ADEM

FINAL

Organic Enrichment/Dissolved Oxygen TMDL

Rabbit Creek	AL/03160205_020-01
Dog River	AL/03160205_020-02

Alabama Department of Environmental Management
Water Quality Branch
Water Division
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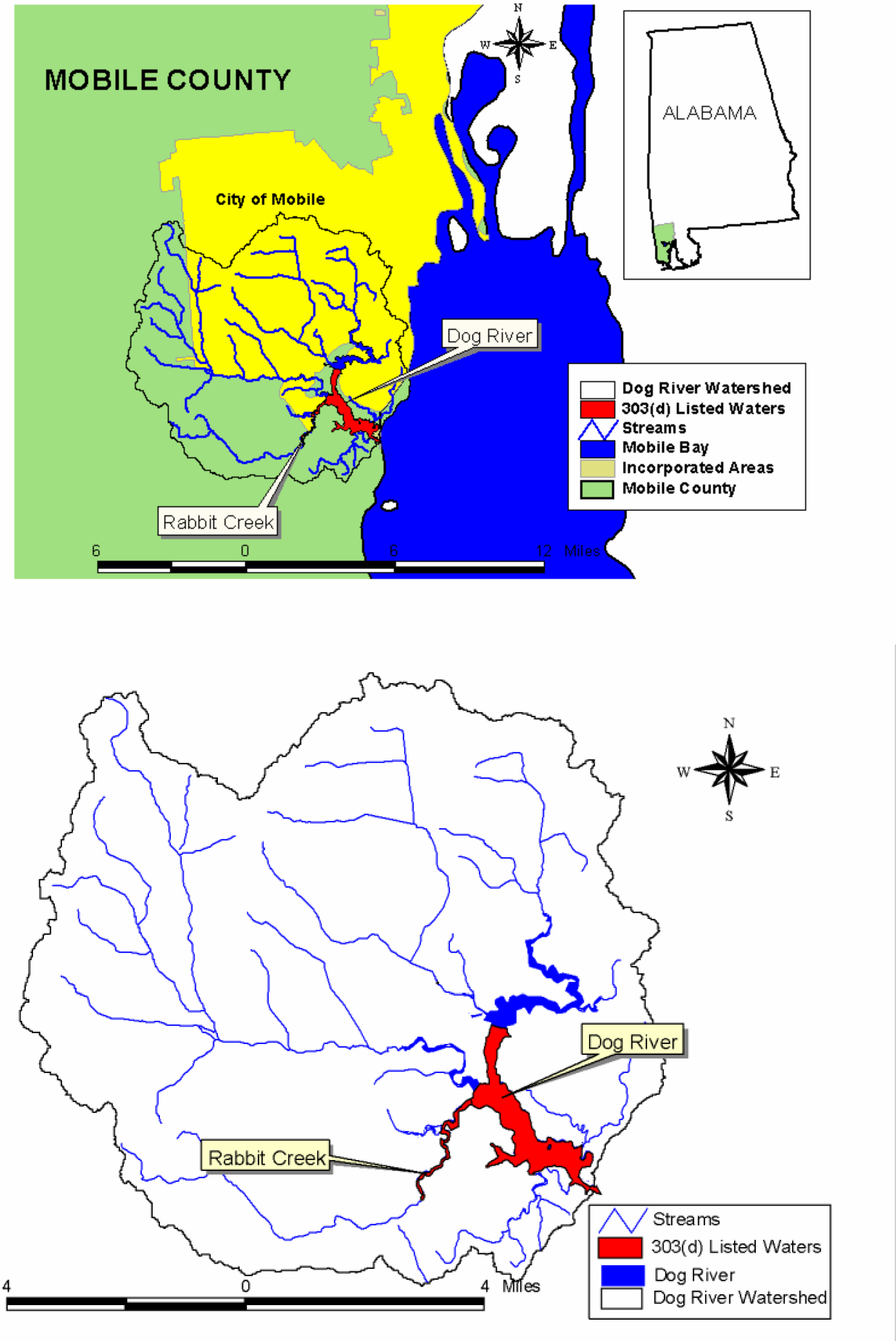

List of Abbreviations

ADEM	Alabama Department of Environmental Management
BMP	Best Management Practices
CFS	Cubic Feet per Second
DEM	Digital Elevation Model
DMR	Discharge Monitoring Report
EPA	Environmental Protection Agency
GIS	Geographic Information System
HSPF	Hydrological Simulation Program - FORTRAN
HUC	Hydrologic Unit Code
LA	Load Allocation
LSPC	Loading Simulation Program C++
MAWSS	Mobile Area Water and Sewer Service
MGD	Million Gallons per Day
MOS	Margin of Safety
MPN	Most Probable Number
MRLC	Multi-Resolution Land Characteristic
MS4	Municipal Separate Stormwater System
NED	National Elevation Database
NHD	National Hydrography Dataset
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
RF3	Reach File 3
SSOs	Sanitary Sewer Overflows
STORET	Storage Retrieval database
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WCS	Watershed Characterization System
WLA	Waste Load Allocation

1.0 Executive Summary

This report presents Total Maximum Daily Loads (TMDLs) for waterbody segments in Dog River and Rabbit Creek impaired by organic enrichment/low dissolved oxygen on Alabama’s 1996 Section §303(d) list of impaired waterbodies.

Dog River is a shallow, tidally influenced, brackish bay connected by a small channel to Mobile Bay. The majority of the 87 square mile Dog River watershed lies within the City of Mobile (pop. 198,915). Rabbit Creek is a major tributary to Dog River that is also tidally influenced. A small portion of the 15.5 square mile Rabbit Creek watershed is within the City of Mobile. Portions of both Dog River and Rabbit Creek are §303(d)-listed due to impairment by organic enrichment/low dissolved oxygen and fecal coliform.[1] Table 1-1 summarizes the listing information related to TMDL development.

Table 1-1 §303(d) Listed Waterbodies in the Dog River Watershed.

Waterbody Name (ID)	Support Status	Use Classification(s)	Sources of Impairment	Size	Downstream/ Upstream Locations
Rabbit Creek (03160205-020_01)	Non	Fish & Wildlife	Urban runoff/Storm sewers Onsite wastewater systems	3.0 mi.	Dog River / AL Hwy. 163
Dog River (03160205-020_02)	Non	Fish & Wildlife Swimming	Land development Urban runoff/Storm sewers Onsite Wastewater Systems	4.0 mi.	Mobile River / 4 miles upstream

The Dog River watershed has two designated uses classifications, Fish and Wildlife (F&W) and Swimming. Locations of these use classifications are shown in Figure 1-1. In accordance with ADEM water quality standards, the minimum dissolved oxygen concentration in a stream classified as F&W or Swimming is 5.0 mg/L except in extreme conditions due to natural causes where DO levels are not permitted to drop below 4.0 mg/L. Since Dog River and Rabbit Creek both experience salinity intrusion, which naturally causes the DO to decrease due to vertical stratification, a dissolved oxygen minimum of 4.0 mg/L will be allowed for this TMDL.

A summary of the organic enrichment/low dissolved oxygen TMDL for Dog River and Rabbit is provided in Tables 1-2 and 1-3. The pollutants shown in the table for the two listed segments include ultimate carbonaceous biochemical oxygen demand ($CBOD_u$) and nitrogenous biochemical oxygen demand ($NBOD_u$). Based upon analysis of available data, it has been identified that low dissolved oxygen measurements within Dog River and Rabbit Creek are associated with low flow conditions and vertical stratification. The demand upon oxygen within the water column comes from Sediment Oxygen Demand (SOD) created through the deposition of Particulate Organic Matter (POM). Excess particulate organic material comes from non-point source runoff to the system from adjacent land uses. For the purposes of these TMDLs the source material has been identified as Carbonaceous and Nitrogenous Oxygen Demand ($CBOD_u$, $NBOD_u$). Because organic nitrogen can be converted to ammonia, its potential oxygen demand is included in the $NBOD_u$ component of the TMDL. The first table lists allowable pollutant loadings by $CBOD_u$ and the second table lists the loads for $NBOD_u$. Compliance under critical summer conditions assures that standards are met throughout the year. For the purposes of this TMDL a critical low flow summer period as measured in 2000 was utilized. An additional finding from the data analysis was that during flooding tides, low dissolved oxygen waters enter Dog River

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[1] Fecal coliform TMDLs for these segments are presented in a separate report, “Rabbit Creek and Dog River Fecal Coliform TMDLs.”

from Mobile Bay. These waters reflect conditions in Mobile Bay and are not a function directly of loads to Dog River or Rabbit Creek.

Table 1-2 Maximum Allowable $CBOD_u$ Loads in Dog River and Rabbit Creek.

Impaired Segment	Existing $CBOD_u$ Load (kg/yr)	MS4 WLA (percent reduction)	LA (percent reduction)	TMDL $CBOD_u$ (kg/yr)	TMDL (percent reduction)
Rabbit Creek	57,226	90%	90%	5,723	90%
Dog River	548,768	75%	75%	137,192	75%

Table 1-3 Maximum Allowable $NBOD_u$ Loads in Dog River and Rabbit Creek.

Impaired Segment	Existing $NBOD_u$ Load (kg/yr)	MS4 WLA (percent reduction)	LA (percent reduction)	TMDL $NBOD_u$ (kg/yr)	TMDL (percent reduction)
Rabbit Creek	9,886	90%	90%	989	90%
Dog River	426,565	75%	75%	106,641	75%

The wasteload allocations (WLA) within the system represent the contributions from point source discharges, including illegal discharges from sanitary sewer overflows (SSOs) from collection systems delivering wastewater to NPDES-permitted municipal wastewater treatment plants (WWTPs) discharging to Mobile Bay. The NPDES permits in the watershed are construction site activities and the Phase I Stormwater permit for the Greater Mobile Area Municipal Separate Storm Sewer System (MS4). Since it is impossible at this time to determine the proportion of the TMDL attributable to MS4 pipes and conveyances, the load allocation and MS4 wasteload allocation are designated as identical percent reductions from the existing condition. Construction site permits are also considered in the WLA above in Tables 1-2 and 1-3 and are equal to the LA. 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 ADEM’s basin rotation schedule.

For the load allocation to the nonpoint sources (LA), the impacts are associated with increased levels of organic material in the benthic layers that result in increased sediment oxygen demand within the system. Additionally, during low flow conditions, background sources of oxygen demand entering the system through failing septic systems and upstream inflows may contribute to the oxygen deficit. The allocation to the nonpoint sources therefore represents reductions necessary to reduce long-term sediment oxygen demand within the system to meet water quality standards for dissolved oxygen. As the buildup of materials is a long-term process, nonpoint source loads are estimated as annual average loadings.

The United States Fish and Wildlife Service have documented the endangered Florida manatee (*Trichechus manatus latirostris*) and the endangered Alabama redbelly turtle (*Pseudemys alabamensis*) in Dog River. Also, the threatened Gulf sturgeon (*Acipenser oxyrinchus desotoi*) may occur in Dog River. The TMDLs proposed for Dog River are organic enrichment and low dissolved oxygen in this document and pathogens in a separate document. The manatee and turtle are air-breathing vegetarians, so it is doubtful that they would be directly affected by organic enrichment or low dissolved oxygen. However, pathogens may affect these species, particularly if their immune systems are compromised or they are injured. The Gulf sturgeon is a bottom dwelling species that is probably used to some degree of low dissolved oxygen. It may also be affected by pathogens in certain circumstances. The Alabama redbelly turtle has been found at the mouth of Rabbit Creek. The Florida manatee and the Gulf sturgeon may occur in Rabbit Creek.

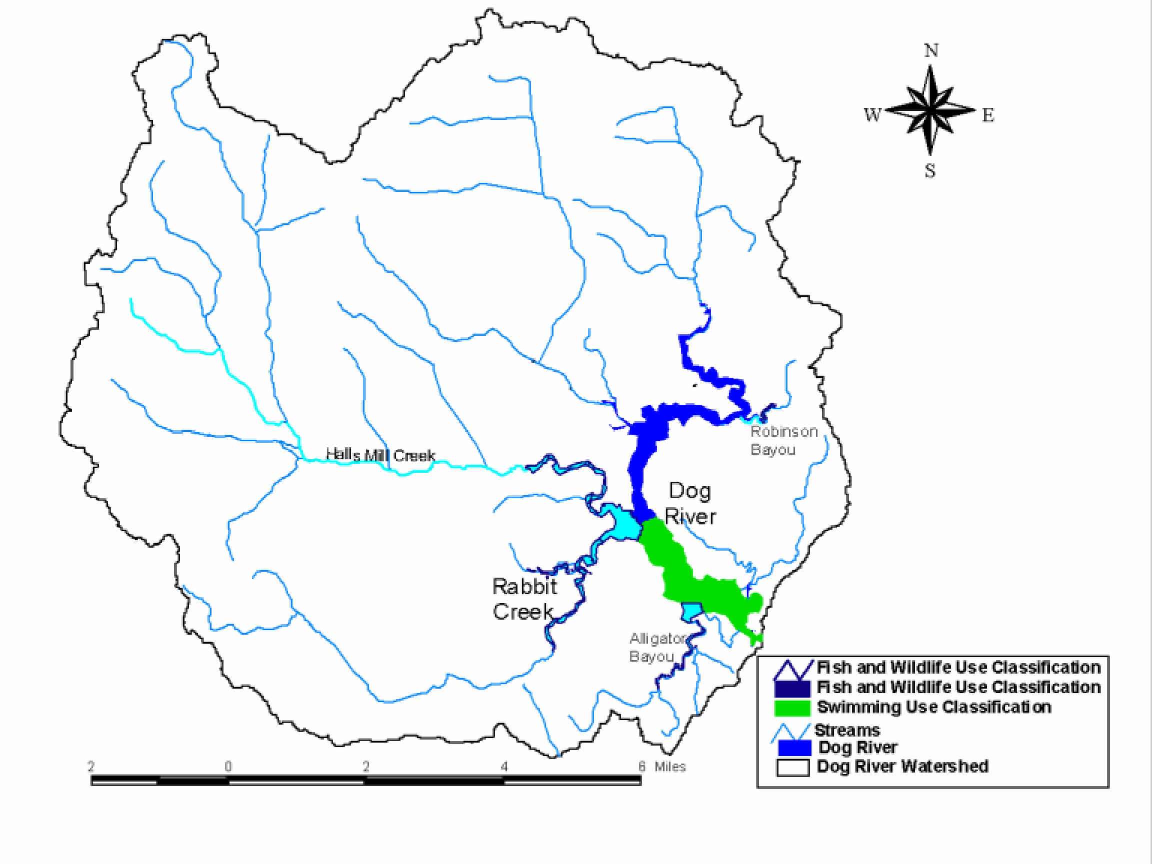

Figure 1-1 Use Classification Within the Dog River Watershed Including Rabbit Creek

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 two segments within the Dog River watershed as being impaired by organic loading (i.e., $CBOD_u$ and $NBOD_u$). The listings are reported on the 1996 §303(d) list(s) of impaired waters.

The TMDLs developed for the Dog River Watershed illustrate the steps that can be taken to address a waterbody impaired by low dissolved oxygen levels where nonpoint source loads are the primary cause of impairment. The TMDLs are consistent with a phased-approach: estimates are made of needed pollutant reductions, load reduction controls will be implemented, and water quality will be monitored for plan effectiveness. Flexibility is built into the plan so that load reduction targets and control actions can be reviewed and updated if monitoring indicates continuing water quality problems.

2.2 Problem Definition

Hydrologic conditions that affect surface-water quality in Dog River and Rabbit Creek include long hydraulic residence times during low flow conditions, and density stratification due to salinity intrusion from Mobile Bay and heating of the surface waters. Oxygen-consuming organic matter from both natural and anthropogenic sources settles in tidal areas and exerts high sediment oxygen demand (SOD) on the water column.

The purpose of these TMDLs is to establish the acceptable loading of organic material from all sources, such that the State of Alabama water quality criteria for dissolved oxygen are not violated.

Water Quality Criterion Violation:	Dissolved Oxygen
Pollutant of Concern:	Organic Enrichment
Water Use Classification (multiple):	Fish and Wildlife/Swimming

Usage of waters in the Fish and Wildlife 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 criteria of water quality for outdoor swimming places and will be considered satisfactory for swimming and other whole body water-contact sports.

Usage of waters in the Swimming classification is described in ADEM Admin. Code R. 335-6-10-.09(3)(a) and (b).

(a) Best usage of waters:

Swimming and other whole body water-contact sports. In assigning this classification to waters intended for swimming and water-contact sports, the Commission will take into consideration the relative proximity of discharges of wastes and will recognize the potential hazards involved in locating swimming areas close to waste discharges. The Commission will not assign this classification to waters, the bacterial quality of which is dependent upon adequate disinfection of waste and where the interruption of such treatment would render the water unsafe for bathing.

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

Alabama’s water quality criteria document (ADEM Admin. Code R. 335-6-10-.09-(5)(e)(4.) and Admin. Code R. 335-6-10-.09-(3)(c)(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 coastal waters, surface dissolved oxygen concentrations shall not be less than 5 mg/L, except where natural phenomena cause the value to be depressed. In estuaries and tidal tributaries, dissolved oxygen concentrations shall not be less than 5 mg/L, except in dystrophic waters or where natural conditions cause the value to be depressed.”

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 (or Swimming) is 5.0 mg/L, except under extreme natural conditions where a 4.0 mg/L will be allowed. For the purpose of these TMDLs, a minimum dissolved oxygen level of 4.0 mg/L will be implemented within waters classified as F&W or Swimming for the critical summer periods. The target is established at a depth of 5 feet in waters 10 feet or greater in depth; for those waters less than 10 feet in depth, dissolved oxygen criteria are applied at mid-depth. The target $CBOD_u$ and $NBOD_u$ concentrations may not deplete the daily dissolved oxygen concentration below this level as a result of the decaying process.

3.2 Source Assessment

3.2.1 General Sources of CBODu and NBODu

Both point and nonpoint sources may contribute $CBOD_u$ and $NBOD_u$ to a given waterbody. Potential sources of organic loading are numerous and often occur in combination. In rural areas, runoff can transport significant loads of organic material from natural sources, while onsite wastewater (septic) systems can contribute a steady source of oxygen-consuming wastes to groundwater. Nationwide, poorly treated municipal sewage comprises a major source of organic compounds that decay and create additional organic loading. Urban storm water runoff and sanitary sewer overflows can also 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., urban high density or forested land). The source assessment was used as the basis of development of the model and ultimate analysis of the TMDL allocations. Organic and nutrient loading within the watershed included both point and non-point sources.

3.2.2 Point Sources in the Dog River 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.

Although there are several NPDES construction and industrial permits located in the basin, no NPDES-permitted facilities discharge a significant amount of oxygen-consuming wastes. However, with the issuance of an NPDES Stormwater Phase I Municipal Separate Storm Sewer System (MS4) permit to the Greater Mobile Area Storm Sewer System effective October 1, 2001, the watershed loads traditionally considered as nonpoint source loads became the responsibility of the municipalities included in the permit.

Table 3-1 NPDES Permitted Discharges of Oxygen-consuming Wastes in the Dog River Watershed

NPDES Permit	Type of Facility	Facility Name	Significant Contributor (Yes/No)
ALS000002	MS4	Greater Mobile Area Municipal Separate Storm Sewer System	YES*
ALS000007	MS4	City of Mobile; AL DOT	YES*

* Note: In the MS4 service area, pollutant loads which could include urban runoff and/or failing septic systems are considered in the Load Allocations. Unpermitted sources such as illicit discharges and sanitary sewer overflows have a 100% reduction and are not considered part of the Wasteload Allocations or Load Allocations.

Furthermore, there have been a large number of SSOs reported by the Mobile Area Water and Sewer Service (MAWSS), from collection systems delivering wastewater to two major municipal wastewater treatment plants (WWTPs). Sites of reported overflows are shown in Figure 3-1, and listed in Appendix 9.5.

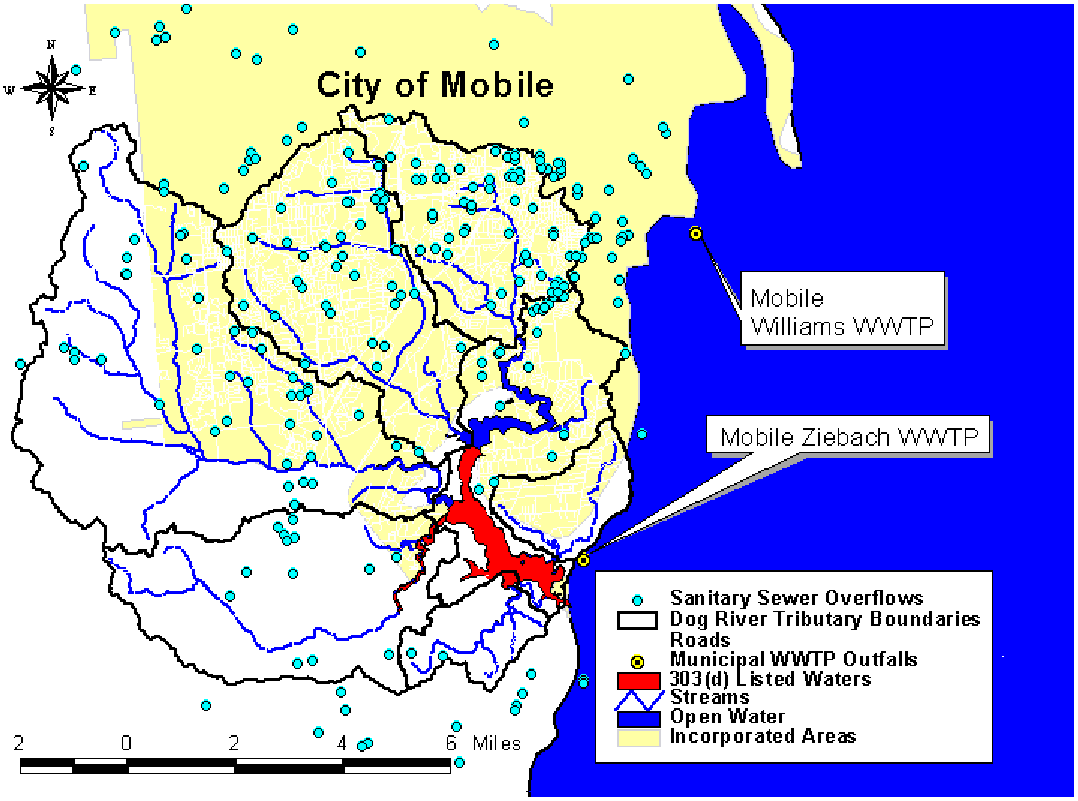

Figure 3-1 Sites of Sanitary Sewer Overflows Reported From 1997-April 2002

3.2.3 Nonpoint Sources in the Dog River Watershed

A land use map of the Dog River watershed is presented in Figure 3-2. The predominant land uses within the watershed are Forest and Urban. Their respective percentages of the total watershed are 30 percent and 13 percent respectively. Each land use type 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.

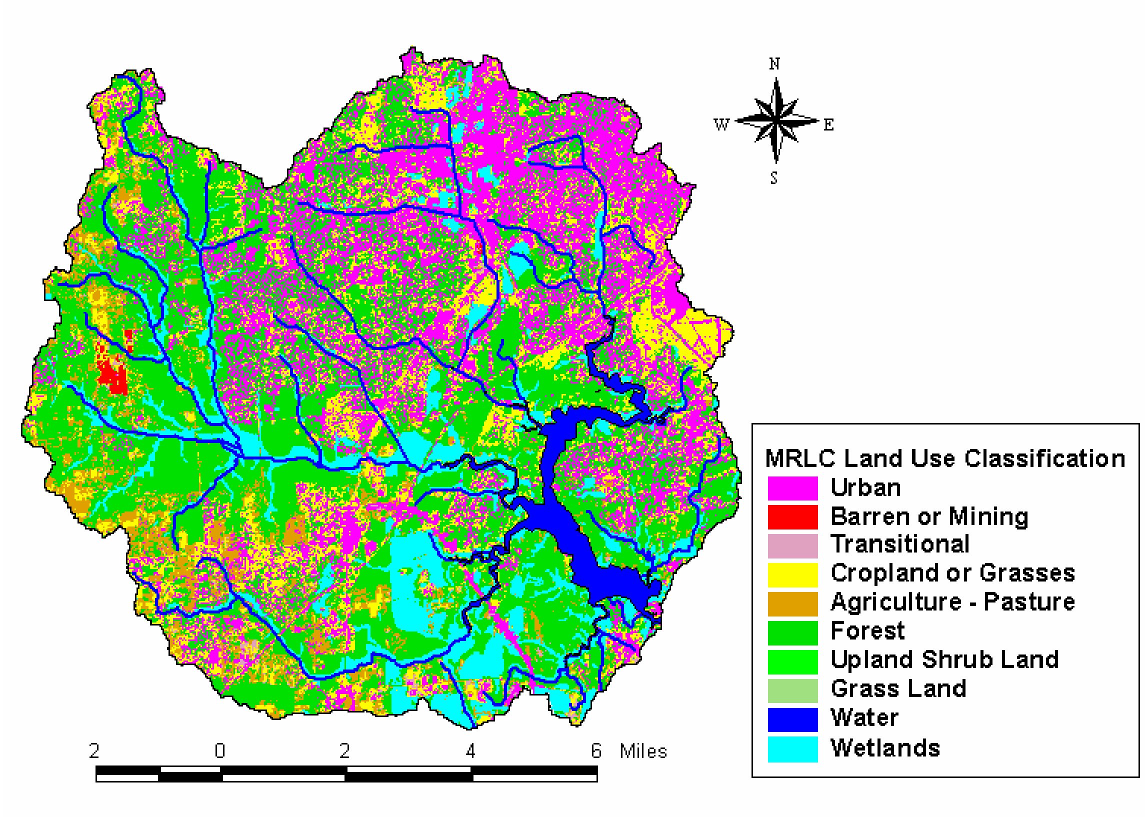

Figure 3-2 Land Use Distribution in the Dog River Watershed

Onsite wastewater (septic) systems are common in unincorporated portions of the watershed and may be direct or indirect sources of nutrients and organic enrichment via ground and surface waters. A high percentage of the citizens in the Dog River watershed rely on septic systems for wastewater treatment (Bureau of the Census 1990, 2000). Onsite septic systems have the potential to deliver loads to surface waters due to system failure and malfunction. The Mobile area is also problematic because the height of the water table limits percolation and filtration—in many cases septic wastes mix directly with groundwater. To evaluate this loading, it is necessary to identify where septic tanks are located and to estimate what proportion of septic tanks are malfunctioning.

The number of septic systems in the Dog River watershed is available by tract (Bureau of the Census 1990) and the current number can be estimated by population growth. The density of septic systems (number per acre) was determined for each tributary basin within the Dog River watershed based on the GIS overlap of census tracts, Figure 3-3. It was assumed that septic systems are distributed evenly throughout each tract. After estimating the number of septic systems per subwatershed, the number of failing systems per subwatershed was determined in order to calculate nutrient and organic material loading. Table 3-2 summarizes the results by subwatersheds as shown in Figure 3-3.

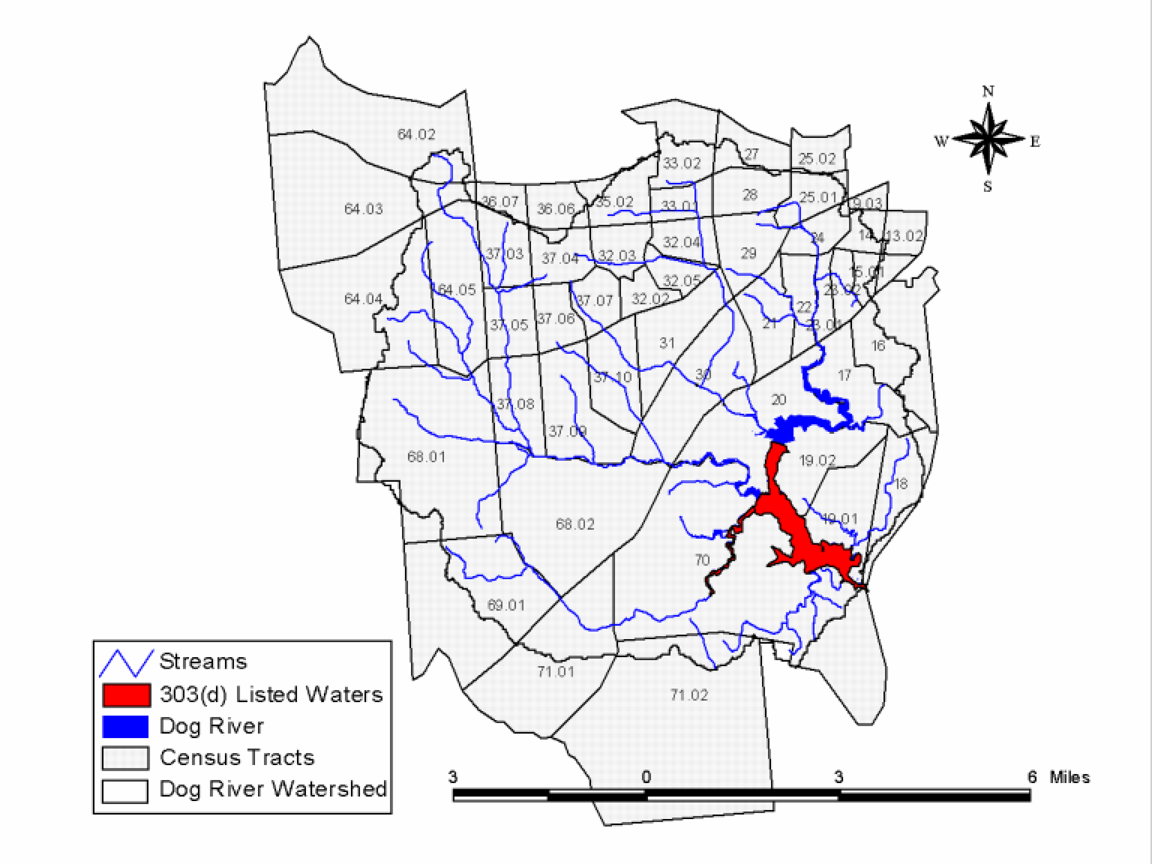

Figure 3-3 Census Tracts in the Dog River Watershed

Table 3-2 Estimated Onsite Wastewater Treatment Summary for Tributary Watersheds

Subbasin	1990 Population	1990 Onsite Wastewater Systems	2000 Population (estimated*)	2000 Onsite Wastewater Systems (estimated*)
Alligator	2,781	597	3,173	673
Dog River	13,840	573	14,259	625
Eslava Creek	24,883	88	25,217	89
Halls Mill Creek	43,309	4,741	47,176	5,341
Moore Creek	45,892	441	46,609	448
Perch Creek	4,046	127	4,100	128
Rabbit Creek	8,427	2,542	10,121	2,981

*2000 Population by tract was estimated by applying the percent change in Municipal population between the 2000 and 1990 Census populations to the 1990 population. 2000 Onsite Wastewater Systems were estimated from the 2000 population estimates assuming the number of people per household and percentage of household units with onsite systems in the 1990 Census.

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)).

Using the D.O. water quality criterion of 4.0 mg/L, a TMDL model analysis was performed through a critical summer period to determine the loading capacity for the watershed. This was accomplished through a dynamic simulation aimed at meeting the dissolved oxygen target limit by varying source contributions, either point or nonpoint sources. In the case of the nonpoint source loads, the simulations reflect the effects of NPS loads on sediment oxygen demand as well as background loads from failing septic systems and other upstream sources. The final acceptable simulation represents the TMDL (and loading capacity of the waterbody).

In addition to loading capacity, the linkage between the nonpoint source loading model developed for Dog River and Rabbit Creek and the instream dissolved oxygen simulations were achieved by identification of impacted and reference SOD values in the system. EPA has conducted studies to develop a database of measured sediment oxygen demand throughout the Mobile Bay system. From this database, values of sediment oxygen demand within Dog River were identified.

3.4 Data Availability and Analysis

A wide range of data and information were used to characterize the watershed and the instream conditions. The categories of data used include physiographic data that describe the physical conditions of the watershed, environmental monitoring data that identify potential pollutant sources and their contribution, and in-stream water quality monitoring data.

The data available throughout the Dog River watershed include very few chemical samples, which are necessary to characterize watershed loading inputs in tributary streams of Dog River, although an intensive study in 2001 detailed the conditions in Rabbit Creek. The following presents the data sources and their use within the TMDL development.

3.4.1 Watershed Characterization Data

Three types of spatial watershed information are utilized in the TMDLs. These are:

- Digital Elevation Data (DEM)
- MLRC Landuse Coverage
- National Hydrography Database Reach Network (NHD).

Figure 3-4 presents a spatial contour plot of the DEM data. This outlines the gradients seen in the system and highlights the low slope and grade of the land surface. Figure 3-5 presents the NHD stream network within the Dog River watershed. The DEM and NHD provide the general connectivity and routing within the system for both the watershed and in-stream receiving water model.

The MLRC Landuse Coverage was presented and discussed in Section 3.2.3. These data provided the landuse distribution utilized within the watershed model to develop the relative loads from urban, forested, agricultural, residential, and wetland uses.

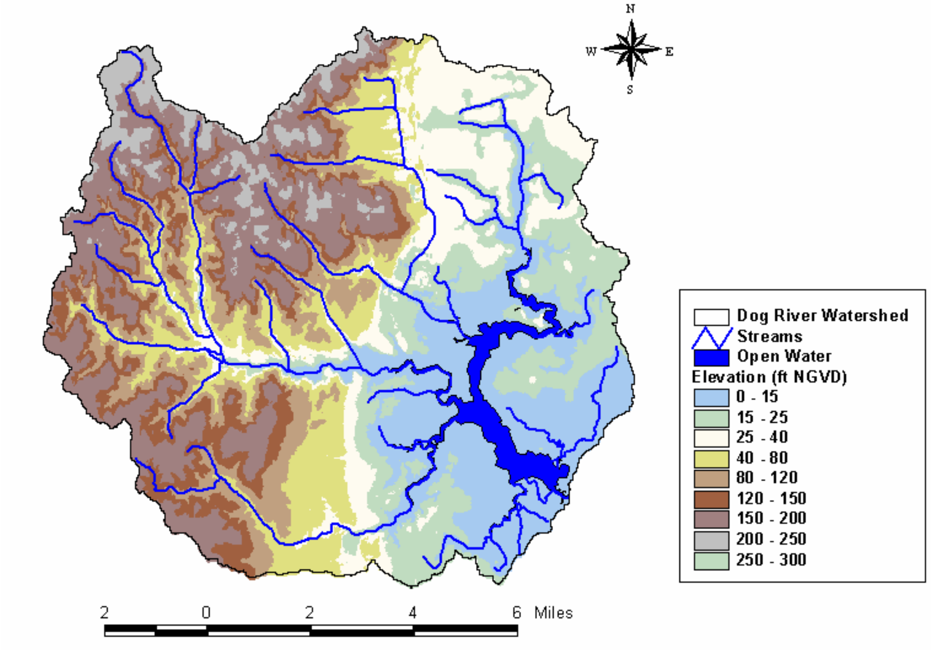

Figure 3-4 DEM Data

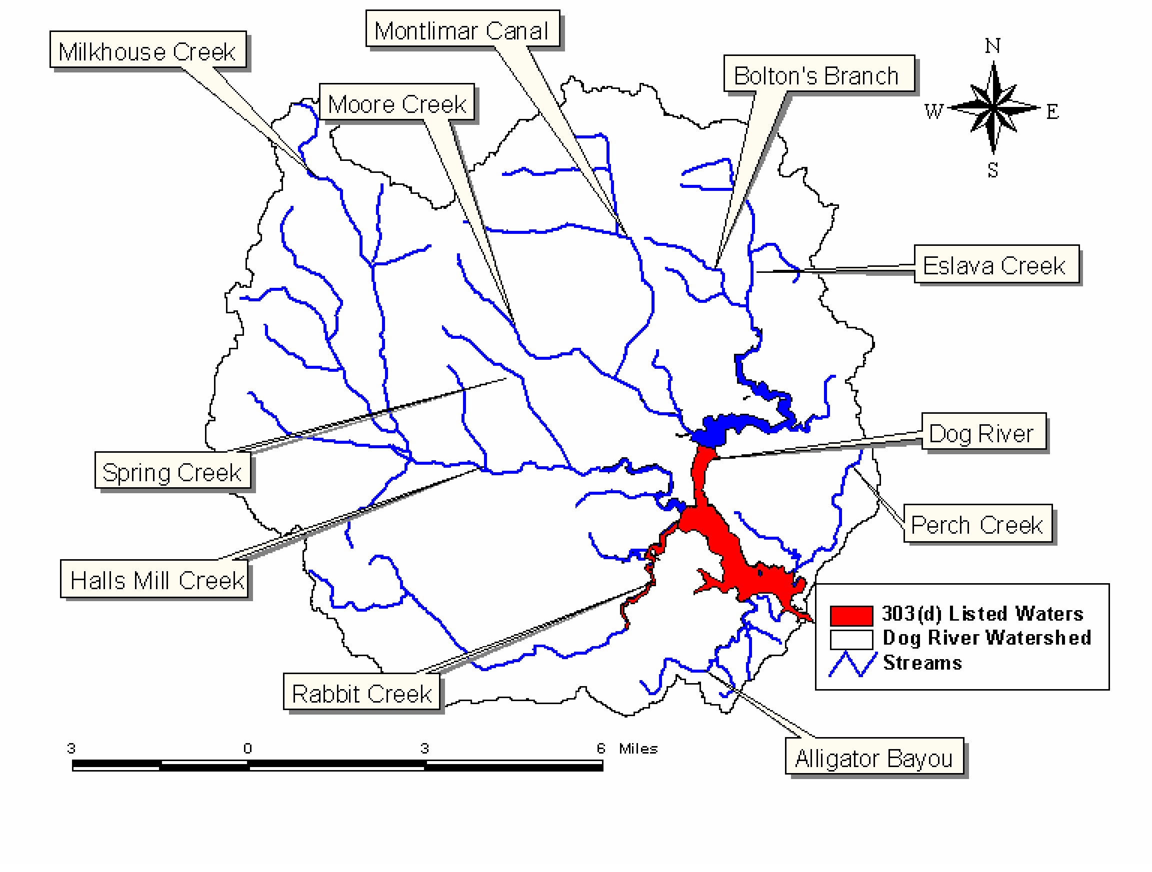

Figure 3-5 NHD Stream Network Data

3.4.2 Instream Flow Data

Although there have been no continuous flow gages in operation for many years, stations located in neighboring watersheds provide an index to hydrologic conditions necessary for the calibration of watershed simulations. Table 3-3 shows the USGS flow gaging station used in this study and the corresponding period of record. This station was the only nearby monitoring with sufficient data to characterize the stream flow in the watershed. Figure 3-6 shows the location of the USGS flow station used in the analysis.

Table 3-3 USGS Flow Station Employed in TMDL Development

Longitude	Latitude	USGS ID	Station Description	Period of Record
88.215	30.7416	247100550	Eightmile Creek at Highpoint Blvd.	10/1/1996-9/30/2000

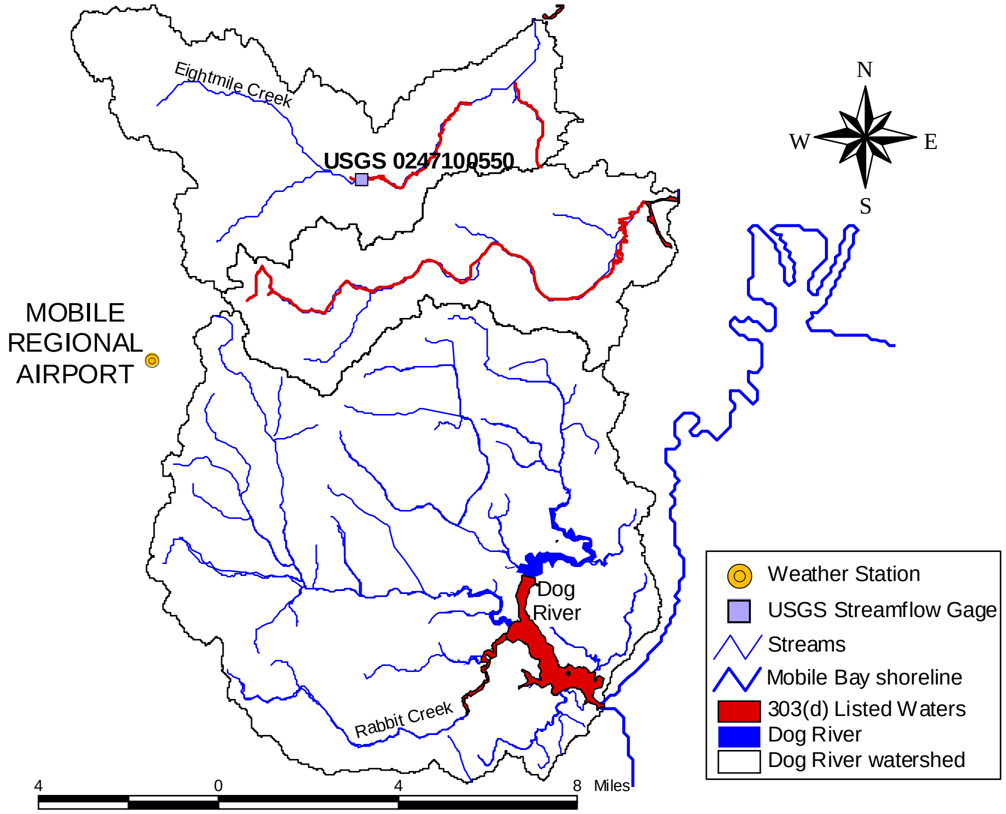

Figure 3-6 USGS Streamflow Gage and Weather Station Locations

3.4.3 Meteorological Data

Meteorological data are a critical component of the watershed model and the instream model. The following meteorological parameters are necessary for the watershed and in-stream water quality model:

- Rainfall
- Air temperature
- Solar radiation
- Wind speed and direction
- Relative humidity
- Cloud cover

Long-term hourly data of these parameters is available at a National Climatic Data Center (NCDC) weather station located at the Mobile Regional Airport, Figure 3-6. These data were utilized to provide meteorological inputs to the model.

3.4.4 Instream Water Quality

Data utilized for the development of the Organic Enrichment/Dissolved Oxygen TMDL were collected under five programs and special studies, these are:

- EPA Mobile Bay Water Quality Intensive Surveys (July 2000/May 2001)
- ADEM §303(d) Sampling Program
- ADEM Mobile Field Office Coastal Monitoring Program
- ADEM Long-Term Trend Monitoring Program
- ADEM Rabbit Creek Intensive Water Quality Studies (July/October 2001)

Figure 3-7 presents the locations of the water quality stations in the Dog River watershed. The stations for each study are identified individually. The following outlines the types and distribution of data collected under each study along with data analyses to identify key processes that influence the dissolved oxygen conditions in the receiving waters of the Dog River watershed.

<u>EPA Mobile Bay Water Quality Intensive Surveys (July 2000/May 2001)</u>
In July of 2000 (7/11/00-7/15/00) and May of 2001 (5/14/01-5/18/01), EPA conducted intensive water quality surveys of Mobile Bay and its surrounding receiving waters. These two measurement periods reflect distinctly different hydrologic conditions. In 2000, flows were very low and near critical 7Q10 conditions, while in 2001 flows were higher.

Under these studies a single sampling station (DR) was established just inside of the mouth of the entrance to Dog River. At this station the following sampling was conducted.

- Installation of a continuous recording water quality meter that measured dissolved oxygen, pH, conductivity, temperature, and water surface elevation. This instrument was installed at a depth of 5.0 feet below the water surface.
- Vertical profiles of dissolved oxygen, conductivity, temperature, and pH at various tide stages (high slack tide, low slack tide, ebbing tide).
- Grab samples analyzed for BODu, CBOD5, Total Organic Carbon (TOC), NH3, NO2/NO3, TKN, Total P, Dissolved P, Total Suspended Solids (TSS) at various tide stages (high slack tide, low slack tide, ebbing tide)

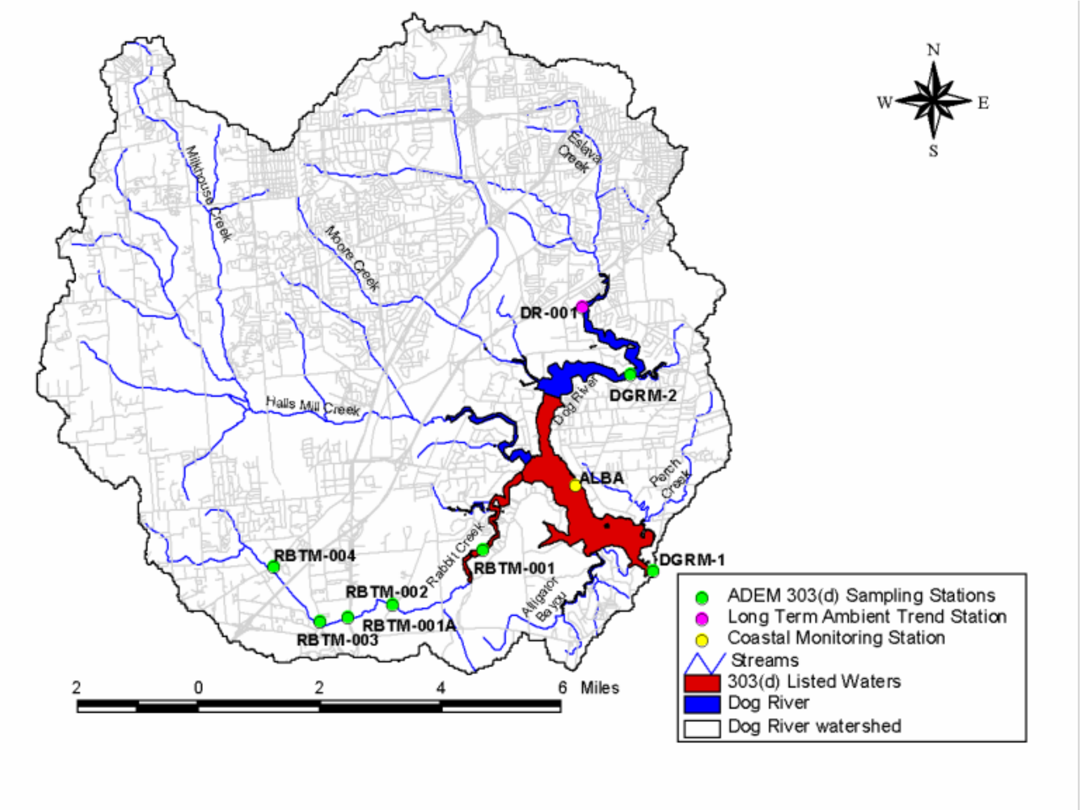

Figure 3-7 Sampling Station Locations

The DR sampling station was located near the mouth of Dog River and measured the water quality conditions entering from the Bay and leaving Dog River (Figure 3-8). These data therefore are critical in defining the influence of the Mobile Bay water quality conditions on conditions within Dog River. While the continuous measurements provide detailed quantification of the temporal changes in dissolved oxygen, and correlated with tide measurements, can indicate the source of waters, the water quality sampling conducted at various tide stages provides information on potential boundary sources.

Figures 3-9 and 3-10 present time series plots of the measured dissolved oxygen, temperature, and salinity versus the measured water surface elevation. Additionally, Figure 3-11 presents vertical profiles measured near the site of the continuous meters (Figure 3-8, DR1). Examination of Figures 3-9 and 3-10 shows a correlation between the water surface elevation, salinity, temperature, and dissolved oxygen. The correlation with salinity is expected given that during flooding tides, more saline waters enter from Mobile Bay and intrudes into Dog River and Rabbit Creek. This denser saline water moves along the bottom while freshwater, entering through various tributaries moves over the denser waters. Examination of Figure 3-10 shows that the vertical profiles are at times well mixed and at times stratified. The location of the continuous meter at 5 feet below the water surface would put it near the area of the pycnocline (area of high density gradient) and therefore it would at times measure the conditions in the lower waters and at times the conditions in the waters above the pycnocline.

Examination of the dissolved oxygen conditions during flooding tide, indicate that low dissolved oxygen water enters Dog River from the Mobile Bay with summer conditions showing measured values as low as 2.0 mg/L. These low values are generally in the bottom waters below the pycnocline. The compliance point for dissolved oxygen is at 5 feet below the water surface. The vertical profile data indicate that at times the pycnocline is located at or potentially above the compliance point. This would create conditions of low dissolved oxygen at the point of compliance and this is reflected within the data.

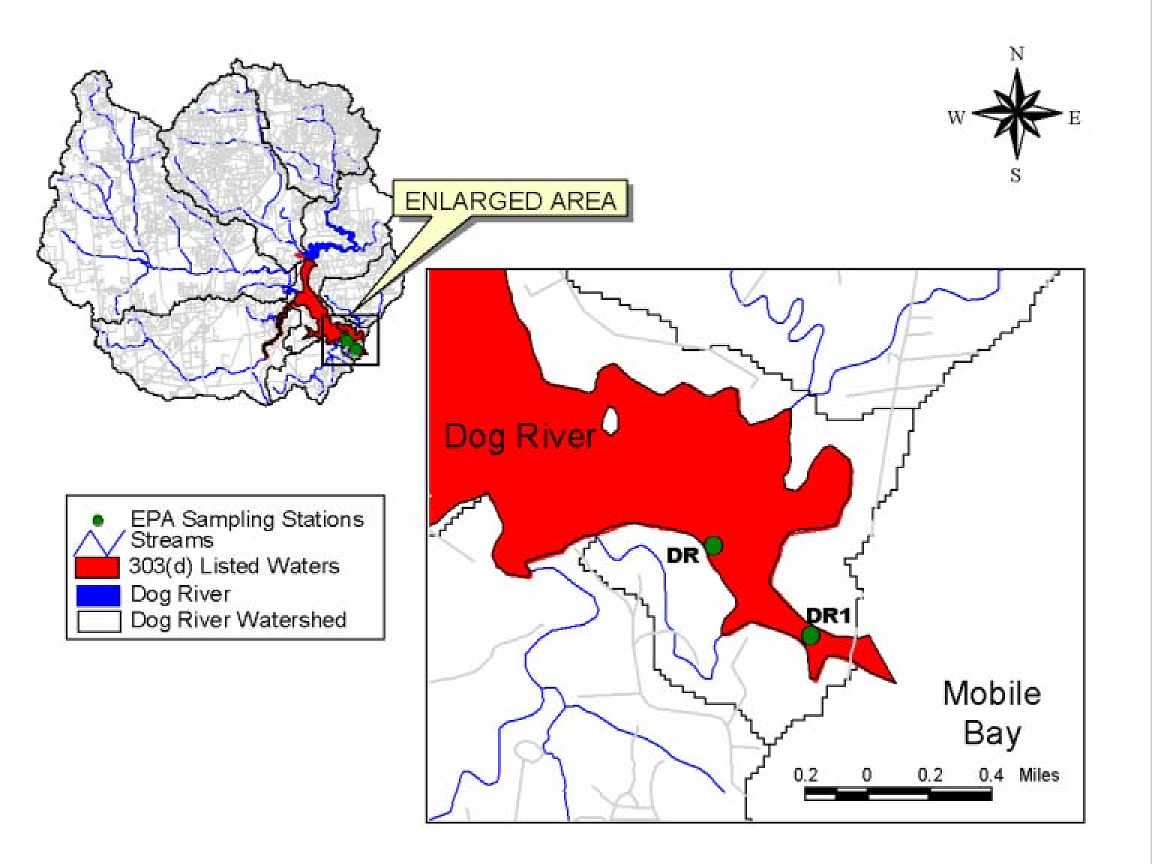

Figure 3-8 EPA Sampling Station Locations

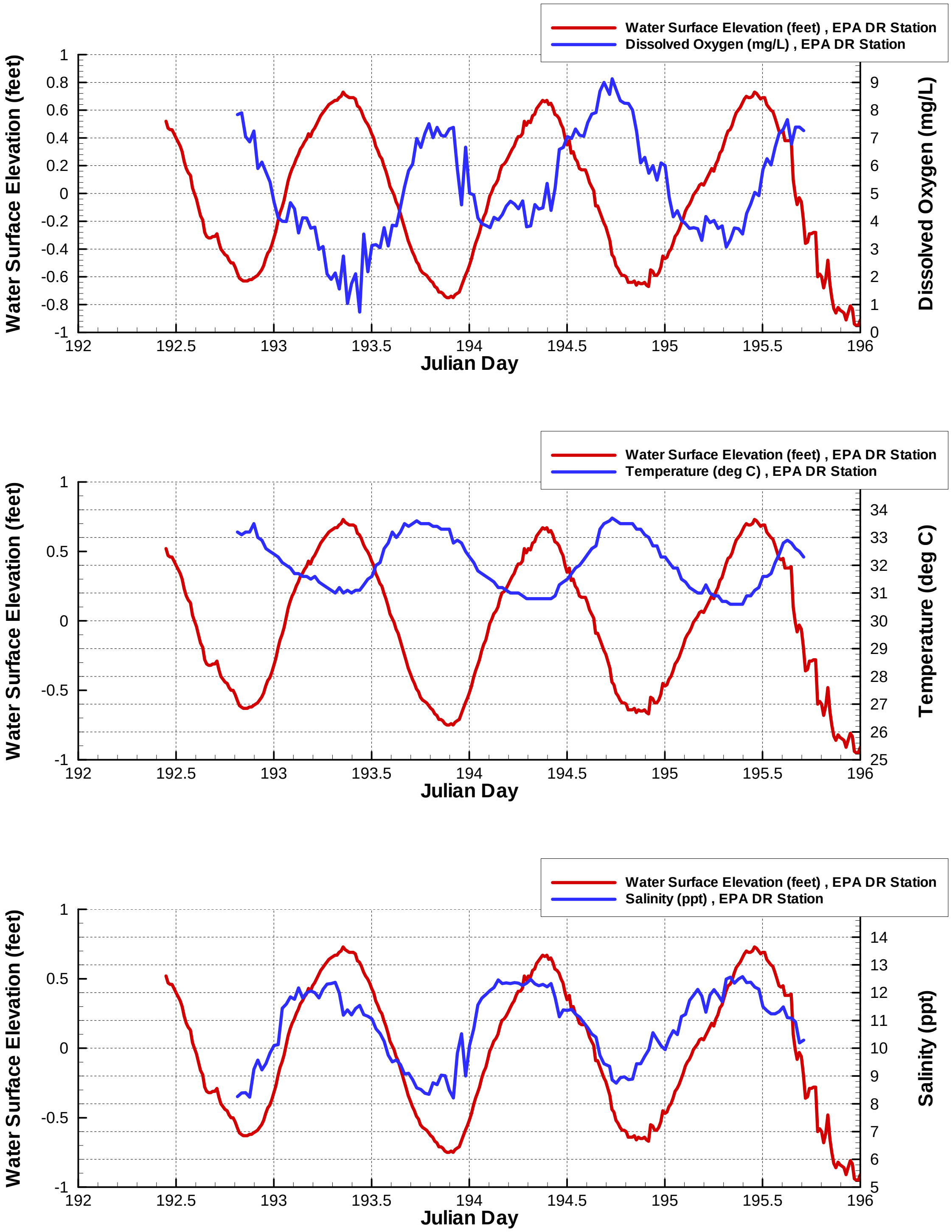

Figure 3-9 Measured Time Series of Dissolved Oxygen, Temperature, Salinity and Water Surface Elevation (July 11-15, 2000)

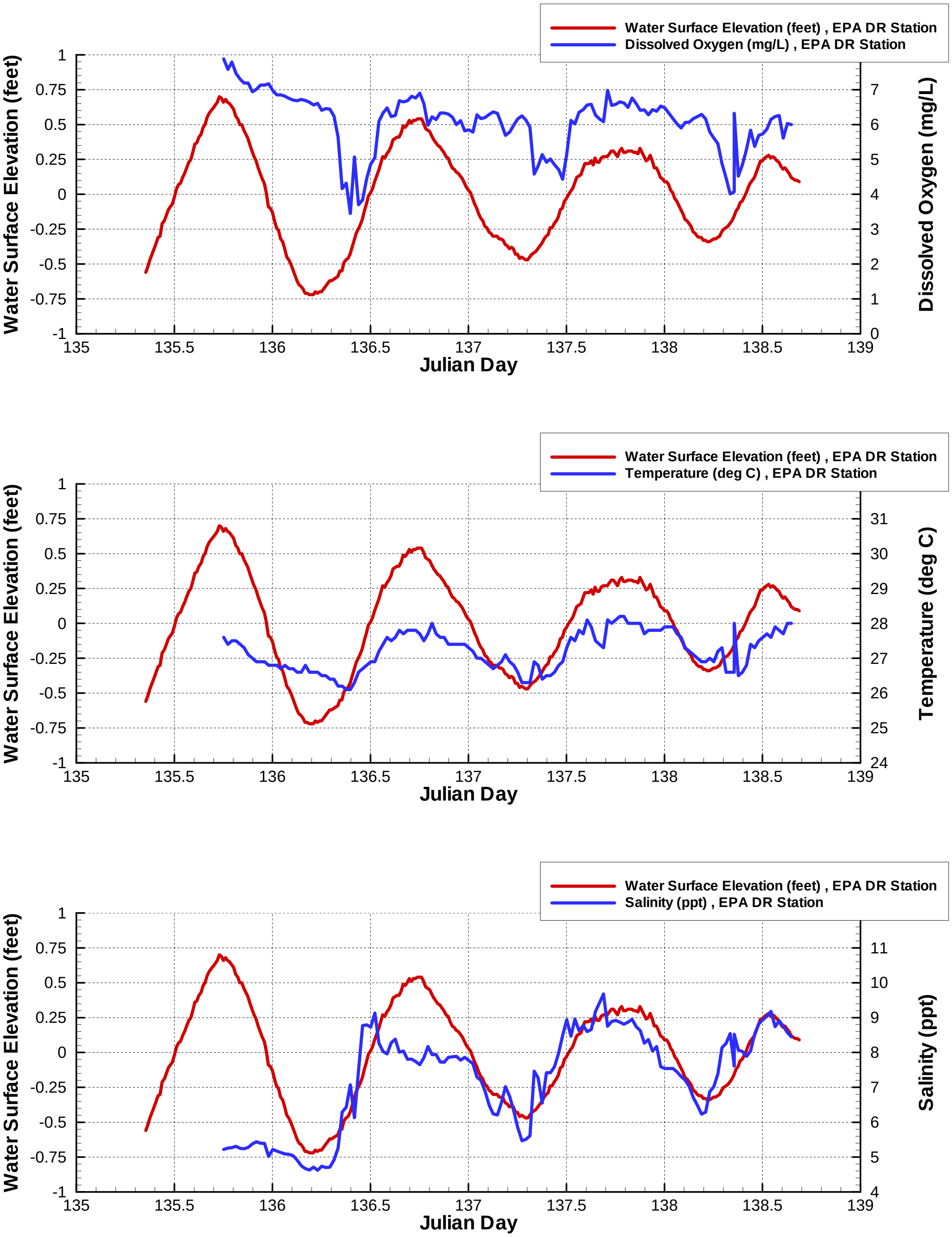

Figure 3-10 Measured Time Series of Dissolved Oxygen, Temperature, Salinity and Water Surface Elevation (May 14-18, 2001)

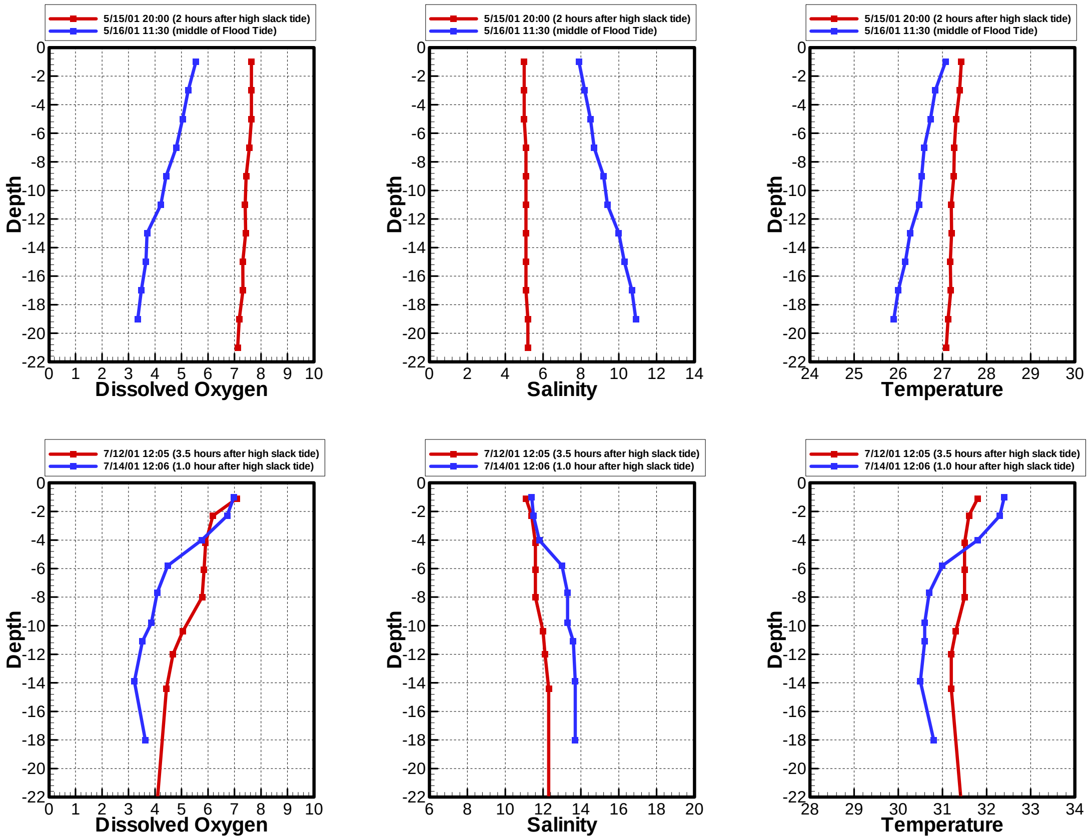

Figure 3-11 Measured Vertical Profiles at DR1 (July 11-14, 2000 and May 14-18, 2001)

Examination of the ebbing tide data shows that dissolved oxygen conditions within Dog River are generally good (> 5.0 mg/L) throughout the water column, once the fresher waters push out the more saline waters and stratification is reduced. It is clear from the data that stratification plays a critical role in the degree of dissolved oxygen deficit created within the waters below the pycnocline. Generally, the data collected in 2000 and 2001 support the idea that waters above the pycnocline are not impaired for dissolved oxygen.

Station	Date	Time	BODu	CBOD5 (mg/l)	TOC (mg/l)	NH3-N (mg/l)	NO2/NO3 (mg/l)	TKN (mg/l)	Total P (mg/l)	Diss. P (mg/l)
DR1	7/12/00	1230	10.8	2.0 UJ	3.6	0.050 U	0.050 U	0.506	0.064	0.023 AJ
DRT	7/14/00	1230	NA	3.5 J	NA	0.050 U	0.050 U	0.595 J	0.073	0.064
DRB	7/14/00	1235	NA	2.0 UJ	NA	0.050 U	0.050 U	0.592 J	0.078 A	0.068
DR1	5/15/01	2010	-	1.4	3.9	0.050 U	0.050 U	0.42	0.038	0.033
DR1 (Dupe)	5/15/01	2010	-	1.3	4.2	0.050 U	0.050 U	0.33	0.035	0.026
DR1	5/16/01	1140	6.11	1.7	3.9	0.45 J	0.050 U	0.38	0.037	0.023

A - Average Value; J - Estimated Value; U - material analyzed for but not detected (number is minimum quantitation limit); NA - Not analyzed

Table 3-4 Measured Nutrients and BOD at DR1 Station (July 2000, May 2001)

Table 3-4 presents the water chemistry measurements collected during the period of the vertical profile measurements. The data show some higher ultimate BOD measurements with values upwards of 10 mg/L. Nutrients measured at the DR station do not show elevated values in general. One sample did record a high value of ammonia during a flood tide condition. This high value of ammonia, during the May 2001 sampling event, corresponds to low dissolved oxygen water entering in from Mobile Bay.

ADEM §303(d) Sampling – Dog River Monitoring Stations

Table 3-5 presents the results of samples collected during the year 2001 at two stations within Dog River. The first was located at the entrance to Dog River from Mobile Bay (DGRM-1). The second was approximately 0.16 miles upstream of the entrance of Dog River. At both stations measurements of dissolved oxygen, temperature, salinity, ammonia, and BOD5 were collected near the surface from May through December. The measured dissolved oxygen was not below the standard of 5.0 mg/L at any of the measurements. Examination of the salinity data does indicate that these measurements reflect near surface conditions rather than measurements taken below the pycnocline, as salinity does not go above 8.0 ppt.

Date	DO	Temp	NH3	BOD5U	Salinity
DGRM-001					
5/14/2001 12:00	7.7	26.0	0.04	1.3	5.4
6/12/2001 8:45	6.5	25.3	0.11	1.0	2.1
7/11/2001 9:30	4.9	29.5	0.01	2.6	7.3
9/12/2001 9:35	6.5	28.0	0.05	0.1	3.9
11/1/2001 12:40	11.3	18.8	0.01	2.5	7.1
12/5/2001 9:40	8.6	18.3	0.01	1.7	7.6
DGRM-002					
5/14/2001 12:45	8.5	27.2	0.01	1.7	2.0
6/12/2001 9:30	5.3	24.7	0.15	1.9	0.4
7/11/2001 9:45	5.9	29.6	0.01	2.2	1.6
9/12/2001 10:30	6.4	29.1	0.04	0.1	1.9
11/1/2001 12:50	9.9	20.3	0.01	2.6	5.3
12/5/2001 10:10	7.7	19.2	0.01	3.1	7.8

Table 3-5 Measured Water Quality Data at Dog River Monitoring Stations (2001)

Ammonia and BOD5 measurements taken at both stations do not show significantly elevated levels. Measurements of ammonia are at or below 0.1 mg/L for nearly all of the samples while BOD5 measurements do not go above 3.0 generally.

ADEM Mobile Field Office Coastal Monitoring Program

A measurement station (Figure 3-7, ALBA) was established by the ADEM Mobile Field Office Coastal Monitoring Program and was sampled extensively for dissolved oxygen during the years 2000 and 2001. This station measured dissolved oxygen at a single point at mid-depth off of a dock. Depths at the end of the dock were between 9 and 11 feet. The data show that throughout the period of measurement, no readings were found below the standard of 5.0 mg/L with a minimum measured dissolved oxygen of 5.1 mg/L. Examination of the salinity data does show periods during the summer of 2000 where high salinity values were measured indicating that salinity intrusion reached the station but measured dissolved oxygen was still above 5.0 mg/L. Appendix 9.3 presents the measured data from the Alba Station.

ADEM §303(d) Sampling - Rabbit Creek Intensive Water Quality Studies (July/October 2001)

In July and October of 2001, ADEM conducted special studies on Rabbit Creek in support of TMDL development for organic enrichment and low dissolved oxygen. Under these studies, five sampling locations were established along Rabbit Creek (RBTM Stations Figure 3-7). Four of these stations were established in the more riverine sections with depths ranging from 1 to 4 feet with depths on the average of 2 to 3 feet. One station was established in the transition zone between the riverine portion and the tidal areas at the mouth to Dog River (RBTM 001).

Lab Parameters: Rabbit Creek TMDL Study #1
Mobile County: July 9-12, 2001

Station	Date	Time	CBOD$_U$ (mg/l)	CBOD$_5$ (mg/l)	TKN (mg/l)	NH$_3$-N (mg/l)	TON (mg/l)	NO$_X$-N* (mg/l)	Total P (mg/l)	Ortho P (mg/l)
RBTM4	7/11/2001	0905	2.96	0.4	0.15	0.083	0.07	0.393	0.051	0.01
	7/11/2001	1445		2.0	0.15	0.015	0.14	0.392	0.082	0.01
	7/11Dupe	1447		0.8	0.15	0.015	0.14	0.399	0.086	0.01
	7/12/2001	0750		0.7	0.15	0.015	0.14	0.321	0.085	0.01
RBTM3	7/11/2001	0925	2.54	0.9	0.15	0.068	0.08	0.314	0.116	0.02
	7/11/2001	1500		1.4	0.15	0.06	0.09	0.316	0.082	0.01
	7/12/2001	0808		0.8	0.15	0.015	0.14	0.374	0.083	0.01
RBTM2	7/11/2001	0843	3.72	1.4	0.15	0.043	0.11	0.182	0.08	0.02
	7/11/2001	1420		2.1	0.15	0.015	0.14	0.191	0.084	0.02
	7/12/2001	0825		0.9	0.15	0.015	0.14	0.159	0.083	0.01
	7/12 Dupe	0827		1.4	0.15	0.015	0.14	0.169	0.081	0.01
RBTM1	7/11/2001	0742	3.73	1.8	0.15	0.015	0.14	0.044	0.101	0.02
	7/11/2001	1315		1.8	0.15	0.015	0.14	0.04	0.099	0.02
	7/12/2001	0900		2.4	0.28	0.155	0.13	0.026	0.105	0.01

Lab Parameters: Rabbit Creek TMDL Study #2
Mobile County: October 16-19, 2001

Station	Date	Time	CBOD$_U$ (mg/l)	CBOD$_5$ (mg/l)	TKN (mg/l)	NH$_3$-N (mg/l)	TON (mg/l)	NO$_X$-N* (mg/l)	Total P (mg/l)	Ortho P (mg/l)
RBTM4	10/17/2001	0900	1.90	1	0.30	0.02	0.28	0.475	0.024	0.020
	10/17/2001	1405		1	0.29	0.02	0.27	0.518	0.015	0.021
	10/18/2001	0915		1	0.23	0.01	0.22	0.533	0.013	0.019
RBTM3	10/17/2001	0920	1.74	1	0.37	0.01	0.36	0.359	0.010	0.031
	10/17/2001	1350		1	0.27	0.01	0.26	0.385	0.012	0.023
	10/18/2001	0925		1	0.26	0.02	0.24	0.400	0.012	0.019
RBTM2	10/17/2001	1000	2.27	1	0.28	0.02	0.26	0.190	0.012	0.032
	10/17/2001	1335		1	0.34	0.02	0.32	0.200	0.027	0.034
	10/18/2001	0950		1	0.23	0.01	0.22	0.213	0.014	0.026
RBTM1	10/17/2001	1105	4.19	1.1	0.54	0.03	0.51	0.008	0.033	0.067
	10/17/2001	1250		1.4	0.53	0.01	0.52	0.020	0.028	0.043
	10/18/2001	1030		2.1	0.62	0.01	0.61	0.053	0.041	0.021
RBTM1a**	10/17/2001	1110	4.12	1.6	0.72	0.10	0.62	0.008	0.014	0.024
	10/17/2001	1300		1.6	0.45	0.02	0.43	0.023	0.014	0.014
	10/18/2001	1035		1.2	0.46	0.02	0.44	0.044	0.026	0.023

Table 3-6 Measured Water Quality at RBTM Stations (2001)

Table 3-6 presents the results of laboratory testing of samples collected at all of the Rabbit Creek sampling locations for July and October of 2001. For both of the sampling periods the data show three distinct longitudinal trends. First, the data show an increase in the carbonaceous oxygen demand moving from upstream to downstream with the highest values in the transition area at Station RBTM 001. The second visible trend is a decrease in the Nitrate/Nitrite samples with ranges around 0.4 mg/L in the upstream down to less than 0.05 in the transition area. In contrast, the Total Phosphorus data show a slight increasing trend moving down the system although this is not as apparent in the October sampling event. The conditions indicate a shift in the limiting nutrient within the system moving from phosphorus limited to nitrogen limited in the downstream estuarine areas, this is typical of transitions from riverine to estuarine areas.

Field Parameters: Rabbit Creek TMDL Study #1*
Mobile County: July 9-12, 2001

			Temp (°C)		Stream Depth	D.O.	Conductivity	pH
Station	**Date**	**Time**	**Air**	**Water**	**(ft)**	**(mg/l)**	**(μmhos/cm)**	**(s.u.)**
RBTM4	7/10/2001	1520	No Thermom.	24.99	1.20	5.23	77	6.01
	7/10/2001	1522	No Thermom.	25.01	1.20	5.08	77	5.95
	7/11/2001	0905	27	24.11	2.4	5.02	81	6.06
	7/11/2001	1445	27	24.03	2.5	5.27	77	6.07
	7/12/2001	0750	26	23.41	2.5	5.00	77	6.10
RBTM3	7/10/2001	1445	No Thermom.	26.22	0.95	6.18	86	6.33
	7/11/2001	0925	26	25.39	1.9	6.10	92	6.44
	7/11/2001	1500	27.5	25.14	1.9	6.02	89	6.40
	7/12/2001	0808	27	24.34	2.0	6.64	88	6.40
	7/12/2001	0809	27	24.34	2.0	6.57	88	6.42
Hwy 90	7/10/2001	1540	No Thermom.	27.30	0.92	6.40	86	6.45
	7/11/2001	0940	33	25.52	1.1	5.90	90	6.49
	7/11/2001	1520	34.5	25.33	1.1	6.25	90	6.45
	7/12/2001	0730	27.5	24.53	1.1	6.36	90	6.38
RBTM2	7/10/2001	1350	No Thermom.	25.86	0.91	5.92	84	6.33
	7/11/2001	0843	27	25.34	1.9	5.66	86	6.40
	7/11/2001	1420	28	25.14	1.9	5.70	83	6.41
	7/12/2001	0825	28	24.45	2.1	6.07	90	6.38

Field Parameters: Rabbit Creek TMDL Study #2*
Mobile County: Oct 16-19, 2001

			Temp (°C)		Stream Depth	D.O.	Conductivity	pH
Station	**Date**	**Time**	**Air**	**Water**	**(ft)**	**(mg/l)**	**(μmhos/cm)**	**(s.u.)**
RBTM4	10/16/2001	1435	26	18.1	1.8	5.83	75	7.04
	10/17/2001	0900	11	14.8	1.8	6.53	64	4.69
	10/17/2001	1400	20	15.4	>4	7.09	64	6.95
	10/18/2001	0910	12	13.8	>4	7.23	60	6.02
RBTM3	10/16/2001	1425	25	18.7	1	6.87	78	7.29
	10/17/2001	0920	11	15.3	2.6	7.72	70	5.81
	10/17/2001	1350	20	16	2.6	7.92	72	7.19
	10/18/2001	0925	13	14.1	2.6	8.76	67	5.27
Hwy 90**	10/16/2001	1455	25	19.3	3.6	7.12	77	6.75
	10/17/2001	0940	14	15.6	ND	3.40	70	5.35
	10/17/2001	1420	21	16.5	3.4	8.31	71	6.89
	10/18/2001	0940	13	14.2	3.4	8.92	66	5.45
RBTM2	10/16/2001	1400	25	18.5	1.1	6.67	73	8.00
	10/17/2001	1000	13	15.3	1.1	7.54	67	5.60
	10/17/2001	1330	19	15.7	1.1	8.23	84	8.20
	10/18/2001	0950	13	14.1	1.1	9.36	63	5.53

Table 3-7 Measured Water Quality at RBTM Stations (2001)

Table 3-7 presents the corresponding in-situ profiling of dissolved oxygen, temperature, pH, and conductivity. The table only presents the data from the four stations upstream of the transition zone. Examination of the data shows that at no time during this study was there significant salinity intrusion to the upper stations. The dissolved oxygen measurements at these stations do not show any periods where measurements drop below the standard of 5.0 mg/L.

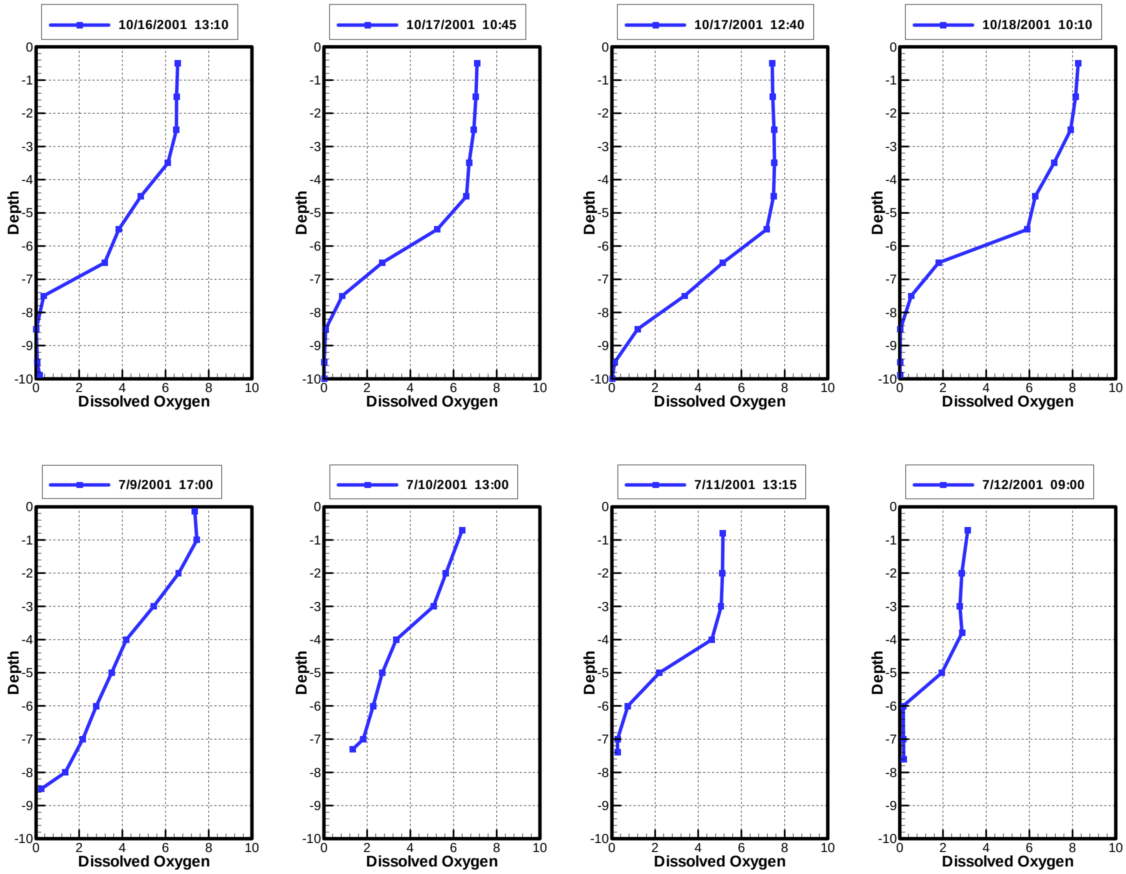

Figure 3-12 Measured Vertical Profiles at RBTM-01 (July and October, 2001)

Figure 3-12 presents the measured dissolved oxygen profiles at RBTM-001. The depths at this transition area are such that vertical stratification occurs creating reduced reaeration to the bottom waters and resultant lower dissolved oxygen. Examination of the data show that for many of the profiles the dissolved oxygen conditions at the surface are above standards during most times. Only one measurement in July 2001 at 9:00 a.m. shows a corresponding surface measurement below the standard of 5.0 mg/L. Examination of the data at the compliance depth of 5 feet clearly shows that during the warm summer months (July data) the system is impaired relative to dissolved oxygen. It is clear that the degree of stratification caused by the slow moving deeper waters in the transition zone create conditions where dissolved oxygen deficit occurs in the bottom and at times the near surface (compliance point) waters.

ADEM Long-Term Trend Monitoring Stations

A long-term trend monitoring station was established in the upstream reaches of Dog Creek (Figure 3-7, DR-001). At this station, periodic samples of dissolved oxygen, temperature, salinity, ammonia and BOD5 were collected. The data collection spanned from 1978 to the present. The data from 1994 to the present was evaluated to see what dissolved oxygen and other constituents were loading to the upper reaches of Dog River. The dissolved oxygen data show periodic samples below the water quality criteria. Evaluation of the data from the summer months (May through September) show around 7 percent of samples below 5.0 mg/L. Ammonia levels range from 0.01 up to 0.39 with median values around 0.015. BOD5 levels range from 0.1 to 9.0 mg/L with median values around 2.5, typical for estuarine systems. The high ammonia and BOD5 levels appear to coincide with storm events.

3.4.5 Point Source Discharge Data

No NPDES permitted point sources discharge to the watershed, but sewer overflows are simulated in the model as reported with assumed concentrations. Details on the discharges are presented in Appendix 9.6.

3.4.6 Special Studies

Special studies used in the development of this TMDL provided measurements of the following:

- Sediment Oxygen Demand within Dog River
- Ultimate Biochemical Oxygen Demand within Rabbit Creek

Sediment oxygen demand was measured at a point near the mouth of Dog River in 2000. The location is shown on Figure 3-8. The measured SOD values ranged from 1.0 gm/m^2/day to 2.41 gm/m^2/day.

Measurements of Ultimate Biochemical Oxygen Demand within Rabbit Creek were conducted as part of the intensive surveys in July and October 2001. Table 3-6 presents the measured UBOD values at the RBTM stations.

4.0 Model Development

Establishing the relationship between instream water quality and source loading is an important component of TMDL development. It allows the determination of the relative contribution of sources to total pollutant loading and the evaluation of potential changes to water quality resulting from implementation of various management options. This relationship can be developed using a variety of techniques ranging from qualitative assumptions based on scientific principles to numerical computer modeling. In this section, the numerical modeling techniques developed to simulate the loading of organic material and nutrients, and the resulting in-stream response of dissolved oxygen, are presented. For these TMDLs a system of models was developed to allow the determination of the watershed loads to the listed reaches, the instream flow and transport within the listed reaches, and the instream response of critical water quality parameters. The system of models includes the following:

- Loading Simulation Program in C++ (LSPC) – to quantify the loads of organic material and nutrients to the listed reaches
- Environmental Fluid Dynamics Code (EFDC) – to simulate the flow and transport of material within the listed reaches.
- Water Quality Analysis and Simulation Program (WASP) – to simulate the instream response of critical water quality parameters to the watershed loads.

The following presents general descriptions of each of the models along with brief descriptions of the model calibrations and applications.

4.1 Watershed Model – LSPC

Hydrologic response and pollutant loading model calibrations must occur to determine the watershed loads to the receiving waters. First, the model is calibrated for the hydrologic response of the watershed to rainfall and background source flows. During periods of precipitation, the rainfall will govern hydrology and subsequent loads of organic material and nutrients. During dry periods, past events and their associated deposition within the system, and background inflows will govern the system hydrology. In each case there is a subsequent load to the listed waters that must be carried forward to the instream modeling. Loads washed into the system will pass through and/or react during dry periods if the loads still remain in the water column. In addition, build up of organic material in the listed reaches from past high flow events can create increased sediment oxygen demand that exerts itself during low flow periods. In each case, the development of a TMDL that accounts for the nonpoint source impacts upon the system requires the quantification of the total load and it's distribution.

4.1.1 Hydrology Model Selection, Set Up and Calibration

Based on the considerations described above, analysis of the monitoring data, review of the literature, and past modeling experience, the Loading Simulation Program C++ (LSPC) was used to represent the source-response linkage in the Dog River watershed. LSPC is a comprehensive data management and modeling system that is capable of representing loading from nonpoint and point sources and simulating in-stream processes. This program is based on the Mining Data Analysis System (MDAS), with modifications for non-mining applications such as nutrient and fecal coliform modeling. MDAS was developed by EPA Region 3 through mining TMDL applications in Region 3.

LSPC is a system designed to support TMDL development for areas impacted by nonpoint and point sources. The most critical component of LSPC to TMDL development is the dynamic watershed model, because it provides the linkage between source contributions, instream response during routing of flows, and delivery of loads to receiving streams. The comprehensive watershed model is used to simulate watershed hydrology and pollutant transport as well as stream hydraulics and in-stream water quality. It is capable of simulating flow, sediment, metals, nutrients, pesticides, and other conventional pollutants, as well as temperature and pH for pervious and impervious lands and waterbodies. LSPC was configured for Dog River to simulate the watershed as a series of the hydrologically connected subwatersheds that contribute loads to various lengths of the listed reaches. Configuration of the model involved subdivision of the Dog River and Rabbit Creek watersheds into modeling units and continuous simulation of flow and water quality for these units using meteorological, land use, and stream data. The only pollutants simulated are nutrients and biochemical oxygen demand. This section describes the configuration process and key components of the model in greater detail.

The watershed was divided into 50 subwatersheds to represent watershed loadings and resulting concentrations of nutrients and biochemical oxygen demand to the stream segments. Figure 4-1 presents the subwatershed breakdown in LSPC. These subwatersheds represent hydrologic boundaries. The division was based on elevation data from the 30m resolution National Elevation Dataset (NED) from USGS, stream connectivity from the National Hydrography Dataset (NHD) stream coverage, and the locations of monitoring stations.

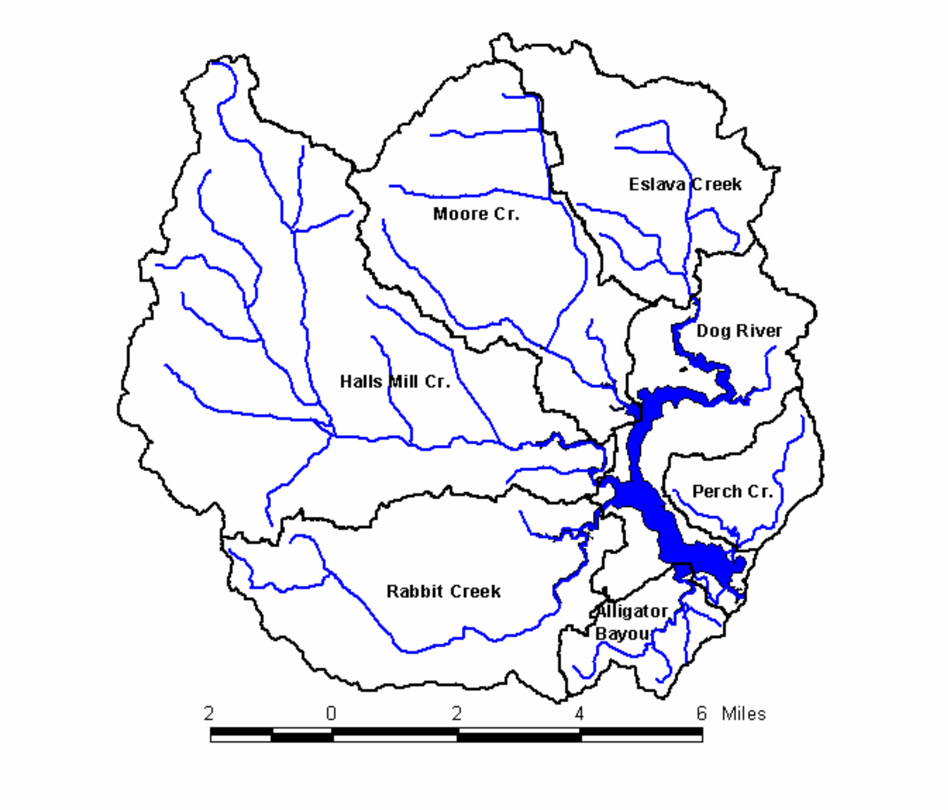

Figure 4-1 Subwatershed Delineation

The hydrology of the LSPC model was calibrated for the period of record 10/1/96-9/30/00 at USGS gage 247100550 on Eightmile Creek. The hydrology calibration was performed prior to water quality calibration and involved adjustment of the model parameters used to represent the hydrologic cycle until acceptable agreement was achieved between simulated flows and historic stream flow data measured at USGS gage 247100550 for the same period of time. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge. Modeled flow was also compared to flow observations available at each of the water quality stations. The hydrological calibration plots are presented in the Appendix 9.4.

4.1.2 Water Quality Loading Model Selection, Set Up and Calibration

A dynamic computer model was selected for nutrients and CBODu analysis in order to: a) simulate the time varying nature of deposition on land surfaces and transport to receiving waters; and b) incorporate seasonal effects on the production and fate of CBODu and NBODu.

For modeling purposes, the CBODu and NBODu sources are represented by the following components:

- runoff loads from land uses (build-up and washoff due to runoff)
- direct source loads from failing septic systems and SSOs

Typically, nonpoint sources are characterized by buildup and washoff processes: they contribute material to the land surface, where they accumulate and are available for runoff during storm events. These nonpoint sources can be represented in the model as land-based runoff from the land use categories to account for their contribution to form loading within the watersheds. Accumulation rates (mass per acre per day) can be calculated for each land use based on all sources contributing nutrients and CBODu to the surface of the land use.

Literature values for typical CBODu and NBODu accumulation rates were used for the urban land uses. The literature value used for urban land uses is the median default value for commercial land (Horner, 1992). The value used for barren and strip-mining land uses was half of the urban value. The value used for CBODu and NBODu accumulation rates on the harvested woodland use was the same value as forest.

The LSPC model is a build-up and washoff model that represents the pollutant by accumulating the pollutant over time, storing the pollutant to some maximum limit, and then transporting the pollutant through overland flow to the stream. The model represents these processes with an accumulation rate (ACQOP) and the storage limit (SQOLIM). WSQOP is defined as the rate of surface runoff (inches per hour) that results in 90 percent washoff in one hour. The lower the value, the more easily washoff occurs. This parameter is user-defined and was determined for each land use by EPA recommended ranges. The ACQOP and SQOLIM can be varied monthly or be a constant through the simulation. If specific data such as timing of manure applications, livestock rotations, and crop rotations are known, these rates can be calculated monthly. For the Dog River watershed modeling, the rates were input as constant values.

Failing septic systems represent a nonpoint source that can contribute nutrients and CBODu to receiving waterbodies through surface or subsurface malfunctions. The estimated number of septic systems was calculated from the number of onsite wastewater systems identified in the 1990 census and population change between the 1990 and 2000 Census. To provide for a margin of safety accounting for the uncertainty of the number, location, and behavior (e.g., surface vs. subsurface breakouts; proximity to stream) of the failing systems, failing septic systems are represented in the model as direct sources of nutrients and CBODu to the stream reaches. Contributions from failing septic system discharges are included in the model with a representative flow and concentration, which were quantified based on the following information:

- Number of failing septic systems in each subwatershed.
- Estimated population served by septic systems (an average per household, calculated from 1999 and 2000 population estimates Bureau of the Census data).
- An average daily discharge of 70 gallons/person/day (Horsley & Witten,1996).
- Septic effluent concentration of 220 mg/L of CBOD5, 15 mg/L organic nitrogen, 25 mg/L ammonia, 3 mg/L organic phosphorus, and 5 mg/L inorganic phosphorus (Metcalf and Eddy, 1991).

Following hydrology calibration, the water quality constituents were calibrated. Modeled versus observed instream concentrations for all of the nutrient species along with the CBODu were directly compared during model calibration. The water quality calibration consisted of executing the watershed model, comparing water quality time series output to available water quality observation data, and adjusting water quality parameters within a reasonable range. The parameters that were adjusted to obtain a calibrated model were the build-up and washoff of nutrients and CBODu from the land use coverages and the direct loads such as sanitary sewer overflows and failing septic systems.

The approach taken to calibrate water quality focused on matching trends identified during the water quality analysis. Daily average in-stream concentrations from the model were compared directly to observed data. Observed nutrient and CBODu data were obtained from ADEM. The objective was to best simulate low flow, mean flow, and storm peaks at representative water quality monitoring stations. The model was calibrated at all water quality stations with observation data during the chosen calibration period. These stations were typically ADEM monitoring stations (see Figure 3-7).

The time period of the model simulation was from 2000 to 2001. This time period was selected based on the availability and relevance of the observed data to the current conditions in the watershed. The model was calibrated for the year 2000, which represented both high and low flow periods. For each water quality station, model results were plotted against the respective observed data to assess the model’s response to spatial variation of loading sources.

4.2 Receiving Water Models – EFDC and WASP

Section 4.1 presented the watershed model utilized to develop the time dependent overland flows and pollutant concentrations to be input to the receiving water models. The receiving water models take the pollutant loads from the watershed model (nonpoint source loads) along with available information on the point source loads to the system, and provide for the transport and transformation of the material as it moves through the system. In the case of nutrients and organic material, the models provide for the oxidation, nitrification, uptake through photosynthesis, and other processes, and simulates the instream dissolved oxygen concentrations. Additionally, the instream models provide for the balance in the water column between oxygen depletion due to the processes described above, sediment oxygen demand, and reaeration across the water surface. These processes act on the water as it moves through the system under the simulated flow and transport.

4.2.1 Hydrodynamic Model Selection, Set Up and Calibration (EFDC)

A hydrodynamic model was developed to simulate the flow, velocity and transport in the listed reaches. The EFDC model was applied with 61 grid cells, each with four vertical layers. Figure 4-2 presents the grid utilized for the instream modeling. The grid extents cover from immediately outside of the mouth of Dog River to Mobile Bay; upstream in the Dog River and Rabbit Creek to where the extent of salinity intrusion and tidal influence is negligible.

The Environmental Fluid Dynamics Code (EFDC) is a general purpose modeling package for simulating 1-D, 2-D, and 3-D flow and transport in surface water systems including: rivers, lakes, estuaries, reservoirs, wetlands and near shore to shelf scale coastal regions. The EFDC model was originally developed at the Virginia Institute of Marine Science for estuarine and coastal applications and is considered public domain software. The EFDC code has been extensively tested and documented.

Within the EFDC modeling package, solutions for flow and transport can be made on multiple scales i.e. 1-D or 2-D. These models solve the 1-D/2-D continuity, momentum, and transport equations. The models use the efficient numerical solution routines within the more general 2-D/3-D EFDC hydrodynamic model, as well as the transport and meteorological forcing functions. In addition, it allows for specification of time variable water surface elevation at the downstream boundary, i.e. allowing a time-dependent Mobile Bay water surface elevation as the downstream boundary. Specific details on the model equations, solution techniques and assumptions may be found in Hamrick (1996).

Inputs to the EFDC Dog River and Rabbit Creek hydrodynamic model include the following:

- Model grid and geometry
- Mobile Bay tidal water surface elevation (measured and hindcast)
- Flows at headwaters and distributed flows from the watershed model (LSPC)

The model grid was developed based upon the shorelines from USGS Topographic Maps, measured cross-sectional information from ADEM, bathymetry from NOAA, elevation data from the 30m resolution National Elevation Dataset (NED) from USGS, and stream connectivity from the National Hydrography Dataset stream coverage. Figure 4-2 presents the extents of the EFDC model grid. The grid covers all of the listed reaches along with those stream sections required to provide overall connectivity between the listed segments and tributary inputs. Figure 4-3 shows the bathymetry represented in the grid. The lower boundary of the model grid is at the mouth of Dog River at Mobile Bay and is controlled by the tidal surface boundary. Flow inputs to the system include 11 flows from the LSPC watershed model. Appendix 9.6 presents a discussion of the calibration of the hydrodynamic model for Dog River and Rabbit Creek. The appendix outlines all assumptions utilized in the model set up and calibration along with model inputs and critical parameters.

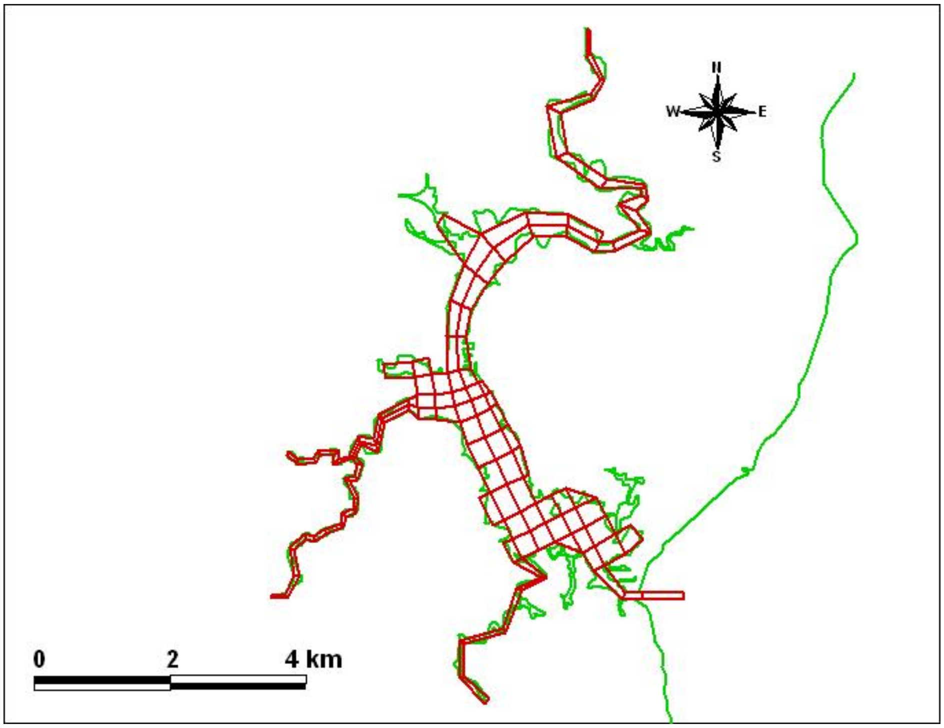

Figure 4-2 Extents of Instream Model Grid

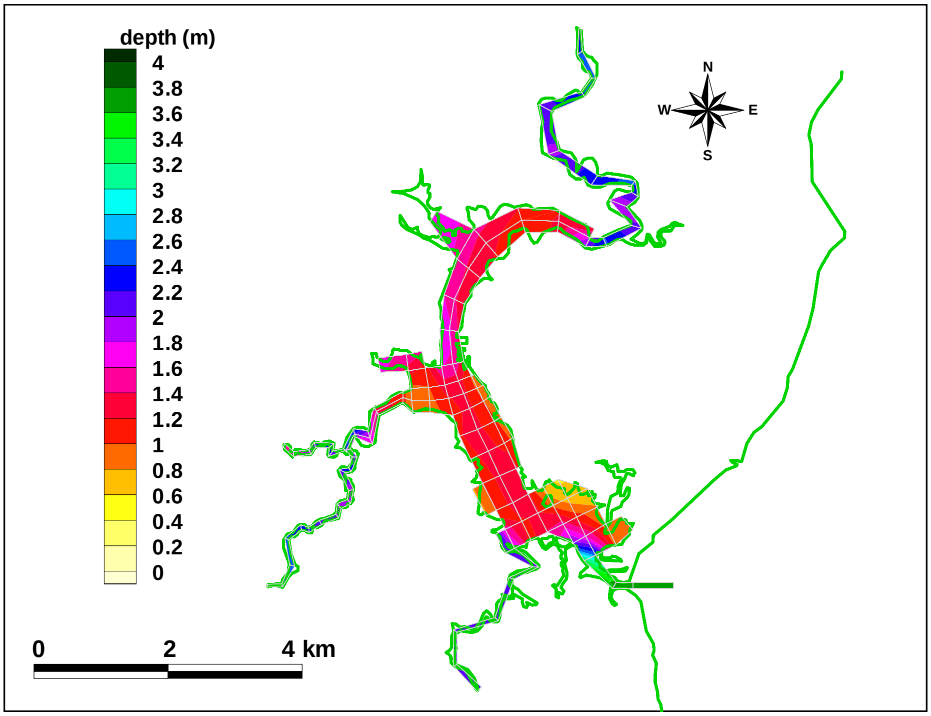

Figure 4-3 Bathymetry of the EFDC Model Grid (smoothed plot)

4.2.2 Water Quality Model Selection, Set Up and Calibration (WASP)

In order to simulate the temporal and spatial dissolved oxygen concentrations, a water quality model must be utilized which simulates the full eutrophication kinetics including phosphorus and nitrogen cycling, oxidation of organic material, sediment oxygen demand, and reaeration across the water surface. The WASP model was utilized with a four-layer grid identical to the EFDC grid, with the exception of one boundary cell at the inlet from Mobile Bay.

For simulation of the water quality within Dog River and Rabbit Creek, the EFDC model was externally linked to the Water Quality Analysis Simulation Program (WASP5) through a hydrodynamic forcing file that contains the flows, volumes, and exchange coefficients between adjacent cells. WASP5, an enhancement of the original WASP model (Di Toro et al., 1983; Connolly and Winfield, 1984; Ambrose, R.B. et al., 1988), a dynamic compartment model program for aquatic systems, including both the water column and the underlying benthos. The time varying processes of advection, dispersion, point and diffuse mass loading, and boundary exchange are represented in the basic program.

Water quality processes are represented in special kinetic subroutines that are either chosen from a library or written by the user. WASP is structured to permit easy substitution of kinetic subroutines into the overall package to form problem-specific models. WASP5 permits the modeler to structure one, two, and three-dimensional models; allows the specification of time-variable exchange coefficients, advective flows, waste loads and water quality boundary conditions; and permits tailored structuring of the kinetic processes, all within the larger modeling framework without having to write or rewrite large sections of computer code.

For the Dog River watershed simulations, the WASP model was run under full eutrophication kinetics with the following state variables simulated:

- Dissolved oxygen (DO)
- Ultimate Carbonaceous Biochemical Oxygen Demand (CBODU)
- Ammonia as Nitrogen (NH_3-N)
- Nitrate/Nitrite as N (NO_3-NO_2-N)
- Organic Nitrogen (ON)
- Phosphorus (TP)
- Ortho-Phosphorus (O-PO_4)
- Chlorophyll-a

In order to perform the full eutrophication simulations the following general input conditions were required.

- Boundary flows and concentrations for all 8 state variables where flow enters the model (see Appendix 9.6)
- Spatial distribution of Sediment Oxygen Demand
- Meteorological forcings
- Model input coefficients

Boundary flows and concentrations came from the LSPC simulations described in Section 4.1.1 and 4.1.2. As described in Section 3.4.5 sediment oxygen demand measurements were taken at various locations throughout the system. These values were utilized to develop the sediment oxygen demand throughout the system with average values used in the model.

Meteorological data used in the WASP model came from the Mobile Regional Airport weather station data described in Section 3.4.3. For the WASP model, hourly weather data is utilized for the inputs.

The WASP model input coefficients reflect the best available literature values, and where available (i.e. CBOD decay rate) site-specific values are utilized. The best fit between the WASP model simulations and the measured data is obtained by variation of critical parameters within the range of acceptable literature values. Where site specific measured values are used, no adjustment of those coefficients is made.

Appendix 9.6 presents a discussion of the calibration of the water quality model for Dog River and Rabbit Creek. The appendix outlines all assumptions utilized in the model set up and calibration along with model inputs and critical parameters.

4.3 Critical Conditions

Data analysis shows that the critical condition is the summer low flow periods. The dissolved oxygen conditions within the Dog River and Rabbit Creek watersheds correspond to summer periods of low flow, high temperature and salinity-induced density stratification. For the purpose of these TMDLs a low flow year with high temperatures was utilized for the purpose of determining the TMDLs to represent the worst-case conditions. The simulations were performed with time-dependent daily fluctuations of the Mobile Bay tidal boundary of water surface elevation, simulated inflows from the LSPC model with simulated concentrations of the eight state variables, measured meteorological conditions, and measured sediment oxygen demand. For the purposes of these TMDLs the 2000-year was utilized as the critical low flow period. 2000 was a relatively dry year and was one of the time periods over which the models were calibrated, lending confidence to the simulations.

4.4 Margin of Safety (MOS)

There are two methods for incorporating a MOS in the analysis: a) by implicitly incorporating the MOS using conservative model assumptions to develop allocations; or b) by explicitly specifying a portion of the TMDLs as the MOS and using the remainder for allocations. An implicit MOS was incorporated in these TMDLs. These TMDLs used the worst-case conditions of low flow year with high temperatures. Also this implicit MOS included conservative modeling assumptions and a continuous simulation that incorporates a range of meteorological events. Conservative modeling assumptions used include: septic systems discharging directly into the streams, conservative estimates of in-stream decay, and all land areas considered to be connected directly to streams. Organic material loss on the land surface is not computed in the model. Therefore, the loads delivered to the model do not account for decay and are conservative.

4.5 Seasonal Variation

Seasonal variation is considered in the development of the TMDLs because the allocation runs are performed over an entire calendar year. The model simulates the response of the dissolved oxygen under various hydrologic, meteorological and loading conditions, thus fully evaluating the potential seasonal variations. The modeling included daily meteorological data in the hydrology model. The watershed hydrology model simulated a five year period based on the USGS gage data and the receiving water model was setup for the intensive EPA dataset from July through October 2001.

For these TMDLs, the wet weather allocations were a complete removal of sanitary sewer overflows since they are not permitted to discharge into the impaired segments. The illicit discharges are not seasonally based and are also not permitted to discharge. The failing septic systems and leaking sewer lines occur all year but are more evident in the low-flow time periods as shown on the loading curves.

5.0 TMDL Development

This section presents the TMDLs developed for organic enrichment and dissolved oxygen for the Dog River watershed, including Rabbit Creek. The TMDLs are presented as annual average lbs. per year of CBOD and NBOD. Model output for 2000 was used to determine the TMDLs and allocation scenarios because the modeled water quality during 2000 represented critical conditions during the modeling period. The year 2000 was chosen to determine TMDLs and allocation scenarios because it was representative of typical weather conditions, but still contained significant low-flow periods.

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality criteria, in this case Alabama's water quality criteria for aquatic life. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are comprised of the sum of individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly of explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the equation:

$$\text{TMDL} = \text{WLAs} + \text{LAs} + \text{MOS}$$

In order to develop the TMDL presented herein, the following approach was taken:

- Define TMDL endpoints
- Simulate baseline conditions
- Determine the TMDL and source allocations

5.1 TMDL Endpoints

TMDL endpoints represent the instream water quality targets used in quantifying TMDLs and their individual components. The spatially and temporally varying instream dissolved oxygen concentration was selected as the TMDL endpoint for the organic enrichment and dissolved oxygen TMDLs within the Dog River watershed. For the critical summer period when extreme low flow conditions occur, a 4.0 mg/L target was considered in the portions of the listed reaches classified as Fish and Wildlife and Swimming.

5.2 Baseline Conditions

The calibrated model provided the basis for performing the allocation analysis. The first step in the analysis involved simulation of baseline conditions. Baseline conditions represent existing nonpoint source loading conditions and permitted point source discharge conditions. The existing load for the listed segments is represented as the sum of the daily discharge load of the direct nonpoint sources, the point sources loads, and the daily load indirectly going to surface waters from all land uses (e.g., surface runoff) for 2000. Table 5-1 presents the baseline loading conditions for the 2000 and 2001 water years. For the purposes of establishing an annual baseline loading condition upon which the TMDL percent reductions will be determined, the year 2001 was utilized. The buildup of organic material and the resulting increase in sediment oxygen demand will be the ultimate loading target for this TMDL. Therefore it is not reasonable to utilize the dry year loads as the baseline conditions upon which to establish the TMDL. 2001, which represents a wet condition with an approximately 50 percent increase in loads over the dry year (2000), was used as the baseline.

Constituent	**Year**	Perch Cr.	Alligator Bayou	adjacent Dog R.	adjacent Dog R.	Halls Mill Cr.	**Rabbit Cr.**	Rattlesnake Bayou	Moore Creek	adjacent Dog R.	Eslava Creek	Robinson Bayou	**TOTAL DOG R.**
BOD5	**2000**	3672	4167	246	650	30332	**12313**	5287	30334	2373	34453	3447	**127275**
	2001	7823	6316	520	1131	56372	**22890**	9287	49630	4314	55373	5851	**219507**
TN	**2000**	1715	1488	128	326	12913	**4714**	1978	12102	1200	13554	1271	**51390**
	2001	3863	2606	292	674	27626	**9886**	3853	22815	2555	24850	2436	**101457**
TP	**2000**	107	144	6	19	939	**363**	151	1005	65	1130	93	**4022**
	2001	257	243	14	44	1966	**728**	271	1689	158	1832	155	**7357**

Table 5-1 Baseline Watershed Loading Conditions in kg/yr

For the instream hydrodynamic and water quality model, the baseline conditions were run from January 1, 2000, through December 31, 2001. During this period the data from the entire model were analyzed to determine the spatial distribution of dissolved oxygen minimums at the compliance point (5 feet for waters deeper than 10 feet and mid-depth for all other waters). Figure 5-1 presents contours of the model predicted minimum values. This became the baseline upon which reductions in the spatial distribution of Sediment Oxygen Demand were performed to achieve the water quality target of 4.0 mg/L.

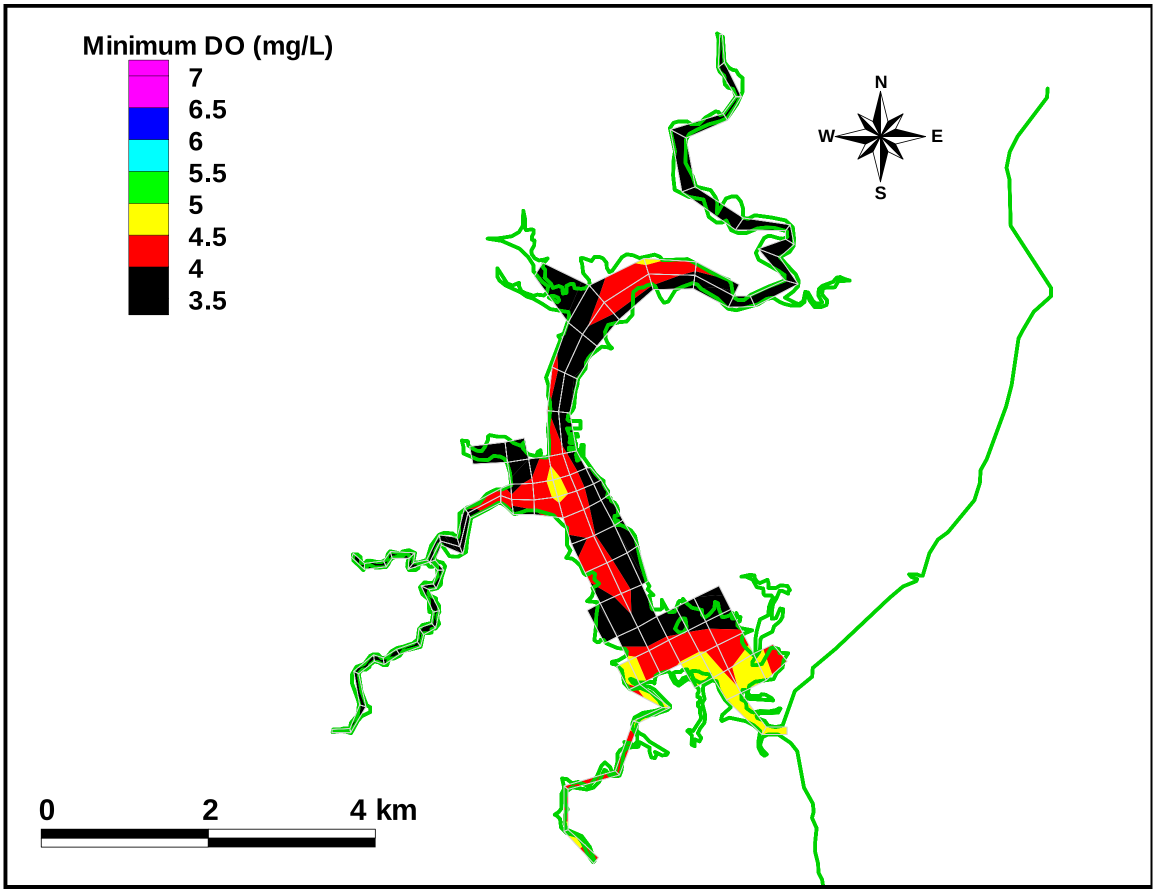

Figure 5-1 Spatial Distribution of Dissolved Oxygen Minimums at the Compliance Depth for the Year 2000 Simulations

5.3 TMDLs and Source Allocations

During critical low flow periods no direct association between nonpoint source loads and instream pollutant concentrations can be made. In general nonpoint source impacts are associated with prior deposition of organic material washed into the system during winter storm periods. This excess organic material then creates increased sediment oxygen demand during critical low flow periods. Allocation to the nonpoint sources therefore requires development of links between the nonpoint source loads and the level of sediment oxygen demand within the system. Under load allocations the sediment oxygen demand is reduced in order to meet water quality standards and then the associated nonpoint load reductions are determined based upon the SOD/load relations.

The reductions of the SOD values throughout the system to meet water quality targets were adjusted spatially, with no change made within the area adjacent to the entrance of Dog River to Mobile Bay. In this region the low dissolved oxygen values are primarily due to inflow from Mobile Bay. Adjustments within Rabbit Creek and the upper Dog River were performed until water quality standards were met. The total pre-adjusted SOD demand was determined within Rabbit Creek and Dog River and compared with the adjusted demand. The demand was determined by multiplying the SOD rate by the total area over which it’s demand is exerted. The pre- versus post- values then define the percent reduction in total SOD load to be made within each of the listed segments.

A simplified model of sediment oxygen demand that relates the SOD to the flux of nitrogenous and carbonaceous components has been proposed (DiToro, 2001). It states:

A model of sediment oxygen demand can be constructed that ultimately dispenses with the apparent complexity by relating sediment oxygen demand to the flux of the oxygen equivalents of all reduced substances in the interstitial water without specific regard to their identity.

Under conditions of equilibrium therefore the net reduction in SOD required to achieve water quality standards can be directly related to a proportional reduction in the settling flux of organic matter loadings. This percent reduction therefore is independent of the partition of the particulate and dissolved matters assuming this ratio remains relatively constant year to year. The net load reduction can then be directly related to the net reduction in overall SOD demand.

Segment	Baseline SOD Demand (kg/year)	Reduced SOD Demand (kg/year)	Percent Reduction	Baseline CBODU Load (kg/year)	Reduced CBODU Load (kg/year)	Baseline NBODU Load (kg/year)	Reduced NBODU Load (kg/year)
Rabbit Creek	180020	18002	90%	57226	5723	9886	989
Dog River	4000200	1000050	75%	548768	137192	426565	106641

Table 5-2 SOD Equivalent Loads and Associated Watershed Loads

5.4 Wasteload Allocations

Within the Dog River Watershed no permitted direct discharges of significant oxygen consuming wastes exist, therefore the wasteload allocation to this system is set at zero. Sanitary sewer collection systems delivering waste to permitted facilities are required to eliminate unpermitted discharges.

The Mobile area MS4 stormwater permit, effective October of 2001, was established to regulate discharges from municipal stormwater systems. Presently we do not know the extent of the contribution from the MS4 system for the Mobile area, the loads associated with the municipal stormwater discharges are considered equal to the load allocation discussed below.

5.5 Load Allocations

Significant nonpoint source loads of organic material and nutrients within the Dog River watershed are associated with washoff from urban, residential, and forested lands. Loads associated with direct discharge from failing septic systems are also considered in the load allocation presented below.

5.6 TMDL Results

Table 5-2 presents the pre- and post-reduction total SOD demand and the associated percent reductions in loads required for each of Rabbit Creek and Dog River. The total loads to Dog River also reflect the cumulative reductions established first within Rabbit Creek, and the percent reductions are adjusted accordingly.

6.0 TMDL Implementation

6.1 Non-Point Source Approach

The Dog River watershed is impaired by both nonpoint sources and sanitary sewer overflows. 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 State and local governments will take the primary lead in the TMDL implementation. Options include the following. 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, 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 Education Source for Municipal Officials (NEMO) outreach program. Memorandums of Agreement (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 these TMDLs. 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

Point source reductions to meet the TMDLs for the Dog River watershed should begin with full compliance with the MAWSS Consent Decree to reduce SSOs (Consent Decree 2002). In the first quarter of 2002, MAWSS began development of programs outlined in the Consent Decree (MAWSS 2002). These programs require MAWSS to identify and repair leaky sewer connections, provide service to low-income areas, and perform water quality monitoring.

MAWSS has proposed methods to determine wastewater collection and transmission capacity. Plans are being developed to convey flows from the Ziebach Wastewater Collection System and future customers in the Dog River watershed to the Williams WWTP. These plans include modifications to the Perch Creek Pump Station, a new force and lift station to take the Ziebach Wastewater Treatment Plant out of service.

A hydraulic model of the sewer basins served by MAWSS is being developed to determine the capacity of collection systems and what is require for future growth. New development may be limited until capacity assessments have been finalized for wastewater collection and treatment systems.

Preventative maintenance and rehabilitation to collection systems to decrease the occurrence of SSOs is already underway. Sewer lines are cleaned after overflows and the cause for failure is noted. A public service announcement to educate the public on proper grease disposal has aired on television. Force mains are to be simulated to predict the locations of air pockets. Levels of hydrogen sulfide are being measured at lift stations and manholes as a part of the Corrosion Control Program. The equipment on pump stations is also being inspected for preventative maintenance.

MAWSS has contracted with TAI Environmental Services to implement a water quality assessment program. This program includes routine monitoring of Halls Mill Creek and Eslava Creek in the Dog River Watershed. Monitoring will also be performed to determine unknown sources of pollution and the impact of unpermitted discharges to receiving waters.

A long-term plan is being developed for a regional WWTP to provide service for the Cities of Mobile, Prichard, Chickasaw, and Saraland. The goal of this plan is to reduce the number of discharges and provide for growth over the next 50 years.

Final compliance of the Consent Decree, Civil Action 02-0058-CB-S, is September 2007 (Consent Decree 2002). Implementation of programs outlined in the Consent Decree should decrease oxygen-consuming waste loads in the Dog River watershed.

6.3 MS4 Considerations

A large area in Mobile and Baldwin Counties has been issued an MS4 Phase I Stormwater permit (NPDES ALS000002). According to NPDES Permit No. ALS000002, the Mobile Area MS4 permit area is defined below.

"This permit covers all areas within the corporate boundaries of Mobile and Baldwin Counties that were designated by the Department [ADEM] and all municipalities named as permittees. The designated area in Mobile and Baldwin Counties are as follows:

The portion of Mobile County designated as part of the Greater Mobile Area Storm Sewer System consists of all unincorporated areas of Mobile County within the boundaries defined as: beginning as the mouth of the south fork Deer River and extending west to southwest corner of Section 18, Township 6 South, Range 2 West, then north to northwest corner, Section 6, Township 2 South, Range 2 West, then east to the Mobile County line, then south along county line to U.S. Highway 90 bridge."

In the MS4 service area, pollutant loads which could include urban runoff and/or failing septic systems are considered in the Load Allocations. Unregulated sources such as illicit discharges and sanitary sewer overflows have a 100% reduction and are not considered part of the Wasteload Allocations or Load Allocations.

6.4 T&E Documented Species

The United States Fish and Wildlife Service have documented the endangered Florida manatee (*Trichechus manatus latirostris*) and the endangered Alabama redbelly turtle (*Pseudemys alabamensis*) in Dog River. Also, the threatened Gulf sturgeon (*Acipenser oxyrinchus desotoi*) may occur in Dog River. The TMDLs proposed for Dog River are organic enrichment and low dissolved oxygen in this document and pathogens in a separate document. The manatee and turtle are air-breathing vegetarians, so it is doubtful that they would be directly affected by organic enrichment or low dissolved oxygen. However, pathogens may affect these species, particularly if their immune systems are compromised or they are injured. The Gulf sturgeon is a bottom dwelling species that is probably used to some degree of low dissolved oxygen. It may also be affected by pathogens in certain circumstances. The Alabama redbelly turtle has been found at the mouth of Rabbit Creek. The Florida manatee and the Gulf sturgeon may occur in Rabbit Creek.

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 schedule in Table 7-1. The Dog River watershed is located in the Mobile Basin.

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

Table 7-1 Monitoring Schedule for Alabama River Basins

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

8.0 Public Participation

As part of the public participation process, a public notice/review period was provided for the subject TMDLs. Any additional information supporting the TMDLs was made available to the public upon request. The public was invited to provide comments on the draft TMDL. Based on public comments received during the public notice period, appropriate revisions were made and the TMDLs were finalized March 2005.

9.0 Appendices

9.1 References

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9.2 Water Quality Sampling Stations

Year	Station	Stream Section	Road Crossing	Latitude	Longitude	Duplicity
Long Term Monitoring (1978-1999 & 2001)	DR-001	Dog River	Luscher Park	30.62861	-88.1014	
1993	HMC-93	Halls Mill	near Point Rd.	30.59683	-88.12693	
1993	EC1-93	Eslava Creek	Holcombe Ave	30.66378	-88.09272	
1993	EC2-93	Eslava Creek	I-10	30.63595	-88.09579	
1993	RB1-93	Robinson Bayou	near Pickell Dr.	30.61016	-88.08289	
1993	MC1-93	Moore Creek	Lipscombs Landing	30.61778	-88.12538	
1993	MC2-93	Moore Creek	Linksman Golf Course	30.61243	-88.11598	
1993	HMC1-93	Halls Mill	500 meters Upstream of Dog River	30.59415	-88.12526	
1993	HMC2-93	Halls Mill	I-10	30.60508	-88.14938	
1993	RC1-93	Rabbit Creek	Upstream Rangeline Rd.	30.57143	-88.13852	
1993	RC2-93	Rabbit Creek	200 meters Upstream of Dog River	30.5892	-88.12333	
1993	RSB-93	Rattlesnake Bayou	Upstream Rangeline Rd.	30.58382	-88.14403	
1993	ECSA-93	Eslava Creek	Sage Ave	30.67371	-88.1145	
1993	ECPH-93	Eslava Creek	Pinehill Drive	30.67	-88.09698	
1993	ECMV-93	Eslava Creek	McVay Drive	30.64367	-88.09682	same as 6005004
1993	BBHM-93	Bolton Branch	Halls Mill Rd.	30.6514	-88.10622	
1993	BBN-93	Bolton Branch	Navco Rd.	30.64486	-88.10264	same as 6005018
1993	BBMV-93	Bolton Branch	McVay Drive	30.64572	-88.10295	
1993	BBT1-93	Bolton Branch	Halls Mill Rd.	30.64529	-88.1122	
1993	HMD-93	Halls Mill	Demotropolis Rd	30.60606	-88.15687	same as 6005010
1993	HMHM-93	Halls Mill	Halls Mill Rd.	30.60683	-88.16015	same as 6005009
1993	MCPV-93	Montlimar Creek	Pleasant Valley Rd.	30.6614	-88.13153	
1993	MCHM-93	Moore Creek	Halls Mill Rd.	30.62674	-88.13611	
1993	MCLL-93	Moore Creek	Lloyd's Landing	30.61952	-88.1277	
1999	6005004	Eslava Creek	McVay Drive	30.643717	-88.096817	same as ECMV-93
1999	6005010	Halls Mill	Demotropolis Rd	30.606017	-88.15705	same as HMD-93
1999	6005009	Halls Mill	Halls Mill Rd.	30.607133	-88.16005	same as HMHM-93
1999	6005003	Montlimar Creek	Azalea Rd.	30.628433	-88.135233	
1999	6005002	Moore Creek	Halls Mill Rd.	30.627367	-88.136967	
1999	6005001	Spring Creek	Halls Mill Rd.	30.613133	-88.15435	

Table 9.2 (continued)

Year	Station	Stream Section	Road Crossing	Latitude	Longitude	Duplicity
2000	ALBA	Dog River	ALBA Club	30.586666	-88.106667	
2000	6005018	Bolton Branch	Navco Rd.	30.64568	-88.10298	
2000	6005020	Dog River	near Timberlane Rd.	30.5687	-88.0976	
2000	6005004	Eslava Creek	McVay Drive	30.643717	-88.096817	same as ECMV-93
2000	6005010	Halls Mill	Demotropolis Rd	30.606017	-88.15705	same as HMD-93
2000	6005009	Halls Mill	Halls Mill Rd.	30.607133	-88.16005	same as HMHM-93
2000	6005003	Montlimar Creek	Azalea Rd.	30.628433	-88.135233	
2000	6005002	Moore Creek	Halls Mill Rd.	30.627367	-88.136967	
2000	6005029	Perch Creek	McNalley Park	30.582467	-88.077033	
2000	6005017	Rabbit Creek	Carol Plantation Rd.	30.55877	-88.181	same as RBTM-003
2000	6005001	Spring Creek	Halls Mill Rd.	30.613133	-88.15435	
2000	6005011	Halls Mill	Cypress Shores	30.6031	-88.131983	
2000	6005027	Dog River	Marcia Dr.	30.6025	-88.113116	
2000	DR	Dog River	Mid-Channel	30.57	-88.095	
2000	DR1	Dog River	Upstream of Hwy 163	30.566	-88.09	
2001	DR	Dog River	Mid-Channel	30.57	-88.095	
2001	DR1	Dog River	Upstream of Hwy 163	30.566	-88.09	
2001	RBTM-001	Rabbit Creek	Al Hwy 193	30.573	-88.1348	
2001	RBTM-001A	Rabbit Creek	Hwy 90	30.559066	-88.1729666	
2001	RBTM-002	Rabbit Creek	Todd Acres Rd.	30.56156	-88.1607	
2001	RBTM-003	Rabbit Creek	Carol Plantation Rd.	30.55877	-88.181	same as 6005017
2001	RBTM-004	Rabbit Creek	Old Pascagoula Rd.	30.57326	-88.1933	
2001	ALBA	Dog River	ALBA Club	30.586666	-88.106667	
2001	DGRM-1	Dog River	Al Hwy 163	30.56493	-8808765	
2001	DGRM-2	Dog River	near Riverside Dr.	30.61175	-88.08965	
2001	6005018	Bolton Branch	Navco Rd.	30.64568	-88.10298	
2001	6005020	Dog River	near Timberlane Rd.	30.5687	-88.0976	
2001	6005004	Eslava Creek	McVay Drive	30.643717	-88.096817	same as ECMV-93
2001	6005010	Halls Mill	Demotropolis Rd	30.606017	-88.15705	same as HMD-93
2001	6005009	Halls Mill	Halls Mill Rd.	30.607133	-88.16005	same as HMHM-93
2001	6005030	Milkhouse Creek	Cottage Hill	30.639967	-88.200867	
2001	6005003	Montlimar Creek	Azalea Rd.	30.628433	-88.135233	
2001	6005002	Moore Creek	Halls Mill Rd.	30.627367	-88.136967	
2001	6005029	Perch Creek	McNalley Park	30.582467	-88.077033	
2001	6005017	Rabbit Creek	Carol Plantation Rd.	30.55877	-88.181	same as RBTM-003
2001	6005001	Spring Creek	Halls Mill Rd.	30.613133	-88.15435	
2001	6005027	Dog River	Marcia Dr.	30.6025	-88.113116	

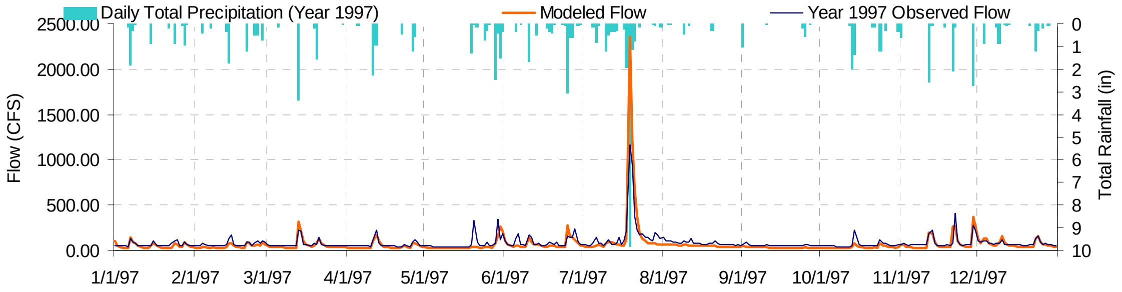
Table 9.2 (continued)

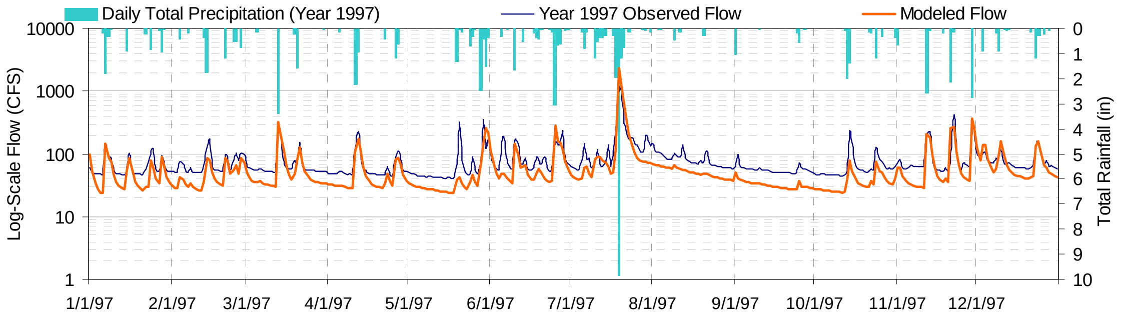
Year	Station	Stream Section	Road Crossing	Latitude	Longitude	Duplicity
2002	ALBA	Dog River	ALBA Club	30.586666	-88.106667	
2002	6005018	Bolton Branch	Navco Rd.	30.64568	-88.10298	
2002	6005004	Eslava Creek	McVay Drive	30.643717	-88.096817	same as ECMV-93
2002	6005030	Milkhouse Creek	Cottage Hill	30.639967	-88.200867	
2002	6005003	Montlimar Creek	Azalea Rd.	30.628433	-88.135233	
2002	6005002	Moore Creek	Halls Mill Rd.	30.627367	-88.136967	
2002	6005029	Perch Creek	McNalley Park	30.582467	-88.077033	
2002	6005017	Rabbit Creek	Carol Plantation Rd.	30.55877	-88.181	same as RBTM-003
2002	6005001	Spring Creek	Halls Mill Rd.	30.613133	-88.15435	
2002	6005027	Dog River	Marcia Dr.	30.6025	-88.113116	

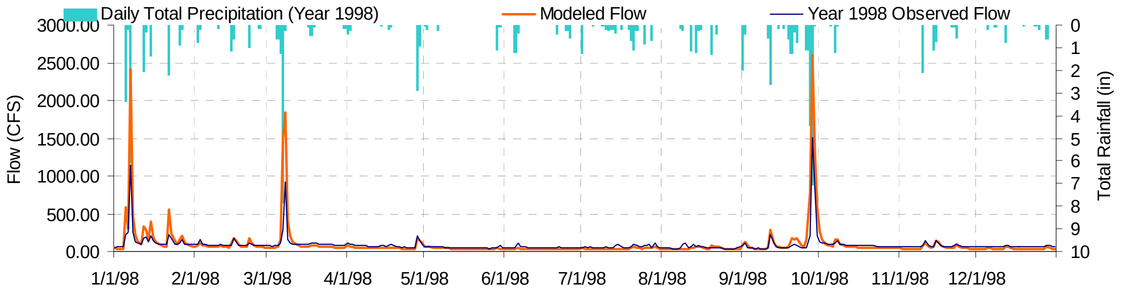
9.3 Measured Water Quality Data at ALBA Beach Club

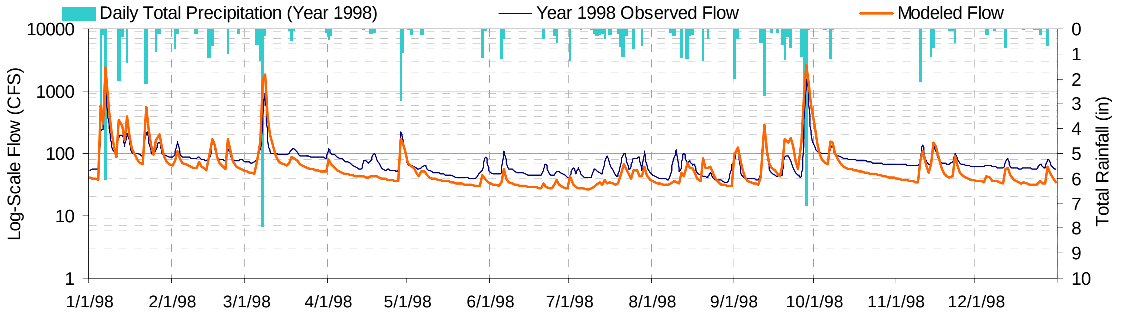
Date	DO	Temp	Salinity
7/26/2000 0:00	6.1	27.2	1.9
8/10/2000 0:00	10.6	32.6	10.9
8/17/2000 0:00	7.2	32.0	13.0
8/24/2000 0:00	7.5	30.4	13.5
8/31/2000 0:00	7.5	31.6	13.8
9/7/2000 0:00	8.9	27.0	10.4
9/14/2000 0:00	9.0	30.0	10.3
9/21/2000 0:00	8.2	30.1	12.3
9/28/2000 0:00	ND	ND	15.2
10/4/2000 0:00	8.0	28.5	14.1
11/7/2000 0:00	ND	23.8	15.6
11/8/2000 0:00	ND	ND	18.3
11/13/2000 0:00	ND	ND	0.0
11/16/2000 0:00	ND	ND	15.8
12/5/2000 0:00	11.7	10.9	9.3
1/9/2001 0:00	14.2	10.5	8.7
2/5/2001 0:00	12.5	11.3	4.1
3/13/2001 0:00	8.7	19.0	0.3
3/15/2001 0:00	ND	ND	0.3
4/4/2001 0:00	ND	22.0	2.0
5/2/2001 0:00	9.9	25.0	3.4
5/10/2001 0:00	9.9	26.1	4.4
5/17/2001 0:00	8.6	28.4	4.0
5/23/2001 0:00	7.6	26.2	7.0
5/31/2001 0:00	8.3	28.8	5.0
6/7/2001 0:00	8.3	28.7	5.3
6/14/2001 0:00	9.5	28.7	0.7
6/20/2001 0:00	9.4	30.7	1.2
6/27/2001 0:00	7.1	28.2	2.3
7/5/2001 0:00	7.8	28.9	4.7
7/11/2001 0:00	5.7	29.9	3.8
7/18/2001 0:00	8.6	32.1	5.0
7/25/2001 0:00	6.9	29.2	4.2
7/27/2001 0:00	5.5	25.7	0.3
7/30/2001 0:00	6.7	29.7	2.9
8/1/2001 0:00	5.1	30.2	6.3
8/8/2001 0:00	6.4	29.6	3.6
8/15/2001 0:00	9.2	30.8	2.2
8/22/2001 0:00	8.3	30.3	3.6
8/29/2001 0:00	9.9	30.0	5.2
9/6/2001 0:00	10.1	31.1	4.1
9/12/2001 0:00	8.2	30.1	3.4
9/19/2001 0:00	7.3	26.8	3.7
9/24/2001 0:00	6.3	27.9	5.5
10/1/2001 0:00	8.8	21.9	8.7
11/5/2001 0:00	9.1	20.1	7.1
12/10/2001 0:00	8.1	17.5	5.7
1/7/2002 0:00	12.3	7.0	3.2
1/9/2002 0:00	10.4	7.4	2.1
1/10/2002 0:00	ND	ND	ND
2/4/2002 0:00	11.4	14.4	2.3
3/18/2002 0:00	9.0	22.0	3.6
4/1/2002 0:00	7.4	20.4	2.5
4/2/2002 0:00	8.6	22.3	2.7

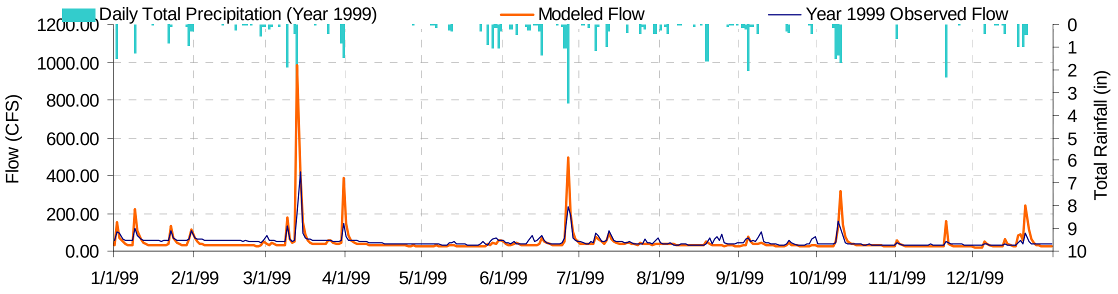
9.4 LSPC Watershed Model Calibration







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Year 1999 Observed Flow
Flow (CFS)
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1000.00
800.00
600.00
400.00
200.00
0.00
Total Rainfall (in)
0
1
2
3
4
5
6
7
8
9
10
1/1/99
2/1/99
3/1/99
4/1/99
5/1/99
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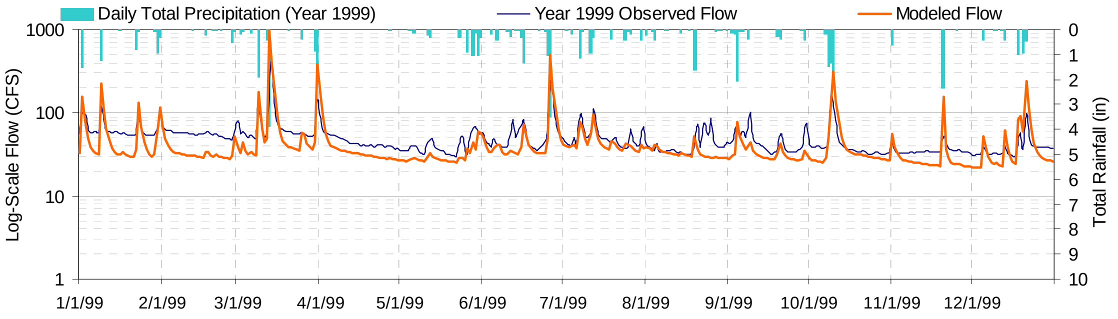
12/1/99


Daily Total Precipitation (Year 1999)
Year 1999 Observed Flow
Modeled Flow
Log-Scale Flow (CFS)
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100
10
1
Total Rainfall (in)
0
1
2
3
4
5
6
7
8
9
10
1/1/99
2/1/99
3/1/99
4/1/99
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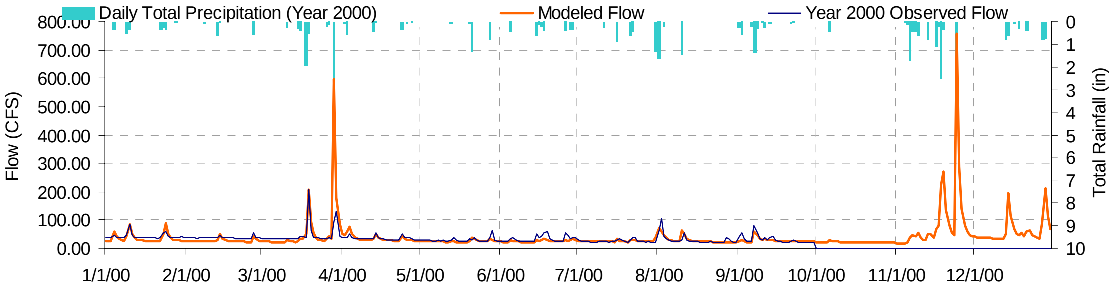
Daily Total Precipitation (Year 2000)
Modeled Flow
Year 2000 Observed Flow
Flow (CFS)
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
Total Rainfall (in)
0
1
2
3
4
5
6
7
8
9
10
1/1/00
2/1/00
3/1/00
4/1/00
5/1/00
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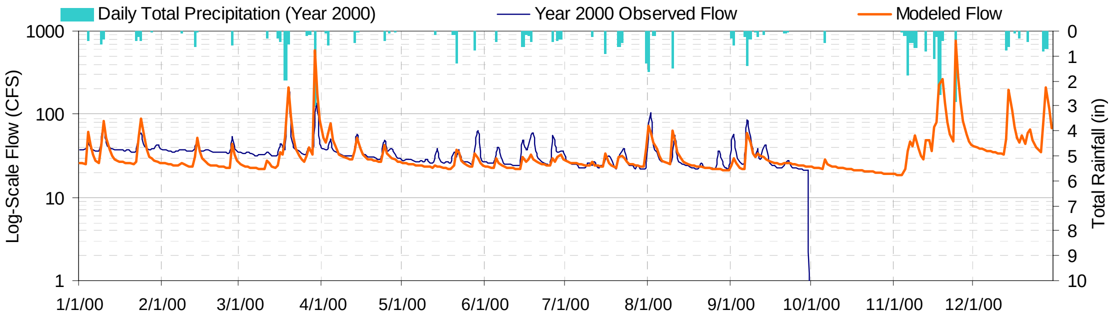
12/1/00


Daily Total Precipitation (Year 2000)
Year 2000 Observed Flow
Modeled Flow
Log-Scale Flow (CFS)
1000
100
10
1
Total Rainfall (in)
0
1
2
3
4
5
6
7
8
9
10
1/1/00
2/1/00
3/1/00
4/1/00
5/1/00
6/1/00
7/1/00
8/1/00
9/1/00
10/1/00
11/1/00
12/1/00

9.5 *Sanitary Sewer Overflows*

Table 9.3 1997 – April 2002 Sanitary Sewer Overflows Reported to MAWSS

Date of Spill	Reported Cause*	Duration*	Estimated Reported Volume (gallons)	Location	Reported Stream Impacted*
4/2/97			12750	Crenshaw Street--500 block	Bolton Branch
6/16/98			5200	833 Southern Oaks Apartments	Bolton Branch
2/16/99			5000	Emelda Drive 903	Bolton Branch
3/13/97			5600	1450 Avon Circle (manhole behind this address)	Dog River
3/13/97			5600	Englewood Street and Linwood Drive West	Dog River
3/13/97			5600	Englewood Lift Station (manhole outside)	Dog River
3/13/97			5600	1459 Linwood Drive West (manhole behind)	Dog River
3/21/97			10500	Scenic Drive Lift Station	Dog River
4/14/97			9600	Riviere du Chien Lift Station #74	Dog River
7/19/97			18720	2456 Venetia Road	Dog River
7/20/97			5600	Englewood Lift Station (manhole outside station	Dog River
7/20/97			5600	Englewood Street and Linwood Drive West	Dog River
7/20/97			5600	1450 Avon Circle (manhole in rear)	Dog River
10/7/97			15000	Columbus Avenue Lift Station	Dog River
1/7/98			16600	1350 Gulffield Drive East	Dog River
1/7/98			16600	1710 Gulffield Drive North	Dog River
1/7/98			16600	1301 Gulffield Drive East	Dog River
1/7/98			16600	1702 Gulffield Drive West	Dog River
1/26/98			12500	Park at Gimon Circle	Dog River
5/27/98			8000	3011 McGough	Dog River
5/30/98			12000	3007 McGough Drive	Dog River
7/26/98			8400	Scenic Drive L/S #48	Dog River
9/16/98			42500	Days Inn (DIP) L/S #79	Dog River
9/16/98			37500	Dauphin Island Pkwy 1705 & Gone with the Wind	Dog River
12/9/98			9000	Days Inn DIP #79	Dog River
12/29/98			15000	Days Inn DIP #79	Dog River
12/7/99			6000	Kent Road 3608	Dog River
1/7/98			12500	Homewood Street and Westwood Street	Eslava Creek
1/7/98			12500	Poydras Avenue and Ralston Road	Eslava Creek

Table 9.3 (continued)

Date of Spill	Reported Cause*	Duration*	Estimated Reported Volume (gallons)	Location	Reported Stream Impacted*
1/7/98			19750	224 Westwood at Creek	Eslava Creek
1/7/98			12500	Elizabeth and Mohawk	Eslava Creek
1/7/98			12500	Homewood & Mohawk	Eslava Creek
1/7/98			12500	Briley Street and West Collins	Eslava Creek
1/7/98			12500	Esplanade and Ralston Road	Eslava Creek
1/26/98			12500	225 Crenshaw Street	Eslava Creek
1/26/98			12500	Conti and Demouy (in intersection)	Eslava Creek
2/9/98			6000	1209 Buena Drive	Eslava Creek
9/13/98			7750	1005 Woodlawn Drive West	Eslava Creek
10/7/98			9000	119 Esplanade Avenue	Eslava Creek
12/7/98			9000	Ralston Road Lift Station	Eslava Creek
3/13/99			5000	Gulf Field Dr 1710	Eslava Creek
5/30/97			9600	3723 Riviere du Chien Rd.	Halls Mill Creek
1/21/98			15000	Yorkwood Drive at Spring Creek	Halls Mill Creek
9/23/98			6000	Wiley Orr Road	Halls Mill Creek
2/23/99			10500	I-10 West Inn Road	Halls Mill Creek
3/9/99			10000	Wiley Orr Road	Halls Mill Creek
3/20/99			15500	Coronado Ct 2800	Halls Mill Creek
6/3/99			6000	Wall Street (1st manhole south of The Timbers)	Halls Mill Creek
7/8/99			700000	Highway 90 5101	Halls Mill Creek
7/8/99			700000	Halls Mill Road 5118	Halls Mill Creek
7/8/99			700000	Halls Mill Lift Station	Halls Mill Creek
11/6/99			9000	Azalea Road 1374	Halls Mill Creek
1/23/99			5150	Airport Blvd 6801 (Providence Hospital)	Milkhouse Branch
1/24/99			26000	Airport Blvd 6801 (Providence Hospital	Milkhouse Branch
1/27/99			30000	Airport Blvd 6801 (Providence Hospital)	Milkhouse Branch
2/2/99			250000	Airport Blvd 6801 (behind Providence Hospital)	Milkhouse Branch
10/9/97			36000	Cottage Hill Road--200 ft west of Blue Ridge Bl	Milkhouse Creek
10/13/97			11000	Cottage Hill Road--200 ft. west of Blue Ridge B	Milkhouse Creek

Table 9.3 (continued)

Date of Spill	Reported Cause*	Duration*	Estimated Reported Volume (gallons)	Location	Reported Stream Impacted*
2/7/98			6250	6605 Sugar Creek Drive South	Milkhouse Creek
2/9/98			7500	6724 Candle Light Court	Milkhouse Creek
2/12/98			10125	Schillinger Road	Milkhouse Creek
3/3/98			7350	6420 Wall Street	Milkhouse Creek
6/14/98			25500	6100 Pine Needle Drive South	Milkhouse Creek
8/20/98			7500	Wall Street	Milkhouse Creek
8/28/98			6500	Wall Street	Milkhouse Creek
2/1/99			12600	Wall Street	Milkhouse Creek
4/19/99			49500	Wall Street	Milkhouse Creek
3/14/97			19500	Brookley/Golf Lane Lift Station	Mobile Bay
5/29/97			7000	Golf Lane Lift Station	Mobile Bay
1/19/98			12600	Cheshire Drive L/S #35	Montlimar Creek
3/18/98			15000	Behind Davidson High in creek- Pleasant Valley R	Montlimar Creek
4/24/98			6000	230 Redwood Place	Montlimar Creek
4/26/98			9000	Redwood Place Building	Montlimar Creek
9/18/98			9375	Pep Boys (Montlimar Drive)	Montlimar Creek
10/7/98			28500	Wal-Mart at Festival Center	Montlimar Creek
10/13/98			6000	50 Beltline Highway South	Montlimar Creek
11/25/98			5250	3600 Michael Boulevard	Montlimar Creek
1/15/99			6000	Highway 90 W 3941	Montlimar Creek
10/13/99			9000	Claridge Road East 107	Montlimar Creek
6/27/98			180000	974 Highpoint Drive West	Moore Creek
6/3/97			200000	Coca Cola Lift Station	Rabbit Creek
10/5/97			9498	Hamilton Boulevard Lift Station	Rabbit Creek
11/11/97			6930	Woodchase Lift Station	Rabbit Creek
3/10/98			7560	Woodchase L/S #98	Rabbit Creek
3/18/98			12750	Andrew Road & Highway 90	Rabbit Creek
3/18/98			10080	Woodchase L/S #98	Rabbit Creek
7/25/98			27000	Giblin L/S #91	Rabbit Creek
8/3/98			9000	Giblin Road L/S #91	Rabbit Creek
8/15/98			36000	Giblin Road L/S #91	Rabbit Creek
9/30/98			5040	Woodchase L/S #98	Rabbit Creek
1/19/99			5040	Woodchase LS #98	Rabbit Creek
2/2/99			60000	Old Pascagoula Road 5982	Rabbit Creek
2/3/99			9000	Giblin Road [#91]	Rabbit Creek

Table 9.3 (continued)

Date of Spill	Reported Cause*	Duration*	Estimated Reported Volume (gallons)	Location	Reported Stream Impacted*
2/4/99			50000	Giblen Rd 4315 (Lift Station #91)	Rabbit Creek
2/6/99			9000	Giblin Road [#91]	Rabbit Creek
2/8/99			51000	Giblin Road [#91]	Rabbit Creek
5/14/99			18000	Giblin Road 4315	Rabbit Creek
12/7/99			8745	Tillman's Corner Parkway	Rabbit Creek
12/13/99			9000	Hamilton Boulevard behind Winn Dixie	Rabbit Creek
4/28/98			6000	5451 Halls Mill Road	Rattlesnake Bayou
9/30/98			21000	Inn Road	Rattlesnake Bayou
11/13/99			27000	Inn Boulevard	Rattlesnake Bayou
11/14/99			9000	Inn Boulevard	Rattlesnake Bayou
12/31/99			9125	McGough Drive 3007	Robinson Creek
10/20/98			180000	Wall Street	Second Creek
12/29/98			30000	8040 Cottage Hill Road	Second Creek
1/2/99			32400	Schillinger Road	Second Creek
3/15/99			10400	Quincy Dr S 7561	Second Creek
11/24/98			5250	Cottage Hill and Freemont	Spencer Branch
12/31/98			28500	6609 Bentley Court	Spencer Branch
6/10/97			18000	Englewood Drive	Storm drain to Dog River
1/10/00	line failure	6	36000	7453 Burning Tree Ct.	Milkhouse Creek
4/17/00	broken main	1	33000	Hurtel St. / Antwerp St.	
5/4/00	sand/grease	3	1000000	5260 Hwy 90	Halls Mill Creek
5/4/00	sand/grease	3	1000000	US Hwy 90	Halls Mill Creek
7/18/00	broken line	2	4500	606 Bel Air Blvd.	Eslava Creek
7/28/00	roots/grease	3	2000	5928 Cinnamon Ct.	Milkhouse Creek
8/8/00	broken line	2	12000	south of Cottage Hill Rd.	Milkhouse Creek
8/11/00	grease	2	2400	442 Azalea Rd.	Bolton Branch Creek
8/22/00	grease/paper	3	1800	5409 Crosscreek Dr.	Halls Mill Creek
8/23/00	broken line	24	1440	764 Lundy Ln.	Bolton Branch Creek
8/28/00	obstruction	9	13500	Short Leaf Dr. & Cross Creek	Spring Creek
10/2/00	stoppage	3	100000	S Florida St. & Walton Ave.	Woodcock Creek
10/22/00	grease	1	1100	505 Bel Air Blvd.	Eslava Creek
11/2/00	roots/grease	4	10000	450 Azalea Rd.	Montlimar Creek
11/19/00	overtapped with rainwater	1	3000	1761 Quincy Dr.	Second Creek
11/24/00	grease/ heavy rain	4	165000	Service Rd. / Airport Rd. / Baby Superstore	Montlimar Creek

Table 9.3 (continued)

Date of Spill	Reported Cause*	Duration*	Estimated Reported Volume (gallons)	Location	Reported Stream Impacted*
11/25/00	heavy rain	4	240000	Hillcrest Rd. @ Halls Mill Creek	Halls Mill Creek
11/30/00	grease	3	3600	Three Medical Park / Girby Rd.	Halls Mill Creek
11/30/00	grease	2	1800	1997 Ostrom Dr.	Dog River
12/1/00	grease	5	1625	928 Butler Dr.	Montlimar Creek
12/2/00	grease	4	2150	1952 Eagle Dr.	Eslava Creek
12/9/00	manhole break	7	42000	Oakleigh Trace Subdivision	Spring Creek
12/10/00	grease	4	48000	3016 Brookline Dr.	Spring Creek
12/10/00	manhole break	3	18000	Oakleigh Trace Subdivision	Spring Creek
12/13/00	lift station failure	1	36000	Giblin #91 (off Hamiliton Blvd.)	Rabbit Creek
12/16/00	roots	1	2500	2914 Longleaf Dr.	Spencer Branch
12/16/00	debris	1	5700	5713 Oakleigh Trace	Spring Creek
12/17/00	grease	1	1350	5255 Maudelayne Dr. N	Spencer Branch
12/22/00	grease	7	3900	3800 Hillcrest Ln. E	Montlimar Creek
12/29/00	grease	4	6000	1402 Arlington St.	Mobile Bay
1/5/01	debris	2	12000	behind Timber Ridge Apts.(between Johnston Ln. & Wall St.	Milkhouse Creek
1/7/01	roots	1	1500	450 Azalea Rd.	Bolton Branch Creek
2/13/01	broken bypass pipe	1	2000	Hwy 90 (near Wiley Orr Rd.)	Halls Creek
2/28/01	grease	2	4500	8305 Reidy Ct.	Second Creek
3/3/01	infil/inflow	3	3800	1254 W. Becker Rd.	Eslava Creek
3/3/01	infil/inflow	3	3800	2118 N. Gimon Cir.	Eslava Creek
3/8/01	grease	2	3600	6229 Brynolyn Ct.	Campground Branch Creek
3/12/01	infil/inflow	3	7500	2112 Gimon Cir.	Eslava Creek
3/12/01	infil/inflow	2	1200	1350 Guffield Dr. E	Eslava Creek
3/12/01	infil/inflow	2	6000	1252 Houston St.	Eslava Creek
3/12/01	force main break	2	4000	Semmes Middle School	Crooked Creek
3/12/01	infil/inflow	3	4500	Homewood St. & Westwood St.	Eslava Creek
3/12/01	infil/inflow	5	36000	120 Demouy Ave.	Eslava Creek
3/12/01	infil/inflow	2	1200	Central Rd. & Gulffield Dr. N	Eslava Creek
3/12/01	infil/inflow	3	9000	Houston St. and Duval St.	Eslava Creek
3/12/01	infil/inflow	6	36000	Conti St. & Demouy Ave.	Eslava Creek
3/14/01	infil/inflow	3	9000	Giblin Rd. @ LS (off Hamiliton Blvd.)	Rabbit Creek
3/18/01	grease	3	5250	133 McGregor Ave.	Eslava Creek
3/30/01	force main break	2	70080	5590 Todd Acres Dr.	Moore Creek
4/4/01	force main break	1	10800	Todd Acres Dr. near Commerce Blvd.	Moore Creek

Table 9.3 (continued)

Date of Spill	Reported Cause*	Duration*	Estimated Reported Volume (gallons)	Location	Reported Stream Impacted*
4/12/01	grease	2	3000	2060 Japonica Ln.	Montlimar Creek
4/20/01	grease	4	1200	1209 E. Buena Dr.	Eslava Creek
5/1/01	grease	2	1350	3968 Airport Blvd.	Eslava Creek
5/21/01	grease	1	600	1000 Farnell Ln.	Bolton Branch Creek
5/23/01	grease	2	2500	1209 Buena Dr. E	Eslava Creek
5/25/01	grease	3	750	1512 Heron Dr.	Eslava Creek
5/25/01	force main break	3	3300	4386 Fatherbrook Ln.	Spring Creek
5/29/01	force main break	4	1300	5775 Hwy 90 W	
6/4/01	grease	3	900	1364 Plaza Dr.	Eslava Creek
6/4/01	grease	1	120	24 Benedict Place	Eslava Creek
6/11/01	infil/inflow	3	5400	Halls Mill #155	Moore Creek
6/11/01	force main break	0	5	Crenshaw St. near Clearmont St.	Eslava Creek
6/11/01	infil/inflow	1	1000	Conti St. & Demouy Ave.	Eslava Creek
6/11/01	infil/inflow	1	300	Mohawk St. & Elizabeth St.	Eslava Creek
6/11/01	infil/inflow	1	50	Glenwood St. @ Clearmont St.	Eslava Creek
6/11/01	infil/inflow	1	30	Glenwood St. @ Clearmont St.	Eslava Creek
6/11/01	infil/inflow	1	200	2107 Highland Ct.	Eslava Creek
6/11/01	infil/inflow	1	10	1710 Gulffield Dr.	Eslava Creek
6/11/01	grease	2	450	1909 Nice Ave.	Eslava Creek
6/11/01	break	2	6750	2007 Senator St.	Eslava Creek
6/14/01	grease	3	449	7380 Hitt Rd.	Milkhouse Creek
6/14/01	infil/inflow	2	420	Hamilton Blvd. (Gammex LS)	Deer River
7/14/01	grease	3	800	3945 Airport Blvd.	Eslava Creek
7/14/01	grease	5	2850	7380 Hitt Rd.	Milkhouse Creek
7/17/01	grease	1	1500	1475 Goldfinch St.	Eslava Creek
7/19/01	break	6	2100	2610 Schillinger St. @ Cottage Hill Rd.	Second Creek
7/20/01	grease	6	1440	Van Lee Cir.	Eslava Creek
7/25/01	debris	1	112	651 Azalea Rd Apt 35 Blvd D	Bolton Branch Creek
7/25/01	debris	1	112	651 Azalea Rd Apt 35 Blvd D	Bolton Branch Creek
7/26/01	infil/inflow	4	1150	Houston St. and Duval St.	Eslava Creek
7/26/01	infil/inflow	3	825	Hurtel St. and Stewart St.	Eslava Creek
7/26/01	infil/inflow	3	1950	257 Island Ct.	Eslava Creek
7/26/01	infil/inflow	5	27000	Giblin #91 (off Hamiliton Blvd.)	Rabbit Creek
7/26/01	infil/inflow	6	3450	Crenshaw LS #152	Eslava Creek
7/26/01	grease	1	375	422 Durande Dr.	Eslava Creek

Table 9.3 (continued)

Date of Spill	Reported Cause*	Duration*	Estimated Reported Volume (gallons)	Location	Reported Stream Impacted*
7/26/01	infil/inflow	2	6000	2122 Gimon Cir. N	Eslava Creek
7/26/01	infil/inflow	4	240000	Old Military Rd. LS #91	Rabbit Creek
7/26/01	infil/inflow	7	21000	Elizabeth St. & Mohawk St.	Eslava Creek
7/26/01	infil/inflow	7	8400	Gulffield Dr. N & Gulffield Dr. W	Eslava Creek
7/26/01	infil/inflow	9	13500	Gulffield Dr. N & Central Dr.	Eslava Creek
7/26/01	infil/inflow	7	4200	1352 Gulffield Dr. E	Eslava Creek
7/26/01	infil/inflow	9	270000	Conti St. & Demouy Ave.	Eslava Creek
7/26/01	infil/inflow	9	162000	Murray St. & Demouy Ave.	Eslava Creek
7/26/01	infil/inflow	4	24000	5118 Halls Mill Rd.	Halls Creek
7/26/01	infil/inflow	4	288000	5121 Halls Mill Rd.	Halls Creek
7/26/01	infil/inflow	6	36000	5136 Hwy 90	Halls Creek
7/26/01	infil/inflow	6	9000	5136 Hwy 90	Halls Creek
7/26/01	infil/inflow	6	8250	5136 Hwy 90	Halls Creek
7/26/01	infil/inflow	6	396000	5136 Hwy 90	Halls Creek
7/27/01	grease	2	650	155 Sage Ave. S	Eslava Creek
7/27/01	infil/inflow	0	100	Crenshaw LS #152	Eslava Creek
7/31/01	break	0	1496	woods by creek	Eslava Creek
7/31/01	infil/inflow	0	374	woods by creek	Eslava Creek
8/5/01	grease	1	300	3945 Airport Blvd.	Eslava Creek
8/28/01	roots	3	15	720 Raines Dr.	Montlimar Creek
8/8/01	grease	1	300	702 Jemison St.	Eslava Creek
8/11/01	rain event	5	360000	Mohawk St. & Elizabeth St.	Eslava Creek
8/12/01	rain event	5	12000	Mohawk St. & Elizabeth St.	Eslava Creek
8/12/01	rain event	1	94	2459 Mt. Island Dr. N	Eslava Creek
8/12/01	rain event	3	360000	2122 Gimon Cir. W	Eslava Creek
8/16/01	grease	1	300	2007 McVay Dr.	Eslava Creek
8/17/01	infil/inflow	2	14400	Clearmont St. & Kenan St.	Eslava Creek
8/17/01	infil/inflow	2	14400	Westwood St & Homewood St.	Eslava Creek
8/17/01	infil/inflow	2	14400	Mohawk St. & Elizabeth St.	Eslava Creek
8/19/01	grease	2	450	1284-B Bayview Ct.	Robinson Bayou
8/19/01	lift station failure	0	3750	HM #155	Moore Creek
8/23/01	force main break	1	2500	800' W of Navco Rd. on S side of track	Moore Creek
8/30/01	hose came out of manhole pump	1	4800	2610 Schillingers Rd.	Second Creek

Table 9.3 (continued)

Date of Spill	Reported Cause*	Duration*	Estimated Reported Volume (gallons)	Location	Reported Stream Impacted*
9/5/01	grease	2	1400	1000 W. Woodlawn Dr.	Eslava Creek
9/6/01	grease	8	48000	270 Hillcrest in easement	Twelve Mile Creek
9/16/01	grease	1	600	1715 Dog River Dr. W	Dog River
9/16/01	grease	1	449	5901 Live Oak Ct.	Milkhouse Creek
9/17/01	force main break	15	13090	1856 Navco Rd.	Dog River
9/28/01	grease	0	200	Jackson Rd. between State Route 16 & Calhoun Rd.	Halls Creek
10/9/01	debris	3	5672	Michael Blvd. Between Montlimar Dr. & Hutson Dr.	Montlimar Creek
10/17/01	debris	1	120	6600 Wall St.	Milkhouse Creek
10/24/01	grease	3	4875	Springbank Rd. & Rutledge Place	Eslava Creek
11/1/01	grease	1	750	4321 Carlyle Way	Eslava Creek
11/6/01	debris	1	1200	962 Westbury Dr.	Bolton Branch Creek
11/8/01	debris	2	12000	8260 Reidy St.	Second Creek
11/8/01	force main break	4	14500	Pleasant Valley @ Executive Park (Pleasant Valley Rd. & Grayson D	Bolton Branch Creek
11/19/01	grease	5	3000	Southern Oaks Apt- University Blvd.	Bolton Branch Creek
11/22/01	grease	2	450	310 Emelye Dr.	Spring Creek
2/18/02	grease	1	600	3071 Ralston Rd.	Eslava Creek
1/18/02	grease	1	120	Navco St. & McVay St.	Bolton Branch Creek
1/18/02	grease	2	1200	1271 Azalea Rd.	Moore Creek
1/20/02	grease	2	1200	3800 Michael Blvd.	Eslava Creek
1/28/02	grease	2	150	1875 Panorama Blvd.	Bolton Branch Creek
1/31/02	grease	3	1500	557 Azalea Rd.	Bolton Branch Creek
2/4/02	grease	5	3300	3316 Melody Ln.	Payne's Creek
2/6/02	log blockage	6	2250	3316 Melody Ln.	Payne's Creek
2/11/02	grease	2	25	2717 Perin Ct.	Moore Creek
2/13/02	debris	2	1800	4151 Seabreeze Rd. N	Bolton Branch Creek
2/28/02	grease	1	300	133 McGregor Ave.	Eslava Creek
3/4/02	grease	1	200	1717 Dogriver Dr. W @ Bream Dr.	Dog River
3/11/02	debris/grease	1	3000	2750 N Barksdale Dr.	
3/11/02	grease	1	600	90 Spring St.	Eslava Creek
3/13/02	roots	1	600	450 Azalea Rd.	Bolton Branch Creek
3/14/02	debris	4	2700	151 Hillside Ln.	Montlimar Creek
3/14/02	grease	4	1050	262 Glenwood St.	Eslava Creek
3/19/02	grease	1	300	3805 Shelly Dr.	Montlimar Creek
4/2/02	grease	2	1000	1258 Skywood Dr.	Moore Creek

9.6 EFDC and WASP Calibrations

9.6.1 Model Description

The Environmental Fluid Dynamics Code (EFDC) is a general purpose modeling package for simulating three-dimensional flow, transport and biogeochemical processes in surface water systems including: rivers, lakes, estuaries, reservoirs, wetlands and near shore to shelf scale coastal regions. The EFDC model was originally developed at the Virginia Institute of Marine Science for estuarine and coastal applications and is considered public domain software.

In addition to hydrodynamic, salinity, and temperature transport simulation capabilities, EFDC is capable of simulating cohesive and non-cohesive sediment transport, near field and far field discharge dilution from multiple sources, eutrophication processes, the transport and fate of toxic contaminants in the water and sediment phases, and the transport and fate of various life stages of finfish and shellfish. Special enhancements have been made to the hydrodynamic portion of the code, including: vegetation resistance, drying and wetting, hydraulic structure representation, wave-current boundary layer interaction and wave induced currents, allowing refined modeling of wetland and marsh systems, controlled flow systems, and nearshore wave induced currents and sediment transport. The EFDC code has been extensively tested and documented and for more than twenty modeling studies. The following sections summarize the major features and capabilities of the hydrodynamic and water quality sub-models of the EFDC modeling package.

9.6.1.1 Hydrodynamic Model

The physics of the EFDC model, and many aspects of the computational scheme, are equivalent to the widely used Blumberg-Mellor model (Blumberg & Mellor, 1987) and the U. S. Army Corps of Engineers' CH3D or Chesapeake Bay model (Johnson, et al, 1993). The EFDC model solves the three-dimensional, vertically hydrostatic, free surface, turbulent averaged equations of motions for a variable density fluid. Dynamically coupled transport equations for turbulent kinetic energy, turbulent length scale, salinity and temperature are also solved. The two turbulence parameter transport equations implement the Mellor-Yamda level 2.5 turbulence closure scheme (Mellor & Yamada, 1982; Galperin et al, 1988). The EFDC model uses a stretched or sigma vertical coordinate and Cartesian or curvilinear, orthogonal horizontal coordinates.

The numerical scheme employed in EFDC to solve the equations of motion uses second order accurate spatial finite differencing on a staggered or C grid. The model's time integration employs a second order accurate three-time level, finite difference scheme with an internal-external mode splitting procedure to separate the internal shear or baroclinic mode from the external free surface gravity wave or barotropic mode. The external mode solution is semi-implicit, and simultaneously computes the two-dimensional surface elevation field by a preconditioned conjugate gradient procedure. The external solution is completed by the calculation of the depth average barotropic velocities using the new surface elevation field. The model's semi-implicit external solution allows large time steps that are constrained only by the stability criteria of the explicit central difference or high order upwind advection scheme (Smolarkiewicz and Margolin, 1993) used for the nonlinear accelerations. Horizontal boundary conditions for the external mode solution include options for simultaneously specifying the surface elevation only, the characteristic of an incoming wave (Bennett & McIntosh, 1982), free radiation of an outgoing wave (Bennett, 1976; Blumberg & Kantha, 1985) or the normal volumetric flux on arbitrary portions of the boundary. The EFDC model's internal momentum equation solution, at the same time step as the external, is implicit with respect to vertical diffusion. The internal solution of the momentum equations is in terms of the vertical profile of shear stress and velocity shear, which results in the simplest and most accurate form of the baroclinic pressure gradients and eliminates the over-determined character of alternate internal mode formulations. Time splitting inherent in the three time level scheme is controlled by periodic insertion of a second order accurate two time level trapezoidal step. The EFDC model is also readily configured as a two-dimensional model in either the horizontal or vertical planes.

The EFDC model implements a second order accurate in space and time, mass conservation fractional step solution scheme for the Eulerian transport equations for salinity, temperature, suspended sediment, water quality constituents and toxic contaminants. The transport equations are temporally integrated at the same time step or twice the time step of the momentum equation solution (Smolarkiewicz and Margolin, 1993). The advective step of the transport solution uses either the central difference scheme used in the Blumberg-Mellor model or a hierarchy of positive definite upwind difference schemes. The highest accuracy upwind scheme, second order accurate in space and time, is based on a flux corrected transport version of Smolarkiewicz's multidimensional positive definite advection transport algorithm (Smolarkiewicz & Clark, 1986, Smolarkiewicz & Grabowski, 1990) which is monotonic and minimizes numerical diffusion. The horizontal diffusion step, if required, is explicit in time, while the vertical diffusion step is implicit. Horizontal boundary conditions include time variable material inflow concentrations, upwinded outflow, and a damping relaxation specification of climatological boundary concentration. For the temperature transport equation, the NOAA Geophysical Fluid Dynamics Laboratory's atmospheric heat exchange model (Rosati & Miyakoda, 1988) is implemented.

9.6.1.2 Water Quality Model

The EFDC code includes two internal eutrophication submodels for water quality simulation (Park, et al., 1995). The simple or reduced eutrophication model is functionally equivalent to the WASP5 EUTRO model (Ambrose, et al., 1993). The complex or full eutrophiction model is functionally equivalent to the CE-QUAL-ICM or Chesapeake Bay Water Quality model (Cerco and Cole, 1993). Both water column eutrophication models are coupled to a functionally equivalent implementation of the CE-QUAL-ICM sediment diagensis or biogeochemical processes model (DiToro and Fitzpatrick, 1993). The eutrophication models can be executed simultaneously with the hydrodynamic component of EFDC, or EFDC simulated hydrodynamic transport fields may be saved allowing the EFDC code to execute in a water quality only simulation model.

The computational scheme used in the internal eutrophication models employees a fractional step extension of the same advective and diffusive algorithms used for salinity and temperature, which guarantee positive constituent concentrations. A novel ordering of the reaction sequence in the reactive source and sink fractional step allows the linearized reactions to be solved implicitly further guarantying positive concentrations. The eutrophication models accept an arbitrary number of point and nonpoint source loadings as well as atmospheric and ground water loadings.

In addition to the internal eutrophication models, the EFDC model can be externally linked to the WASP5 model. In the external linking mode, the EFDC model generates WASP5 input files describing cell geometries and connectivity as well and advective and diffusive transport fields. For estuary simulation, the transport fields may be intratidally time averaged or intertidally time averaged using the averaging procedure described by Hamrick (1994a).

9.6.2 Model Calibration

9.6.2.1 Calibration Methodology

The hydrodynamic application for Dog River and Rabbit Creek utilized the EFDC code in a three-dimensional simulation with tidal forcing at the Mobile Bay boundary, and freshwater inflow at the upstream boundaries. The shoreline and bathymetry are represented through the use of a curvilinear grid whose boundaries are based upon the digital NOAA shoreline data, and whose depths are interpolated from the NOAA digital depth data.

The water quality application utilized the WASP code. The hydrodynamic conditions, including the temporal and spatial variations in the cell volumes, depths, flows and dispersion coefficients, are imported as an external forcing file generated by the EFDC 3-D hydrodynamic application. The advective and dispersive transport solutions within the WASP simulation were performed on the identical model grid used to simulate the hydrodynamics.

The simulation period was chosen based upon the availability of profile data that was collected by Alabama ADEM at Station RBTM-001 during an intensive survey study on July and October of 2001. The data collected were conductivity, temperature, Ph and dissolved oxygen. Figure 9-1 shows the location of station RBTM-001.

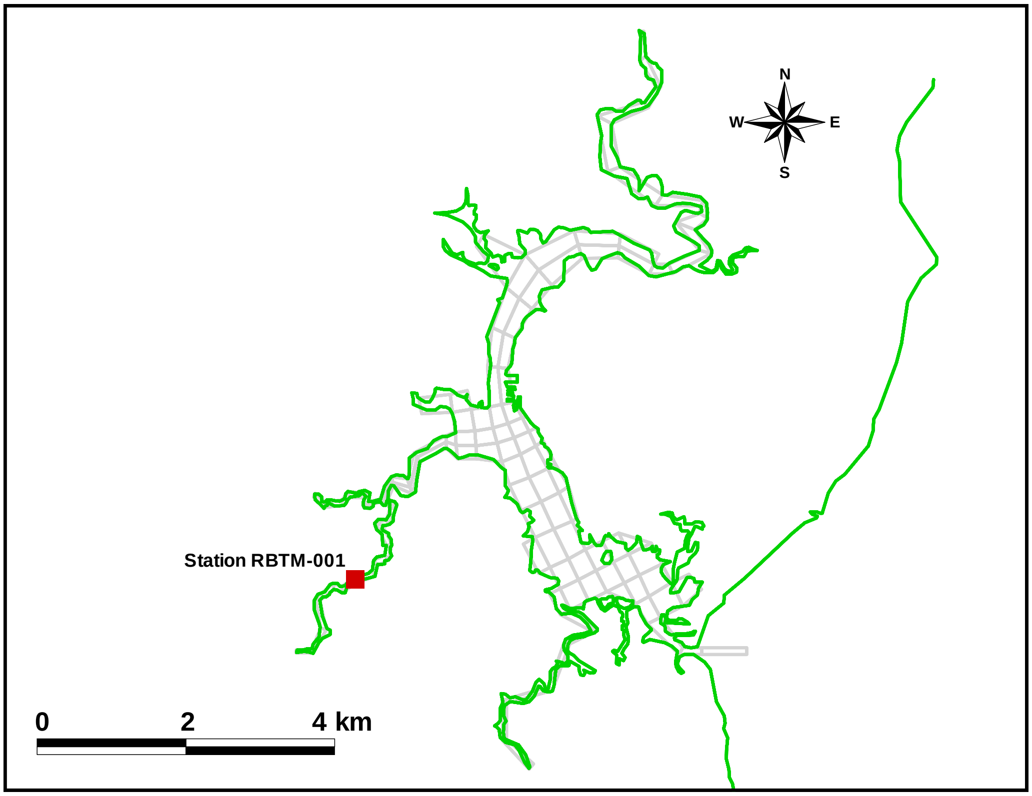


Figure 9-1 Locations of Sampling Station in Rabbit Creek

For the calibration period, no tidal records were available and the hydrodynamic model was forced using astronomical tide projections at the mouth of Dog River in Mobile Bay. Tidal predictions for the Fowl River Station in Mobile Bay were used. The local effects of wind were also considered inside the model domain. The freshwater inflows at the headwaters of the tributaries were determined utilizing the watershed model LSPC.

The kinetic processes, sources, and sinks considered within the WASP simulations that impact the mass balance of dissolved oxygen were:

- Ultimate Biochemical Oxygen Demand (BODU) decay,
- Reaeration,
- Sediment Oxygen Demand (SOD), and
- Headwater and offshore boundary fluxes of BODU and dissolved oxygen.

Based upon the data available, the model was calibrated to the vertical distribution of salinity, temperature and dissolved oxygen. As the data available were scarce only graphical comparisons are presented.

9.6.2.2 Model Inputs

9.6.2.2.1 Bathymetry and Geometry

Figure 9-2 presents the model grid used to simulate hydrodynamics and water quality in Dog River and Rabbit Creek. The grid resolution is medium to coarse with 2 to 3 cells across in Dog River, and 1 to 2 cells across in Rabbit Creek.

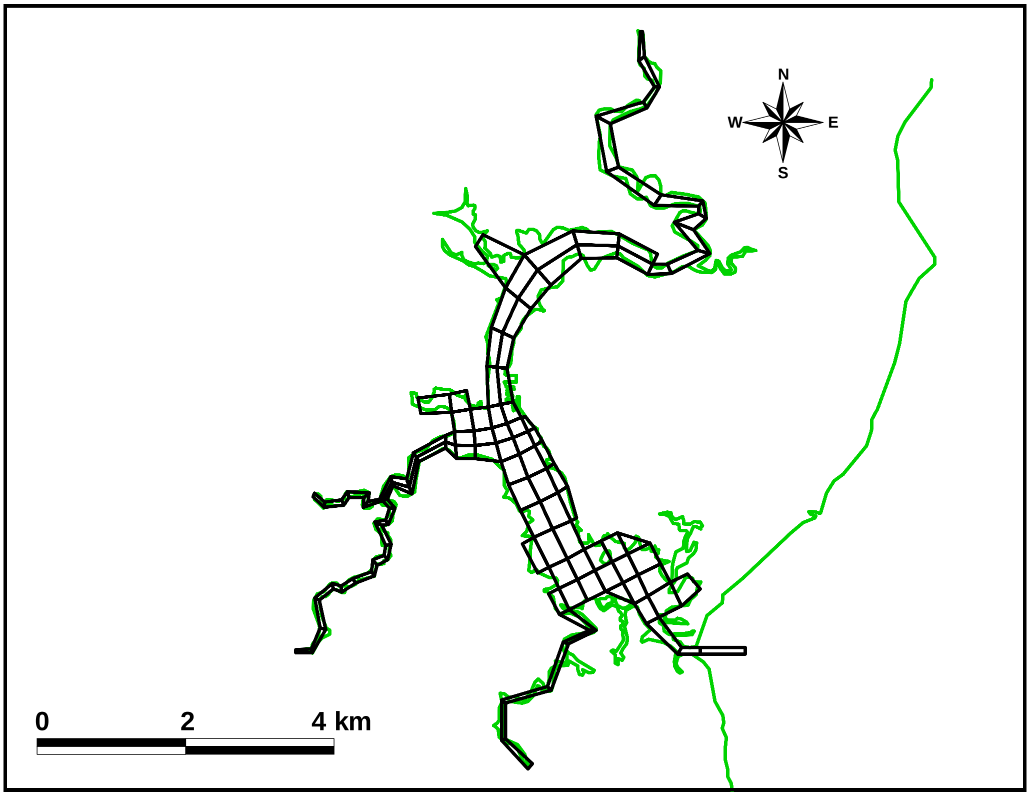


Figure 9-2 Model Grid

Figure 9-3 present a graphical representation of the bathymetric conditions used in the model simulations. Based upon this figure, the model is able to capture the lateral variations in bathymetric conditions in Dog River. In Rabbit Creek, where the model grid representation is coarse in relation to the overall channel width, the model captures primarily the longitudinal bathymetric variations.

Based upon the shallow characteristics of the bathymetry, four vertical layers were considered in the simulation, that are sufficient to fairly reproduce the vertical structure conditions present in the area.

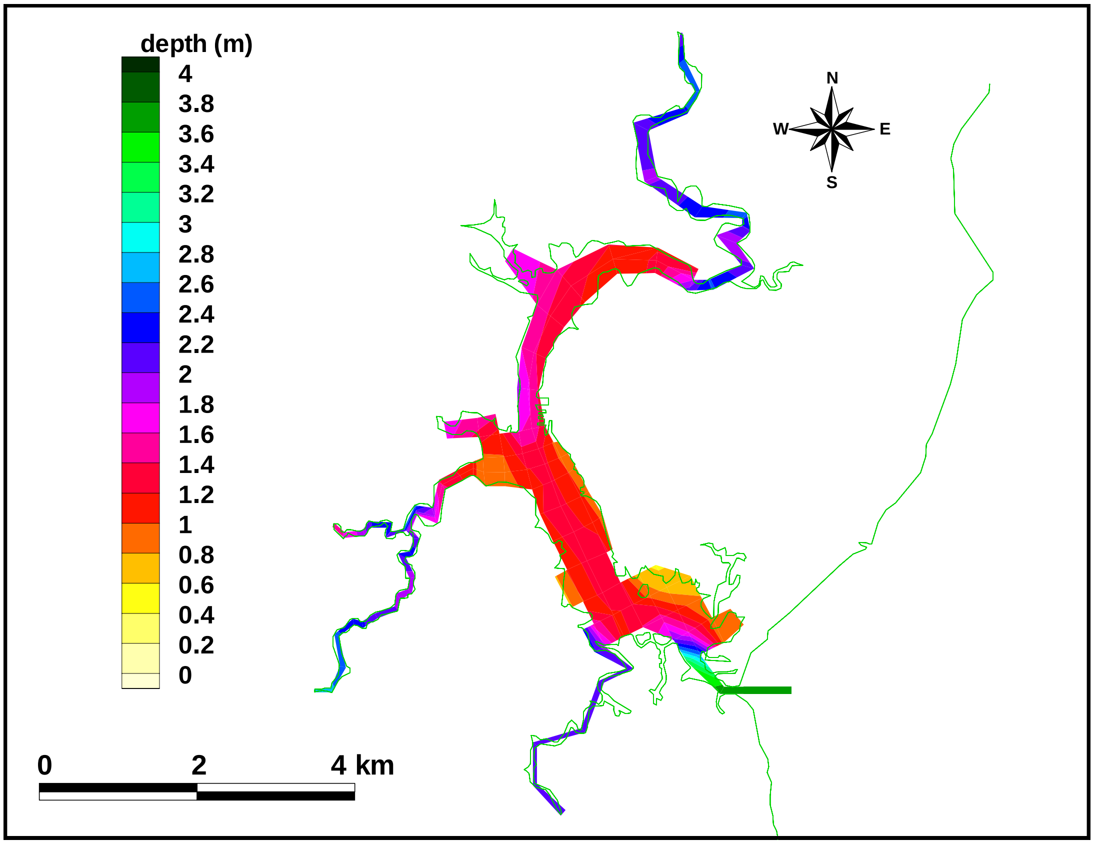


Figure 9-3 Model Bathymetry

9.6.2.2.2 Tidal Forcing and Freshwater Inflow

As stated earlier, the model utilizes projected astronomical tides to force the open boundary condition at the confluence of Dog River and Mobile Bay. Figure 9-4 presents these projected tidal conditions used to drive the model. The tides range over several full spring to neap cycles during the period of simulation. For the model, the water surface elevations at the open boundary were referenced to the North American Geodetic Vertical Datum (NGVD).

Constituent concentrations at the open boundary were based on measurements done by Alabama ADEM and EPA at the Dog River mouth and in Mobile Bay. These boundary conditions reflect the concentrations flowing into the model system during a flooding tide through the Dog River entrance channel. The headwater concentrations flowing in at all times at a mass rate dependant upon the freshwater inflow were obtained from the watershed model application.

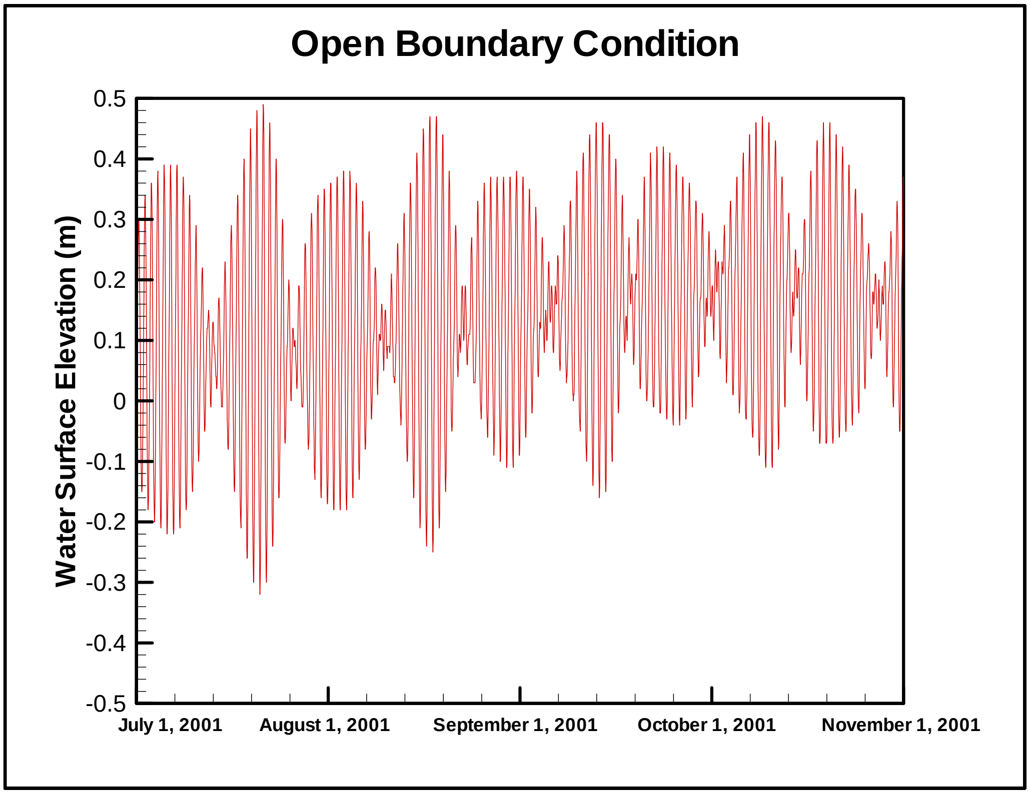


Figure 9-4 Projected Astronomic Tides in Mobile Bay at Fowl River

9.6.2.2.3 Wind

The shallow bathymetry and relatively weak astronomical tidal conditions increase the importance of wind effects on the hydrodynamics and water quality conditions. Figures 9-5 and 9-6 present the wind conditions during the period of simulation measured by NCDC at Mobile Airport. Strong and persistent winds affect the surface circulation and stratification conditions. These winds are also responsible, most of the time, for the reaeration generated in Dog River.

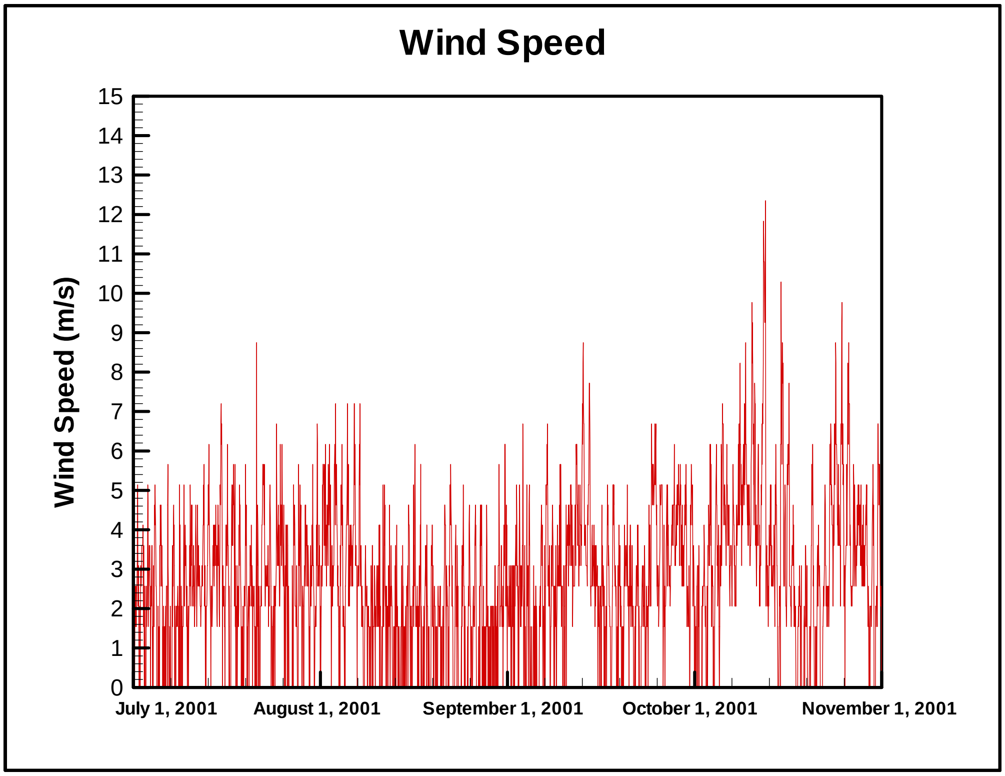


Figure 9-5 Wind Speed at Mobile Airport

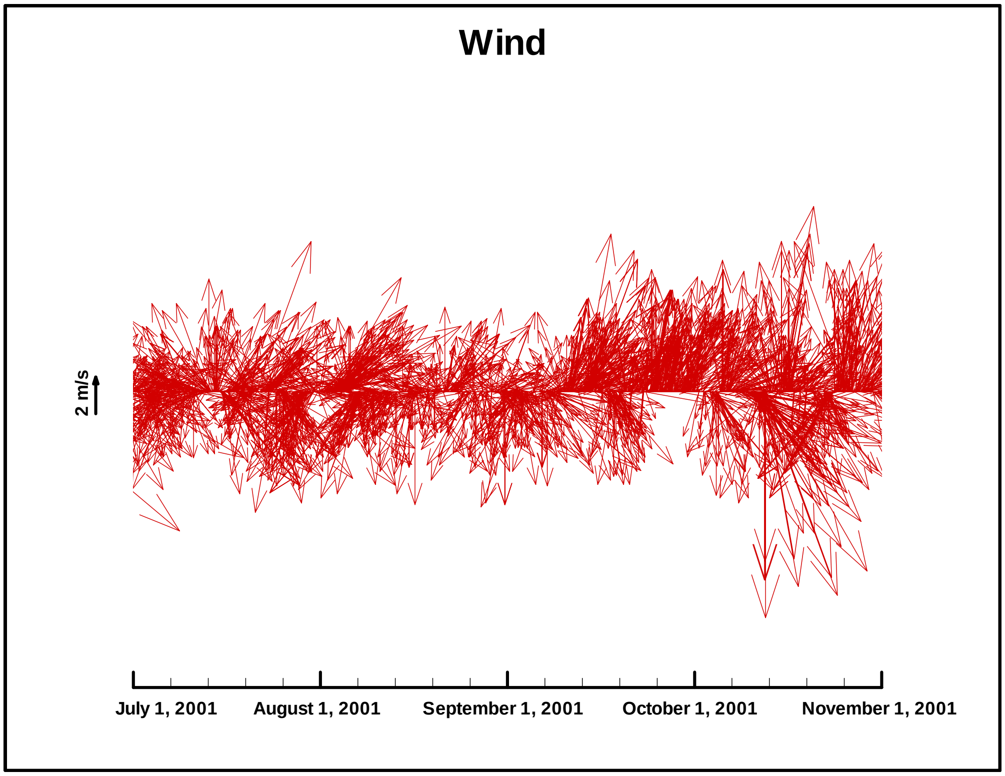


Figure 9-6 Wind Speed and Direction at Mobile Airport

9.6.2.2.4 Sediment Oxygen Demand

Based on field measurements done by EPA in Dog River and in other Alabama rivers and creeks with similar characteristics of the upper Dog River and Rabbit Creek, a spatial distribution of SOD was developed for the model. Figure 9-7 presents the spatial SOD values (at 20 deg C) utilized in the WASP model calibration. Values ranged from 1.7 g/m^2/day up to 2.25 g/m^2/day.

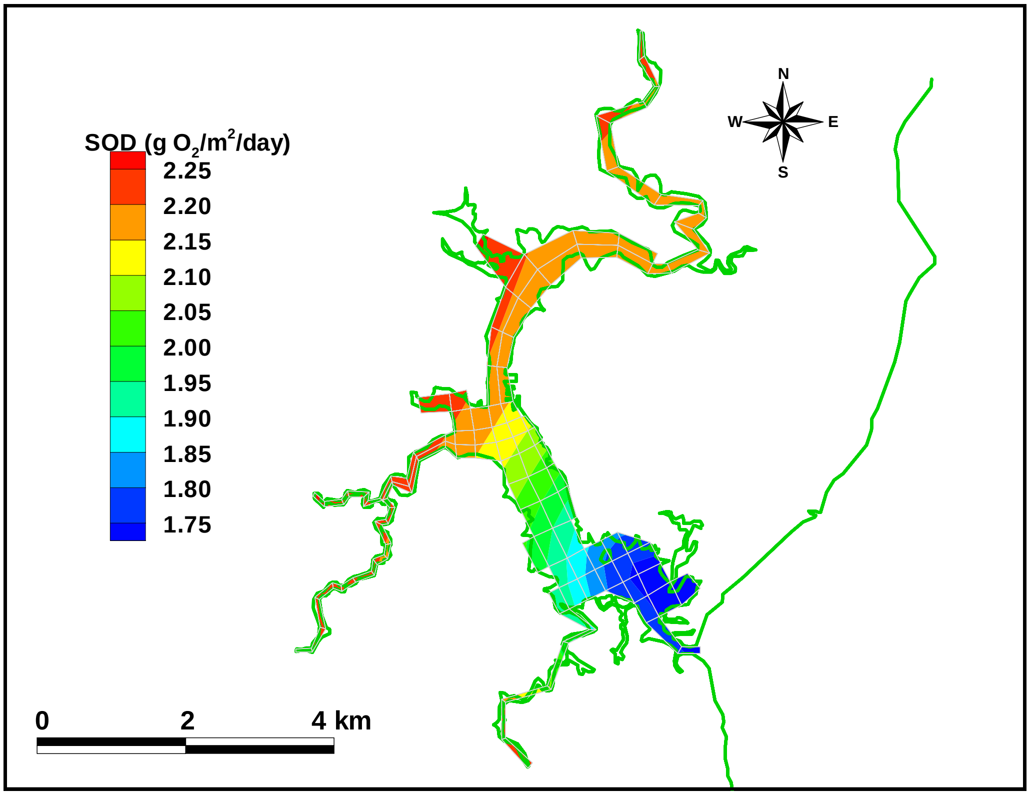


Figure 9-7 Spatial Distribution of Sediment Oxygen Demand at 20^o C

9.6.2.2.5 Reaeration

The O'Connor-Dobbins formulation, as well as the wind effect, was utilized to define the spatial and time varying reaeration rate over the period of the simulation. A minimum value of 1 m/day of the oxygen transfer coefficient was considered.

9.6.2.3 Model Calibration

The following presents comparisons between the simulated and measured profiles in July and October of 2001 for salinity, temperature and dissolved oxygen. These simulations represent the best overall results achieved under the existing forcing conditions.

Figure 9-8 presents profile comparisons at Station RBTM-001 for salinity for the period July 9-July 11, 2001, when negligible salinity was present, and Figure 9-9 presents the salinity profile comparisons for the period October 16-October 18, 2001, where levels of salt intrusion and stronger stratification are present. Both periods illustrate the model capabilities of capturing the salinity range and stratification present in the area of Station RBTM-001.

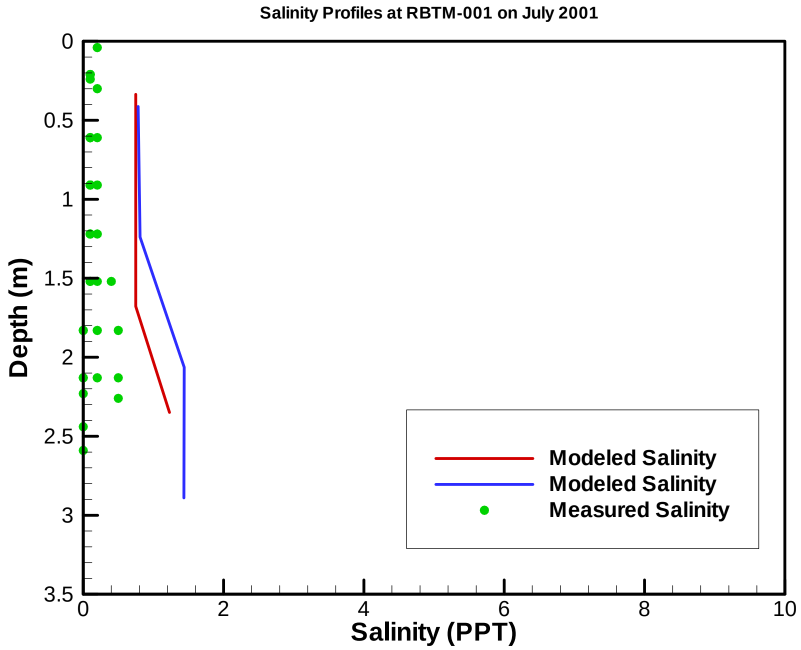


Figure 9-8 Simulated and Measured Salinity in July 2001

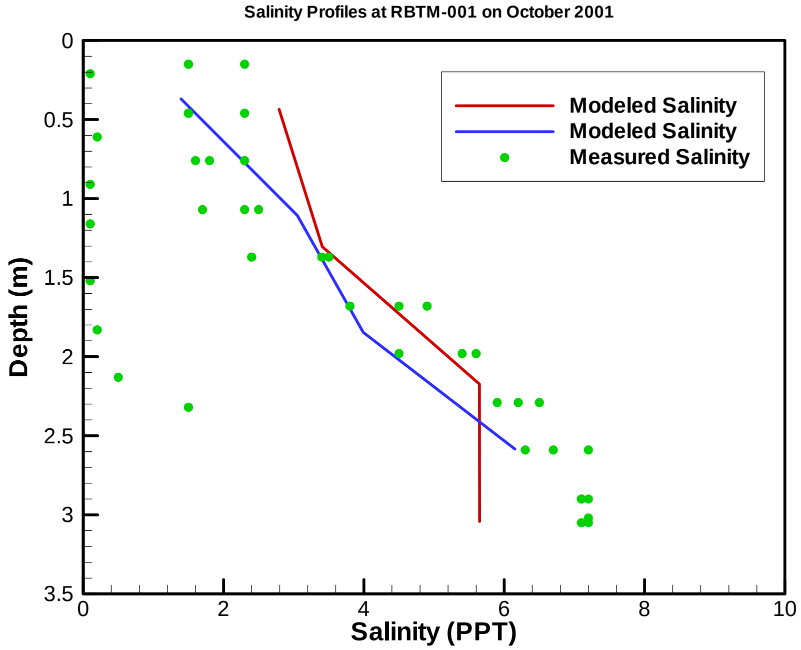


Figure 9-9 Simulated and Measured Salinity in October 2001

Figure 9-10 presents temperature profile comparisons at Station RBTM-001 for the period July 9-July 11, 2001. Figure 9-11 presents temperature profile comparison for the period October 16-October 18, 2001. The model is able to capture the range value and degree of stratification for both periods.

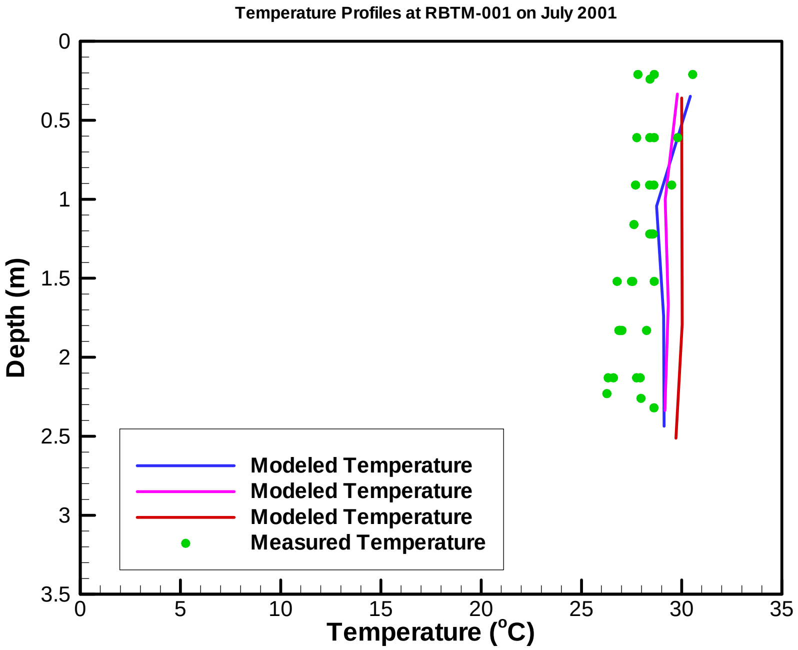


Figure 9-10 Simulated and Measured Temperature in July 2001

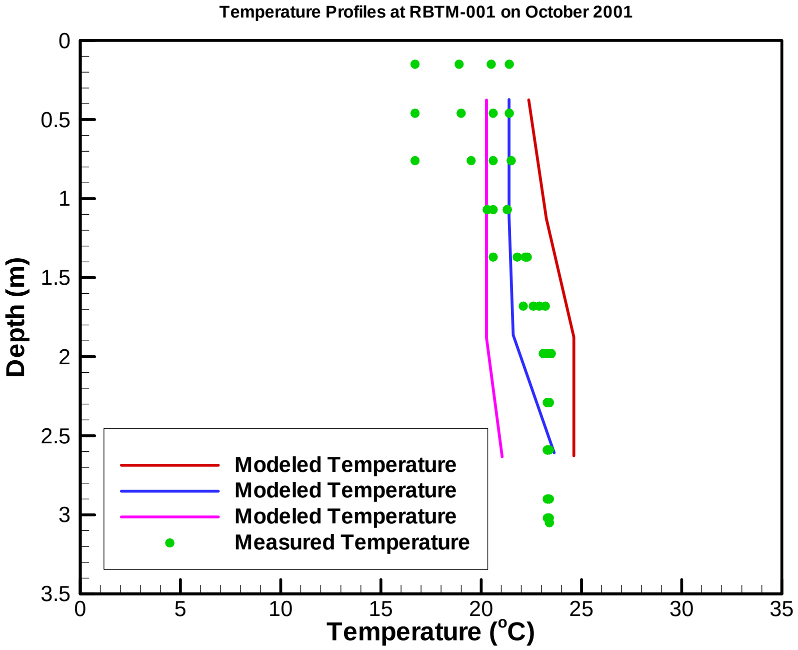


Figure 9-11 Simulated and Measured Temperature in October 2001

Figures 9-12 through 9-17 present comparisons of measured and modeled dissolved oxygen profiles at Station RBTM-001. Examination of the plots shows that the model appears to be capturing the value range and strong DO stratification present at this location.

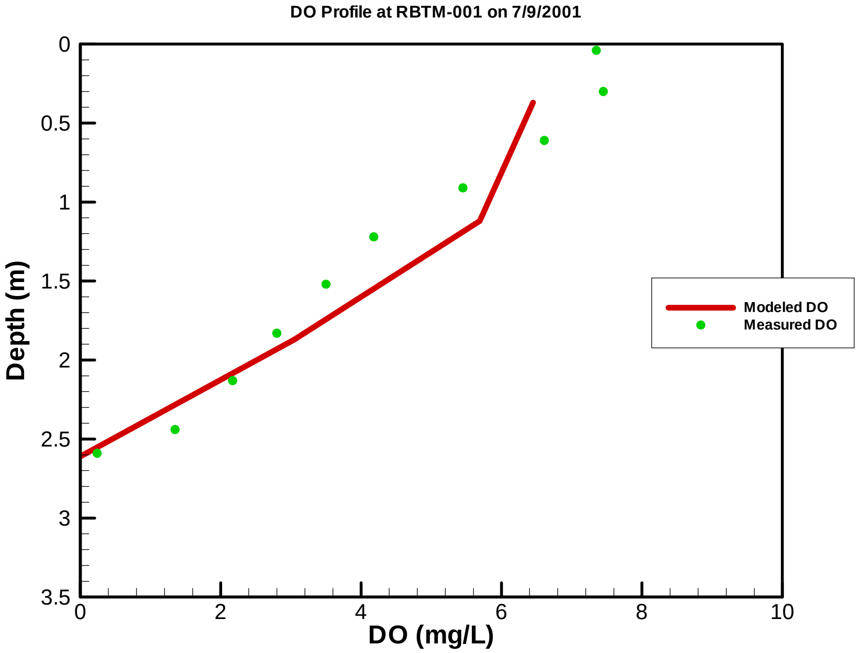


Figure 9-12 Simulated vs. Measured Dissolved Oxygen on July 9, 2001

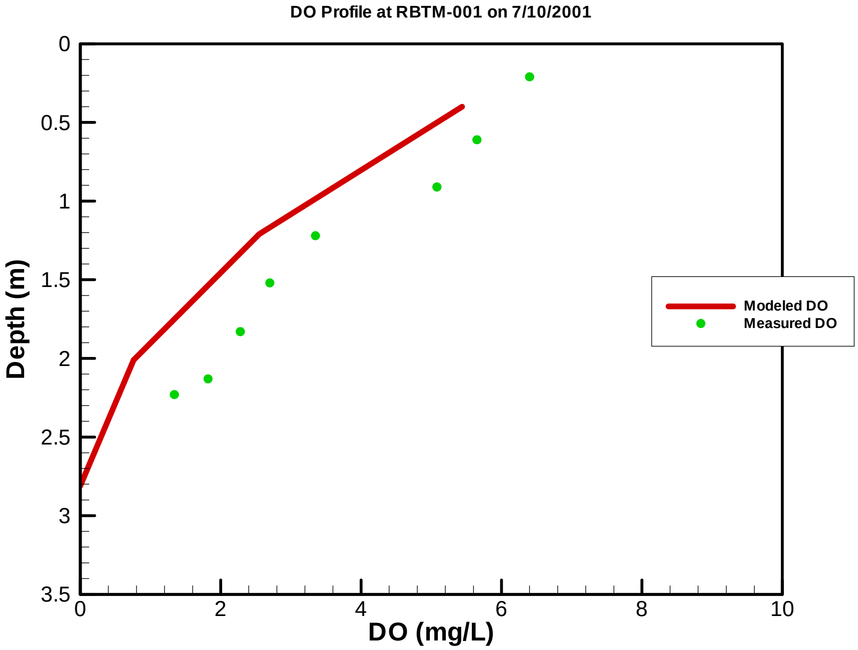


Figure 9-13 Simulated vs. Measured Dissolved Oxygen on July 10, 2001

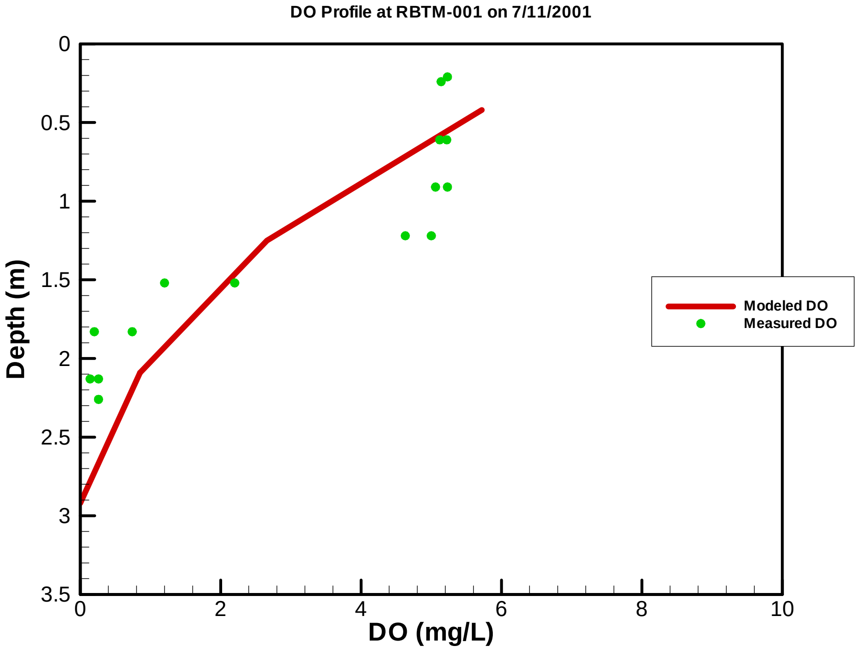


Figure 9-14 Simulated vs. Measured Dissolved Oxygen on July 11, 2001

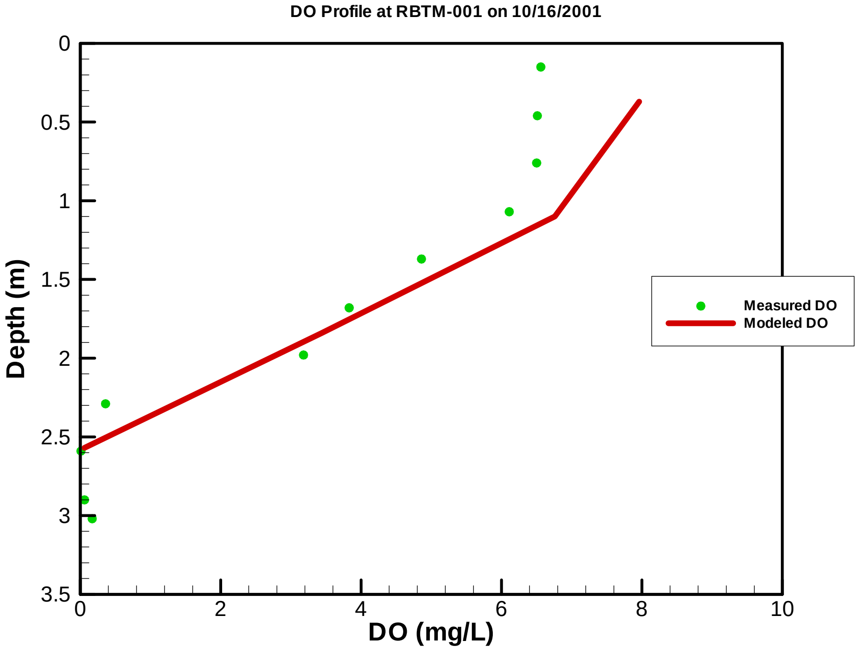


Figure 9-15 Simulated vs. Measured Dissolved Oxygen on October 16, 2001

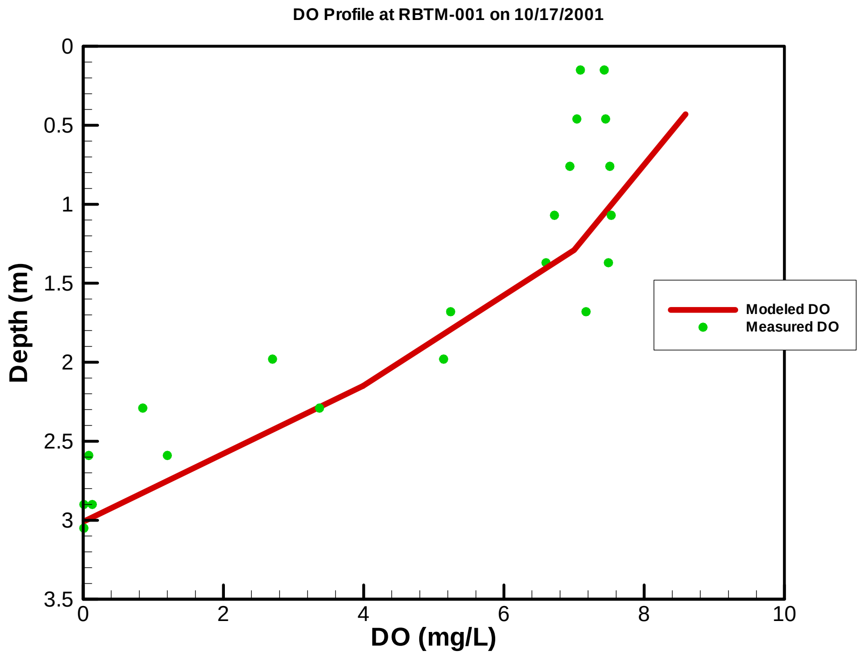


Figure 9-16 Simulated vs. Measured Dissolved Oxygen on October 17, 2001

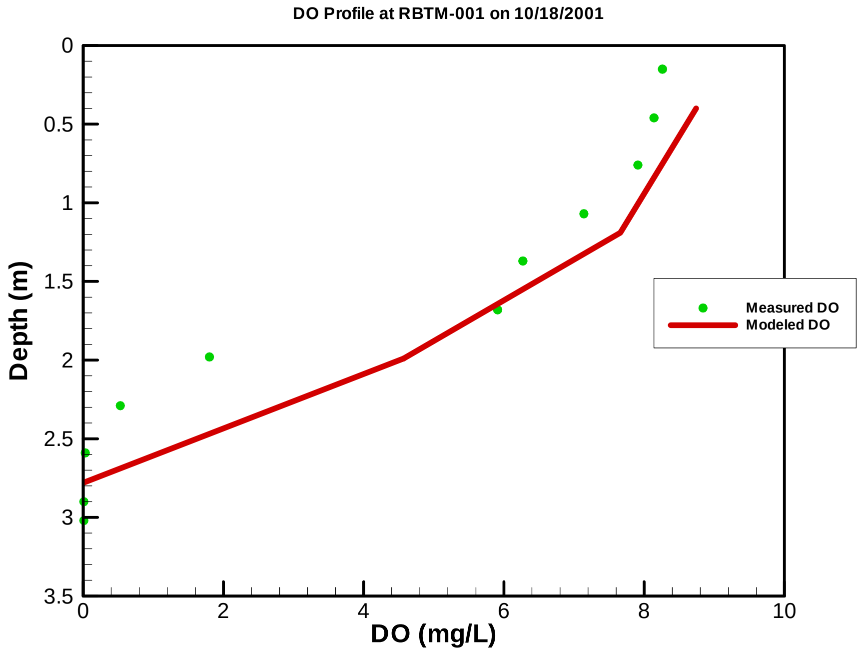


Figure 9-17 Simulated vs. Measured Dissolved Oxygen on October 18, 2001

9.6.4 Summary and Conclusions

A three-dimensional hydrodynamic and water quality model was developed for assistance in the determination of a TMDL for dissolved oxygen within listed segments of Dog River and Rabbit Creek. The Environmental Fluid Dynamics Code (EFDC) was utilized for the hydrodynamic forcing while the Water Quality Analysis and Simulation Program (WASP) was used for water quality.

The model extended from the mouth of Dog River in Mobile Bay, up the Dog River and the Rabbit Creek. Model boundaries and bathymetry were developed from NOAA digital shoreline and bathymetric data.

Model inputs included: tidal fluctuations at the mouth of Dog River, freshwater inflow at the headwaters of the tributaries, water quality concentrations and water temperature at the upstream and downstream boundaries and sediment oxygen demand.

The model was calibrated for the best period of available data in the summer and fall of 2001. The calibration shows that the models are appropriate for relative impact of different scenarios and for assistance in the evaluation of TMDL for dissolved oxygen relative to loads of oxygen demanding material and the resultant impacts to dissolved oxygen concentrations.