Altamaha River Basin Dissolved Oxygen TMDLs

Submitted to:

U.S. Environmental Protection Agency
Region 4
Atlanta, Georgia

Submitted by:

Georgia Department of Natural Resources
Environmental Protection Division
Atlanta, Georgia

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1.0 TMDL Executive Summary

Basin Name: **Altamaha River**

Table 1-1. 2000-303(d) Listed Segments for Dissolved Oxygen in the Altamaha River Basin.

SEGMENT NUMBER	STREAM	SEGMENT LENGTH, (Miles)	1999 MONITORING STATION	12 DIGIT HUC ID
1	Alex Creek	3	02226150	030701060501
2	Big Cedar Creek	3	02225157	030701070104
3	Cobb Creek	13	02225110	030701060105
4	Doctors Creek	5	02226060	030701060405
5	Jacks Creek	9	02225318	030701070303
6	Jones Creek	11	02225950	030701060405
7	Little Ohoopee River (upper)	14	02225198	030701070202, 030701070201
8	Little Ohoopee River (middle)	15	02225235	030701070204, 030701070203
9	Little Ohoopee River (lower)	18	02225255	030701070205, 030701070206
10	Milligan Creek	11	02224995	030701060102
11	Oconee Creek	11	02225015	030701060104
12	Ohoopee River (upper)	18	02225175	030701070107, 030701070108
13	Ohoopee River (lower)	23	02225270, 02225340	030701070304, 030701070301
14	Pendleton Creek (upper)	7	02225348	030701070402, 030701070401
15	Pendleton Creek (lower)	12	02225360	030701070402
16	Penholoway River	13	02226100	030701060401, 030701060403
17	Rocky Creek (lower)	11	02225640	030701070504
18	Rocky Creek (upper)	10	02225590	030701070503
19	Swift Creek	5	02225420	030701070404
20	Ten Mile Creek	13	02225127	030701060204
21	Thomas Creek	12	02225695	030701070505
22	Tiger Creek	16	02225371	030701070405, 030701070403
23	Yam Grandy Creek	3	02225290	030701070302

Description of Analysis

USGS water quality data collected in 1999 identified dissolved oxygen (DO) impairments for Altamaha stream segments listed in Table 1-1, and further indicated that these impairments occurred during, and were limited to, summer months, low flow and high temperature conditions. Stream flows during periods of impairment were at, or below, 7Q10 (the minimum 7-day average flow that occurs once in 10 years on the average), which is consistent with the 3-year drought experienced in Georgia from 1998 to 2000. Since the observed DO impairments were clearly driven by persistent low flows and high temperatures, occurring over several summer months, a steady state modeling approach was adopted as appropriate for DO TMDL analysis.

Applicable Water Quality Standards

The applicable dissolved oxygen water quality standards for waters in the Altamaha River Basin are as follows:

> _Numeric - GAEPD._ A daily average of 5.0 mg/L and no less than 4.0 mg/L at all times for waters supporting warm water species of fish. 391-3-6-.03 (c) (I). (GAEPD, 2000)
>
> _Natural Water Quality – GAEPD._ It is recognized that certain natural waters of the State may have a quality that will not be within the general or specific requirements contained herein. This is especially the case for the criteria for dissolved oxygen, temperature, pH and fecal coliform. NPDES permits and best management practices will be the primary mechanisms for ensuring that the discharges will not create a harmful situation. 391-3-6-.03 (7). (GAEPD, 2000)
>
> _Natural Water Quality – EPA_. Where natural conditions alone create dissolved oxygen concentrations less than 110 percent of the applicable criteria means or minima or both, the minimum acceptable concentration is 90 percent of the natural concentration. (USEPA, 1986).

Due to naturally occurring low dissolved oxygen in the impaired segments, the EPA natural water quality standard was appropriate to support the proposed allocations. That is, if a model result showed a natural dissolved oxygen less than 5.0 mg/L, the natural model result would define the DO standard to be applied. In this case, the standard would become 90 percent of the computed natural DO.

Technical Approach

Model Adopted: Georgia DoSag – steady-state water quality model developed by Georgia Environmental Protection Division.

Calibration Data: USGS field data from June 1999.

Calibration Conditions:
(1) USGS flows measured in June 1999.
(2) USGS Temperatures measured in June 1999.
(3) Point source DMR data for June 1999.
(4) SOD values for 'mixed land uses' based on year-2000 TMDLs for the South 4 Basins.
(5) Depths, velocities, kinetic rates, reaeration, and boundary conditions based on 1999 USGS field data and/or GAEPD standard modeling practices.

Critical Conditions:
(1) 7Q10 flows recomputed to include data through 1998.
(2) Temperatures derived from historic trend monitoring data.
(3) Point source discharges at current permit limits.
(4) Same SOD for 'mixed land uses' as calibration conditions.
(5) Same depths, velocities, kinetic rates, reaeration, and boundary conditions as calibration conditions.

Natural Conditions:
(1) Same flows as critical conditions.
(2) Same temperatures as critical conditions.
(3) All point sources completely removed.

(4) SOD for natural (i.e., fully forested) land use based on year-2000 TMDLs for the South 4 Basins.
(5) Same depths, velocities, kinetic rates, reaeration, and boundary conditions as calibration conditions.

MOS: Implicit, based on the following conservative assumptions:
(1) Drought streamflows persist through the critical summer months at monthly 7Q10 flow values.
(2) Hot summer temperatures, based on the historical record, persist for the same critical period.
(3) All point sources discharge continuously at their NPDES permit limits for the same critical period.
(4) DO saturation, for all flows entering the system, equal those measured during the low DO period in the summer of 1999.
(5) Water depths are shallow, generally less than one foot, which aggravates the effect of SOD.
(6) Water velocities are sluggish, generally 0.5 fps or less, which intensifies the effect of BOD decay.

Seasonality: Dissolved oxygen data showed no impairments outside of the high-temperature, low-flow conditions which occur during the summer months.
Monitoring: Follow-up monitoring according to 5-year River Basin Planning cycle (Georgia EPD, 1996)
Approach: NPDES Permits for point sources; Best management practices for nonpoint sources.
Date Submitted: Draft on June 30, 2001, Final on February 2002.

Table 1-2. Summary of TMDLs for Dissolved Oxygen Listed Segments in the Altamaha River Basin.

SEGMENT NUMBER	STREAM	TMDL (lbs/day)
1	Alex Creek	34
2	Big Cedar Creek	29
3	Cobb Creek	160
4	Doctors Creek	85
5	Jacks Creek	63
6	Jones Creek	131
7	Little Ohoopee River (upper)	58
8	Little Ohoopee River (middle)	122
9	Little Ohoopee River (lower)	177
10	Milligan Creek	172
11	Oconee Creek	81
12	Ohoopee River (upper)	213
13	Ohoopee River (lower)	496
14	Pendleton Creek (upper)	71
15	Pendleton Creek (lower)	78
16	Penholoway River	141
17	Rocky Creek (lower)	87
18	Rocky Creek (upper)	36

19	Swift Creek	413
20	Ten Mile Creek	93
21	Thomas Creek	37
22	Tiger Creek	54
23	Yam Grandy Creek	27

2.0 TMDL Background

The State of Georgia is required to develop Total Maximum Daily Loads (TMDLs) for waters not meeting water quality standards, in accordance with Section 303(d) of the Clean Water Act and the U. S. Environmental Protection Agency (EPA) Water Quality Planning and Management Regulations (40 CFR Part 130). Water quality data collected by the United States Geological Survey (USGS) in 1999 indicate that a number of waterbodies in the Altamaha River Basin did not achieve water quality standards for dissolved oxygen (DO). These waterbodies were included in the state's 2000-303(d) list, along with the historical list of impaired segments, and proposed by the Georgia Environmental Protection Division (GAEPD).

There are 38 segments listed on the state's 2000-303(d) list as impaired for dissolved oxygen, with 23 in the Altamaha, 10 in the Ocmulgee, and 5 in the Oconee River Basins. The TMDLs are organized in 3 separate reports, 1 for each basin. This report presents the dissolved oxygen TMDLs for the 23 listed segments in the Altamaha River Basin identified in Table 1-1. The Altamaha River Basin is part of the Middle Three Basins in Georgia as shown in Figure 2-1. The three river basins, the Altamaha, Ocmulgee, and Oconee, are required by the consent decree to have TMDLs developed by June 30, 2001 (Sierra Club v. Hankinson 1997). As shown in the Table 2-1, there are two 8-digit Hydrologic Unit Codes (HUCs) within the Altamaha River Basin: the Ohoopee River Basin, HUC 03070107; and, the Altamaha River Basin, HUC 03070106. The Ohoopee River flows into the Altamaha River near Reidsville, GA.

Table 2-1. Summary of Georgia Middle 3 Dissolved Oxygen TMDLs.

River Basin	Drainage Area (square miles)	Impaired Segments	1999 WQ Stations	8-digit Hydrologic Unit Codes
Oconee	5,333	5	66	• Upper Oconee (HUC 03070101) • Lower Oconee (HUC 03070102)
Ocmulgee	6,086	10	86	• Upper Ocmulgee (HUC 03070103) • Lower Ocmulgee (HUC 03070104) • Little Ocmulgee (HUC 03070105)
Altamaha	2,852	23	35	• Altamaha (HUC 03070106) • Ohoopee (HUC 03070107)

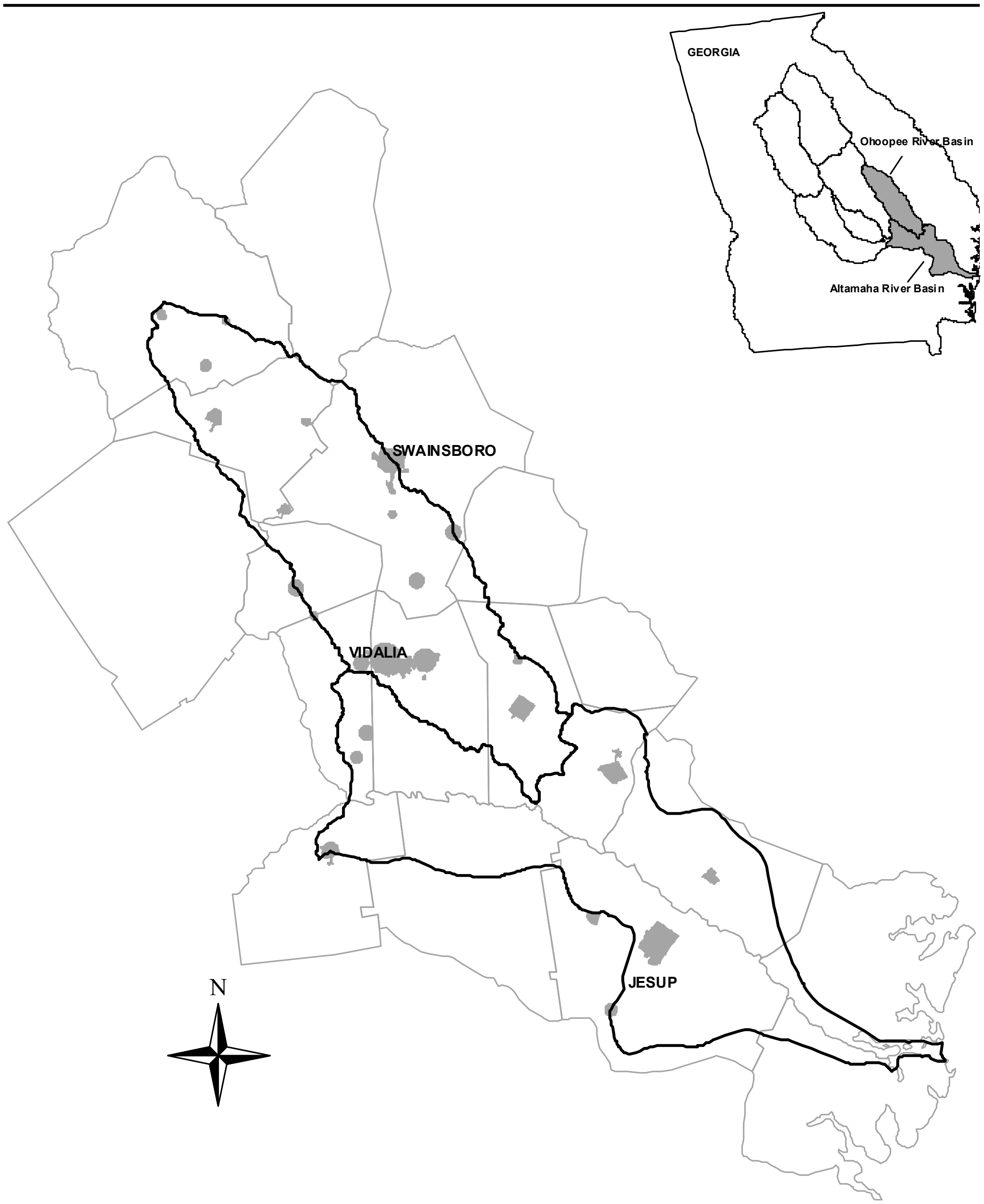


Figure 2-1. Location of the Altamaha River Basin.

3.0 Problem Understanding

USGS collected water quality data in Georgia during 1999. There were a total of 214 stations, including 187 in the Middle Three Basins. There were 35 water quality stations in the Altamaha River Basin for 1999. These data showed that dissolved oxygen impairments occurred exclusively during the summer months. Furthermore, all of the impairments were limited to small, headwater streams where the drainage areas are relatively small and dry weather flows are low, or zero. In the downstream reaches of larger watersheds where the flows are higher and not intermittent, and the assimilative capacity is therefore greater, the dissolved oxygen concentrations always met the minimum standard of 4.0 mg/L, and the daily average of 5.0 mg/L.

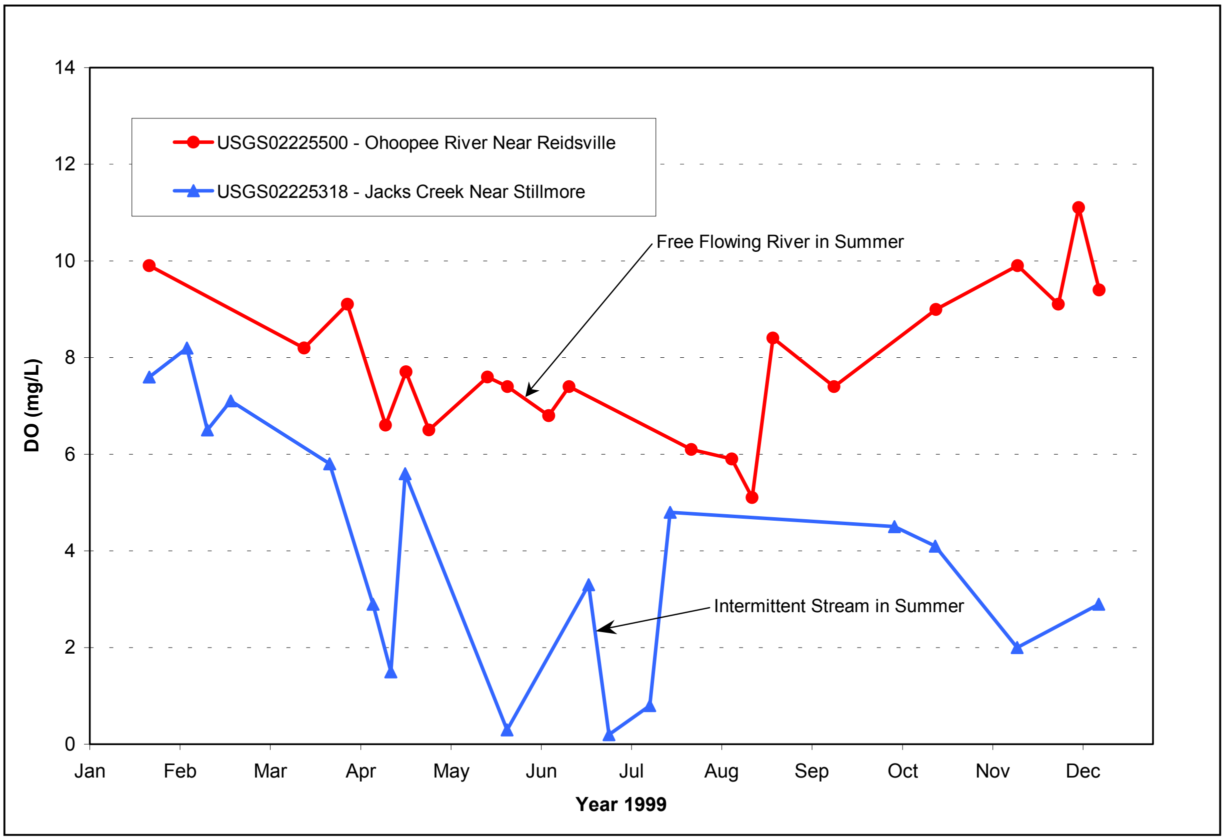


Figure 3-1. Comparison of Dissolved Oxygen Data at Two Ohoopee River Basin Locations.

Figure 3-1 illustrates this important finding by comparing measured DO levels in a non-intermittent, free-flowing stream to DO levels found in a small stream with low or no observable flow. The free flowing river data were collected at USGS 02225500 (GAEPD 06010001), which is located on the Ohoopee River at Reidsville near its confluence with the Altamaha River. This station also had historic trend data back to 1972, which showed no dissolved oxygen violations over the historic period of record. The other data in Figure 3-1 were collected at Jacks Creek near Stillmore, GA, a small headwater stream in the upper part of the Ohoopee River Basin. These two sets of data are representative of DO conditions observed at other stations in the basin.

GAEPD staff visited the Ohoopee River Basin on April 11, 2001 to observe stream characteristics such as velocities, depths, floodplain widths and vegetation, and adjacent land use. These characteristics have a direct bearing on low dissolved oxygen concentrations. At all sampling stations visited on the Ohoopee River mainstem and its tributaries, the streams flowed through dense, forested swamps with forested stream buffers. All of the visited sites were similar in that the stream would flow out of the shaded forested swamp, which receives a significant amount leaf litterfall, into small clearings for bridges and road access. At each clearing, direct sunlight, small patches of aquatic plants, and heavily vegetated floodplains were observed. Figure 3-2 depicts a sampling site on the Little Ohoopee River. Even though the site visit occurred during a period of higher flow, these essential characteristics are still apparent.

Figure 3-2. Picture of Sampling Site on Little Ohoopee River (SR56) Near Covena, GA.

Figures 3-3 and 3-4 show the impaired segments for dissolved oxygen and the water quality stations that indicated each impairment. All 23 segments shown in Table 1-1 were listed as a direct result of the 1999 dissolved oxygen data. Typically, there are some historical 303(d) listings, but this was not the case for the Altamaha River Basin.

All field data relevant to the Middle Three Basins TMDLs were compiled by GAEPD and included in electronic database files. The data are managed in the Water Resources Data Base (WRDB), a software database that was developed by GAEPD. Project data file(s) contain the following information comprising over a half million records:

1. Historic trend monitoring data through December 31, 1998,
2. 1999 GAEPD/USGS water quality data, and
3. Historic USGS daily average flow data through December 31, 1998.

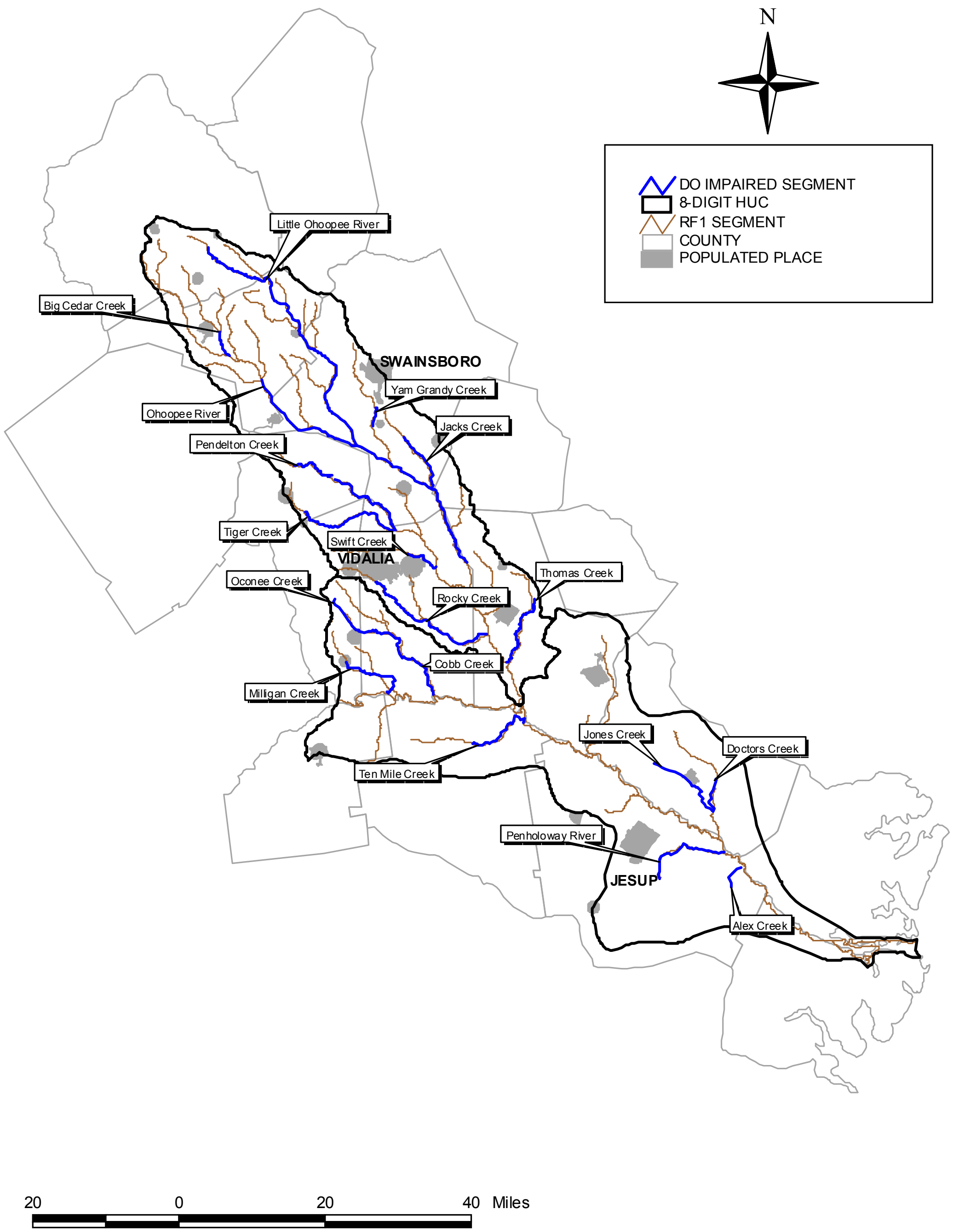


Figure 3-3. 303(d) Listed Segments for Dissolved Oxygen in the Altamaha River Basin.

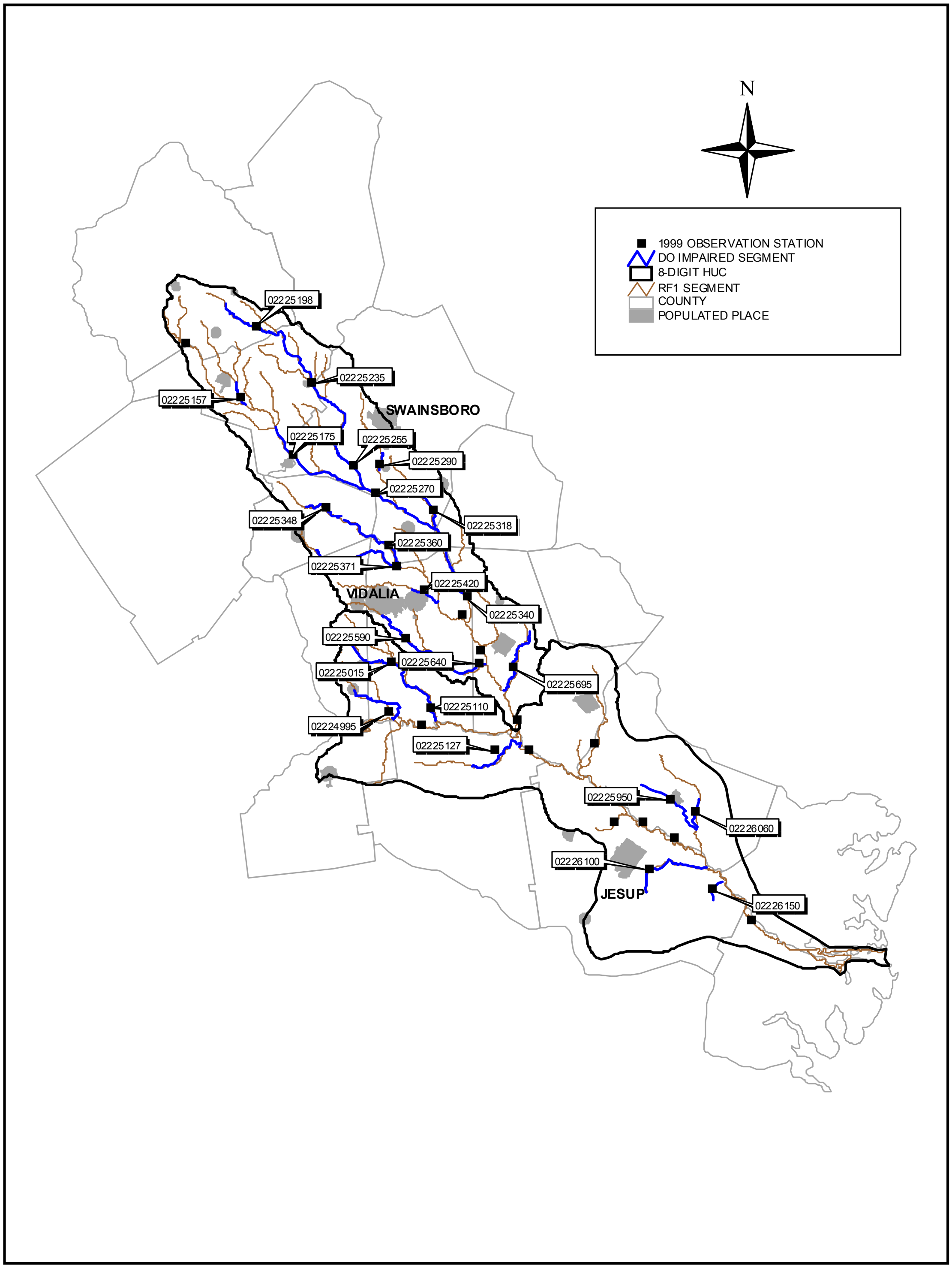


Figure 3-4. 1999 USGS Water Quality Stations in the Altamaha River Basin.

4.0 Water Quality Standards

All DO impaired waterbodies in the Altamaha River Basin have been assigned a water use classification of fishing. Georgia's water quality standards specify the following DO criteria for this use classification:

Numeric. A daily average of 5.0 mg/L and no less than 4.0 mg/L at all times for waters supporting warm water species of fish*. A daily average of 6.0 mg/L and no less than 5.0 mg/L at all times for waters designated as trout streams by the Wildlife Resource Division. (*There are no designated trout streams in the Altamaha River Basin).

Georgia EPD, 2000

Certain waters of the state may have conditions where dissolved oxygen is naturally lower than the numeric criteria specified above and therefore cannot meet these standards unless naturally occurring loads are reduced or streams are artificially or mechanically aerated.

Natural Water Quality. "It is recognized that certain natural waters of the State may have a quality that will not be within the general or specific requirements contained herein. This is especially the case for the criteria for dissolved oxygen, temperature, pH and fecal coliform. NPDES permits and best management practices will be the primary mechanisms for ensuring that the discharges will not create a harmful situation." 391-3-6-.03(7)

Georgia EPD, 2000

EPA Dissolved Oxygen Criteria were used to address these situations. Alternative EPA limits are defined as 90% of the naturally occurring dissolved oxygen concentration at critical conditions.

"Where natural conditions alone create dissolved oxygen concentrations less than 110 percent of the applicable criteria means or minima or both, the minimum acceptable concentration is 90 percent of the natural concentration." Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Freshwater), EPA440/5-86-003, April 1986.

US EPA, 1986

Accordingly, if the naturally occurring dissolved oxygen exceeds GAEPD numeric limits at critical conditions then the GAEPD numeric limits apply. If naturally occurring DO is lower than the GAEPD numeric limits then 90% of the natural DO will become the minimum allowable.

5.0 Source Assessment

Point Sources

GAEPD maintains a database of current NPDES Permits and GIS files that locate each permitted outfall. Monthly Discharge Monitoring Reports (DMRs) for 1999 were downloaded from the Permit Compliance System (PCS). Table 5-1 shows the 7 point sources in the Ohoopee River Basin and 2 in the Altamaha River Basin that discharge into or upstream of an impaired segment. Table 5-2 contains the June 1999 DMR data that were available for model development. Figure 5-1 shows the location of each facility relative to the impaired segments.

Table 5-1. Contributing Point Sources in the Altamaha River Basin.

NPDES Permit	Facility Name	Receiving Water	8-Digit HUC	County
GA0022900	Doc Rogers Correction Inst.	Ohoopee River	Ohoopee	Tattnall
GA0025488	Vidalia WPCP	Swift Creek	Ohoopee	Toombs
GA0032395	Wrightsville Pond	Big Cedar Creek	Ohoopee	Johnson
GA0033391	Lyons North WPCP #2	Swift Creek	Ohoopee	Toombs
GA0033405	Lyons Pond #1	Pendleton Creek	Ohoopee	Toombs
GA0049956	Tennille Pond	Dyers Creek	Ohoopee	Washington
GA0050059	Santa Claus Pond	Little Rocky Creek	Ohoopee	Toombs
GA0049166	Ludowici WPCP	Jones Creek	Altamaha	Long
GA0034771	Cato's MHP Lyons	Williams Creek	Altamaha	Toombs

Table 5-2. NPDES Permit Limits for Contributing Point Sources.

		June 1999 Monthly Average Permit Limits			
NPDES Permit	Facility Name	Flow (mgd)	DO (mg/L)	BOD5 (mg/L)	NH3 (mg/L)
GA0022900	Doc Rogers Correction Inst.	0.85	2	30	17.4
GA0025488	Vidalia WPCP	1.88	6	10	2
GA0032395	Wrightsville Pond	0.75	6	30	17.4
GA0033391	Lyons North WPCP #2	0.67	6	10	2
GA0033405	Lyons Pond #1	0.67	5	10	2
GA0049956	Tennille Pond	0.45	6	15	1.1
GA0050059	Santa Claus Pond	0.009	5	30	NA
GA0049166	Ludowici WPCP	0.24	5	30	NA
GA0034771	Cato's MHP Lyons	0.013	NA	30	NA

Notes: Vidalia, Lyons #1, and Lyons #2 have seasonal permit limits.
NA = not available.

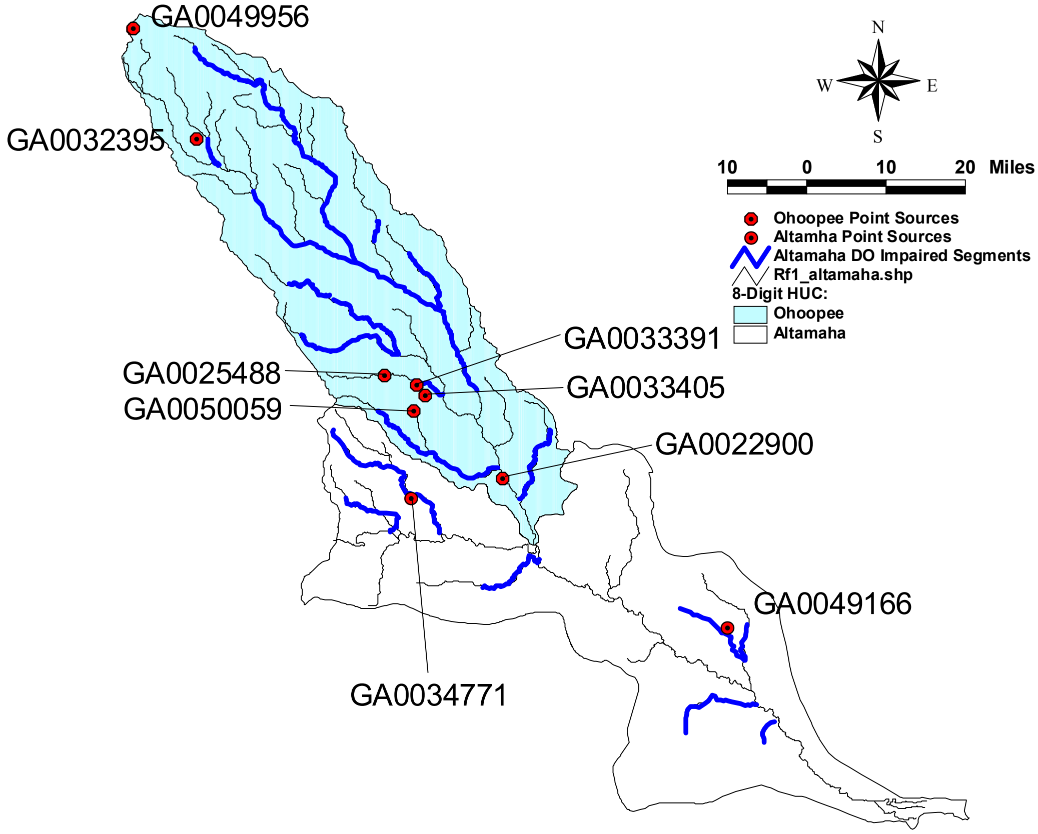


Figure 5-1. Contributing Sources in the Altamaha River Basin.

Nonpoint Sources – Surface Washoff and Leaf Litter Decay

In 1999, many streams in the basin were dry or had ponded areas and stagnant pools as a result of a 3-year drought in Georgia. Due to the absence of rainfall during the summer months of 1999, the critical time period, stormwater did not contribute any washoff of materials into the streams. Any constituents that may have washed off of disturbed land surfaces in previous months or years have either: (1) already flushed out of the system along with the water column flow; or, (2) a portion may have settled out to become a part of the stream channel bottom. In this manner, the historic washoff of settleable material could accumulate and exert an additional sediment oxygen demand attributable to man's land disturbing activities. The constituents of concern from surface washoff include the fraction of ammonia and BOD5 that become an integral part of channel bottom sediments and thus become a potential source of sediment oxygen demand. Table 5-3 describes the land use distributions associated with each impaired stream. Note the relatively high percentages of forested and wetland land uses combined and the low percentages of built up areas. This land use distribution typified the Altamaha and Ohoopee Basins.

Table 5-3. Land Uses Associated with Impaired Segments in the Altamaha River Basin.

Seg. #	Stream	Total Contributing Area (acres)	Cropland (%)	Pasture (%)	Forest (%)	Wetland (%)	Built-Up Impervious (%)	Built-Up Pervious (%)
1	Alex Creek	17,881	3.2	0.4	60.8	30.3	0.6	4.8
2	Big Cedar Creek	32,018	35.6	2.7	41.9	14.7	1.2	3.8
3	Cobb Creek	63,016	39.5	4.5	43.9	5.8	0.7	5.7
4	Doctors Creek	26,724	5.6	1.6	59.8	18.5	1.5	13.1
5	Jacks Creek	41,490	29.7	3.4	55.5	4.9	1.2	5.3
6	Jones Creek	72,646	4.2	0.8	55.5	31.5	1.0	7.0
7	Little Ohoopee River	29,414	26.4	2.0	47.3	18.5	0.6	5.2
8	Little Ohoopee River	90,207	31.0	3.0	44.6	15.2	0.7	5.5
9	Little Ohoopee River	159,209	27.5	2.9	49.7	11.8	0.8	7.3
10	Milligan Creek	28,703	41.4	4.5	39.7	4.9	1.1	8.4
11	Oconee Creek	19,456	34.4	3.9	49.5	5.3	0.7	6.1
12	Ohoopee River	189,360	29.4	4.5	49.3	10.8	0.8	5.1
13	Ohoopee River	496,737	28.6	3.4	50.4	10.5	1.0	6.1
14	Pendleton Creek	28,272	24.4	2.3	62.2	2.4	1.3	7.3
15	Pendleton Creek	68,959	25.5	3.4	57.0	4.6	1.4	8.0
16	Penholoway River	130,619	3.9	1.0	64.9	18.7	1.9	9.6
17	Rocky Creek	55,825	37.7	5.4	42.6	5.6	2.1	6.6
18	Rocky Creek	23,542	33.8	3.6	43.2	4.7	4.0	10.7
19	Swift Creek	35,662	35.7	7.2	41.3	7.1	1.9	6.7
20	Ten Mile Creek	61,817	24.7	3.6	56.9	6.1	1.0	7.6
21	Thomas Creek	27,695	31.9	2.8	51.9	4.0	1.3	8.0
22	Tiger Creek	43,049	31.4	6.1	49.3	5.4	1.0	6.7
23	Yam Grandy Creek	39,329	23.8	2.8	60.0	4.4	2.0	7.0

Most of the streams in the Altamaha Basin receive significant natural contributions of oxygen demanding organic materials from local wetlands and forested stream corridors, in addition to the aforementioned nonpoint sources of sediment oxygen demand associated with man's land disturbing activities. The following sources of naturally occurring organic materials have been identified:

- Adjacent wetlands and swamps with organically rich bottom sediments; and,
- Direct leaf litterfall onto water surfaces and adjacent floodplains from overhanging trees and vegetation.

Leaf litterfall is a major contributor to the amount of dissolved organic matter in the stream water column and the amount of sediment oxygen demand being exerted. Many streams in southern Georgia are also referred to as "blackwater" streams because of highly colored humic substances leached from surrounding marshes and swamps. In addition, low dissolved oxygen in blackwater streams is very common in the summer months when the temperatures are high and the flows are low (Meyer, 1992). The oxygen demanding effects of leaf litterfall were reflected here in two ways: (1) by lowering the DO saturation of water entering the channel from adjacent swampy areas caused by decaying vegetation; and, (2) by increasing SOD associated with vegetation decaying on stream channel bottoms.

6.0 Technical Approach

The technical approach is described by the steps below:

- Model Selection and Setup,
- Calibration Data,
- SOD Representation,
- Calibration Conditions,
- Critical Conditions,
- Natural Conditions, and
- Allocations

Model Selection and Setup
Initially, an analysis was performed to correlate indicated impairments to basic causes such as point and nonpoint contributions, flow conditions, stream and watershed characteristics, seasonal temperature effects, and others. From this analysis it was obvious that impairments coincided with low or zero flows, slow stream velocities, shallow water depths, and high temperatures. Inflows of very low dissolved oxygen waters from adjacent marshes and forested swamps compounded the situation. Since all of the impairments noted in 1999 occurred during sustained periods of consistently low flows, a steady-state modeling approach was adopted as appropriate to represent the relevant conditions in the impaired streams. The steady-state Georgia DoSag, developed by the Georgia Environmental Protection Division, was selected for the following reasons:

- It's simplified without unnecessary complexity.
- Conforms to GAEPD standard practices for developing wasteload allocations.
- Works well for low flow and high temperature conditions.
- Can be developed with a limited dataset, which existed in 1999.
- Able to handle branching tributaries and both point and nonpoint source inputs.

Georgia DoSag also provides a complete spatial view of a system, upstream to downstream, indispensible for understanding important differences in stream behavior at various locations throughout a basin. The model computes dissolved oxygen using an enhanced form of the Streeter-Phelps equation (Thomann and Mueller, 1987). It is applied to each stream reach over small incremental distance intervals.

There were a total of 9 DOSAG models developed to represent the 23 listed segments in the Altamaha River Basin. USGS quadrangle maps along with Arcview and MapInfo spatial graphics files were used to develop drainage areas, stream lengths, bed slopes, and other physical input data for each model.

Calibration Data
The model calibration period was determined from an examination of the USGS 1999 water quality data, for each station located on an impaired segment. The data were plotted and evaluated for streamflow, dissolved oxygen, water temperature, BOD5, and ammonia to determine a worst case for dissolved oxygen. The combination of the lowest, steady flow period with the lowest dissolved oxygen, and highest BOD concentrations, defined the critical modeling period. For all 23 of the impaired segments in this report, June 1999 was adopted as the critical period for model calibration. Accordingly, the 30-day average streamflow of 52.2 cfs for June

1999 at USGS 02225500 (Ohoopee River near Reidsville) was used to compute a productivity factor of 0.047 cfs/mi^2 (using a drainage area of 1,110 square miles). This productivity factor was applied consistently to the basin. The June 1999 average of dissolved oxygen, BOD5, and ammonia were also extracted from the dataset for each sampling station. BOD5 was converted to CBODU by multiplying by an f-ratio of 2.5 (standard GAEPD modeling practice) and ammonia was converted to NBODU by multiplying by the stoichometric conversion factor of 4.57. These values, thusly determined, were incorporated into the DoSag model calibration files.

SOD Representation

There were no field sediment oxygen demand (SOD) measurements in the Middle Three Basins. For the 2000 TMDLS in the South 4 Basins, there were several SOD measurements that ranged from 0.9 to 1.9 g/m^2/day. SOD is an important part of the oxygen budget in these shallow streams. Accordingly, it is necessary to be realistic in the development and application of SOD values in the Middle Three Basins models and to be consistent with last year's findings from the South 4 Basins. For this reason, an examination of SOD results from the year-2000 TMDLs in the South 4 Basins was performed. Results from all calibrated models of existing conditions in June 1998 were compiled and summarized. An average value of existing SOD was determined to be 1.35 g/m^2/day. This represented 12 models that had mixed land uses and varying degrees of point source activity. When the same 12 models were re-run under natural conditions (assuming zero point source discharges and completely forested watersheds), SOD averaged 1.25 g/m^2/day. These two values were adopted for the Middle Three Basins to represent SOD for: (1) mixed land uses, including agriculture; and, (2) natural or totally forested watersheds, respectively. From this, the anthropogenic nonpoint source contributions, those caused by man's land disturbing activities, are accounted for in the 0.1 g/m^2/day difference between the two adopted SOD values.

Calibration Conditions

Monthly average values of DO, CBODU, and NBODU for June 1999 were used as in-stream targets to calibrate the models as discussed previously. Calibration flows throughout the basin were set equal to 0.047 cfs/mi^2 derived from daily flow records at USGS 02225500 (Ohoopee River near Reidsville). Water temperature varied across the basin using June 1999 monthly averages from each sampling station. Point source discharges were put into the model at their June 1999 DMR values for DO, BOD5, NH3, and flow. Headwater and tributary water quality boundaries were developed from in-stream field data, expected low DO saturation values (Meyer, 1992), and GAEPD standard modeling practices. SOD was set to 1.35 g/m^2/day to reflect mixed land uses. Figure 6-1 depicts a longitudinal dissolved oxygen calibration curve for the mainstem of the Ohoopee River developed using this approach. The Ohoopee River serves as a good illustrative example because it had more instream sampling stations than any other listed segment and thus can provide the best indication of the success to be expected from this modeling approach throughout a river system and for other river basins. The reader is free to judge the success of this calibration. However, considering the serious scarcity of field data to work with and the fact that major portions of the Ohoopee River Basin had low or no observable flow, this calibration is viewed as exceptionally good. Accordingly, the DoSag models developed for TMDL analysis can be viewed as dependable and instructive.

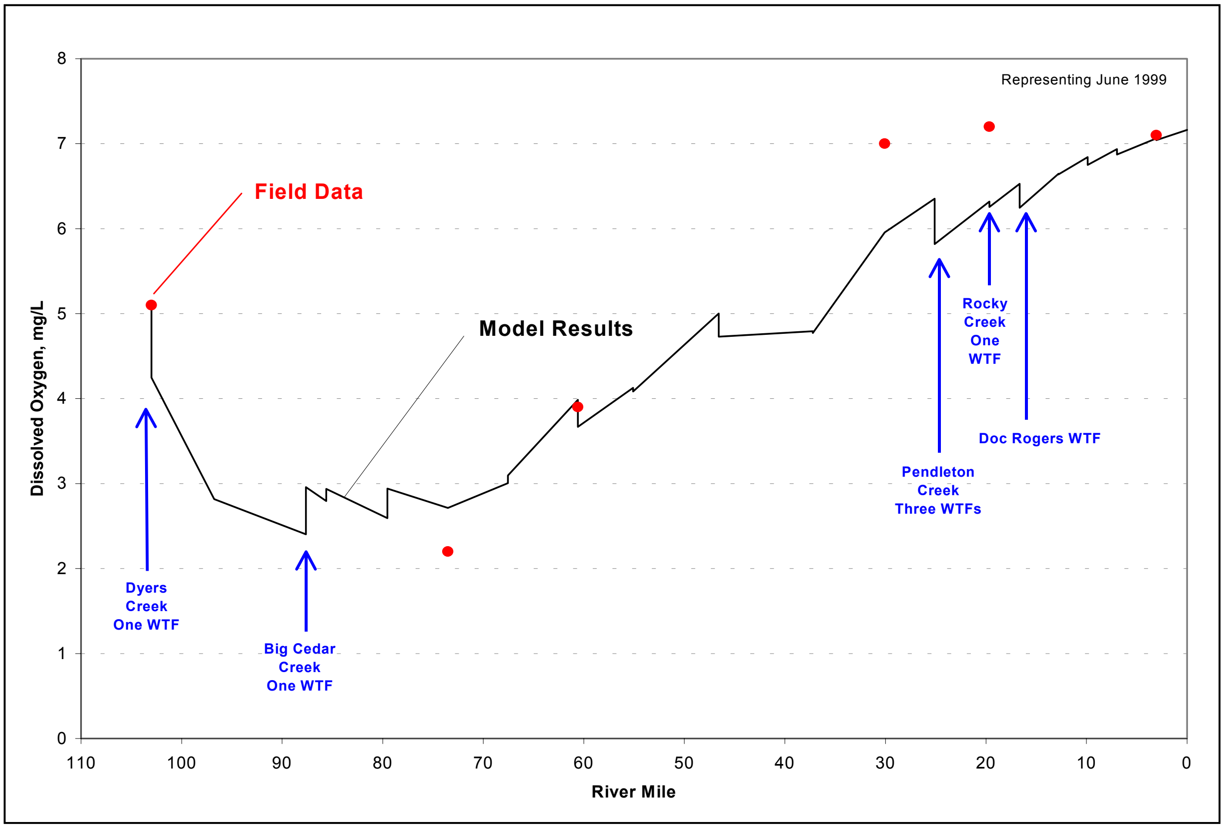


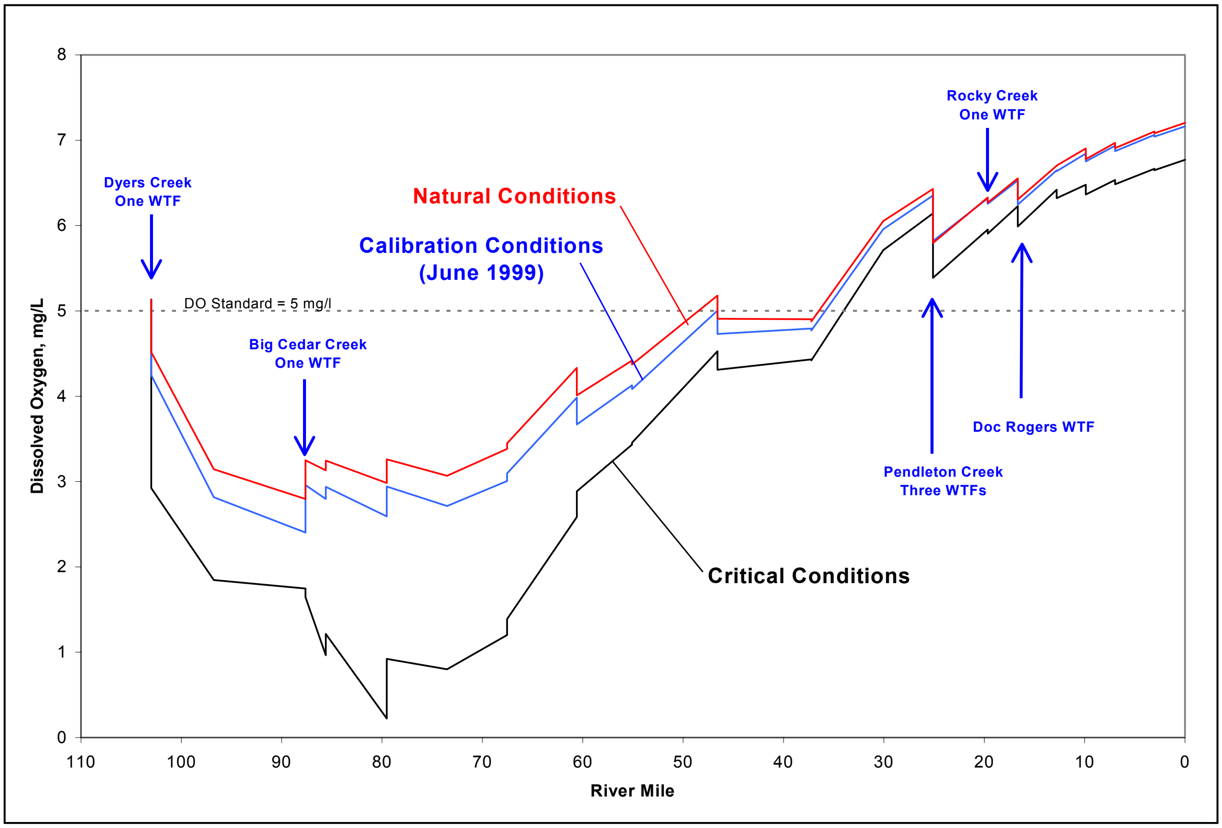
Figure 6-1. Dissolved Oxygen Calibration for the Ohoopee River.

Critical Conditions

Model critical conditions were developed, in accordance with GAEPD standard practices, to assess dissolved oxygen standards, to determine if a problem exists requiring regulatory intervention, and to establish a level of protection if necessary. To do this, each calibrated model was modified in the following manner. For flows, a 7Q10 flow (the minimum 7-day average flow that occurs once in 10 years on the average) was adopted consistent with provisions in Georgia's Water Quality Regulations. Older published 7Q10 flow values in the USGS report (Carter and Fanning, 1982) only considered data through 1979. To account for the droughts in the late 1980s and 1990s, new monthly 7Q10 flow values were calculated; and, an average of the June through September 7Q10 low flows was adopted. Productivity factors were then calculated from the revised 7Q10 flow values and applied uniformly throughout the basin. The adopted productivity factor equaled 0.04 cfs/mi^2. Critical water temperatures were developed by examining the long-term trend monitoring data and fitting a harmonic sine function to all of the historical data at a given station. A June through August average temperature from the harmonic fit was used to represent each trend station. Critical temperatures in other locations in the basin were prorated on the basis of June 1999 field data. Point sources were incorporated into the critical conditions models at their current NPDES Permit limits. Water quality boundaries and all other modeling rates and constants were the same as those in the calibrated models, including SOD = 1.35 g/m^2/day representing mixed land uses. To determine the effects of point sources alone, at critical conditions, a parallel set of model runs were made with point source flows set equal to zero.

Natural Conditions

For the natural conditions runs, two relevant changes were made to the critical conditions models. First, SOD was changed from 1.35 g/m^2/ day to 1.25 g/m^2/day to reflect the change from mixed land uses to natural or completely forested land uses. And second, all point source discharges were completely removed. All other model parameters remained the same. The results of the natural conditions runs are plotted in Figure 6-2 along with the June 1999 and critical conditions results for comparison. It's important to note: (1) even though DO was found to be low in the summer of 1999 the results are even lower at standard critical conditions; (2) June 1999 conditions are very close to natural conditions and compare favorably with the 90% of natural DO standard; and, (3) downstream of river mile 35-40 the critical DO rises above 5 mg/L indicating that the GAEPD numeric standard applies in that reach of the River and that a



DO violation does not occur. DoSag models for other impaired reaches can be used to develop similar insights.

Figure 6-2. June 1999, Critical, and Natural Conditions for the Ohoopee River.

Allocations

Allocations were based on EPA Dissolved Oxygen Criteria that states if the natural dissolved oxygen is less than the standard, then only a 10% reduction in the natural condition is allowed. Or, the target limits are defined as 90% of the naturally occurring dissolved oxygen concentration at critical conditions. This target and critical dissolved oxygen results for the Ohoopee River are plotted in Figure 6-3. Two conditions are apparent. First, upstream between river miles 50 and 105 the total cause of oxygen deficits below the 90% of natural standard are two point sources, one on Dyers Creek and the other on Big Cedar Creek. And second, downstream between river miles zero and 40, the free flowing portion of the Ohoopee River, the effects of all point sources in the basin combined are small, and dissolved oxygen at critical conditions rises above the standard of 5 mg/L. This means that regulatory intervention will not be required for the downstream free flowing stretches of the Ohoopee River; but, intervention will be required upstream where dry weather flows are low or zero and stream channels are dominated by the point source discharges. For the Ohoopee River Basin, therefore, 2 point sources will need to be removed completely. They are Tennille Pond (GA0049956) and Wrightsville Pond (GA0032395). There are 2 additional point sources in the Pendleton Creek watershed that need to be reduced by 50%. They are Vidalia WPCP (GA0025488) and Lyons North WPCP #2 (GA0033391). The other 3 point sources in the Ohoopee River Basin do not need reductions.

Figure 6-3 also shows the influence of agricultural nonpoint sources, that is, with point sources removed. The plot includes the target dissolved oxygen concentration (equal to 90% of the natural conditions) and two other sets of model results: (1) with both point and nonpoint sources; and, (2) with nonpoint sources alone. The critical condition without point sources but including nonpoint source (labeled No PS) shows dissolved oxygen above the target line for almost all of the Ohoopee River. From this, the agriculture nonpoint source by itself does not exceed the 10% of natural limit and therefore would not need regulatory intervention. The only exception being, around river mile 80 and 90, where it briefly crosses below the target line. This small excursion is well within model accuracy and could easily be affected by the persistence of low flows during critical conditions.

Figure 6-4 represents a different type of allocation scenario, a watershed that is impaired for DO but does not contain any point sources. The plots in Figure 6-4 are from the Little Ohoopee River where agriculture, which comprises 30% of the watershed, contributes the anthropogenic, nonpoint source load. Moreover, this level of agricultural contribution is typical for all impacted segments in the basin. The results show that the DO at critical conditions, reflecting the full effect of agricultural activities, is consistently above the target DO of 90% of natural conditions. Therefore, no load reductions would be necessary in this watershed because nonpoint contributions do not consume more than 10% of the naturally occurring DO.

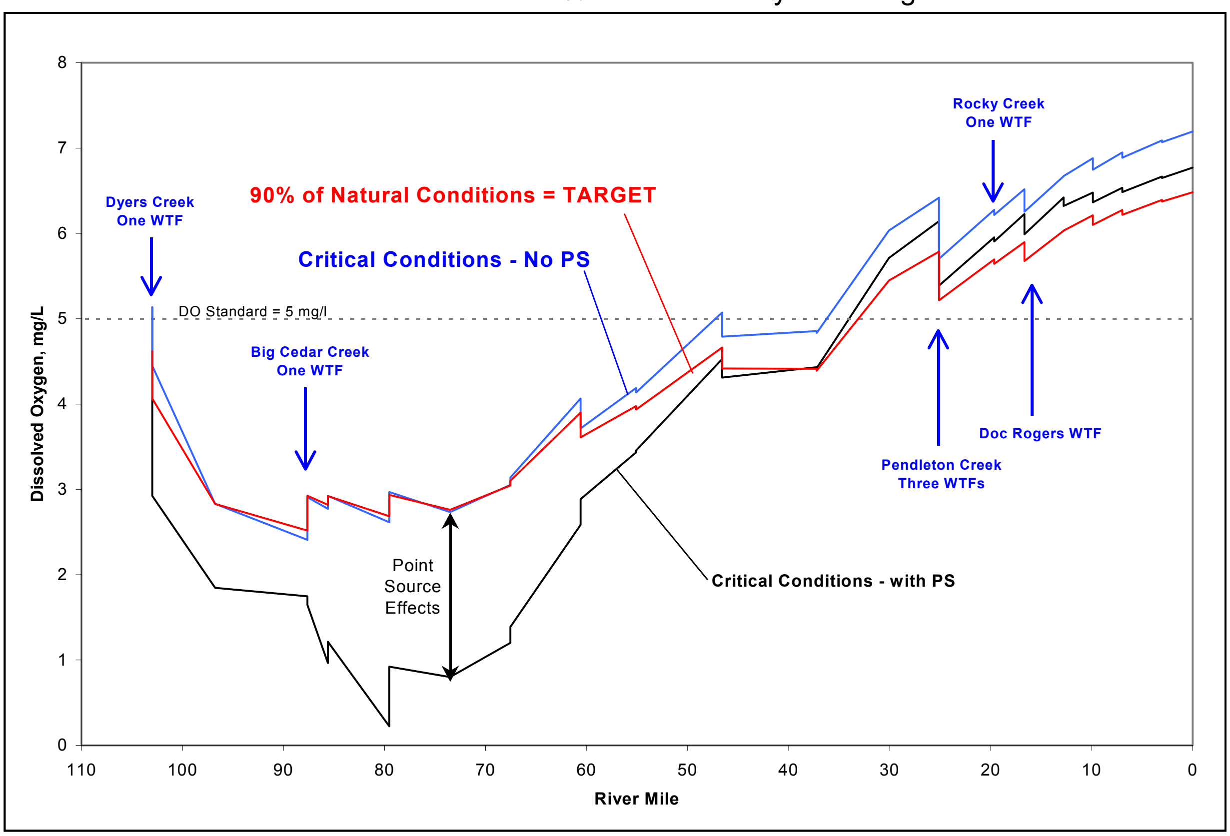


Figure 6-3. Critical, Critical Without Point Sources, and 90% of Natural Conditions of the Ohoopee River Basin.

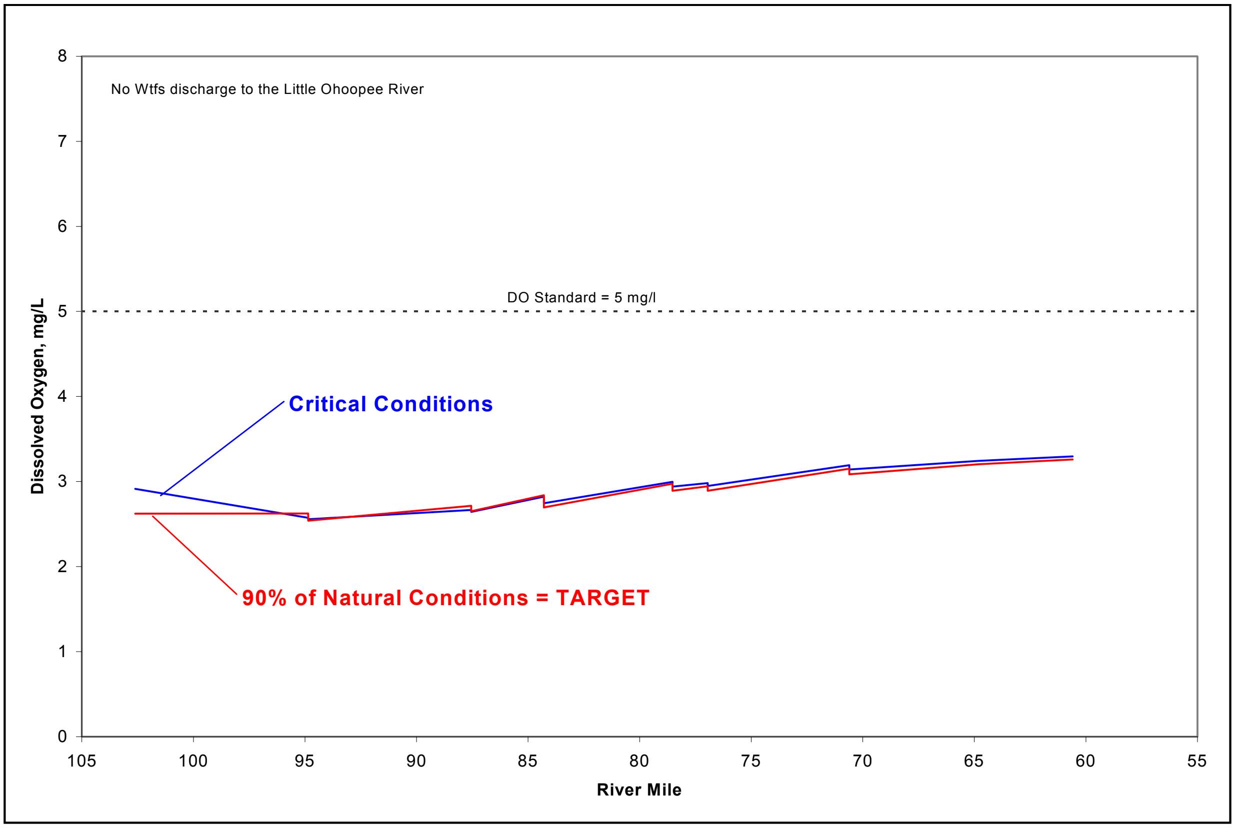


Figure 6-4. Critical Conditions and 90% of Natural Conditions for a Watershed without Point Sources (Little Ohoopee River).

7.0 Loading Capacity

The first step in the process was to determine naturally occurring dissolved oxygen concentrations for the impaired waterbodies. By doing so, the applicable water quality standard used for TMDL development can be identified.

To determine naturally occurring dissolved oxygen concentrations, the steady-state DOSAG models were run, at critical conditions, with zero point source inputs and nonpoint source inputs representing forested or wetland conditions free from man's influences. According to EPA Dissolved Oxygen Criteria, the target limits were identified as 90% of the naturally occurring concentration.

After identifying the dissolved oxygen target limits, the models were run at critical conditions to determine the loading capacity of the waterbody. This was accomplished through a series of simulations aimed at meeting the dissolved oxygen target limit by varying source contributions. The final acceptable scenario represented the TMDL (and loading capacity of the waterbody).

8.0 Waste Load and Load Allocations

Two critical components of the TMDL are the Waste Load Allocations (WLAs) and the Load

Allocations (LAs). The WLAs represent the load allocations to point source facilities contributing to impaired waterbodies, while the LAs represent load allocations to the nonpoint source contributions. WLAs and LAs sum to represent the entire TMDL, because MOS is implicitly considered through model assumptions.

The partitioning of allocations between point (WLA) and nonpoint (LA) sources shown in Table 8-1 was based on modeling results and professional judgment to meet the TMDL. The existing WLA is separated into ‘Direct’ and ‘Upstream’ contributions. The ‘Direct’ loads are the point source loads discharging directly into the impaired stream segment. The ‘Upstream’ load is one that discharges in an upstream segment and is transported downstream into the impaired segment. The model was used to account for in-stream, kinetic processes that would occur from the discharge point to the upstream boundary of the impaired segment. The WLAs may be modified by GAEPD during the NPDES permitting process. The TMDLs will be used to assess the permit renewals in the impaired segments. The nonpoint source loads for the Existing LA and TMDL were computed from the model boundary conditions, which include the stream, tributary, and headwater model boundaries.

Table 8-1. Existing and TMDL Loads for Impaired Segments in the Altamaha River Basin.

Segment Number	Stream	Existing Direct WLA (lbs/day)	Existing Upstream WLA (lbs/day)	Existing LA (lbs/day)	Total Existing Load (lbs/day)	TMDL (lbs/day)	% Reduction WLA	% Reduction LA
1	Alex Creek	NA	NA	34	34	34	NA	None
2	Big Cedar Creek	873	NA	29	902	29	100%	None
3	Cobb Creek	6.5	NA	160	160	160	None	None
4	Doctors Creek	NA	NA	85	85	85	NA	None
5	Jack's Creek	NA	NA	63	63	63	NA	None
6	Jones Creek	14	NA	131	131	131	None	None
7	Little Ohoopee River (upper)	NA	NA	58	58	58	NA	None
8	Little Ohoopee River (middle)	NA	NA	122	122	122	NA	None
9	Little Ohoopee River (lower)	NA	NA	177	177	177	NA	None
10	Milligan Creek	NA	NA	172	172	172	NA	None
11	Oconee Creek	NA	NA	81	81	81	NA	None
12	Ohoopee River (upper)	NA	794	213	1007	213	100%	None
13	Ohoopee River (lower)	0	598	496	1095	496	100%	None
14	Pendleton Creek (upper)	NA	NA	71	71	71	NA	None
15	Pendleton Creek (lower)	NA	NA	78	78	78	NA	None
16	Penholoway River	NA	NA	141	141	141	NA	None
17	Rocky Creek (lower)	5	NA	82	87	87	None	None
18	Rocky Creek (upper)	NA	NA	36	36	36	NA	None

19	Swift Creek	218	534	36	788	413	50%	None
20	Ten Mile Creek	NA	NA	93	93	93	NA	None
21	Thomas Creek	NA	NA	37	37	37	NA	None
22	Tiger Creek	NA	NA	54	54	54	NA	None
23	Yam Grandy Creek	NA	NA	27	27	27	NA	None

9.0 Margin of Safety

The margin of safety (MOS) is required in the TMDL development process. There are two basic methods for incorporating the MOS into the TMDL (USEPA 1991):

- Implicitly incorporate the MOS using conservative model assumptions.
- Explicitly specify a portion of the total TMDL as the MOS.

MOS was incorporated implicitly in this dissolved oxygen TMDL development based on the following conservative assumptions:

- Drought streamflows that persist through the critical summer months at monthly 7Q10 flow values.
- Hot summer temperatures, based on the historical record, that persist for the same critical period.
- All point sources discharge continuously at their NPDES Permit limits for the same critical period.
- DO saturation, for all flows entering the system, equal to those measured during the low DO period in the summer of 1999.
- Shallow water depths, generally less than one foot, which aggravates the effect of SOD.
- Slow water velocities, generally 0.5 fps or less, which intensifies the effect of BOD decay.

10.0 Seasonal Variation

The Statute and regulations require that a TMDL be established with consideration of seasonal variations. Since impairments occurred only during critical summer months, and not during other times of year, a seasonal variation in the TMDL was neither necessary nor appropriate.

11.0 Monitoring Plan

The GAEPD has adopted a basin approach to water quality management; an approach that divides Georgia's major river basins into five groups. Each year, the GAEPD water quality monitoring resources are concentrated in one of the basin groups. One goal is to continue to monitor 303(d) listed waters. This monitoring will occur in the next monitoring cycle for the Altamaha in 2004 and will help further characterize water quality conditions resulting from the implementation of best management practices in the watershed.

12.0 Point and Nonpoint Source Approaches

Permitted discharges will be regulated through the NPDES permitting process described in this report. GAEPD is working with local governments, agricultural, and forestry agencies such as the Natural Resources Conservation Service, The Regional Development Councils, the Georgia

Soil and Water Conservation Commission, and the Georgia Forestry Commission to foster the implementation of best management practices to address nonpoint sources. In addition, public education efforts will be targeted to individual stakeholders to provide information regarding the use of best management practices to protect water quality.

13.0 Public Participation

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

14.0 Initial TMDL Implementation Plan

EPD has coordinated with EPA to prepare this Initial TMDL Implementation Plan for this TMDL. EPD has also established a plan and schedule for development of a more comprehensive implementation plan after this TMDL is established. EPD and EPA have executed a Memorandum of Understanding that documents the schedule for developing the more comprehensive plans. This Initial TMDL Implementation Plan includes a list of best management practices and provides for an initial implementation demonstration project to address one of the major sources of pollutants identified in this TMDL while State and/or local agencies work with local stakeholders to develop a revised TMDL implementation plan. It also includes a process whereby EPD and/or Regional Development Centers (RDCs) or other EPD contractors (hereinafter, "EPD Contractors") will develop expanded plans (hereinafter, "Revised TMDL Implementation Plans").

This Initial TMDL Implementation Plan, written by EPD and for which EPD and/or the EPD Contractor are responsible, contains the following elements.

1. EPA has identified a number of management strategies for the control of nonpoint sources of pollutants, representing some best management practices. The "Management Measure Selector Table shown below identifies these management strategies by source category and pollutant. Nonpoint sources are the primary cause of excessive pollutant loading in most cases. Any wasteload allocations in this TMDL will be implemented in the form of water-quality based effluent limitations in NPDES permits issued under CWA Section 402. See 40 C.F.R. § 122.44(d)(1)(vii)(B). NPDES permit discharges are a secondary source of excessive pollutant loading, where they are a factor, in most cases.

2. EPD and the EPD Contractor will select and implement one or more best management practice (BMP) demonstration projects for each River Basin. The purpose of the demonstration projects will be to evaluate by River Basin and pollutant parameter the site-specific effectiveness of one or more of the BMPs chosen. EPD intends that the BMP demonstration project be completed before the Revised TMDL Implementation Plan is issued. The BMP demonstration project will address the major category of contribution of the pollutant(s) of concern for the respective River Basin as identified in the TMDLs of the watersheds in the River Basin. The demonstration project need not be of a large scale, and may consist of one or more measures from the Table or equivalent BMP measures proposed by the EPD Contractor and approved by EPD. Other such measures may include those found in EPA's "Best Management Practices Handbook", the "NRCS National Handbook of Conservation Practices, or any similar reference, or measures that the volunteers, etc., devise that EPD approves. If for any reason the EPD Contractor does not complete the BMP demonstration project, EPD will take responsibility for doing so.

3. As part of the Initial TMDL Implementation Plan the EPD brochure entitled "Watershed Wisdom -- Georgia's TMDL Program" will be distributed by EPD to the EPD Contractor for use with appropriate stakeholders for this TMDL, and a copy of the video of that same title will be provided to the EPD Contractor for its use in making presentations to appropriate stakeholders, on TMDL Implementation plan

development.

4. If for any reason an EPD Contractor does not complete one or more elements of a Revised TMDL Implementation Plan, EPD will be responsible for getting that (those) element(s) completed, either directly or through another contractor.

5. The deadline for development of a Revised TMDL Implementation Plan, is the end of August, 2003.

6. The EPD Contractor helping to develop the Revised TMDL Implementation Plan, in coordination with EPD, will work on the following tasks involved in converting the Initial TMDL Implementation Plan to a Revised TMDL Implementation Plan:
   A. Generally characterize the watershed;
   B. Identify stakeholders;
   C. Verify the present problem to the extent feasible and appropriate, (e.g., local monitoring);
   D. Identify probable sources of pollutant(s);
   E. For the purpose of assisting in the implementation of the load allocations of this TMDL, identify potential regulatory or voluntary actions to control pollutant(s) from the relevant nonpoint sources;
   F. Determine measurable milestones of progress;
   G. Develop monitoring plan, taking into account available resources, to measure effectiveness; and
   H. Complete and submit to EPD the Revised TMDL Implementation Plan.

7. The public will be provided an opportunity to participate in the development of the Revised TMDL Implementation Plan and to comment on it before it is finalized.

8. The Revised TMDL Implementation Plan will supersede this Initial TMDL Implementation Plan when the Revised TMDL Implementation Plan is approved by EPD.

Management Measure Selector Table

Land Use	Management Measures	Fecal Coliform	Dissolved Oxygen	pH	Sediment	Temperature	*Toxicity*	*Mercury*	Metals (copper, lead, zinc, cadmium)	PCBs, toxaphene
Agriculture	1. Sediment & Erosion Control	_	_		_	_				
	2. Confined Animal Facilities	_	_							
	3. Nutrient Management	_	_							
	4. Pesticide Management		_							
	5. Livestock Grazing	_	_		_	_				
	6. Irrigation		_		_	_				
Forestry	1. Preharvest Planning				_	_				
	2. Streamside Management Areas	_	_		_	_				
	3. Road Construction &Reconstruction		_		_	_				
	4. Road Management		_		_	_				
	5. Timber Harvesting		_		_	_				
	6. Site Preparation & Forest Regeneration		_		_	_				
	7. Fire Management	_	_	_	_	_				
	8. Revegetation of Disturbed Areas	_	_	_	_	_				
	9. Forest Chemical Management		_			_				
	10. Wetlands Forest Management	_	_	_		_		_		

Land Use	**Management Measures**	Fecal Coliform	Dissolved Oxygen	pH	Sediment	Temperature	*Toxicity*	*Mercury*	Metals (copper, lead, zinc, cadmium)	PCBs, toxaphene
Urban	1. New Development	–	–		–	–			–	
	2. Watershed Protection & Site Development	–	–		–	–		–	–	
	3. Construction Site Erosion and Sediment Control		–		–	–				
	4. Construction Site Chemical Control		–							
	5. Existing Developments	–	–		–	–			–	
	6. Residential and Commercial Pollution Prevention	–	–							
Onsite Wastewater	1. New Onsite Wastewater Disposal Systems	–	–							
	2. Operating Existing Onsite Wastewater Disposal Systems	–	–							
Roads, Highways and Bridges	1. Siting New Roads, Highways & Bridges	–	–		–	–			–	
	2. Construction Projects for Roads, Highways and Bridges		–		–	–				
	3. Construction Site Chemical Control for Roads, Highways and Bridges		–							
	4. Operation and Maintenance- Roads, Highways and Bridges	–	–			–			–	

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