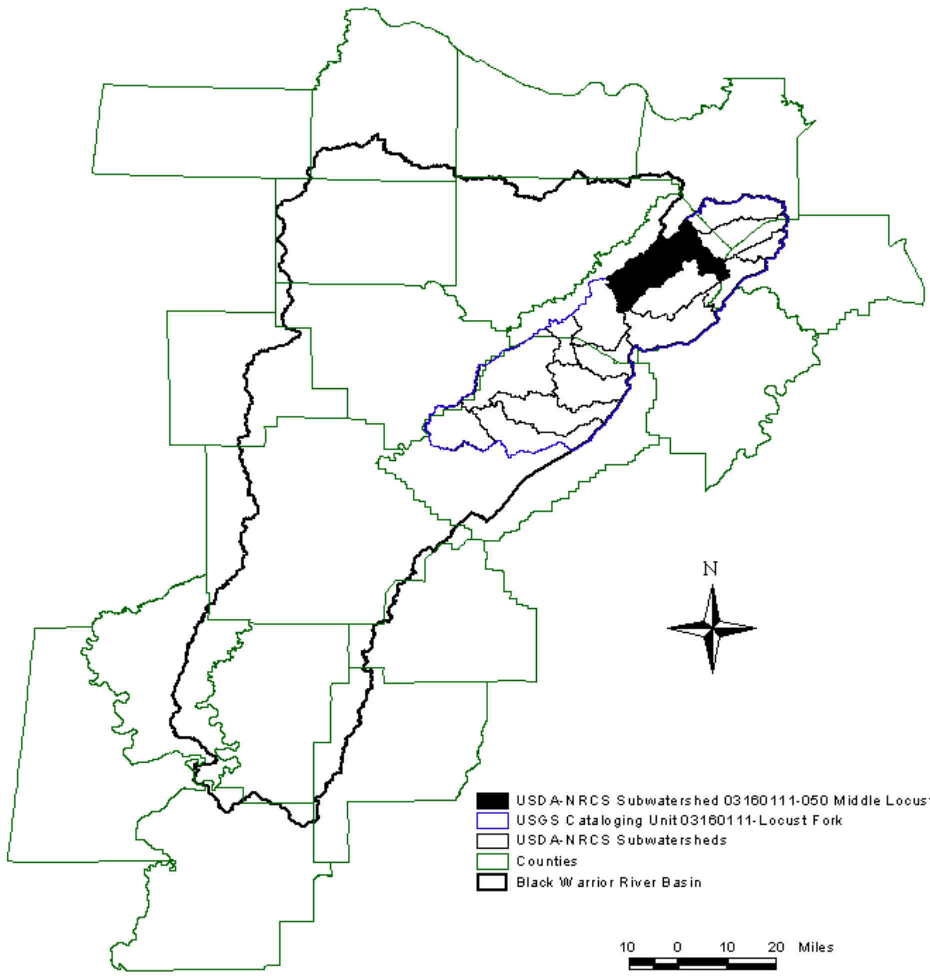
Alabama Department of Environmental Management

Final TMDL Development for
Graves Creek AL/03160111-050_01
Low Dissolved Oxygen/Organic Loading

Water Quality Branch
Water Division
February 2002

Graves Creek Watershed in the Black Warrior 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 the State of Alabama's 1996 and/or 1998 §303(d) List of Impaired Waterbodies. Because of the accelerated schedule required by the court consent decree, many of these TMDLs have been prepared out of sequence with the state's rotating basin schedule. 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.

Graves Creek, a part of the Black Warrior River basin, is located in Blount County near the town of Blountsville. It has been on Alabama's §303(d) use impairment list since 1992 for organic enrichment/low dissolved oxygen (O.E./D.O.). Its use classification is Fish & Wildlife (F&W). Water quality data collected in 1988 and 1991 suggested dissolved oxygen impairments for Graves Creek.

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.

A summary of the TMDL for the watershed is provided in the tables presented on the next page. 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 allowable pollutant loadings by source for winter (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)
$CBOD_u$	162	7.6
NBOD	118	2.8
Total	280	10.4

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

Pollutant	Point Source Loads (lbs./day)	Non-point Source Loads (lbs./day)
$CBOD_u$	296	67.5
NBOD	200	19.6
Total	496	87.1

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 Graves Creek as being impaired by organic loading (i.e., $CBOD_u$ and NBOD) for a length of 9.6 miles, as reported on the 1992-1998 §303(d) lists of impaired waters. Graves Creek is prioritized as "high" on the lists. Graves Creek is located in Blount County and lies within the Locust Fork watershed of the Black Warrior River basin.

The TMDL developed for Graves 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 loading 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

The Graves Creek watershed has a relatively small drainage area of 14.4 square miles. Flows during dry weather periods are zero, or close to it. Water quality data collected for the watershed during 1988 and 1991 indicates that dissolved oxygen impairments occurred primarily during the summer months (May through November). Generally, depressed in-stream D.O. concentrations may be caused by several sources including the decay of oxygen demanding waste from both point and non-point sources, algal respiration, and sediment oxygen demand.

<u>Waterbody Impaired:</u>	Graves Creek from its mouth to its source
<u>Water Quality Standard Violation:</u>	Dissolved Oxygen
<u>Pollutant of Concern:</u>	Organic Enrichment ($CBOD_u$/NBOD)
<u>Water Use Classification:</u>	Fish & Wildlife

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

(a) Best usage of waters:

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

(b) Conditions related to best usage:

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

(c) Other usage of waters:

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

(d) Conditions related to other usage:

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

Low D.O./Organic Loading Criteria:

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

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 of watershed activities (e.g., agricultural management activities). The source assessment was used as the basis of development of the model and ultimate analysis of the TMDL allocations. The organic loading within the watershed included both point and non-point sources.

3.2.2. Point Sources in the Graves 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 on the next page 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 3-2, located on page 16, shows the location of each facility considered a significant source relative to the impaired segment.

Table 3-1. Contributing Point Sources in the Graves 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)
AL0001449	Industrial	Tyson Foods	Yes

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

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

Facility Name/NPDES Permit #		Permit Limitations - Summer					Permit Limitations - Winter				
	Qw (MGD)	$CBOD_5$ (MG/L)		NH_3-N (MG/L)		DO (MG/L)	$CBOD_5$ (MG/L)		NH_3-N (MG/L)		DO (MG/L)
		Max	Avg	Max	Avg	Min	Max	Avg	Max	Avg	Min
Tyson Foods/AL0001449	0.97	9	6	2.4	1.6	6	16.5	11	4.0	2.7	6

Notes: n/a = not applicable
Qw=facility wasteflow

As can be seen in the above table, the Graves Creek watershed has one point source discharge – wastewater from a Tyson Foods poultry processing facility near the town of Blountsville. Tyson Foods has a seasonal permit. Limitations for the permit were derived from previous waste load allocation model work performed in December 1997. An ultimate-to-five-day CBOD ratio ($CBOD_U/CBOD_5$) of 3.33 was employed for Tyson Foods and is based on actual longterm CBOD time series data for the Tyson Foods effluent. The wasteflow value of 0.97 mgd is based on current production levels. To give the reader an idea of the relative magnitude of Tyson's wasteflow with respect to Graves Creek streamflow, $7Q_{10}$ and $7Q_2$ values for Graves Creek at its mouth are 0.26 and 0.52 cfs, respectively. Tyson's 0.97 mgd wasteflow is equivalent to 1.50 cfs. As a percentage of streamflow, then, Tyson Foods wasteflow is 577 and 289%, respectively, of the $7Q_{10}$ and $7Q_2$ flows of Graves Creek.

3.2.3. Non-Point Sources in the Graves Creek Watershed

Shown in Table 3-3 below is a detailed summary of land usage in the Graves Creek watershed. A land use map of the watershed is presented in Figure 3-1. Shown below Figure 3-1 is a pie chart depicting principal land uses. The predominant land uses within the watershed are forest, pasture and row crops. Their respective percentages of the total watershed are 61.7, 27.1 and 9.4%.

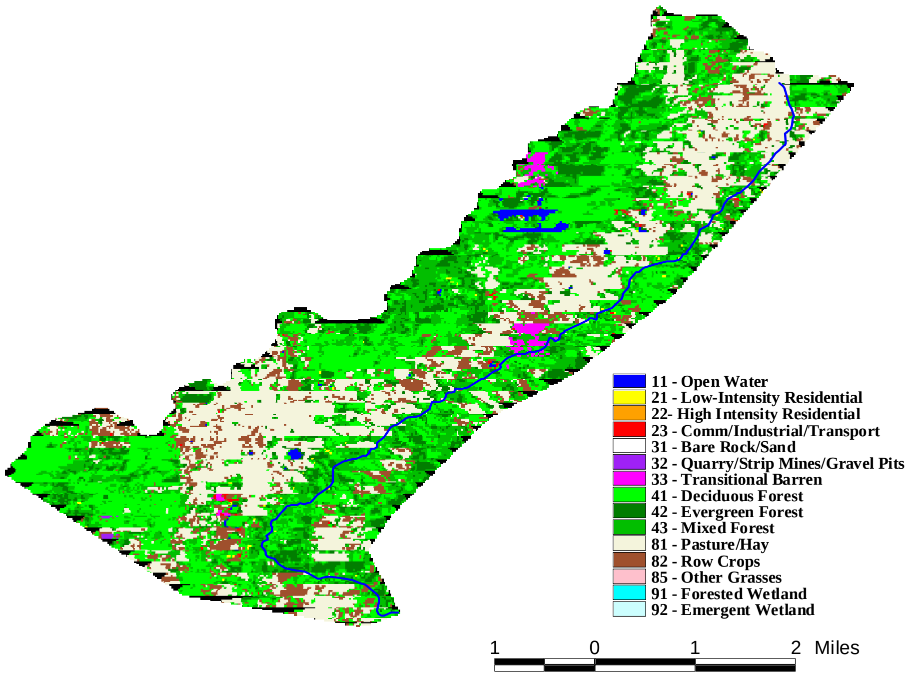
Table 3-3. Land Use in the Graves Creek Watershed.

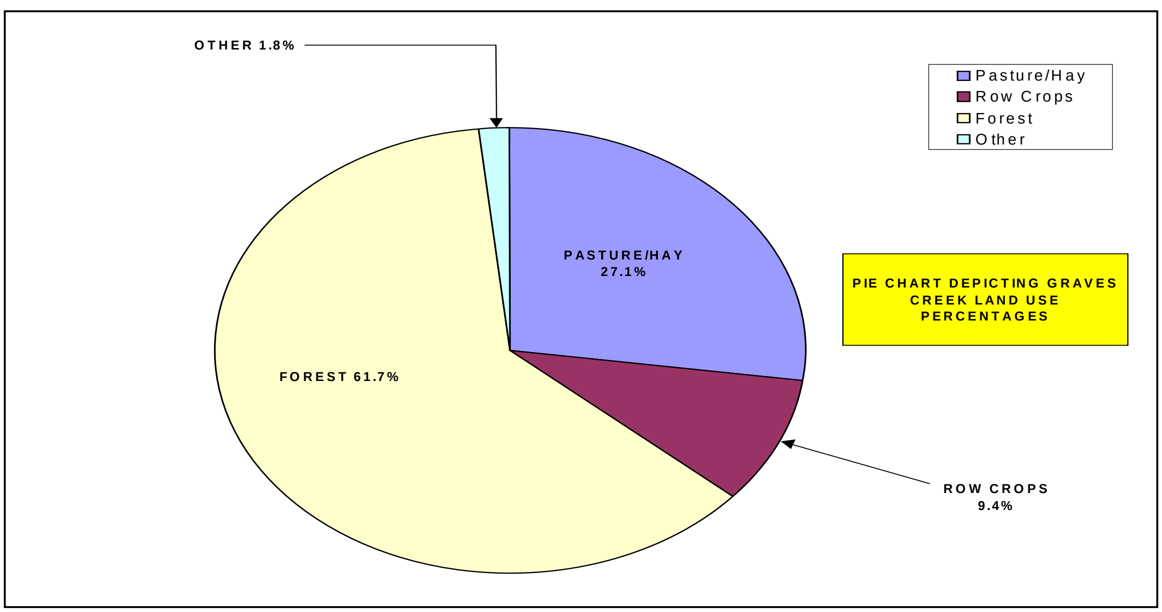
LAND USE	PERCENTAGE
Open Water	0.67
Low-Intensity Industrial Residential	0.14
Commercial/Industrial/Transport	0.20
Quarry/Strip Mine/Gravel Pits	0.05
Transitional Barren	0.77
Deciduous Forest	28.52
Evergreen Forest	10.52
Mixed Forest	22.69
Pasture/Hay	27.09
Row Crops	9.35

The three predominant land uses discussed above make up 98.2% 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 Graves Creek watershed are the pasture and row crop land uses. Compared to other land uses, organic enrichment from forested land is normally considered to be small. This is because forested land tends to serve as a filter of pollution originating within its drainage areas. However, organic loading can originate from forested areas due to the presence of wild animals such as deer, raccoons, turkeys, waterfowl, etc. Control of these sources is usually limited to land management best management practices (BMPs) and may be impracticable in most cases. In contrast to forested land, agricultural land can be a major source of organic loading. Runoff from pastures, animal operations, improper land application of animal wastes, and animals with access to streams are all mechanisms that can introduce organic loading to waterbodies.

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





Loading Capacity – Linking Numeric Water Quality Targets and Pollutant Sources

EPA regulations define the assimilative capacity of a waterbody as the greatest amount of pollutant loading that a waterbody can receive without violating applicable 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 for seasonal critical conditions 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) for each season.

In the TMDL model analysis, the pollutant concentrations from forestland were assumed to be at normal background concentrations. Specific assumed values for forest background pollutant concentrations are as follows: 2 mg/l $CBOD_u$, 0.5 mg/l ammonia oxygen demand (NH_3OD_u), and 1 mg/l total organic nitrogen oxygen demand ($TONOD_u$). Pollutant concentrations for the other land uses in the watershed were assigned in proportion to measured concentrations and were set in the TMDL model at levels necessary to maintain dissolved oxygen concentrations greater than, or equal to, 5 mg/l. The model predictions for instream pollutant concentrations were then compared to actual field data. The model velocities and reaeration coefficients were adjusted in those cases where the field data indicated significant discrepancies from the model predictions.

3.3 Data Availability and Analysis

3.4.1. <u>Watershed Characteristics</u>

A. <u>General Description</u>: Graves Creek, located in Blount County, is a tributary to Locust Fork. The Locust Fork is a part of the Black Warrior River basin. Graves Creek is a part of the USGS (United States Geological Survey) 03160111 cataloging unit and the NRCS 050 sub-watershed. Cataloging unit 03160111 represents the middle Locust Fork basin. NRCS sub-watershed number 050 represents the Graves Creek watershed. Graves Creek begins approximately 1.5 miles northeast of Liberty in NE¼, SW¼, Sec 36, T10S, R1E. It has a linear distance of 9.62 miles and a total drainage area of 14.4 square miles. Graves Creek has a use classification of Fish & Wildlife (F&W).

B. Geological Description: Geology in the Graves Creek watershed consists of the following rock types – limestone, chert, shale, sandstone, conglomerate, siltstone, coal, dolomite and mudstone. The following rock formations are a part of the watershed's geology – Tuscumbia limestone, Fort Payne chert undifferentiated, Pride Mountain formation, Hartselle sandstone, Bangor limestone, Pottsville formation (lower part), and the Pennington formation.

C. Eco-region Description: The Graves Creek watershed overlaps parts of two ecoregions – 68b and 68d. Ecoregion 68b, the elongated **Sequatchie Valley,** extends from the Tennessee border nearly one hundred miles southwest into Alabama. Structurally associated with an anticline, where erosion of broken rock scooped out the linear valley, it is composed mostly of Mississippian to Ordovician-age limestones, dolomites, and shales, with some low cherty ridges. In the north, the open, rolling, valley floor, 600 feet in elevation, is nearly 1000 feet below the top of the Cumberland Plateau and Sand Mountain. South of Blountsville, the topography becomes more hilly and irregular with higher elevations. The Tennessee River flows through the Sequatchie Valley of Alabama, until it turns west near Guntersville and leaves the valley. Similar to parts of the Ridge and Valley, this is an agriculturally productive region, with areas of pasture, hay, soybeans, small grain, corn, and tobacco. Ecoregion 68d, the **Southern Table Plateaus,** include Sand Mountain, Lookout Mountain, and Brindley Mountain. While it has some similarities to the Cumberland Plateau (68a) of Tennessee with its Pennsylvanian-age sandstone caprock, this ecoregion is lower in elevation, has a warmer climate, and contains more agriculture. It has higher elevation and more gentle topography with less dissection than the more forested ecoregions of 68e and 68f. Although the Georgia portion is mostly forested, elevations decrease to the southwest in Alabama and there is more cropland and pasture. It is a major poultry production region in Alabama.

D. Other Notable Characteristics: The Graves Creek watershed has a waterfall approximately 0.2 miles downstream of the Tyson Foods outfall with an elevation drop of approximately 20 feet. It is depicted as section 5 in the modeled reach schematic. Total elevation change in the watershed is approximately 252 feet.

3.4.2 Available Water Quality and Biological Data

Graves Creek has been sampled in the past as a part of the 1988 and 1991 Clean Water Strategy sampling initiatives. There were two sampling locations in 1988. They were sampled monthly from June through October 1988. One station was located at county road 26 east of Blountsville (NW¼, Sec 15, T11S, R1E). This station is approximately four miles upstream of the Tyson Foods outfall. It is identified as Sampling Station 1 in the modeled reach schematic. The second station was at the Mardis Mill Bridge approximately 0.2 mile downstream of the Tyson Foods outfall. Its location is in SE¼, Sec 30, T11S, R1E. It's identified as Sampling Station 2 in the modeled reach schematic. Flow measurements were taken only at the Mardis Mill Bridge station in 1988.

Only one location was sampled on Graves Creek in 1991. This was the county road 26 station (Sampling Station 1). It was sampled monthly from June through October 1991.

Unfortunately, no flow measurements were taken. Consequently, no loadings could be calculated. A complete listing of the data can be found in the appendix of this report.

The worst D.O. violations from the available field data occurred occurred at Sampling Station 1 during the 1988 sampling period. Shown below is a plot of D.O. and water temperature at Sampling Station 1 for 1988:

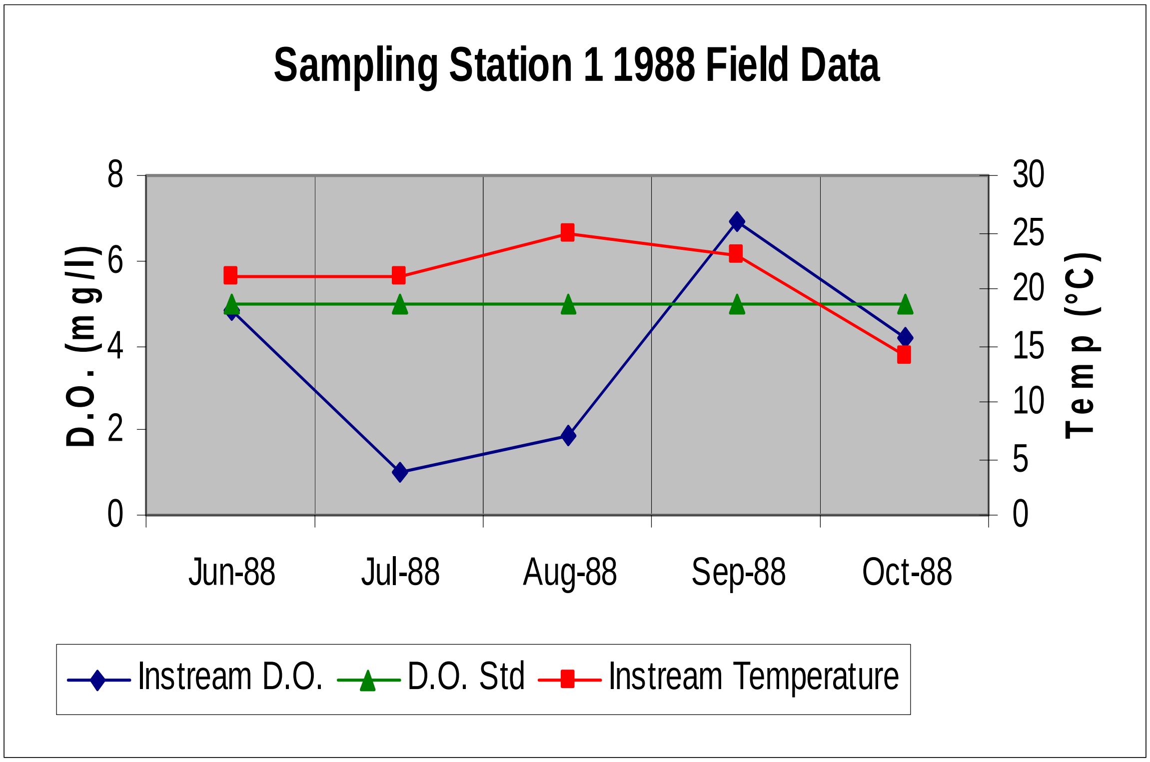
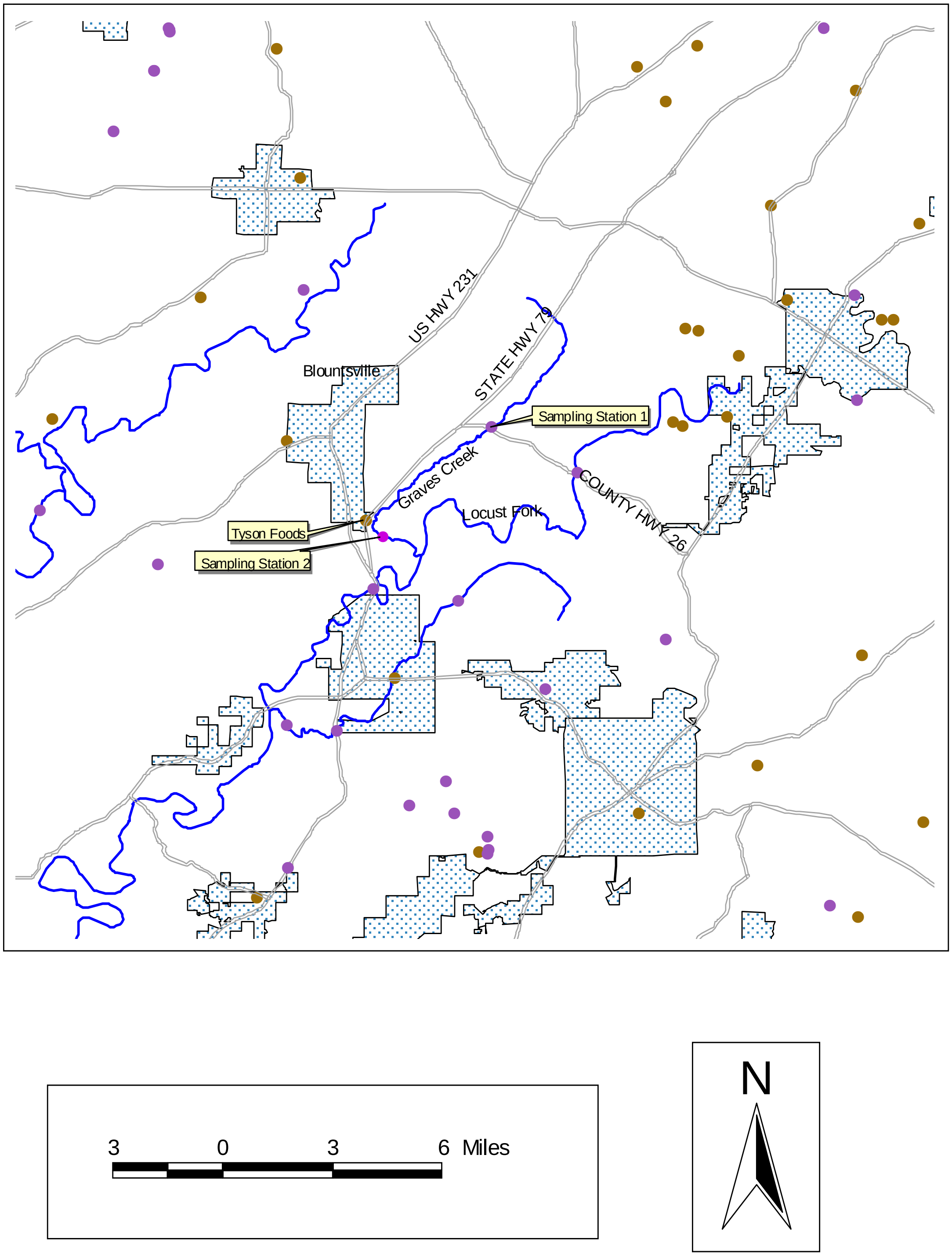


Figure 3-2 on the next page is a map showing both sampling station locations as well as the Tyson Foods outfall.

Figure 3-2. Map of Sampling Locations and Point Source Discharges for the Graves 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):

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

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

The method used to determine the $7Q_{10}$ and $7Q_2$ flows for Graves Creek and Locust Fork was the USGS gage method. The resulting $7Q_{10}$ and $7Q_2$ flows are 0.26 and 0.52 cfs, respectively.

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

3.5 Critical Conditions

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

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

3.6 Margin of Safety (MOS)

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

The MOS is implicit in this TMDL process through the use of conservative model input parameters (**temperature, flow and D.O. concentrations**). Conservative temperature values are employed through the use of the highest average maximum temperature that would normally occur under critical stream flow conditions. The $7Q_{10}$ and $7Q_2$ stream flows employed for summer and winter, respectively, reflect the lowest flows that would normally occur under critical conditions. 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.

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

4.0 Water Quality Model Development

4.1 Water Quality Model Selection and Setup

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

- It is a simplified approach without unnecessary complexity.

- It conforms to ADEM standard practices for developing wasteload allocations.
- It lends itself to being developed with limited data, which is the present situation for this waterbody.
- It has the ability to handle tributary inputs and both point and non-point source inputs.

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

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

- D.O. concentrations for incremental flow were assumed @ 70% of the saturated value at the given temperature. **(MOS)**
- Incremental and tributary loadings 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. These ratios were assigned in the estimation of pollutant concentrations for headwaters, incremental flow, and tributaries for all land uses, except forest and open water. Specific ratios employed for Graves Creek for $CBOD_U/NH_3$-N and $CBOD_U$/TON are 69 and 23, respectively.
- Background conditions were assumed for incremental flow from forests. Background conditions are typically in the following ranges: 2-3 mg/l $CBOD_U$, 0.11-0.22 mg/l NH_3-N, and 0.22-0.44 mg/l TON. Specific pollutant concentrations assumed for forest land usage are 2 mg/l $CBOD_U$, 0.11 mg/l NH_3-N, and 0.22 mg/l TON.
- Pollutant concentrations assumed for open water are 1 mg/l $CBOD_U$, 0.005 mg/l NH_3-N, and 0.01 mg/l TON.

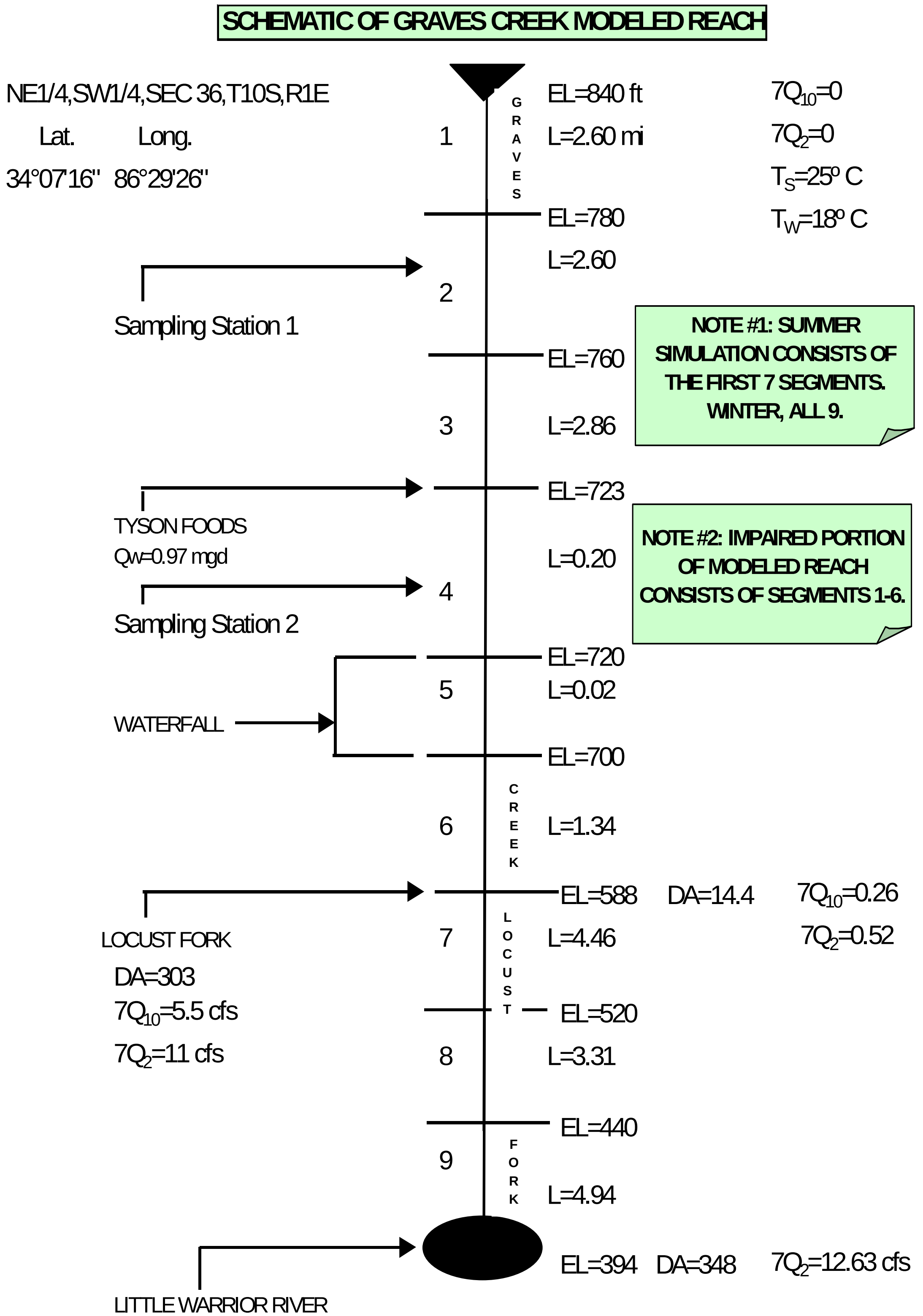
4.1.1. SOD Representation: Sediment oxygen demand (SOD) can be an important part of the oxygen demand budget in shallow streams. However, for shallow streams with steep slopes and rocky substrate, the SOD component is generally small. These hydrogeological conditions are representative of the Graves Creek watershed. It is believed, therefore, that the SOD for this stream is minimal. In the absence of available field SOD measurements for the waterbody, SOD data was obtained from EPA Region IV's SOD database. The EPA SOD database represents mixed land uses and varying degrees of point source activity.

4.1.2. Calibration Data: The model calibration period was determined from an examination of the available field data (ref: Appendix) for the period of July 1988. The combination of the lowest, steady flow period with the lowest dissolved oxygen defined the critical modeling period. The stream conditions (i.e., D.O., temperature) during this period were incorporated into the calibrated model TMDL spreadsheet.

4.2 Water Quality Model Summary

The modeled reach used for each season was longer than the impaired reach. The summer model reach consisted of seven segments. The impaired portion of the summer model reach consists of segments 1-6. The length of the impaired portion is 9.62 miles. Total distance of the summer model reach is 14.08 miles. The winter model reach consisted of nine segments. The impaired portion of the winter model reach consists of segments 1-6. The length of the impaired portion is the same as that for summer. Total distance of the winter model reach is 22.33 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	0	7.02	5.39	0.59	1.45	25
Conditions @ Lowest D.O.	0.14	5.02	3.68	0.32	1.19	25
Flow @ End of Model	1.76	7.90	16.51	4.75	6.21	25

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	5.39	0.59	1.45	7.02	0	25
2	4.40	0.30	1.30	6.38	0.07	25
3	3.68	0.32	1.19	5.02	0.14	25
4	17.82	6.41	6.51	6.06	1.72	25
5	17.52	6.12	6.46	5.99	1.72	25
6	17.52	6.11	6.46	7.86	1.72	25
7	8.17	1.60	2.61	7.23	7.26	25

4.2.2 Winter (December – April) Model

Winter Stream Flow Parameters

Description	Flow (cfs)	DO (mg/l)	$CBOD_U$ (mg/l)	NH_3ODU (mg/l)	$TONOD_U$ (mg/l)	Temp (°C)
Headwaters	0	8.05	24.07	1.82	5.16	18
Conditions @ Lowest D.O.	0.28	5.01	18.14	1.29	4.46	18
Flow @ End of Model	14.13	8.71	22.24	2.06	5.57	18

Winter Incremental Flow Parameters

Sections	$CBOD_U$ (mg/l)	NH_3ODU (mg/l)	$TONOD_U$ (mg/l)	DO (mg/l)	Total Flow (cfs)	Temp. (°C)
1	24.07	1.82	5.16	8.05	0	18
2	20.75	1.23	4.78	7.03	0.14	18
3	18.14	1.29	4.46	5.01	0.28	18
4	31.97	9.85	10.51	6.18	1.93	18
5	31.51	9.52	10.39	6.31	1.95	18
6	31.50	9.51	10.39	8.85	1.95	18
7	25.62	2.84	6.03	8.21	13.02	18
8	24.36	2.58	5.86	8.90	13.41	18
9	23.61	2.28	5.75	9.08	13.70	18

4.3 *Summer and Winter Model Predictions and Graphics*

Figure 4-2. Summer Model Predictions.

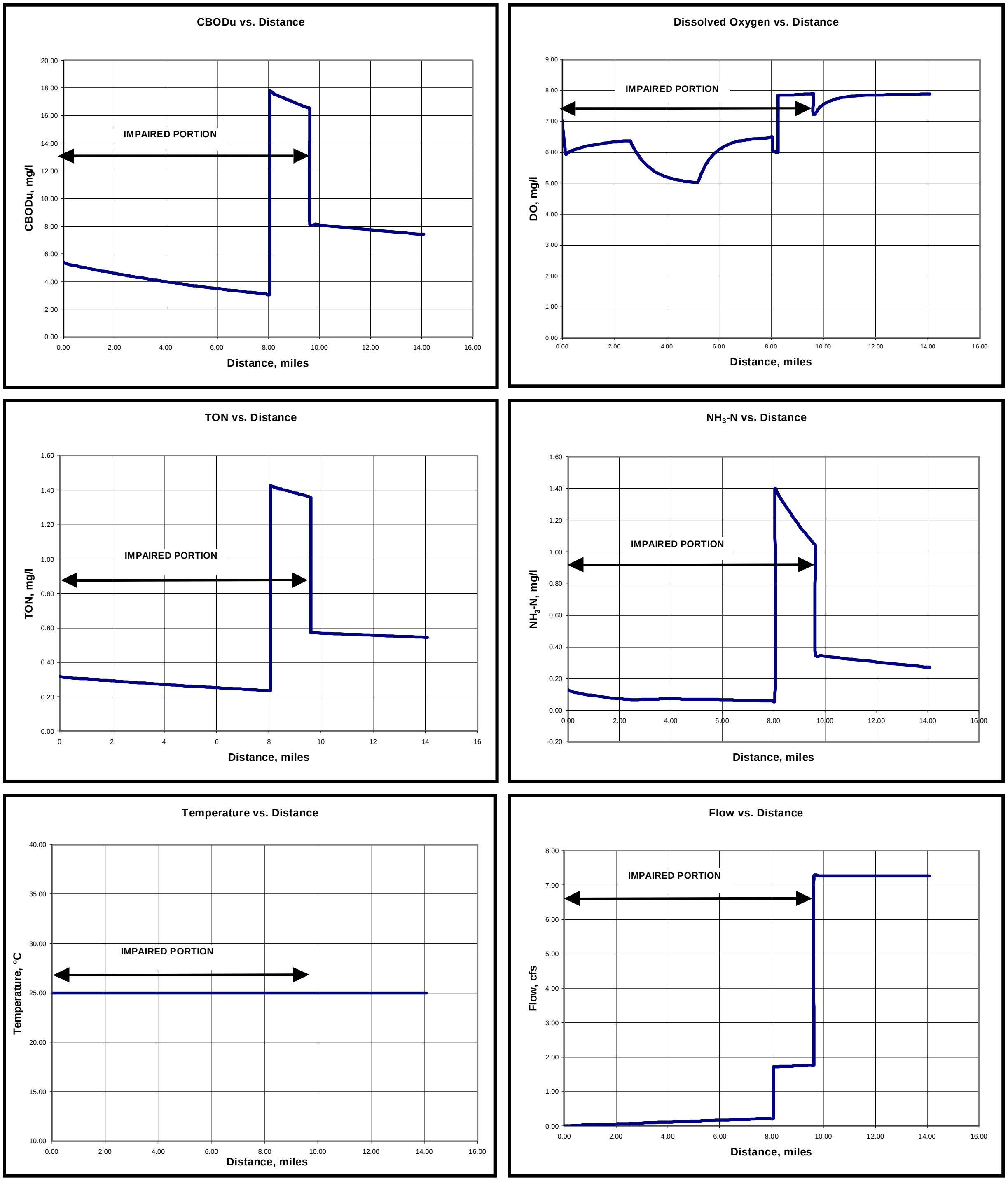
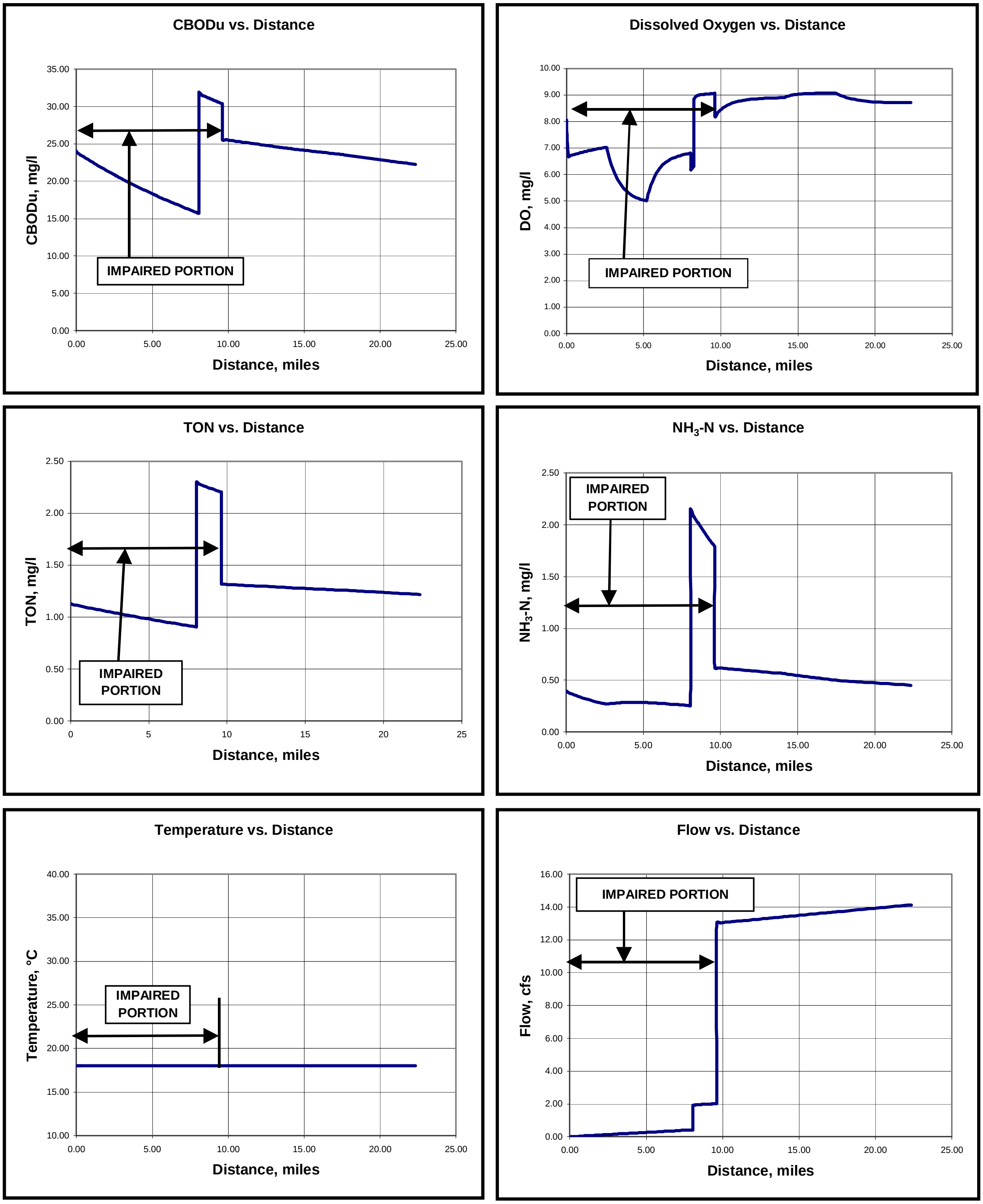


Figure 4-3. Winter Model Predictions.



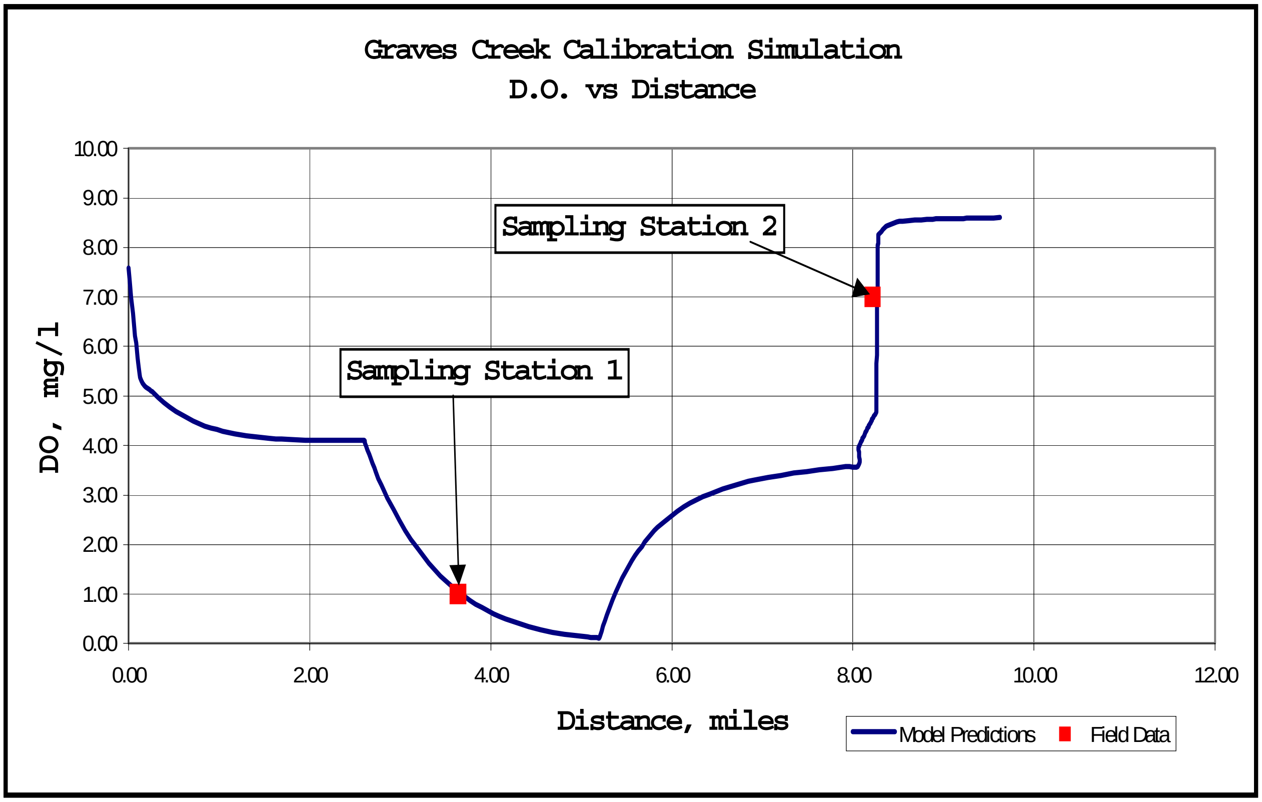
4.4 Loading Reduction Analysis

4.4.1. Calibrated Model

All of the D.O. violations from available field data occurred at Sampling Station 1 (county road 26). The lowest observed D.O. value occurred during the July 6, 1988, sampling event. The measured concentration was 1.0 mg/l. Field data from the sampling event were used as input into the summer TMDL model to perform a third simulation (the first and second simulations are the summer and winter TMDLs, respectively). Nonpoint source loadings to land uses other than forest and open water were adjusted so that model predictions simulated the measured D.O. value as closely as possible at Sampling Station 1, while still providing a reasonable representation of water quality in the stream at the time of the sampling event.

The third simulation is referred to as the calibration simulation. Shown in Figure 4-4 on the next page is a plot of D.O. model predictions vs D.O. field data for the simulation. The model begins at Graves Creek's source.

Figure 4-4. Calibrated Model D.O. Predictions vs. Actual D.O. Field Data.



Calibrated Model Flow Parameters

Description	**Flow (cfs)**	**DO (mg/l)**	**$CBOD_U$ (mg/l)**	**$NH3OD_U$ (mg/l)**	**$TONOD_U$ (mg/l)**	**Temp (°C)**
Headwaters	0	7.58	44.31	3.16	9.18	21
Conditions @ Calibrated Point	1.47	1.25	35.40	2.27	8.19	21
Flow @ End of Model	4.60	8.59	31.01	3.69	8.18	21

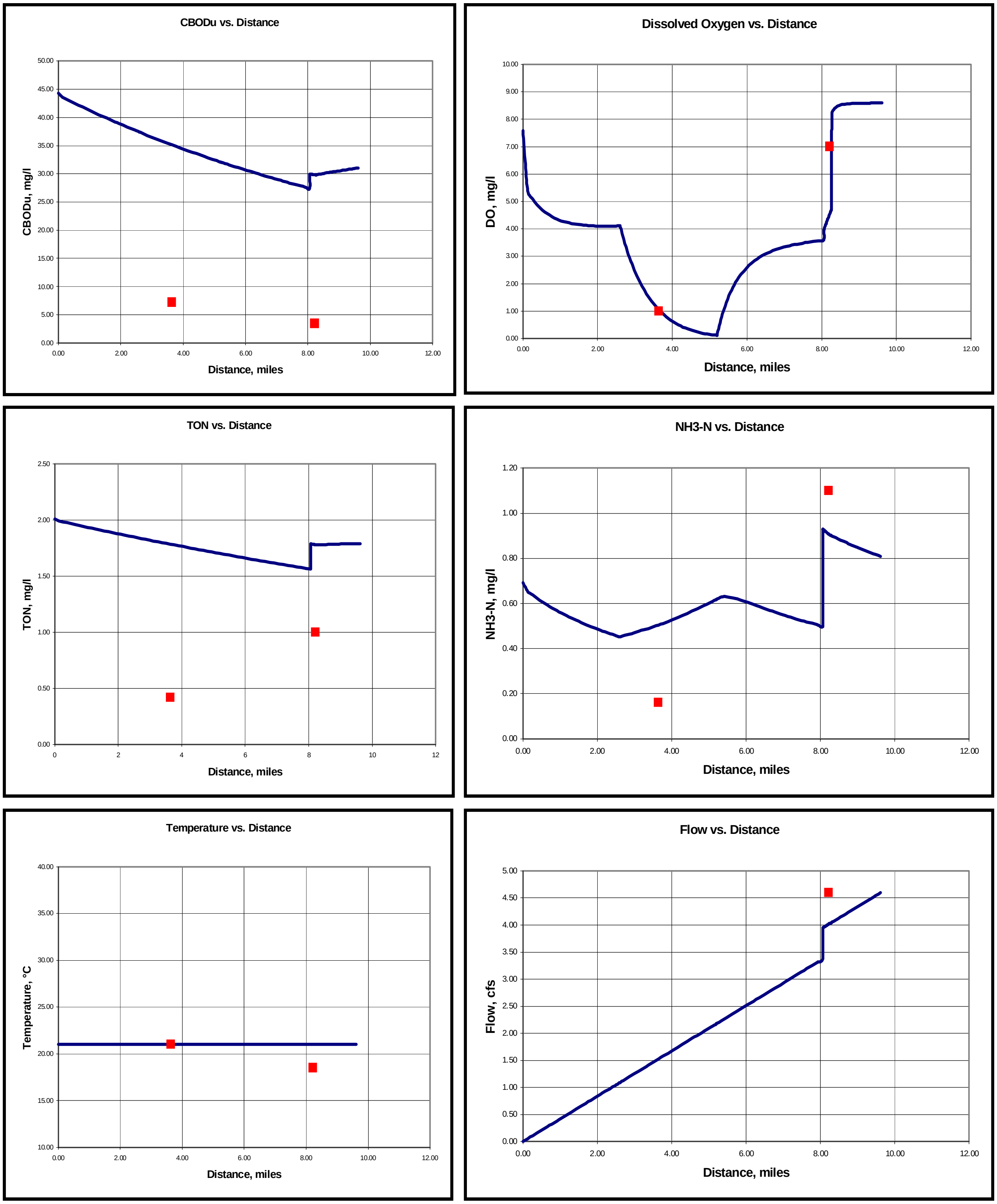
Calibrated Model Incremental Flow Parameters

Sections	**$CBOD_U$ (mg/l)**	**NH_3OD_U (mg/l)**	**$TONOD_U$ (mg/l)**	**DO (mg/l)**	**Total Flow (cfs)**	**Temp. (°C)**
1	44.31	3.16	9.18	7.58	0	21
2	37.38	2.06	8.42	4.11	1.09	21
3	32.09	2.82	7.77	0.11	2.18	21
4	29.91	4.25	8.16	3.94	3.95	21
5	29.80	4.12	8.13	4.68	4.03	21
6	29.82	4.12	8.13	8.25	4.04	21

Comparison of Calibrated Model Flow Parameters to Actual Data

Description	**Flow (cfs)**	**DO (mg/l)**	**$CBOD_U$ (mg/l)**	**$NH3OD_U$ (mg/l)**	**$TONOD_U$ (mg/l)**	**Temp (°C)**
Actual Conditions @ Low D.O.	-	1.0	7.2	0.73	1.92	21
Cal. Conditions @ Low D.O.	1.47	1.25	35.40	2.27	8.19	21

Figure 4-5. Calibrated Model Predictions and Graphics.



4.4.2. Loading Reduction Model

The fourth simulation is referred to as the loading reduction model. In this simulation, non-point source loadings in the calibrated model were adjusted to bring the waterbody into compliance with the 5 mg/l D.O. Fish & Wildlife water quality standard. It should be noted that adjustments were made to all land use components except forest and open water. Loading contributions from forest and open water were assumed to remain constant in both simulations.

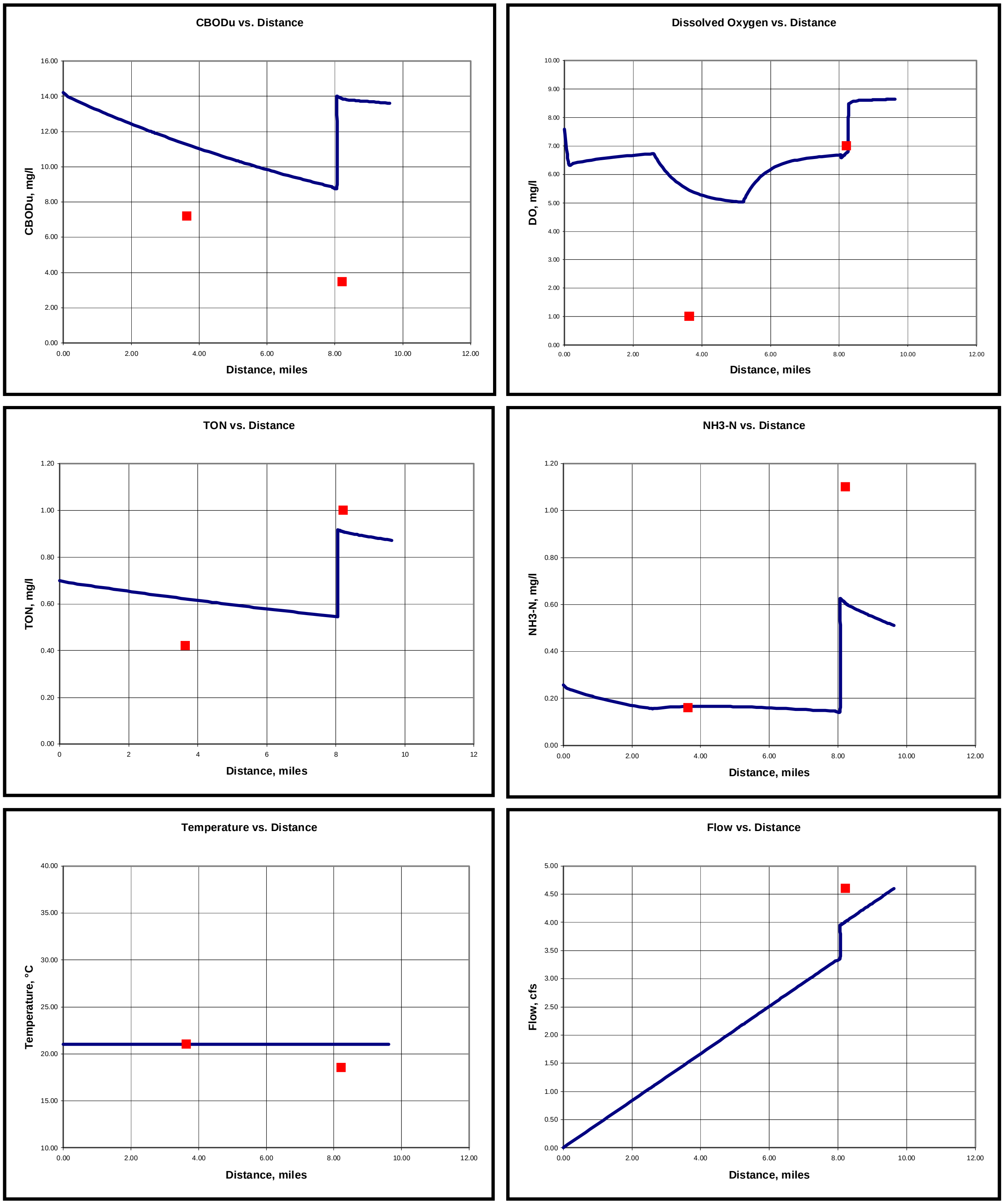
Load Reduction Model Flow Parameters

Description	**Flow (cfs)**	**DO (mg/l)**	**$CBOD_U$ (mg/l)**	**$NH3OD_U$ (mg/l)**	**$TONOD_U$ (mg/l)**	**Temp (^oC)**
Headwaters	0	7.58	14.21	1.17	3.20	21
Conditions @ Calibrated Point	1.47	5.53	11.36	0.76	2.85	21
Flow @ End of Model	4.60	8.64	13.61	2.33	3.99	21

Load Reduction Model Incremental Flow Parameters

Sections	**$CBOD_U$ (mg/l)**	**NH_3OD_U (mg/l)**	**$TONOD_U$ (mg/l)**	**DO (mg/l)**	**Total Flow (cfs)**	**Temp. (^oC)**
1	14.21	1.17	3.20	7.58	0	21
2	11.99	0.71	2.93	6.73	1.09	21
3	10.29	0.75	2.71	5.03	2.18	21
4	14.01	2.86	4.19	6.58	3.95	21
5	13.82	2.74	4.14	6.79	4.03	21
6	13.82	2.74	4.14	8.47	4.04	21

Figure 4-6. Load Reduction Model Predictions and Graphics.



4.4.3. Required Reductions

Total organic loading (i.e., $CBOD_u$ and NBOD) for all land use components except forest and open water (see previous section) was calculated at Sampling Station 1 for both the calibrated and loading reduction simulations. Total organic loading for the calibrated simulation was predicted by the model to be 445 lbs./day. For the loading reduction simulation, total organic loading was predicted to be 134 lbs./day. This would require a theoretical total organic loading reduction of 70% for non-point source loads emanating from land use components other than forest and open water to bring Graves Creek into compliance with the Fish & Wildlife D.O. water quality standard of 5.0 mg/l. No loading reductions were assigned to Tyson Foods because a significant reduction was given to the facility in 1997 as a result of waste load allocation model work performed at that time.

A summary of the required reductions for point and non-point source loads is presented in Table 4-1.

Table 4-1. Required Load Reductions for Point and Non-Point Sources.

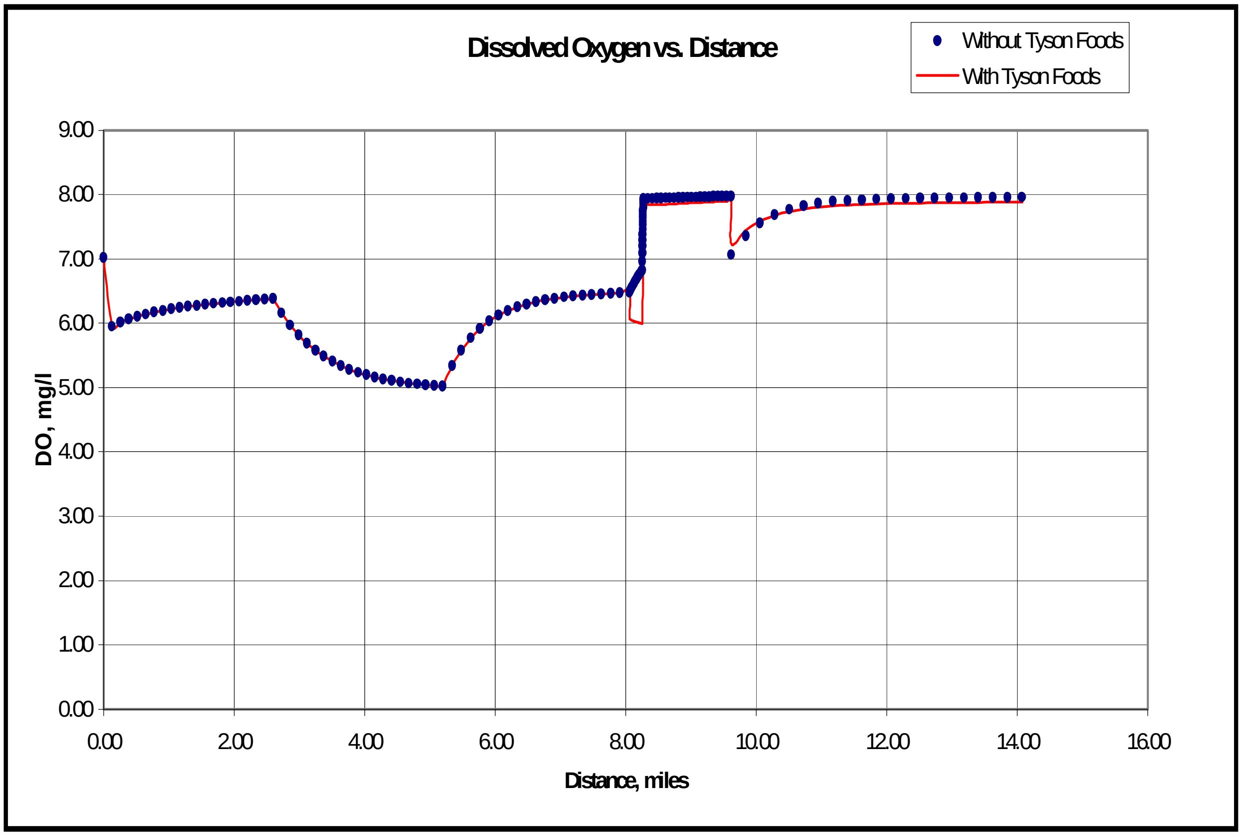
Existing Point Source Load[1]	Existing Non-Point Source Load[1]	Total Existing Load [1]	Reduced Load[1]	% Reduction	% Reduction
(lbs./day)	(lbs./day)	(lbs./day)	(lbs./day)	Point Sources	Non-Point Sources
231	445	676	365	0	70

Notes: 1 = $CBOD_u$ + NBOD

The required reductions will be sought through TMDL implementation with follow up monitoring to determine the effectiveness of implementation. Follow up monitoring as discussed further in this document will be conducted according to the state's basin rotation schedule.

4.4.4 Point Source Sensitivity Analysis

The summer TMDL simulation was rerun without the Tyson Foods discharge to assess the magnitude of the point source impacts on instream dissolved oxygen concentrations. Shown on the next page is a chart depicting summer TMDL D.O. instream predictions with and without the Tyson Foods point source impacts.

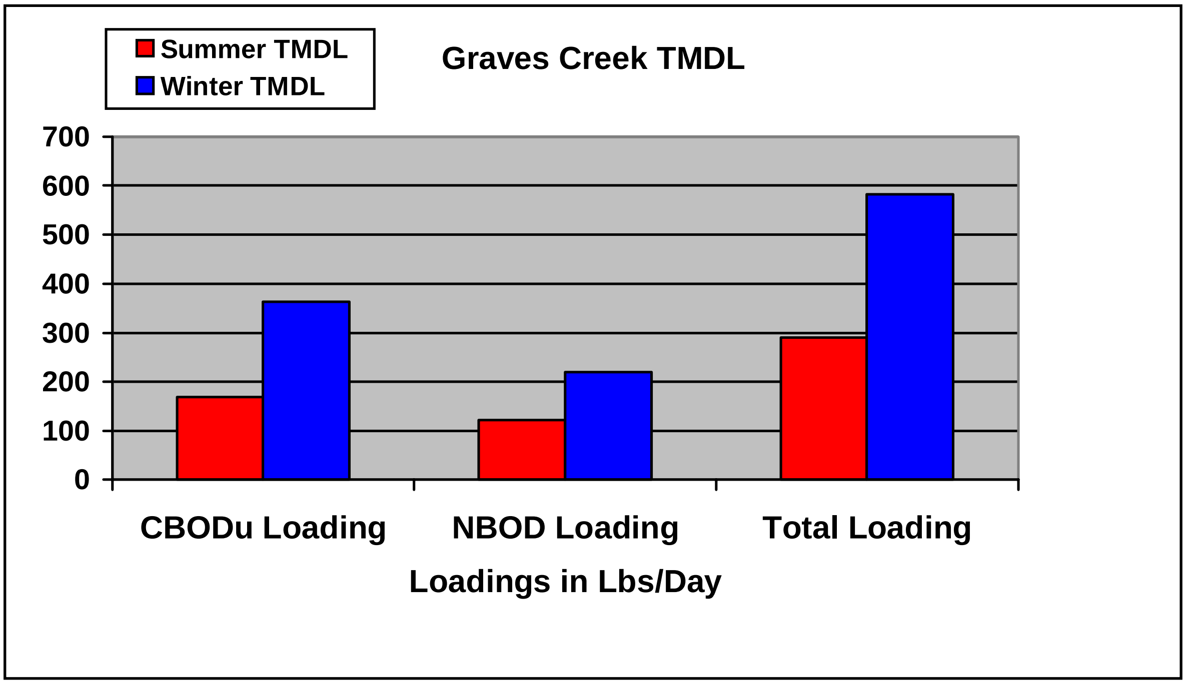


4.5 Seasonal Variation

The regulations require that a TMDL be established with consideration of seasonal variations, if point sources contribute to watershed pollutant loadings. This is the case for Graves Creek.

As discussed previously, TMDLs have been estimated for the summer and winter. Figure 4-7 on the next page illustrates the effect that seasonal temperatures and stream flows have on CBODu, NBOD and total organic loading at the mouth of Graves Creek.

Figure 4-7. 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. The loadings listed in Table 5-1 are depicted graphically in Figure 4-7 above.

Table 5-1. Summer and Winter TMDLs Summary

	TMDL	
	Summer	**Winter**
$CBOD_u$ Loading (lbs./day)	169	364
NBOD Loading (lbs./day)	121	219
Total Loading (lbs./day)	290	583

6.0 TMDL Implementation

6.1 Non-Point Source Approach

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

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

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

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

Additional public/private assistance is available through the Alabama Clean Water Partnership Program (CWP). 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

As discussed previously, no further point source reductions for Tyson Foods are required through this TMDL.

7.0 Follow Up Monitoring

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

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

Monitoring will help further characterize water quality conditions resulting from the implementation of best management practices in the watershed.

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.

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.

Appendix 9.2
Water Quality Data

1988 & 1991 CLEAN WATER STRATEGY DATA

Station	Date	Time	Flow (cfs)	Tw (°C)	pH	D.O. (mg/l)	Cond (uS/cm)	CBOD5 (mg/l)	CBODU (mg/l)	TKN (mg/l)	NH3-N (mg/l)	ANOD (mg/l)	CBODU / ANOD
Co Rd 26*	June 2, 1988	1430		21	7.7	4.8		8.9	13.35	0.26	0.08	0.37	36.5
	July 6, 1988	845		21	6.7	1.0		4.8	7.2	0.58	0.16	0.73	9.8
	August 2, 1988	1520		25	6.6	1.9		7.8	11.7	0.43	0.10	0.46	25.6
	September 1, 1988	1310		23	7.1	6.9		0.1	0.15	0.7	0.04	0.18	0.8
	October 4, 1988	850		14	6.6	4.2		0.8	1.2	0.4	0.08	0.37	3.3
Avg													**15.2**
Co Rd 26*	June 3, 1991	1305		21.5	7	2.2	148	0	0.5	0.38	0.06	0.27	1.8
	July 10, 1991	1015		24	7	4.1	189	1.3	1.95	0.12	0.01	0.05	42.7
	August 1, 1991	915		23	7.1	2.7	195	2.8	4.2	0.06	0.01	0.05	91.9
	September 3, 1991	1020		22.2	7.2	2.1	191	3.6	5.4	0.36	0.33	1.51	3.6
	October 1, 1991	1100		18.2	7.1	4.7	175	3.8	5.7	0.2	0.02	0.09	62.4
Avg													**40.5**
Mardis	June 2, 1988	1250	3.7	19.0	7.6	6.3		1.4	2.1	0.56	0.03	0.14	15.3
Mill	July 6, 1988	935	4.6	18.5	7.2	7.0		2.3	3.45	2.10	1.10	5.03	0.7
Bridge**	August 2, 1988	1350	3.6	22.0	6.8	6.1		0.6	0.9	0.54	0.04	0.18	4.9
	September 1, 1988	1420	2.3	26.2	7.2	20.0		9.0	13.5	0.60	0.08	0.37	36.9
	October 4, 1988	930	25.9	15.0	7.6	8.3		0.6	0.9	0.40	0.05	0.23	3.9
Avg													**12.4**

*County Road 26 east of Blountsville (NW1/4, Sec 15, T11S, R1E)

**Mardis Mill Bridge D/S of Tyson Foods outfall (SE1/4, Sec 30, T11S, R1E)

1988 & 1991 CLEAN WATER STRATEGY DATA (Cont)

TON (mg/l)	ONOD (mg/l)	CBODU ONOD	NO2+NO3-N (mg/l)	T-PO4 (mg/l)	Fecal Coli. (org/100 ml
0.18	0.82	16.2	0.13	0.02	
0.42	1.92	3.8	0.02	0.02	
0.33	1.51	7.8	0.06	0.05	
0.66	3.02	0.0	29.5	0.80	
0.32	1.46	0.8	0.60	0.09	
Avg		**5.7**			
0.32	1.46	0.3	0.16	0.01	90
0.11	0.50	3.9	0.35	0.01	270
0.05	0.23	18.4	0.32	0.01	250
0.03	0.14	39.4	0.11	0	40
0.18	0.82	6.9	0.74	0.01	40
Avg		**13.8**			
0.53	2.42	0.9	8.05	3.5	
1.00	4.57	0.8	4.95	0.48	
0.50	2.29	0.4	20.7	0.54	
0.52	2.38	5.7	0.02	0.11	
0.35	1.60	0.6	2.25	0.19	
Avg		**1.7**			

Appendix 9.3
Water Quality Model
Input and Output Files

SUMMER TMDL MODEL

WINTER TMDL MODEL

CALIBRATED MODEL

LOAD REDUCTION MODEL

Appendix 9.4
Spreadsheet Water Quality Model (SWQM) User Guide