   4.3. Summer and Winter Model Predictions and Graphics 25
   4.4. Loading Reduction Analysis 27
   4.5. Seasonal Variation 27

5. Conclusions 28

6. TMDL Implementation 29

   6.1. Non-Point Source Approach 29
   6.2. Point Source Approach 31

7. Follow Up Monitoring 31

8. Public Participation 32

9. Appendices

   9.1. References 9.1.1
   9.2. Water Quality Data 9.2.1
   9.3. Water Quality Model Input and Output Files 9.3.1
   9.4. Spreadsheet Water Quality Model (SWQM) User Guide 9.4.1

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.

Swan Creek, a part of the Tennessee River basin, is located in Limestone County near Athens, Alabama. It has been on the State of Alabama's §303(d) use impairment list since 1996 for organic enrichment/low dissolved oxygen (O.E./D.O.). Its use classification is Agricultural and Industrial (A&I) from its source to upstream of County Road 24, and Fish and Wildlife (F&W) downstream of County Road 24 to its mouth.

Biological data collected by The Tennessee Valley Authority (TVA) in 1994-1995 indicated impaired macroinvertebrate and fish communities. The impairment was attributed to siltation and organic enrichment/low dissolved oxygen; however, water column sampling was not collected at the time to support this assumption.

Additional data has been collected since the TVA data collection in 1994-1995. TVA collected data again in 1997 and ADEM collected data in 1998. In 1997, TVA collected data at two stations from June to October. In 1998, ADEM collected data at three stations during the months of May, July, and September. In both years, 1997 and 1998, the collected data did not show any D.O. violations; therefore, there were no reductions calculated for the Swan Creek watershed. Reductions will be calculated for Swan Creek if additional data collected as part of the TMDL implementation shows impairment due to D.O..

Since D.O. impairments generally occur during the summer months when stream flows are low and water temperatures are high, a steady state modeling approach was adopted as appropriate for this TMDL analysis. This modeling approach uses the stream's $7Q_{10}$ flow and $7Q_2$ flow. 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.

The following report addresses the results of the TMDL analysis for O.E./D.O. In accordance with ADEM water quality standards, the minimum dissolved oxygen concentration in a stream classified as F&W is 5.0 mg/l, and a minimum dissolved oxygen concentration for a stream classified as A&I is 3.0 mg/l. For the purpose of this TMDL, a minimum dissolved oxygen level of 5.0 mg/l, F&W, and 3.0 mg/l, A&I, 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 tables presented below. The pollutants shown in the tables include ultimate carbonaceous biochemical oxygen demand ($CBOD_u$) and nitrogenous biochemical oxygen demand (NBOD), 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). The second table lists the allowable pollutant loadings by source (point and non-point sources) for the winter season (December through April).

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

Pollutant	Point Source Loads (lbs./day)	*Non-point Source Loads (lbs./day)
$CBOD_u$	31.0	1294.0
NBOD	150.9	999.10
Total	181.9	2293.10

Table 1-2. Maximum Allowable Pollutant Loads by Source – Winter

Pollutant	Point Source Loads (lbs./day)	*Non-point Source Loads (lbs./day)
$CBOD_u$	31.0	2344.5
NBOD	150.9	2518.0
Total	181.9	4862.5

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 Swan Creek as being impaired by organic loading (i.e., $CBOD_u$ and NBOD) for a length of 7.9 miles, as reported on the 1996, 1998, and Draft 2000 §303(d) list(s) of impaired waters. Swan Creek is prioritized as "low" on the list(s). Swan Creek is located in Limestone County and lies within the Swan Creek watershed of the Tennessee River basin.

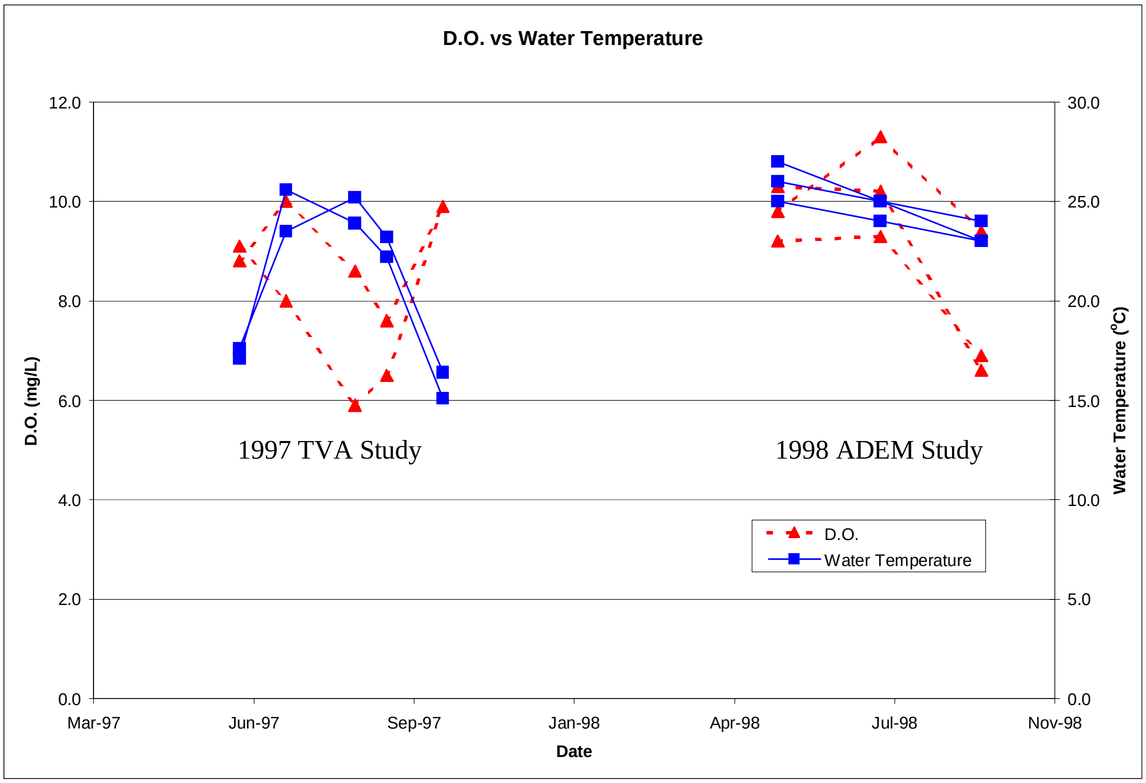
The TMDL developed for Swan Creek illustrates the steps that can be taken to address a waterbody impaired by low dissolved oxygen levels. The TMDL is consistent with a phased-approach: estimates are made of needed pollutant reductions, load reduction controls are implemented, and water quality is monitored 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

Swan Creek is a medium headwater stream with a drainage area of 55.2 square miles. Dry weather flows for the watershed are relatively low, or zero. Swan Creek water quality and biological data is available for the years 1995 and 1998. In 1994-1995, TVA collected macroinvertebrate/EPT and fish/IBI biological data at two Swan Creek stations, 1208 and 1208-13. Flow and chemical data were not collected during this study. For both stations, TVA concluded that the bug health was fair to very poor/poor and the fish health was fair/poor to very poor/poor. TVA attributed the impairment to the following causes: silt, nutrients, and organic enrichment (algal growth). Based on the results from the 1994-1995 TVA study, Swan Creek was placed on the 1996 303(d) list. In 1997, TVA sampled two stations, 11146-2 and 11146-3, once a month during the months of

June through September. In 1998, ADEM sampled three stations; SWNL-390, SWNL-391, and SWNL-392, on Swan Creek once a month during the months of May, July, and September. The data from both sampling events, 1997 and 1998, did not show any D.O. violations for Swan Creek. Generally, if depressed in-stream D.O. concentrations exist in Swan Creek, their existence 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.

The graph below shows the relationship between D.O. and water temperature using data from the 1997 TVA study and the 1998 ADEM study.



<u>Waterbody Impaired:</u> Swan Creek

<u>Water Quality Standard Violation:</u> Dissolved Oxygen

<u>Pollutant of Concern:</u> Organic Enrichment ($CBOD_u$/NBOD)

<u>Water Use Classification:</u> F&W (Downstream of Cnty Rd 24 to the mouth)
A&I (Upstream of Cnty Rd 24 to its source)

The impaired stream segment, Swan Creek is classified as both F&W and A&I.

Usage of waters in F&W 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.

Usage of waters in A&I classification is described in ADEM Admin. Code R. 335-6-10-.09(7)(a), (b), b(i), and b(ii).

(a) Best usage of waters:

Agricultural irrigation, livestock watering, industrial cooling and process water supplies, and any other usage, except fishing, bathing, recreational activities, including water-contact sports, or as a source of water supply for drinking or food-processing purposes.

(b) Conditions related to best usage:

(i) The waters, except for natural impurities which may be present therein, will be suitable for agricultural irrigation, livestock watering, industrial cooling waters, and fish survival. The waters will be usable after special treatment, as may be needed under each particular circumstance, for industrial process water supplies. The waters will also be suitable for other uses which waters of lower quality will be satisfactory.

(ii) This category includes watercourses in which natural flow is intermittent and non-existent during droughts and which may, of necessity, receive treated wastes from existing municipalities and industries, both now and in the future. In such instances, recognition must be given to the lack of opportunity for mixture of the treated wastes with the receiving stream for purposes of compliance. It is also understood in considering waters for this classification that urban runoff or natural conditions may impact any waters so classified.

Low D.O./Organic Loading Criteria for F&W and A&I:

Alabama's water quality criteria document for (F&W) classified streams (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.

Alabama's water quality criteria document for A&I classified streams (ADEM Admin. Code R 335-6-10-.09-(7)(c)(4.)) states sewage, industrial wastes, or other wastes that shall not cause the dissolved oxygen to be less than 3.0 parts per million. In the application of dissolved oxygen criteria referred to above, dissolved oxygen shall be measured at a depth of 5 feet in waters 10 feet or greater in depth; and for those waters less than 10 feet in depth, dissolved oxygen criteria will be applied at mid-depth.

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, and a minimum dissolved oxygen concentration for a stream classified as Agricultural and Industrial is 3.0 mg/l. For the purpose of this TMDL, a minimum dissolved oxygen level of 5.0 mg/l, F&W, and 3.0 mg/l, A&I, 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 these levels as a result of the decaying process.

3.2 Source Assessment

3.2.1. General Sources of $CBOD_u$ and NBOD

Both point and non-point sources may contribute $CBOD_u$ and NBOD (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 for development of the model and ultimate analysis of the TMDL allocations. The organic loading within the watershed included both point and non-point sources.

3.2.2. Point Sources in the Swan 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 shows the permitted point sources in the watershed that discharge into or upstream of the impaired segment. Table 3-2 contains the permit limitations for the significant point sources that were considered in the model development. Figure 3-1 shows the location of each facility considered a source relative to the impaired segment.

Table 3-1. Contributing Point Sources in the Swan Creek 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 $7Q_{10}$ Flow)
AL 0044644	Semi-Public/Private	Piney Chapel Jr. High School	Yes (8%)
ALG 0065684	Industrial Storm Water	Georgia Pacific	No
ALG 0027731	Industrial Storm Water	Martin Industries	No
ALG 0023817	Industrial Storm Water	Sweet Sue Kitchens	No
ALG 0026077	Industrial Storm Water	Conagra Athens Processing	No
ALG 0064424	Industrial Storm Water/Leachate	Athens/Limestone Co. Landfill	No
AL 0020206	Municipal	Athens WWTP	Yes (96%)
AL 0058670	Semi-Public/Private	Lawson Trailer Park	Yes (19%)

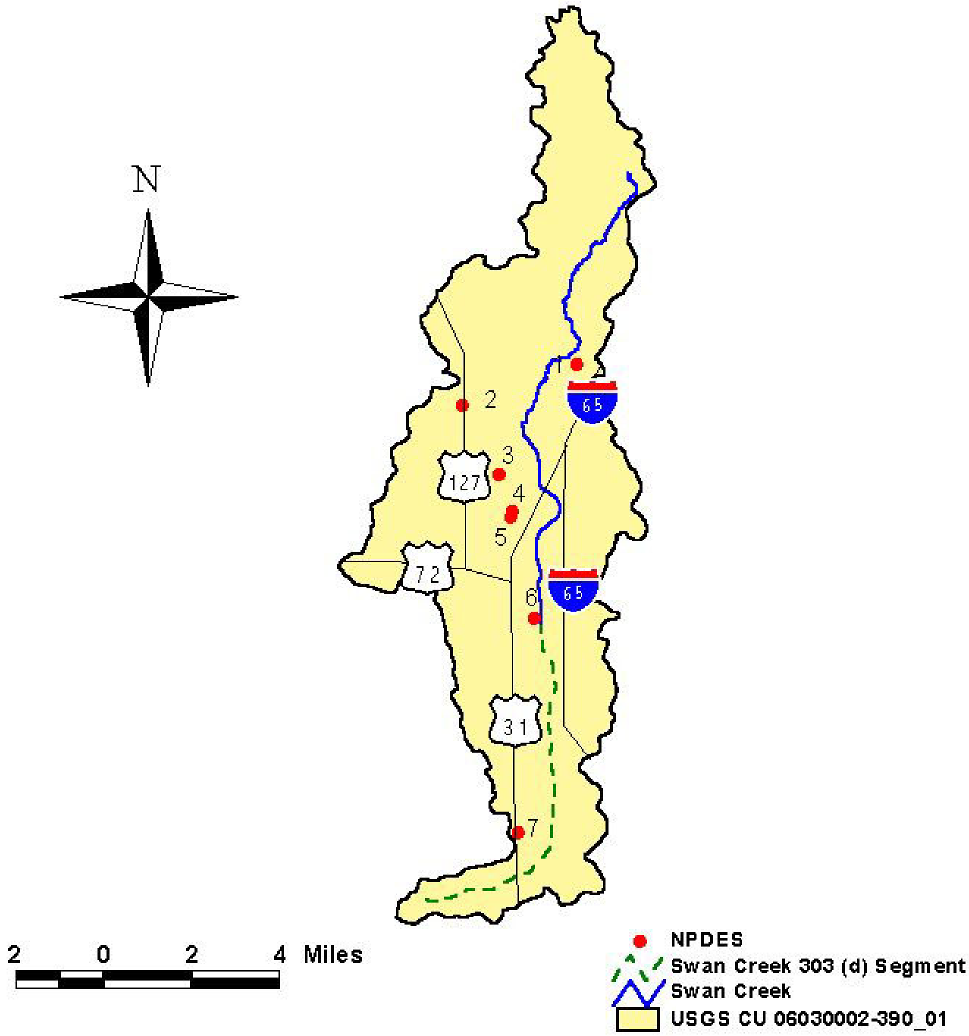
Note: Storm water discharges listed in the above table were marked as not being significant contributors since the discharge would not occur during low flow conditions. Construction storm water discharges are not listed as these discharges do not occur during low flow and generally do not contribute directly to the organic loading. The Athens/Limestone Co. Landfill discharge was not included in the model because the facility was closed in 1998.

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

NPDES Permit	Facility Name	Permit Limitations - Summer					Permit Limitations - Winter					
		$CBOD_5$ (mg/L)	$CBOD_5$ (mg/L)	NH_3-N (MG/L)		DO (MG/L)	$CBOD_5$ (mg/L)	$CBOD_5$ (mg/L)	NH_3-N (MG/L)		DO (MG/L)	Flow (MGD)
		Max	Avg	Max	Avg	Min	Max	Avg	Max	Avg	Min	
AL 0044644	Piney Chapel Jr. High School	45	30	1.8	1.2	6.0	45	30	3.1	2.1	6.0	0.015
AL 0020206	Athens WWTP	16.5	11.0	1.5	1.0	6.0	25.5	17.0	4.6	3.1	6.0	9.0
AL 0058670	Lawson Trailer Park	37.5	25.0	Report	Report	3.0	37.5	25.0	Report	Report	3.0	0.099

Notes: The flow listed is based on design flow.

Figure 3-1. Location Map of Point Sources



Station	Name	Latitude	Longitude
1	Piney Chapel Jr. High School	34° 51' 20"	86° 56' 09"
2	Georgia Pacific - Athens	34° 50' 32"	86° 58' 24"
3	Martin Industries - Athens	34° 49' 10"	86° 57' 39"
4	Sweet Sue Kitchens	34° 48' 27"	86° 57' 25"
5	Conagra Athens Processing	34° 48' 19"	86° 57' 25"
6	Athens WWTP	34° 46' 21"	86° 56' 58"
7	Lawson Trailer Park	34° 42' 07"	86° 57' 17"

3.2.3. Non-Point Sources in the Swan Creek Watershed

Shown in Table 3-3, below, is a detailed summary of land usage in the Swan Creek watershed. A land use map of the watershed is presented in Figure 3-2. The predominant land uses within the watershed are forest, row crops, and pasture/hay. Their respective percentages of the total watershed are 35.4, 27.5, and 23.8%.

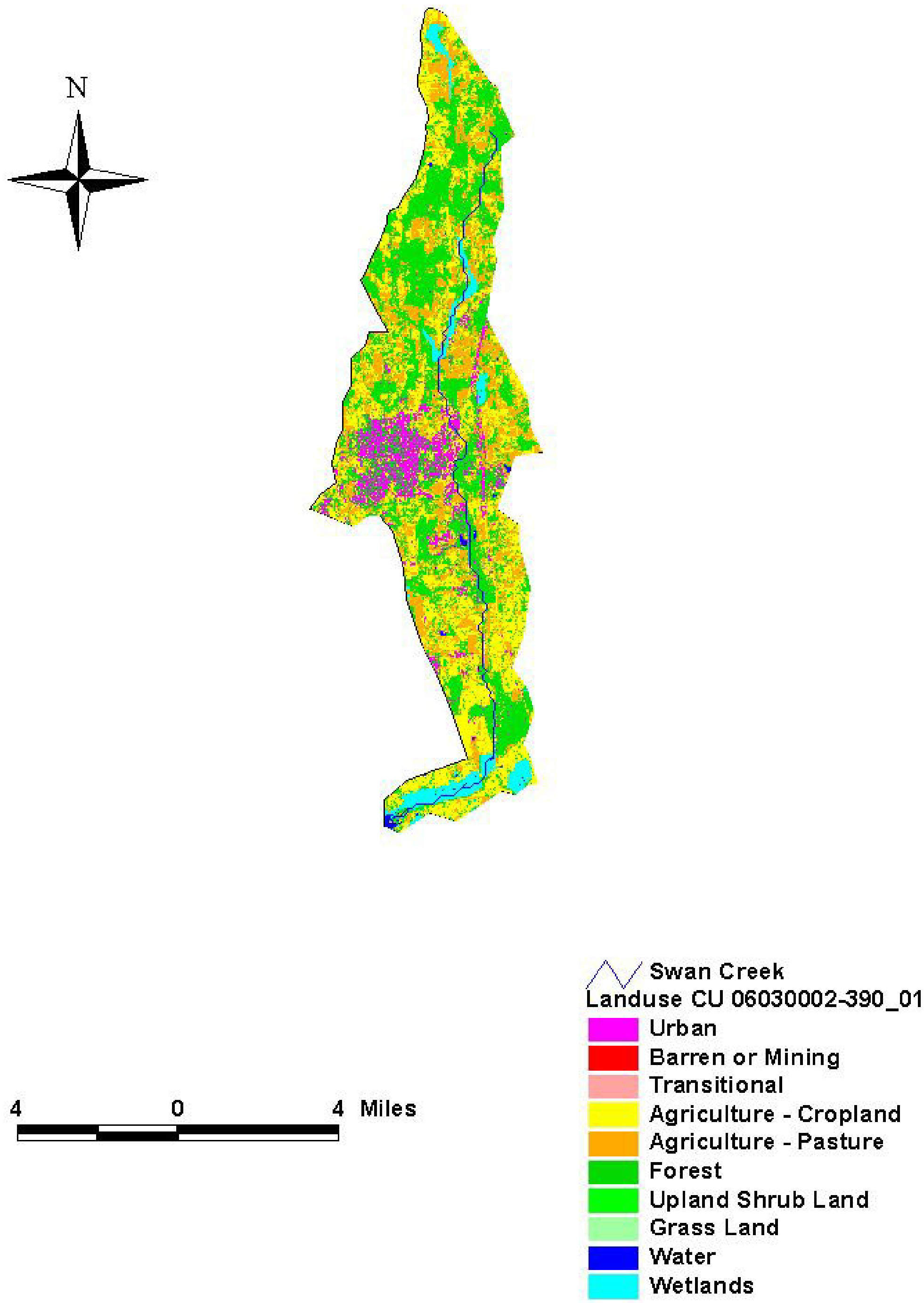
Table 3-3. Land Use in the Swan Creek Watershed.

LAND USE	PERCENTAGE
Open Water	0.4
High/Low Intensity Residential	5.0
Commercial/Industrial/Transport	1.9
Wetlands	4.3
Other	1.7
Deciduous Forest	22.1
Evergreen Forest	4.0
Mixed Forest	9.3
Pasture/Hay	23.8
Row Crops	27.5

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 Swan Creek watershed are the forest, row crops, and pasture/hay 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 3-2. Land Use Map for the Swan 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)).

For Fish and Wildlife (F&W), 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.

For Agricultural and Industrial (A&I), Alabama's water quality criteria document (ADEM Admin. Code R 335-6-10-.09-(7)(c)(4.)) states sewage, industrial wastes, or other wastes that shall not cause the dissolved oxygen to be less than 3.0 parts per million. In the application of dissolved oxygen criteria referred to above, dissolved oxygen shall be measured at a depth of 5 feet in waters 10 feet or greater in depth; and for those waters less than 10 feet in depth, dissolved oxygen criteria will be applied at mid-depth.

Using the D.O. water quality criterion of 5.0 mg/l (F&W), and 3.0 mg/l (A&I) 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). Since 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 for F&W, and greater than, or equal to, 3.0 mg/l for A&I. The model predictions for in-stream pollutant concentrations were then compared to actual field data.

3.4 Data Availability and Analysis

3.4.1. Watershed Characteristics

A. General Description: Swan Creek, located in Limestone County, is a tributary to the Tennessee River. The Swan Creek is a part of the Tennessee River basin. Swan Creek is a part of the USGS (United States Geological Survey) 06030002 cataloging unit and the NRCS (Natural Resources Conservation Service) 390 sub-watershed. Cataloging unit 06030002 includes Wheeler Lake Basin. NRCS sub-watershed number 390 represents the Swan Creek watershed.

   Swan Creek begins approximately 6.0 miles north of the town of Athens, Alabama in Section 8, Township 2S, and Range 4W. It has a linear distance of 17.81 miles and a total drainage area of 55.2 square miles. Swan Creek has a use classification of Agricultural and Industrial (A&I) from its source to upstream of County Road 24, and Fish and Wildlife (F&W) downstream of County Road 24 to its mouth.

B. Geological Description: This region consists of both the Appalachian Plateau and the Interior Low Plateau. The upper part of the watershed consists of Limestone, Chert, and Stale and has the Fort Payne Chert Formation. The lower part of the watershed consists of the following rock types: Limestone and Chert. It also has a formation known as the Tuscumbia Limestone.

C. Eco-region Description: The Eastern Highland Rim has more level terrain and weaker dissection than the Western Highland Rim, with flat to gently rolling landforms. Mississippian-age limestone, chert, shale, and dolemite predominate, and springs, sinks, and caves have formed by solution of the limestone. Cave and spring-associated fish fauna also typify the region. In the southern part of the region, streams flow down from the Pottsville Escarpment of the Southwest Appalachians, cutting north across the Moulton Valley and through narrow valleys of Little Mountain to the impounded Tennessee River. Natural vegetation for the region is transitional between the oak-hickory type to the west and the mixed mesophytic forests to the Appalachian eco-regions to the east. Much of the original bottomland hardwood forest has been inundated by impoundments. The flatter areas in the east and on both sides of the Tennessee River have deep, well-drained, reddish, productive soils that are intensively formed.

D. Other Notable Characteristics: The beginning elevation of Swan Creek is 782 feet and its ending elevation is 556 feet. The total length of Swan Creek is 17.81 miles. The slope is consistent throughout the segment with an average slope of 13 feet.

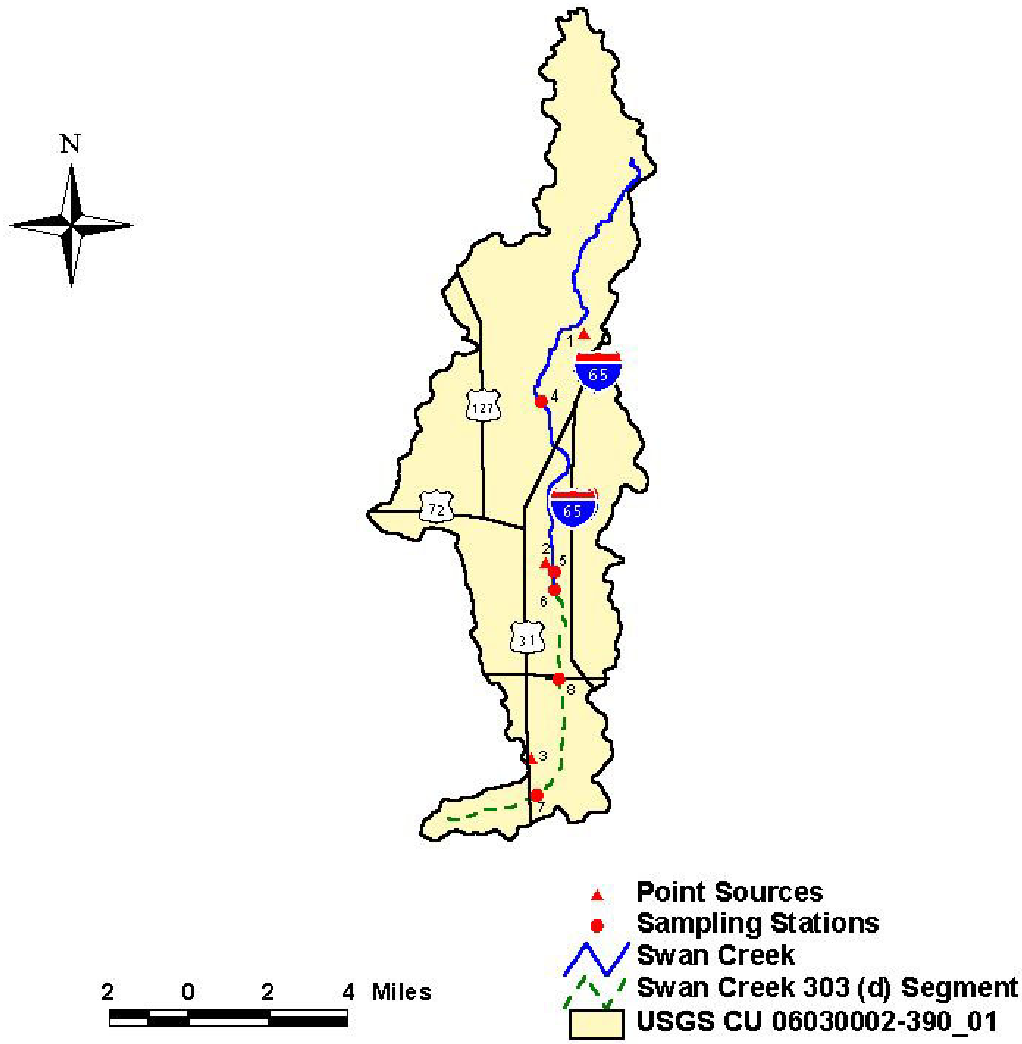
3.4.2 Available Water Quality and Biological Data

Water Quality and biological data for the Swan Creek is available for the period of 1994-1995, 1997, and 1998. TVA collected the data in 1994-1995 and 1997 and ADEM collected the data in 1998. TVA collected data at two stations in 1994-1995: Station 1208 and Station 1208-13. Station 1208 has a site description of Alabama Highway 31 bridge and Station 1208-13 has a site description of being between Elkton Road bridge and Muddy Creek. The data that was collected in 1994-1995 included macroinvertebrate/EPT and fish/IBI biological data. TVA did not collect flow or chemical data at this time. In 1997, TVA collected physical/chemical data at two stations: Station 11146-2 and Station 11146-3. Station 11146-2 has the same site description as Station 1208-13 as listed previously. Station 11146-3 has a site description of Alabama Highway 251 bridge (Strain Rd). In 1998, ADEM collected physical/chemical data at three stations: SWNL-390, SWNL-391, and SWNL-392. Station SWNL-390 has the same site description as the TVA Station 1208 listed previously. Station SWNL-391 has a site description of Limestone County Road 24 near Tanner Crossroads. Station SWNL-392 has a site description of Alabama Highway 72 near Athens, Alabama.

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 3-3.

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



Station	Name	Latitude	Longitude
1	Piney Chapel Jr. High School	34° 51' 20"	86° 56' 09"
2	Athens WWTP	34° 46' 21"	86° 56' 58"
3	Lawson Trailer Park	34° 42' 07"	86° 57' 17"
4	1997 TVA Station 11146-2 & 1995 TVA Station 1208-1308	34° 49' 50"	86° 57' 03"
5	1998 ADEM Station SWNL-392	34° 46' 09"	86° 56' 47"
6	1997 TVA Station 11146-3	34° 45' 45"	86° 56' 47"
7	1995 TVA Station 1208 & 1997 TVA Station 11146-01 & 1998 ADEM Station SWNL-390	34° 41' 20"	86° 57' 11"
8	1998 ADEM Station SWNL-391	34° 43' 48"	86° 56' 24"

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.

The $7Q_{10}$ 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 (Bingham, 1982). The equation used to calculate the $7Q_{10}$ and $7Q_2$ flow for the stream and any associated tributaries was based on the USGS gaging continuous-record station (03577280) on Swan Creek near Whiteside, Alabama, and the equation is as follows (Adkins, 1994):

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

$$7Q_{10} = \frac{(0.1) * (55.2\text{ mi}^2)}{(52.4\text{ mi}^2)}$$

$$7Q_{10} = 0.74\text{ cfs}$$

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

$$7Q_{2} = \frac{(0.3) * (55.2\text{ mi}^2)}{(52.4\text{ mi}^2)}$$

$$7Q_{2} = 1.47\text{ cfs}$$

The method used to determine both the $7Q_{10}$ and $7Q_2$ flows for the Swan Creek was by using gage data from the United States Geological Survey. The resulting $7Q_{10}$ and $7Q_2$ flow is 0.74 cfs and 1.47 cfs, respectively.

The calculated flow was distributed over Swan 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 stream's dissolved oxygen supply. Reaction rates for $CBOD_u$ and NBOD (i.e., organic loading) are temperature dependent and high summer time 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 specifing 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. Finally, 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. In addition, water depths are shallow, generally one foot or less, which aggravates the effect of sediment oxygen demand (SOD).

4.0 Water Quality Model Development

4.1 Water Quality Model Selection and Setup

Since impairments are generally expected to occur during periods of low flow, 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-one 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.
- $CBOD_u/CBOD_5$ ratio used for point and non-point sources was 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.
- 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_3OD_u, 1-2 mg/l $TONOD_u$.

Point source assessments:

- All of the point sources in the Swan Creek watershed have had wasteload allocations (WLA) prior to being permitted.
- Only Lawson Trailer Park discharges directly to Swan Creek and was the only point source input.
- Athens WWTP and Piney Chapel Jr. High School discharge to other streams that discharge to Swan Creek.
- The results from the respective WLA for Athens WWTP and Piney Chapel Jr. High School at the confluence of the point source discharge stream and Swan Creek was used as input parameters as a tributary to Swan Creek. While

treating the point source as a tributary, all the loading from the point source is calculated as Load Allocations

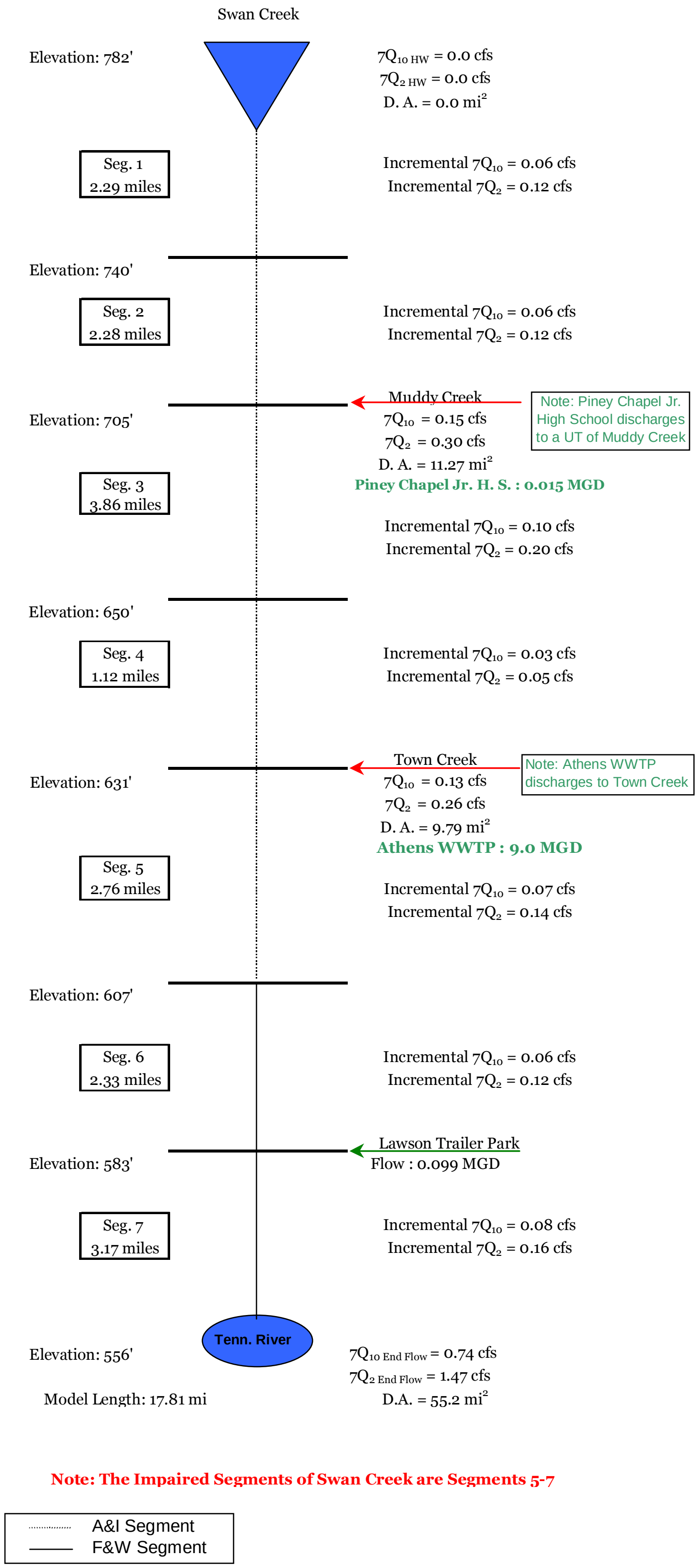
4.1.1. SOD Representation: Sediment oxygen demand (SOD) can be an important part of the oxygen demand budget in shallow streams. At this time, field SOD measurements for Swan Creek are not available; therefore, in the absence of available field SOD measurements for the waterbody, SOD data was obtained 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 for a stream with similar characteristics was chosen from the database and applied to the model for Swan Creek. A SOD value of 0.05 gm-O_2 ft^2/day was chosen based on similar bottom characteristics of sand and gravel (USEPA, Region IV).

4.1.2. Calibration Data: The available data for Swan Creek did not show any D.O. violations; therefore, a calibration model was not done at this time. A calibration model will be performed for Swan Creek if additional data collected as part of the TMDL implementation indicates D.O. violations.

4.2 Water Quality Model Summary

The model reach used for each season was longer than the impaired reach in order to ensure that predicted model pollutant concentrations were at, or near, normal background concentrations at the end of the modeled reach. The summer model reach consisted of 7 segments. The impaired portion of the summer model reach consists of segments 5 through 7. The length of the impaired portion is 8.2 miles. Total distance of the summer model reach is 17.81 miles. The winter model reach consisted of 7 segments. The impaired portion of the winter model reach consists of segments 5 through 7. The length of the impaired portion is the same as that for summer. Total distance of the winter model reach is 17.81 of 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_3OD_u (mg/l)**	**$TONOD_u$ (mg/l)**	**Temp (°C)**
Headwaters	1.00E-23	6.65	23.74	6.19	75.54	28.0
Conditions @ Lowest D.O.	0.03	3.05	16.81	7.15	73.29	28.0
Flow @ End of Model	14.67	6.15	8.09	3.78	8.25	28.0

Summer Incremental Flow Parameters

Sections	**$CBOD_u$ (mg/l)**	**NH_3OD_u (mg/l)**	**$TONOD_u$ (mg/l)**	**DO (mg/l)**	**Total Flow (cfs)**	**Temp. (°C)**
1	23.74	6.193	75.54	5.48	0.06	28.0
2	23.74	6.193	75.54	5.48	0.06	28.0
3	23.75	6.193	75.54	5.48	0.10	28.0
4	23.75	6.193	75.54	5.48	0.03	28.0
5	66.64	14.19	172.53	5.48	0.07	28.0
6	66.64	14.19	172.53	5.48	0.06	28.0
7	66.64	14.19	172.53	5.48	0.08	28.0

4.2.2. Winter (December – April) Model

Winter Stream Flow Parameters

Description	**Flow (cfs)**	**DO (mg/l)**	**$CBOD_u$ (mg/l)**	**NH_3OD_u (mg/l)**	**$TONOD_u$ (mg/l)**	**Temp (°C)**
Headwaters	1.00E-23	8.05	40.15	10.48	129.08	18.0
Conditions @ Lowest D.O.	0.16	3.048	24.57	13.48	123.49	18.0
Flow @ End of Model	15.21	6.24	15.31	8.94	20.51	20.0

Winter Incremental Flow Parameters

Sections	**$CBOD_u$ (mg/l)**	**NH_3OD_u (mg/l)**	**$TONOD_u$ (mg/l)**	**DO (mg/l)**	**Total Flow (cfs)**	**Temp. (°C)**
1	40.15	10.48	129.08	6.63	0.12	18.0
2	40.15	10.48	129.08	6.63	0.12	18.0
3	40.15	10.48	129.08	6.63	0.20	18.0
4	40.15	10.48	129.08	6.63	0.05	18.0
5	113.74	24.20	295.53	6.63	0.14	18.0
6	113.74	24.20	295.53	6.63	0.12	18.0
7	113.74	24.20	295.53	6.63	0.16	18.0

4.3 *Summer and Winter Models Predictions and Graphics*

Figure 4-2. Summer Model Predictions.

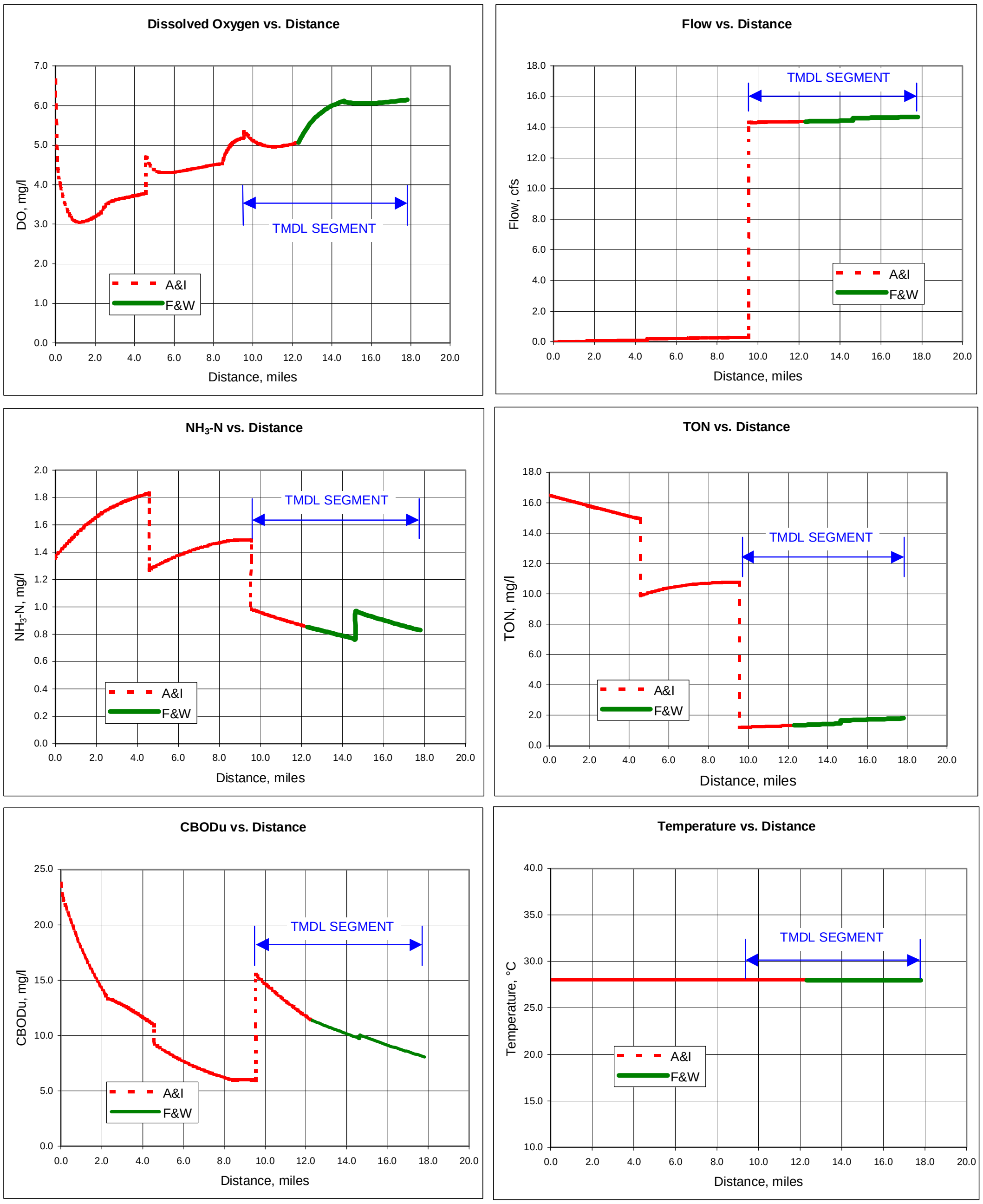
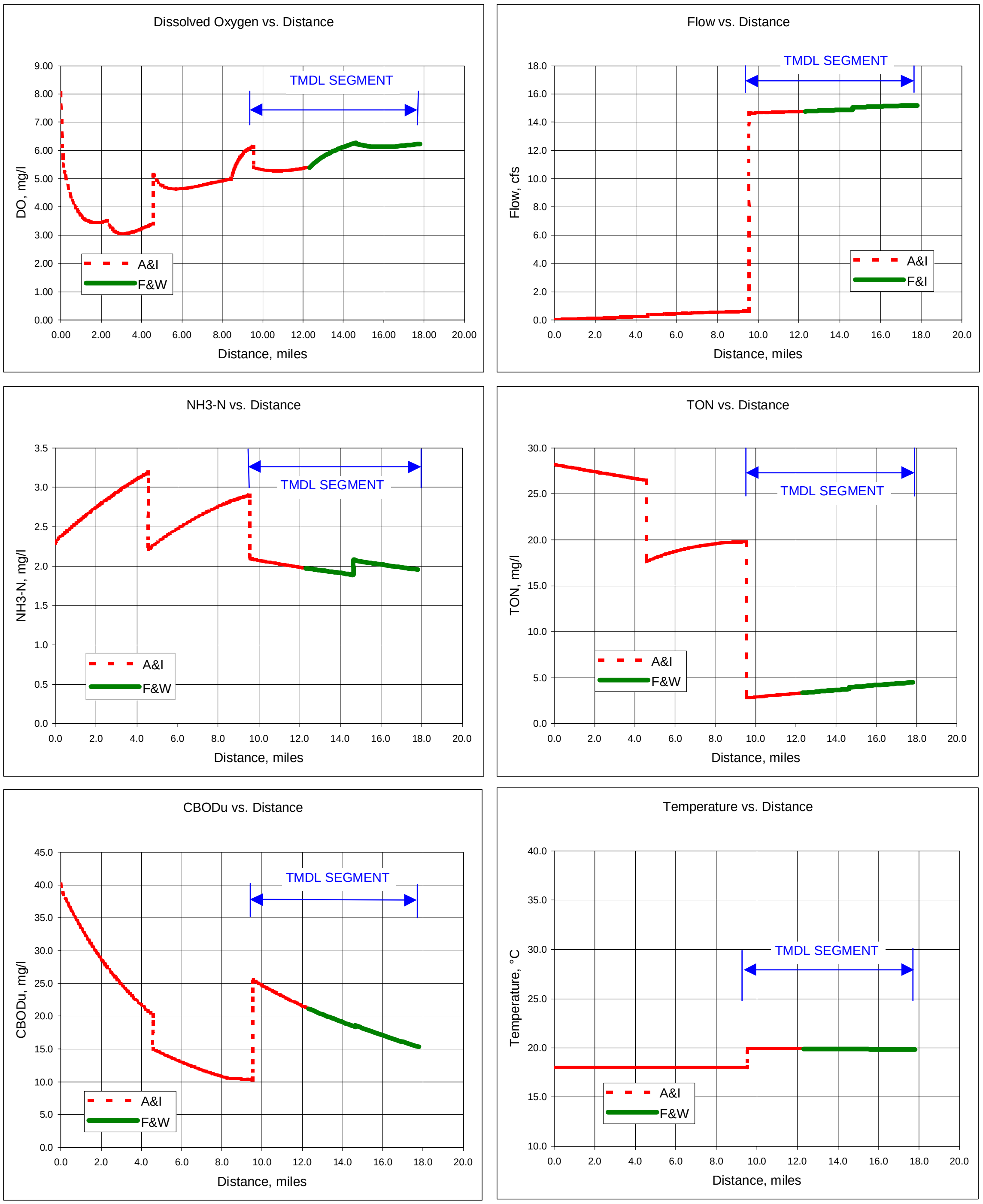


Figure 4-3. Winter Model Predictions.



4.4 Loading Reduction Analysis

4.4.1. Required Reductions

The available data for Swan Creek does not show any D.O. violations; therefore, there are no reductions for Swan Creek at this time. Reductions for Swan Creek will not be required until additional data indicates D.O. violations.

4.4.2. Point Source Sensitivity Analysis

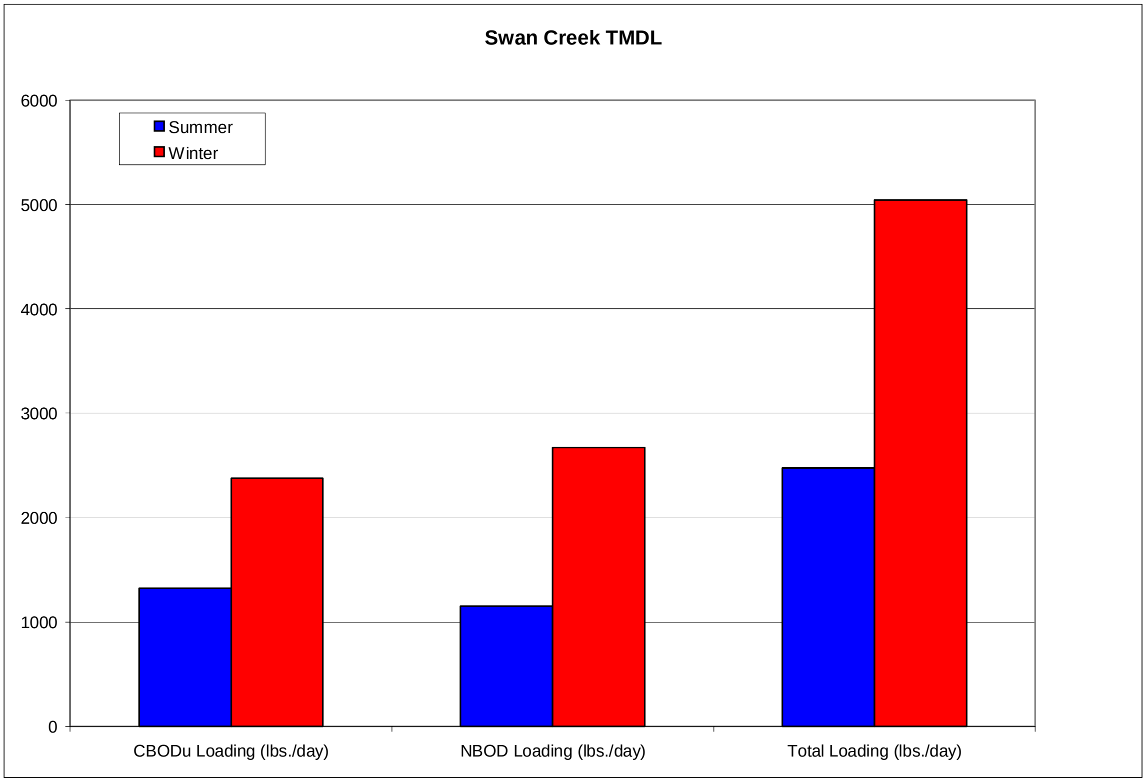
A point source sensitivity analysis was not performed for Swan Creek since the available data did not show any D.O. violations. A point source sensitivity analysis will be done when additional data indicates D.O. violations.

4.5 Seasonal Variation

The regulations require that a TMDL be established with consideration of seasonal variations. Since there were point source loads identified, both summer and winter TMDLs were calculated for the purposes of determination of applicable point source permit limitations year round.

As discussed previously, TMDLs have been estimated for the summer and winter. Figure 4-4, on the next page, illustrates the effect that seasonal temperatures and stream flows have on CBODu, NBOD and total organic loading.

Figure 4-4. Seasonal Temperature and Stream Effects on the TMDLs



5.0 Conclusions

A summary of the TMDL for both summer and winter is presented in Table 5-1.

Table 5-1. Summer and Winter TMDLs Summary

	TMDL	
	Summer	**Winter**
$CBOD_u$ Loading (lbs./day)	1325.0	2375.50
NBOD Loading (lbs./day)	1150.0	2668.90
Total Loading (lbs./day)	2475.0	5044.4

Within the impaired segment, the point source allocations used in development of the summer and winter TMDL will be addressed by the NPDES permit program during permit renewals and modifications. At this time, no revisions will need to be made to the NPDES permit limits for significant point sources.

6.0 TMDL Implementation

6.1 Non-Point Source Approach

Swan Creek is impacted primarily by non-point sources. Since there were no D.O. violations during the TVA and ADEM sampling events, no reductions were calculated at this time. The collection of additional data for Swan Creek will be a major part of the implementation plan. ADEM will be sampling in the Tennessee River basin in 2003. Swan Creek will be a part of this sampling event. Once adequate data is obtained, the TMDL will be revised to calculate the required reductions, if applicable.

For 303(d) listed waters impacted solely or primarily by non-point 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 non-point 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 non-point 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

At this time, reductions from point sources do not need to 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

Swan Creek will be a part of the Tennessee River basin-sampling effort 2003, once sufficient data is obtained the TMDL will be revised to calculate the required reductions, if applicable. Monitoring will help further characterize the water quality conditions resulting from the implementation of best management practices in the watershed.

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

United States Environmental Protection Agency Region IV. Sediment Oxygen Demand Database

Appendix 9.2
Water Quality Data

1994-1995 Tennessee Valley Authority Sampling Event

TVA Station	Bug Health	EPT	Fish Health	IBI	Causes
1208-13	Fair	7	Poor/Fair	36	nutrients, org. enrichment
1208	Very Poor/Poor	2	Very Poor/Poor	26	silt, org. enrich., nutrients

1997 North Alabama Water Quality Survey by Tennessee Valley Authority (TVA)

TVA Station Number	Duplicate	Date	Time	StreamFlow (cfs)	Air Temp (ºC)	Water Temp (ºC)	Stream Depth (feet)*	Turbidity (NTU)	Conductivity (mmhos/cm)	Dissolved Oxygen (mg/L)	pH (S.U.)	BOD_5 (mg/L)	TSS (mg/L)
1114602		06/10/1997	12:40	104.0		17.1	1.0	9.9	64	9.1	6.9	2	6
1114602	Duplicate	06/10/1997	12:41									3	4
1114602		07/09/1997	13:30	34.7	27.4	25.6	0.7	6.0	95	8.0	7.2	2	3
1114602		08/13/1997	8:00	14.9	25.4	23.9	0.6	18.3	173	5.9	7.3	2	6
1114602		09/10/1997	8:00	18.8	22.3	22.2	0.6	7.1	218	6.5	7.5	2	6
1114602		10/15/1997	13:00	54.4	17.3	15.1	0.6	5.0	86	9.9	7.2	2	2
Maximum				**104.0**	**27.4**	**25.6**	**1.0**	**18.3**	**218**	**9.9**	**7.5**	**3**	**6**
Minimum				**14.9**	**17.3**	**15.1**	**0.6**	**5.0**	**64**	**5.9**	**6.9**	**2**	**2**
Mean				**43.1**	**25.0**	**22.2**	**0.7**	**10.3**	**138**	**7.4**	**7.2**	**2**	**5**
1114603		06/10/1997	11:40	42.2		17.6	1.0	8.6	130	8.8	7.3	2	5
1114603		07/09/1997	12:45	5.9	28.0	23.5	0.5	3.6	216	10.0	7.9	2	2
1114603		08/13/1997	11:45	0.9	27.8	25.2	0.3	2.1	408	8.6	7.6	2	2
1114603		09/10/1997	8:00	0.6	21.7	23.2	1.3	13.8	307	7.6	7.4	11	9
1114603		10/15/1997	11:30	8.2	17.5	16.4	0.5	4.6	238	9.9	7.5	2	3
Maximum				**42.2**	**28.0**	**25.2**	**1.3**	**13.8**	**408**	**10.0**	**7.9**	**11**	**9**
Minimum				**0.6**	**17.5**	**16.4**	**0.3**	**2.1**	**130**	**7.6**	**7.3**	**2**	**2**
Mean				**11.6**	**23.8**	**21.2**	**0.7**	**6.5**	**260**	**9.0**	**7.5**	**4**	**4**

1998 ADEM Physical/Chemical Data

Appendix D-1, cont. Results of physical and chemical measurements and water quality samples collected from stations included as part of the nonpoint source watershed screening and CWA §303(d) segment

Sub-Watershed Number	Station Number	Date (YYMMDD)	Time (24hr)	Water Temp. (C)	Dissolved Oxygen (mg/l)	pH (s.u.)	Conductivity (umhos)	Turbidity (ntu)	Flow (cfs)	Fecal Coliform (col/100ml)	TSS (mg/l)	TDS (mg/l)	NO2/NO3 (mg/l)	T-PO4 (mg/l)	TKN (mg/l)	BOD-5 mg/l	Hardness mg/l
Wheeler Lake (0603-0002)																	
390	SWNL-390	980512	1445	26	10.3	8.4	191	5.6	36.9	32	2	114	1.899	0.353	0.057	0.9	
390	SWNL-390	980715	1130	25	10.2	7.9	267	7.0	15	>1200	2	164	3.159	1.845	0.462	1	94
390	SWNL-390	980916	0820	24	6.6	7.9	425	3.5	5.1	134	4	262	6.81	10.285	0.545	1.3	
390	SWNL-391	980512	1525	27	9.8	8.5	202	5.1	37.9	30	2	132	2.091	0.551	0.308	1.1	
390	SWNL-391	980715	1215	25	11.3	8.3	296	3.1	16.9	248	<1	183	4.366	1.506	0.074	0.9	
390	SWNL-391	980916	0930	23	9.4	7.5	450	1.3	6.3	220	2	266	7.608	1.66	<0.005	1.1	

Appendix D-1, cont. Results of physical and chemical measurements and water quality samples collected from stations included as part of the nonpoint source watershed screening and CWA §303(d) segment

Sub-Watershed Number	Station Number	Date (YYMMDD)	Time (24hr)	Water Temp. (C)	Dissolved Oxygen (mg/l)	pH (s.u.)	Conductivity (umhos)	Turbidity (ntu)	Flow (cfs)	Fecal Coliform (col/100ml)	TSS (mg/l)	TDS (mg/l)	NO2/NO3 (mg/l)	T-PO4 (mg/l)	TKN (mg/l)	BOD-5 mg/l	Hardness mg/l
Wheeler Lake (0603-0002)																	
390	SWNL-392	980512	1620	25	9.2	7.7	133	7.5	19.2	100	1	85	0.705	0.078	0.373	0.8	
390	SWNL-392	980715	1300	24	9.3	7.7	211	6.5	7.3	390	<1	127	0.952	0.104	0.345	0.6	
390	SWNL-392	980916	1000	23	6.9	7.4	245	2.3	2.1	67	2	140	0.863	<0.005	0.328	0.9	

Appendix 9.3
Water Quality Model
Input and Output Files

SUMMER TMDL MODEL

WINTER TMDL MODEL

9.4
Spreadsheet Water Quality Model (SWQM) User Guide