Alabama Department of Environmental Management

Final TMDL Development for
Indian Creek / AL06030002-250_02
Low Dissolved Oxygen/Organic Loading

Water Quality Branch
Water Division
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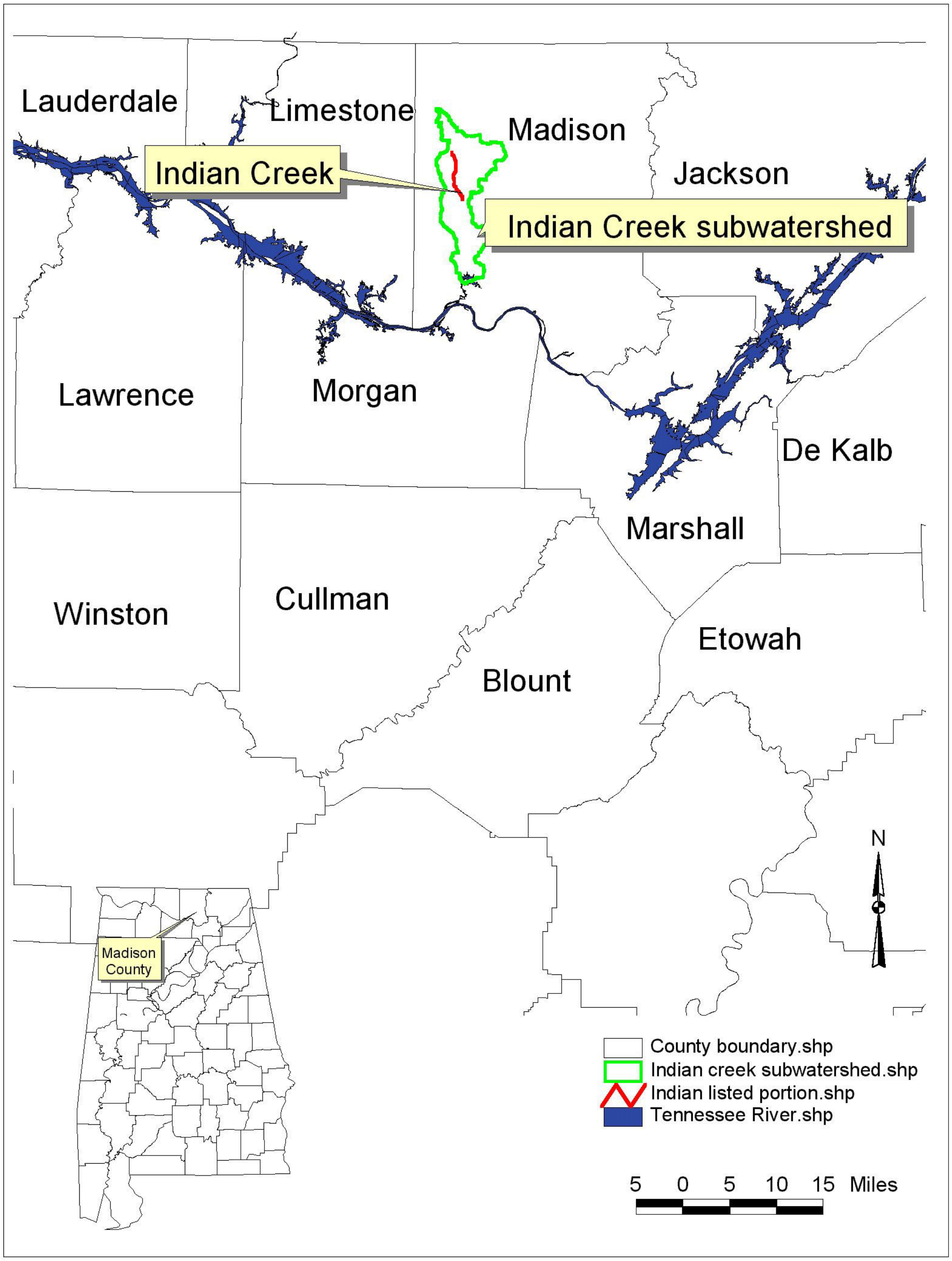
Indian Creek Watershed in the Tennessee River Basin



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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 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.

Indian Creek, a part of the Tennessee River basin, is located in Madison County near Huntsville, Al. It has two separate impaired segments. This report addresses the headwaters portion, listed from Al. Hwy.72 to it source. The other impaired segment will be addressed in a separate report. Indian Creek 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 Fish and Wildlife.

Biological data collected by TVA in 1994 and 1995 indicated impaired macroinvertebrate and fish communities. The impairment was attributed to siltation and organic enrichment/low dissolved oxygen but water column sampling was not conducted at the time to support this assumption.

Besides the TVA study conducted in 1994 and 1995, there has been two additional studies performed on Indian Creek. The Alabama Department of Environmental Management (ADEM), sampled two stations for five months in 1988 (on this impaired portion of Indian Creek.) The other study, conducted by ADEM in 1998, used the same two stations and samples were collected during three separate months. None of the samples from either study showed a D.O. violation.

Due to the fact that no D.O. violations have been recorded for Indian Creek no reductions were calculated for the watershed. In this report the TMDLs for the winter and summer periods were calculated. If additional data indicates that Indian Creek is impaired for D.O., the TMDL will be revised. As part of TMDL implementation Indian Creek will be sampled in 2003.

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 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.

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 using the stream 7Q10 flow (the minimum 7-day flow that occurs, on average, over a 10-year recurrence interval) was adopted as appropriate for this TMDL analysis.

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. Table 1-1 lists allowable pollutant loadings by source (point and non-point sources) for the summer (Critical) season (May through November). Table 1-2 lists 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 for the Summer Critical) Season

Pollutant	Point Source Loads (lbs./day)	Non-point Source Loads (lbs./day)
$CBOD_u$	13.3	236.0
NBOD	16.2	85.5
Total	29.5	321.5

Table 1-2. Maximum Allowable Pollutant Loads by Source for the Winter Season

Pollutant	Point Source Loads (lbs./day)	Non-point Source Loads (lbs./day)
$CBOD_u$	20.5	1962.1
NBOD	25.0	673.2
Total	45.5	2635.3

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 classification. The identified waters are prioritized based on severity of pollution with respect to designated use classification. 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 Indian Creek as being impaired by organic loading (i.e., $CBOD_u$ and NBOD) for a length of 6.9 miles, as reported on the 1996, 1998 and Draft 2000 §303(d) list(s) of impaired waters. While evaluating the stream for modeling, the listed segment was determined to be 5.95 miles. Indian Creek is prioritized as "low " on the list(s). Indian Creek is located in Madison County and lies within Indian Creek subwatershed of the Tennessee River basin.

The TMDL developed for Indian 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

Indian Creek is a headwater stream with a drainage area of 38.8 square miles for the impaired portion of the creek. Dry weather flows for the watershed are relatively low. Water Quality and biological data for Indian Creek is available for the period of 1988-1998. In 1994 and 1995 TVA collected macroinvertebrate/EPT and fish/IBI biological data at one station on Indian Creek. Flow and chemical data were not collected during this study. From this report TVA concluded that the bug health was poor/fair and the fish health was poor and attributed the impairment to siltation, and nutrients. Based on these results Indian Creek was listed on the 1996 303(d) list.

Besides the TVA study conducted in 1994 and 1995, there has been two additional studies performed on Indian Creek. The Alabama Department of Environmental Management (ADEM), sampled two stations for five months in 1988, (on this impaired portion of Indian Creek.) The other study was conducted by ADEM in 1998, used the same two stations and samples were collected during three separate months. None of the samples from either study showed a D.O. violation.

If there are depressed in-stream D.O. concentrations in Indian Creek they may be caused by several sources including the decay of oxygen demanding waste from non-point sources, algal respiration, sediment oxygen demand or other sources.

Waterbody Impaired:	Indian Creek from Al. Hwy. 72 to its source
Water Quality Standard Violation:	Dissolved Oxygen
Pollutant of Concern:	Organic Enrichment ($CBOD_u$/NBOD)
Water Use Classification:	Fish and Wildlife

The impaired stream segment, Indian Creek, is classified as Fish and Wildlife. Usage of waters in this Fish and Wildlife 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 Fish and Wildlife 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.

<u>Low D.O./Organic Loading Criteria:</u>

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.

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.

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 Indian 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 listed segment. Figure 3-1 shows the location of each facility considered a significant source relative to the impaired segment.

Table 3-1. Contributing Point Sources in the Indian Creek Watershed.

NPDES or SID Permit #	Type of Facility (e.g., CAFO, Industrial, Municipal, Semi-Public/Private, Mining, Industrial Storm Water)	Facility Name (latitude)/(longitude)	Significant Contributor (Yes/No) (% of $7Q_{10}$)
AL0066796	Semi-Public/Private	BONNIE ACRES ESTATES WWTP (34.78870000/-86.68385300)	Yes-(1.3)
AL0068608	Semi-Public/Private	MONROVIA SCHOOL (34.78646900/-86.71246100)	Yes-(3.5)
AL0070947	Semi-Public/Private	SPARKMAN HIGH SCHOOL WWTP (34.83300800/-86.71662200)	Yes-(3.3)

All of these point sources have had waste load allocations prior to being permitted. Only Monrovia School discharges directly to Indian Creek. Bonnie Acres and Sparkman High School discharge to tributaries to Indian Creek.

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)		NH_3-N (MG/L)		DO (MG/L)
		Max	Avg	Max	Avg	Max	Avg	Min	Max	Avg	Max	Avg	Max	Avg	Min
AL0066796	BONNIE ACRES	0.02	n/a	8	n/a	1	n/a	6.5	0.02	n/a	30	n/a	20	n/a	6
AL0068608	MONROVIA SCHOOL	0.053	n/a	20	n/a	4	n/a	6	0.053	n/a	20	n/a	4	n/a	6
AL0070947	SPARKMAN HIGH SCH	0.05	n/a	6	n/a	1.2	n/a	6	0.05	n/a	25	n/a	2.1	n/a	6

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 Indian Creek Watershed

Shown in Table 3-3, below, is a detailed summary of land usage in the Indian Creek watershed. Shown in Figure 3-1 is a pie chart depicting principal land uses. A land use map of the watershed is presented in Figure 3-2. The predominant land uses within the watershed are agricultural, forest and residential. Their respective percentages of the total watershed are 51.1%, 32.7% and 15.7 %.

Figure 3-1. Location Map of Significant Point Sources

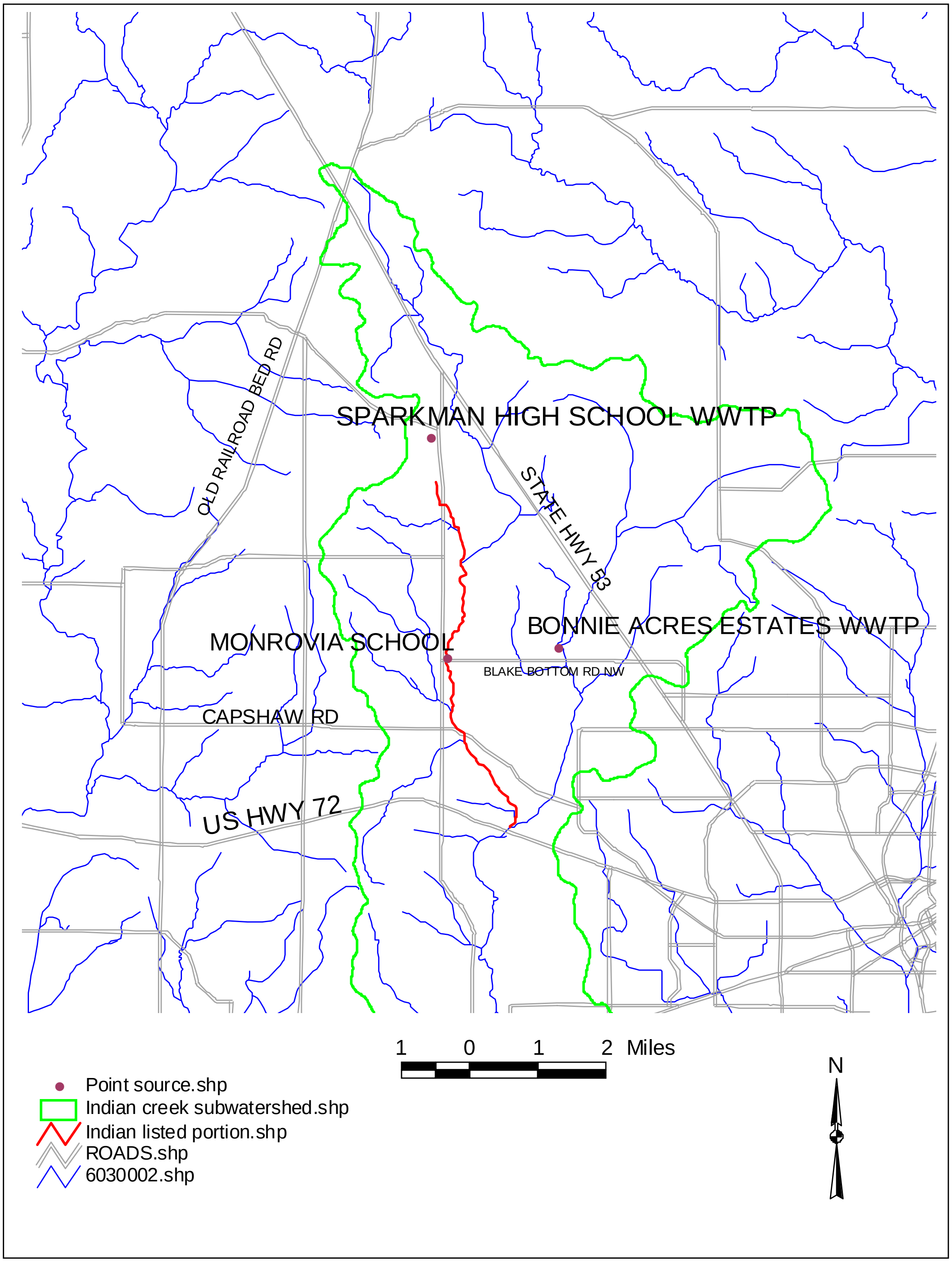


Table 3-3. Land Use in the Indian Creek Watershed.

LANDUSE Indian Creek Watershed	% of total	Acres	sq miles
Cropland	41.0%	11437	17.9
Forest	32.7%	9375	14.6
High Commercial/Industrial/Transportation	0.3%	66	0.1
High Residential	10.2%	38	0.1
Low Residential	5.5%	123	0.2
Pasture	10.1%	3761	5.9
Water	0.2%	47	0.1
Total	**100.0%**	**24847**	**38.8**

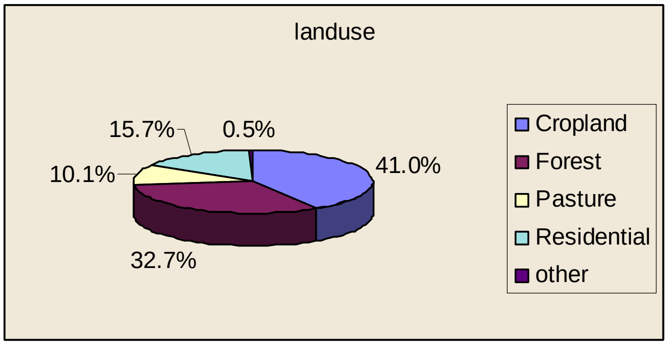
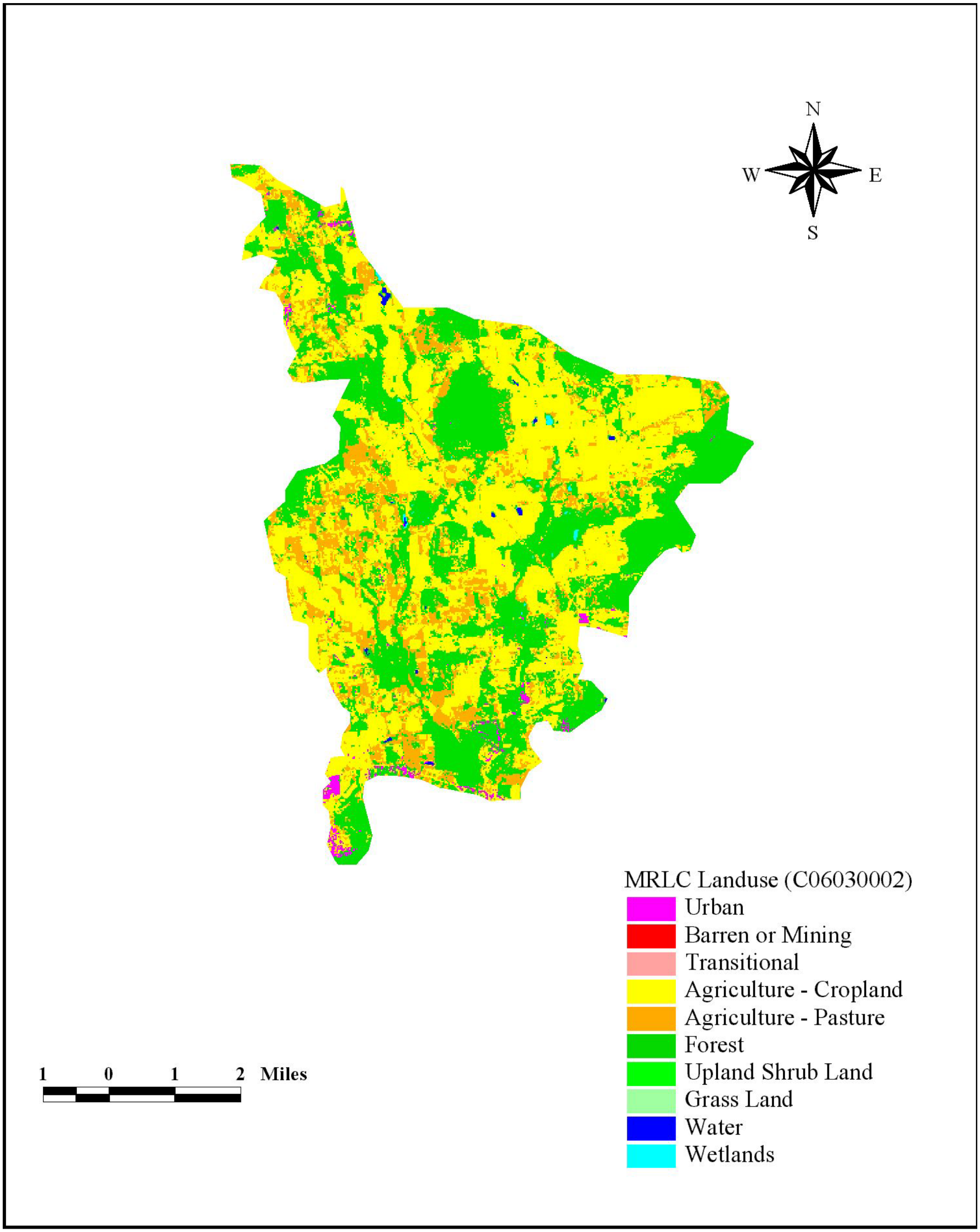


Figure 3-1

The predominant land uses of cropland, forest, residential, and pasture make up 99.5% of the watershed. The other 0.5% 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 Indian Creek watershed are the forest, cropland, residential and pasture 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 Indian 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-(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.

Using the D.O. water quality criterion of 5.0 mg/l as the numerical target, 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. Without specific stream data, background pollutant concentrations are considered to be as follows: 2 mg/l $CBOD_u$, 0.5 mg/l ammonia oxygen demand (NH_3-N), and 1 mg/l total organic nitrogen oxygen demand (TON). For Indian Creek using available field data, background conditions were considered to be as follows: 2 mg/l $CBOD_u$, 0.11 mg/l ammonia oxygen demand (NH_3-N), and 0.22 mg/l total organic nitrogen oxygen demand (TON). 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 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: Indian Creek, located in Madison County, is a tributary to the Tennessee River. Indian Creek is a part of the USGS (United States Geological Survey) 06030002 cataloging unit and the NRCS (Natural Resources Conservation Service) 250 sub-watershed. Cataloging unit 06030002 includes Wheeler Lake. NRCS sub-watershed number 250 represents the Indian Creek subwatershed.

   Indian Creek begins Northwest of Huntsville in Section 34, Township 2S, and Range 2W. It has a linear distance of 5.95 miles and a total drainage area of 38.8 square miles. Indian Creek has a use classification of Fish & Wildlife (F&W).

B. Geological Description: The predominately geology of the Indian Creek Watershed consist primary of Tuscumbia Limestone Formation of the Mississippian system in the Interior Low Plateaus and Appalachian Plateaus province which consist of limestone and chert that of the karst nature.

C. Eco-region Description: Indian Creek is primary in the following Eco-region:
71g. The Eastern Highland Rim which is flatter and has less dissection than the Western Highland Rim (71f). Mississippian-age limestone, chert, shale, and dolomite 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 ecoregion 68, cutting north across the Moulton Valley and through narrow valleys of Little Mountain (71j) 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 of the Appalachian ecoregions 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 very deep, well-drained, reddish, soils that are intensively farmed.

D. Other Notable Characteristics: Indian Creek starts at an elevation of 790 feet and ends at 657 feet. Its total length is 5.95 miles..

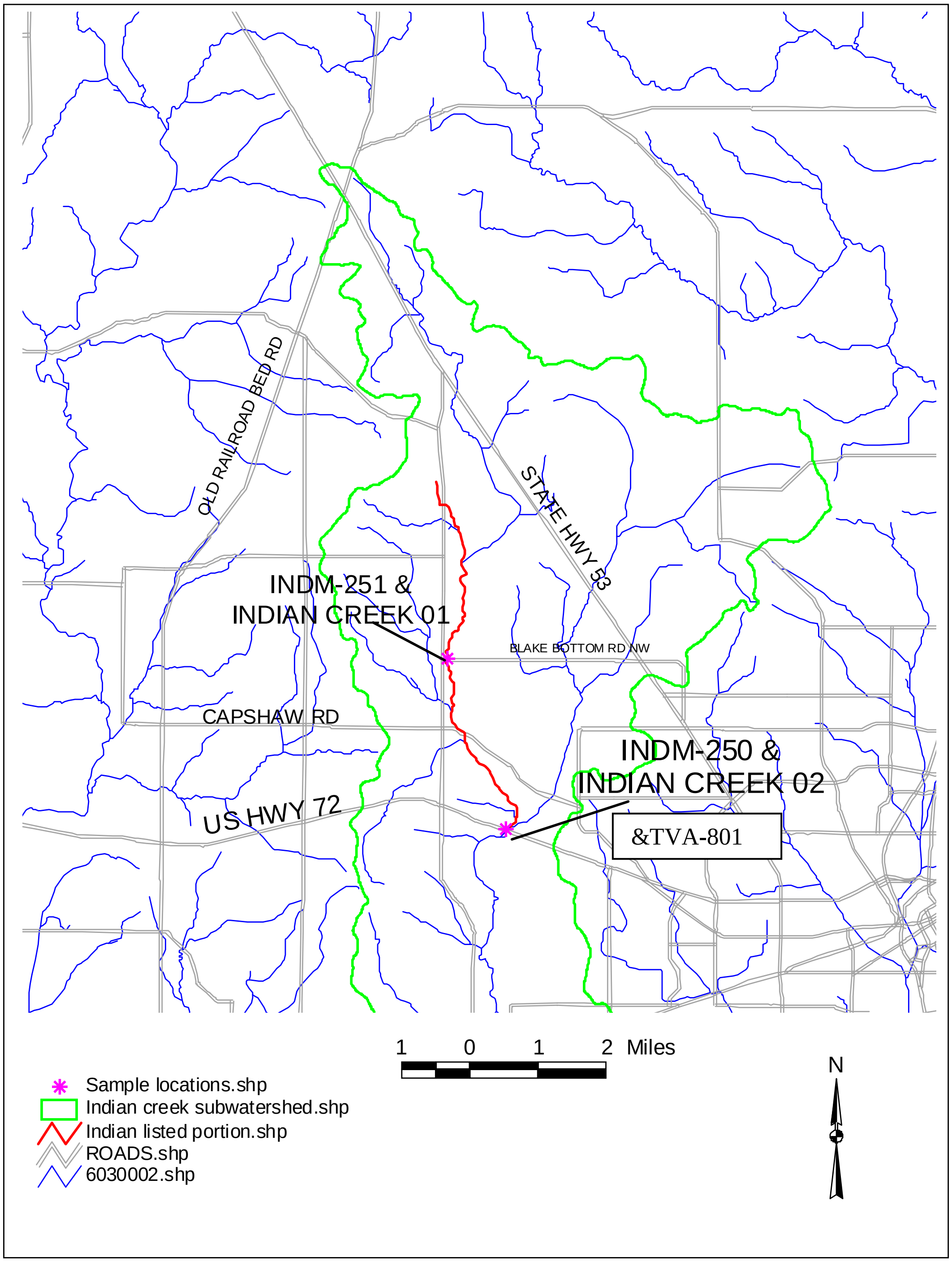
3.4.2 Available Water Quality and Biological Data

Water Quality and biological data for Indian Creek is available for the period of 1988-1998. In 1994 and 1995 TVA collected Macroinvertebrate/EPT and Fish/IBI Biological data, at one station on Indian Creek. Flow and chemical data were not collected during this study. From this report TVA concluded that the bug health was poor/fair and the fish health was poor and attributed the impairment to siltation, and nutrients. Based on these results Indian Creek was listed on the 1996 §303(d) list.

In addition to the TVA study conducted in 1994 and 1995, there has been two additional studies performed on Indian Creek. The Alabama Department of Environmental Management (ADEM), sampled two stations for five months in 1988 (on this impaired portion of Indian Creek.) The other study conducted by ADEM in 1998 used the same two stations and samples were collected during three separate months. None of the samples from either study showed a D.O. violation.

Due to the fact that there were no D. O. violations during a sampling event, reduction in load of pollutants to Indian Creek was not calculated at this time. In this report only the TMDL for the summer and winter periods were calculated. Additional data will be necessary to calculate the required reductions. A complete listing of the available data can be found in the appendix of this report. A map indicating the location of sampling points is presented in Figure 3-3.

Figure 3-3. Map of Sampling Locations for the Indian Creek Watershed.



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:

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

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

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):

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

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

Gage data was used to determine the $7Q_{10}$ and $7Q_2$ flows for Indian Creek. The resulting $7Q_{10}$ and $7Q_2$ flows are 1.50 cfs and 3.56 cfs, respectively. These flows are based on the USGS gage # 03575830 "Indian Creek near Madison", Ala which reports the following:

Drainage area=		49	sq miles
7Q10		1.9	cfs
7Q2=		3.56	cfs

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

The flows for the tributaries in this model were obtained from previous WLA models.

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.

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 $7Q_{10}$ stream flow employed for this TMDL, 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 less than two foot, which aggravates the effect of sediment oxygen demand (SOD).

4.0 Water Quality Model Development

4.1 Water Quality Model Selection and Setup

Since the impairment noted by the available data is 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 elements, with each element assumed to be the functional equivalent of a completely mixed reactor.

The following assumptions and information 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 $CBOD_U/NH_3/N$ and $CBOD_U/TON$ were calculated using water quality data for the waterbody. Their respective ratios are 138 and 15. These ratios were assigned in the estimation of loading parameters for incremental flow and tributaries for all land uses, except forest and open water.
- $CBOD_5/BOD_5$ ratio used for 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_3ODu, 1-2 mg/l $TONOD_u$.

Point source assessments:

- All of the point sources in the Indian Creek watershed have had waste load allocations (WLA) prior to being permitted.
- Only Monrovia School discharges directly to Indian Creek and was the only input as a point source.
- Bonnie Acres and Sparkman High School discharge to other steams that discharge to Indian Creek.
- The results from the respective WLA for Bonnie Acres and Sparkman High School, at the confluence of the stream that the point source discharges to and Indian Creek, was used as input parameters as a tributary to Indian Creek.
- While treating the point source as a tributary all the loading from the point source is calculated as Load Allocations.

4.1.1. <u>SOD Representation</u>: Sediment oxygen demand (SOD) can be an important part of the oxygen demand budget in shallow streams. There was no available field SOD measurements for this waterbody; therefore, SOD data was obtained from the EPA Region IV's SOD database. The EPA SOD database represents mixed land uses and varying degrees of point source activity. An SOD value of 0.05 gm-O_2ft^2/day was chosen based on similar bottom characteristics of sand and gravel.

4.1.2. Calibration Data: From an examination of the available field data (ref: Appendix) it was determined that there have been no D.O. violations recorded; therefore, no calibration run was performed.

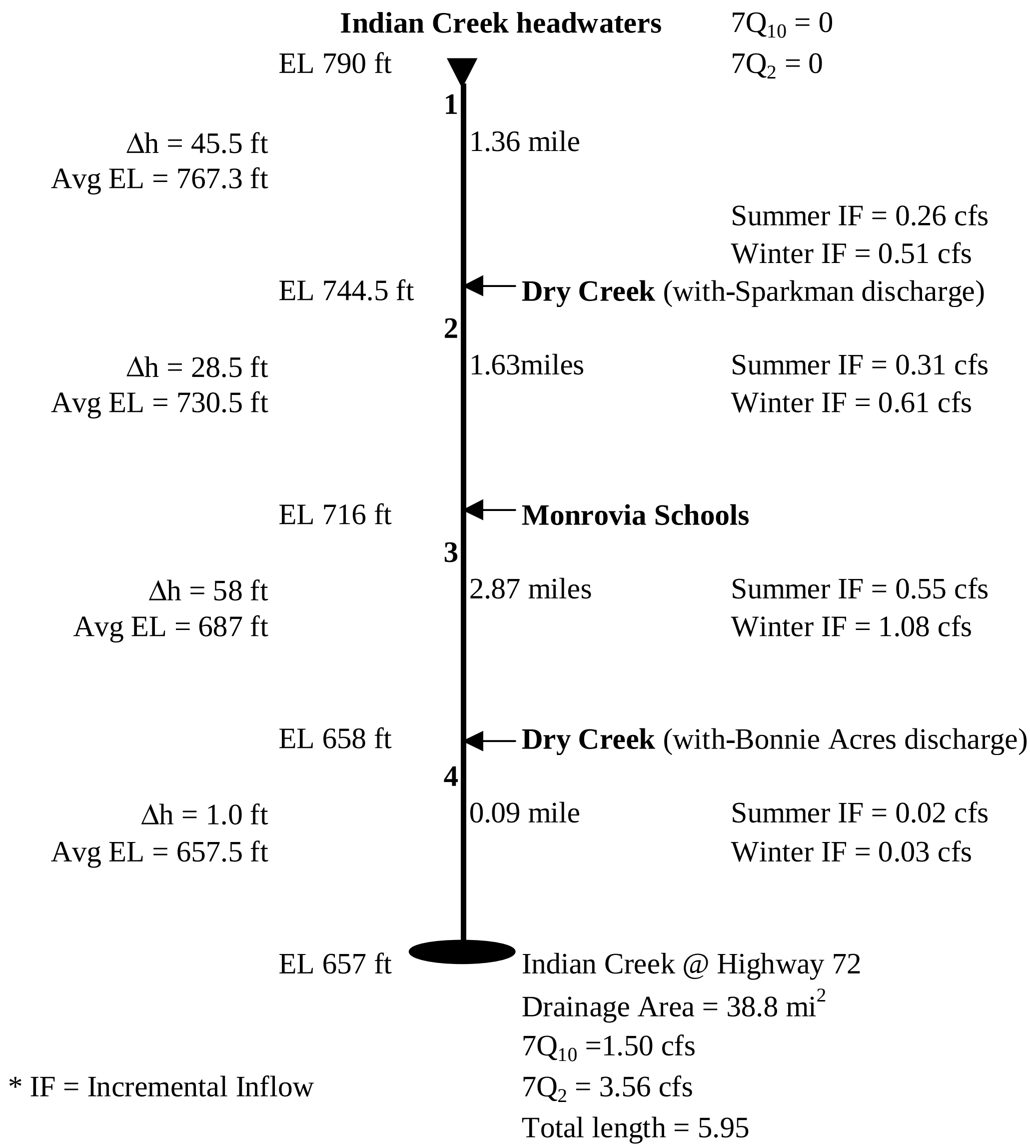
4.2 Water Quality Model Summary

The model reach consisted of 4 segments. 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.

The whole modeled reach is on is in the impaired segment.

Indian Creek TMDL/DO Sketch



4.2.1. Summer (May – November) Model

Summer Stream Flow Parameters

Description	Flow (cfs)	DO (mg/l)	$CBOD_U$ (mg/l)	NH_3-N (mg/l)	TON (mg/l)	Temp (^oC)
Headwaters	0	8.57	37.78	0.30	2.54	26
Conditions @ Lowest D.O.	1.05	5.00	22.25	0.49	1.98	26
Flow @ End of Model	1.488	5.34	17.50	0.29	1.96	26

Summer Incremental Flow Parameters

Sections	$CBOD_U$ (mg/l)	NH_3-N (mg/l)	TON (mg/l)	DO (mg/l)	Total Flow (cfs)	Temp. (^oC)
1	37.88	0.30	5.68	5.687	0.26	26
2	37.88	0.30	5.68	5.68	0.31	26
3	37.88	0.30	5.68	5.68	0.55	26
4	37.88	0.30	5.68	5.68	0.02	26

4.2.2 Winter (December – April) Model

Winter Stream Flow Parameters

Description	Flow (cfs)	DO (mg/l)	$CBOD_U$ (mg/l)	NH_3-N (mg/l)	TON (mg/l)	Temp (^oC)
Headwaters	0	8.57	161.14	1.20	10.71	15
Conditions @ Lowest D.O.	2.21	5.00	97.72	1.13	7.32	15
Flow @ End of Model	3.60	5.98	82.09	0.96	8.33	15

Winter Incremental Flow Parameters

Sections	$CBOD_U$ (mg/l)	NH_3-N (mg/l)	TON (mg/l)	DO (mg/l)	Total Flow (cfs)	Temp. (^oC)
1	161.61	1.20	10.80	7.06	0.51	15
2	161.61	1.20	10.80	7.06	0.61	15
3	161.61	1.20	10.80	7.06	1.08	15
4	161.61	1.20	10.80	7.06	0.03	15

4.3 TMDL Critical Models Predictions and Graphics

Figure 4-1. Summer TMDL Model Predictions.

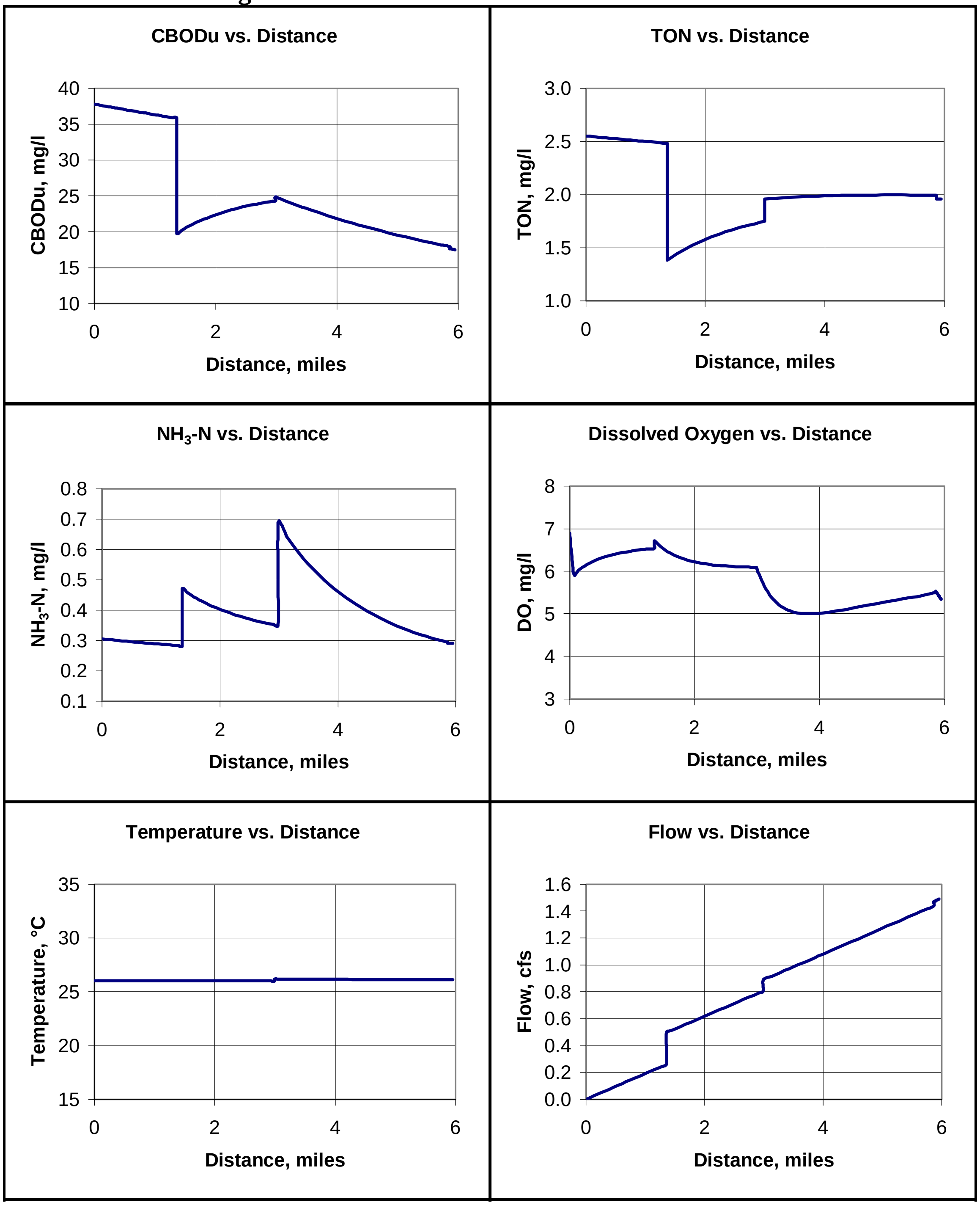
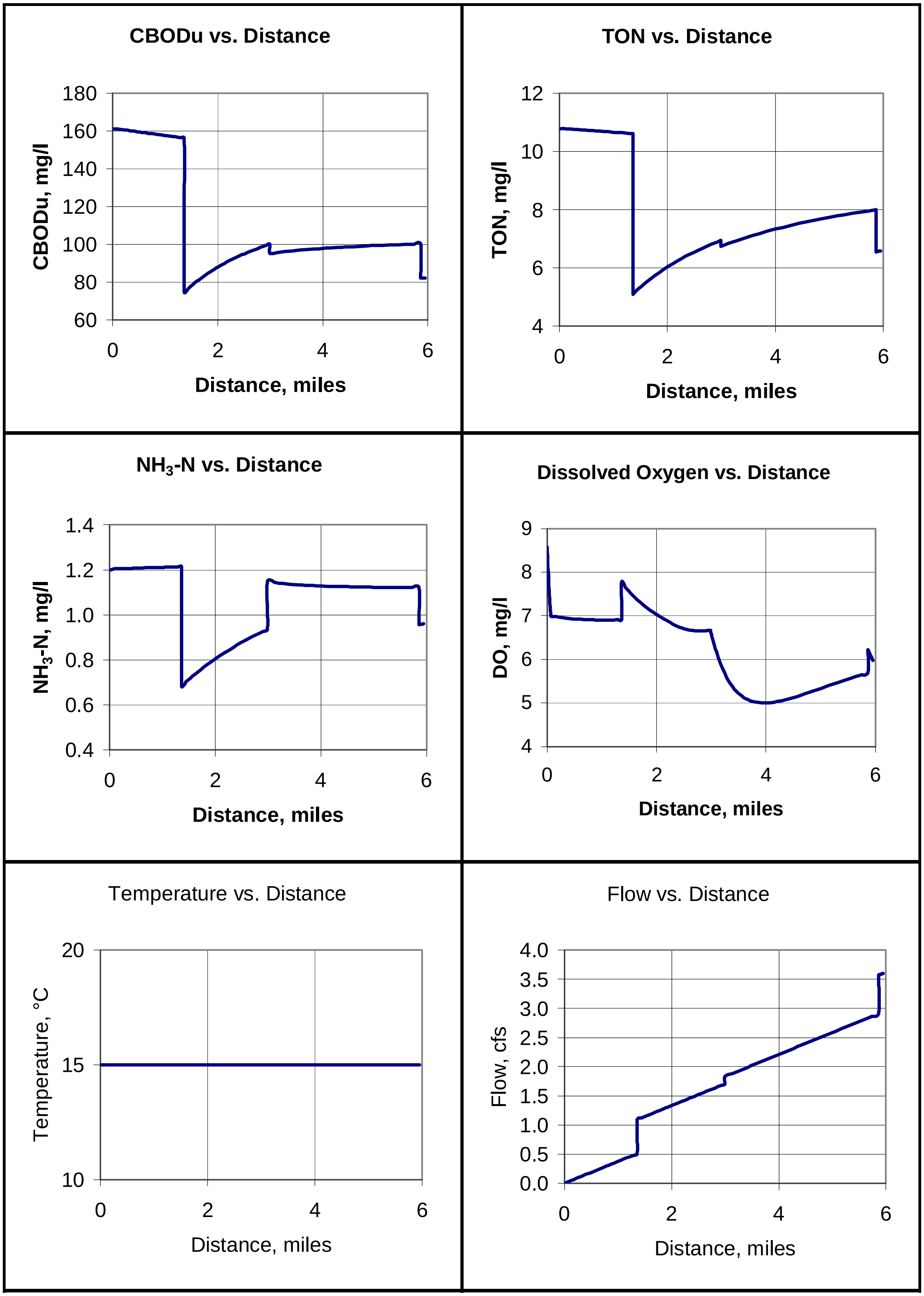


Figure 4-2. Winter TMDL Model Predictions.



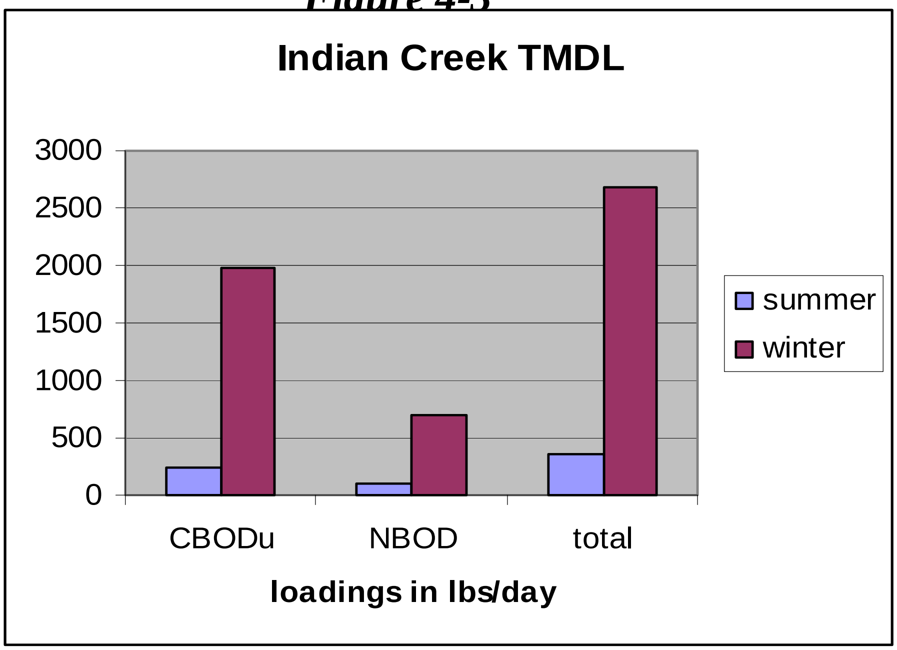
4.4 Loading Reduction Analysis

It was not possible to determine oxygen-demanding loading reductions because none of the available D.O. data indicated violations of the 5 mg/l D.O. water quality standard for Fish & Wildlife streams. Hence there are no calibration or loading reduction simulations for the Indian Creek TMDL.

4.5 Seasonal Variation

The regulations require that a TMDL be established with consideration of seasonal variations. Summer and winter TMDLs were calculated for Indian Creek and are shown in Figure 4-3.

Figure 4-3



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)	249.3	1982.6
NBOD Loading (lbs./day)	101.7	698.2
Total Loading (lbs./day)	351.0	2680.8

6.0 TMDL Implementation

6.1 Non-Point Source Approach

Indian Creek is impaired primarily by nonpoint sources. Due to the fact that there was no D.O. violations during a sampling event, an existing load of pollutants to Indian Creek was not calculated at this time. In this report only the TMDL for the summer (critical) and winter periods were calculated. Until additional data is collected that shows a D.O. violation, no reductions will be required. Collecting additional data will be a major part of the implementation plan. ADEM will be sampling in the Tennessee River Basin in 2002. Indian Creek will be part of this sampling effort. Once adequate data is obtained the TMDL will be revised to calculate the required reductions if applicable.

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. At this time no permits reductions are suggested.

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 monitoring 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

Indian Creek will be a part of the Tennessee River Basin sampling effort in 2003. Once sufficient data is obtained the TMDL will be revised to calculate the required reductions if applicable. Monitoring will help further characterize 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

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

R. H. Bingham, 1982, Geological Survey of Alabama, Low-Flow Characteristics of Alabama Streams.

Nelson, George H., Jr.. 1984. Maps to Estimate Average Streamflow and Headwater Limits for Streams in the U.S. Army Corps of Engineers, Mobile District, Alabama and Adjacent States. Water-Resources Investigations Report 84-4274.

Novotny, Vladimir, Olem, Harvey. 1994. Water Quality Prevention, Identification, and Management of Diffuse Pollution. Van Nostrand Reinhold, New York.

United States Environmental Protection Agency. 1991. Guidance for Water Quality-Based Decisions: The TMDL Process, Office of Water, EPA 440/4-91-001.

EPA Region IV SOD Database

Appendix 9.2
Water Quality 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

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)																	
250	INDM-250	980512	0620	15	8.8	7.5	201	13.9	39.9	500	8	116	1.242	0.081	0.064	0.8	
250	INDM-250	980707	0850	24	8.3	7.7	209	7.7	7.0	80	4	124	1.066	<0.005	<0.05	0.4	
250	INDM-250	980909	0730	19	8.2	6.9	209	4.9	3.2	80	1	169	1.142	<0.005	0.137	0.8	
250	INDM-251	980512	0710	17	8.9	7.3	223	8.1	12.7	152	8	122	1.048	0.085	<0.05	0.9	
250	INDM-251	980707	1000	24	7.6	7.6	210	5.9	4.8	84	2	121	0.71	0.277	0.063	0.5	
250	INDM-251	980909	0815	19	7.8	7.4	214	4.7	1.5	320	<1	154	0.208	0.181	0.181	0.5	

Indian Creek---Madison County								
Agency	**Station ID**	**Stream Name / Location**	**Date**	**Time**	**STORET Parameter Code**	**rameter Na**	**Value**	**Remarks**
21AWIC	INDIANCREEK01	INDIAN CREEK	60988	830	300	DO MG/L	7.1	
21AWIC	INDIANCREEK01	INDIAN CREEK	71488	745	300	DO MG/L	7.2	
21AWIC	INDIANCREEK01	INDIAN CREEK	81088	1000	300	DO MG/L	7.5	
21AWIC	INDIANCREEK01	INDIAN CREEK	90988	700	300	DO MG/L	8.2	
21AWIC	INDIANCREEK01	INDIAN CREEK	101188	930	300	DO MG/L	10	
21AWIC	INDIANCREEK02	INDIAN CREEK	60988	800	300	DO MG/L	8	
21AWIC	INDIANCREEK02	INDIAN CREEK	71488	810	300	DO MG/L	7.9	
21AWIC	INDIANCREEK02	INDIAN CREEK	81088	930	300	DO MG/L	8.1	
21AWIC	INDIANCREEK02	INDIAN CREEK	90988	800	300	DO MG/L	9.1	
21AWIC	INDIANCREEK02	INDIAN CREEK	101188	1000	300	DO MG/L	10.5	

TVA Macroinvertebrate/EPT and Fish/IBI Biological Data for 1994-95

CU	Waterbody	Bug Health	EPT	Fish Health	IBI	Causes	Sources
801	Indian Cr	Poor/Fair	5	Poor	30	siltation, nutrients,	Ag & Urban NPS

Appendix 9.3
Water Quality Model
Input and Output Files

Appendix 9.4
Spreadsheet Water Quality Model (SWQM)
User Guide