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1.0 INTRODUCTION

Weiss Lake lies in the Upper Coosa (HUC# 03150105) Watershed in northeastern Alabama (Figure 1-1). Its watershed, which has a drainage area of approximately 5,273 square miles, extends into Georgia and southern Tennessee. Weiss Lake is the upper most lake in a chain of lakes located on the Coosa River. The Coosa River flows through Weiss Lake discharging through the Weiss Dam. The Dam is located approximately 226 miles upstream from the confluence of the Coosa and Tallapoosa Rivers. These two rivers merge together to form the Alabama River.

Weiss Lake extends approximately 52 miles upstream from the Weiss Dam. Weiss Dam was built in 1961 and is a gravity concrete and earth-fill structure that is approximately 86 ft. tall. The lake has a surface area of 30,200 acres at the normal water surface elevation of 564 ft msl. The lake has 447 miles of shoreline and a maximum depth of 62 ft at the dam and an average depth of 10.2 ft. The storage capacity of Weiss Lake at the normal pool elevation is 306,331 acre-ft.

The lake is primarily used for hydroelectric generation; however, its other uses include flood control, navigation flow augmentation, maintenance of downstream water quality, irrigation, and recreation. The lake also serves as an excellent habitat for fish and wildlife. Although Weiss Lake is used for flood control, there is a limited amount of storage that is available in the lake. Therefore, the operation of the lake is coordinated with the other lakes in the Coosa River chain to minimize flooding.

The water circulation information is critically important for simulation of transport of water quality constituents. This report summarizes the work performed for the Weiss Lake Hydrodynamic and Water Quality Models Development. This work was performed for the Environmental Protection Agency (EPA) Region 4, under contract 68-C-02-108, Task Order 128. The intent of this effort is to build a group of models that will predict the movement of water and the changes in water quality parameters within Weiss Lake.

The hydrodynamics of the lake were modeled with the Environmental Fluid Dynamics Code (EFDC). EFDC while the water quality was modeled using the Water Quality Analysis Simulation Program (WASP) ver 7.2.

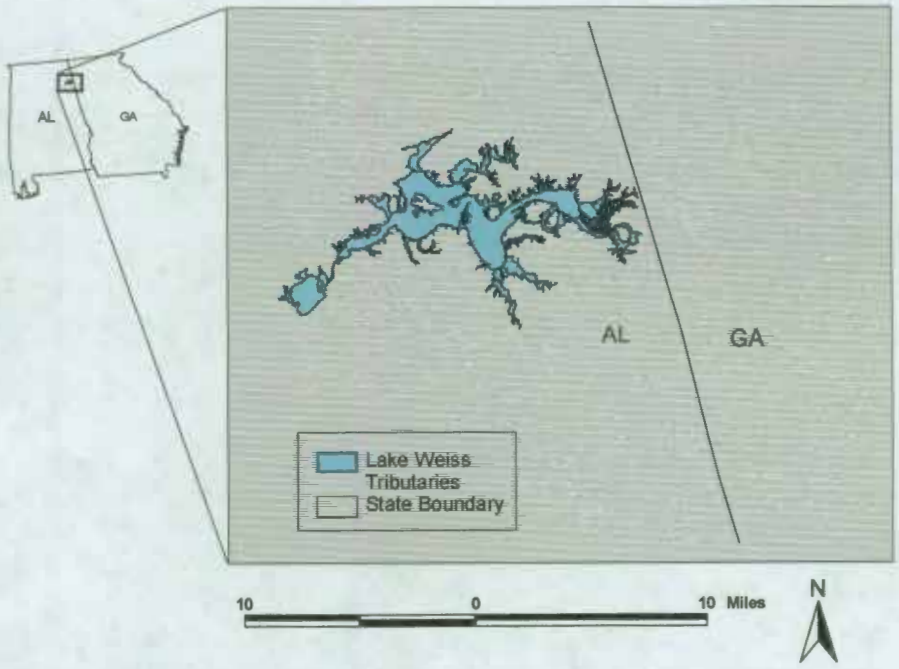

Figure 1-1 Location of Weiss Lake

2.0 MODEL BACKGROUND

2.1 EFDC Hydrodynamic Model

The three-dimensional hydrodynamics of Weiss Lake was modeled using the Environmental Fluid Dynamics Code (EFDC). EFDC was applied with measured inflows at the Coosa and Chattooga Rivers' upstream boundaries, as well as inflows from the lake sub-watersheds obtained from the Loading Simulation Program C++ (LSPC) watershed model. Measured flows released from Weiss Dam and spillway and point sources flows were also considered. Water surface elevation, flows, and temperature were simulated using EFDC.

EFDC is a hydrodynamic modeling package for simulating one-dimensional, two-dimensional, and three-dimensional flow and transport in surface water systems including: rivers, lakes, estuaries, reservoirs, wetlands, and nearshore 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 (Hamrick, 1992).

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 motion 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-Yamada level 2.5 turbulence closure scheme (Mellor & Yamada, 1982; Galperin et al., 1988).

The EFDC model uses 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 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 EFDC model uses either a stretched (sigma) vertical coordinate or a generalized vertical coordinate (Z) option. The EFDC model was originally formulated with a sigma or stretched vertical coordinate. In the sigma coordinate formulation, the number of vertical layers is the same at all horizontal locations in the model grid. Although this formulation is widely accepted, conceptually attractive and adequate for a large range of applications, it may be subject to internal pressure gradient errors (Mellor *et al.*, 1994, 1998). There are a number of applications where a traditional Z or physical vertical grid is desirable, such as deep reservoirs with rapid and large lateral bathymetric changes. There are a number of alternatives for mixing both sigma and physical vertical coordinate systems in a single domain. These include the sigma over Z grid (Martin, 2000) and the generalized sigma grid, often referred to as the S grid (Ezer and Mellor, 2004). A somewhat different approach has been taken in EFDC to arrive at hybrid or generalized vertical grid. The approach allows the horizontal model domain to be partitioned into sigma regions and what can be referred to as laterally constrained, localized sigma regions (LCL sigma). In the LCL region, the number of active vertical layers is variable, while in the sigma region, the number of vertical layers is constant. The vertical coordinate transformation in the LCL sigma region is based on a minor modification of the rescaled height coordinate transformation (Stacey, et al., 1995; Adcroft and Campin, 2004). Although the LCL transformation includes the sigma transformation as a special case, the vertical grid behavior has strong similarities with the traditional Z vertical grid, with the advantage of the free surface being a constant coordinate surface.

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.

2.2 WASP Water Quality Model

The Water Quality Analysis Simulation Program Version 7.2 (WASP7) was used for the water quality model development described in this report. WASP7 was released by USEPA on April 27, 2005 on the Modeling Toolbox website (http://www.epa.gov/athens/wwqtsc/html/wasp.html). WASP7 is the new version of WASP with many upgrades to the user's interface and the model's capabilities. The major upgrades to WASP have been the addition of multiple BOD components, addition of sediment diagenesis routines, and addition of periphyton routines. Figure 2-1 shows a diagram for the water quality model used in this application.

WASP7 is an enhanced Windows version of the USEPA Water Quality Analysis Simulation Program (WASP). The Windows version WASP7 has been developed to aid modelers in the implementation of WASP. With the new WASP7, model execution can be performed up to ten times faster than the previous USEPA DOS version of WASP. Nonetheless, WASP7 uses the same algorithms to solve water quality problems as those used in the DOS version of WASP. WASP7 contains 1) a user-friendly Windows-based interface, 2) a pre-processor to assist modelers in the processing of data into a format that can be used in WASP7, 3) high-speed WASP eutrophication and organic chemical model processors, and 4) a graphical postprocessor (MOVEM) for the viewing of WASP7 results and comparison to observed field data.

The new release of USEPA WASP was an enhancement of the original WASP (Di Toro et al., 1983; Connolly and Winfield, 1984; Ambrose, R.B. et al., 1988). WASP is a dynamic compartment-modeling 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. WASP comes with two such models -- TOXI for toxicants and EUTRO for conventional water quality. Earlier versions of WASP have been used to examine eutrophication of Tampa Bay; phosphorus loading to Lake Okeechobee; eutrophication of the Neuse River and estuary; eutrophication and PCB pollution of the Great Lakes (Thomann, 1975; Thomann et al., 1976; Thomann et al, 1979; Di Toro and Connolly, 1980), eutrophication of the Potomac Estuary (Thomann and Fitzpatrick, 1982), kepone pollution of the James River Estuary (O'Connor et al., 1983), volatile organic pollution of the Delaware Estuary (Ambrose, 1987), and heavy metal pollution of the Deep River, North Carolina (JRB, 1984). In addition to these, numerous applications are listed in Di Toro et al., 1983.

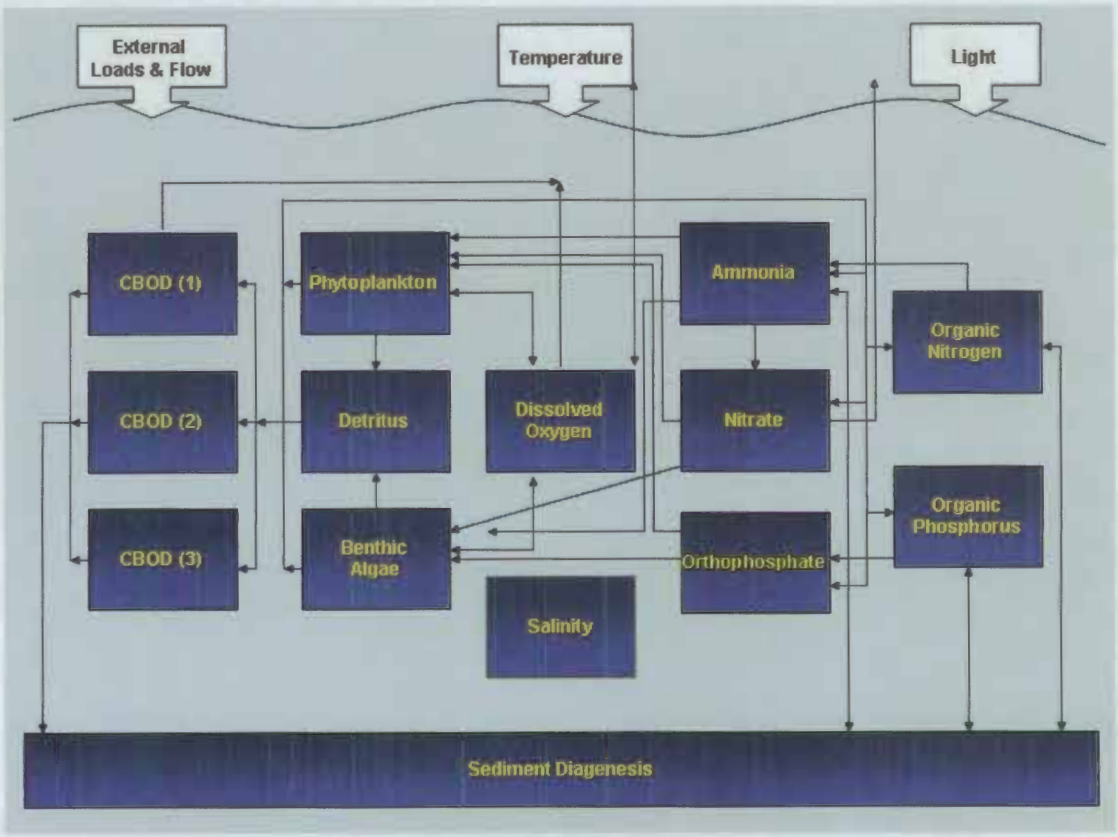

Figure 2-1 Water Quality Diagram for WASP

3.0 HYDRODYNAMIC MODEL DEVELOPMENT

3.1 Hydrodynamic Grid

3.1.1 Model Segmentation

The lake was segmented into curvilinear orthogonal computational grid cells representing horizontal dimensions for the hydrodynamic model. The hydrodynamic model utilizes the generalized vertical coordinate system that allows for a variable number of layers in the vertical direction. The waterbody was segmented into 207 horizontal grid cells (Figure 3-1).

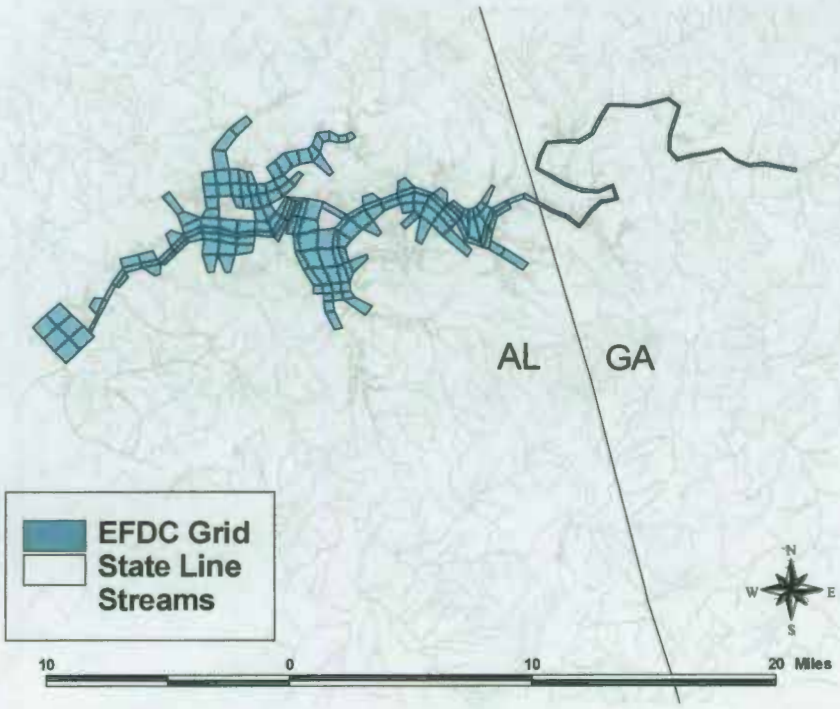

Figure 3-1 Weiss Lake Grid.

The grid on the Coosa River effectively reaches the USGS station 02397000 near Rome, GA. In order to define the domain coverage, a GIS polygon coverage of the pool boundary of Weiss Lake, provided by Alabama Power, was used. Also, a GIS coverage of the Coosa River was used to define the channel in the lake. The grid was first developed to follow the original river channel, where the main flow occurs and then was built to cover the rest of the reservoir area.

The bottom elevation of each grid cell was defined based on the available data from Alabama Power and GAEPD and taking into account the total pool area and volume of the reservoir provided by Alabama Power (Figure 3-2). A longitudinal plot of the riverine portion from the Georgia-Alabama border up to the USGS station 02397000 is shown in Figures 3-3 and 3-4.

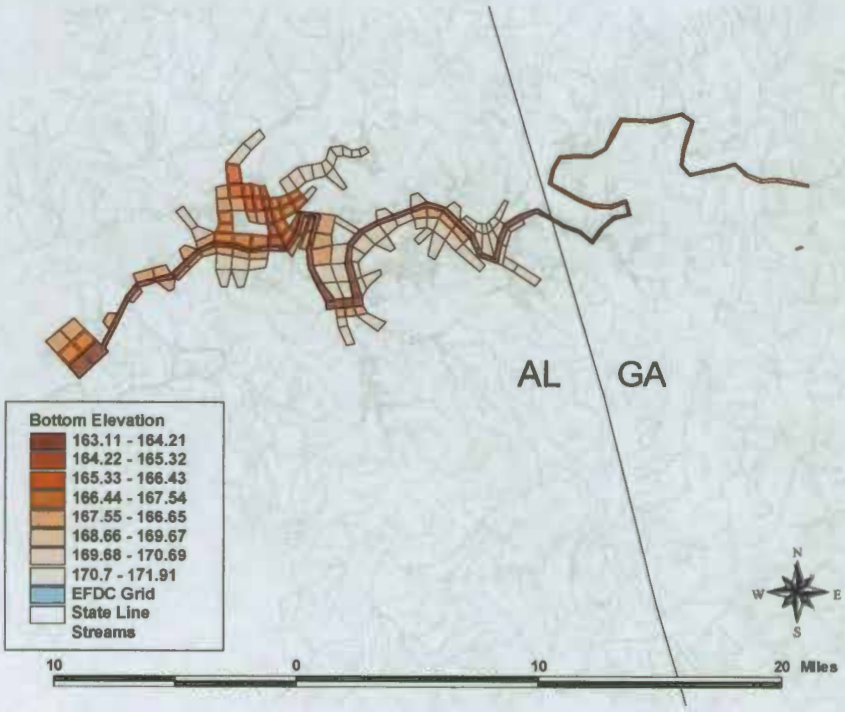

Figure 3-2 Grid bottom elevation for Weiss Lake (meters).

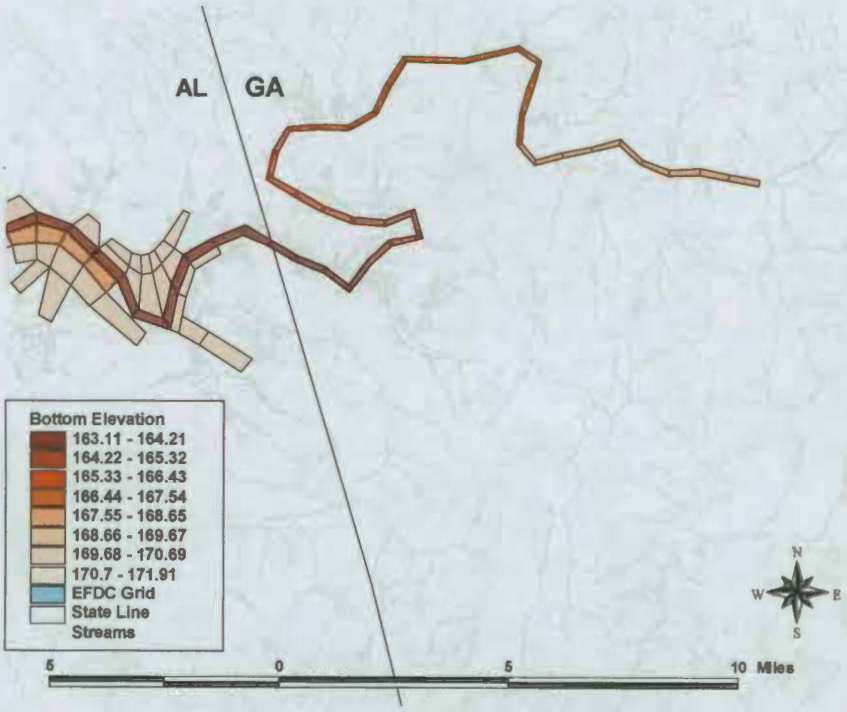

Figure 3-3 Grid bottom elevation from Georgia-Alabama border to 02397000 (meters).

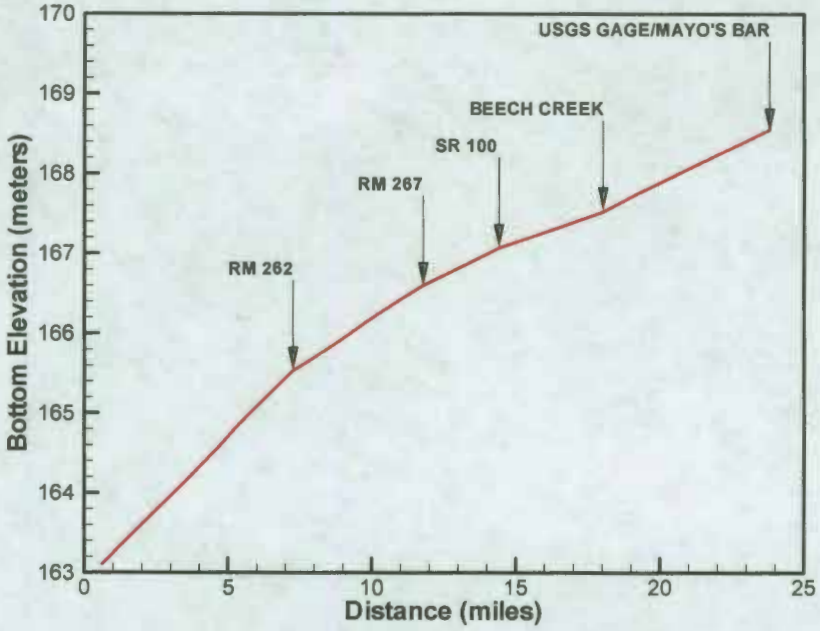

Figure 3-4 Slope of EFDC grid from Georgia-Alabama border to 02397000 showing GAEPD Stations.

A maximum of 8 uniform distributed (equal height) vertical layers were defined along the deepest region of the main channel of the lake up to the state line. This number of layers was selected to have a good resolution of the temperature stratification of the lake along the deepest part of the main channel and to have at least 2 layers in the embayments of the channel to promote the temperature induced convective circulation on those embayments. The number of layers outside the deepest region was defined based on the bathymetry and the water surface elevation at full pool. The height of each layer at full pool was calculated as the water surface elevation minus the deepest bottom elevation divided by the maximum number of layers. At each cell the number of layers was calculated as the total water depth at the cell at full pool divided by the layer depth at the deepest region. Figure 3-5 shows the number of layers for the entire EFDC grid and Figure 3-6 shows the number of layers in the riverine portion. The riverine portion of the EFDC grid ranges from 3 layers at the upstream boundary to 8 layers at the Georgia-Alabama state line.

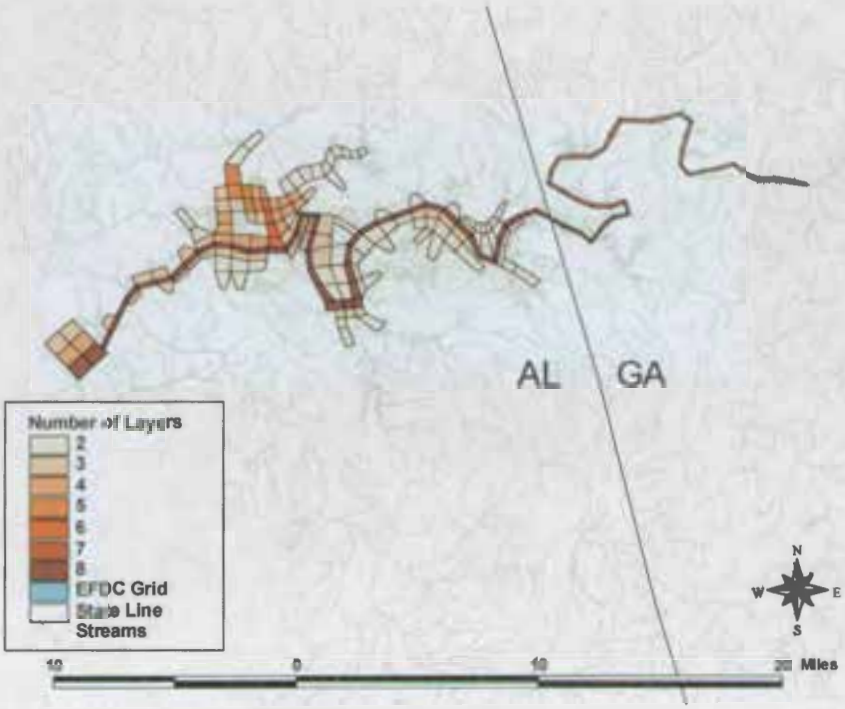

Figure 3-5 Number of layers for Weiss Lake grid.

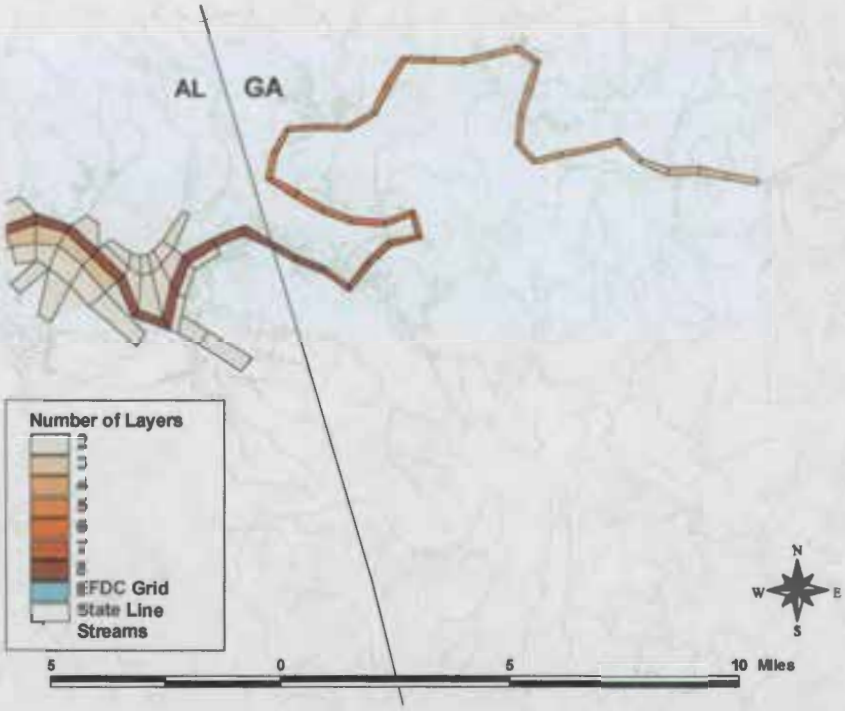

Figure 3-6 Number of layers for Weiss Lake grid from Georgia-Alabama border to 02397000.

3.1.2 Bathymetry

The bathymetry for the model domain was assembled with limited data obtained from electronic topographic maps of the area and from published fishing maps of the lake.

Information provided by Alabama Power for the full pool area and volume of Weiss Lake were used to validate the bottom elevation and dimensions assigned to the grid.

The bathymetry on Weiss Lake from the Georgia-Alabama border up to the USGS station 02397000 were developed using profile data collected by GAEPD in 2005. Data were collected approximately weekly from April through October at six locations along the Coosa River. These stations were:

- Coosa River at Georgia-Alabama border (GAEPD Station 5COO-530),
- Coosa River at River Mile 262 (GAEPD Station 5COO-480),
- Coosa River at River Mile 267 (GAEPD Station 5COO-440),
- Coosa River at State Road 100 (GAEPD Station 5COO-410),
- Coosa River at Beech Creek (GAEPD Station 5COO-370),
- Coosa River at Blacks Bluff Road (GAEPD Station 5COO-340).

The profile data for stations Coosa River at River Mile 262 up to Coosa River at Blacks Bluff Road were averaged, and the value was assigned to the associated grid cell. Bathymetry for intermediate cells were then determined by interpolation.

3.2 Simulation Period

The simulation period for the hydrodynamic model was over a 15-year period – from January 1, 1991 through December 31, 2005. During the 2005 growing season, GAEPD and ADEM performed extensive data collection efforts on Weiss Lake. ADEM also collected data on Weiss Lake during the 2000 growing season. Therefore, temperature profiles were compared for the growing season of 2005 as a calibration period and for the growing season of 2000 as a validation period.

3.3 Hydrodynamic Boundary Conditions

Deterministic time variable models predict conditions within the computational domain of the model based upon perturbations within the model grid caused by outside forcing functions. These forcing functions need to be described to the model in order to predict the perturbations that occur within the model grid. The forcing functions that are required in the hydrodynamic model of Lake Weiss include:

- Inflows and outflows,
- Meteorological conditions (wind, solar radiation, etc.), and
- Temperature.

For calibration purposes, time dependent or constant values for each of these parameters must be applied at each of the appropriate boundaries for the entire model simulation period. These values were applied at all of the boundaries within the system including:

- The dam and spillway release;
- Coosa and Chattooga river inflows;
- Lateral tributaries inflows; and
- Point sources.

The following presents discussions of how the boundary conditions were determined and applied for the hydrodynamic model calibration simulations.

3.3.1 Headwater Flow

The USGS has maintained a flow gaging station on the Coosa River near Rome, Georgia, since 1896. The station location is within the 8-digit HUC 03150105 and drains 4,040 square miles (10,464 sq km). The station receives flow from the Coosa Basin in northeast Georgia. This includes Carters Lake, Allatoona Reservoir, and the cities of Rome, Dalton, and Marietta. This daily average flow record will define the headwater conditions for the modeling application. Figure 3-7 shows the station location in reference to the EFDC model grid.

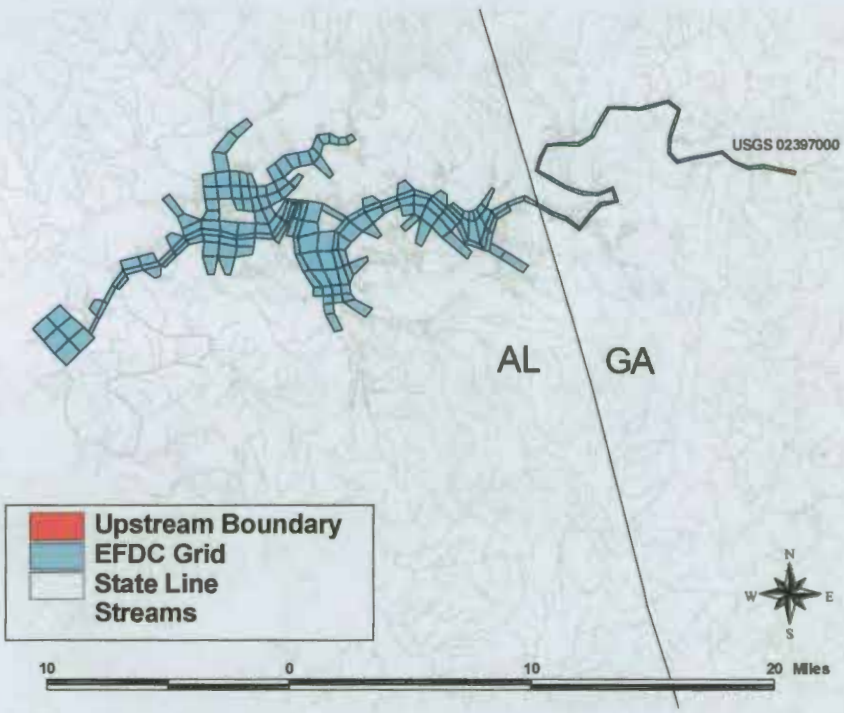

Figure 3-7 USGS Station 02397000 Location at Headwater of EFDC Model Grid

The daily average flow values were developed into statistics for two periods, Table 3-1 is for the period of record and Table 3-2 is for the period of study. These tables reveal that the range of conditions present historically were also likely present during the period of study. This helps validate the period of study as representative of a wide range of conditions.

Table 3-1 Daily Average Flow Statistics 1896-2005

Oct 1896 – Dec 2005		
Statistic	**Flow(cfs)**	**Flow(cms)**
Max	64600	1829
90th	14300	405
75th	7580	215
Med	4260	121
25th	2630	74
10th	1850	52
Min	870	25
Avg	6639	188
Count	27701	

Table 3-2 Daily Average Flow Statistics 1991-2005

Jan 1991 – Dec 2005		
Statistic	**Flow(cfs)**	**Flow(cms)**
Max	43000	1218
90th	14100	399
75th	7895	224
Med	4700	133
25th	2980	84
10th	2110	60
Min	933	26
Avg	6640	188
Count	5479	

Figures 3-8 and 3-9 present the 7-day and 30-day moving averages of the daily flow observations. The use of these moving averages helps highlight periods of higher and lower flow. This has utility in model simulations interpretation and use. The higher flow portion of the period of study seem to be from 1991 through the early part of 1998, except for the second half of 1993 and mid-1995. A drought period appears most evident from the mid-1998 through 2002.

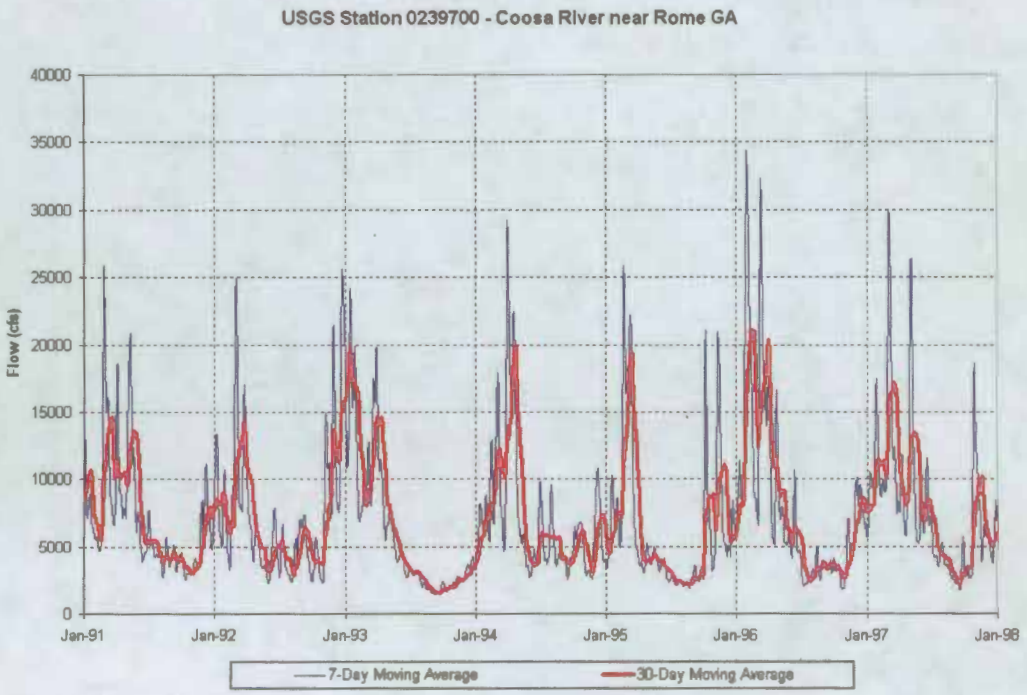

Figure 3-8 7-day and 30-day Moving Average Flow Values from USGS Station 02397000, 1991-1997

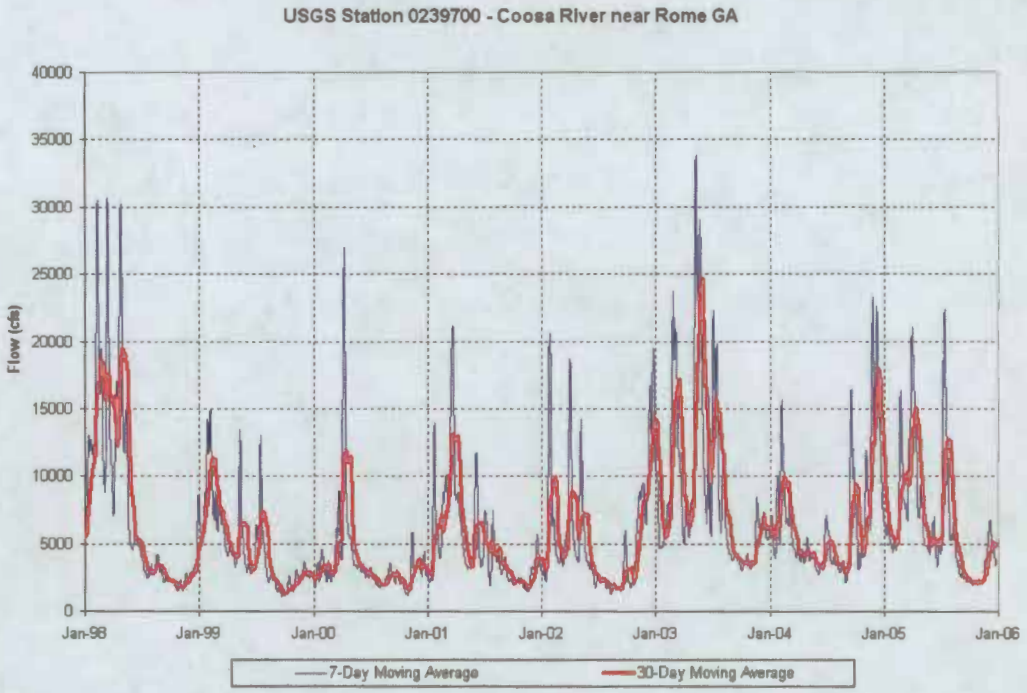

Figure 3-9 7-day and 30-day Moving Average Flow Values from USGS Station 02397000, 1998-2005

3.3.2 Turbine and Spillway Flow

Water is released from Weiss Lake at two locations, the turbines and the spillway. They are approximately 3.5 miles (5.6 km) away from each other (Figure 3-10). The main discharge is through the turbines for power generation. The spillway serves for excess release and increased flexibility in maintaining water surface elevation of Weiss Lake.

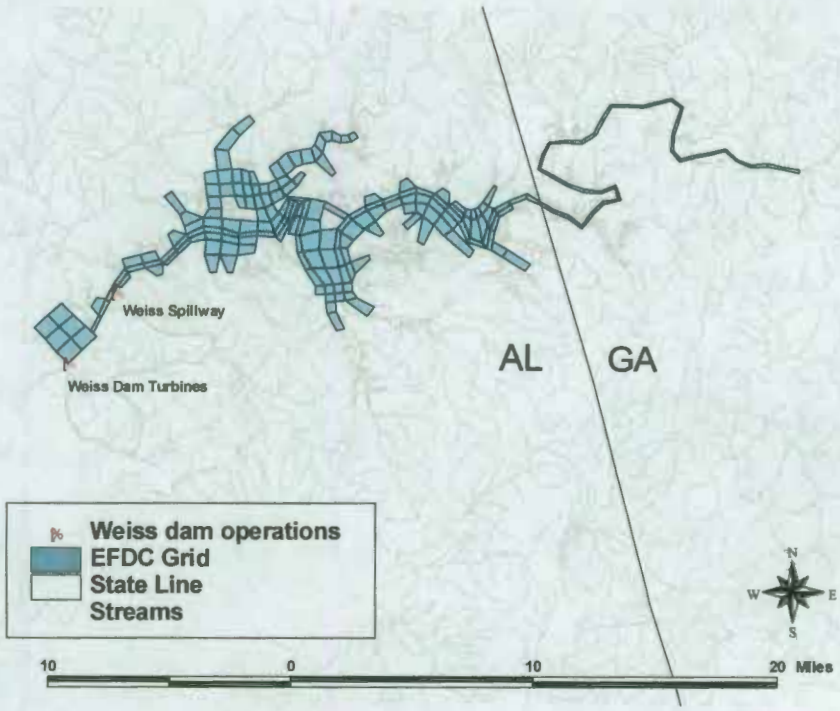

Figure 3-10 Weiss Lake Dam Operations Locations

Table 3-3 presents statistics on the daily average discharge values for the turbines and spillway. Figures 3-11 and 3-12 present the 30-day moving averages of flow for the turbines and spillway. In the early part of the turbine record, the 30-day moving average typically exceeded 16,000 cfs. However, in the latter part of the turbine record, the 30-day moving average infrequently exceeded 16,000 cfs.

Table 3-3 Daily Average Flow Statistics 1991-2005

Jan 1991 – Dec 2005				
	Turbines		Spillway	
Statistic	Flow(cfs)	Flow(cms)	Flow(cfs)	Flow(cms)
Max	29129	825	16120	456
90th	20269	574	0	0
75th	11325	321	0	0
Med	6251	177	0	0
25th	3581	101	0	0
10th	1844	52	0	0
Min	0	0	0	0
Avg	8527	241	206	6
Count	5480	5480	5480	5480

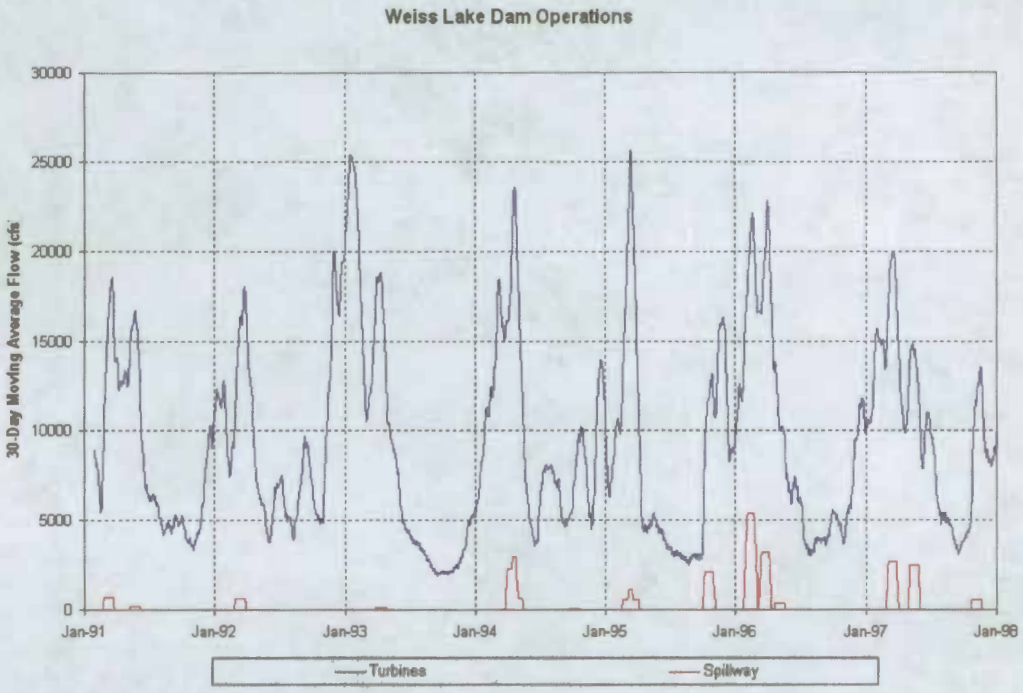

Figure 3-11 30-day Moving Average Flow Values Weiss Dam Turbines and Spillway, 1991-1997

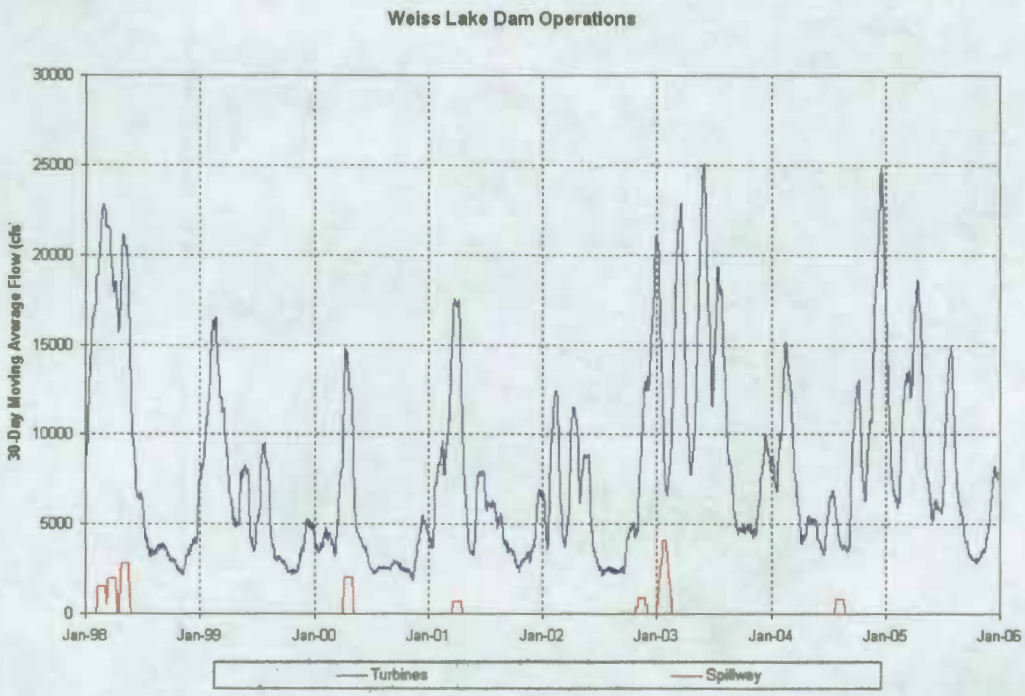

Figure 3-12 30-day Moving Average Flow Values Weiss Dam Turbines and Spillway, 1998-2005

3.3.3 Chattooga River Flow

For this study, river discharge measurements for the Chattooga River were obtained from USGS gauging stations 02398300 on the Chattooga River.

3.3.4 Tributary Flow

Weiss Lake lies in the Upper Coosa (HUC# 03150105) Watershed in northeastern Alabama. The Upper Coosa Watershed receives flow from four upstream watersheds that lie across the state line in northwestern Georgia. These watersheds include the Conasauga (HUC# 03150101), Coosawattee (HUC# 03150102), Oostanaula (HUC# 03150103), and Etowah (HUC# 03150104) Watersheds. A previous LSPC watershed model (Tetra Tech, 2005), which used the 1992 Multi-resolution Land Characterization (MRLC) dataset, was created to approximate all watershed flows entering Weiss Lake. For this modeling effort, the LSPC watershed model was updated with the 2001 MRLC dataset.

The upstream watersheds were included in the model to provide a tool that could estimate the inflow of water quality constituents to the headwater of the Weiss Lake hydrodynamic model. The watershed model was calibrated for hydrology using the daily flow record from a USGS gaging station located on Coosa River near Rome, Georgia (USGS 02397000). A 10-year calibration period was selected from January 1, 1991 to December 31, 2000. A more detailed discussion of the watershed model hydrology calibration can be found in Appendix A.

Once calibrated, the watershed model was used to simulate lateral inflow to Weiss Lake for the 15-year simulation period – from January 1, 1991 through December 31, 2005. Even though the watershed flows are small compared to the dam release flows, they have a major effect on the flow balance in the lake. The watershed input locations are shown in Figures 3-13 and 3-14. Table 3-4 identifies where each LSPC subwatershed were input into each EFDC cell.

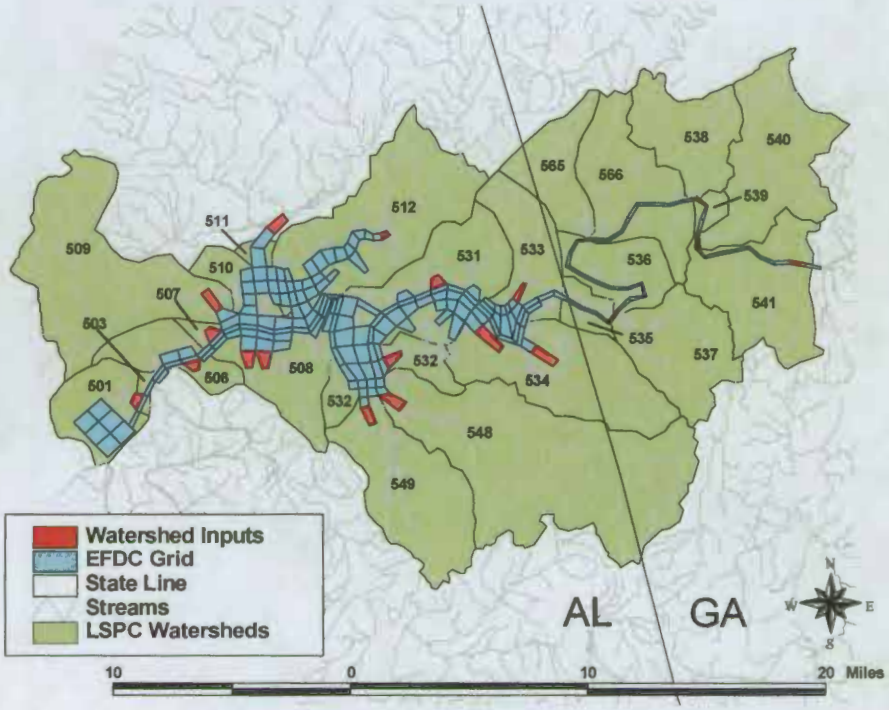

Figure 3-13 LSPC Watershed locations.

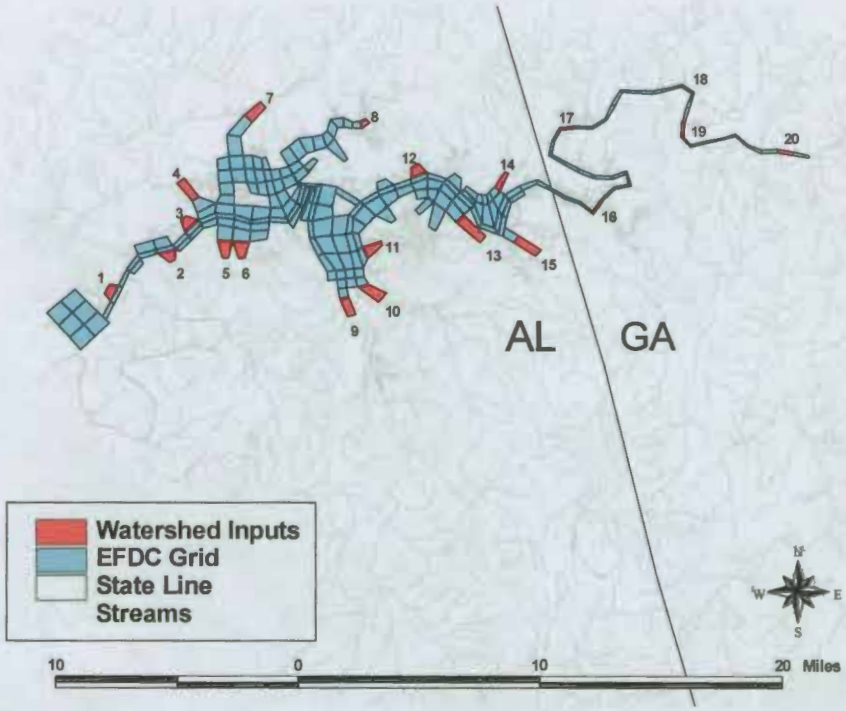

Figure 3-14 Watershed input locations.

Table 3-4 Watershed inputs

Figure ID	EFDC Cell		Watersheds
	I-Value	J-Value	
1	34	23	Subbasins 501 and 503
2	30	25	Subbasin 506
3	28	23	Subbasin 507
4	27	21	Subbasin 509
5	26	27	Subbasin 508 (half)
6	25	27	Subbasin 508 (half)
7	25	15	Subbasin 510 and 511
8	10	18	USGS02398300 + SWS 512
9	11	23	Subbasin 549
10	12	10	Subbasin 548
11	15	8	Subbasin 532
12	22	11	Subbasin 531
13	26	8	Subbasin 534 (half)
14	30	12	Subbasin 533
15	28	7	Subbasin 534 (half)
16	36	10	Cedar Creek (subbasin 537)
17	47	10	Kings Creek (subbasin 565)
18	56	10	Cabin Creek (subbasin 538)
19	59	10	Beech Creek (subbasin (540)
20	67	10	Subbasins 535, 536, 539, 541, 566

3.3.5 Corrective Flow

In a system such as Weiss Lake, where there is a hydroelectric dam, it is important to be able to quantify all of the inputs and outputs. If the mass balance, in terms of flow, is not correct, then it will be near impossible to calibrate the hydrodynamics for water surface elevation. If, for example, the net flow (inputs – outputs) to the system is greater than the change in water surface elevation, then there will be a net increase in water surface elevation. Vice versa, if the net flow is less than the change in water surface elevation, there will be a net decrease. Since this is a mass balance system, the associated error in water surface elevation would be carried throughout the simulation.

To help minimize the difference between simulated and measured water surface elevation, the corrective flow feature of EFDC was applied. This feature allows EFDC to calculate, at a given time scale, the amount of flow required to force a match between the calculated and observed water surface elevations. The calculated flow, or "corrective flow," represents the error in volume associated with the model. This flow can be due to a combination of inaccurate readings of flow inputs or outputs, inaccurate estimates of watershed flow, spatial discrepancies in meteorological data, or unaccounted flow terms.

Once calculated, this flow was entered as a time series to adjust the simulated water surface elevation. Positive corrective flows (inflows) were added to the upstream flow and negative corrective flows (outflows) were added at the dam discharge. It is believed that reporting the error in this manner, as a flow time series, could later be insightful as to the nature of the simulation error. Such a time series could show constant volume errors in the simulation, an error dependent on lake storage, or an error that correlates with particular flow inputs.

Figures 3-15 and 3-16 present the USGS Station 02397000 versus the positive corrective flow that was determined. Figures 3-17 and 3-18 present the Weiss Dam discharge versus the negative corrective flow that was determined.

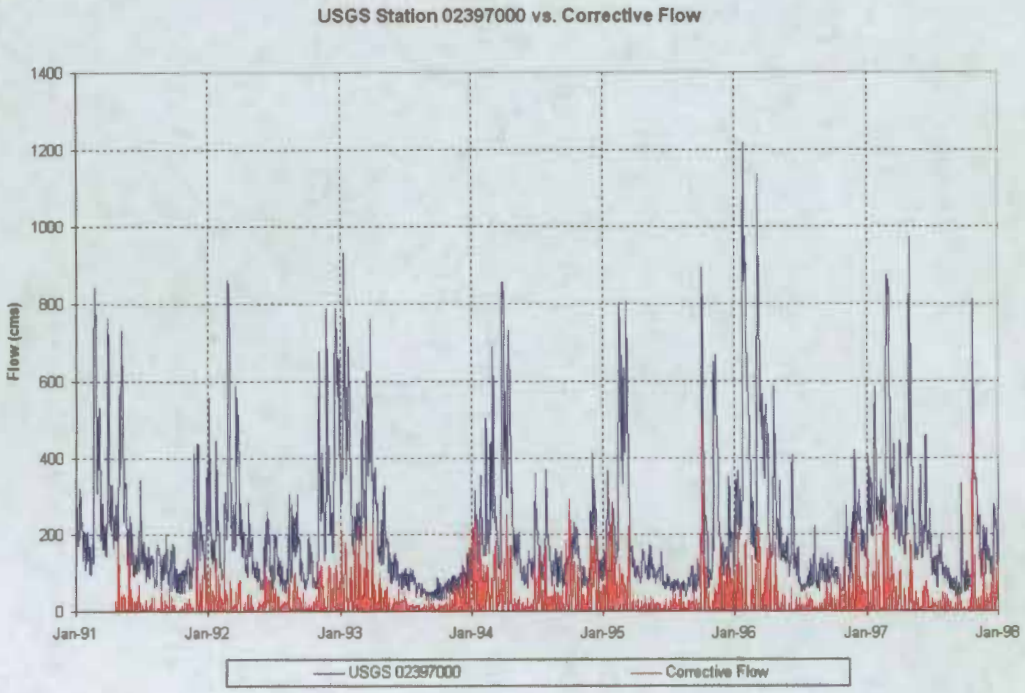

Figure 3-15 USGS Station 02397000 vs. Positive Corrective Flow, 1991-1997

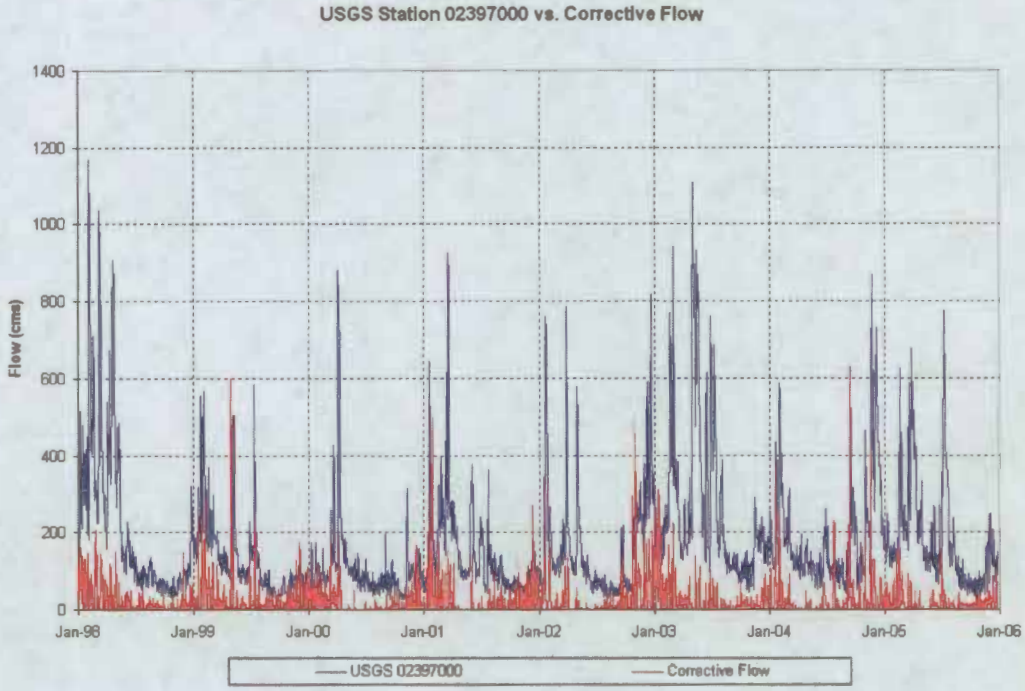

Figure 3-16 USGS Station 02397000 vs. Positive Corrective Flow, 1998-2005

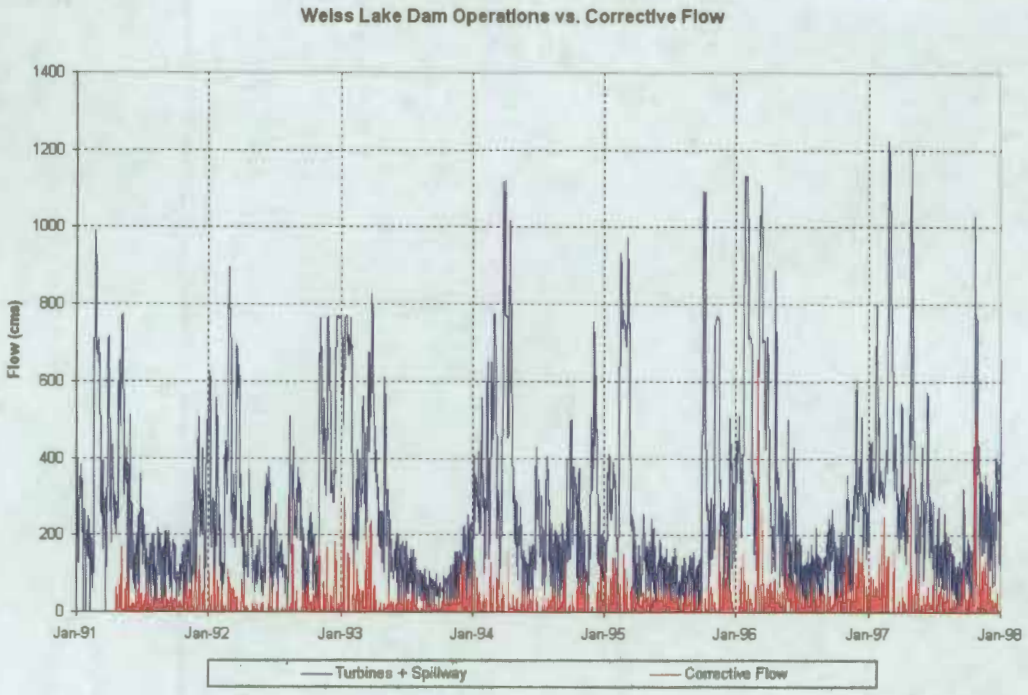

Figure 3-17 Weiss Dam Operations vs. Negative Corrective Flow, 1991-1997

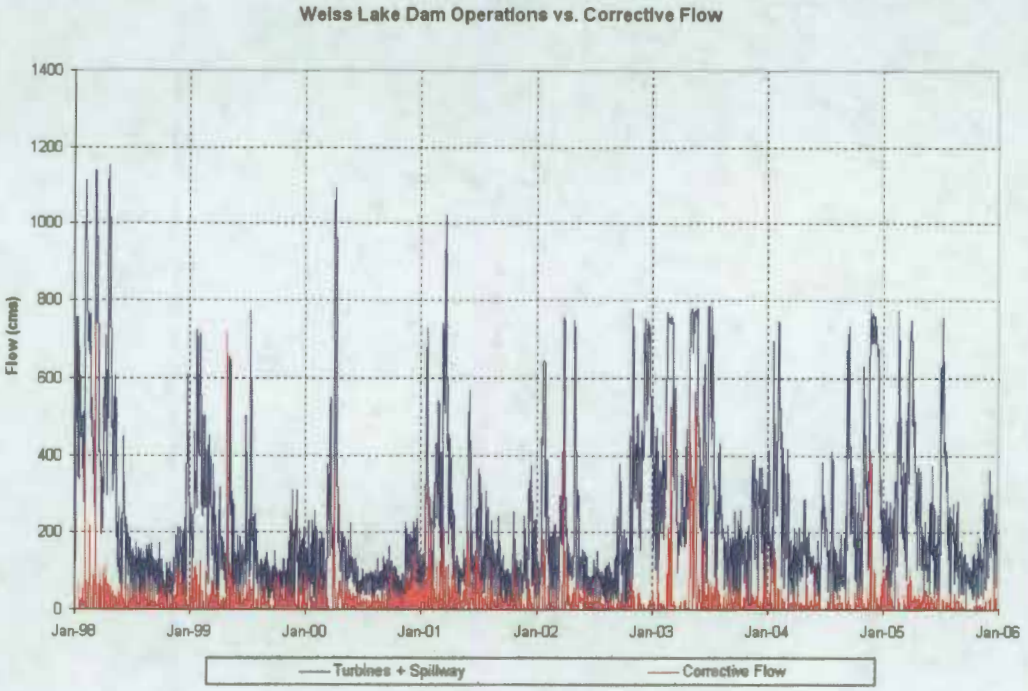

Figure 3-18 Weiss Dam Operations vs. Negative Corrective Flow, 1998-2005

3.3.6 Meteorological Data

The relative humidity, pressure, and wind records were developed by using data from Birmingham, AL (WBAN 13876) for 1990 through April 1997 and Rome, GA (WBAN 93801) for May 1997 through 2005. The rainfall record was developed from the cooperative station GA7605 in Rome, GA. Likewise, the disaggregated hourly air temperature record developed for Rome, GA was used.

Cloud cover is a difficult parameter to characterize in modeling applications. As cloud cover, or sky condition, is typically reported from an observer, not monitoring equipment, there are inherent challenges in its development. For consistency, and utilizing available data, a cloud cover time series estimate was developed from Birmingham, AL (WBAN 13876). Consideration in taking the complete cloud cover record from one station was also given to the calculation of solar radiation. Solar radiation was calculated with the use of the cloud cover record from Birmingham, AL (WBAN 13876).

During the hydrodynamic and water quality calibration, measured solar radiation from the Georgia Automated Environmental Monitoring Network (GAEMN) station No. 200 (Rome, Georgia) was evaluated. Utilizing this data did not provide nearly as good a calibration as using the calculated solar radiation data, and therefore the calculated solar radiation data were used.

3.3.7 Temperature

Influent tributary and upstream flows to Weiss Lake have associated heat energy, and the temperature balance in the lake is sensitive to the temperatures of these inflows. Each flow time-series entered into the model has an associated temperature time-series.

For the upstream flow boundary on the Coosa River, daily temperature data from USGS station 02397000, Coosa River near Rome, GA, was used to develop a water temperature forcing for the Coosa River headwater inflow to Weiss Lake (Figure 3-19) for the entire simulation period.

Tributary temperature data were collected on the Alabama side of Weiss Lake at station 05004028. This station is part of the Alabama Water Watch (AWW) citizen volunteer water quality monitoring program. The station was observed on an approximately monthly basis about 70 times from 1994 through 2001. A sine curve was generated from these data and was used to represent tributary inputs on a daily basis (Figure 3-20) from 1991 through 2003.

There were four tributaries on the Georgia side of Weiss Lake where temperature values were collected during 2005. Two tributaries, Cedar Creek and Beech Creek, temperature values were collected daily from January 12 through December 31, and March 11 through December 31, respectively. Temperature data on the other two tributaries, Kings Creek and Cabin Creek, were collected approximately weekly from April through October in 2005. A sine curve was generated from each set of data and was used to represent daily temperature values for each of the four tributarires for the years 2004 and 2005. Figures 3-21 through 3-24 present the observed data and the representative sine curve for each tributary. The sine curve for Beech Creek was also used to represent the watersheds coming in at the upstream boundary for years 2004 and 2005.

The sine curve that represents AWW 05004028 is approximately 5-8 °C warmer during the peak as opposed to the four Georgia tributaries (Table 3-5). This difference might be attributed to the time period when the AWW data were collected, which occurred during a warmer, dryer period. Due to this difference, tributaries located on the Alabama side of Weiss Lake were represented by the sine curve from Cedar Creek for the years 2004 and 2005.

Figure 3-25 presents the location of the USGS station 02397000, the four tributary stations in Georiga, and the Alabama Water Watch station 05004028.

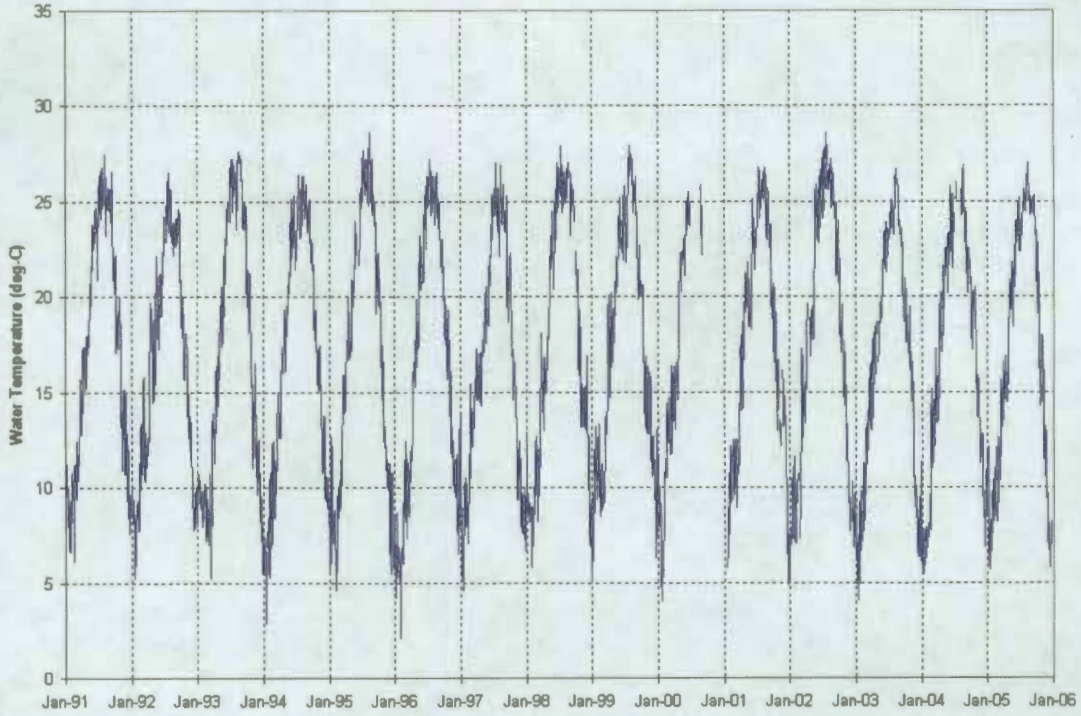

Figure 3-19 Observed Temperature Data for USGS 02397000 from 1991 through 2005

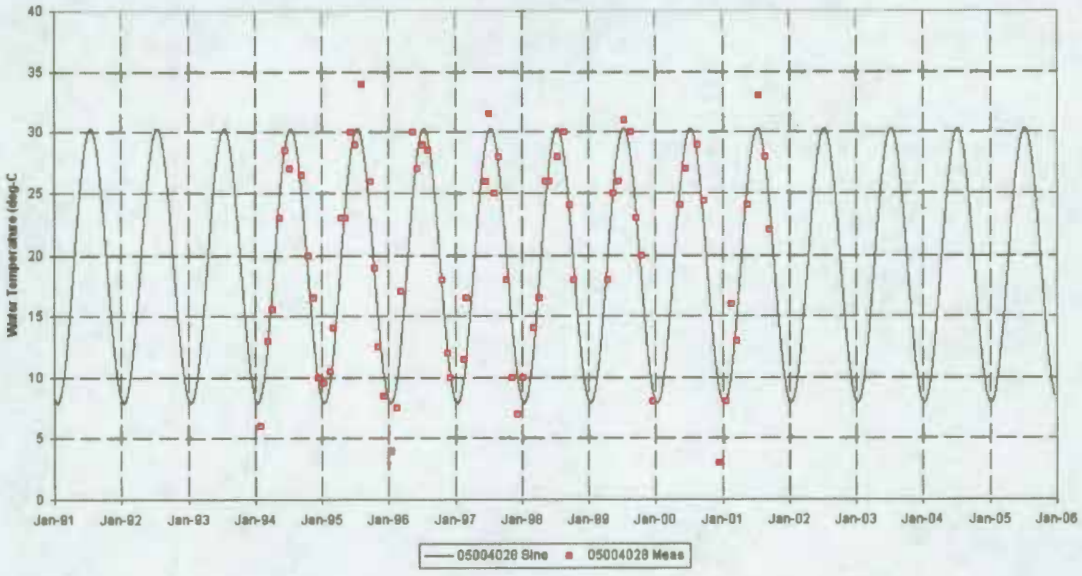

Figure 3-20 Observed Data Versus Fitted Sine Curve for AWW 05004028

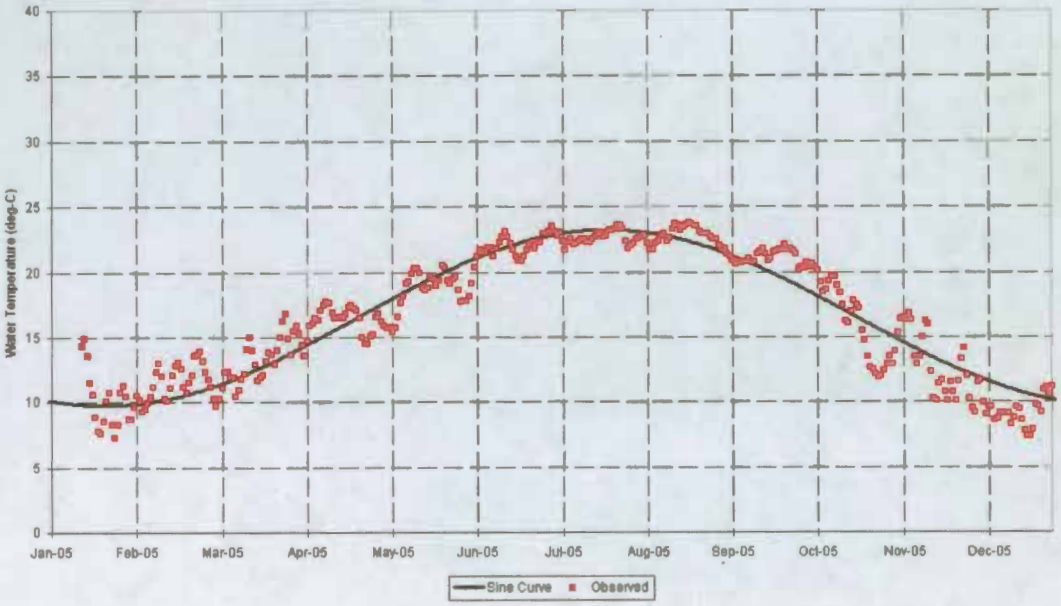

Figure 3-21 Observed Data Versus Fitted Sine Curve for Cedar Creek (02397500)

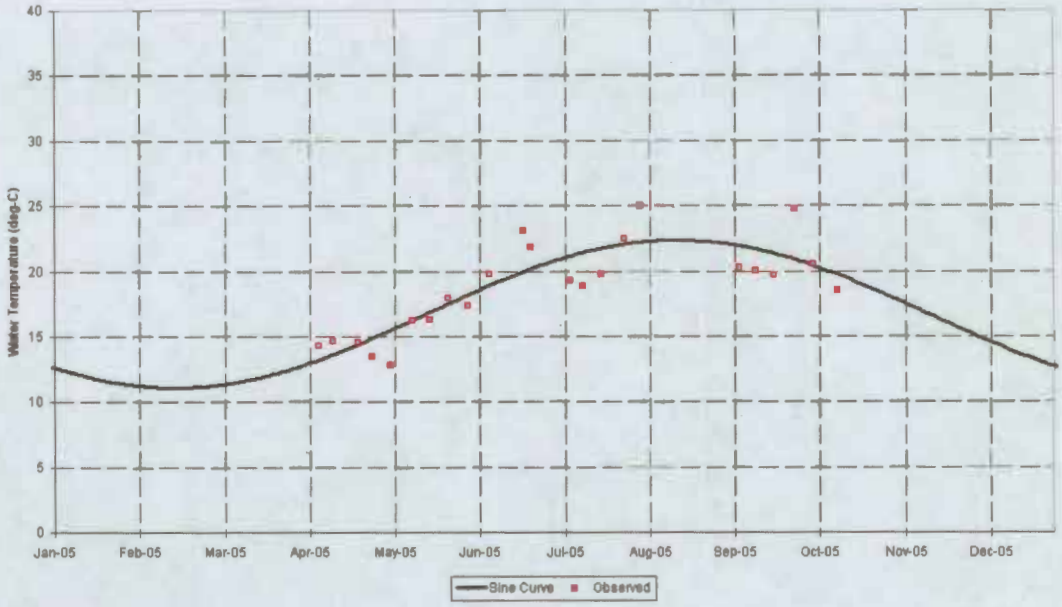

Figure 3-22 Observed Data Versus Fitted Sine Curve for Kings Creek (02397150)

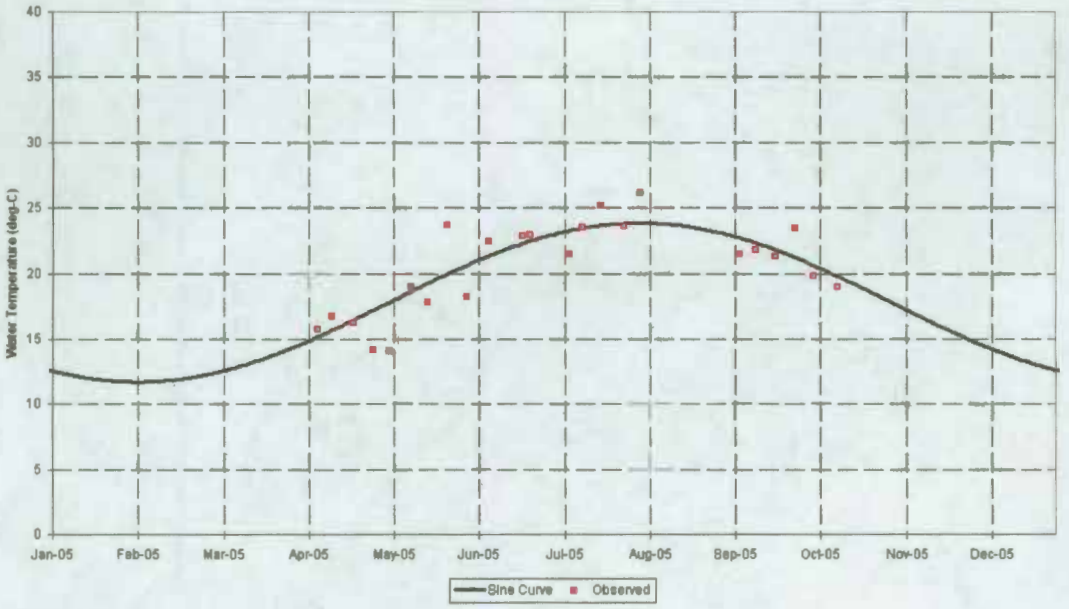

Figure 3-23 Observed Data Versus Fitted Sine Curve for Cabin Creek (02397095)

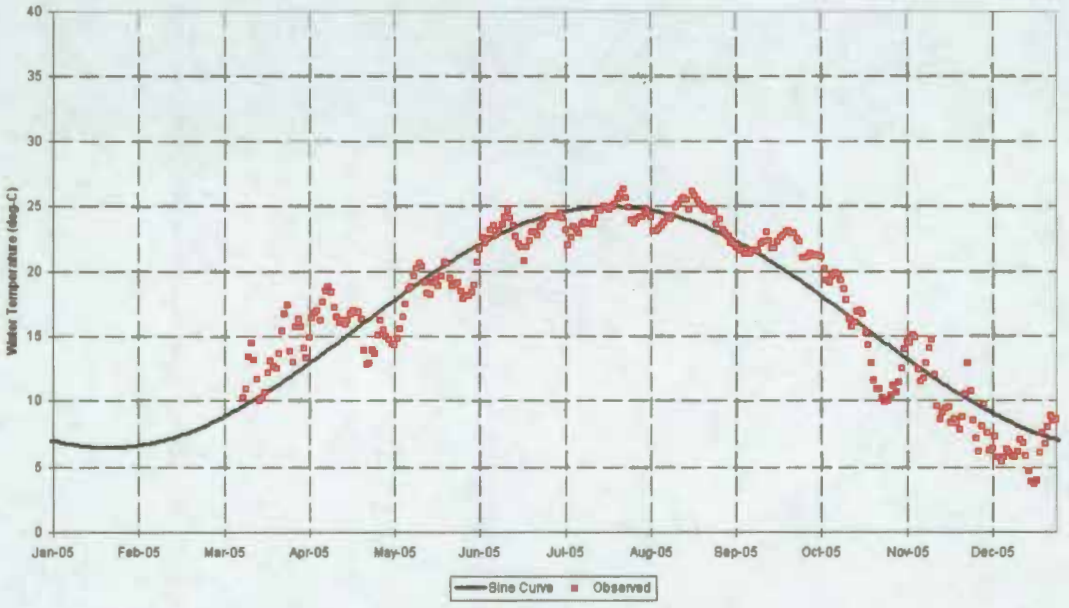

Figure 3-24 Observed Data Versus Fitted Sine Curve for Beech Creek (02397075)

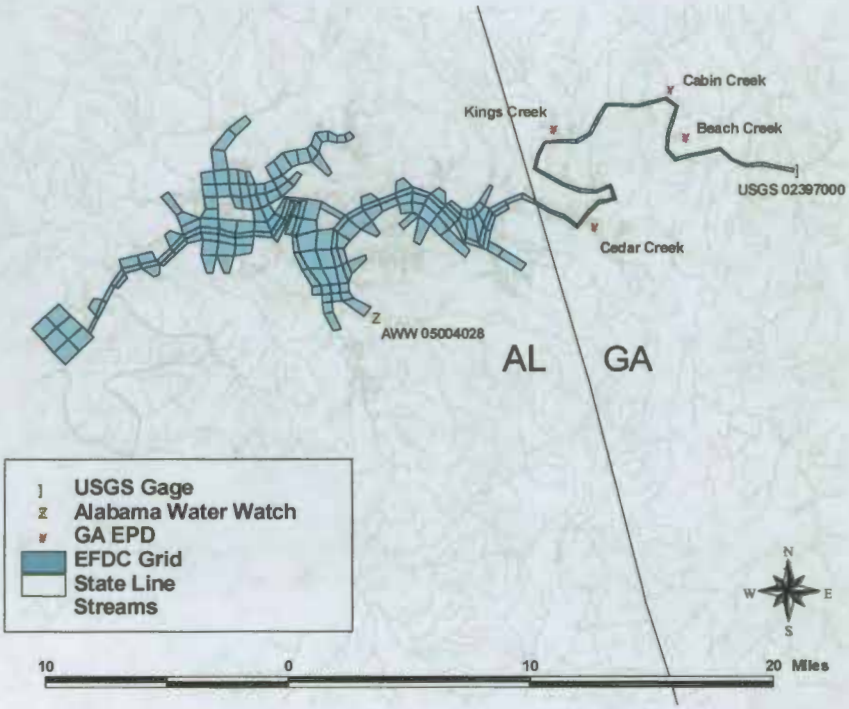

Figure 3-25 Stations Used for Water Temperature Forcings

Table 3-5 Statisitcs for Observed Water Temperature (deg-C)

Statistic	USGS 02397000*	AWW 05004028	Cedar Creek (02397500)	Kings Creek (02397150)	Cabin Creek (02397095)	Beech Creek (02397075)
Max	28.6	34.0	23.8	25.0	26.2	26.3
90th	25.3	30.0	22.7	23.0	23.7	24.5
75th	23.1	27.0	21.7	20.4	23.2	23.0
Med	17.2	22.5	16.8	19.3	21.5	18.9
25th	11.0	13.0	12.1	16.3	18.0	13.2
10th	8.3	8.5	9.8	14.4	15.8	8.5
Min	2.1	3.0	7.3	12.8	14.0	3.7
Avg	16.9	20.1	16.7	18.8	20.5	17.7
Count	5150	70	354	23	23	296

* Statistics for USGS 02397000 were calculated on data from January 1, 1991 through December 31, 2005.

4.0 POINT SOURCES

4.1 Flow

There are five point sources that were included in the EFDC hydrodynamic and WASP models (Figure 4-1 and Table 4-1). From 1991 through 1999, flows for the City of Rome – Coosa WPCP (GA0024341) were input at the design flow, and daily flows were input for 2000 through 2005. Cherokee WPCP (AL57592) and Cedar Bluff WPCP (AL24678) were input at their design flow from 1991 through 2004 and at the monthly average flow for 2005.

Two of the point sources (Georgia Power and Inland Paperboard) have water withdraw permits. These facilities withdraw water from the Coosa River for their power plant operations. Daily discharge data were available for the Georgia Power facility during 2005. It was assumed that the flow discharged was the same amount that was withdrawn. No data were available for Georgia Power from 1991 through 2004. Therefore, the intake and discharge flow was input at 655 MGD.

The Inland Paperboard facility has 5 permitted outfalls (#1 through #5). These outfalls were grouped into 2 separate inputs into the hydrodynamic and water quality model, Outfall 1 and Outfall 2. Outfall 1 in the models represented the permitted outfall #1 and Outfall 2 represented the permitted outfall #2 and #4. Daily intake and discharge data were available for the two outfalls at the Inland Paperboard facility during 2005. No data were available for Inland Paperboard from 1991 through 2000 or for 2002 and 2003. Therefore, the intake flow was input at 32 MGD, and the discharge flow at Outfall 1 and Outfall 2 were input at 16.7 and 8.4 MGD, respectively.

Table 4-1 Point Sources included in Weiss Lake Model

Permit Number	Facility Name	Average Monthly Flow (MGD)	Design Flow (MGD)
GA0001457	GA Power – Plant Hammond	655	--
GA0001104	Inland Rome	32	--
GA0024341	Rome Coosa WPCP	--	2.0
AL0057592	Cherokee WPCP	--	0.06
AL0024678	Cedar Bluff WPCP	--	0.15

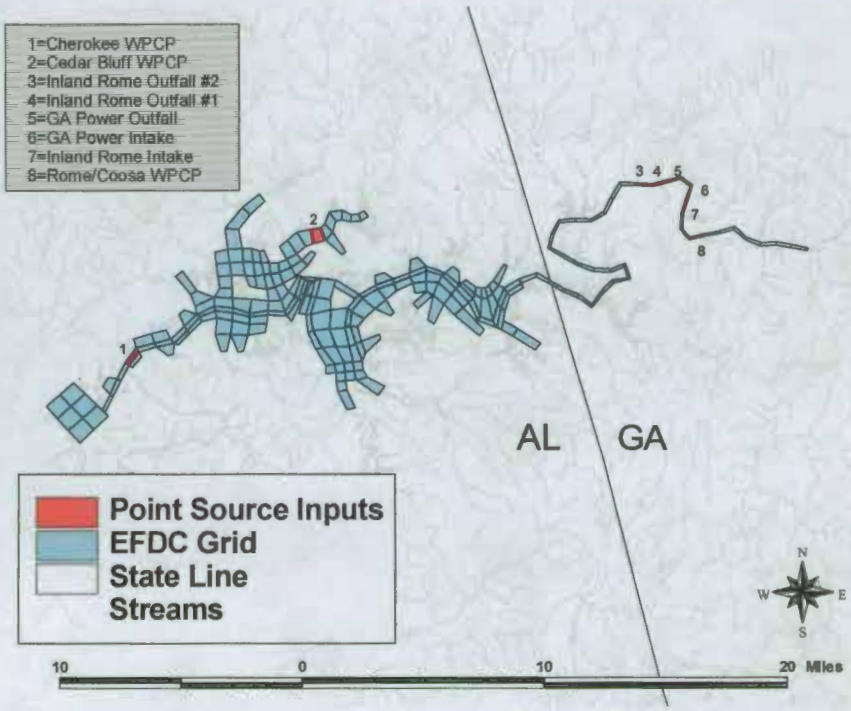

Figure 4-1 Point Sources Locations

4.2 Temperature

Temperature data were not available for the Rome-Coosa WPCP. Therefore, a constant temperature value of 20°C was input for this facility. The Cherokee and Cedar Bluff WPCP's were input at 28°C from May through November and 18°C from December through April. This is consistent with ADEM's Waste Load Allocation (WLA) and modeling guidance.

Daily data were available for the Georgia Power-Hammond Plant and Inland Paperbound during 2005. From 1991 through 2004, temperature data were not available for the Hammond Plant, and no data were available for Inland Paperboard from 1991 through 2000 or for 2002 and 2003. Therefore an average of the 2005 data were input at each facility for 1991 through 2004. Table 4-2 summaries the temperature inputs for the point sources.

Table 4-2 Point Source Temperatures

Permit Number	Facility Name	1991 – 2004 (°C)	2005 (°C)
GA0001457	GA Power – Plant Hammond	22.0[A]	Daily Data
GA0001104	Inland Rome Outfall 1 Outfall 2	 23.51[A] 21.75[A]	 Daily Data Daily Data
GA0024341	Rome Coosa WPCP	20.0	20.0
AL0057592	Cherokee WPCP May through November December through April	 28.0 18.0	 28.0 18.0
AL0024678	Cedar Bluff WPCP May through November December through April	 28.0 18.0	 28.0 18.0

[A] Represents the average of 2005 data.

4.3 Water Quality

Since the water quality model will be calibrated to data collected during 2005, and validated to data collected in 2000, all available data for the point sources were collected for these years. The following water quality parameters were needed for each point source.

- Ammonia (NH3),
- Nitrate+Nitrite (NO2+NO3),
- Organic Nitrogen,
- Orthophosphate (PO4),
- Organic Phosphorus,
- Chlorophyll-a (Chl-a),
- Dissolved Oxygen (DO), and
- Carbonaceous Biochemical Oxygen Demand (CBOD).

Rome-Coosa WPCP

Ammonia, Dissolved Oxygen, BOD5 and Total Phosphorus data were available for the Rome-Coosa WPCP. Table 4-3 and 4-4 summaries the available data for 2005 and 2000, respectively.

Table 4-3 Water Quality Data for Rome-Coosa WPCP (GA0024341) for 2005

Constituent	No. of Obs.	Min	Max	Average
Ammonia (mg/l)	154	0.10	1.40	0.18
Dissolved Oxygen (mg/l)	365	6.3	11.7	8.4
BOD5 (mg/l)	155	0.0	9.0	0.9
Total Phosphorus (mg/l)	155	0.23	3.26	1.49

Table 4-4 Water Quality Data for Rome-Coosa WPCP (GA0024341) for 2000

Constituent	No. of Obs.	Min	Max	Average
Ammonia (mg/l)	158	0.10	10.6	0.19
Dissolved Oxygen (mg/l)	366	3.2	10.2	6.79
BOD5 (mg/l)	157	1.0	3.0	1.16
Total Phosphorus (mg/l)	123	0.7	3.4	1.80

BOD5 was converted to CBODU using an f-Ratio of 5.0. The f-Ratio was determined from a July 2005 long-term BOD study performed by the USEPA's Science and Ecosystem Support Division. Nitrate, Organic Nitrogen and Chlorophyll-a were not available for either the calibration or validation periods, and were therefore input at a value of 1.0. Inputs for Organic Phosphorus and Orthophosphate were determined using the Total Phosphorus data from the following equations:

Organic Phosphorus (mg/l) = 20% * Total Phosphorus (mg/l)

Orthophosphate (mg/l) = 80% * Total Phosphorus (mg/l)

Cherokee WPCP

Ammonia, Dissolved Oxygen, BOD5 and Total Phosphorus data were available for the Cherokee WPCP during 2005. No data were obtained at the Cherokee WPCP for the year 2000. Therefore, the water quality data for 2005 was also applied during 2000. Table 4-5 summaries the available data for 2005.

Table 4-5 Water Quality Data for Cherokee WPCP (AL0057592) for 2005

Constituent	No. of Obs.	Min	Max	Average
Ammonia (mg/l)	2	22.7	22.7	22.7
Dissolved Oxygen (mg/l)	12	6.2	9.6	7.9
BOD5 (mg/l)	12	1.2	4.1	1.7
Total Phosphorus (mg/l)	2	5.7	5.7	5.7

BOD5 was converted to CBODU using an f-Ratio of 2.0. Nitrate, Organic Nitrogen and Chlorophyll-a were input at a value of 1.0. Inputs for Organic Phosphorus and Orthophosphate were determined from the following equations:

Organic Phosphorus (mg/l) = 20% * Total Phosphorus (mg/l)

Orthophosphate (mg/l) = 80% * Total Phosphorus (mg/l)

Cedar Bluff WPCP

Ammonia, Nitrate+Nitrite, TKN, Total Phosphorus and Orthophosphate data were available for the Cedar Bluff WPCP for 2005. No data were obtained at the Cedar Bluff WPCP for the year 2000. Therefore, the water quality data for 2005 was also applied during 2000. Table 4-6 summaries the available data for 2005.

Table 4-6 Water Quality Data for Cedar Bluff WPCP (AL0024678) for 2005

Constituent	No. of Obs.	Min	Max	Average
Ammonia (mg/l)	8	0.4	6.8	3.4
Nitrate+Nitrite (mg/l)	8	0.3	5.0	1.3
TKN (mg/l)	8	0.55	4.1	1.9
Total Phosphorus (mg/l)	8	0.11	1.2	0.7
Orthophosphate (mg/l)	6	0.11	1.85	0.8

BOD5 was assumed to be 1.0 and was converted to CBODU using an f-Ratio of 2.0. Dissolved Oxygen was input at 6.0 and Chlorophyll-a was input at a value of 1.0. Inputs for Organic Nitrogen and Organic Phosphorus were determined from the following equations:

Organic Nitrogen (mg/l) = TKN (mg/l) – Ammonia (mg/l)

Organic Phosphorus (mg/l) = Total Phosphorus (mg/l) – Orthophosphate (mg/l)

Georgia Power – Hammond Plant

No water quality data were collected at the Georgia Power – Hammond Plant. Since the Hammond Plant withdraws water for cooling purposes, and immediately discharges back into the Coosa River, it was assumed that the change in water quality was negligible. Therefore the water quality inputs for the intake and discharge were set to 0.

Inland Rome Paperboard

Dissolved Oxygen and BOD5 data were collected daily at both discharge points for the Inland Rome plant. Table 4-7 and 4-8 summaries the available data for 2005. Daily data were not available for 2000, but were available for 2001, 2004 and 2005. To determine a dissolved oxygen and BOD5 time series for both discharge points, daily data from the three years were averaged to develop a single time series for each discharge point. Table 4-9 and 4-10 summaries the time series data input for 2000.

Table 4-7 Water Quality Data for Inland Rome Paperboard – Outfall 1 (GA0001104) for 2005.

Constituent	No. of Obs.	Min	Max	Average
Dissolved Oxygen (mg/l)	365	2.1	9.8	4.39
BOD5 (mg/l)	365	12.0	54.0	20.6

Table 4-8 Water Quality Data for Inland Rome Paperboard – Outfall 2 (GA0001104) for 2005

Constituent	No. of Obs.	Min	Max	Average
Dissolved Oxygen (mg/l)	365	5.80	12.50	8.34
BOD5 (mg/l)	345	1.0	9.0	1.89

Table 4-9 Water Quality Data for Inland Rome Paperboard – Outfall 1 (GA0001104) for 2000.

Constituent	Min	Max	Average
Dissolved Oxygen (mg/l)	1.57	7.17	4.31
BOD5 (mg/l)	9.0	49.7	20.6

Table 4-10 Water Quality Data for Inland Rome Paperboard – Outfall 2 (GA0001104) for 2000

Constituent	Min	Max	Average
Dissolved Oxygen (mg/l)	4.76	11.74	8.44
BOD5 (mg/l)	0.7	23.6	3.9

BOD5 was converted to CBODU using an f-Ratio of 13.0 for Outfall 1 and 6.0 for Outfall 2. The f-Ratios were determined from a July 2005 long-term BOD study performed by the USEPA's Science and Ecosystem Support Division. For the calibration period, the remaining water quality parameters were input with the same data collected at Coosa River at Blacks Bluff Road (Table 4-11). For the validation period, it was assumed that the water quality associated with the intake and discharge was the same as the monthly average values calculated at the upstream boundary (Table 4-12).

Table 4-11 Water Quality Data for Coosa River at Blacks Bluff Road (5COO-340) for year 2005

Constituent	No. of Obs.	Min	Max	Average
Ammonia (mg/l)	24	0.01	0.07	0.03
Nitrate+Nitrite (mg/l)	24	0.26	0.70	0.50
TKN (mg/l)	24	0.03	0.70	0.31
Total Phosphorus (mg/l)	24	0.03	0.33	0.13
Orthophosphate (mg/l)	23	0.06	0.34	0.18
Dissolved Oxygen (mg/l)	25	5.40	9.77	7.95
BOD5 (mg/l)	23	0.75	2.99	1.29
Chlorophyll-a (ug/l)	14	1.30	22.4	6.67

Table 4-12 Water Quality Data Input at Upstream Boundary for year 2000

Constituent	Min	Max	Average
Ammonia (mg/l)	0.03	0.05	0.04
Nitrate+Nitrite (mg/l)	0.40	0.63	0.53
TKN (mg/l)	0.26	0.41	0.32
Total Phosphorus (mg/l)	0.09	0.16	0.12
Orthophosphate (mg/l)	0.09	0.16	0.12
Dissolved Oxygen (mg/l)	6.81	9.31	7.85
BOD5 (mg/l)	0.75	1.41	1.12
Chlorophyll-a (ug/l)	2.61	6.75	4.33

5.0 HYDRODYNAMIC CALIBRATION

The main calibration objective for the hydrodynamic model was to adequately represent the physics of the system by propagating momentum and energy based upon freshwater inflow, and wind. Density stratification plays a major role in the water quality of the system. For this reason, another calibration objective was to have the ability to predict temperature that affects the hydrodynamics through density changes.

The hydrodynamic model was calibrated to the following:

- Water surface elevation from 1991 to 2005 at the Weiss Dam Spillway,
- Water surface elevation collected by GAEPD in 2005 at Georgia-Alabama border,
- Depth data collected by GAEPD in 2005 along the Coosa River,
- Temperature time-series data collected by ADEM,
- Temperature time-series data collected by GAEPD,
- Temperature profiles collected by ADEM in 2005,
- Temperature profiles collected by GAEPD in 2005,

The hydrodynamic model calibration was validated to the following:

- Water surface elevation from 1991 to 2005 at the Weiss Dam Spillway,
- Temperature profiles collected by ADEM during 2000.

The stations that were used for the hydrodynamic calibration are presented in Table 5-1.

Table 5-1 Stations Used for Hydrodynamic Calibration

Station Name	Station Number	River Mile	Description	EFDC Cell		Layers
				I-Value	J-Value	
Alabama Power Stations						
Weiss Dam Spillway	--	227	Channel	33	24	8
ADEM Stations						
WEISS1A	--	223	Channel	37	24	8
WEISS2	--	237	Channel	15	10	8
WEISS3	--	246	Channel	21	10	8
WEISS4	--	251	Channel	29	10	8
WEISS12	--	254	Channel	31	10	8
GAEPD Stations						
Coosa River at Stateline	5COO-530	254	Channel	32	10	8
Coosa River at RM 262	5COO-480	262	Coosa River	42	10	6
Coosa River at RM 267	5COO-440	267	Coosa River	49	10	5
Coosa River at SR 100	5COO-410	270	Coosa River	53	10	4
Coosa River at Beech Creek	5COO-370	272.5	Coosa River	59	10	4
Coosa River at Blacks Bluff Road	5COO-340	280	Coosa River	67	10	3
USGS Stations						
USGS at Georgia/Alabama Border	02397530	254	Channel	32	10	8

5.1 Water Surface Elevation

Water surface elevation data were compared to measurements taken Alabama Power at the Weiss Lake spillway and by GAEPD at the Georgia-Alabama border (Figure 5-1).

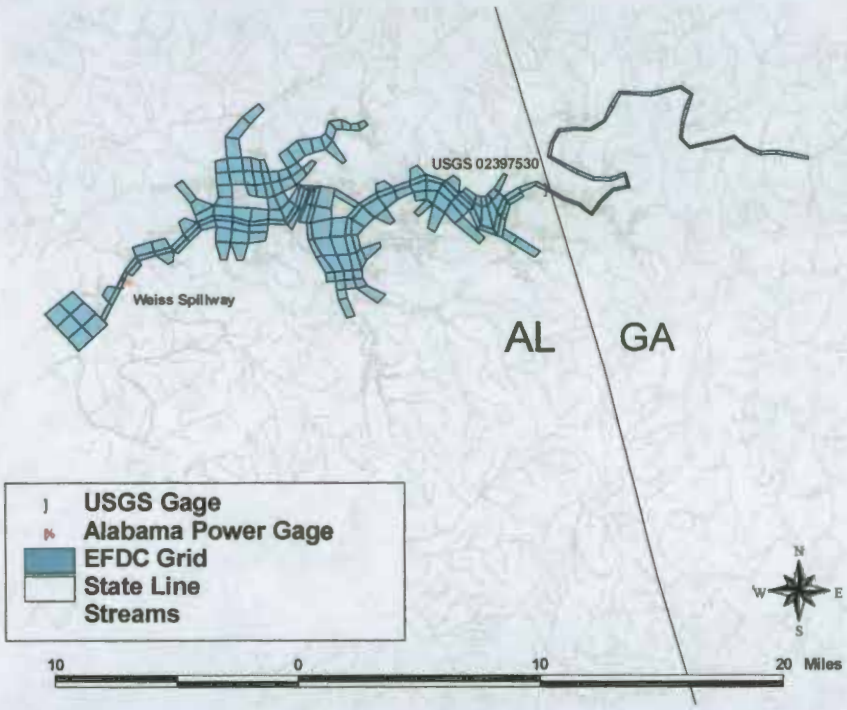

Figure 5-1 Location of Water Surface Elevation Comparison stations.

5.1.1 Weiss Lake Spillway

Simulated water surface elevation data were compared to measurements taken at the Weiss Lake spillway. Figure 5-2 illustrates the observed versus predicted water surface elevation for the period 1991 through 2005. Figure 5-3 presents the observed versus predicted water surface elevation for 2005. The model predicted water surface elevation quite well. During winter periods the model slightly over predicts the water surface elevation in order to avoid very shallow water in shallow areas.

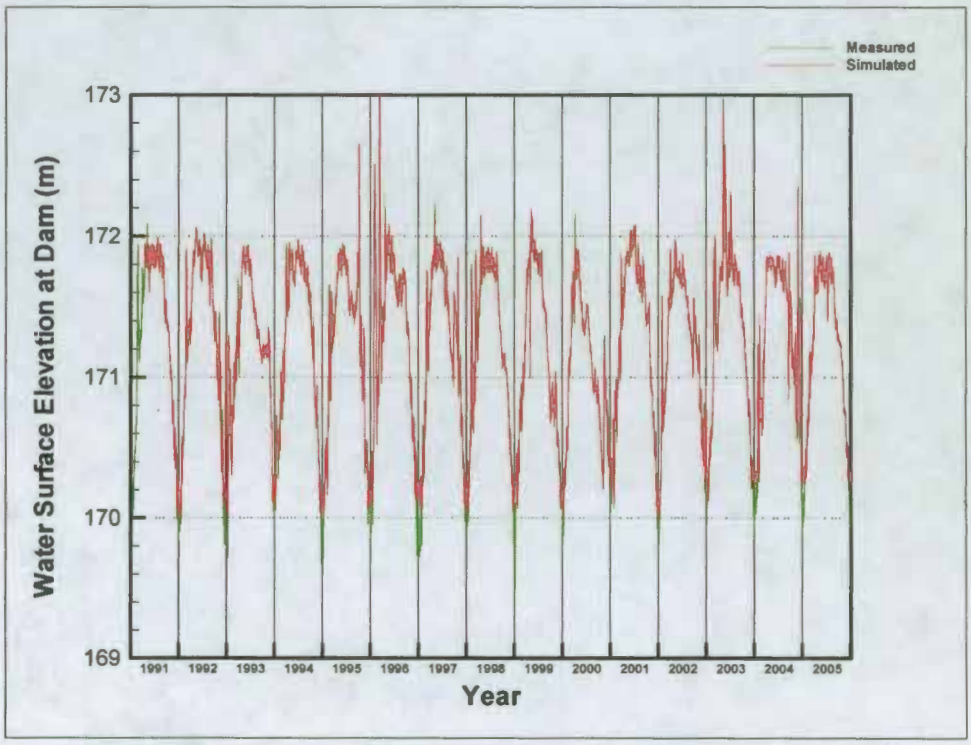

Figure 5-2 Water Surface Elevation Comparison at Weiss Lake Spillway for the period 1991-2005.

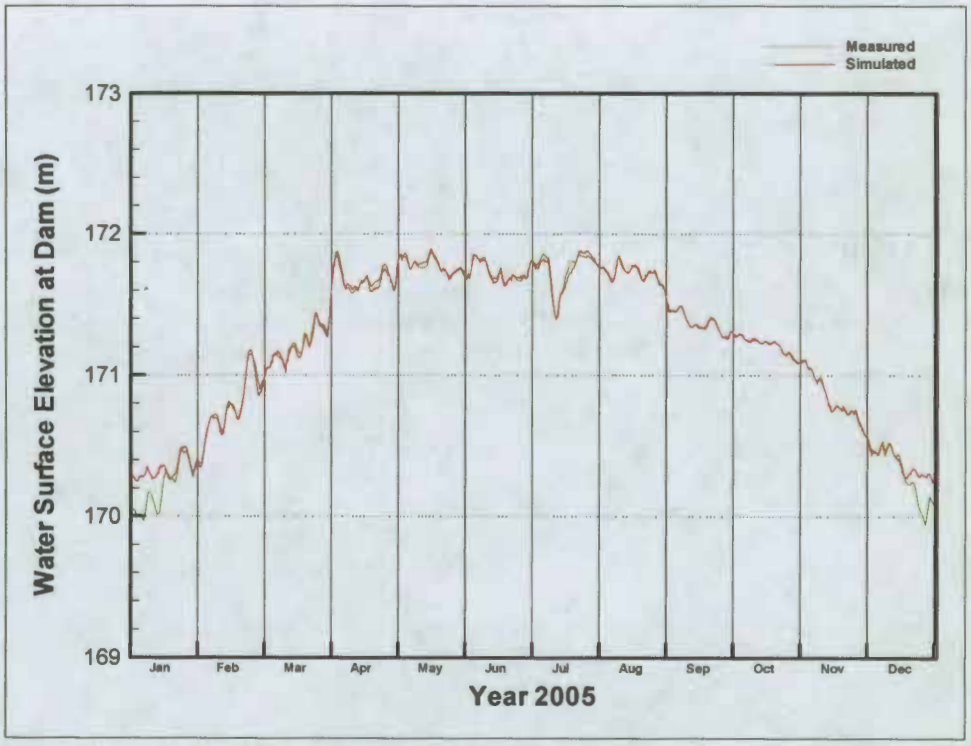

Figure 5-3 Water Surface Elevation Comparison at Weiss Lake Spillway for the year 2005.

5.1.2 Georgia-Alabama Border

Water surface elevation data were compared to measurements taken by GAEPD at the Georgia-Alabama border during 2005. This comparison is presented in Figure 5-4.

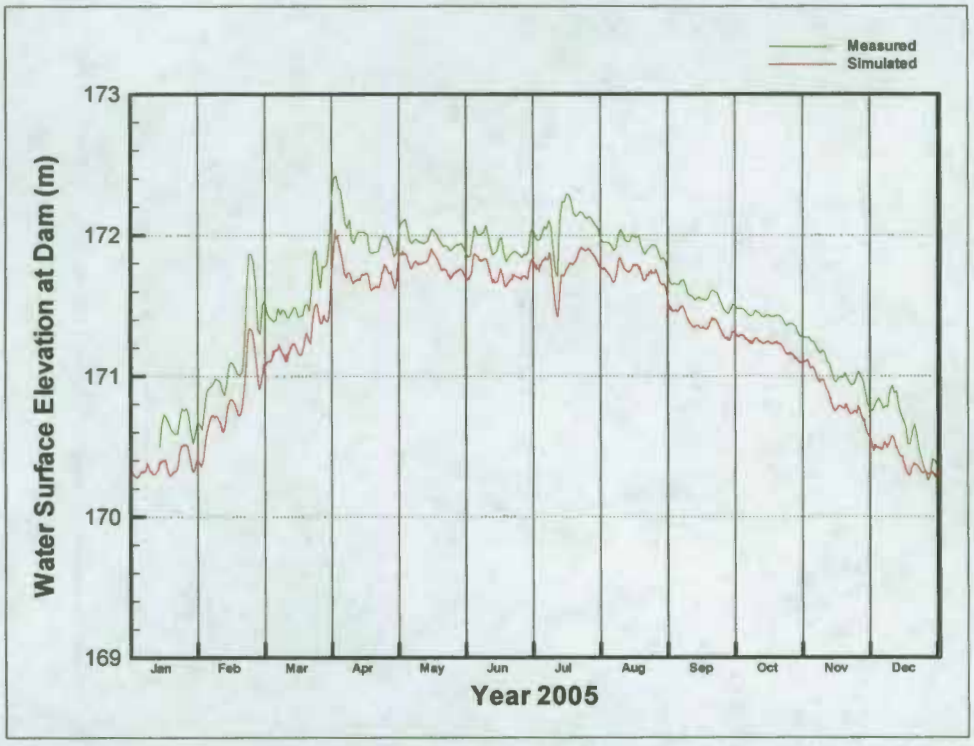

Figure 5-4 Water Surface Elevation Comparison at Georgia-Alabama border for the year 2005 (Daily Average).

5.2 Depths along Coosa River

Simulated water depth data were compared to depth measurements taken by GAEPD in 2005 (Figure 5-5). Data were collected approximately weekly from April through October at six locations along the Coosa River. Figures 5-6 through 5-11 present the depth comparison at the six locations.

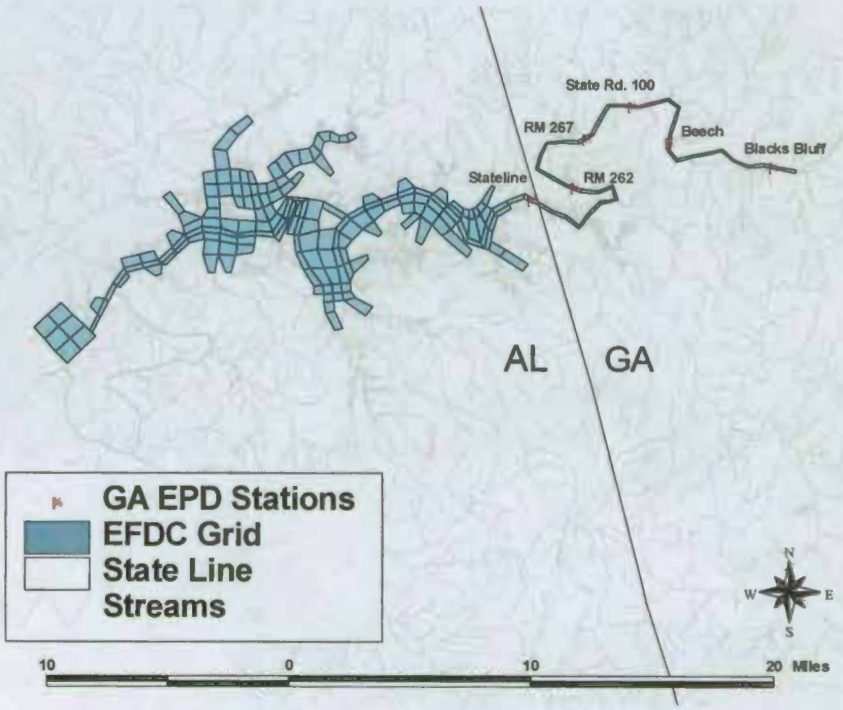

Figure 5-5 Location of Depth Comparison Stations.

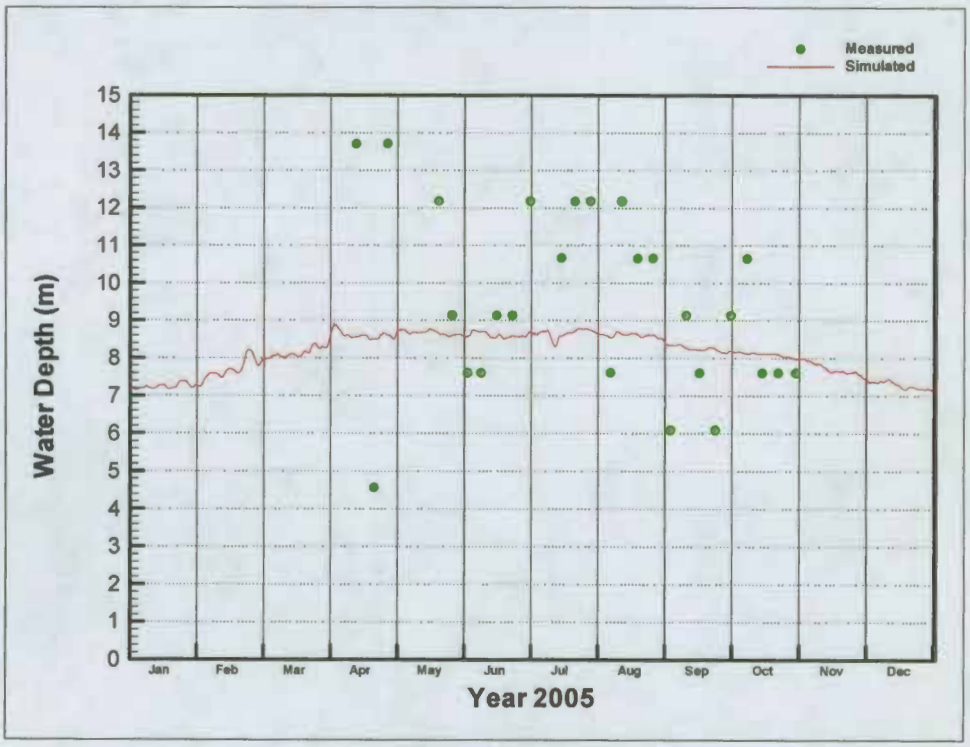

Figure 5-6 Depth Comparison at Georgia-Alabama border for the year 2005.

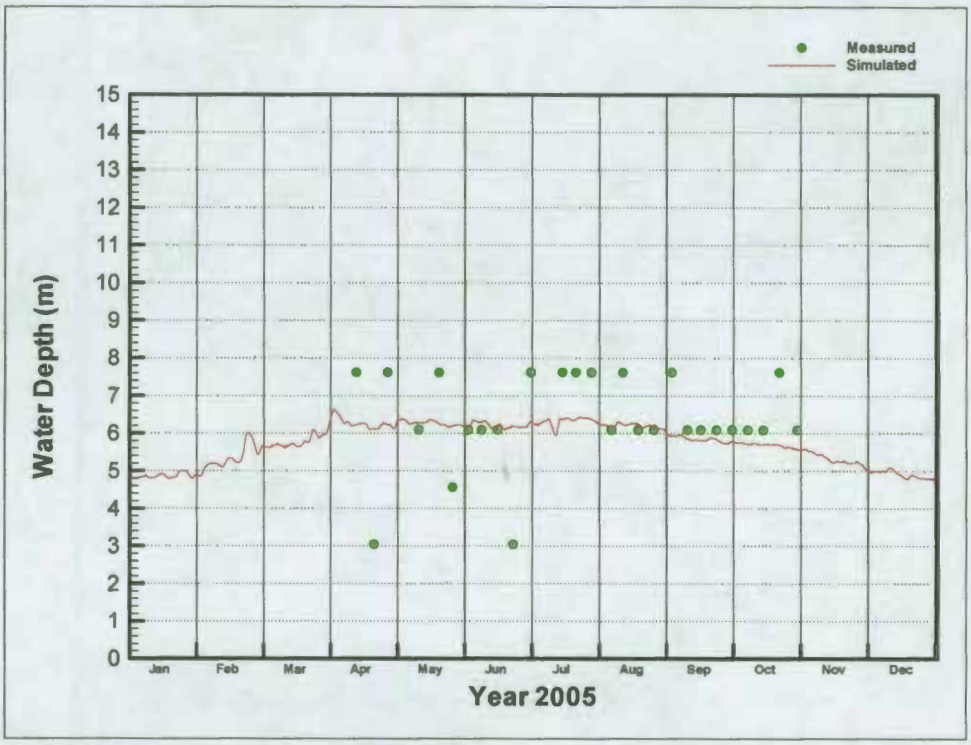

Figure 5-7 Depth Comparison at Coosa River at River Mile 262 for the year 2005.

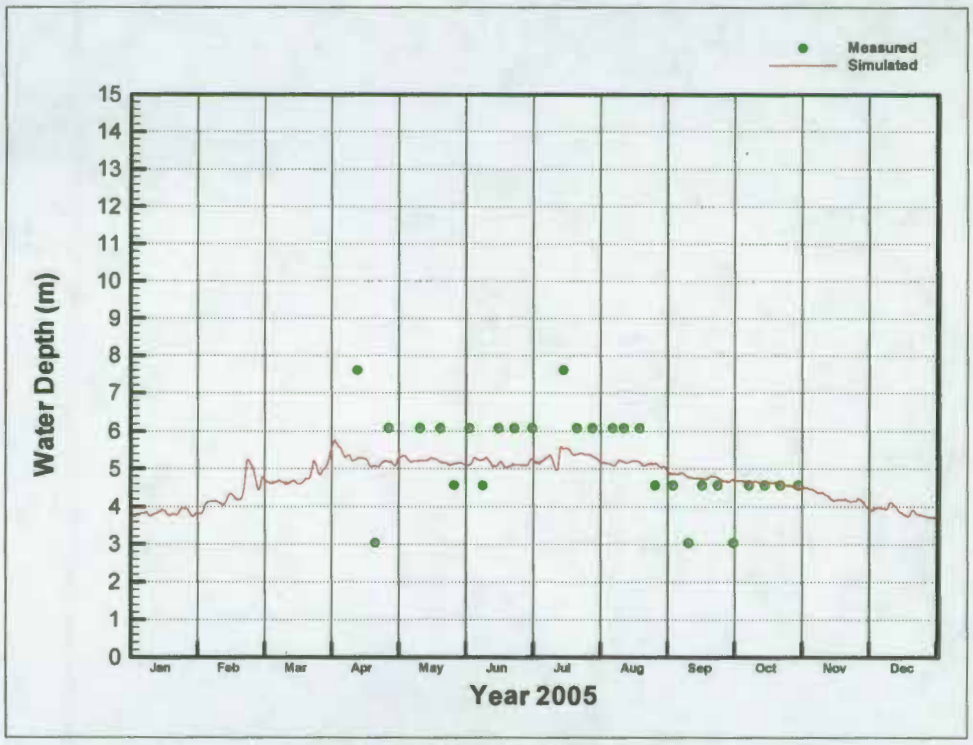

Figure 5-8 Depth Comparison at Coosa River at River Mile 267 for the year 2005.

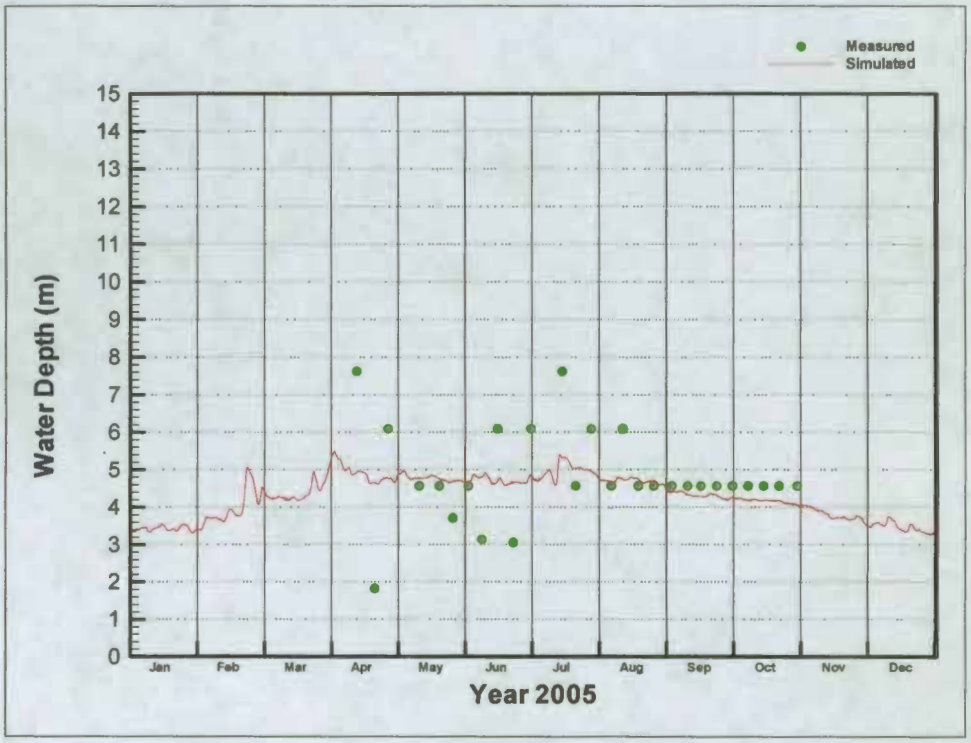

Figure 5-9 Depth Comparison at Coosa River at State Road 100 for the year 2005.

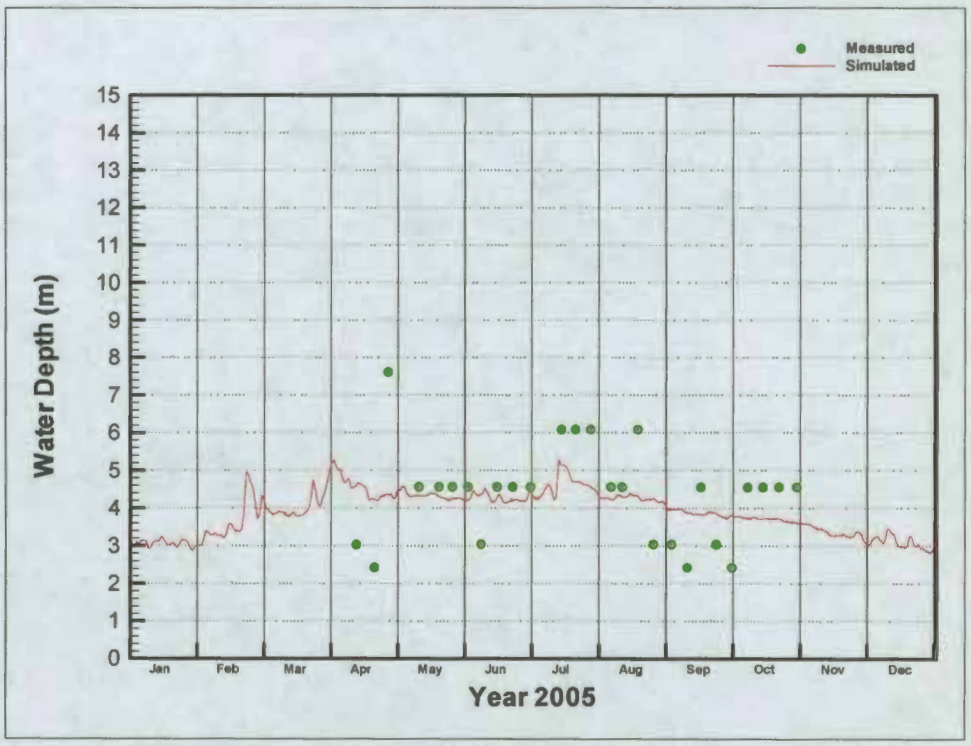

Figure 5-10 Depth Comparison at Coosa River at Beech Creek for the year 2005.

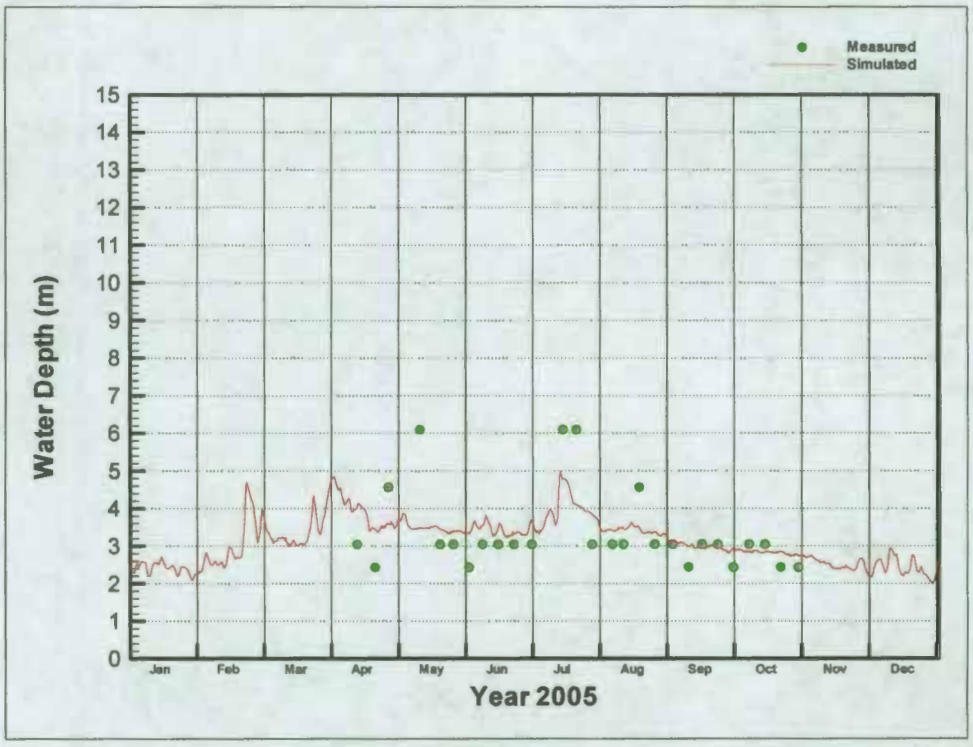

Figure 5-11 Depth Comparison at Coosa River at Blacks Bluff Road for the year 2005.

5.3 Temperature

The calibration of temperature was a two-fold graphical comparison. First, time series plots were generated to compare model simulations to measured data. Then, vertical profiles were compared to better assess the model capabilities to capture the system stratification. The sampling stations for Weiss Lake are presented in Figure 5-12. Sampling summary information for ADEM stations are presented in Table 5-2, and for information for GAEPD stations are presented in Table 5-3. This includes the number of observations, minimum, and maximum.

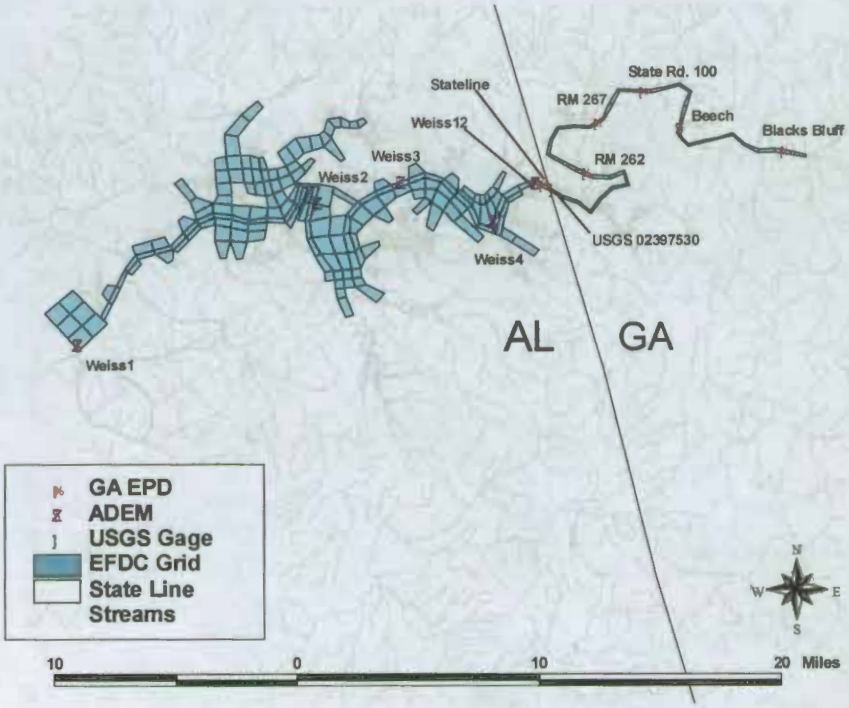

Figure 5-12 Weiss Lake Water Temperature Sampling Stations

Table 5-2 Weiss Lake Water Temperature Sampling Stations (ADEM)

Station	Unique Sampling Dates	No. of Obs.	Mean (C^O)	Min (C^O)	Max (C^O)	First Date	Last Date
WEISS0	7	34	25.03	15.71	29.61	25-Apr-01	30-Oct-01
WEISS1	7	100	23.64	17.25	31.13	27-Apr-05	24-Oct-05
WEISS1A	53	701	24.33	15.46	31.73	5-May-92	24-Oct-05
WEISS2	53	705	23.72	13.89	32.51	5-May-92	24-Oct-05
WEISS3	51	565	24.26	0	31.48	6-May-93	24-Oct-05
WEISS4	51	607	24.61	15.48	32.09	6-May-93	24-Oct-05
WEISS5	9	91	23.7	14.9	31.61	18-Apr-00	25-Oct-05
WEISS6	9	82	24.36	16.11	32.3	18-Apr-00	25-Oct-05
WEISS7	9	74	23.8	15.31	31.77	18-Apr-00	25-Oct-05
WEISS8	9	108	23.69	15.44	29.87	18-Apr-00	25-Oct-05
WEISS9	9	76	24.28	16.32	30.99	18-Apr-00	25-Oct-05
WEISS12	25	366	22.08	8.57	31.75	23-Apr-02	1-Mar-06

Table 5-3 Weiss Lake Water Temperature Sampling Stations (GAEPD)

Station	Unique Sampling Dates	No. of Obs.	Mean (C^O)	Min (C^O)	Max (C^O)	First Date	Last Date
Stateline[A]	26	812	27.43	15.28	30.11	12-Apr-05	26-Oct-05
RM 262[B]	27	273	24.38	15.15	30.16	12-Apr-05	26-Oct-05
RM 267[B]	27	257	23.86	14.85	29.99	12-Apr-05	26-Oct-05
SR 100[B]	27	247	23.65	15.21	29.08	12-Apr-05	26-Oct-05
Beech Creek[B]	27	239	22.06	14.69	26.85	12-Apr-05	26-Oct-05
Blacks Bluff[B]	27	218	22.01	14.37	26.85	12-Apr-05	26-Oct-05

[A] Statistics include data collected at 25%, 50%, 75% and 95% of the cross section.
[B] Statistics include data collected at 50% of the cross section.

5.2.1 Time Series

Time series plots for the temperature calibration for Weiss Lake are presented in Figures 5-13 through 5-31. Figures 5-13 through 5-22 compare simulated temperature values to data collected at ADEM profile stations. Figures 5-23 and 5-24 compares simulated temperature values to time series data collected at USGS station 02397530. Figure 5-25 compares simulated temperature values to time series data collected at GAEPD station 5COO-530. Figures 5-26 through 5-31 compare simulated temperature values to data collected at GAEPD profile stations.

To compare the simulated data to the measured profile data, the measured profile data were averaged to obtain a single value of temperature for each profile. The simulated data were averaged over all layers and then for each day to obtain a single value of temperature per day. Since all the measured observations were taken during the summer period, it is difficult to compare the simulation temperatures on a seasonal basis. However, the simulated temperatures seem to capture the range and fluctuations of temperature throughout the system.

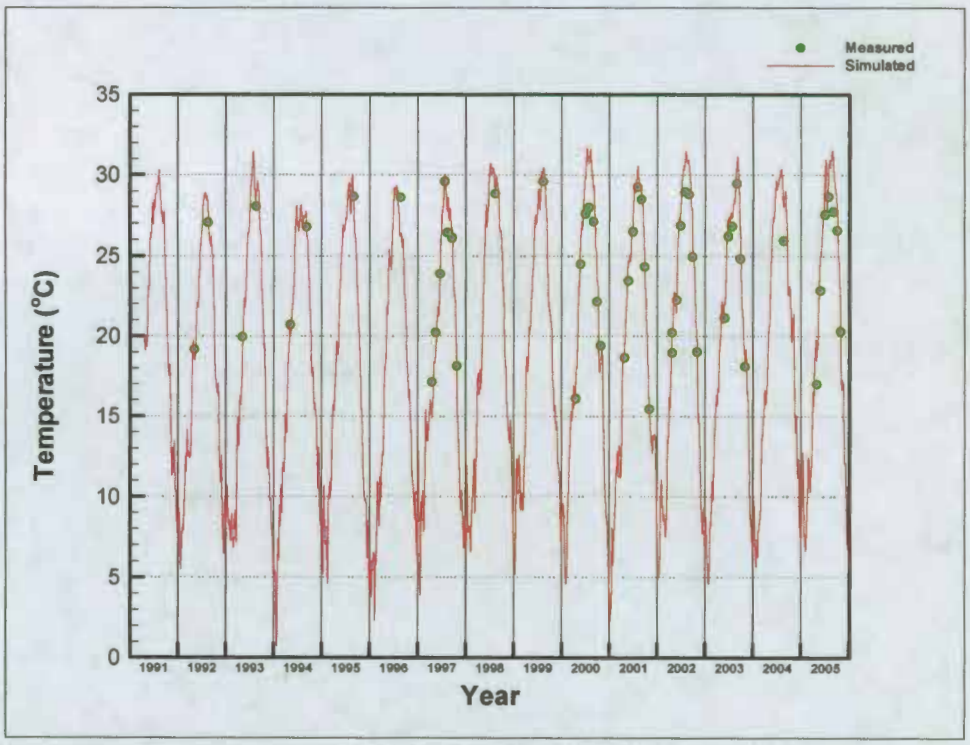

Figure 5-13 Simulated vs. Measured Temperature at Weiss 1A (1991-2005).

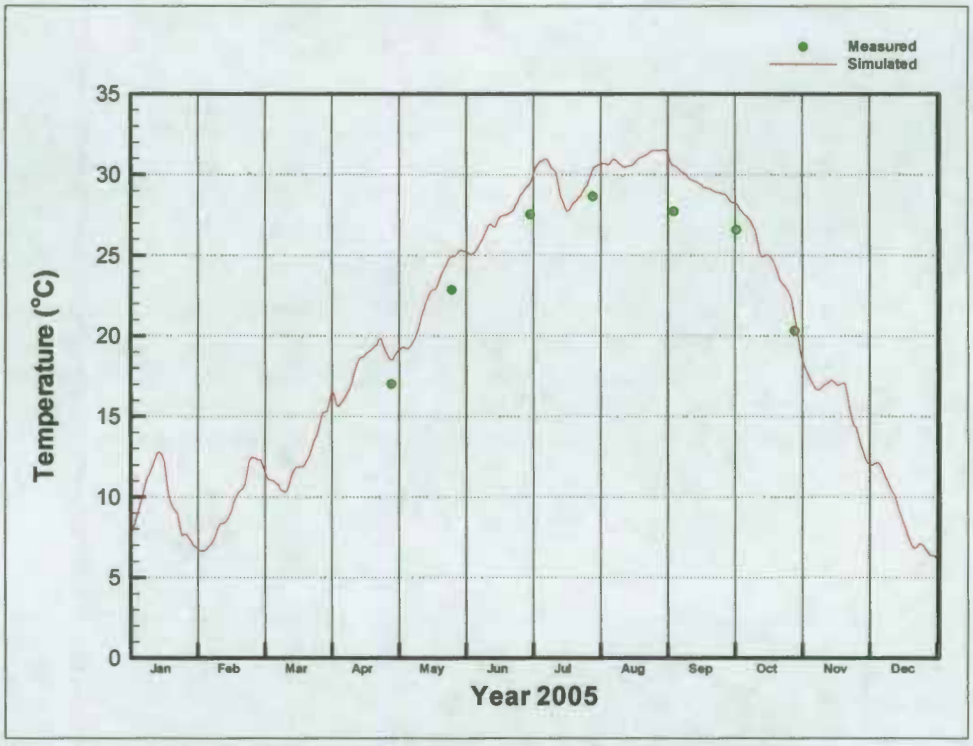

Figure 5-14 Simulated vs. Measured Temperature at Weiss 1A (2005).

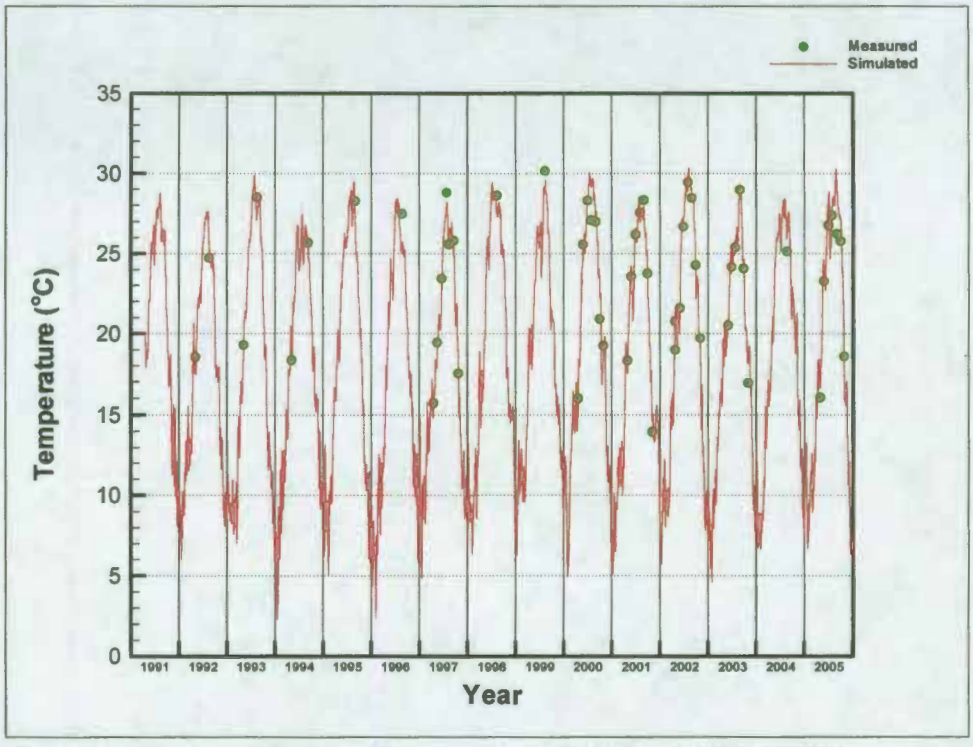

Figure 5-15 Simulated vs. Measured Temperature at Weiss 2 (1991-2005).

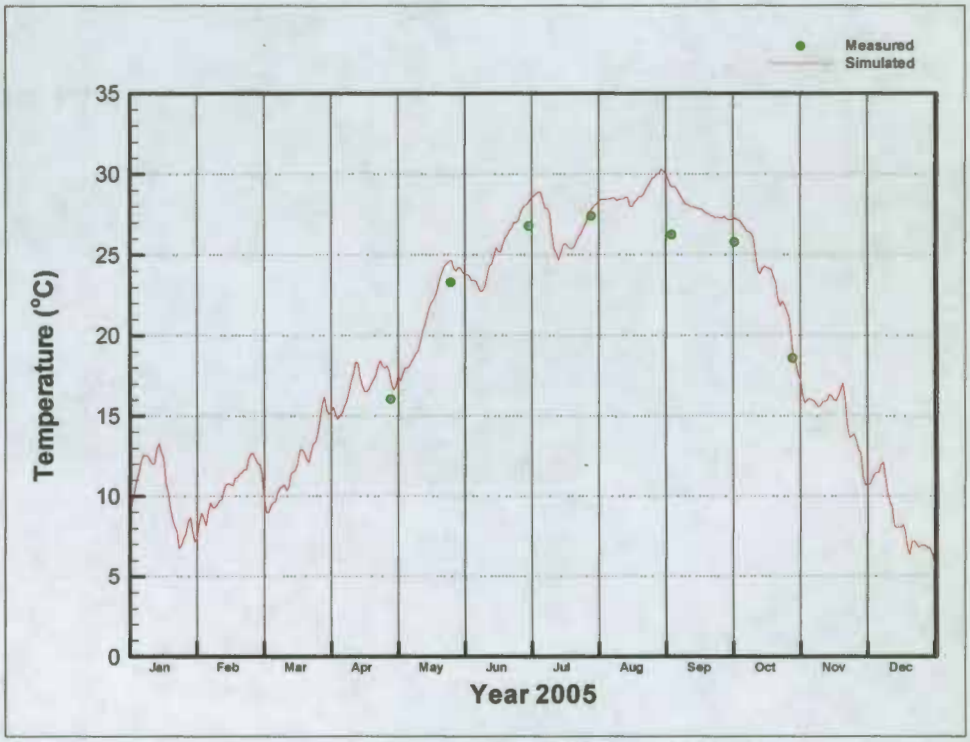

Figure 5-16 Simulated vs. Measured Temperature at Weiss 2 (2005).

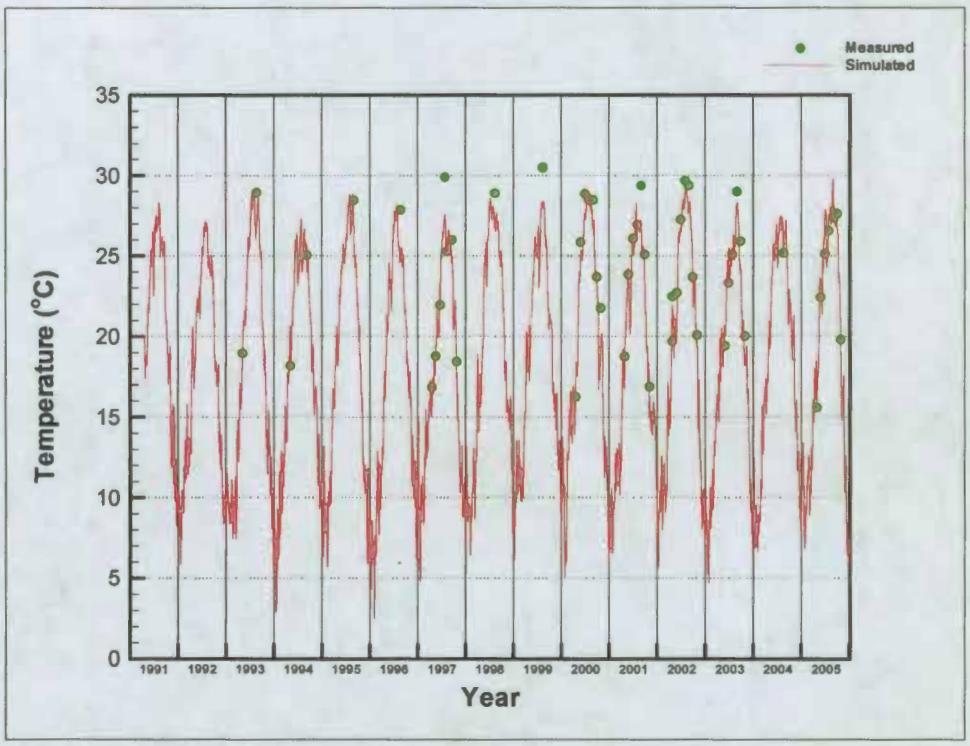

Figure 5-17 Simulated vs. Measured Temperature at Weiss 3 (1991-2005).

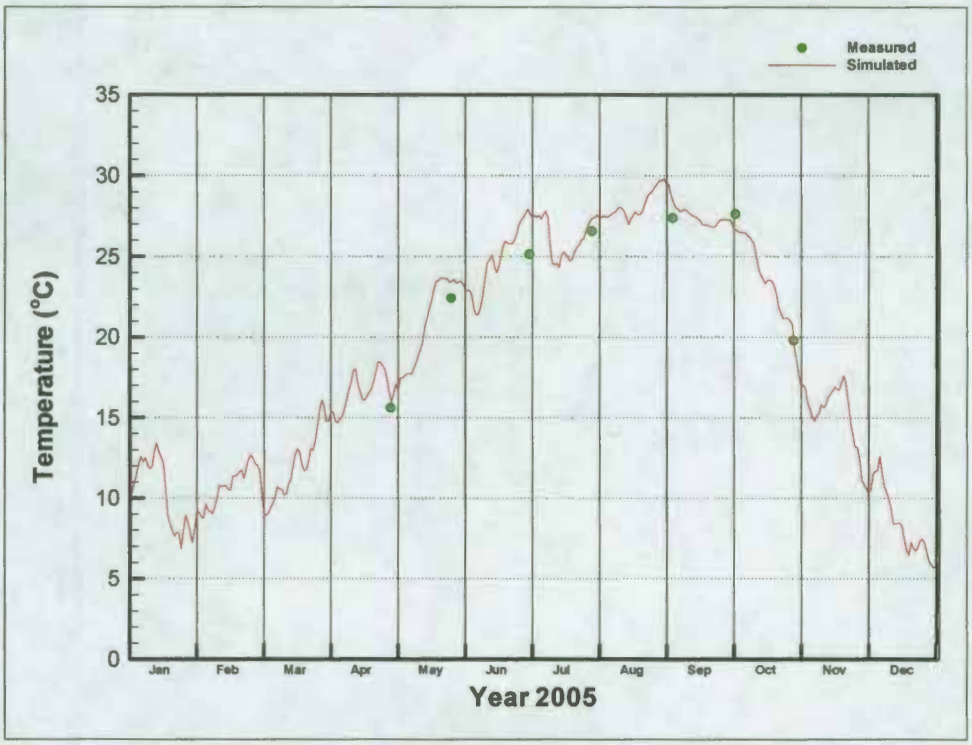

Figure 5-18 Simulated vs. Measured Temperature at Weiss 3 (2005).

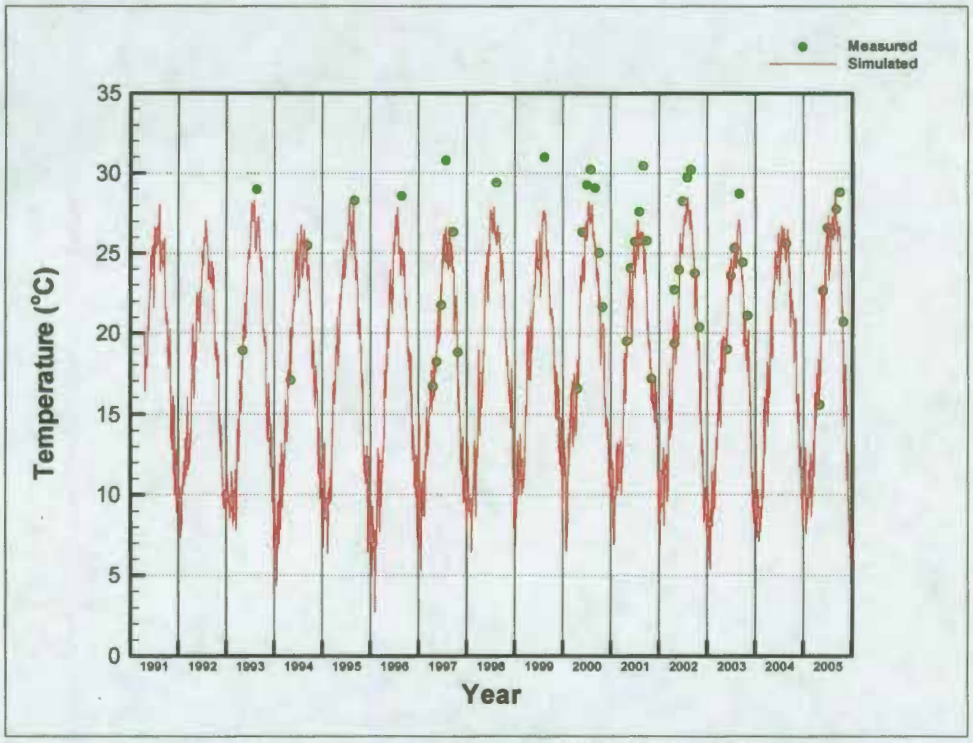

Figure 5-19 Simulated vs. Measured Temperature at Weiss 4 (1991-2005).

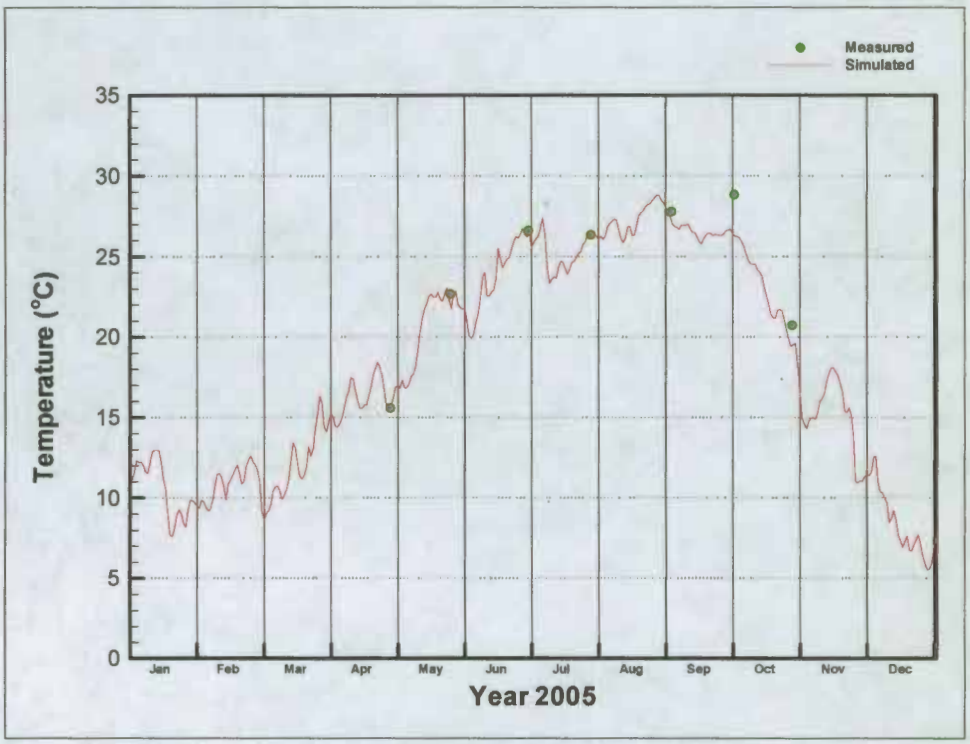

Figure 5-20 Simulated vs. Measured Temperature at Weiss 4 (2005).

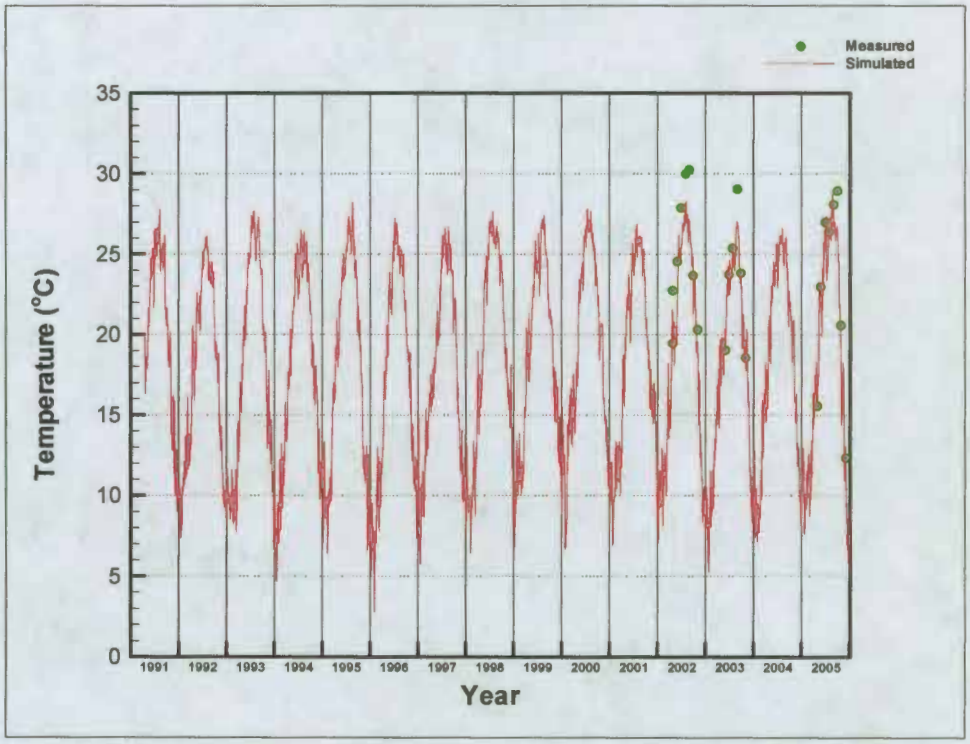

Figure 5-21 Simulated vs. Measured Temperature at Weiss 12 (1991-2005).

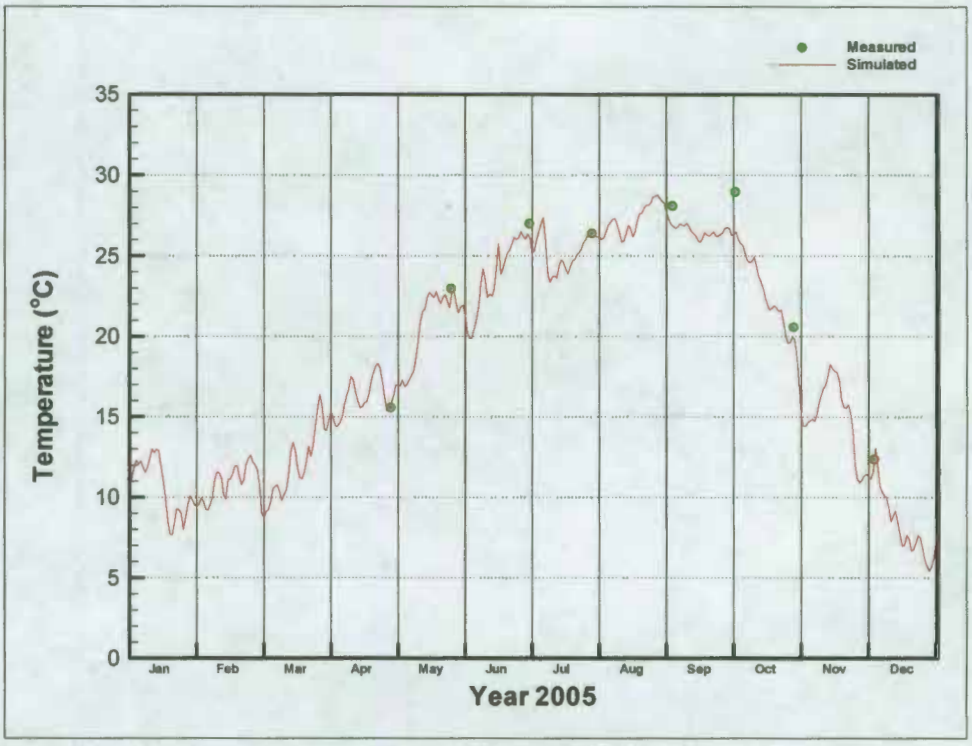

Figure 5-22 Simulated vs. Measured Temperature at Weiss 12 (2005).

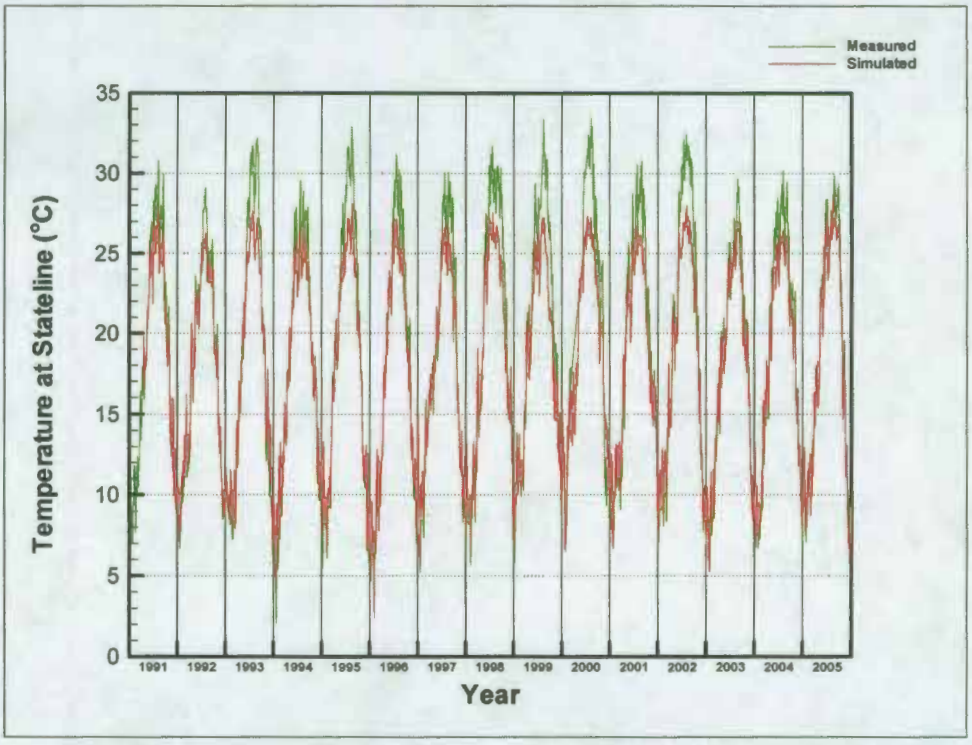

Figure 5-23 Simulated vs. Measured Temperature at Georgia-Alabama border (USGS station 02397530) (1991-2005).

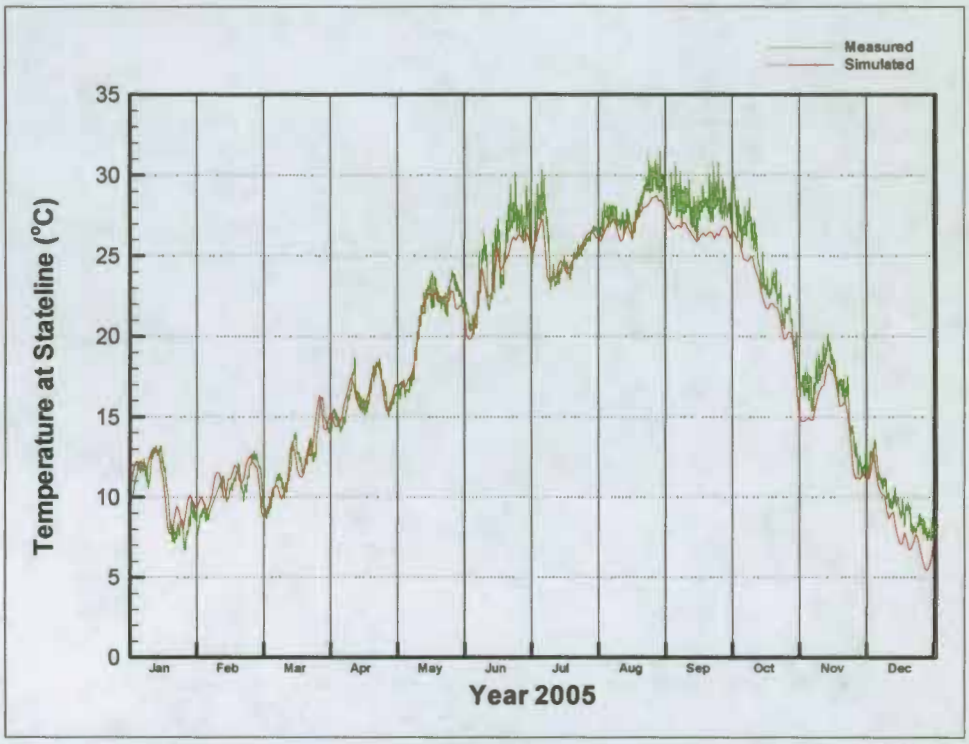

Figure 5-24 Simulated vs. Measured Temperature at Georgia-Alabama border (USGS station 02397530) (2005).

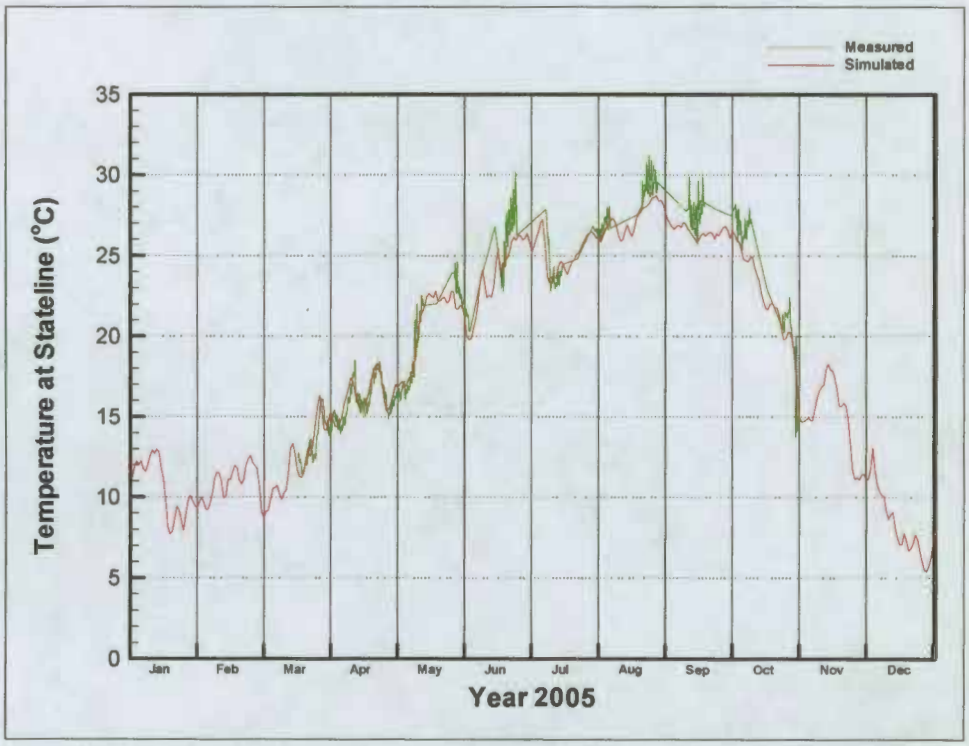

Figure 5-25 Simulated vs. Measured Temperature at Georgia-Alabama border (GAEPD station 5COO-530).

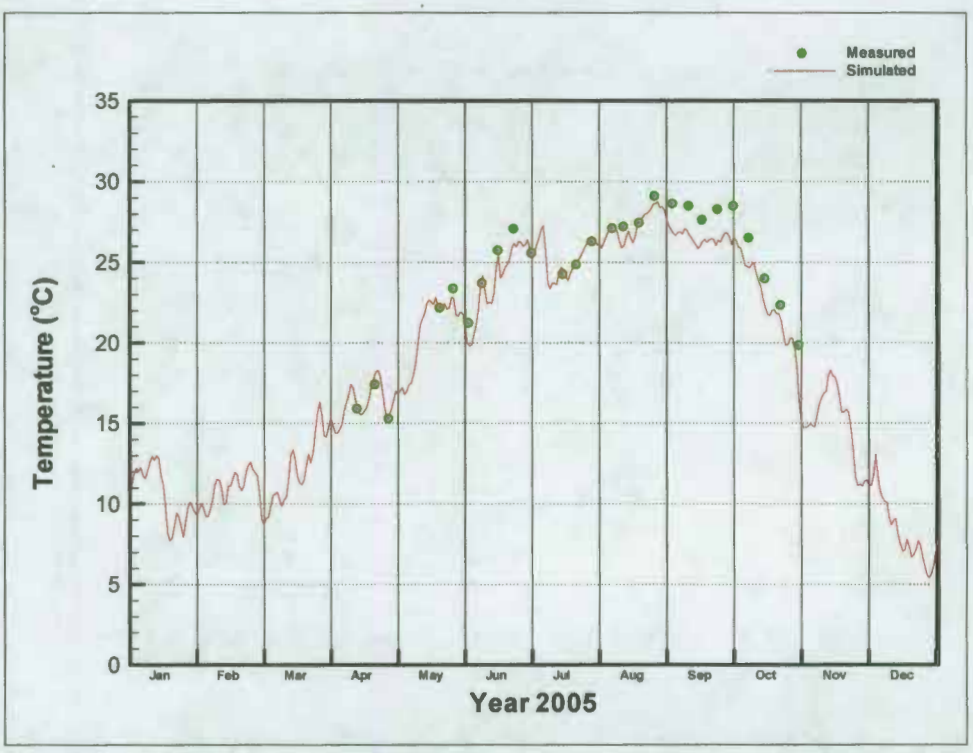

Figure 5-26 Simulated vs. Measured Temperature at Coosa River at Georgia-Alabama border.

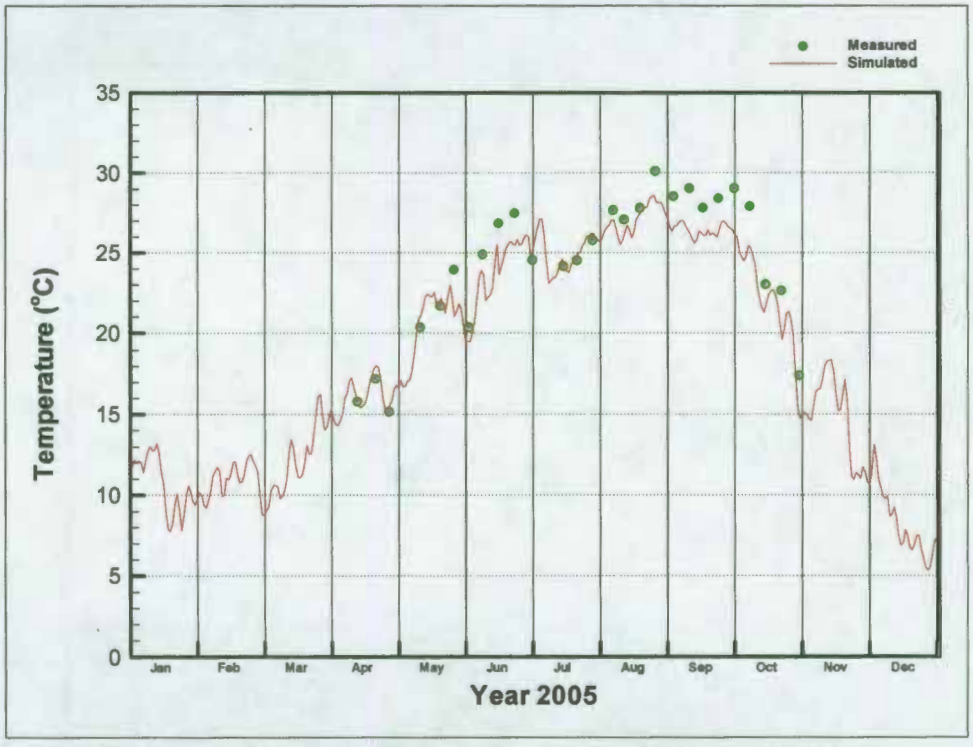

Figure 5-27 Simulated vs. Measured Temperature at Coosa River at RM 262.

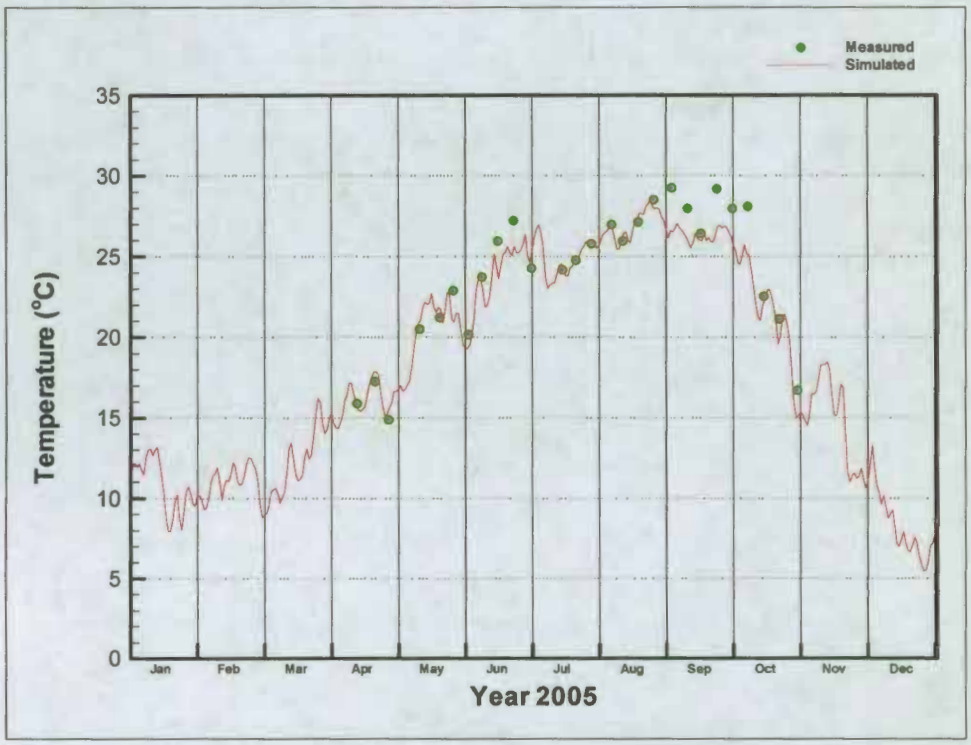

Figure 5-28 Simulated vs. Measured Temperature at Coosa River at RM 267.

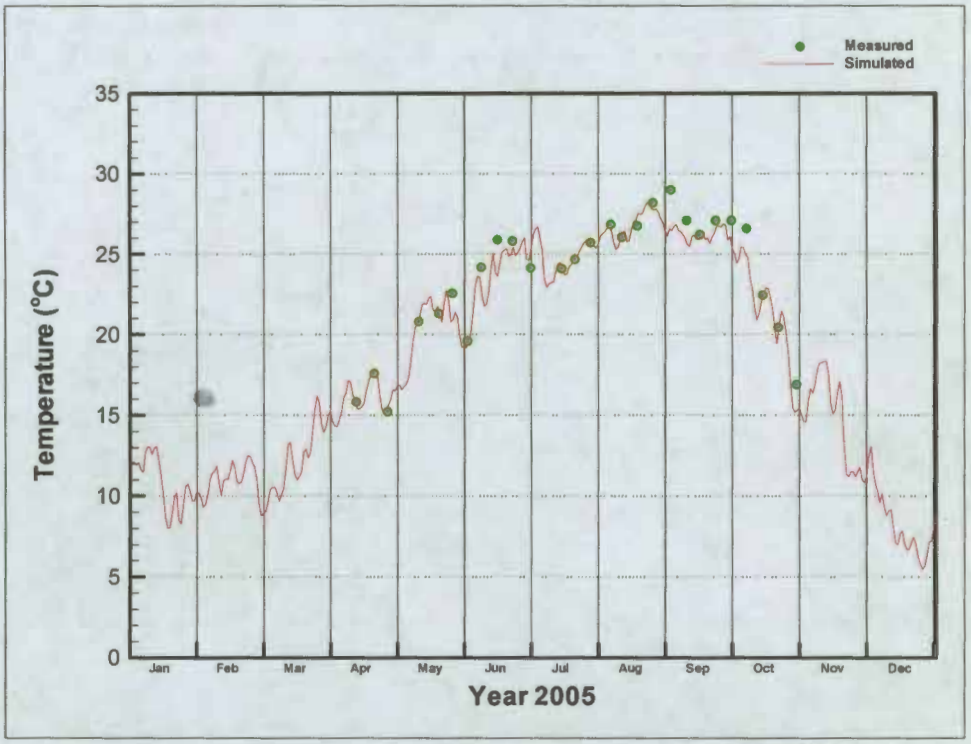

Figure 5-29 Simulated vs. Measured Temperature at Coosa River at SR 100.

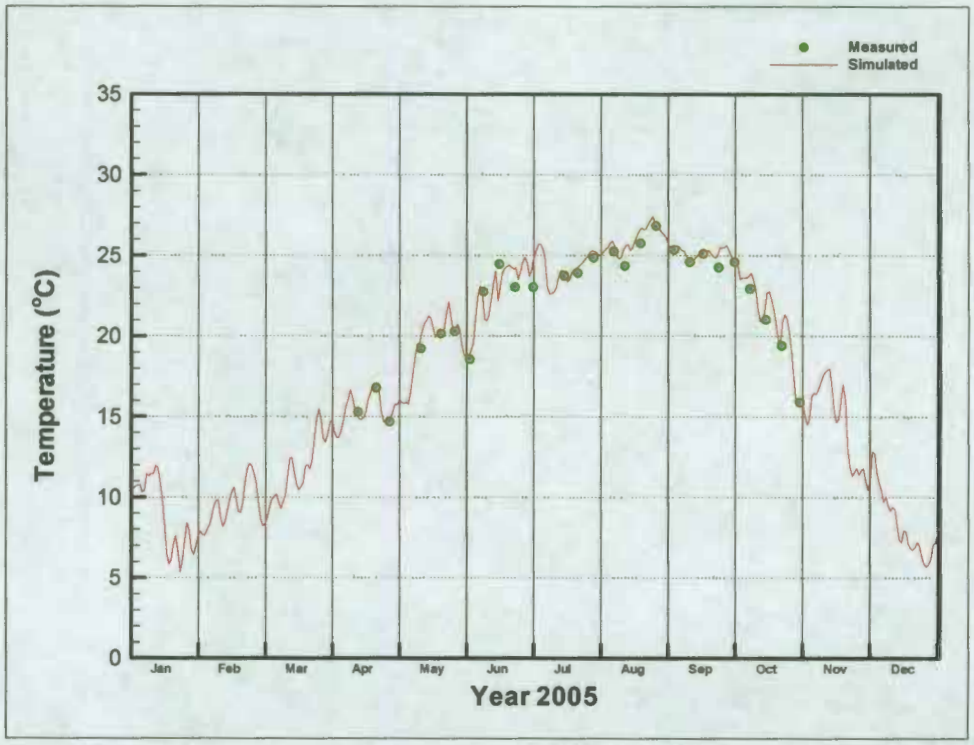

Figure 5-30 Simulated vs. Measured Temperature at Coosa River at Beech Creek.

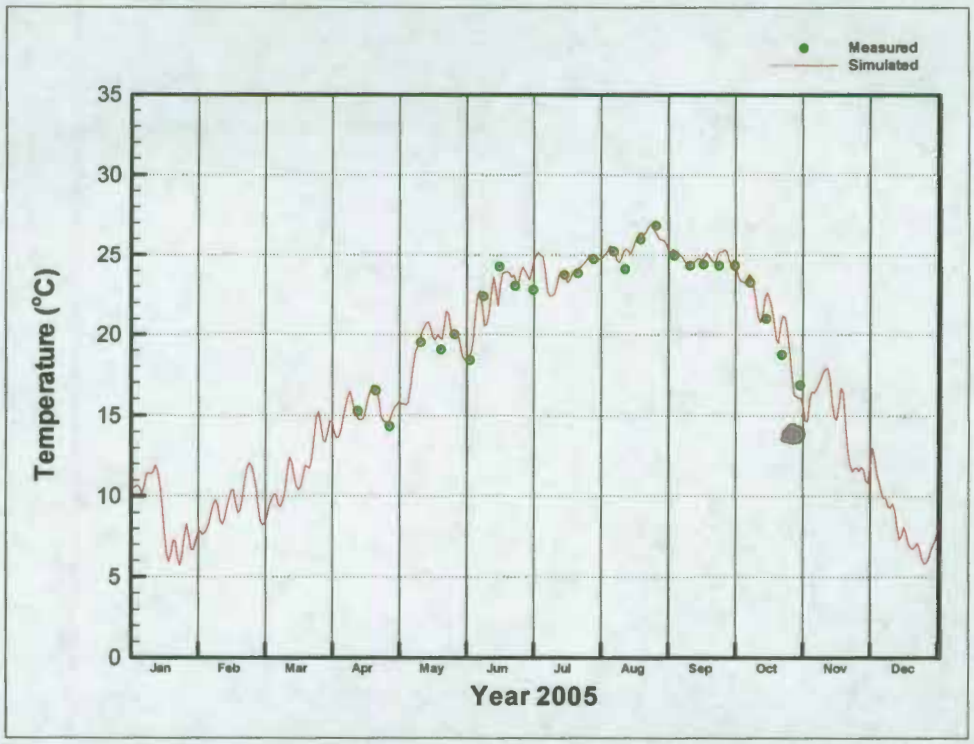

Figure 5-31 Simulated vs. Measured Temperature at Coosa River at Blacks Bluff.

5.2.2 Vertical Profiles

Temperature vertical profiles were also compared. Figures 5-32 through 5-36 present the temperature profile comparisons at ADEM stations. Figures 5-37 through 5-42 present the temperature profile comparisons at GAEPD stations. The model captures the stratification along the main channel of the lake, though for some profiles lower values are predicted in the upstream stations, specifically for the months of September and October. The degree of stratification between bottom and surface is also captured.

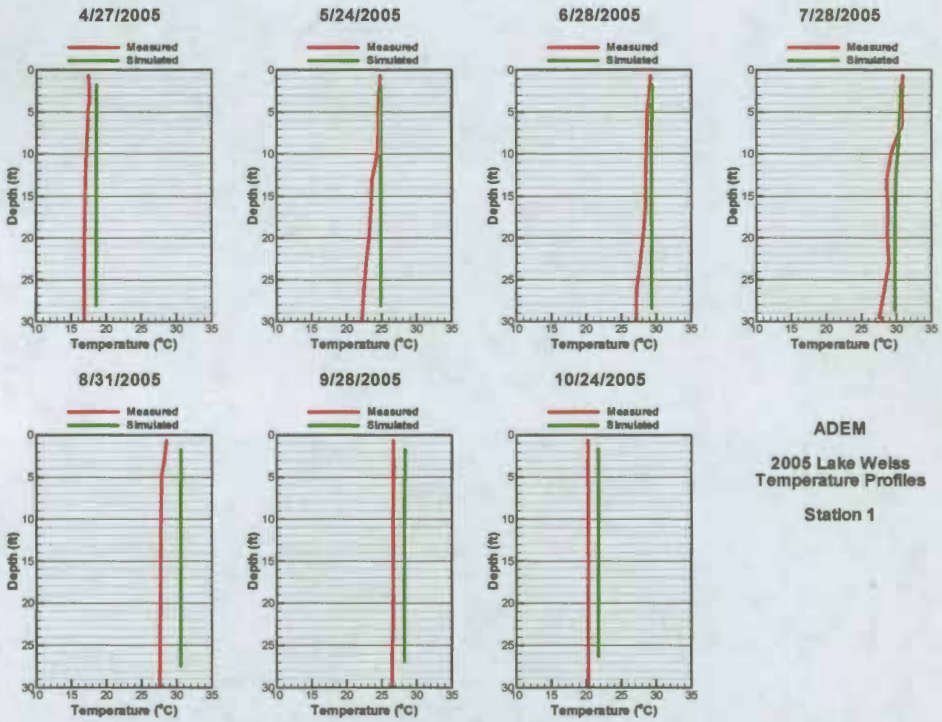

Figure 5-32 Temperature Profiles Comparison at Station Weiss 1A in 2005

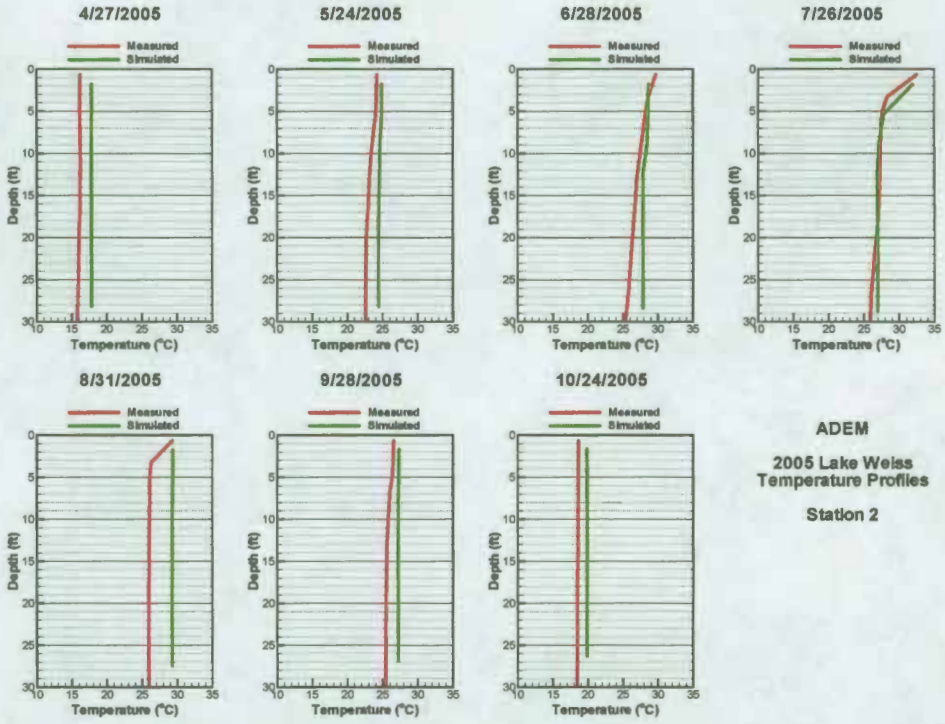

Figure 5-33 Temperature Profiles Comparison at Station Weiss 2 in 2005

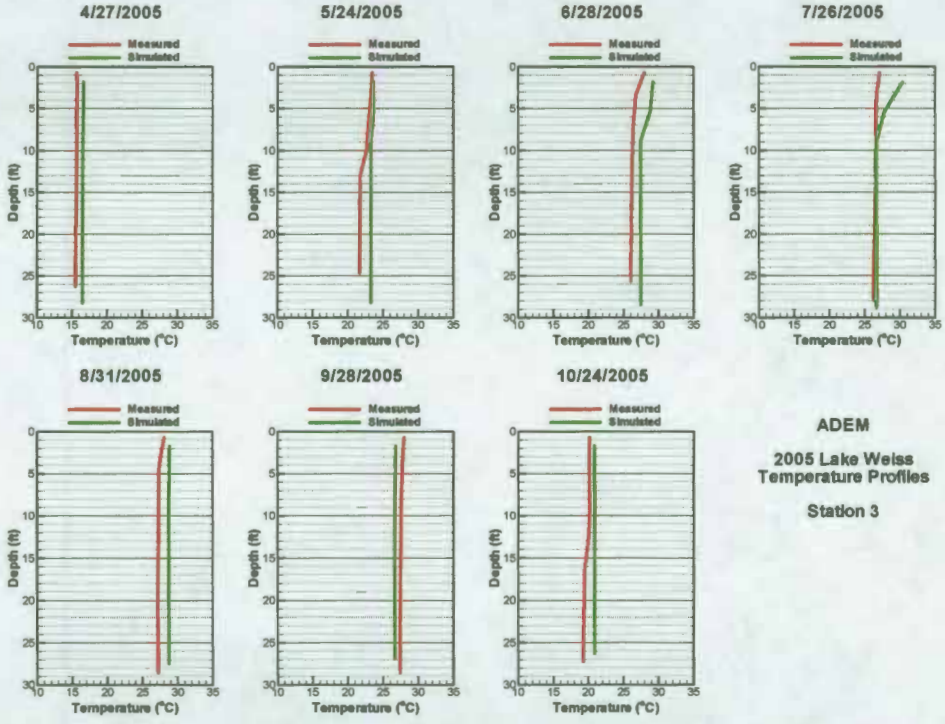

Figure 5-34 Temperature Profiles Comparison at Station Weiss 3 in 2005

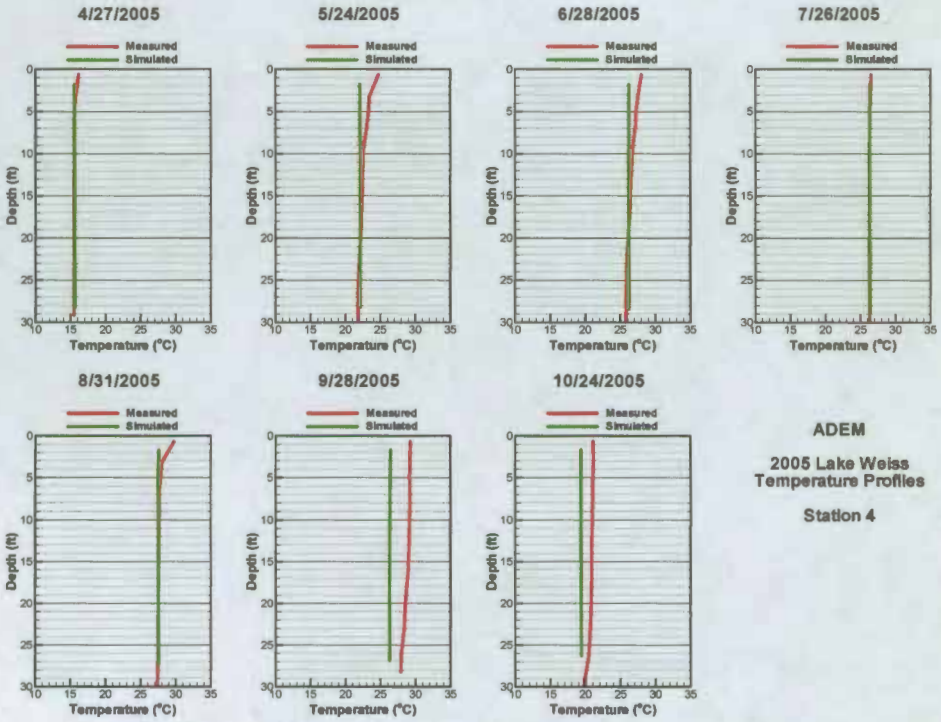

Figure 5-35 Temperature Profiles Comparison at Station Weiss 4 in 2005

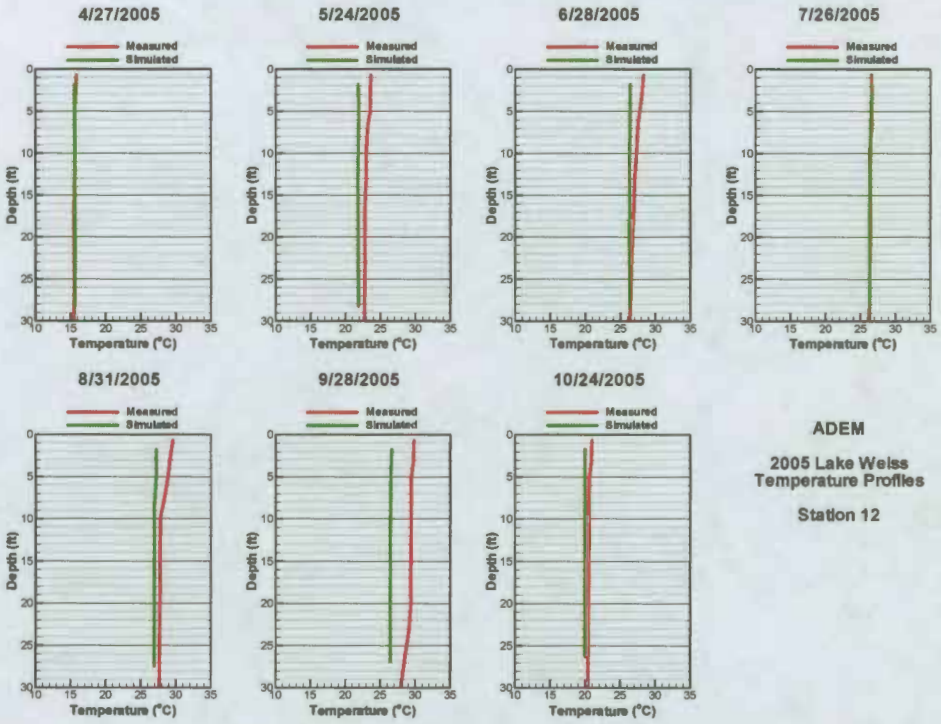

Figure 5-36 Temperature Profiles Comparison at Station Weiss 12 in 2005

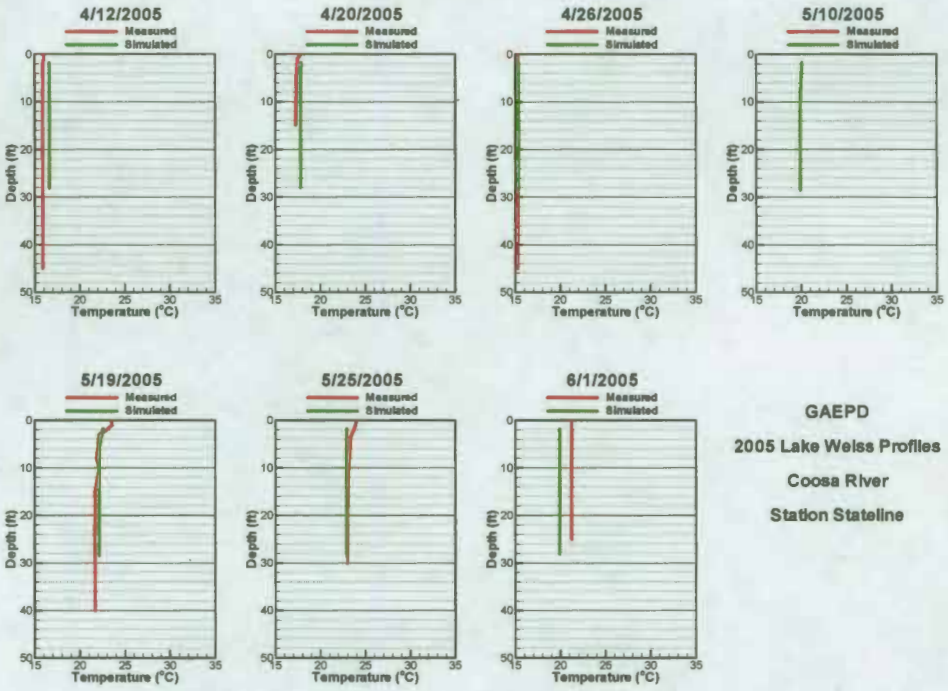

Figure 5-37 Temperature Profiles Comparison at Coosa River at Georgia-Alabama border.

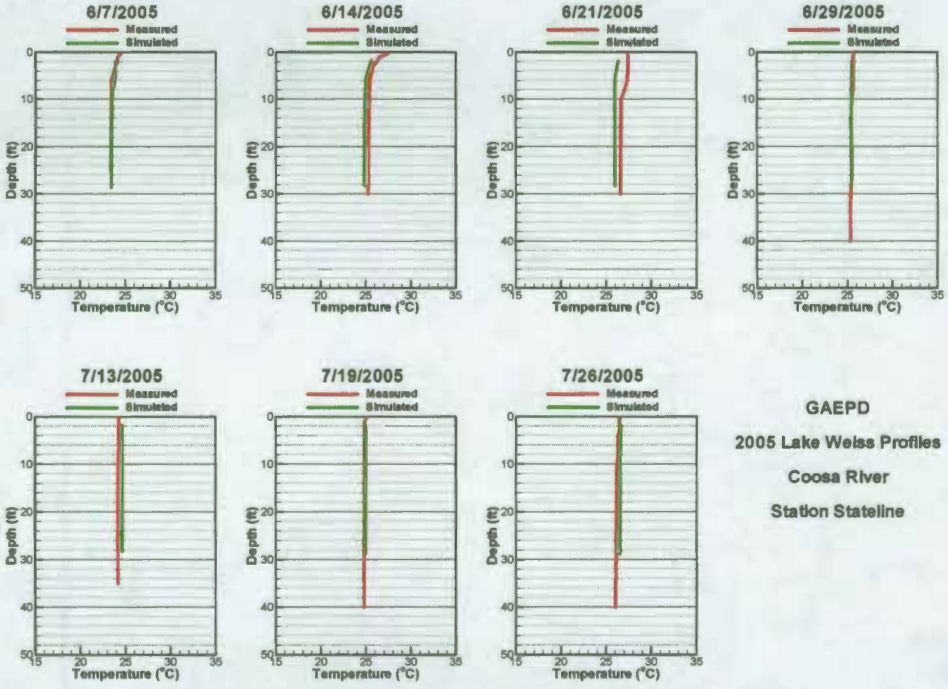

Figure 5-37 Temperature Profiles Comparison at Coosa River at Georgia-Alabama border (cont).

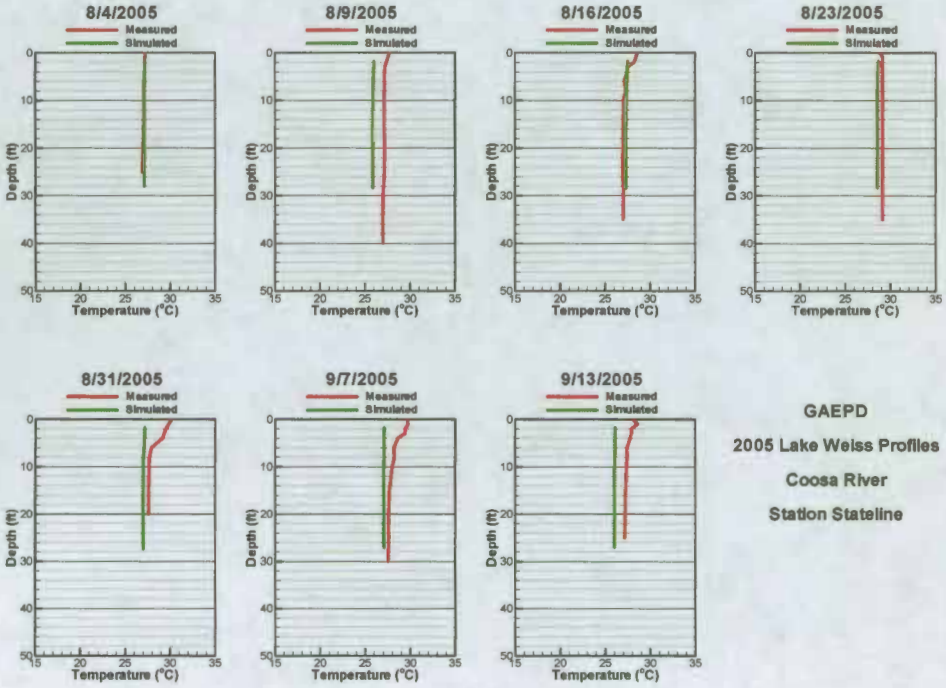

Figure 5-37 Temperature Profiles Comparison at Coosa River at Georgia-Alabama border (cont).

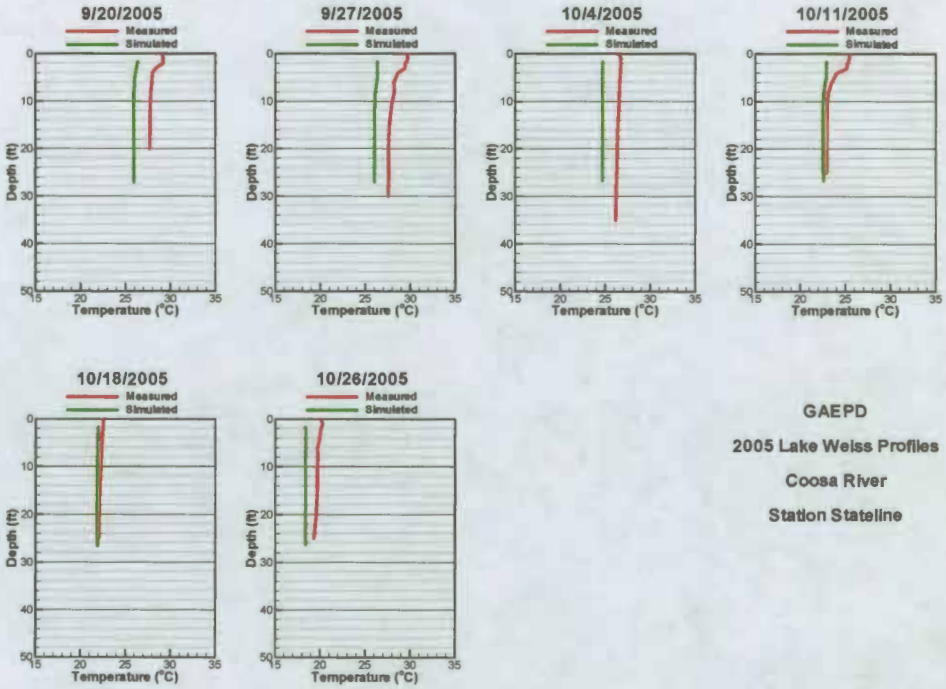

Figure 5-37 Temperature Profiles Comparison at Coosa River at Georgia-Alabama border (cont).

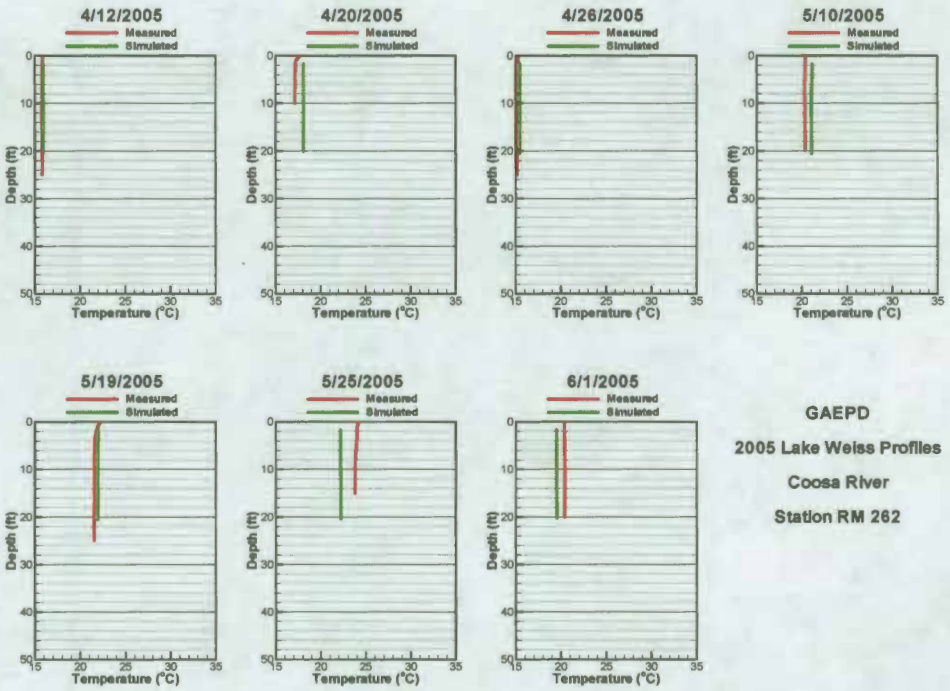

Figure 5-38 Temperature Profiles Comparison at Coosa River at RM 262.

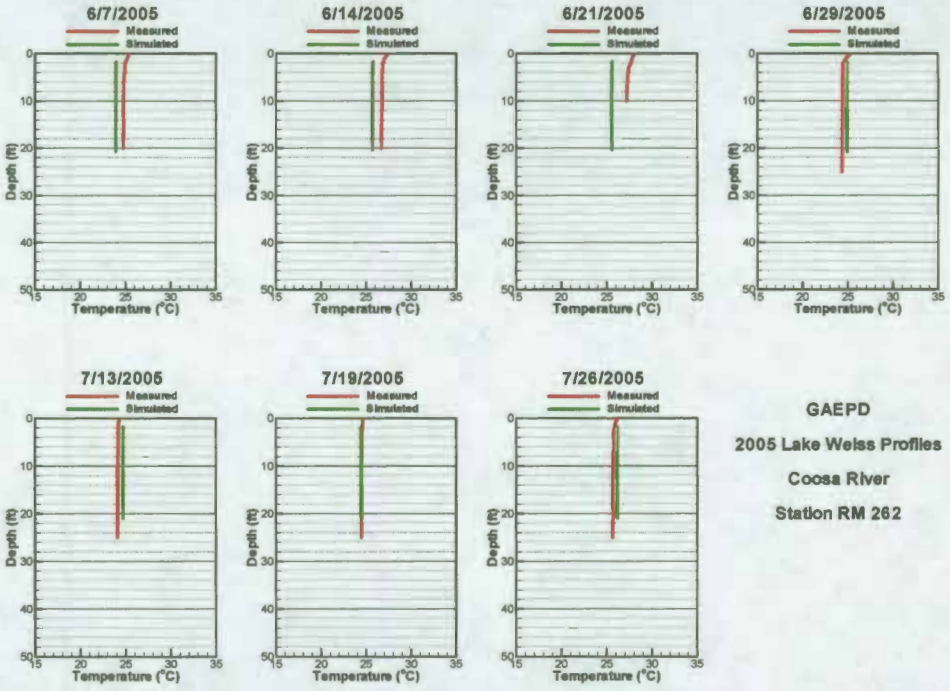

Figure 5-38 Temperature Profiles Comparison at Coosa River at RM 262 (cont).

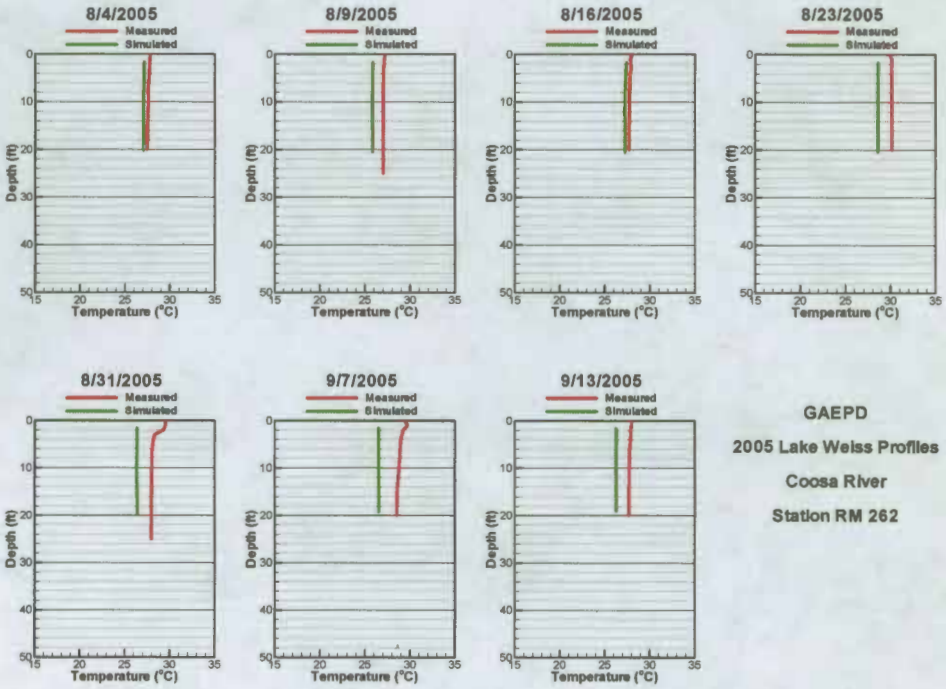

Figure 5-38 Temperature Profiles Comparison at Coosa River at RM 262 (cont).

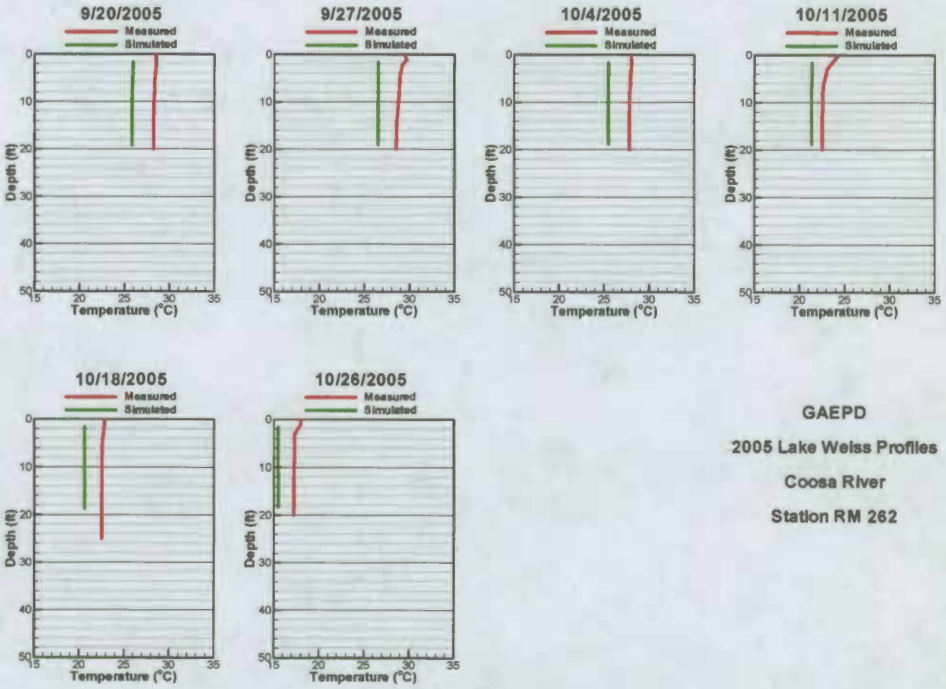

Figure 5-38 Temperature Profiles Comparison at Coosa River at RM 262 (cont).

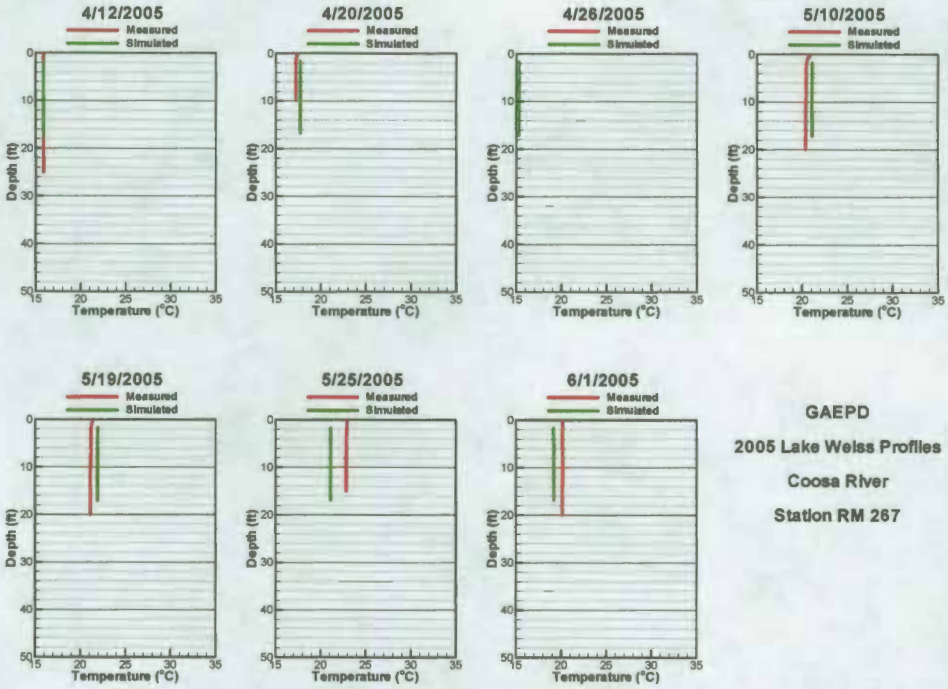

Figure 5-39 Temperature Profiles Comparison at Coosa River at RM 267.

Figure 5-39 Temperature Profiles Comparison at Coosa River at RM 267 (cont).

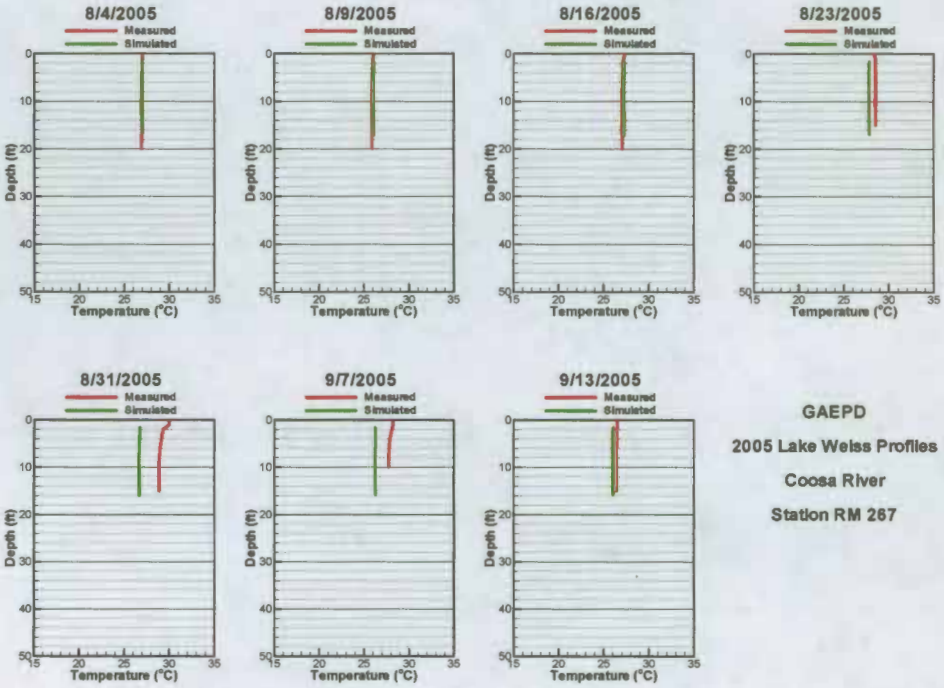

Figure 5-39 Temperature Profiles Comparison at Coosa River at RM 267 (cont).

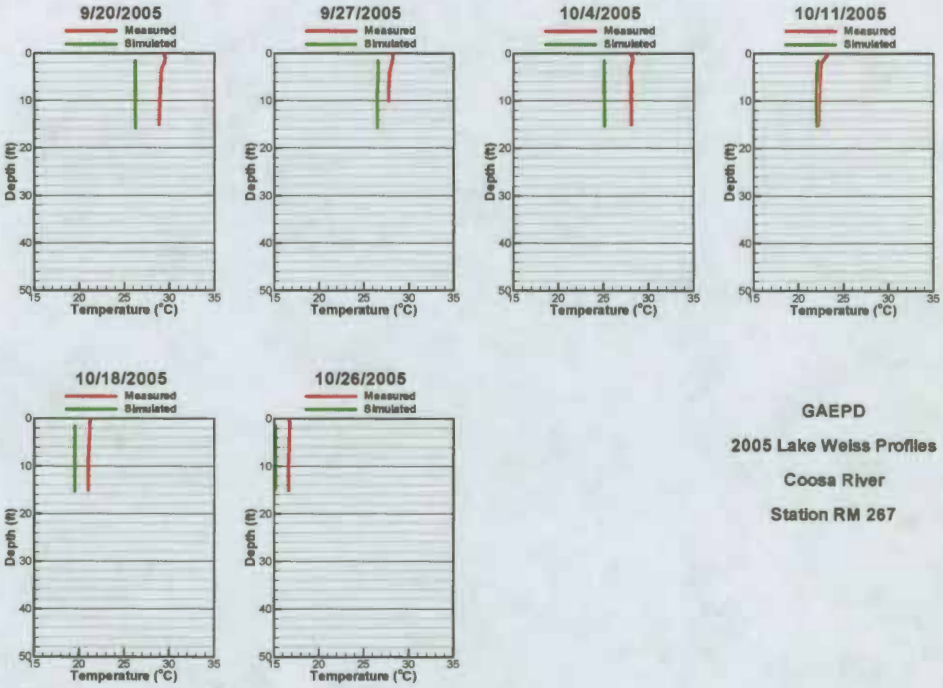

Figure 5-39 Temperature Profiles Comparison at Coosa River at RM 267 (cont).

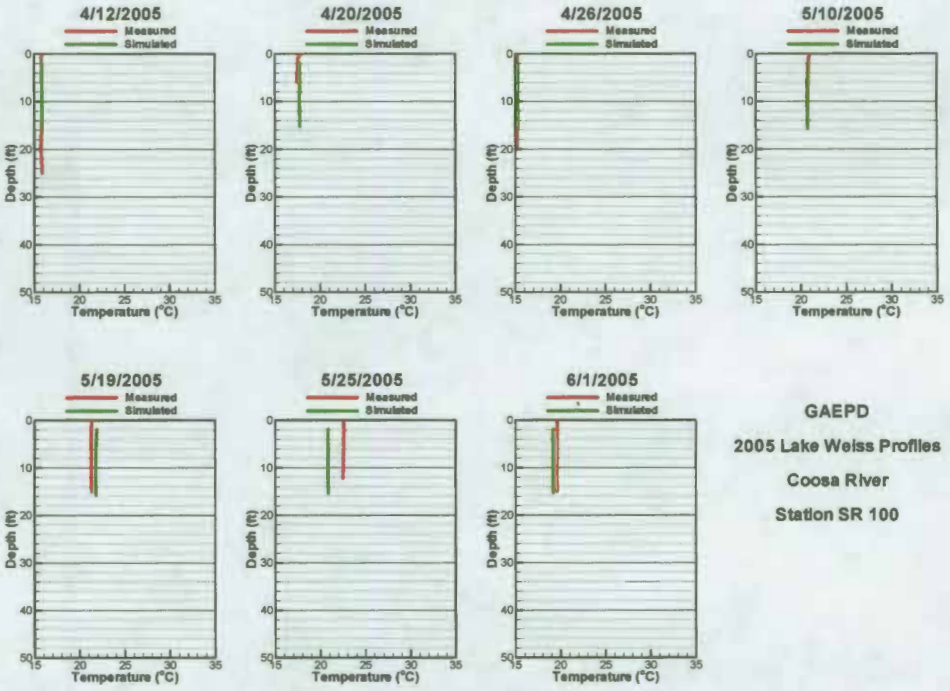

Figure 5-40 Temperature Profiles Comparison at Coosa River at State Road 100.

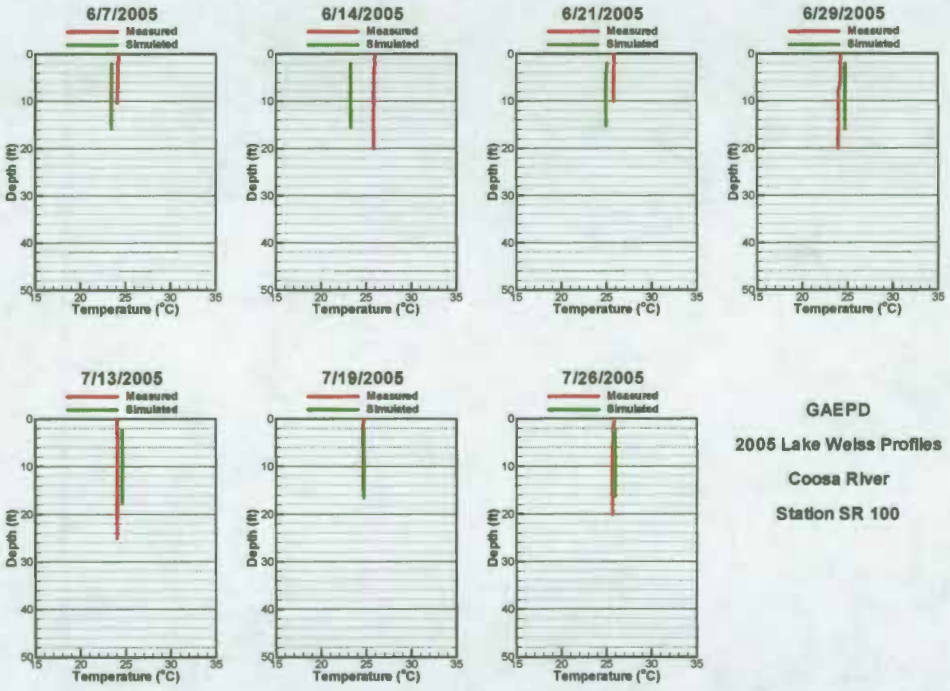

Figure 5-40 Temperature Profiles Comparison at Coosa River at State Road 100 (cont).

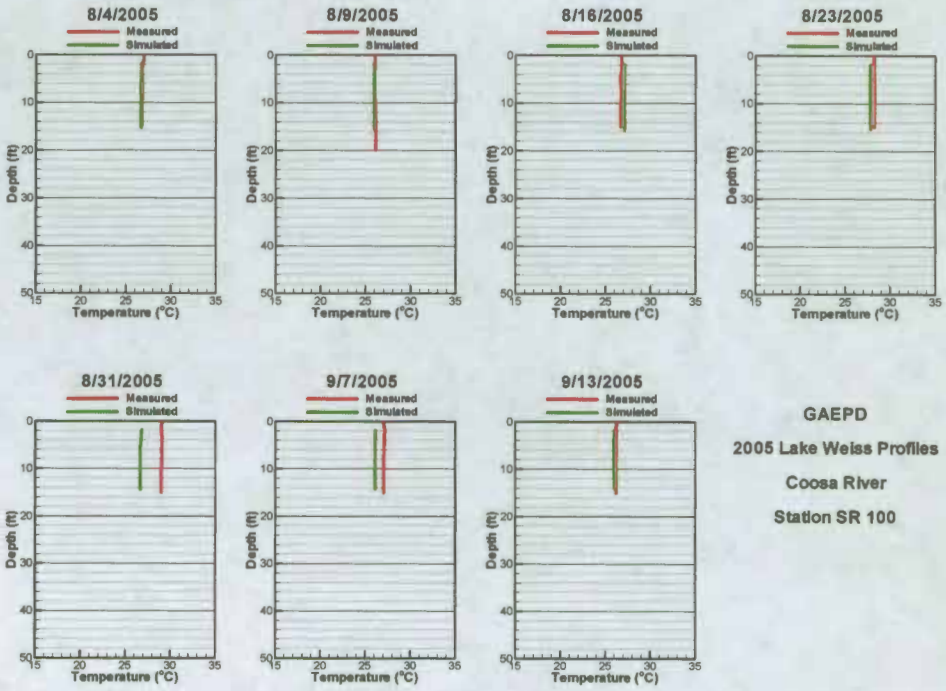

Figure 5-40 Temperature Profiles Comparison at Coosa River at State Road 100 (cont).

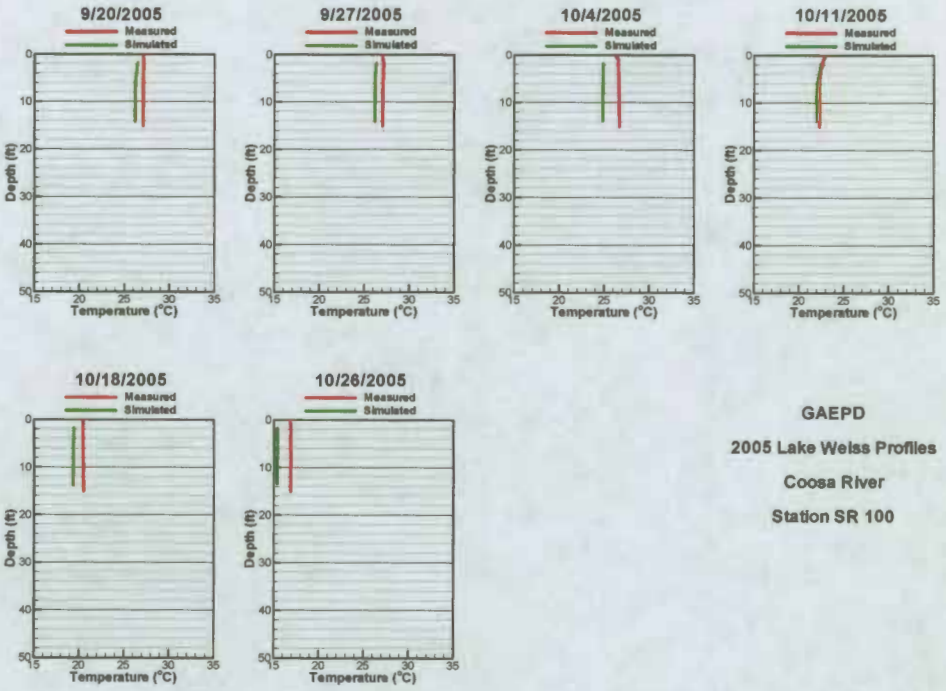

Figure 5-40 Temperature Profiles Comparison at Coosa River at State Road 100 (cont).

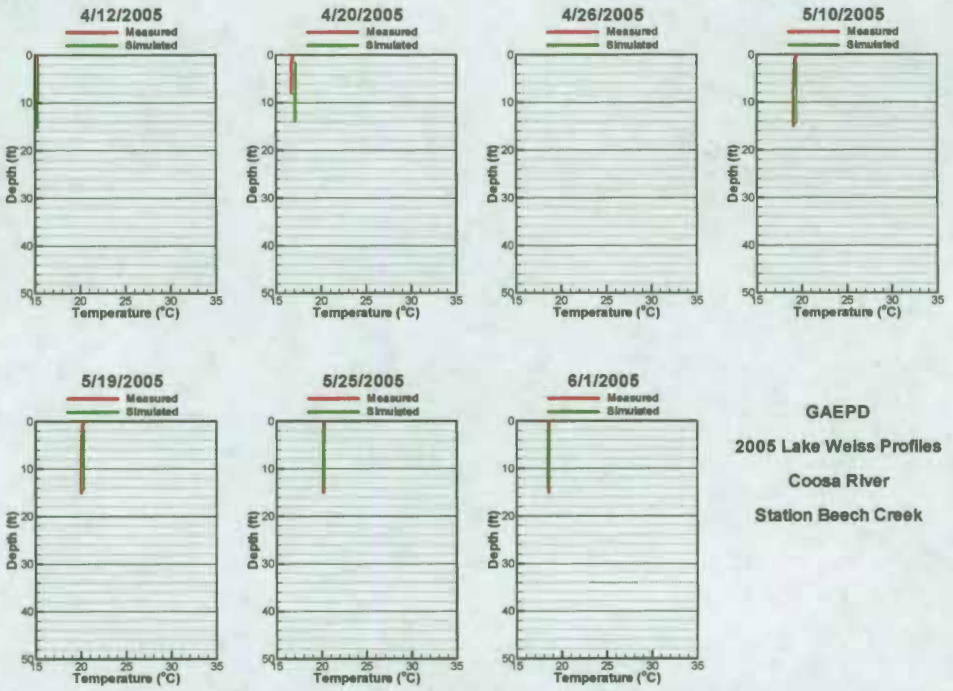

Figure 5-41 Temperature Profiles Comparison at Coosa River at Beech Creek.

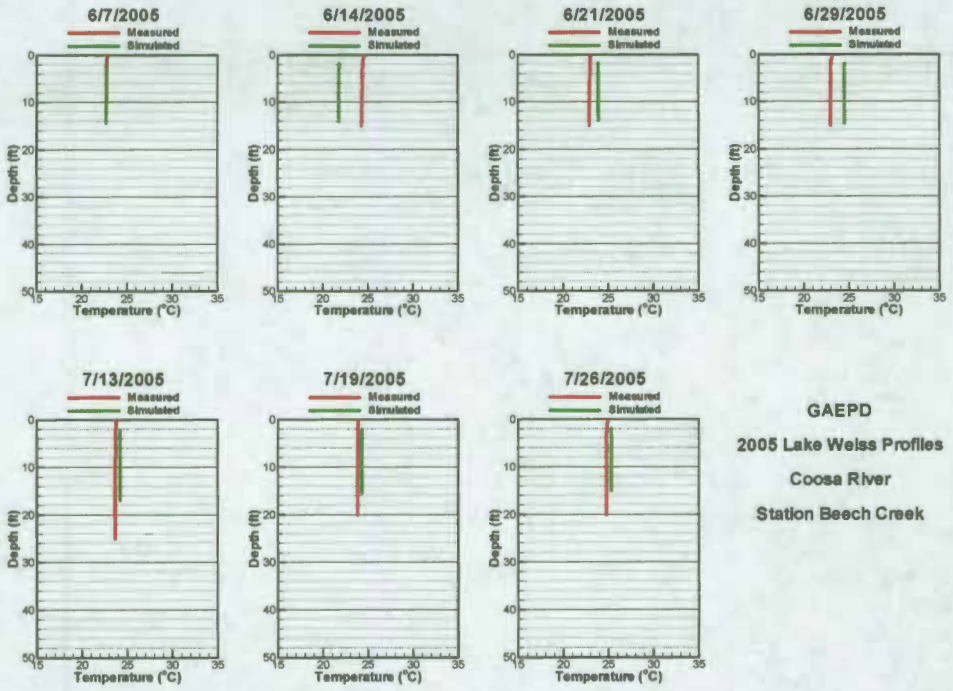

Figure 5-41 Temperature Profiles Comparison at Coosa River at Beech Creek (cont).

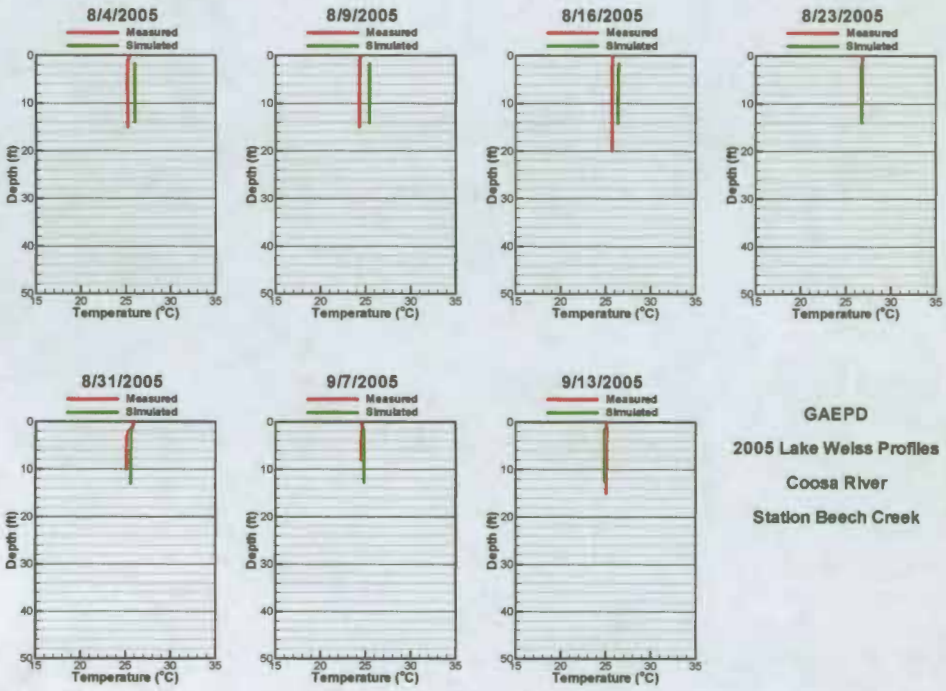

Figure 5-41 Temperature Profiles Comparison at Coosa River at Beech Creek (cont).

Figure 5-41 Temperature Profiles Comparison at Coosa River at Beech Creek (cont).

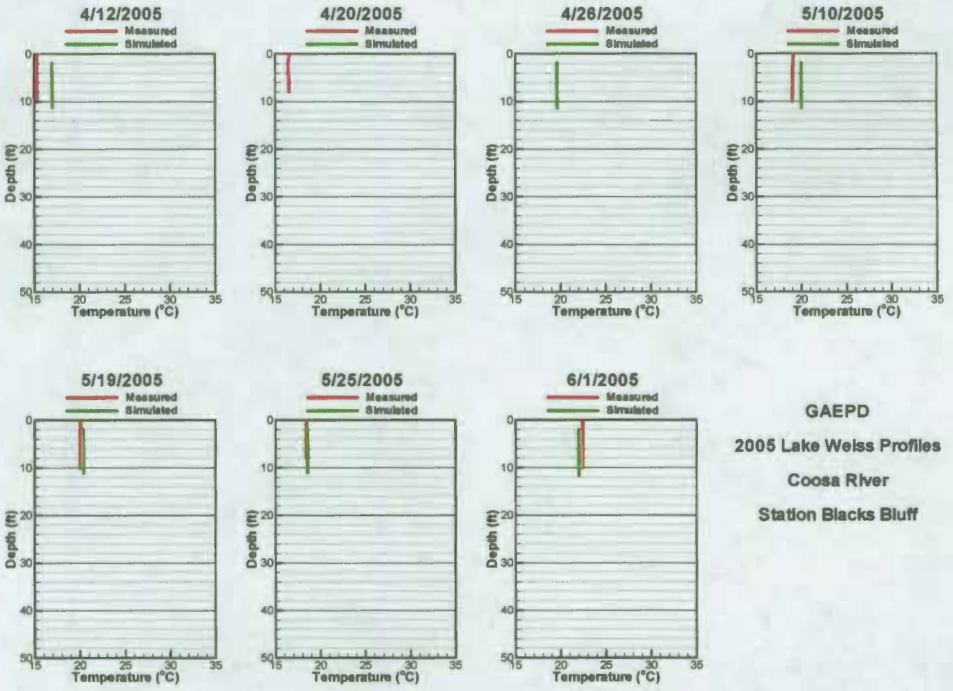

Figure 5-42 Temperature Profiles Comparison at Coosa River at Blacks Bluff Road.

Figure 5-42 Temperature Profiles Comparison at Coosa River at Blacks Bluff Road (cont).

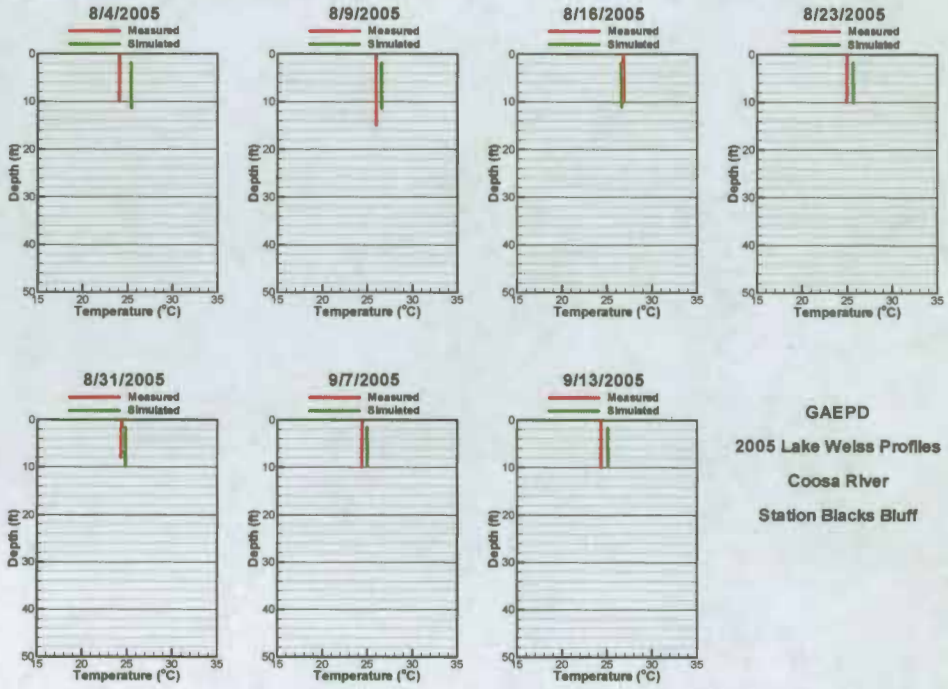

Figure 5-42 Temperature Profiles Comparison at Coosa River at Blacks Bluff Road (cont).

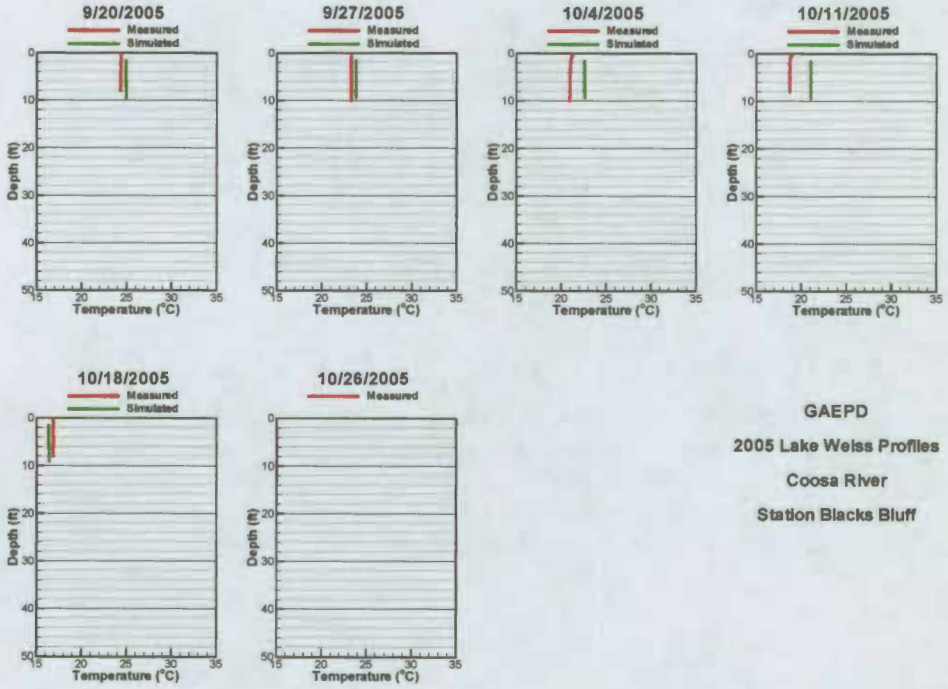

Figure 5-42 Temperature Profiles Comparison at Coosa River at Blacks Bluff Road (cont).

5.4 Hydrodynamic Validation

Once the hydrodynamic model was calibrated to data collected during 2005, it was validated to 2000 data. The validation was performed by comparing simulated data to measured water surface elevation and temperature profile data.

5.4.1 Water Surface Elevation

Simulated water surface elevation data were validated to measurements taken at the Weiss Lake spillway. Figure 5-43 presents the observed versus predicted water surface elevation for year 2000.

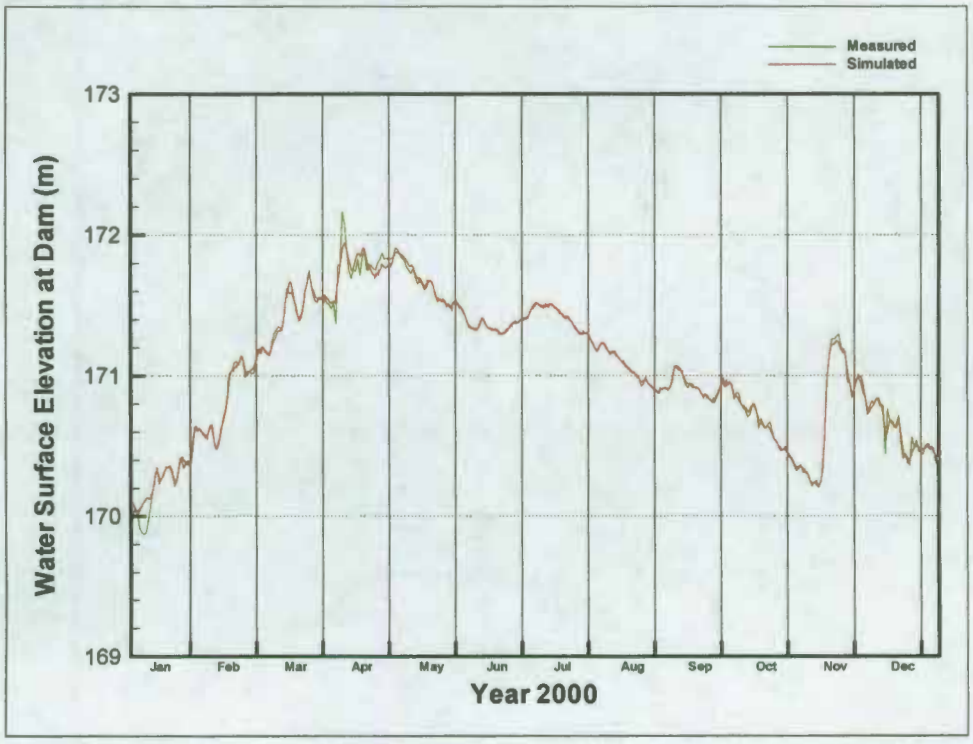

Figure 5-43 Water Surface Elevation Comparison at Weiss Lake Spillway for the year 2000

5.4.2 Temperature Time Series

Simulated temperature time series were validated to data collected in year 2000 at the ADEM stations and at the USGS station (02397530) at the Georgia-Alabama border. Figures 5-44 through 5-47 present the temperature time series comparisons at the ADEM stations, and Figure 5-48 presents the comparison at the USGS station. Data collected efforts at station Weiss 12 did not begin until 2002, and therefore, temperature profile data were not reviewed at this location for the validation.

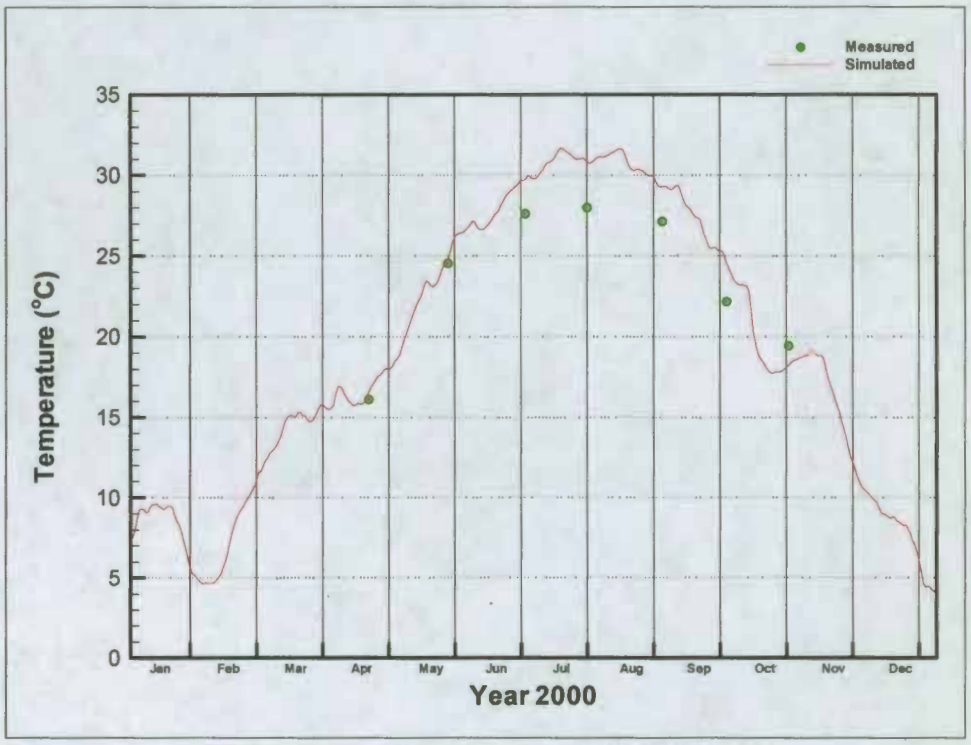

Figure 5-44 Simulated vs. Measured Temperature at Weiss 1 (2000).

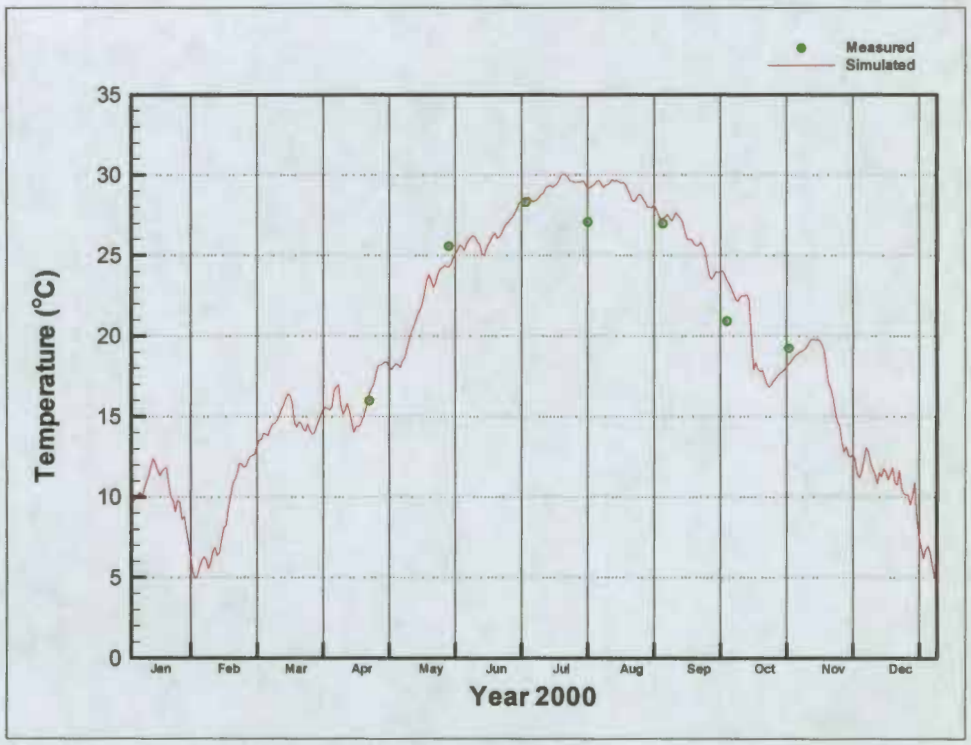

Figure 5-45 Simulated vs. Measured Temperature at Weiss 2 (2000).

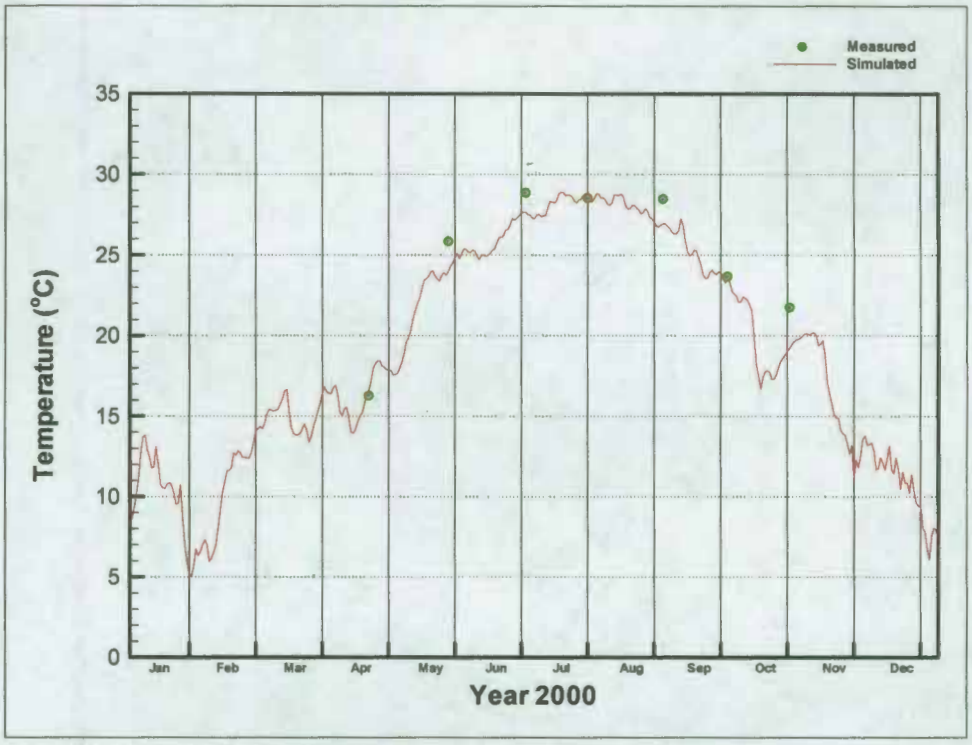

Figure 5-46 Simulated vs. Measured Temperature at Weiss 3 (2000).

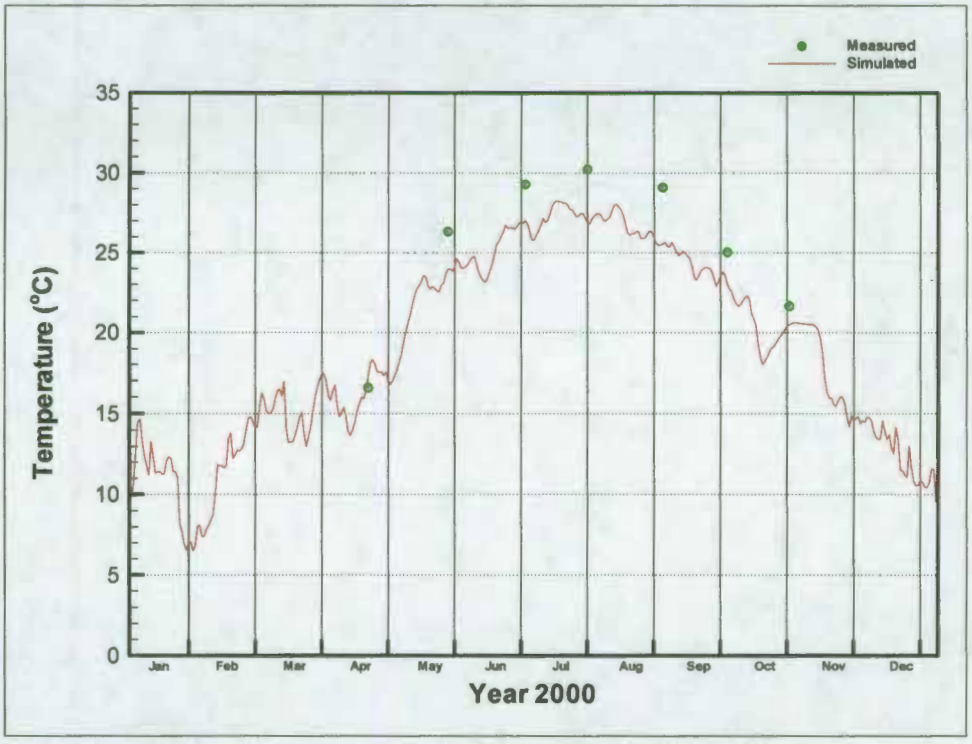

Figure 5-47 Simulated vs. Measured Temperature at Weiss 4 (2000).

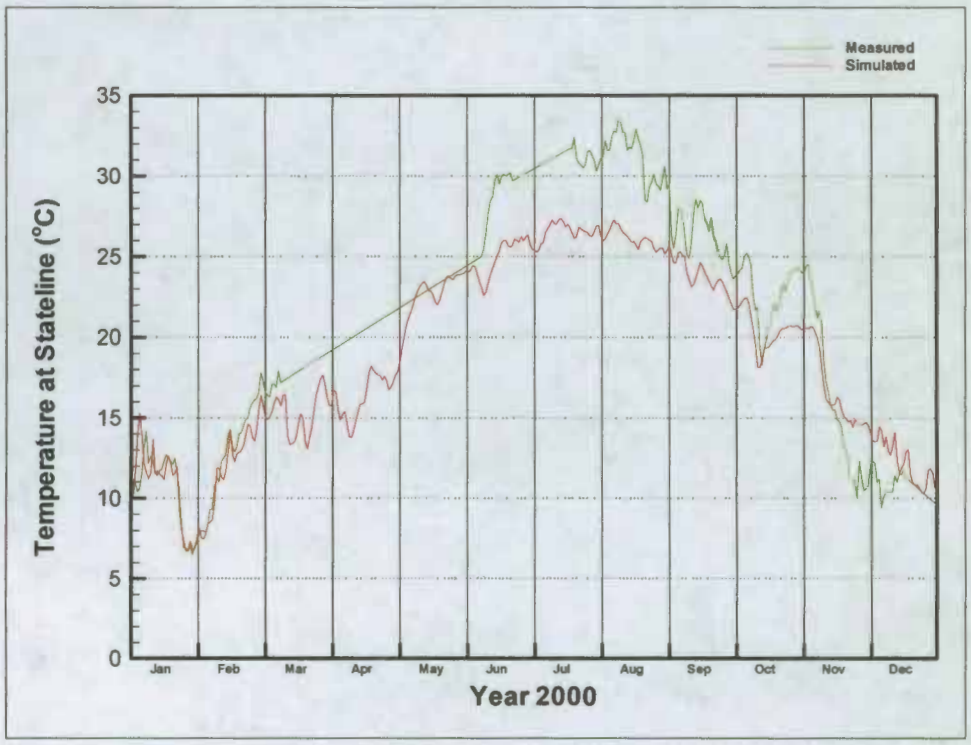

Figure 5-48 Simulated vs. Measured Temperature at Georgia-Alabama border (USGS station 02397530) (2000).

5.4.3 Temperature Profiles

Temperature vertical profiles obtained during 2000 were also compared for the hydrodynamic validation. Figures 5-49 through 5-52 present the temperature profile comparisons at ADEM stations. Data collected efforts at station Weiss 12 did not begin until 2002, and therefore, temperature profile data were not reviewed at this location for the validation.

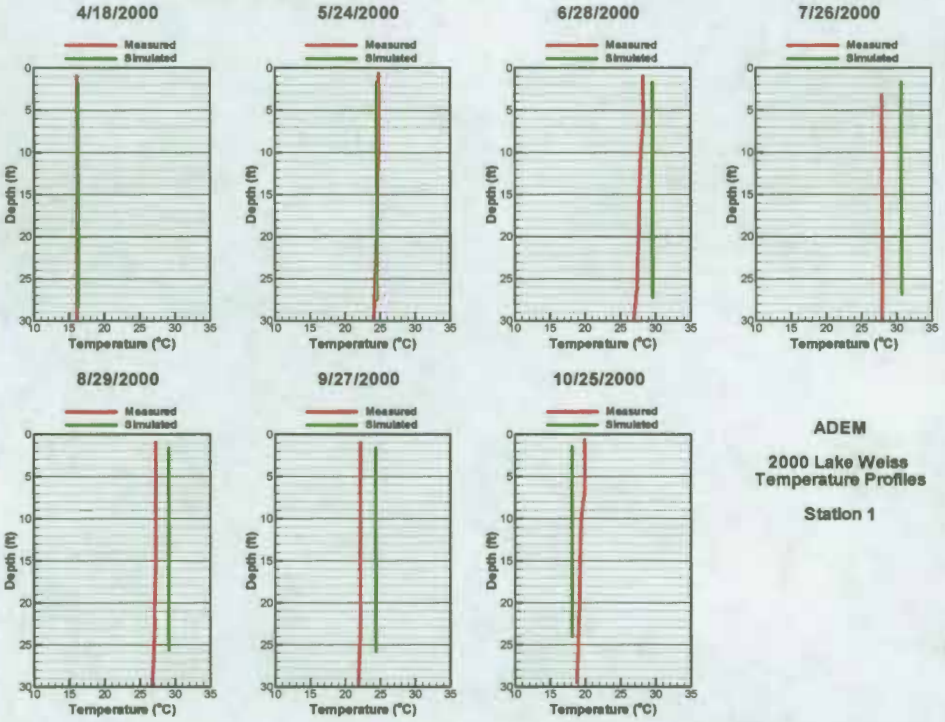

Figure 5-49 Temperature Profiles Comparison at Station Weiss 1 in 2000

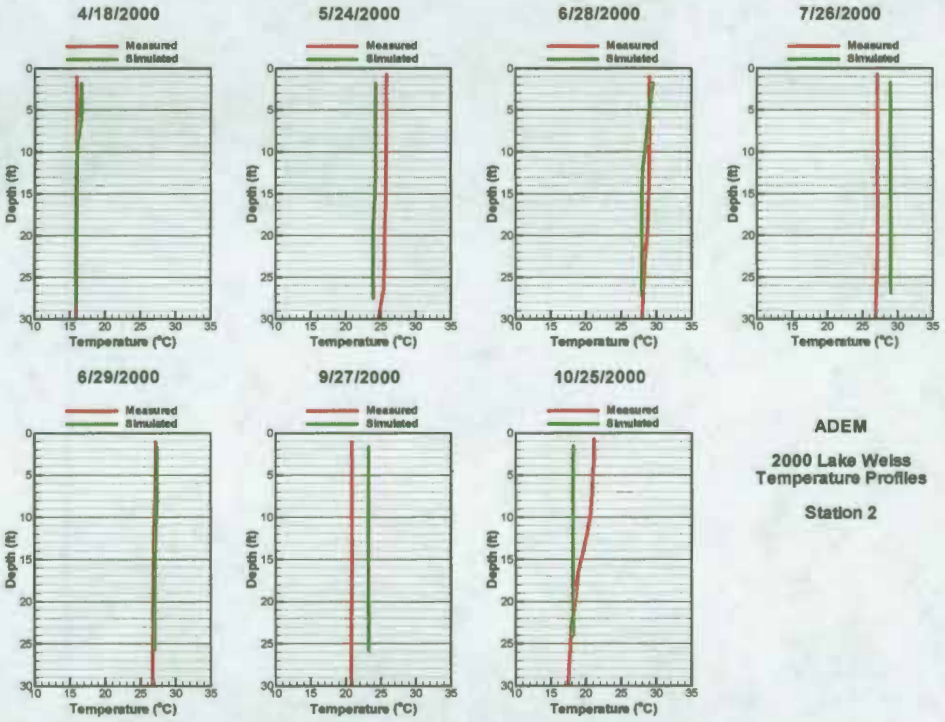

Figure 5-50 Temperature Profiles Comparison at Station Weiss 2 in 2000

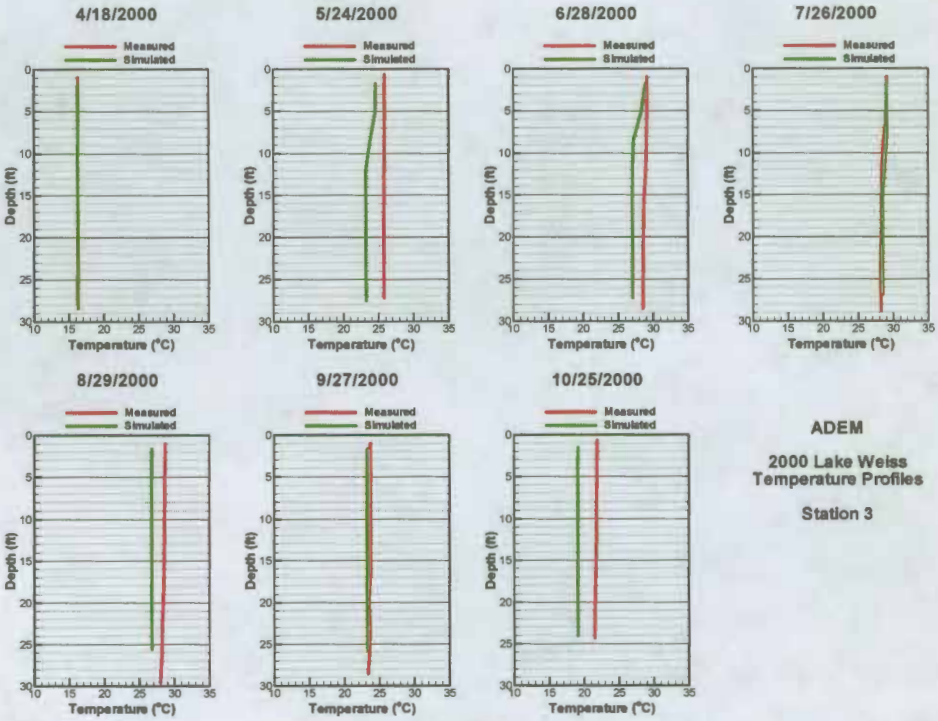

Figure 5-51 Temperature Profiles Comparison at Station Weiss 3 in 2000

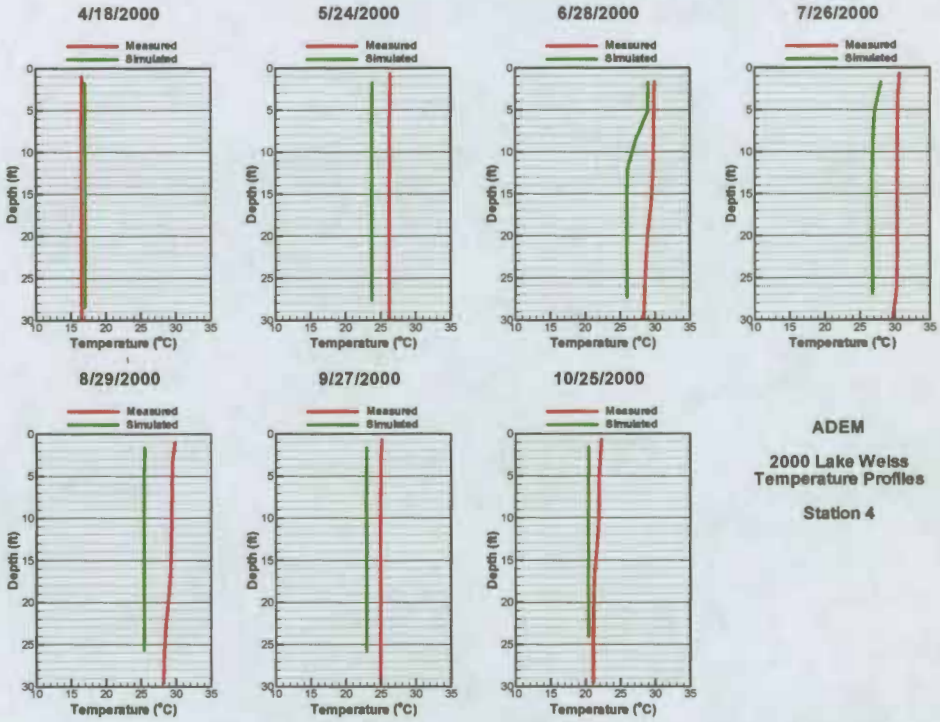

Figure 5-52 Temperature Profiles Comparison at Station Weiss 4 in 2000

6.0 WATER QUALITY MODEL DEVELOPMENT

A water quality model was developed for Weiss Lake to allow the simulation of different loading conditions, using the WASP 7.2 modeling package. The WASP model for Weiss Lake was setup using the following state variables:

- Ammonia (NH3),
- Nitrate+Nitrite (NO2+NO3),
- Organic Nitrogen,
- Orthophosphate (PO4),
- Organic Phosphorus,
- Chlorophyll-a (Chl-a),
- Dissolved Oxygen (DO), and
- Carbonaceous Biochemical Oxygen Demand (CBOD).

6.1 Incorporation of EFDC Hydrodynamic Model

The EFDC hydrodynamic model was incorporated into the WASP water quality model through the hydrodynamic linkage file (*.hyd). The EFDC model provided the following information to WASP:

- Flows from the upstream boundary, point sources and watersheds,
- Temperatures from the upstream boundary, point sources and watersheds,
- Three dimensional model cell structure and volumes, and
- Cell volumes and transport.

6.2 Simulation Period

The simulation period for the calibration of the water quality model was from January 1, 2005 through December 31, 2005. This period was selected because during the 2005 growing season, GAEPD and ADEM performed extensive data collection efforts on Weiss Lake. ADEM also collected water quality data on Weiss Lake during the 2000 growing season. Therefore, the water quality model will be validated to the 2000 dataset.

6.3 Water Quality Boundary Conditions for Calibration

6.3.1 Upstream Boundary

Water quality data for the upstream boundary was collected at the USGS station 02397000. Dissolved Oxygen and Chlorophyll-a data were collected daily from March 12 through December 23, 2005. All other parameters were collected approximately weekly from mid-April through mid-October. On 19 of the 25 days where Total Phosphorus and Orthophosphate were measured, the Orthophosphate value was higher. For these days, it was assumed that the Orthophosphate concentration was equal to the Total Phosphorus, and that Organic Phosphorus was equal to 0. Figures 6-1 through 6-8 present the input time series. To convert BOD5 to CBODu, an f-Ratio of 5.0 was used.

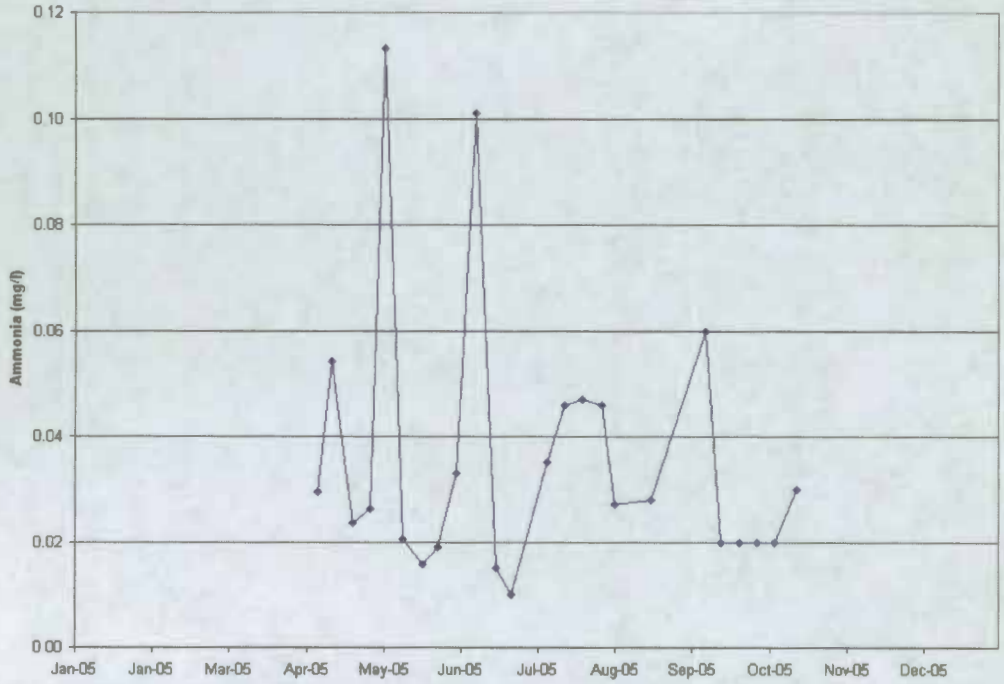

Figure 6-1 Ammonia (NH3) Input at USGS 02397000 for year 2005.

Figure 6-2 Nitrate+Nitrite (NO2+NO3) Input at USGS 02397000 for year 2005.

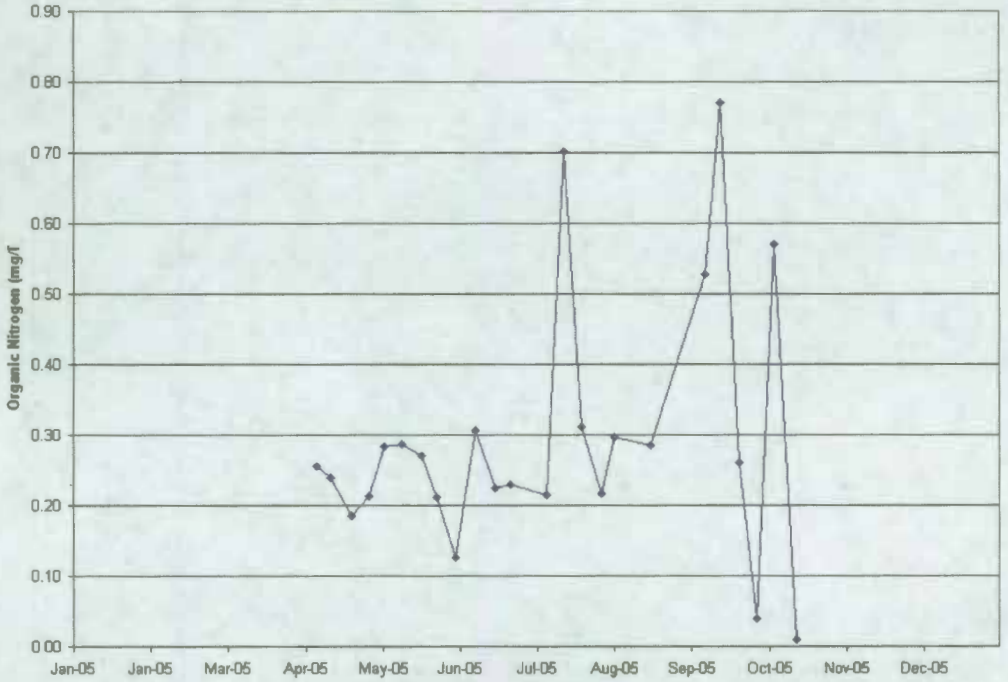

Figure 6-3 Organic Nitrogen Input at USGS 02397000 for year 2005.

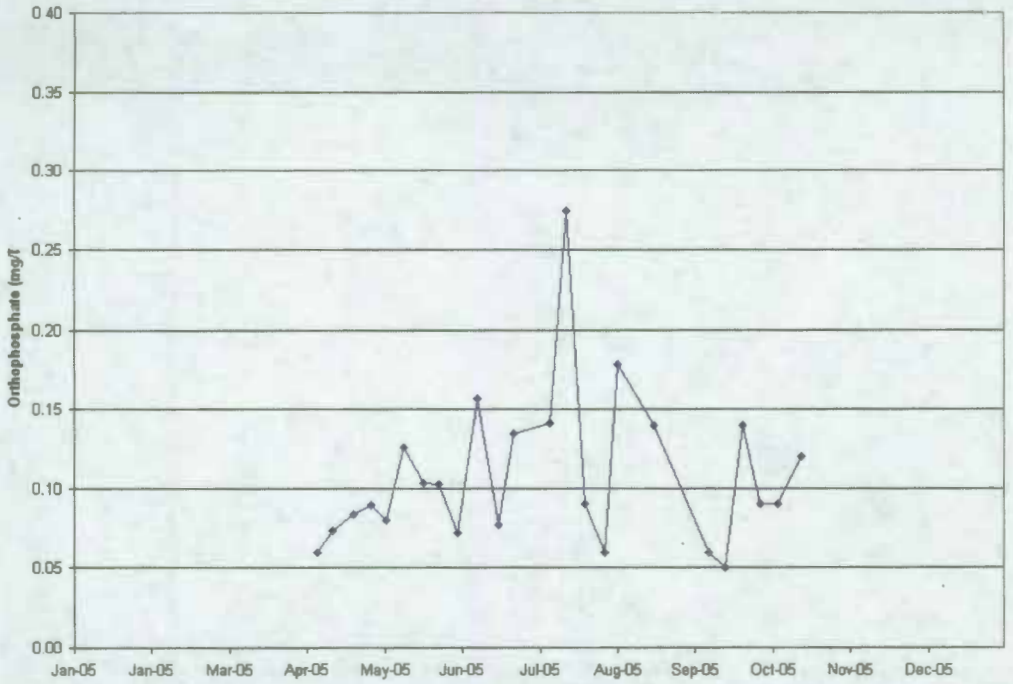

Figure 6-4 Orthophosphate Input at USGS 02397000 for year 2005.

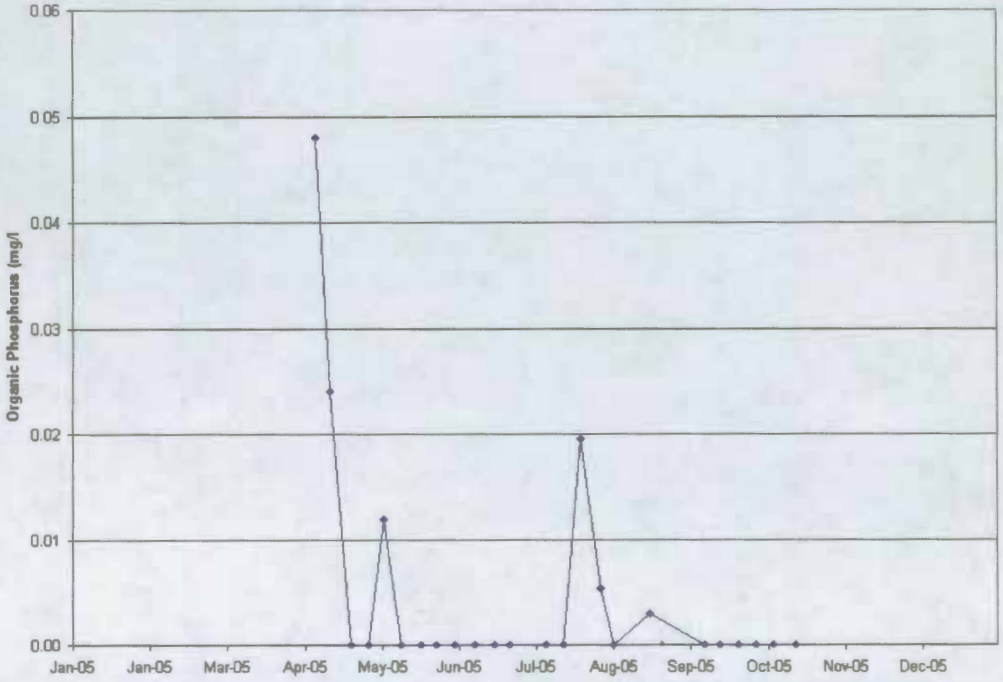

Figure 6-5 Organic Phosphorus Input at USGS 02397000 for year 2005.

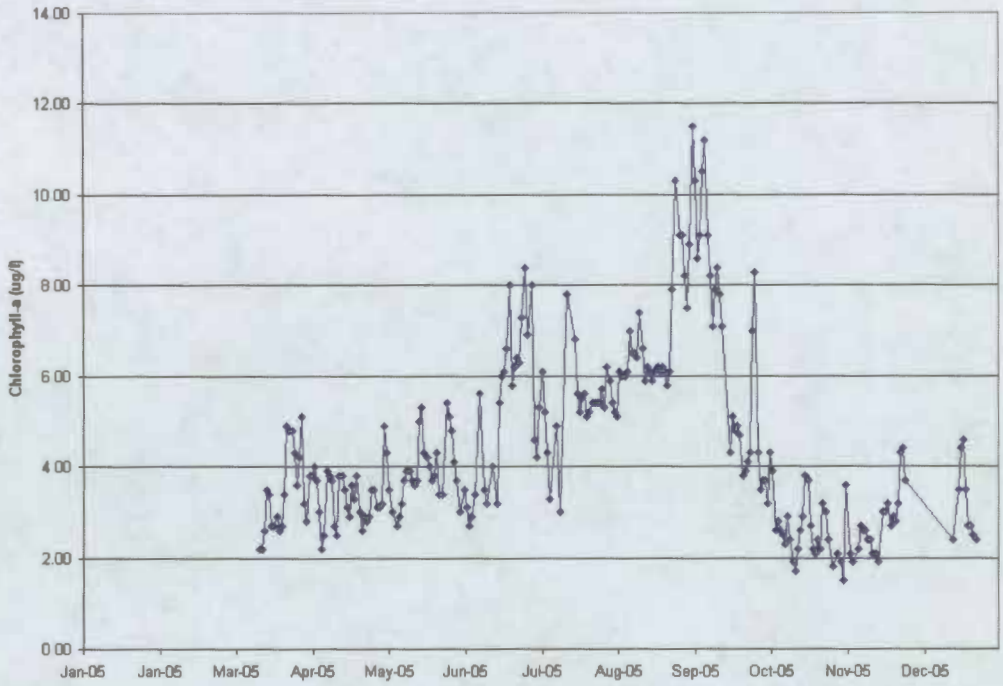

Figure 6-6 Phytoplankton (Chl-a) Input at USGS 02397000 for year 2005.

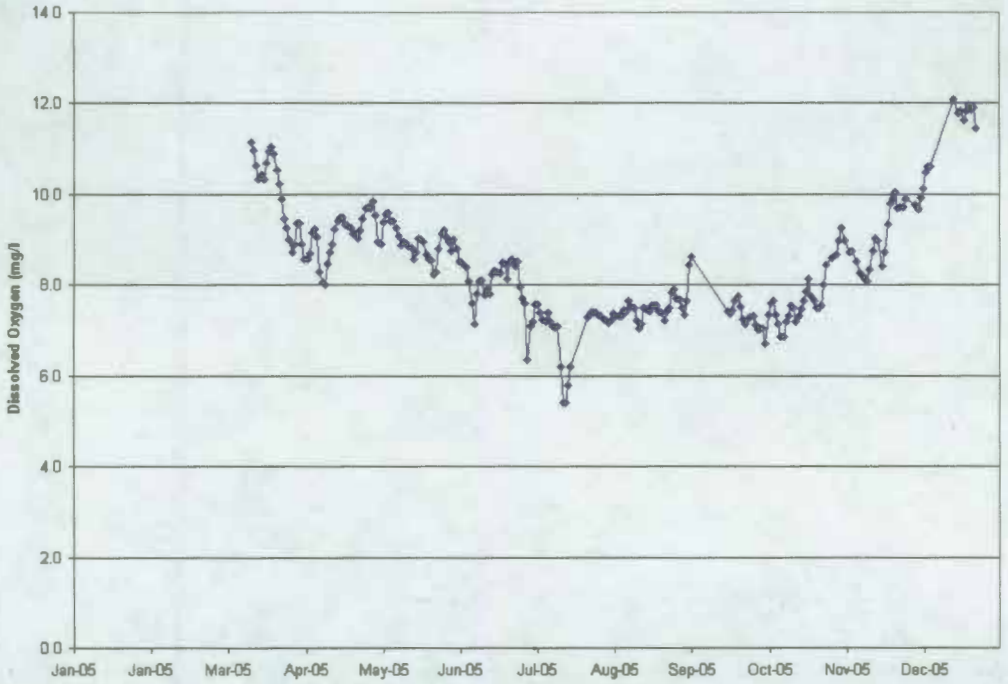

Figure 6-7 Dissolved Oxygen (DO) Input at USGS 02397000 for year 2005.

Figure 6-8 BOD5 Input at USGS 02397000 for year 2005.

6.3.2 Turbine and Spillway

The turbine and spillway outflow discharge was represented by water quality data measured at Weiss 1 (Figure 3-10 and 5-12). Data were collected approximately monthly during the growing season (April through October). BOD5 data were not collected at Weiss 1, therefore a constant value of 1.0 was assumed. To convert BOD5 to CBODu, an f-Ratio of 1.5 was used. Organic Nitrogen, Organic Phosphorus and Orthophosphate data were also not collected, however, TKN and Total Phosphorus data were collected. The following equations were used to determine the missing time series.

Organic Nitrogen (mg/l) = TKN (mg/l) – Ammonia (mg/l)

Organic Phosphorus (mg/l) = 20% * Total Phosphorus (mg/l)

Orthophosphate (mg/l) = 80% * Total Phosphorus (mg/l)

All ammonia data were either equal to or greater than the TKN data. Therefore the Organic Nitrogen was input at 0. Figures 6-9 through 6-16 present the outflow time series for the Weiss turbine and spillway.

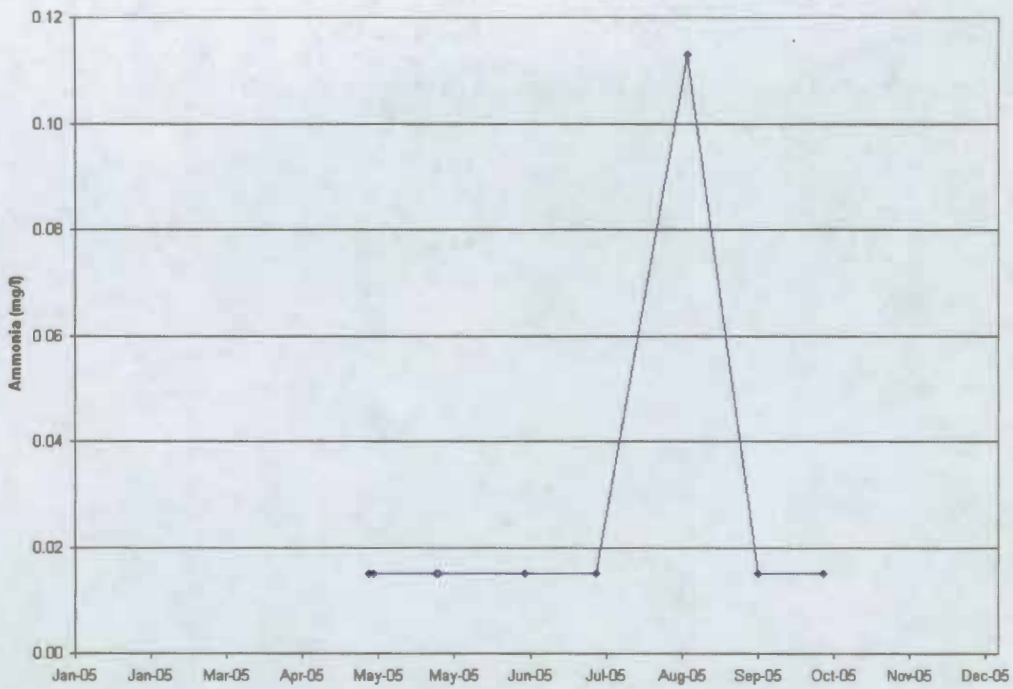

Figure 6-9 Ammonia (NH3) Outflow at Weiss Dam for year 2005.

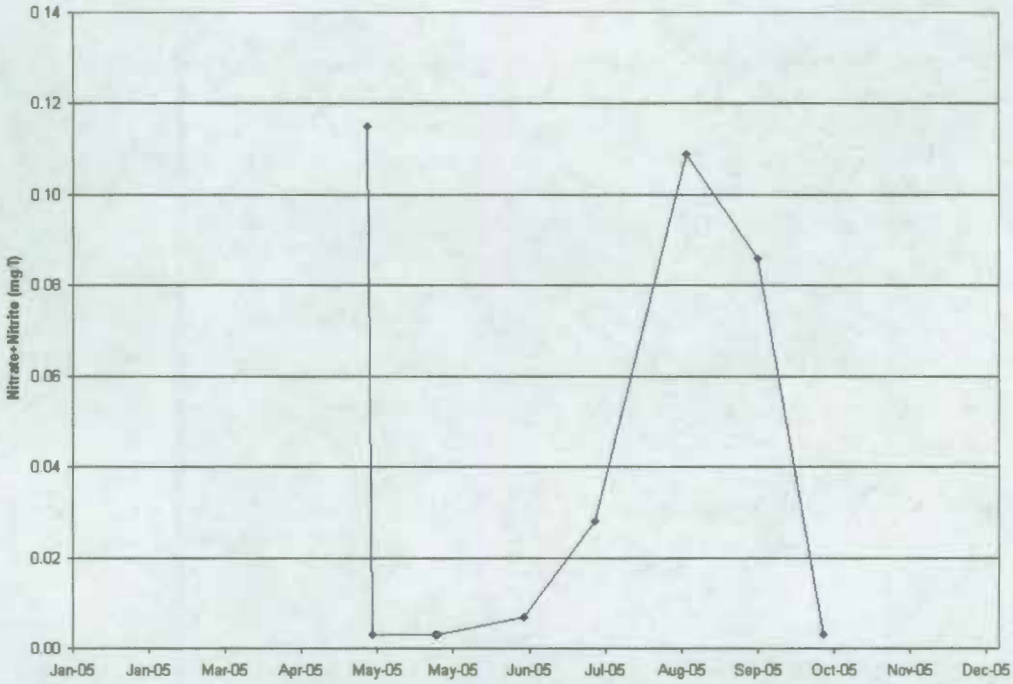

Figure 6-10 Nitrate+Nitrite (NO2+NO3) Outflow at Weiss Dam for year 2005.

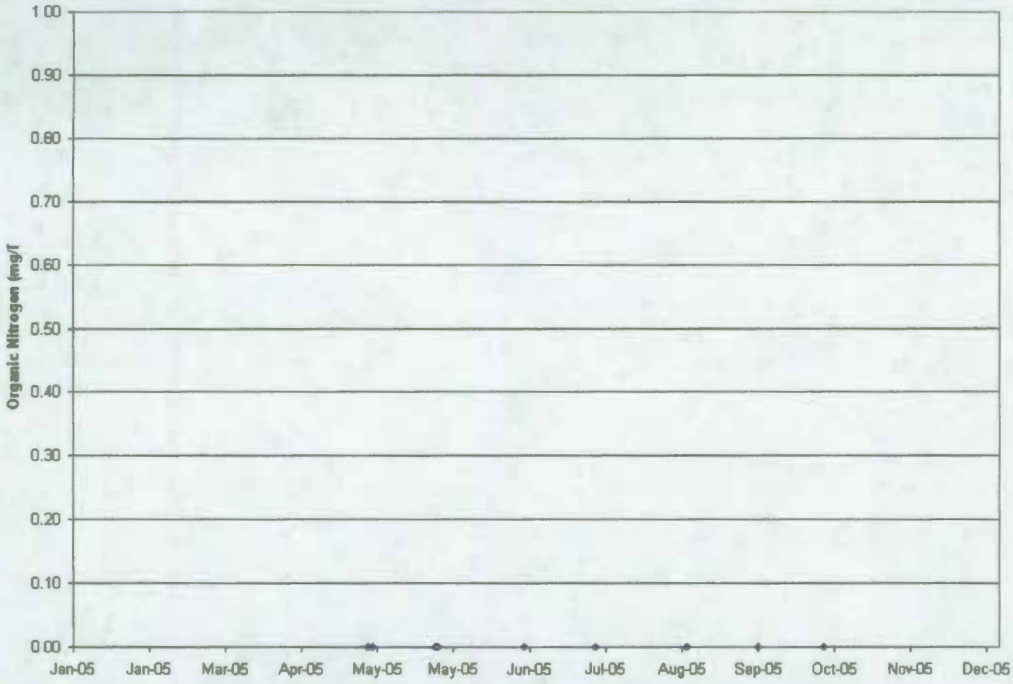

Figure 6-11 Organic Nitrogen Outflow at Weiss Dam for year 2005.

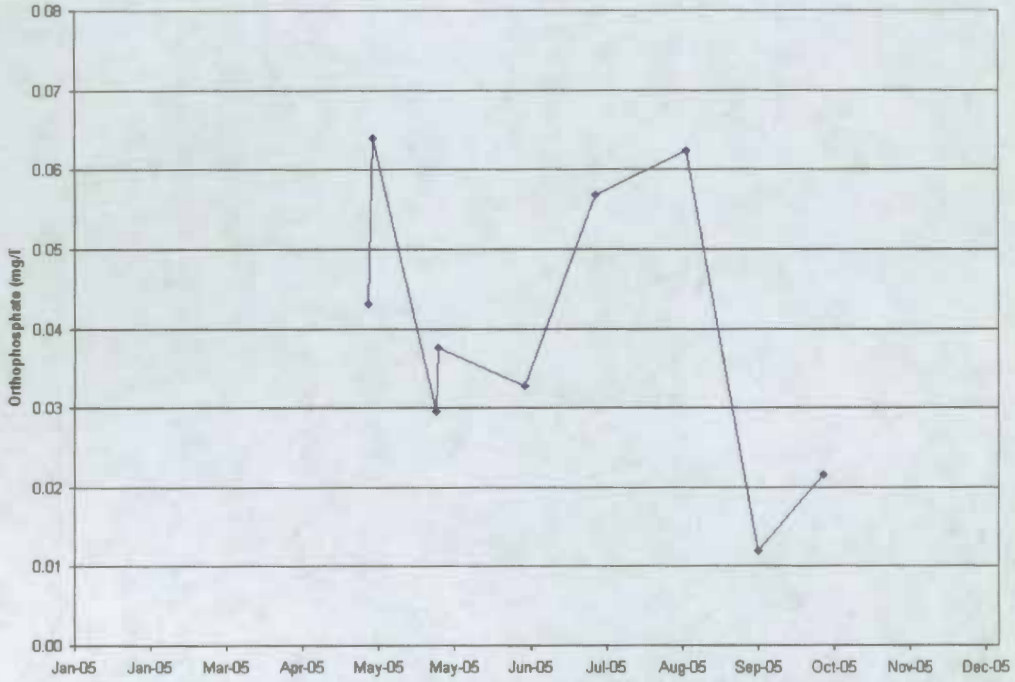

Figure 6-12 Orthophosphate Outflow at Weiss Dam for year 2005.

Figure 6-13 Organic Phosphorus Outflow at Weiss Dam for year 2005.

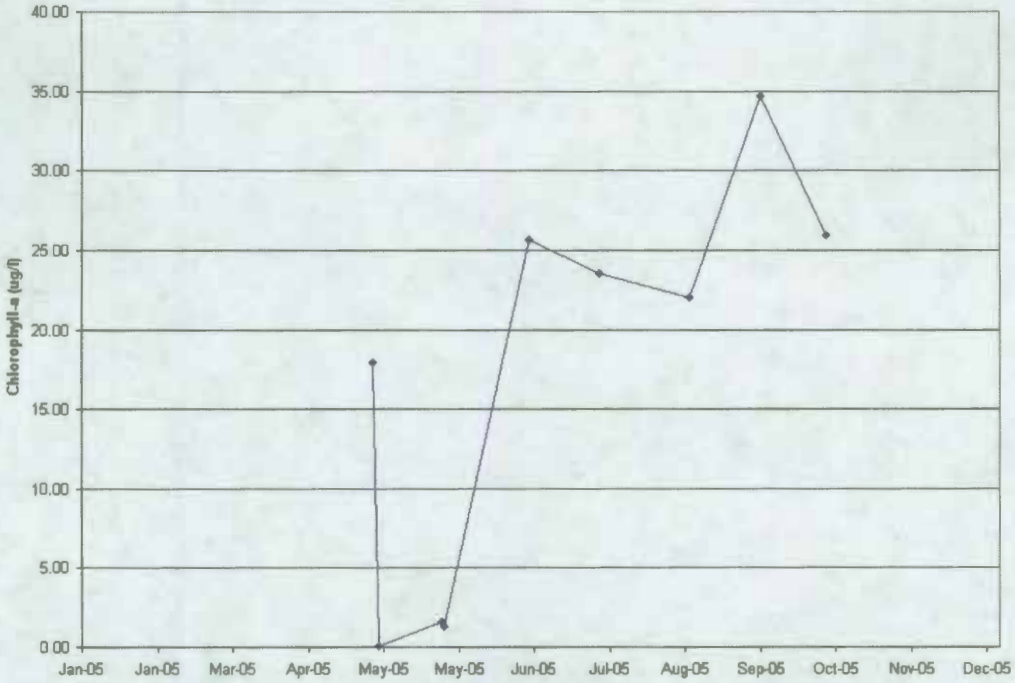

Figure 6-14 Phytoplankton (Chl-a) Outflow at Weiss Dam for year 2005.

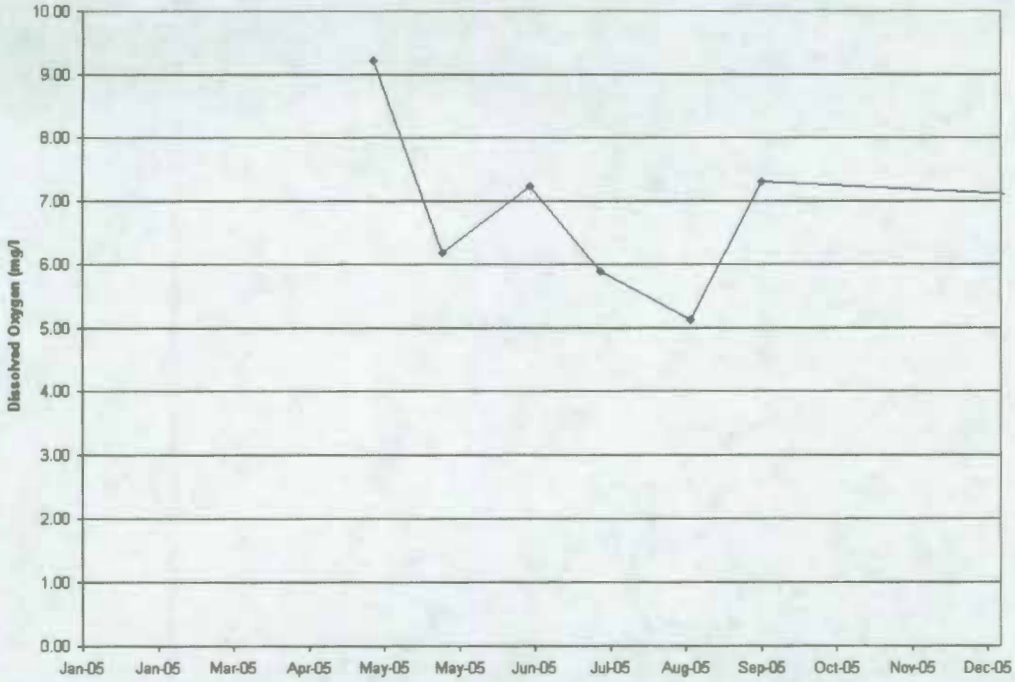

Figure 6-15 Dissolved Oxygen (DO) Outflow at Weiss Dam for year 2005.

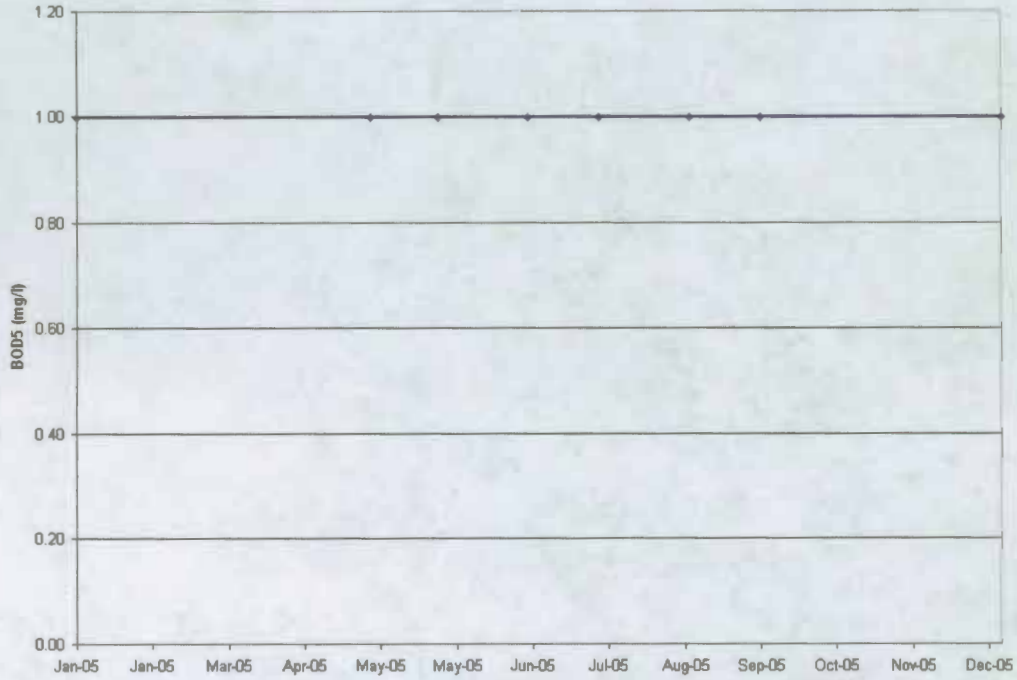

Figure 6-16 BOD5 Outflow at Weiss Dam for year 2005.

6.3.3 Tributaries

The Loading Simulation Program C++ (LSPC) was used to represent the watershed runoff to Weiss Lake downstream of USGS flow gage 02397000. The model was also used to represent the accumulation and washoff of nutrients within the entire Weiss Lake drainage area. The model was calibrated for BOD, nitrate-nitrite, ammonia, organic nitrogen, total phosphorus, and orthophosphate using observed 2005 concentration data from four tributary stations discharging to Weiss Lake (Cedar, Kings, Cabin and Beech Creeks). The model was validated using data from three additional water quality stations, Chattooga River at Mills Creek, Little River and Coosa River. Figure 6-17 shows the drainage area represented in the model and the seven water quality stations used for calibration and validation. The setup and calibration of the watershed water quality model are presented in Appendix B.

The calibrated watershed model was run for the entire simulation period (January 1, 1991 – December 31, 2005) to generate a time series of water quality concentrations for the watersheds. LSPC provided concentrations for BOD, nitrate-nitrite, ammonia, organic nitrogen, orthophosphate, and total phosphorus. LSPC was not calibrated to organic phosphorus, and therefore organic phosphorus was determined by subtracting the orthophosphate time series from the total phosphorus time series. In addition, the watershed model was not calibrated to dissolved oxygen, and therefore all watershed inputs, except the four tributary stations, were input at a value of 6.0 mg/l. These time series were used to represent water quality contributions from non-point sources, as well as upstream point sources, and served as inputs to the WASP water quality model of Weiss Lake. The concentration data were then applied at each of the locations where a tributary flow was assigned. For the four tributaries that were used for the watershed water quality calibration (Cedar, Kings, Cabin and Beech Creeks), measured data were used as inputs for the year 2005.

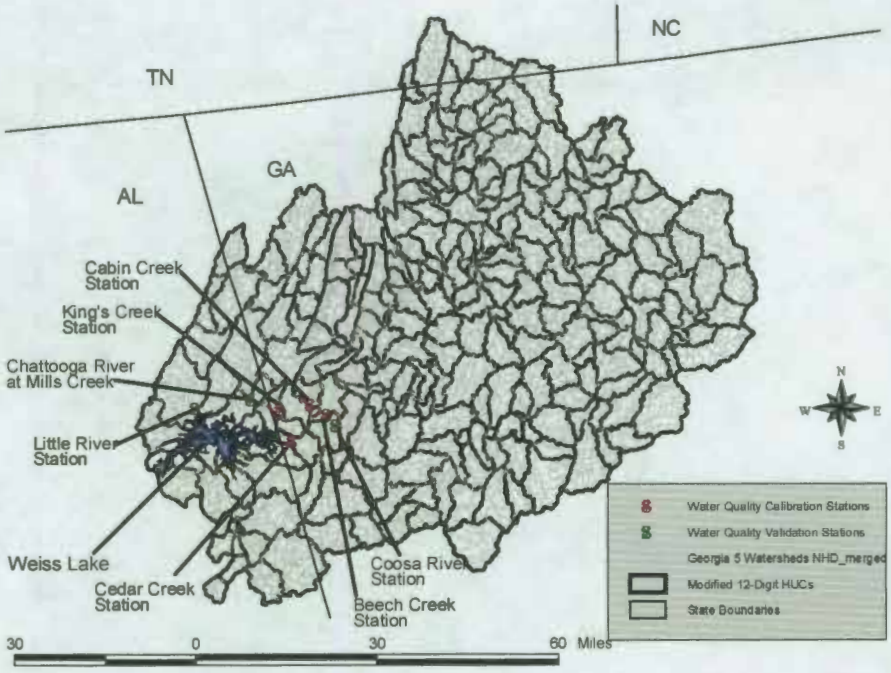

Figure 6-17 Location of LSPC Watershed water quality calibration and validation stations

6.3.4 Meteorological Data

Wind speed and air temperature were developed using data from Rome, Georgia (WBAN 93081). As in the hydrodynamic calibration, solar radiation was not measured, and was calculated from cloud cover obtained from Birmingham, Alabama (WBAN 13876). Fraction of daily light was determined by a sine curve.

As mentioned in section 3.3.6, measured solar radiation from the Georgia Automated Environmental Monitoring Network (GAEMN) station No. 200 (Rome, Georgia) was evaluated for the hydrodynamic and water quality calibration. Utilizing the measured data did not provide nearly as good a calibration as using the calculated solar radiation data, and therefore the calculated solar radiation data were used.

Figures 6-18 through 6-21 present the meteorological data input into the water quality model for the calibration period.

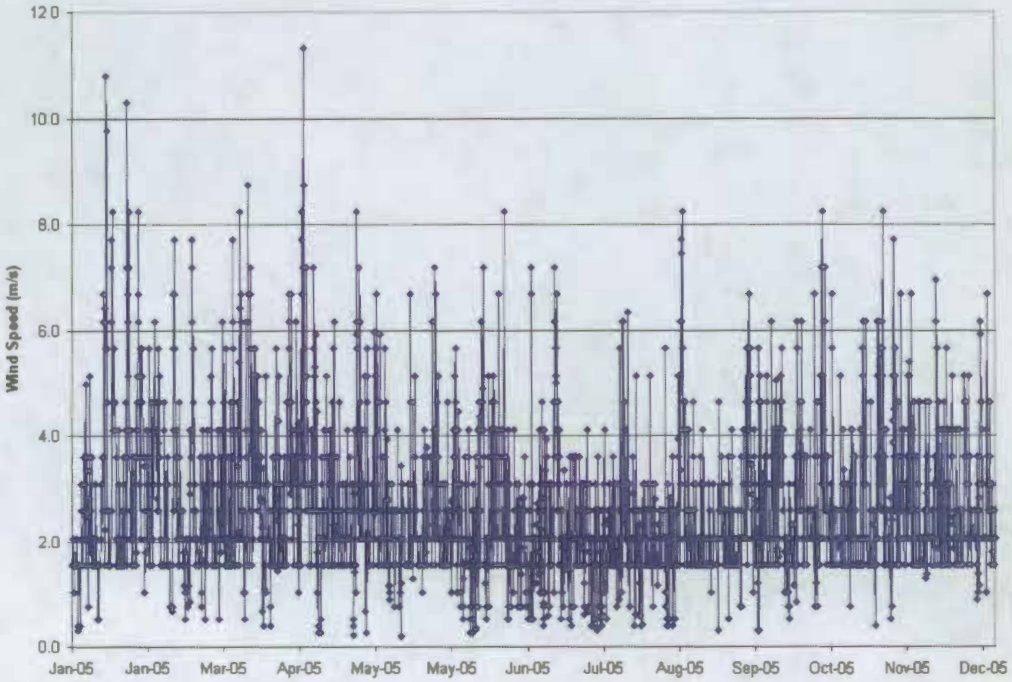

Figure 6-18 Wind Speed Input for 2005.

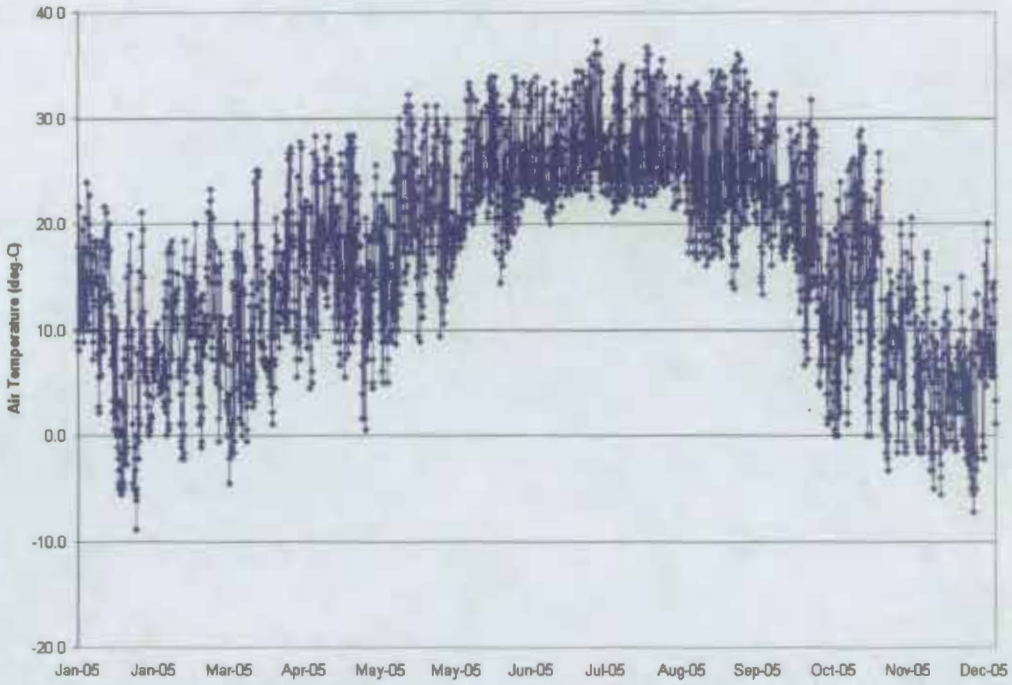

Figure 6-19 Air Temperature Input for 2005.

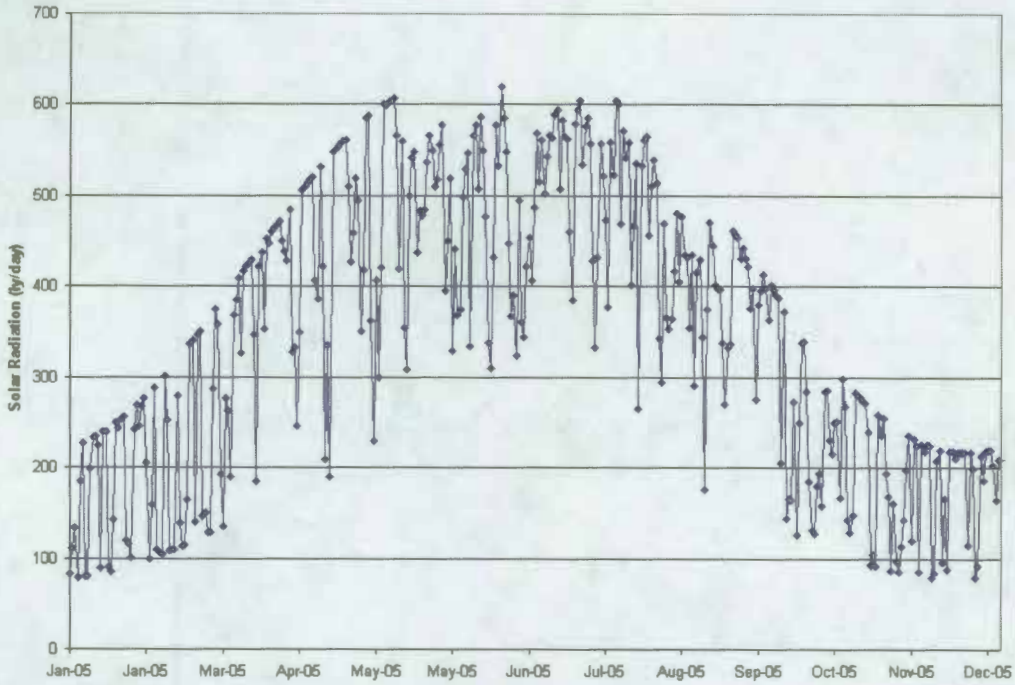

Figure 6-20 Solar Radiation Input for 2005.

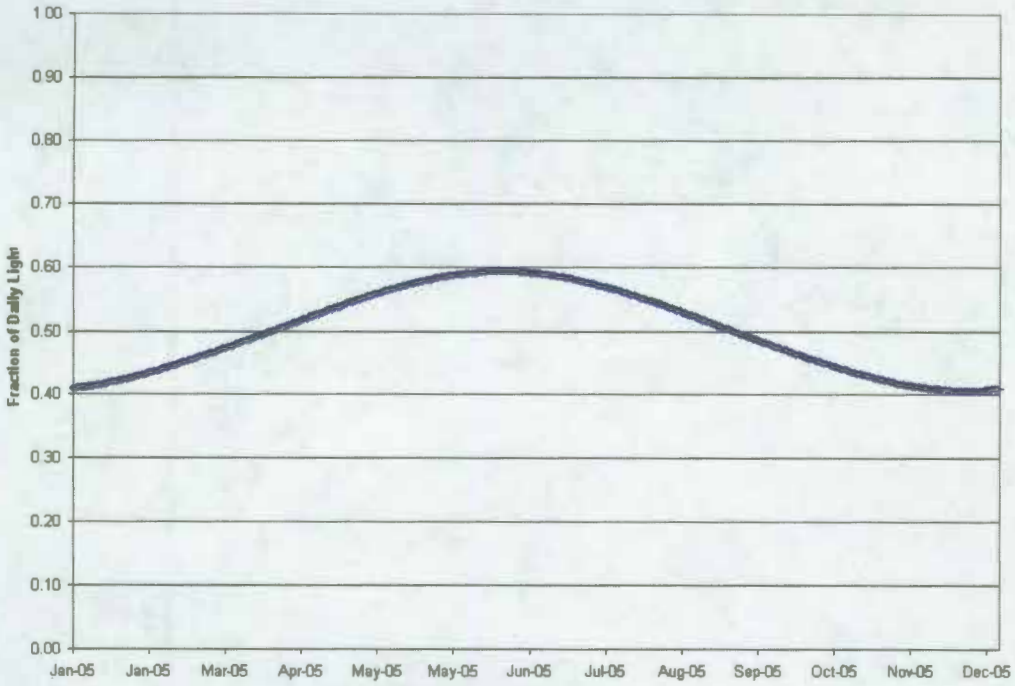

Figure 6-21 Fraction of Daily Light Input for 2005.

6.4 Water Quality Boundary Conditions for Validation

The simulation period for the validation of the water quality model was from January 1, 2000 through December 31, 2000.

6.4.1 Upstream Boundary

No measured water quality data were available at the upstream boundary during 2000. Therefore, the LSPC watershed model was utilized to generate water quality data for the validation period. Organic phosphorus, Dissolved oxygen and Chlorophyll-a were not modeled in LSPC. Organic phosphorus inputs were determined by subtracting the orthophosphate time series from the total phosphorus time series. Measured data collected in 2000 at Weiss 4 was used for the chlorophyll-a input time series and the dissolved oxygen inputs were determined by calculating monthly average values from data collected at the USGS station 02397000 during 2005. Figures 6-22 through 6-29 present the input time series. To convert BOD5 to CBODu, an f-Ratio of 5.0 was used.

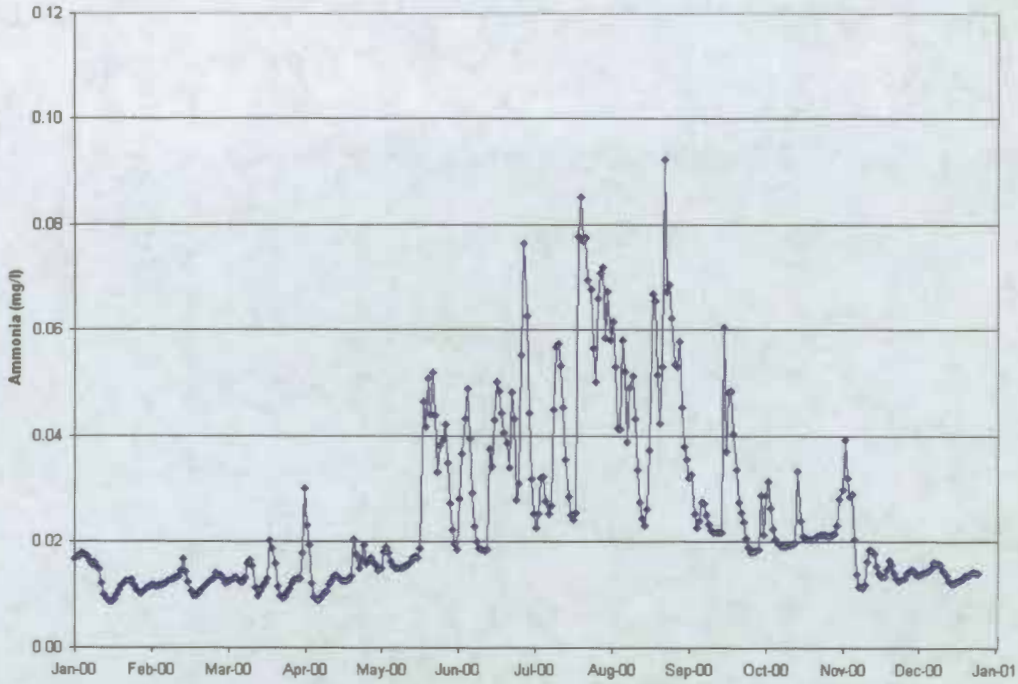

Figure 6-22 Ammonia (NH3) Input at Upstream Boundary for year 2000.

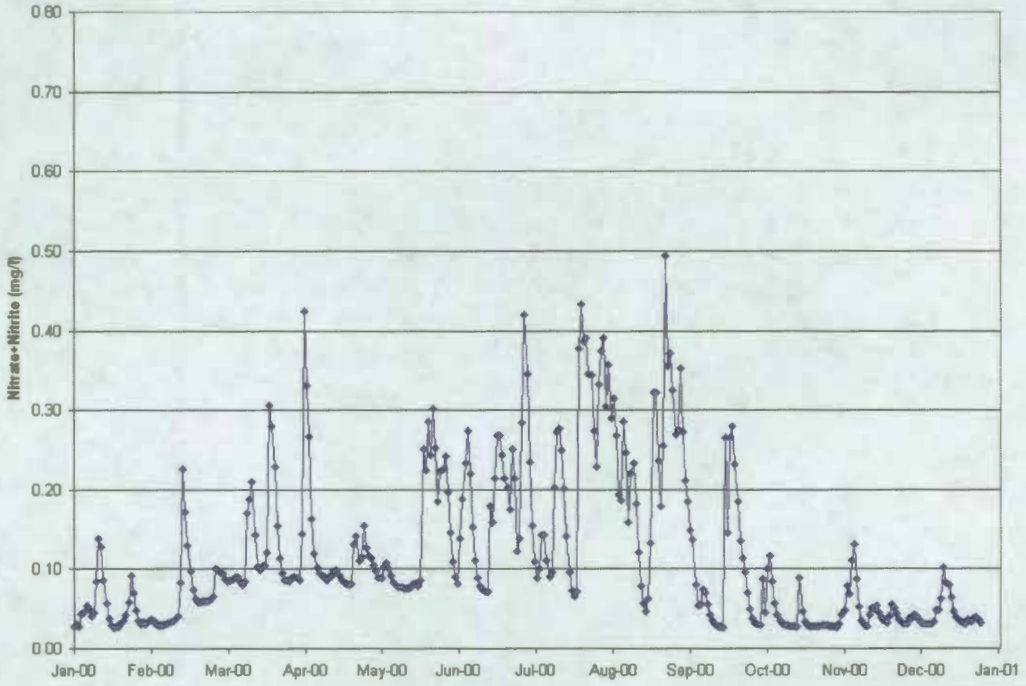

Figure 6-23 Nitrate+Nitrite (NO2+NO3) Input at Upstream Boundary for year 2000.

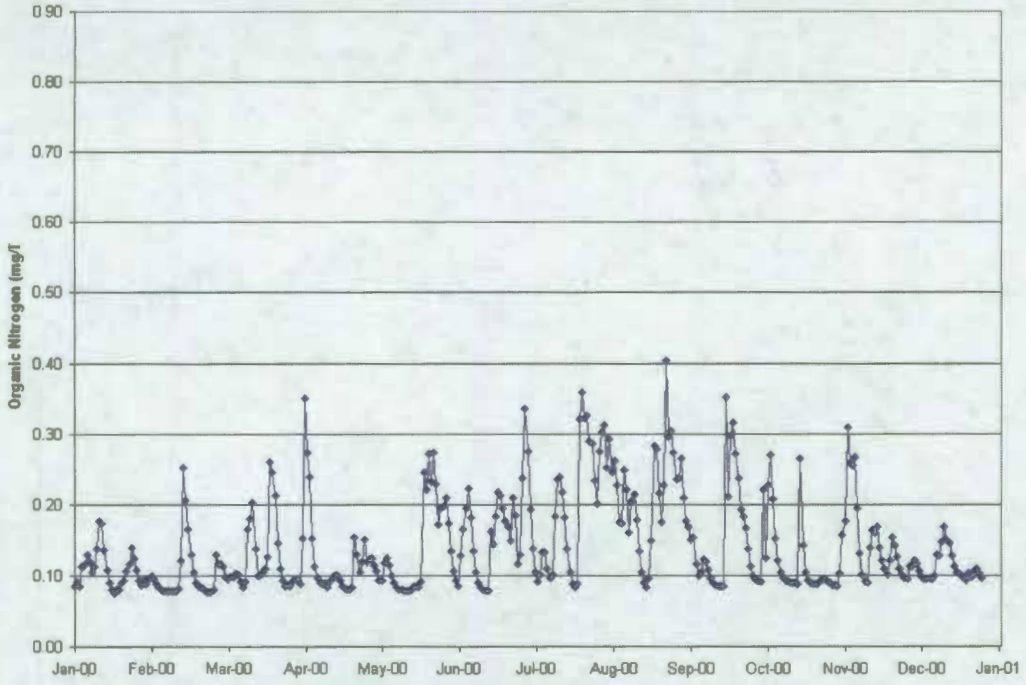

Figure 6-24 Organic Nitrogen Input at Upstream Boundary for year 2000.

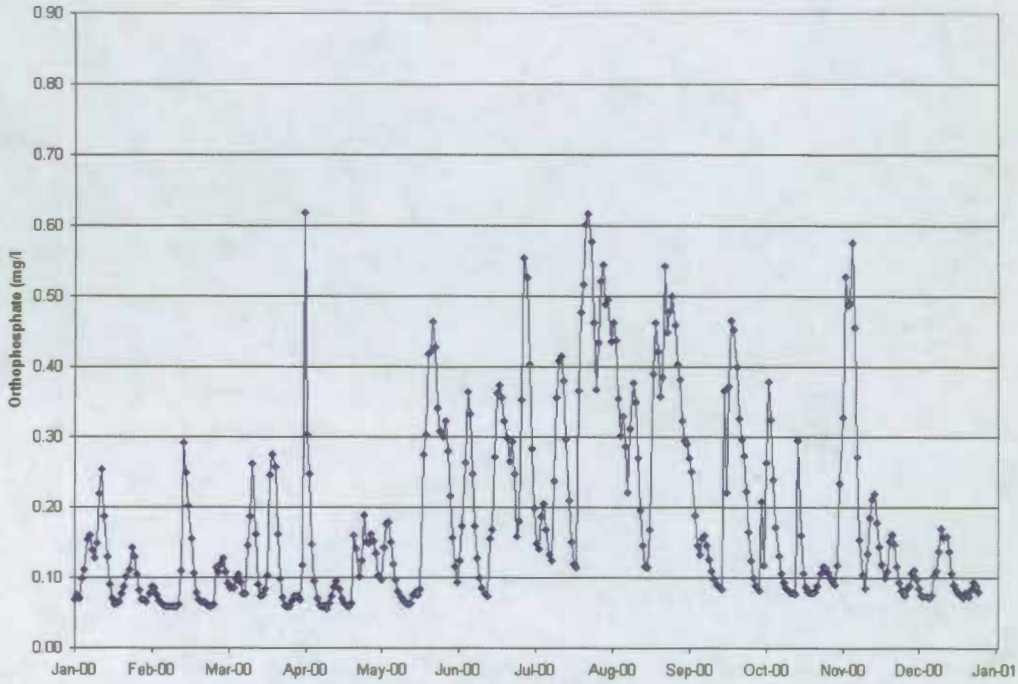

Figure 6-25 Orthophosphate Input at Upstream Boundary for year 2000.

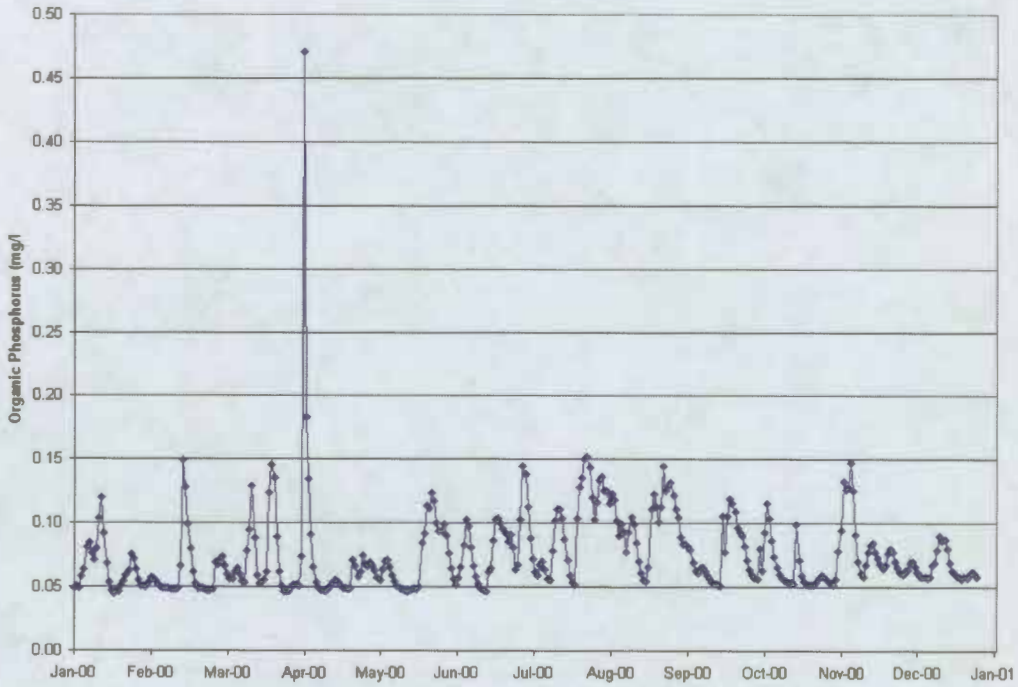

Figure 6-26 Organic Phosphorus Input at Upstream Boundary for year 2000.

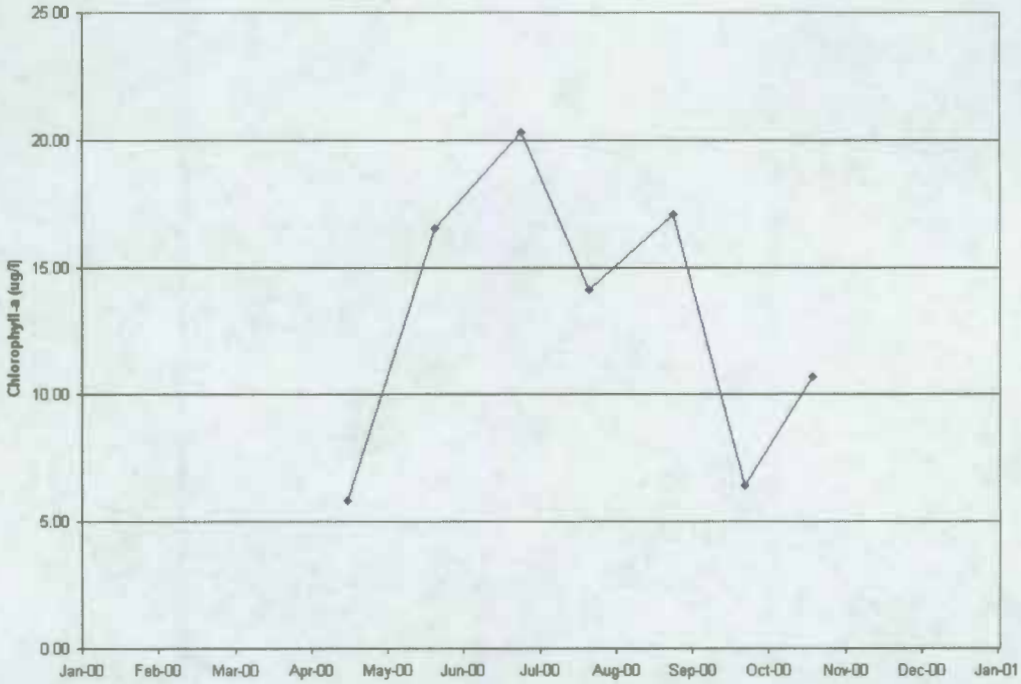

Figure 6-27 Phytoplankton (Chl-a) Input at Upstream Boundary for year 2000.

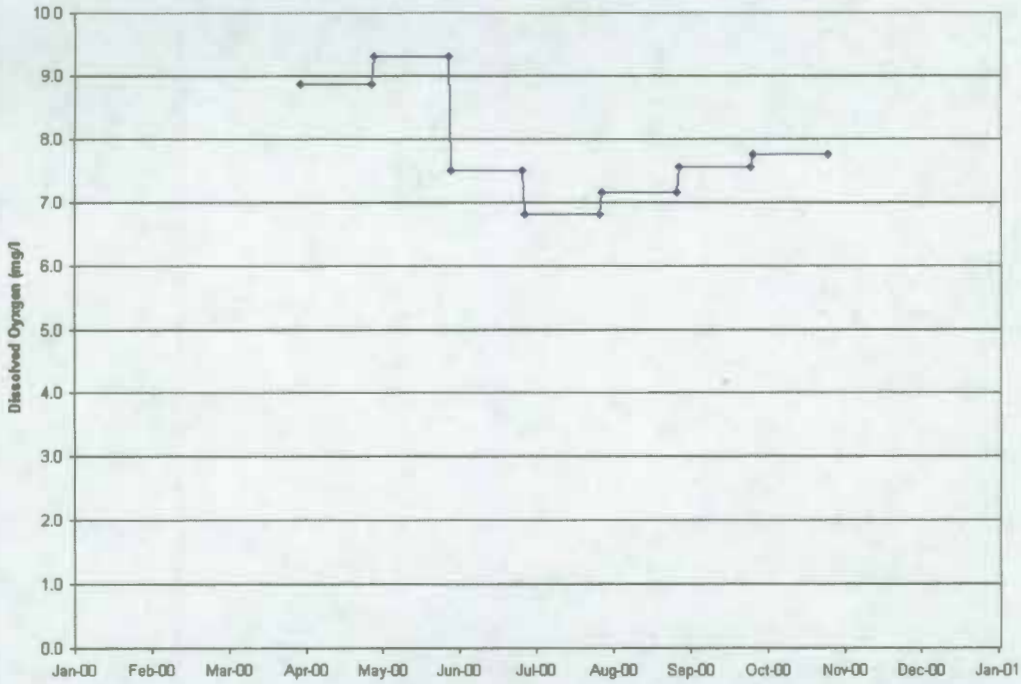

Figure 6-28 Dissolved Oxygen (DO) Input at Upstream Boundary for year 2000.

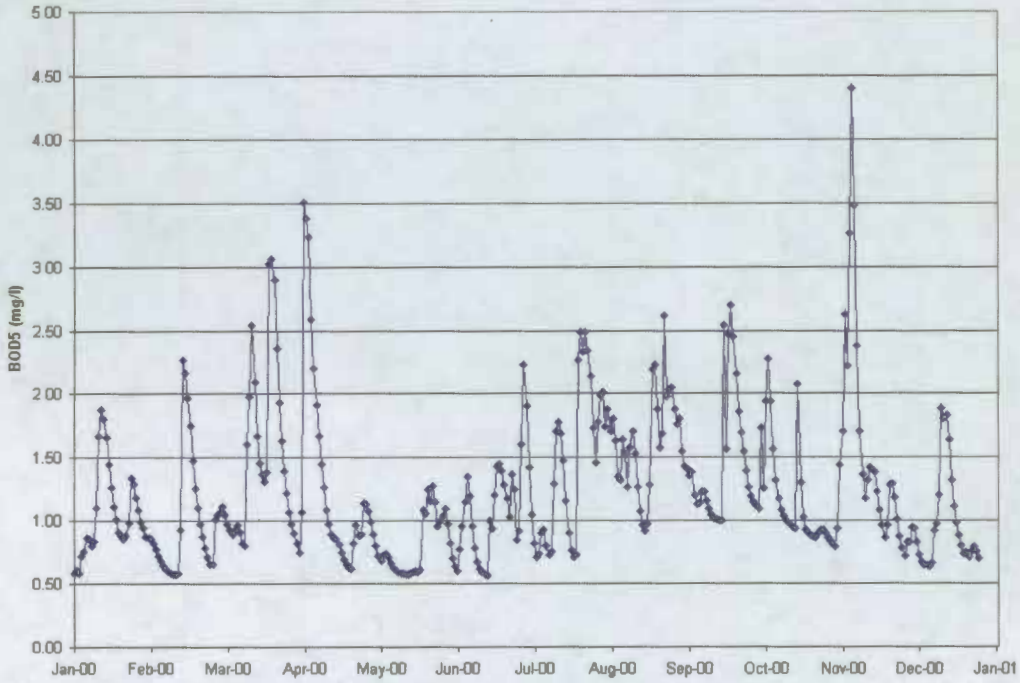

Figure 6-29 BOD5 Input at Upstream Boundary for year 2000.

6.4.2 Turbine and Spillway

The turbine and spillway outflow discharge for 2000 was represented by water quality data measured at Weiss 1 (Figure 3-10 and 5-12). Data were collected approximately monthly during the growing season (April through October). BOD5 data were not collected at Weiss 1, therefore a constant value of 1.0 was assumed. To convert BOD5 to CBODu, an f-Ratio of 1.5 was used. Organic Nitrogen, Organic Phosphorus and Orthophosphate data were also not collected, however, TKN and Total Phosphorus data were collected. The following equations were used to determine the missing time series.

Organic Nitrogen (mg/l) = TKN (mg/l) – Ammonia (mg/l)

Organic Phosphorus (mg/l) = 20% * Total Phosphorus (mg/l)

Orthophosphate (mg/l) = 80% * Total Phosphorus (mg/l)

Figures 6-30 through 6-37 present the outflow time series for the Weiss turbine and spillway.

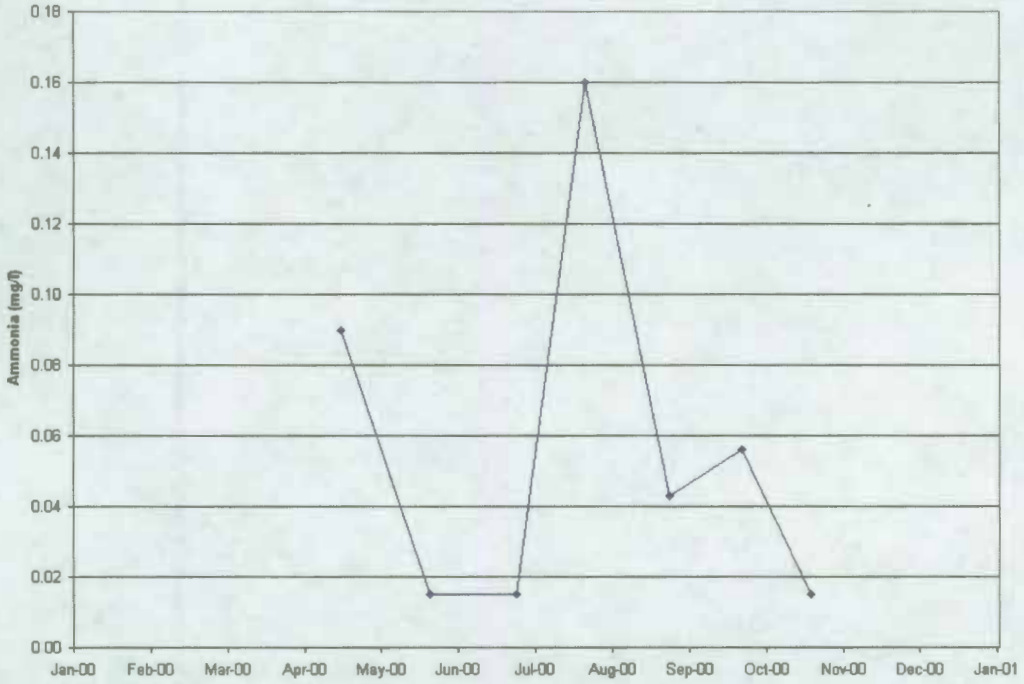

Figure 6-30 Ammonia (NH3) Outflow at Weiss Dam for year 2000.

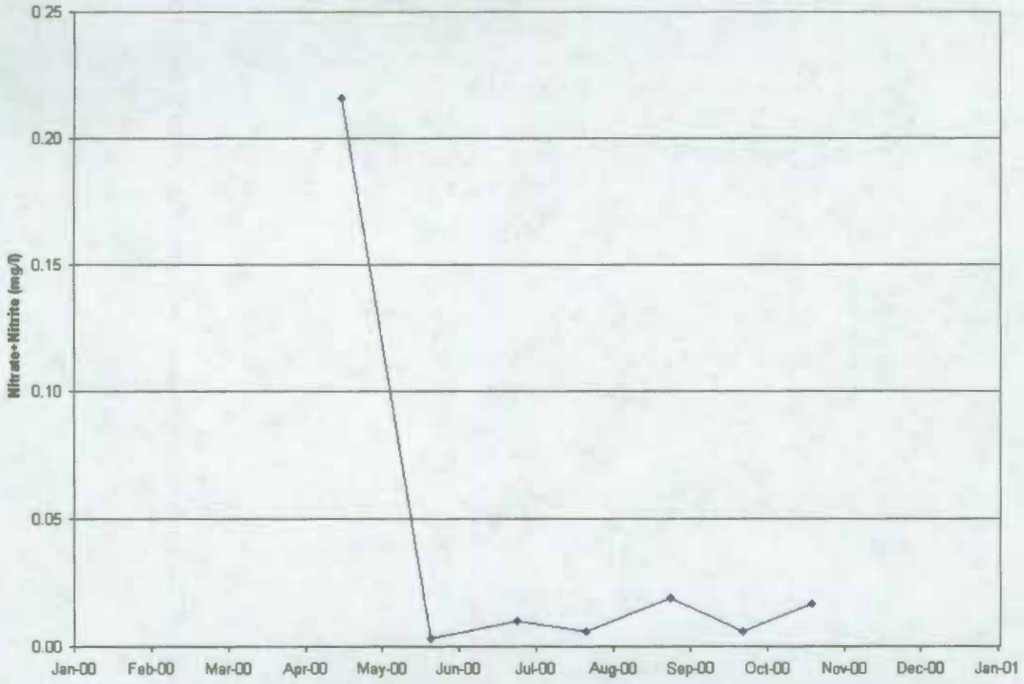

Figure 6-31 Nitrate+Nitrite (NO2+NO3) Outflow at Weiss Dam for year 2000.

Figure 6-32 Organic Nitrogen Outflow at Weiss Dam for year 2000.

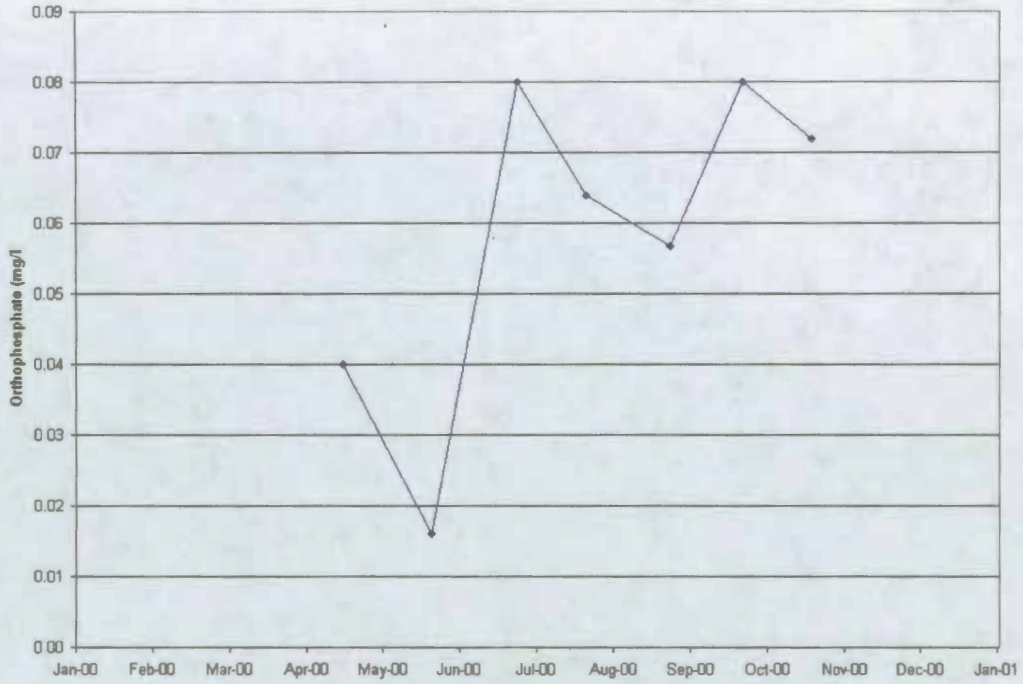

Figure 6-33 Orthophosphate Outflow at Weiss Dam for year 2000.

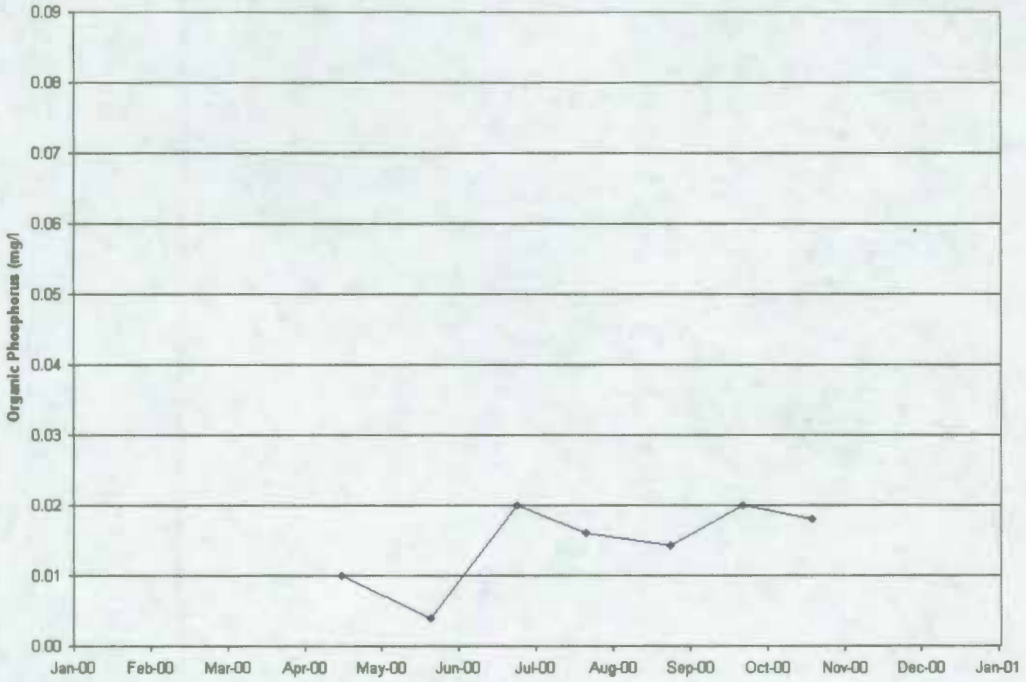

Figure 6-34 Organic Phosphorus Outflow at Weiss Dam for year 2000.

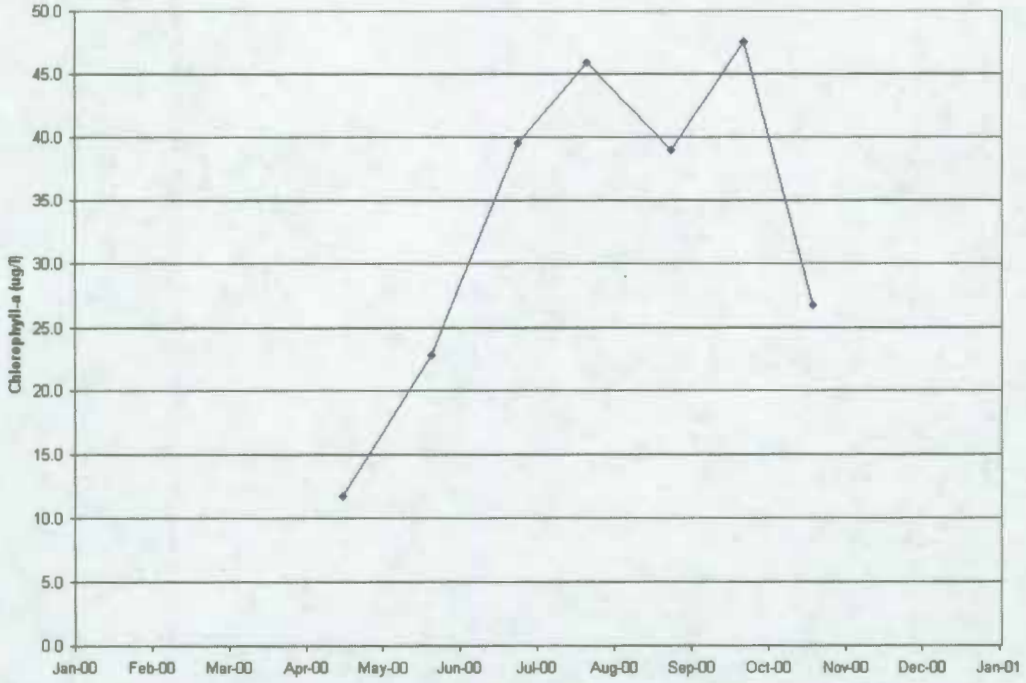

Figure 6-35 Phytoplankton (Chl-a) Outflow at Weiss Dam for year 2000.

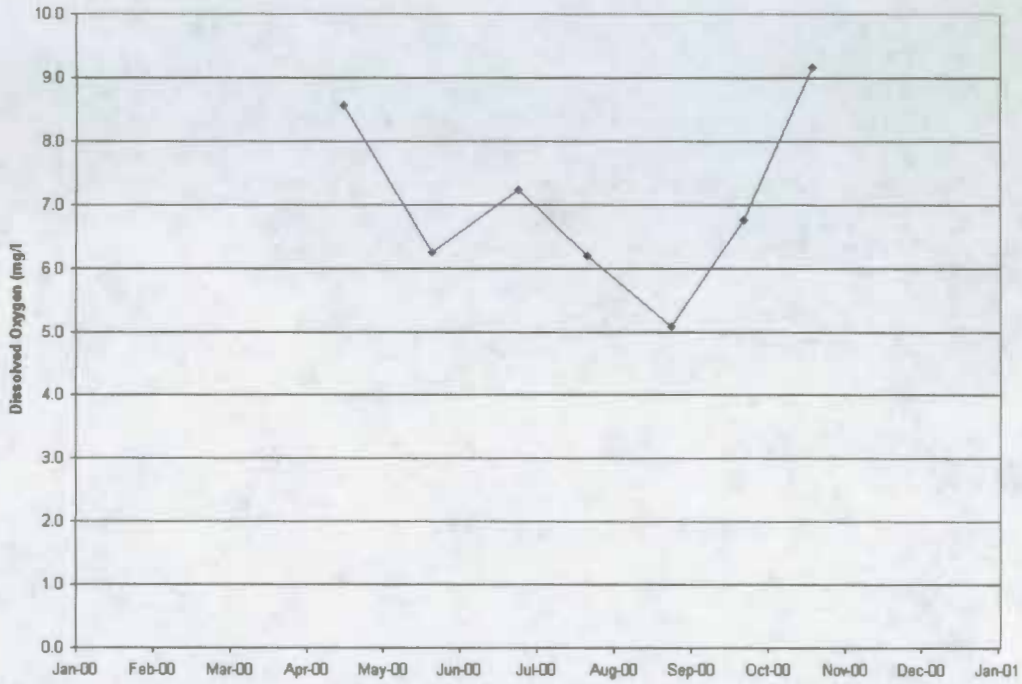

Figure 6-36 Dissolved Oxygen (DO) Outflow at Weiss Dam for year 2000.

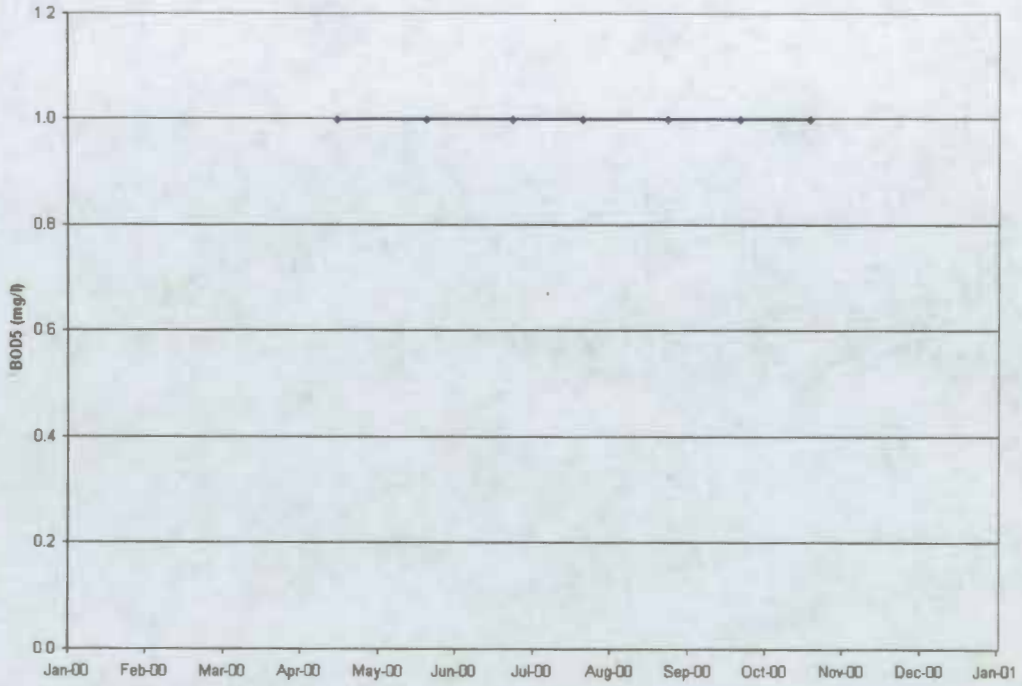

Figure 6-37 BOD5 Outflow at Weiss Dam for year 2000.

6.4.3 Tributaries

The calibrated LSPC watershed model was used to generate a time series of water quality concentrations for the watersheds during 2000. LSPC provided concentrations for BOD, nitrate-nitrite, ammonia, organic nitrogen, orthophosphate, and total phosphorus. LSPC was not calibrated to organic phosphorus, and therefore organic phosphorus was determined by subtracting the orthophosphate time series from the total phosphorus time series. In addition, the watershed model was not calibrated to dissolved oxygen, and therefore all watershed inputs were input at a value of 6.0 mg/l. These time series were used to represent water quality contributions from non-point sources, as well as upstream point sources, and served as inputs to the WASP water quality model of Weiss Lake. The concentration data were then applied at each of the locations where a tributary flow was assigned. Further information about the LSPC watershed model is presented in Appendix A (flow calibration and validation) and Appendix B (water quality calibration and validation).

6.4.4 Meteorological Data

The meteorological inputs for 2000 are presented in Figures 6-38 through 6-41.

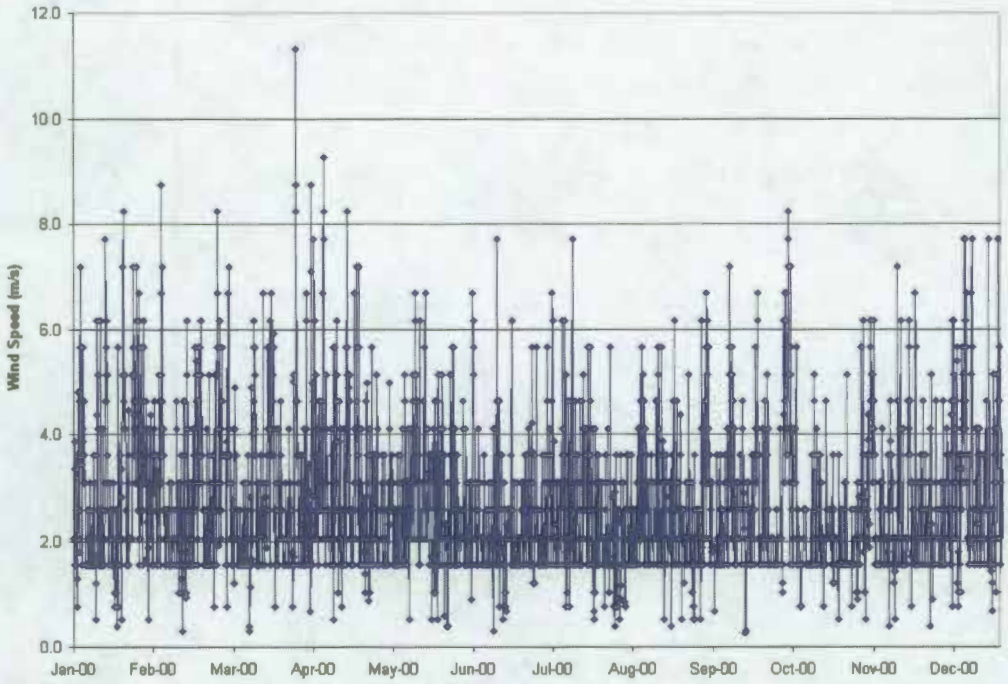

Figure 6-38 Wind Speed Input for 2000.

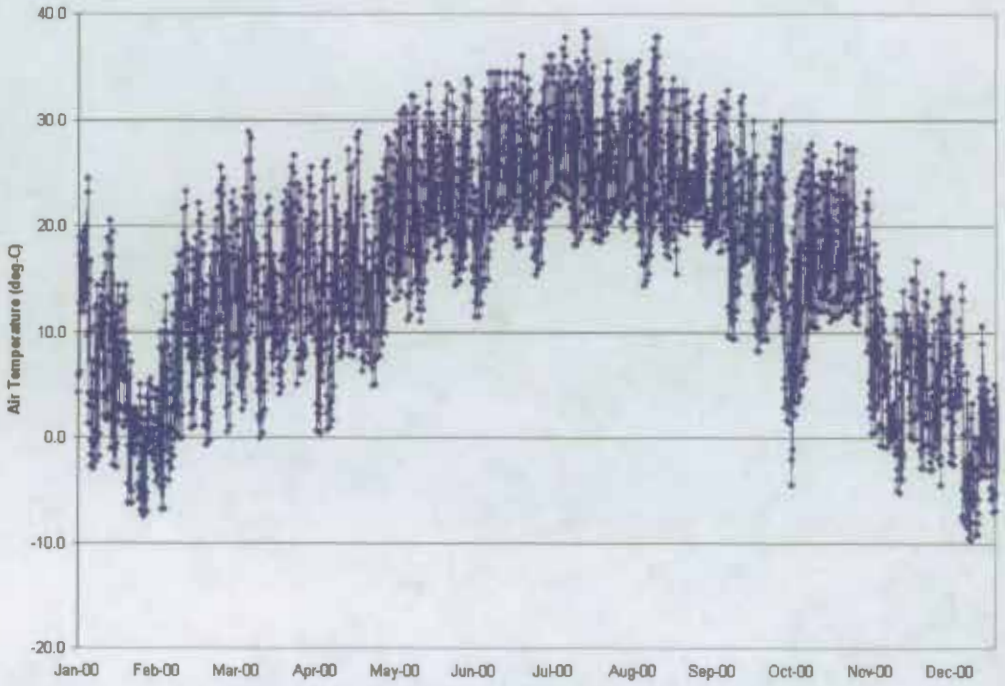

Figure 6-39 Air Temperature Input for 2000.

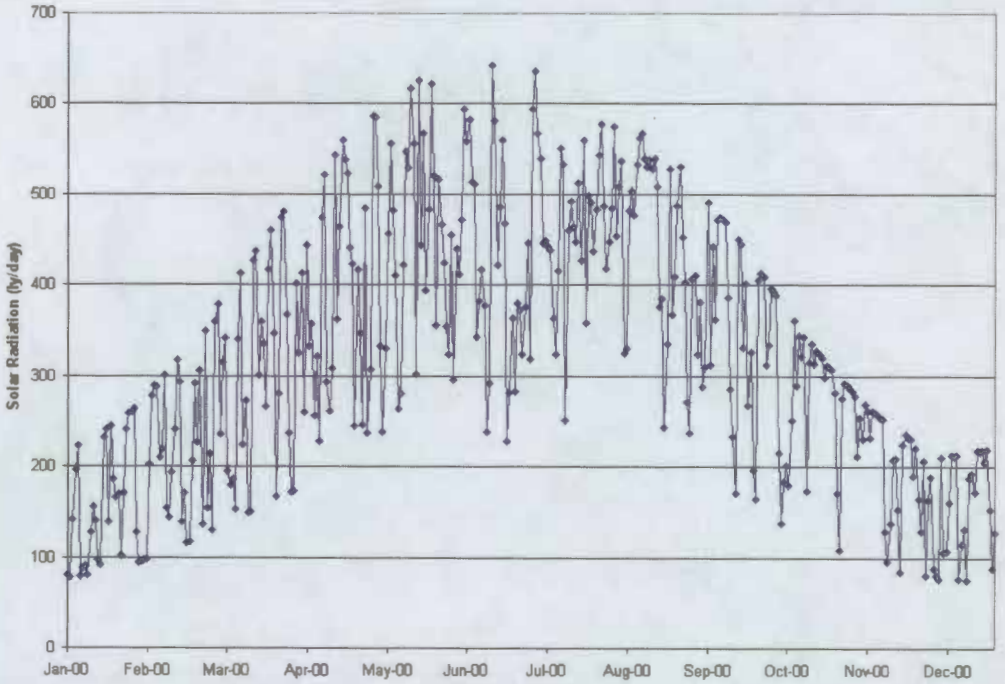

Figure 6-40 Solar Radiation Input for 2000.

Figure 6-41 Fraction of Daily Light for 2000.

6.5 Sediment Oxygen Demand

At the request of the US-EPA, Region 4's Science and Ecosystem Support Division (SESD), Ecological Assessment Branch (EAB), conducted a Sediment Oxygen Demand (SOD) and nutrient exchange study on Lake Weiss, Alabama during the week of August 6th through August 11th, 2001.

During this study SOD data were collected at 3 stations along the main channel and 1 station in an overbank area. Figure 6-42 shows the approximate location of the 4 SOD sampling stations and Table 6-1 presents the data collected at each station and the mean value.

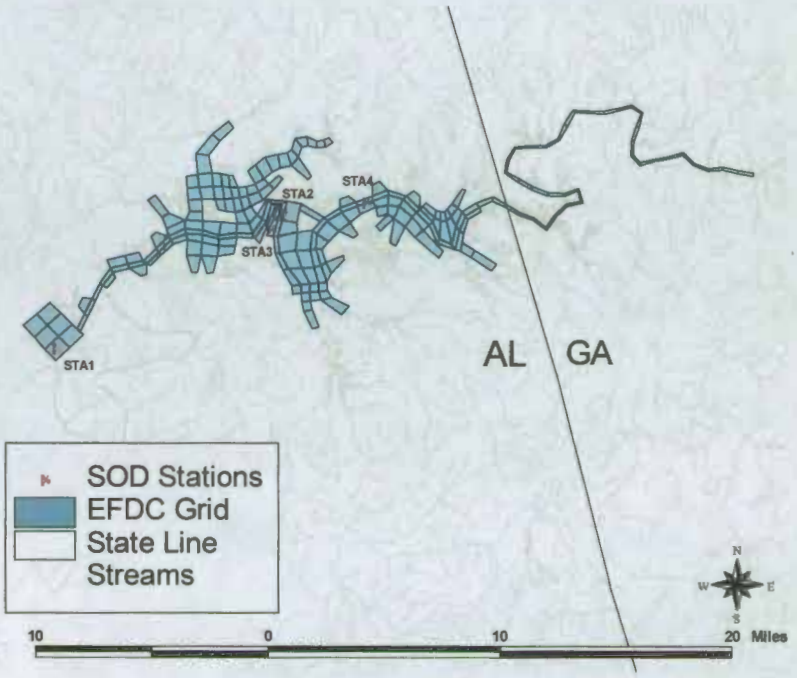

Figure 6-42 USEPA SOD Sampling Stations.

Table 6-1 Sediment Oxygen Demand Data from US EPA study

Sample Name	Station Location	SOD (g O2/m2/d)	Mean SOD Value (g O2/m2/d)
STA 1	Dam Pool / In Channel	3.64071	**4.16856**
		3.54313	
		4.49881	
		4.99160	
STA 2	In-Channel	2.33790	**2.28818**
		2.22411	
		1.94259	
		2.64814	
STA 4	In-Channel	3.00224	**3.13901**
		2.42520	
		4.82281	
		2.30579	
STA 3	Overbank	1.99338	**1.97727**
		2.08570	
		2.09175	
		1.73824	

There was no SOD value taken at the upstream boundary, and therefore a value of 2.0 was assumed. The mean SOD values were then corrected to 20 °C to be input into WASP using the following equation:

$$SOD_{20}{}^{\circ}C = SOD_{T}{}^{\circ}C / [1.065^{(T-20)}]$$

The temperature that was used to correct the mean SOD values were taken from profile data that was collected by ADEM on July 31, 2001. Table 6-2 presents the original and corrected SOD values.

Table 6-2 Corrected SOD Values

SOD Station	SOD (g O2/m2/d)	Temperature (°C) (July 31, 2001)	SOD (g O2/m2/d) (Corrected to 20°C)
STA 1	**4.16856**	**29.271**	**2.325**
STA 2	**2.28818**	**27.573**	**1.420**
STA 4	**3.13901**	**26.962**	**2.025**
Upstream Boundary	**2.00000**	**27.616**	**1.238**

The corrected SOD values for stations STA 1, STA 2 and STA 4 were then placed with its corresponding WASP segment. Table 6-3 presents where each measured SOD value was assigned. SOD values for the intermediate segments along the main channel were then determined by interpolation. For segments adjacent to the main channel, their values were assumed to be equal to those in the main channel. For the area of Weiss Lake north of Hog Island (where Little River and Chattooga Rivers enter), SOD values for all segments were assumed to be the average of the three segments entering the area, 624, 626 and 768 (Table 6-4). Figure 6-43 presents the final SOD values for Weiss Lake.

Table 6-3 USEPA SOD Values vs. Corresponding WASP Segment

SOD Station	WASP Segment	Layers	EFDC Cell		SOD Value (g O2/m2/d)
			I-Value	J-Value	
STA 1	892	8	37	24	**2.325**
STA 2	874	8	19	24	**1.420**
STA 4	853	8	22	10	**2.025**
--	474*	3	68	10	**1.238**

* - Segment 474 is the Upstream Boundary of the model.

Table 6-4 SOD Values for Little River and Chattooga River Embayment

WASP Segment	Layers	EFDC Cell		SOD Value (g O2/m2/d)
		I-Value	J-Value	
624	4	22	22	1.451
768	6	23	22	1.680
626	4	26	22	1.947
			Average Value =	**1.718**

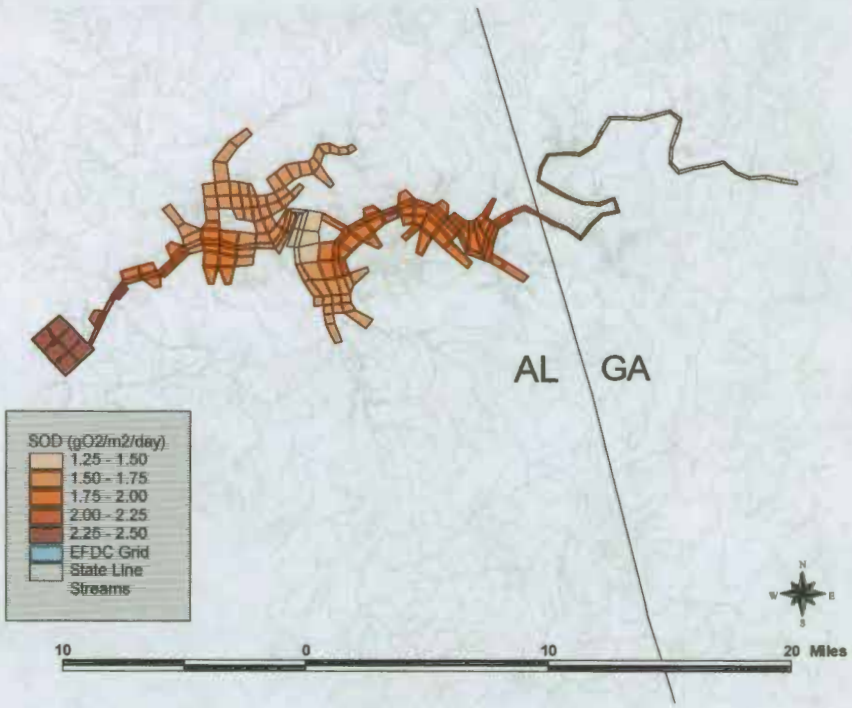

Figure 6-43 Final SOD Values.

6.6 Nutrient Fluxes

At the request of the US-EPA, Region 4's Science and Ecosystem Support Division (SESD), Ecological Assessment Branch (EAB), conducted a Sediment Oxygen Demand (SOD) and nutrient exchange study on Lake Weiss, Alabama during the week of August 6th through August 11th, 2001.

During this study Ammonia and Phosphate flux data were collected at 3 stations along the main channel and 1 station in an overbank area. Figure 6-42 shows the approximate location of the 4 nutrient flux sampling stations. Tables 6-5 and 6-6 presents the ammonia and phosphate flux data collected at each station and the mean value.

Table 6-5 Ammonia Flux Data from US EPA study

Sample Name	Station Location	Ammonia Flux (g NH3/m2/d)	Mean Flux Value (g NH3/m2/d)
STA 1	Dam Pool / In Channel	0.15560	**0.11179**
		0.14884	
		0.16543	
		0.18568	
		0.00812	
		0.00710	
STA 2	In-Channel	0.15688	**0.09313**
		0.13059	
		0.11194	
		0.12953	
		0.01478	
		0.01506	
STA 4	In-Channel	0.05789	**0.02987**
		-0.02712	
		0.07570	
		0.06971	
		0.00213	
		0.00091	
STA 3	Overbank	0.05092	**0.03311**
		0.06000	
		0.03612	
		0.03914	
		0.00582	
		0.00667	

Table 6-6 Phosphate Flux Data from US EPA study

Sample Name	Station Location	Phosphate Flux (g Total P/m2/d)	Mean Flux Value (g Total P/m2/d)
STA 1	Dam Pool / In Channel	0.02233	**0.01194**
		0.01996	
		0.02600	
		0.02026	
		-0.01015	
		-0.00676	
STA 2	In-Channel	0.00581	**-0.00818**
		-0.01020	
		-0.01166	
		-0.00290	
		-0.01217	
		-0.01795	
STA 4	In-Channel	-0.00609	**-0.01004**
		-0.02590	
		-0.00606	
		-0.00394	
		-0.01096	
		-0.00728	
STA 3	Overbank	-0.01439	**-0.01142**
		-0.00553	
		-0.01028	
		-0.01194	
		-0.01635	
		-0.01000	

There was no nutrient flux data taken at the upstream boundary, and therefore the value measured at STA 4 was assumed to be constant for all upstream cells. The average nutrient flux values for stations STA 1, STA 2 and STA 4 were then placed with its corresponding WASP segment. Table 6-7 presents where each nutrient flux value was assigned. Nutrient flux values for the intermediate segments along the main channel were then determined by interpolation. For segments adjacent to the main channel, their values were assumed to be equal to those in the main channel. For the area of Weiss Lake north of Hog Island (where Little River and Chattooga Rivers enter), nutrient flux values for all segments were assumed to be the average of the three segments entering the area, 624, 626 and 768 (Table 6-8). Figures 6-44 and 6-45 presents the final ammonia and phosphate flux values for Weiss Lake.

Table 6-7 USEPA Nutrient Flux Values vs. Corresponding WASP Segment

SOD Station	WASP Segment	Layers	EFDC Cell		Ammonia Flux Value (g NH3/m2/d)	Phosphate Flux Value (g Total P/m2/d)
			I-Value	J-Value		
STA 1	892	8	37	24	**0.11179**	**0.01194**
STA 2	874	8	19	24	**0.09313**	**-0.00818**
STA 4	853	8	22	10	**0.02987**	**-0.01004**
--	474*	3	68	10	**0.02987**	**-0.01004**

* - Segment 474 is the Upstream Boundary of the model.

Table 6-8 Nutrient Flux Values for Little River and Chattooga River Embayment

WASP Segment	Layers	EFDC Cell		Ammonia Flux Value (g NH3/m2/d)	Phosphate Flux Value (g Total P/m2/d)
		I-Value	J-Value		
624	4	22	22	0.09624	-0.00483
768	6	23	22	0.09728	-0.00371
626	4	26	22	0.10039	-0.00036
			Average Value =	**0.09797**	**-0.00296**

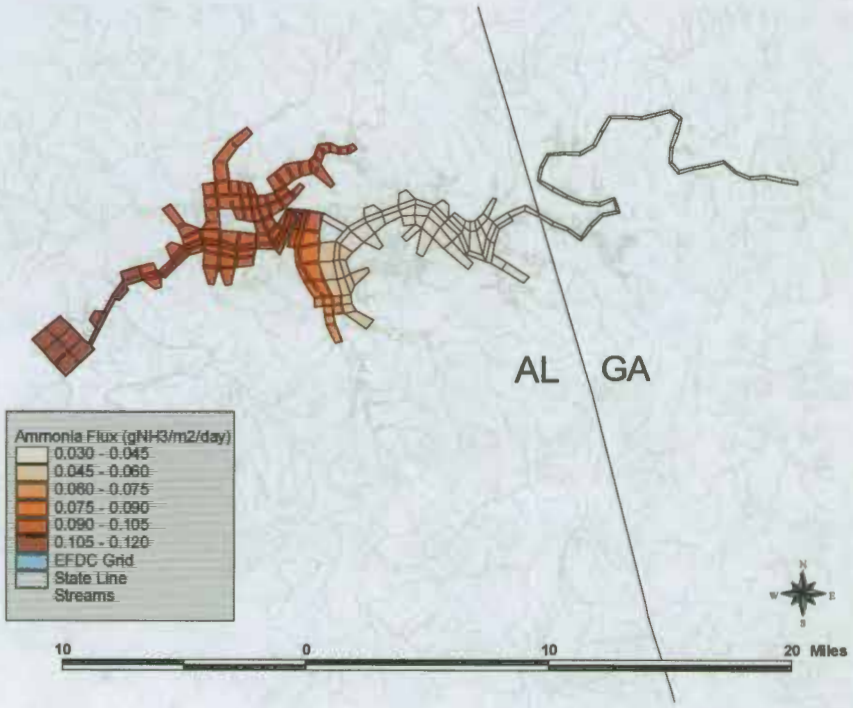

Figure 6-44 Final Ammonia Flux Values.

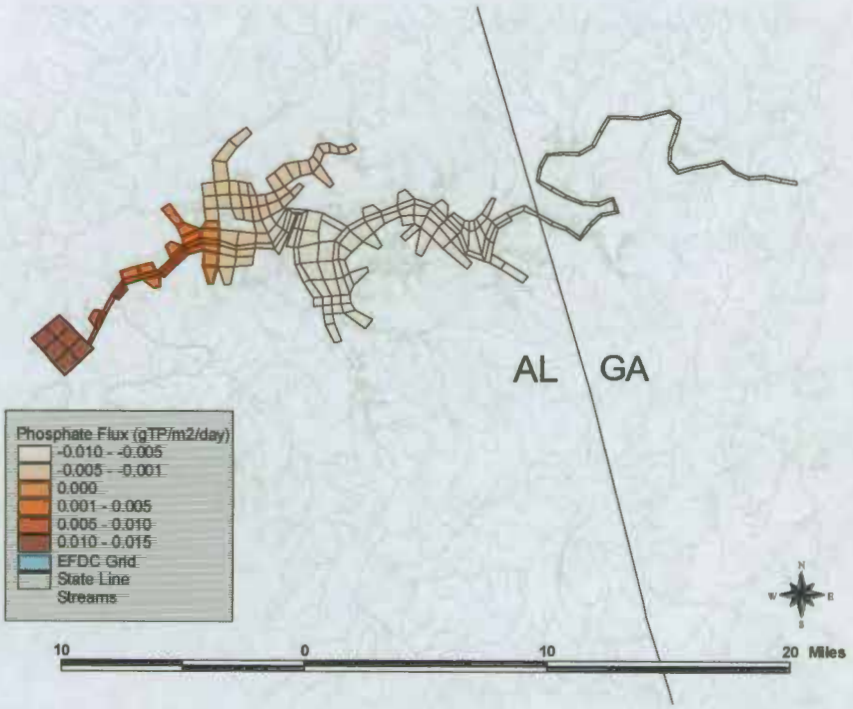

Figure 6-45 Final Phosphate Flux Values.

6.7 Rates and Constants

The rates and constants that were used in the WASP water quality model are presented in Tables 6-9 through 6-19.

Table 6-9 Constants used for Ammonia

Constant	Used	Value
Nitrification Rate Constant @20 °C (per day)	Yes	0.2
Nitrification Temperature Coefficient	Yes	1.047
Half Saturation Constant for Nitrification Oxygen Limit (mg O/L)	Yes	1.5
Minimum Temperature for Nitrification Reaction, °C	No	0
Ammonia Partition Coefficient to Water Column Solids, L/kg	No	0
Ammonia Partition Coefficient to Benthic Solids, L/kg	No	0

Table 6-10 Constants used for Nitrate

Constant	Used	Value
Denitrification Rate Constant @20 °C (per day)	Yes	0.1
Denitrification Temperature Coefficient	Yes	1.045
Half Saturation Constant for Denitrification Oxygen Limit (mg O/L)	Yes	0.01

Table 6-11 Constants used for Organic Nitrogen

Constant	Used	Value
Dissolved Organic Nitrogen Mineralization Rate Constant @20 °C (per day)	Yes	0.05
Dissolved Organic Nitrogen Mineralization Temperature Coefficient	Yes	1.047
Organic Nitrogen Decay Rate Constant in Sediments @20 °C (per day)	No	0
Organic Nitrogen Decay in Sediment Temperature Coefficient	No	0
Fraction of Phytoplankton Death Recycled to Organic Nitrogen	Yes	0.8

Table 6-12 Constants used for Organic Phosphorus

Constant	Used	Value
Mineralization Rate Constant for Dissolved Organic P @20 °C (per day)	Yes	0.05
Dissolved Organic Phosphorus Mineralization Temperature Coefficient	Yes	1.00
Organic Phosphorus Decay Rate Constant in Sediments @20 °C (per day)	No	0
Organic Phosphorus Decay in Sediments Temperature Coefficient	No	0
Fraction of Phytoplankton Death Recycled to Organic Phosphorus	Yes	0.8

Table 6-13 Constants used for Phytoplankton

Constant	Used	Value
Phytoplankton Maximum Growth Rate Constant @20 °C (per day)	Yes	3.0
Phytoplankton Growth Temperature Coefficient	Yes	1.07
Include Algal Self Shading Light Extinction in Steele (0=Yes, 1=No)	Yes	1
Exponent for Self Shading (Mult * TCHLA^Exp)	No	0
Multiplier for Self Shading (Mult * TCHLA^Exp)	No	0
Phytoplankton Self Shading Extinction (Dick Smith Formulation)	No	0
Phytoplankton Carbon to Chlorophyll Ratio	Yes	65
Phytoplankton Half-Saturation Constant for Nitrogen Uptake (mg N/L)	Yes	0.01
Phytoplankton Half-Saturation Constant for Phosphorus Uptake (mg P/L)	Yes	0.001
Phytoplankton Endogenous Respiration Rate Constant @20 °C (per day)	Yes	0.15
Phytoplankton Respiration Temperature Coefficient	Yes	1.06
Phytoplankton Death Rate Constant (Non-Zooplankton Predation) (per day)	Yes	0.05
Phytoplankton Zooplankton Grazing Rate Constant (per day)	No	0
Nutrient Limitation Option	No	0
Phytoplankton Decay Rate Constant in Sediments (per day)	No	0.02
Phytoplankton Temperature Coefficient for Sediment Decay	No	1.08
Phytoplankton Phosphorus to Carbon Ratio	Yes	0.025
Phytoplankton Nitrogen to Carbon Ratio	Yes	0.176
Phytoplankton Half-Sat. for Recycle of Nitrogen and Phosphorus (mg Phyt C/L)	Yes	0.005

Table 6-14 Constants used for Light

Constant	Used	Value
Light Option (1 uses input light; 2 uses calculated diel light)	Yes	2
Phytoplankton Maximum Quantum Yield Constant	Yes	360
Phytoplankton Optimal Light Saturation	Yes	300
Background Light Extinction Multiplier	Yes	0.50
Detritus & Solids Light Extinction Multiplier	Yes	0.34
DOC Light Extinction Multiplier	Yes	0.50

Table 6-15 Constants used for Dissolved Oxygen

Constant	Used	Value
Waterbody Type Used for Wind Driven Reaeration Rate	Yes	2
Calc Reaeration Option (0=Covar, 1=O'Connor, 2=Owens, 3=Churchill, 4=Tsivoglou)	Yes	1
Global Reaeration Rate Constant @ 20 °C (per day)	No	0
Elevation above Sea Level (meters) used for DO Saturation	Yes	650
Reaeration Option (Sums Wind and Hydraulic Ka)	Yes	1
Minimum Reaeration Rate, per day	No	0
Theta -- Reaeration Temperature Correction	Yes	1.024
Oxygen to Carbon Stoichiometric Ratio	Yes	2.667

Table 6-16 Constants used for CBOD1 (Ultimate)

Constant	Used	Value
BOD (1) Decay Rate Constant @20 °C (per day)	Yes	0.04
BOD (1) Decay Rate Temperature Correction Coefficient	Yes	1.047
BOD (1) Decay Rate Constant in Sediments @20 °C (per day)	No	0
BOD (1) Decay Rate in Sediments Temperature Correction Coefficient	No	0
BOD (1) Half Saturation Oxygen Limit (mg O/L)	Yes	0.2
Fraction of Detritus Dissolution to BOD (1)	No	0
Fraction of BOD (1) Carbon Source for Denitrification	No	0

Table 6-17 Constants used for CBOD2 (Ultimate)

Constant	Used	Value
BOD (2) Decay Rate Constant @20 °C (per day)	Yes	0.15
BOD (2) Decay Rate Temperature Correction Coefficient	Yes	1.047
BOD (2) Decay Rate Constant in Sediments @20 °C (per day)	No	0
BOD (2) Decay Rate in Sediments Temperature Correction Coefficient	No	0
BOD (2) Half Saturation Oxygen Limit (mg O/L)	Yes	0.2
Fraction of Detritus Dissolution to BOD (2)	No	0
Fraction of BOD (2) Carbon Source for Denitrification	No	0

Table 6-18 Constants used for CBOD3 (Ultimate)

Constant	Used	Value
BOD (3) Decay Rate Constant @20 °C (per day)	Yes	0.2
BOD (3) Decay Rate Temperature Correction Coefficient	Yes	1.047
BOD (3) Decay Rate Constant in Sediments @20 °C (per day)	No	0
BOD (3) Decay Rate in Sediments Temperature Correction Coefficient	No	0
BOD (3) Half Saturation Oxygen Limit (mg O/L)	Yes	0.2
Fraction of Detritus Dissolution to BOD (3)	Yes	1
Fraction of BOD (3) Carbon Source for Denitrification	No	0

Table 6-19 Constants used for Detritus

Constant	Used	Value
Detritus Dissolution Rate (1/day)	Yes	0.1
Temperature Correction for detritus dissolution	Yes	1.08

7.0 WATER QUALITY CALIBRATION

The water quality model calibration was performed using data collected by ADEM and GAEPD during 2005, and the validation was performed using data collected by ADEM during 2000. The EFDC hydrodynamic model was used to provide the model grids, depths, volumes, velocities, and diffusion parameters along with the predicted temperatures. The hydrodynamic model was run from January 1, 1991 through December 31, 2005. The WASP water quality model for calibration was run from January 1, 2005 to December 31, 2005, and for validation from January 1, 2000 to December 31, 2000.

The water quality model was calibrated to the following:

- Monthly Ammonia, Nitrate+Nitrite, and Total Phosphorus data collected by ADEM,
- Bimonthly Ammonia, Nitrate+Nitrite, and Total Phosphorus data collected by GAEPD,
- Bimonthly Biochemical Oxygen Demand (BOD5) data collected by GAEPD,
- Light extinction values determined from secchi disk measurements collected by ADEM,
- Light extinction values determined from secchi disk measurements collected by GAEPD,
- Monthly Chlorophyll-a data collected by ADEM,
- Hourly Chlorophyll-a data collected by USGS,
- Monthly Dissolved oxygen profiles collected by ADEM,
- Bimonthly Dissolved oxygen profiles collected by GAEPD.

The water quality model was validated to the following:

- Monthly Ammonia, Nitrate+Nitrite, and Total Phosphorus data collected by ADEM,
- Light extinction values determined from secchi disk measurements collected by ADEM,
- Monthly Chlorophyll-a data collected by ADEM,
- Dissolved oxygen profiles collected by ADEM.

The stations that were used for the water quality calibration are presented in Table 7-1, and the stations used for the water quality validation are presented in Table 7-2.

Table 7-1 Stations Used for Water Quality Calibration

Station Name	Station Number	Light Extinction	Chlorophyll-a	Dissolved Oxygen	NH3	NO2+NO3	Total Phosphorus
ADEM Stations							
WEISS1A	--	Yes	Yes	Yes	Yes	Yes	Yes
WEISS2	--	Yes	Yes	Yes	Yes	Yes	Yes
WEISS3	--	Yes	Yes	Yes	Yes	Yes	Yes
WEISS4	--	Yes	Yes	Yes	Yes	Yes	Yes
WEISS12	--	Yes	Yes	Yes	Yes	Yes	Yes
GAEPD Stations							
Coosa River at Stateline	5COO-530	Yes	Yes	Yes	Yes	Yes	Yes
Coosa River at RM 262	5COO-480	Yes		Yes			
Coosa River at RM 267	5COO-440	Yes		Yes			
Coosa River at SR 100	5COO-410	Yes	Yes	Yes	Yes	Yes	Yes
Coosa River at Beech Creek	5COO-370	Yes		Yes			
Coosa River at Blacks Bluff Road	5COO-340	Yes	Yes	Yes	Yes	Yes	Yes
USGS Stations							
USGS at Georgia/Alabama Border	02397530		Yes				

Table 7-2 Stations Used for Water Quality Validation

Station Name	Station Number	Light Extinction	Chlorophyll-a	Dissolved Oxygen	NH3	NO2+NO3	Total Phosphorus
ADEM Stations							
WEISS1A	--	Yes	Yes	Yes	Yes	Yes	Yes
WEISS2	--	Yes	Yes	Yes	Yes	Yes	Yes
WEISS3	--	Yes	Yes	Yes	Yes	Yes	Yes
WEISS4	--	Yes	Yes	Yes	Yes	Yes	Yes

7.1 Ammonia

Simulated ammonia values were compared to measured ammonia data collected by ADEM and GAEPD. Data were collected monthly at the ADEM stations during the growing season (April through October). Data were collected approximately weekly from April through October at the GAEPD stations. Sampling summary information for ADEM stations are presented in Table 7-3, and information for GAEPD stations are presented in Table 7-4. This includes the number of observations, minimum, and maximum.

Figures 7-1 through 7-5 present the ammonia comparisons at the ADEM stations. Figures 7-6 through 7-8 present the ammonia comparisons at the GAEPD stations.

Table 7-3 Weiss Lake Ammonia Sampling Stations (ADEM)

Station	No. of Obs.	Mean (mg/l)	Min (mg/l)	Max (mg/l)	First Date	Last Date
WEISS1	56	0.049	0.015	0.160	5-May-92	24-Oct-05
WEISS2	54	0.061	0.015	0.250	5-May-92	24-Oct-05
WEISS3	53	0.048	0.015	0.140	6-May-93	24-Oct-05
WEISS4	52	0.054	0.015	0.140	6-May-93	24-Oct-05
WEISS12	22	0.039	0.015	0.118	23-April-02	24-Oct-05

Table 7-4 Weiss Lake Ammonia Sampling Stations (GAEPD)

Station	No. of Obs.	Mean (mg/l)	Min (mg/l)	Max (mg/l)	First Date	Last Date
Stateline	24	0.038	0.006	0.140	4/6/2005	10/13/2005
SR 100	24	0.036	0.016	0.086	4/6/2005	10/13/2005
Blacks Bluff	24	0.031	0.010	0.069	4/6/2005	10/13/2005

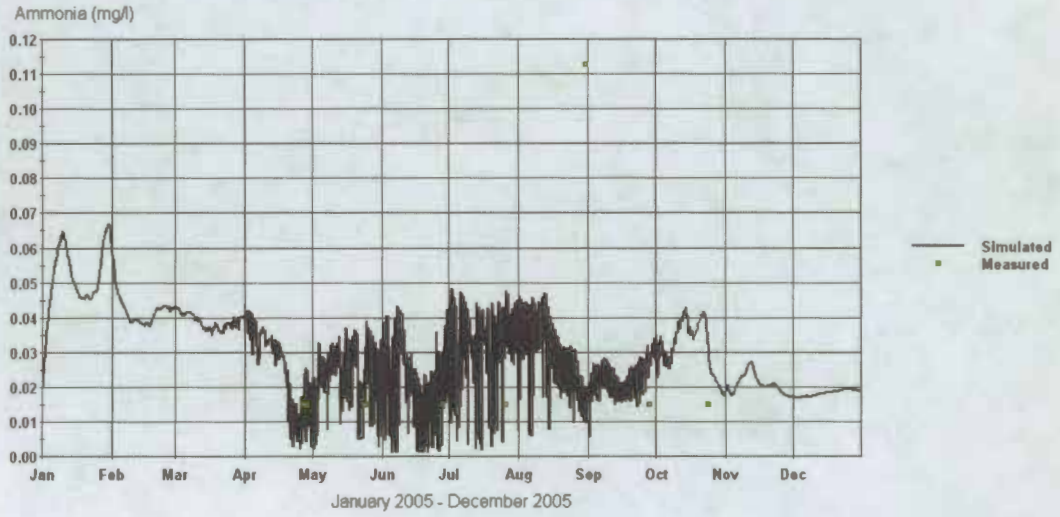

Figure 7-1 Simulated vs. Measured Ammonia at Station Weiss 1.

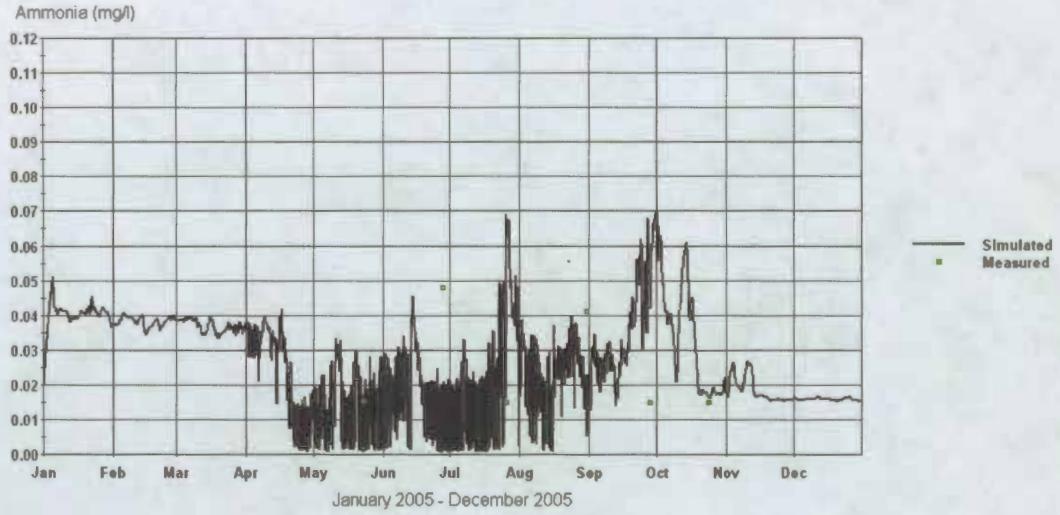

Figure 7-2 Simulated vs. Measured Ammonia at Station Weiss 2.

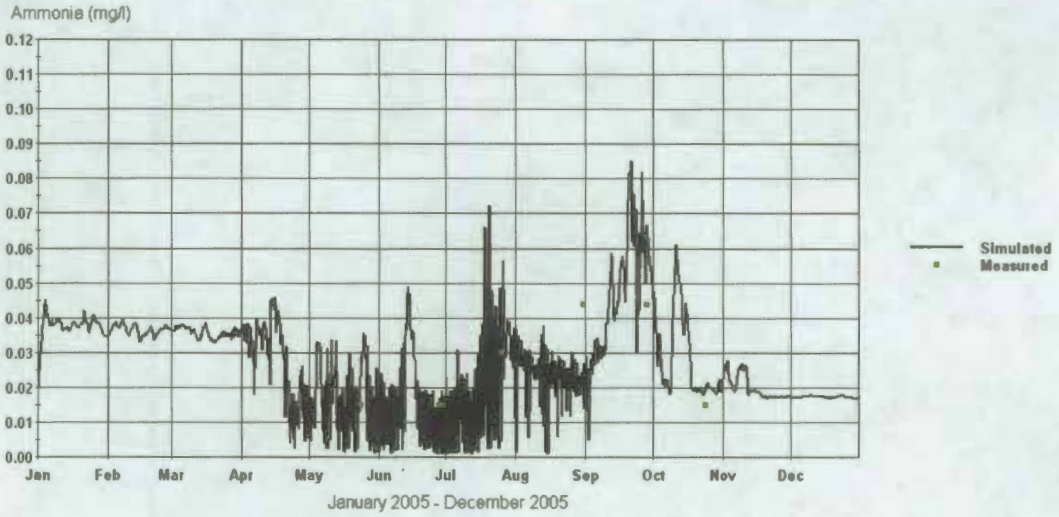

Figure 7-3 Simulated vs. Measured Ammonia at Station Weiss 3.

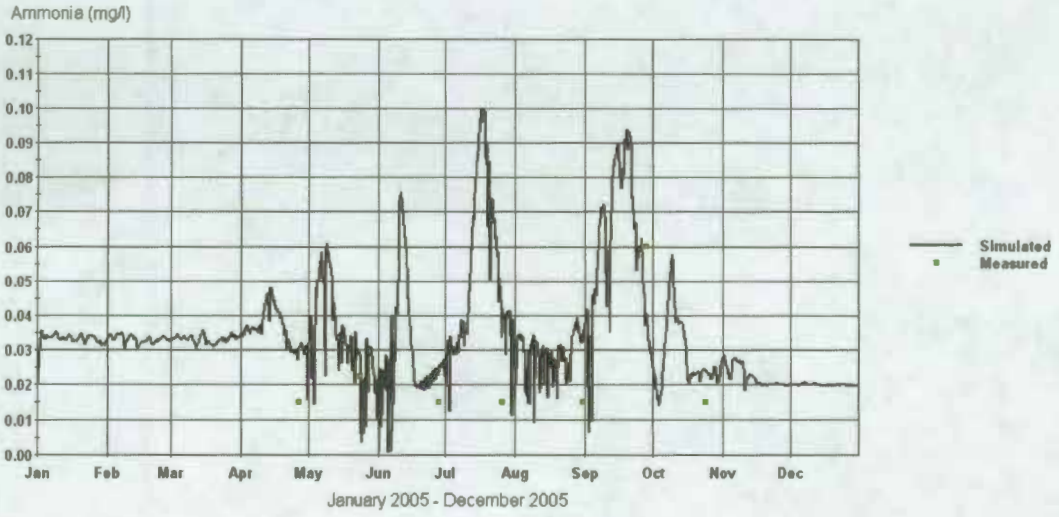

Figure 7-4 Simulated vs. Measured Ammonia at Station Weiss 4.

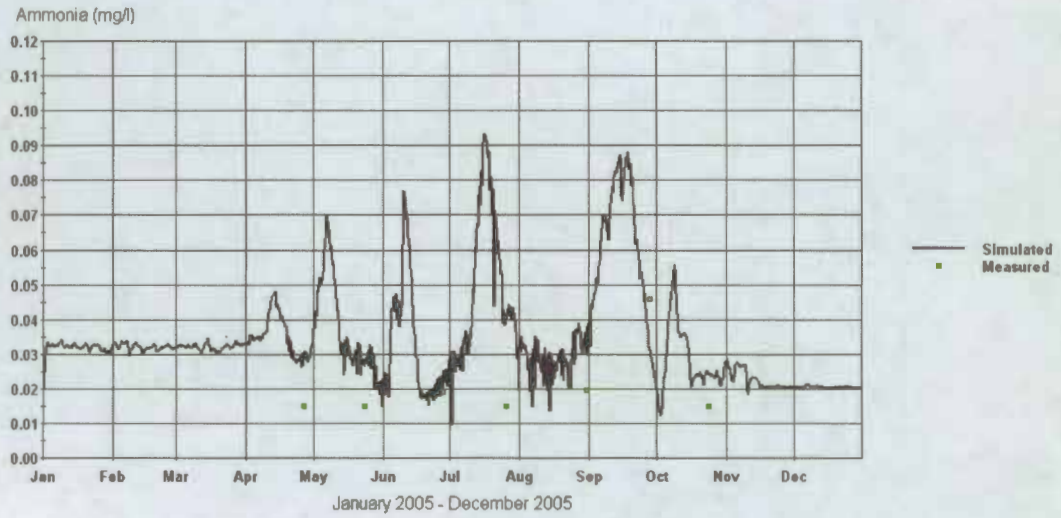

Figure 7-5 Simulated vs. Measured Ammonia at Station Weiss 12.

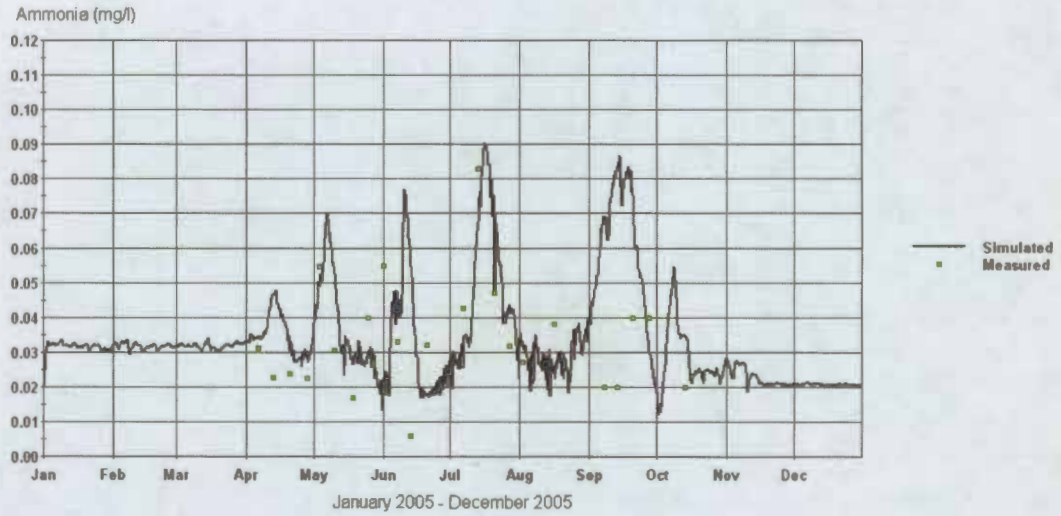

Figure 7-6 Simulated vs. Measured Ammonia at Coosa River at Georgia-Alabama border.

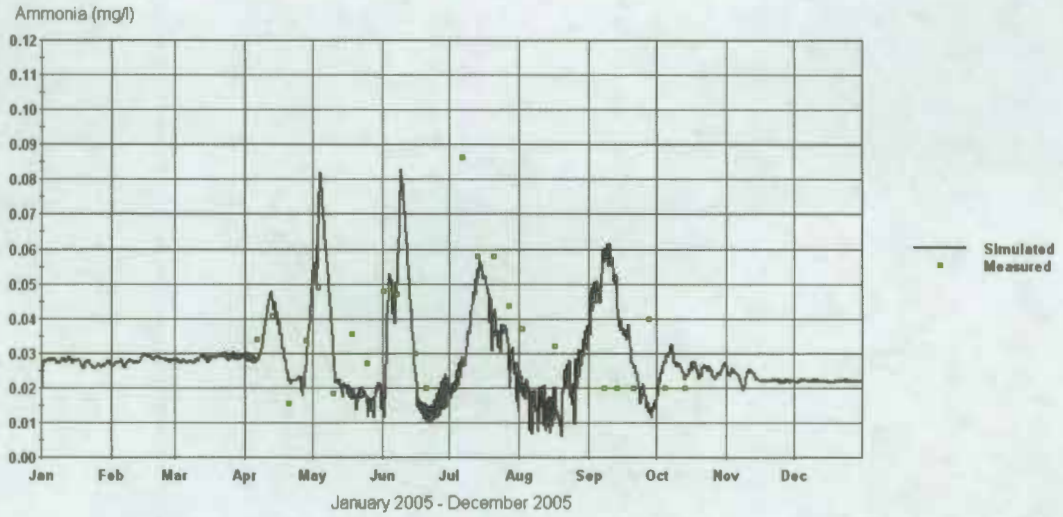

Figure 7-7 Simulated vs. Measured Ammonia at Coosa River at State Road 100.

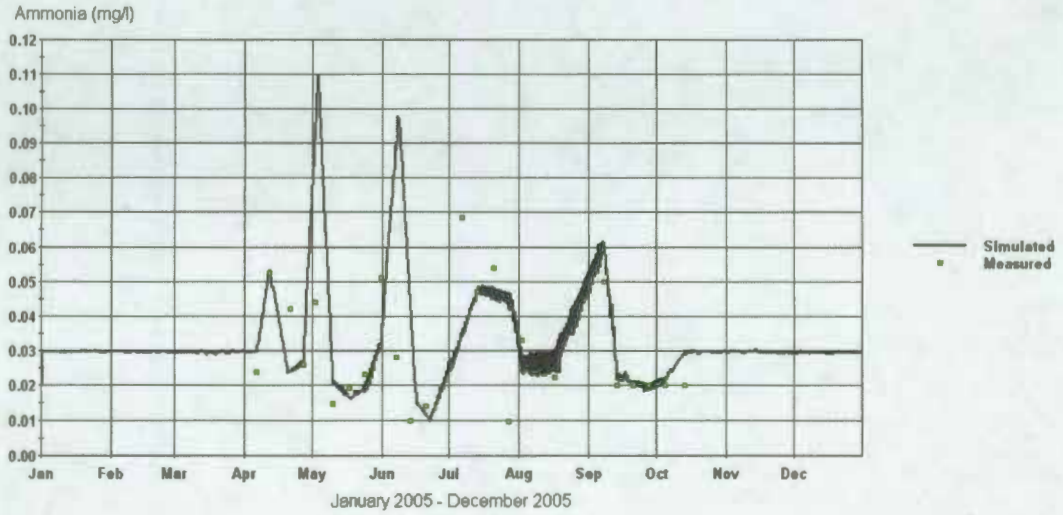

Figure 7-8 Simulated vs. Measured Ammonia at Coosa River at Blacks Bluff Road.

7.2 Nitrate+Nitrite

Simulated nitrate+nitrite values were compared to measured nitrate+nitrite data collected by ADEM and GAEPD. Data were collected monthly at the ADEM stations during the growing season (April through October). Data were collected approximately weekly from April through October at the GAEPD stations. Sampling summary information for ADEM stations are presented in Table 7-5, and information for GAEPD stations are presented in Table 7-6. This includes the number of observations, minimum, and maximum.

Figures 7-9 through 7-13 present the nitrate+nitrite comparisons at the ADEM stations. Figures 7-14 through 7-16 present the nitrate+nitrite comparisons at the GAEPD stations.

Table 7-5 Weiss Lake Nitrate+Nitrite Sampling Stations (ADEM)

Station	No. of Obs.	Mean (mg/l)	Min (mg/l)	Max (mg/l)	First Date	Last Date
WEISS1	56	0.056	0.002	0.216	5-May-92	24-Oct-05
WEISS2	54	0.110	0.003	0.429	5-May-92	24-Oct-05
WEISS3	53	0.324	0.003	1.068	6-May-93	24-Oct-05
WEISS4	52	0.349	0.003	0.605	6-May-93	24-Oct-05
WEISS12	22	0.388	0.007	0.540	23-April-02	23-Oct-05

Table 7-6 Weiss Lake Nitrate+Nitrite Sampling Stations (GAEPD)

Station	No. of Obs.	Mean (mg/l)	Min (mg/l)	Max (mg/l)	First Date	Last Date
Stateline	24	0.429	0.258	0.540	4/6/2005	10/13/2005
SR 100	24	0.484	0.267	0.672	4/6/2005	10/13/2005
Blacks Bluff	23	0.501	0.260	0.702	4/12/2005	10/13/2005

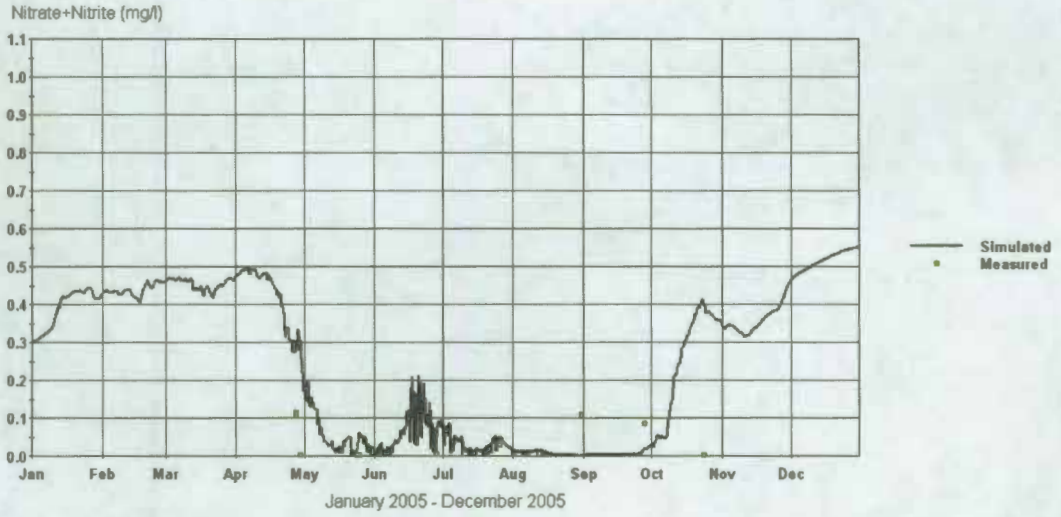

Figure 7-9 Simulated vs. Measured Nitrate+Nitrite at Station Weiss 1.

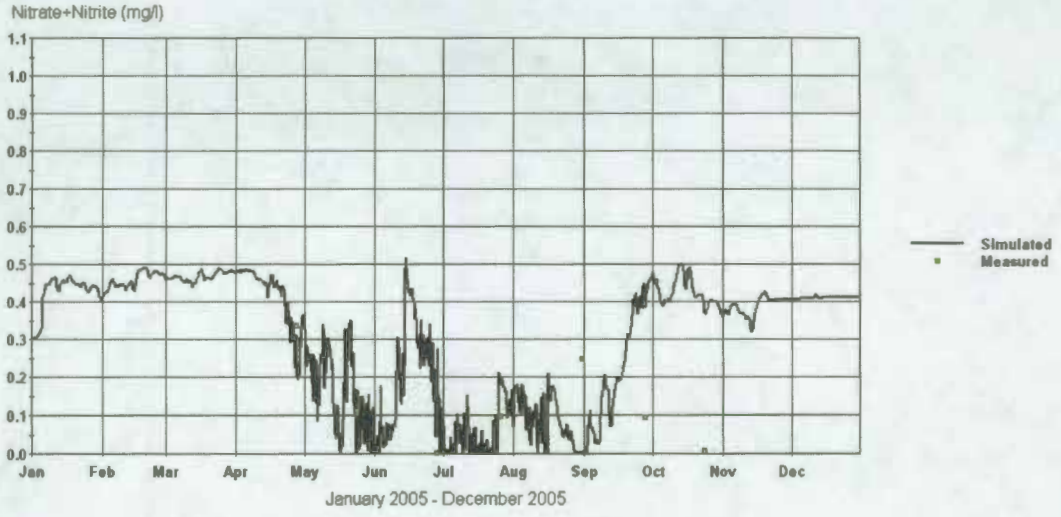

Figure 7-10 Simulated vs. Measured Nitrate+Nitrite at Station Weiss 2.

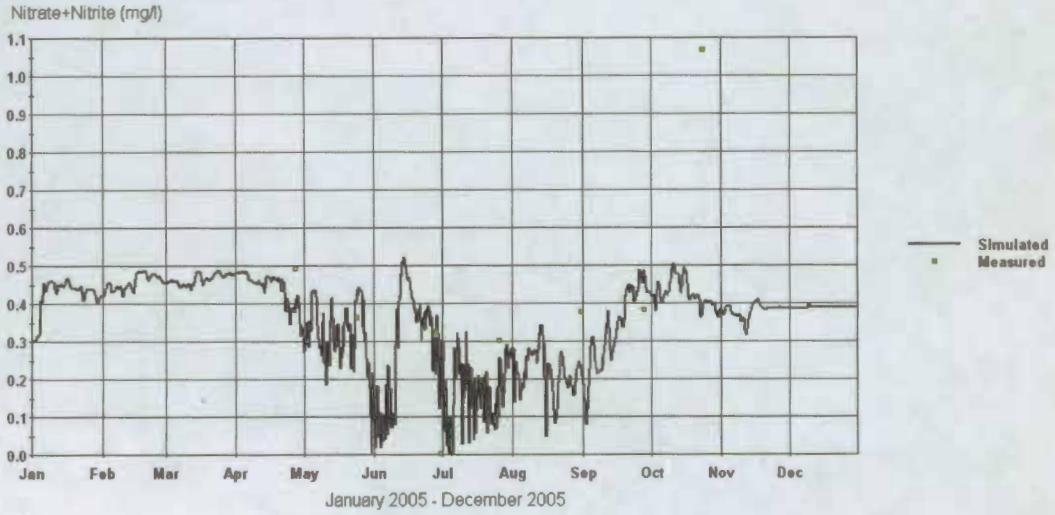

Figure 7-11 Simulated vs. Measured Nitrate+Nitrite at Station Weiss 3.

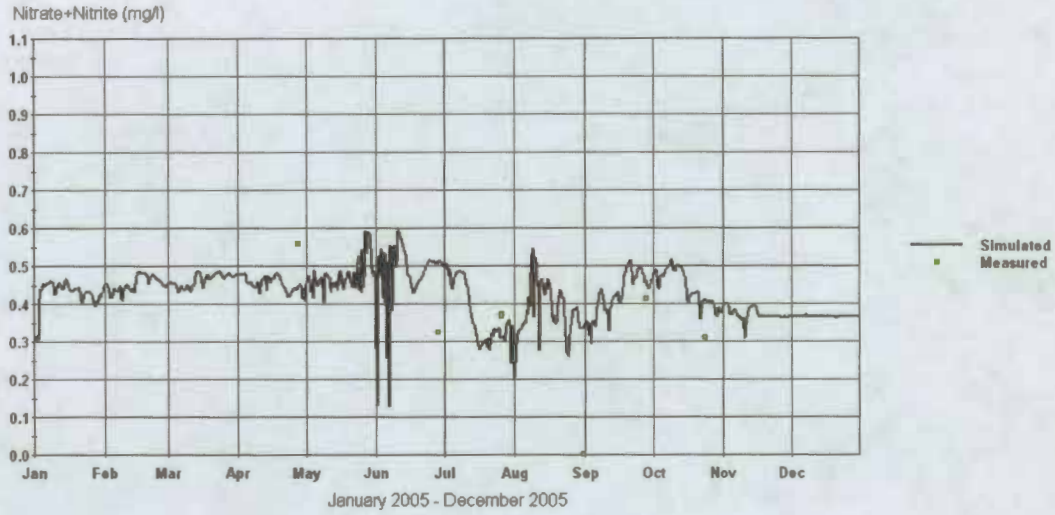

Figure 7-12 Simulated vs. Measured Nitrate+Nitrite at Station Weiss 4.

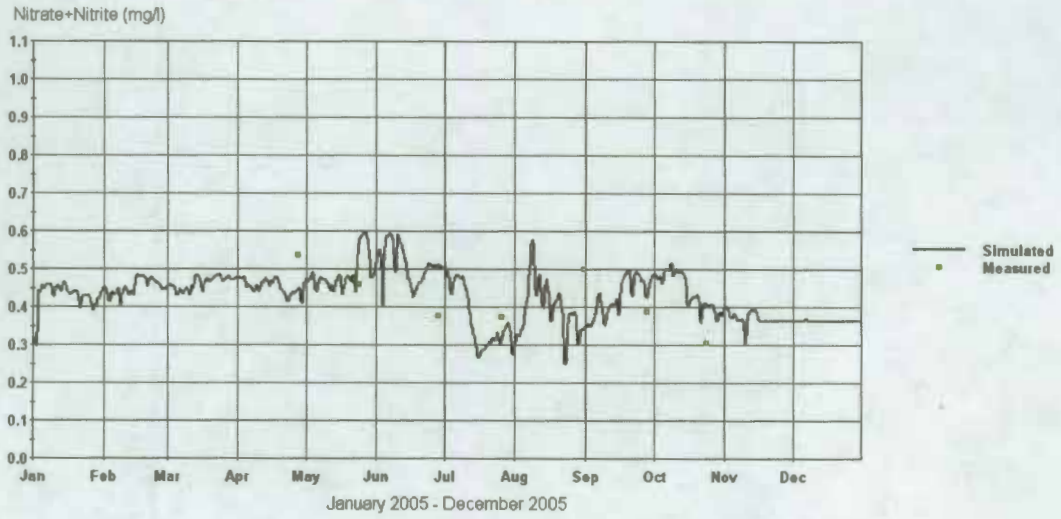

Figure 7-13 Simulated vs. Measured Nitrate+Nitrite at Station Weiss 12.

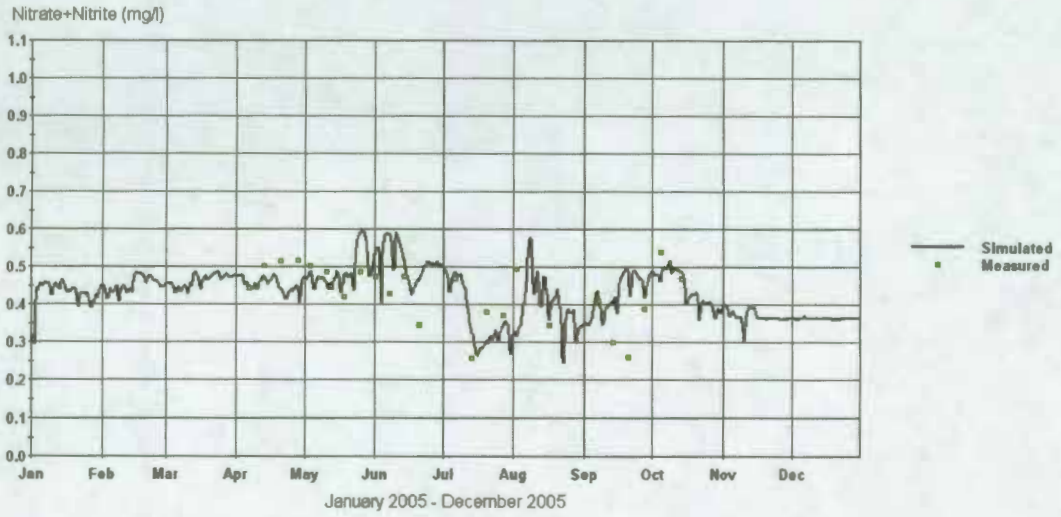

Figure 7-14 Simulated vs. Measured Nitrate+Nitrite at Coosa River at Georgia-Alabama border.

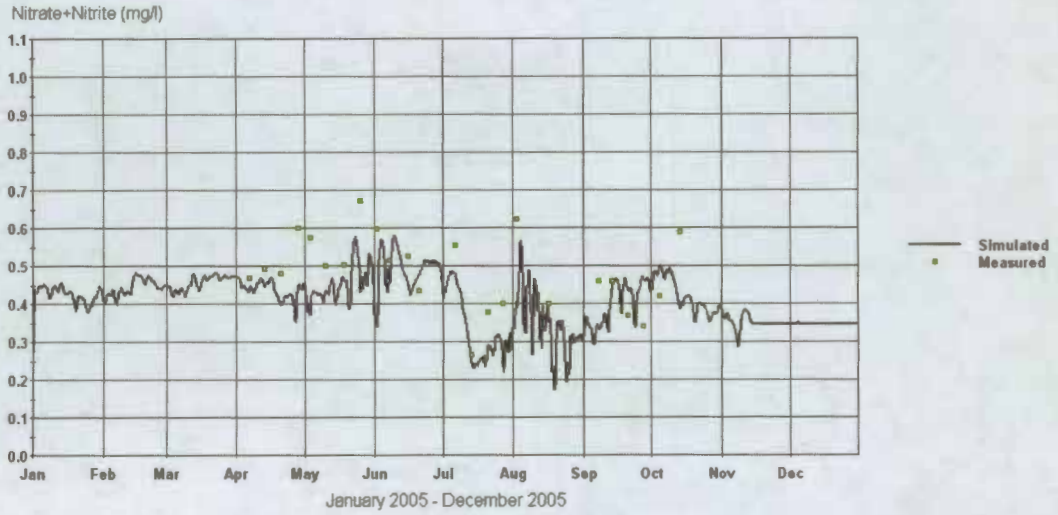

Figure 7-15 Simulated vs. Measured Nitrate+Nitrite at Coosa River at State Road 100.

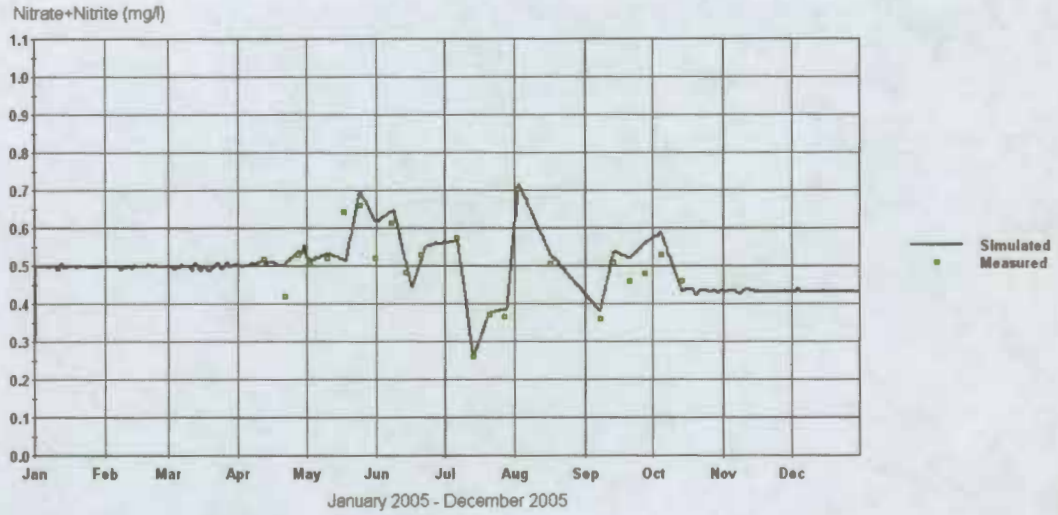

Figure 7-16 Simulated vs. Measured Nitrate+Nitrite at Coosa River at Blacks Bluff Road.

7.3 Total Phosphorus

Simulated total phosphorus values were compared to measured total phosphorus data collected by ADEM and GAEPD. Data were collected monthly at the ADEM stations during the growing season (April through October). Data were collected approximately weekly from April through October at the GAEPD stations. Sampling summary information for ADEM stations are presented in Table 7-7, and information for GAEPD stations are presented in Table 7-8. This includes the number of observations, minimum, and maximum.

Figures 7-17 through 7-21 present the total phosphorus comparisons at the ADEM stations. Figures 7-22 through 7-24 present the total phosphorus comparisons at the GAEPD stations.

Table 7-7 Weiss Lake Total Phosphorus Sampling Stations (ADEM)

Station	No. of Obs.	Mean (mg/l)	Min (mg/l)	Max (mg/l)	First Date	Last Date
WEISS1	56	0.067	0.010	0.160	5-May-92	24-Oct-05
WEISS2	54	0.087	0.026	0.170	5-May-92	24-Oct-05
WEISS3	53	0.141	0.004	1.614	6-May-93	24-Oct-05
WEISS4	52	0.102	0.041	0.200	6-May-93	24-Oct-05
WEISS12	22	0.104	0.044	0.293	23-April-02	24-Oct-05

Table 7-8 Weiss Lake Total Phosphorus Sampling Stations (GAEPD)

Station	No. of Obs.	Mean (mg/l)	Min (mg/l)	Max (mg/l)	First Date	Last Date
Stateline	24	0.106	0.040	0.316	4/6/2005	10/13/2005
SR 100	24	0.116	0.030	0.286	4/6/2005	10/13/2005
Blacks Bluff	24	0.127	0.030	0.330	4/6/2005	10/13/2005

Figure 7-17 Simulated vs. Measured Total Phosphorus at Station Weiss 1.

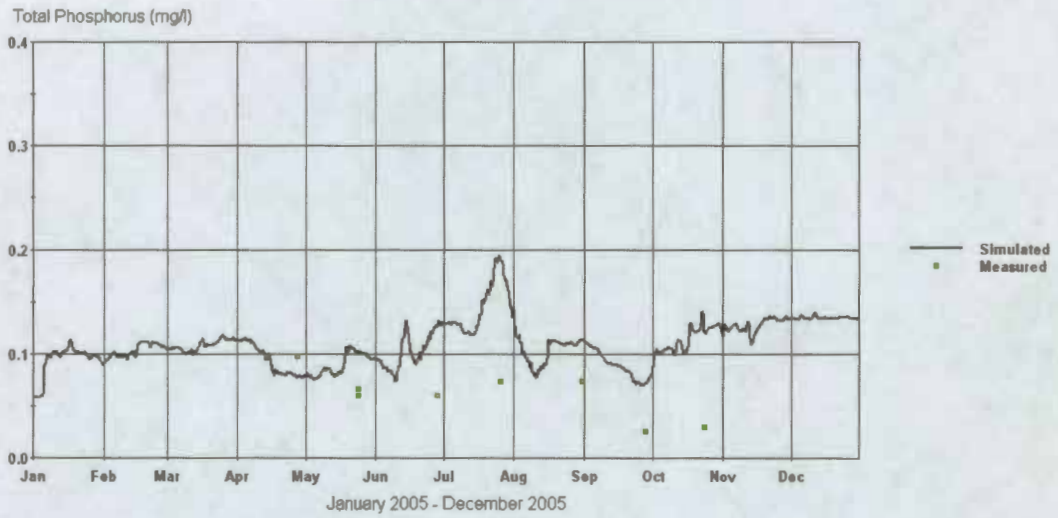

Figure 7-18 Simulated vs. Measured Total Phosphorus at Station Weiss 2.

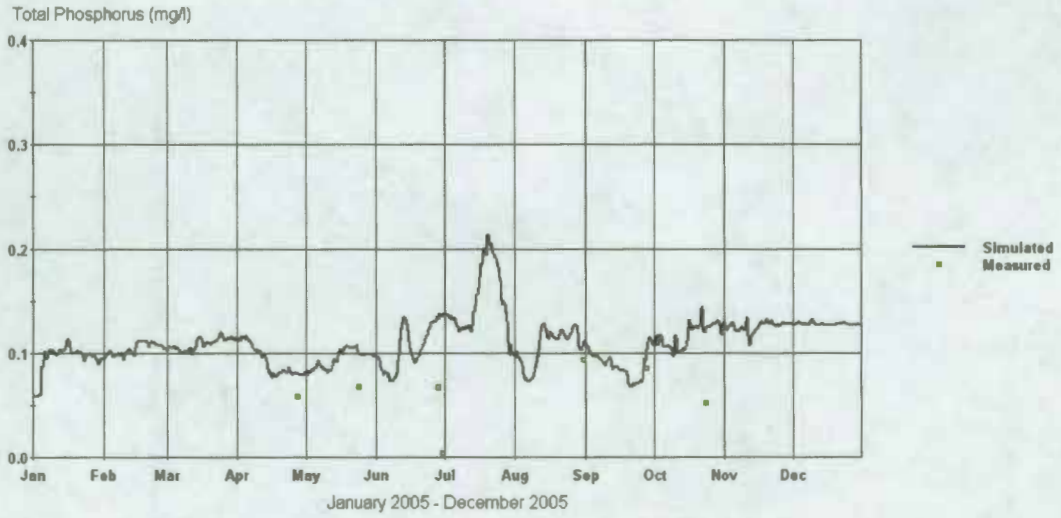

Figure 7-19 Simulated vs. Measured Total Phosphorus at Station Weiss 3.

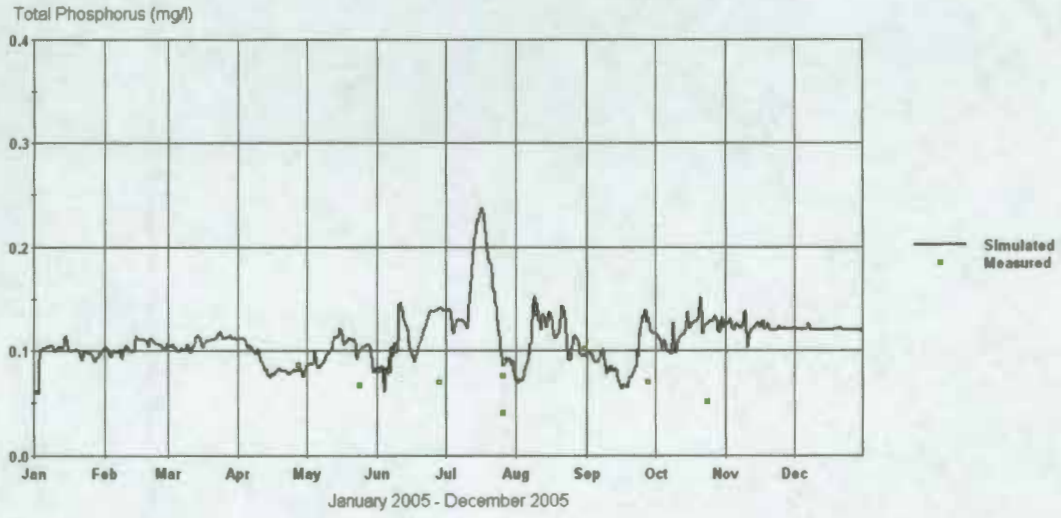

Figure 7-20 Simulated vs. Measured Total Phosphorus at Station Weiss 4.

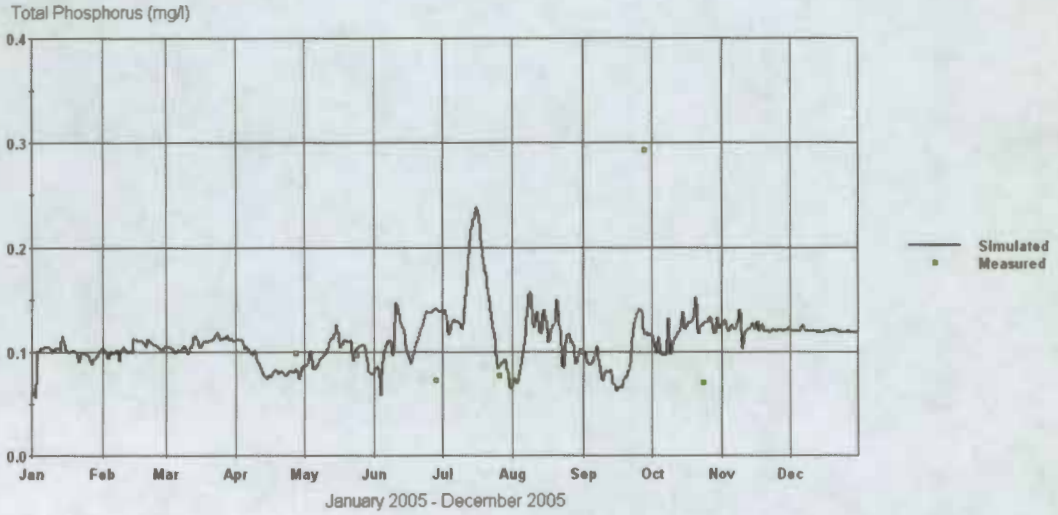

Figure 7-21 Simulated vs. Measured Total Phosphorus at Station Weiss 12.

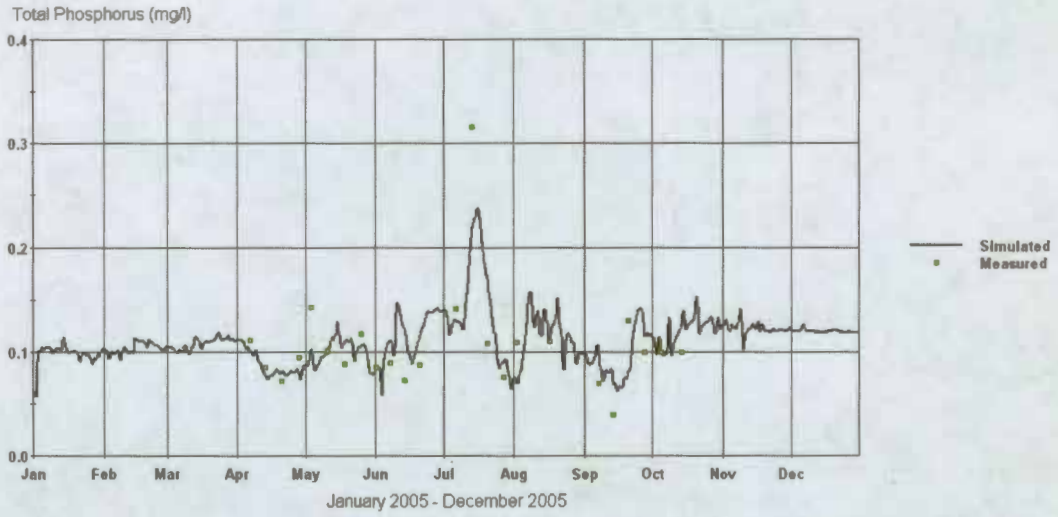

Figure 7-22 Simulated vs. Measured Total Phosphorus at Coosa River at Georgia-Alabama border.

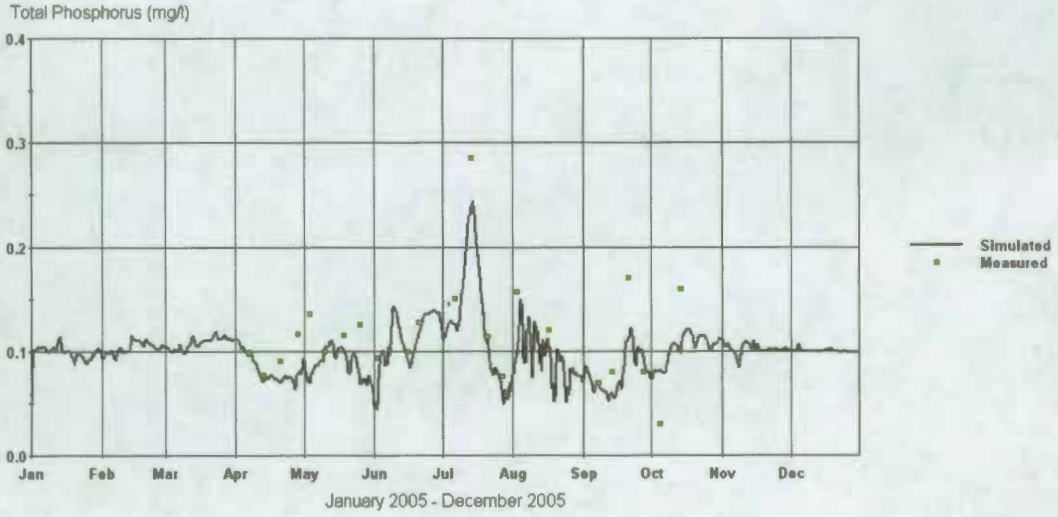

Figure 7-23 Simulated vs. Measured Total Phosphorus at Coosa River at State Road 100.

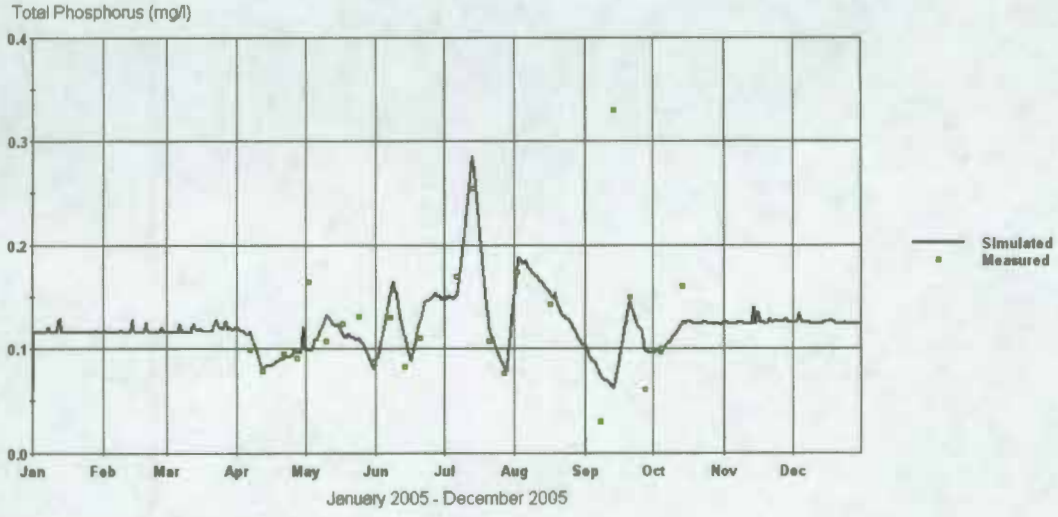

Figure 7-24 Simulated vs. Measured Total Phosphorus at Coosa River at Blacks Bluff Road.

7.4 CBOD

Simulated CBOD values were compared to measured BOD5 data collected approximately weekly from April through October by GAEPD. BOD5 was converted to CBODu using an f-Ratio of 5.0. Sampling summary information for GAEPD stations are presented in Table 7-9. This includes the number of observations, minimum, and maximum.

Figures 7-25 through 7-27 present the CBOD comparisons at the GAEPD stations.

Table 7-9 Weiss Lake BOD5 Sampling Stations (GAEPD)

Station	No. of Obs.	Mean (mg/l)	Min (mg/l)	Max (mg/l)	First Date	Last Date
Stateline	24	1.55	0.77	3.21	4/13/2005	10/13/2005
SR 100	24	1.32	0.63	3.13	4/13/2005	10/13/2005
Blacks Bluff	23	1.29	0.75	2.99	4/12/2005	10/13/2005

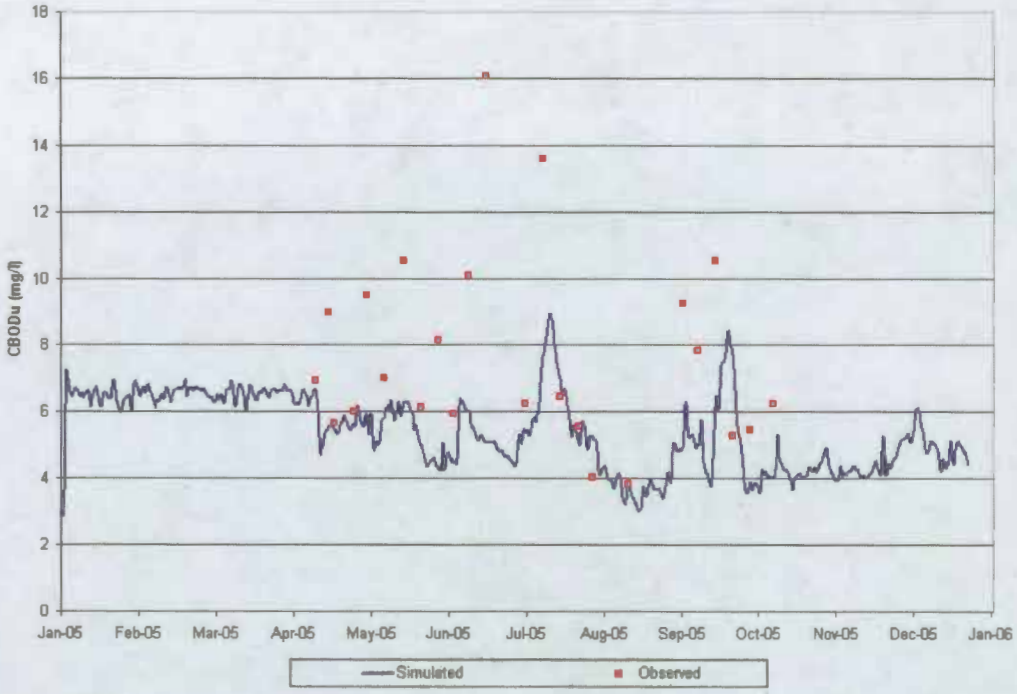

Figure 7-25 Simulated vs. Measured CBODu at Coosa River at Georgia-Alabama border.

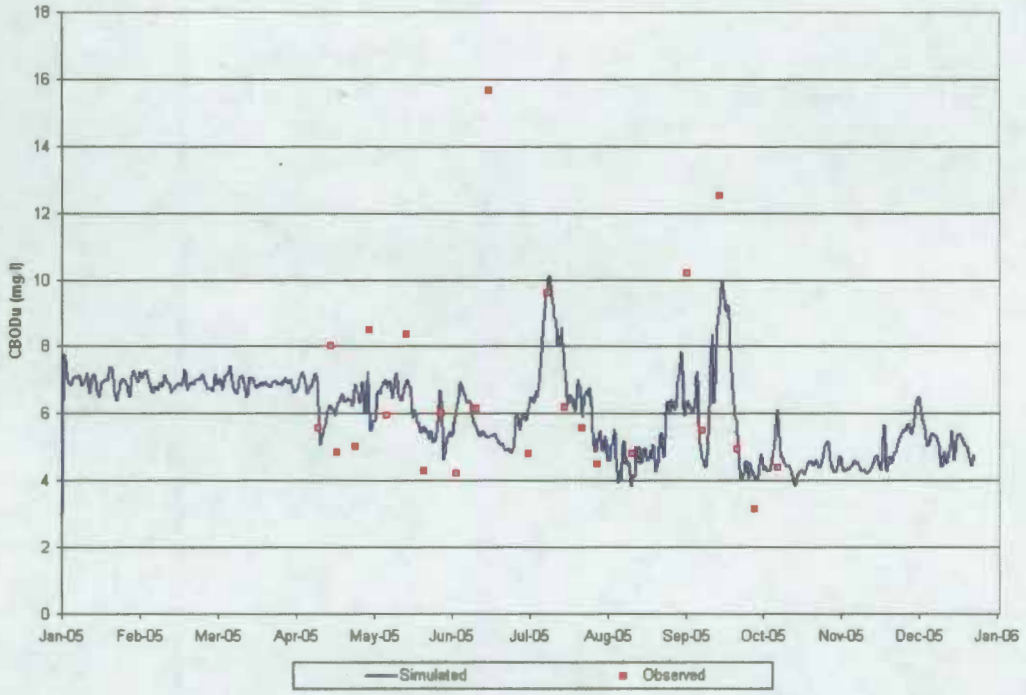

Figure 7-26 Simulated vs. Measured CBODu at Coosa River at State Road 100.

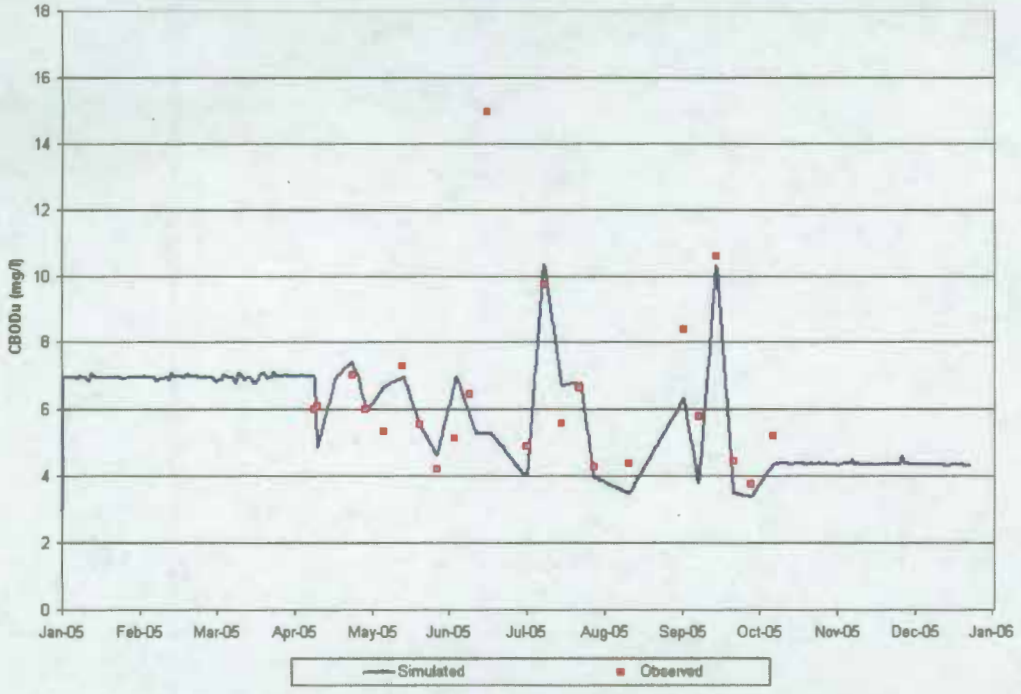

Figure 7-27 Simulated vs. Measured CBODu at Coosa River at Blacks Bluff Road.

7.5 Light Extinction

Simulated light extinction coefficient values were compared to light extinction coefficient values calculated from secchi depth and photic zone measurements. The following equation was used to calculate the light extinction coefficient from measured data:

$$K_e\ (1/m) = -\ln(I/Io) / \text{Secchi Depth (m)}$$

Where: Ke = light extinction coefficient and I/Io = fraction of light in the water column remaining at the secchi depth. It was assumed that at the secchi depth, 90% of the light was attenuated and that only 10% (0.1) remained. Therefore, the above equation becomes:

$$K_e\ (1/m) = -\ln(0.1) / \text{Secchi Depth (m)} = 2.3 / \text{Secchi Depth (m)}$$

Tables 7-10 and 7-11 present statistics for the calculated light extinction values from both ADEM and GAEPD stations for year 2005 data. Data were collected monthly at the ADEM stations during the growing season (April through October). Data were collected approximately weekly from April through October at the GAEPD stations. Figures 7-28 through 7-32 present the light extinction comparisons at the ADEM stations. Figures 7-33 through 7-38 present the light extinction comparisons at the GAEPD stations.

Table 7-10 Light Extinction Coefficient for 2005 Weiss Lake Sampling Stations (ADEM)

Station	No. of Obs.	Mean (1/m)	Min (1/m)	Max (1/m)
WEISS1	7	2.672	1.885	3.651
WEISS2	6	3.774	3.151	5.111
WEISS3	7	3.427	2.805	4.340
WEISS4	7	3.067	2.584	3.594
WEISS12	8	3.013	2.150	3.770

Table 7-11 Light Extinction Coefficient for 2005 Weiss Lake Sampling Stations (GAEPD)

Station	No. of Obs.	Mean (1/m)	Min (1/m)	Max (1/m)
Stateline	26	3.163	1.643	4.600
RM 262	27	3.485	1.278	14.375
RM 267	27	4.026	1.278	19.167
SR 100	27	4.036	0.085	14.375
Beech Creek	27	4.325	1.150	23.000
Blacks Bluff	27	4.806	1.643	25.556

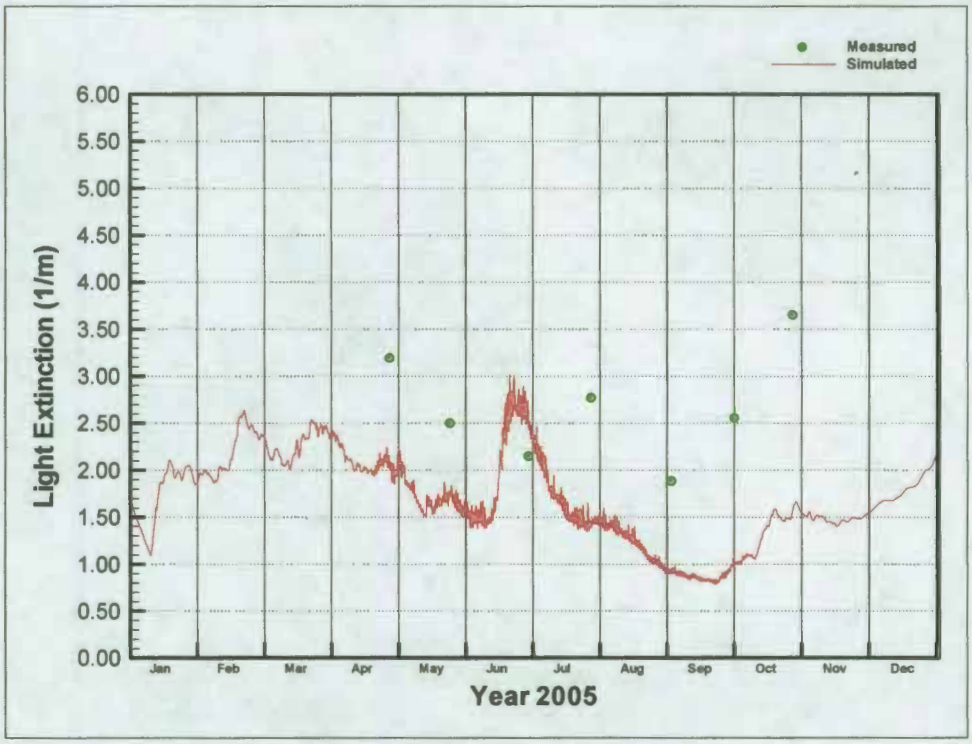

Figure 7-28 Light Extinction Comparison at Station Weiss 1.

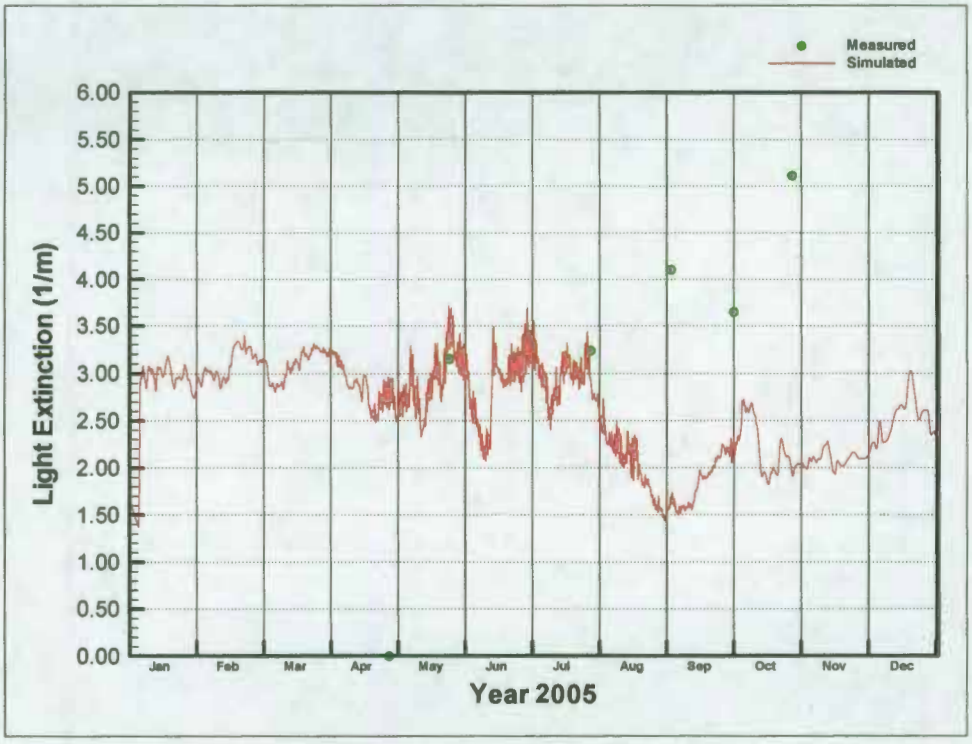

Figure 7-29 Light Extinction Comparison at Station Weiss 2.

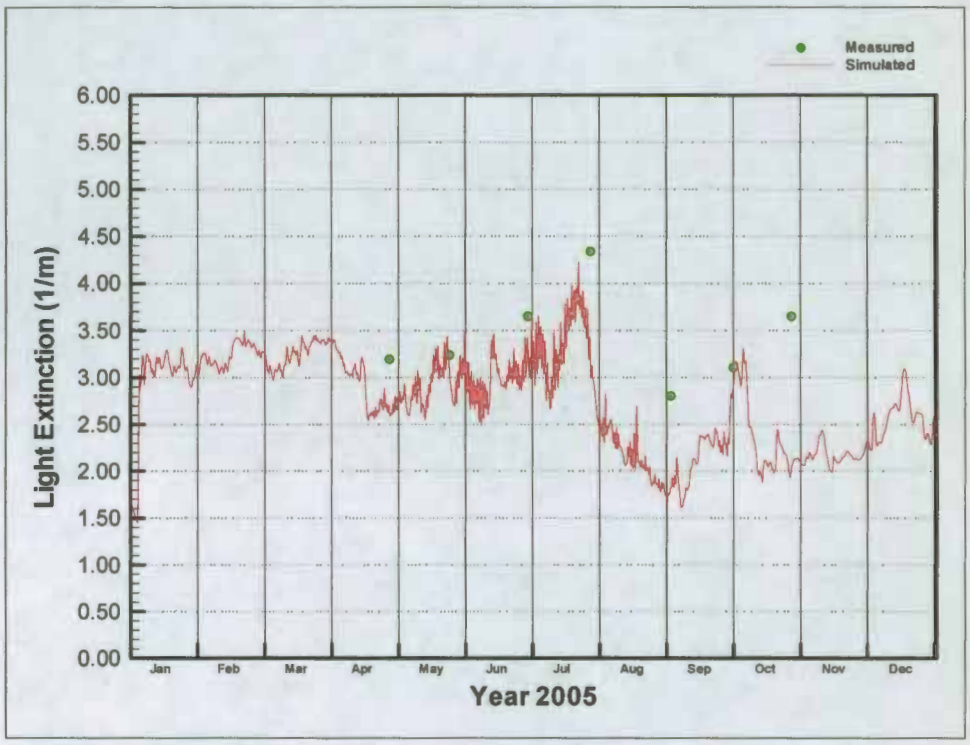

Figure 7-30 Light Extinction Comparison at Station Weiss 3.

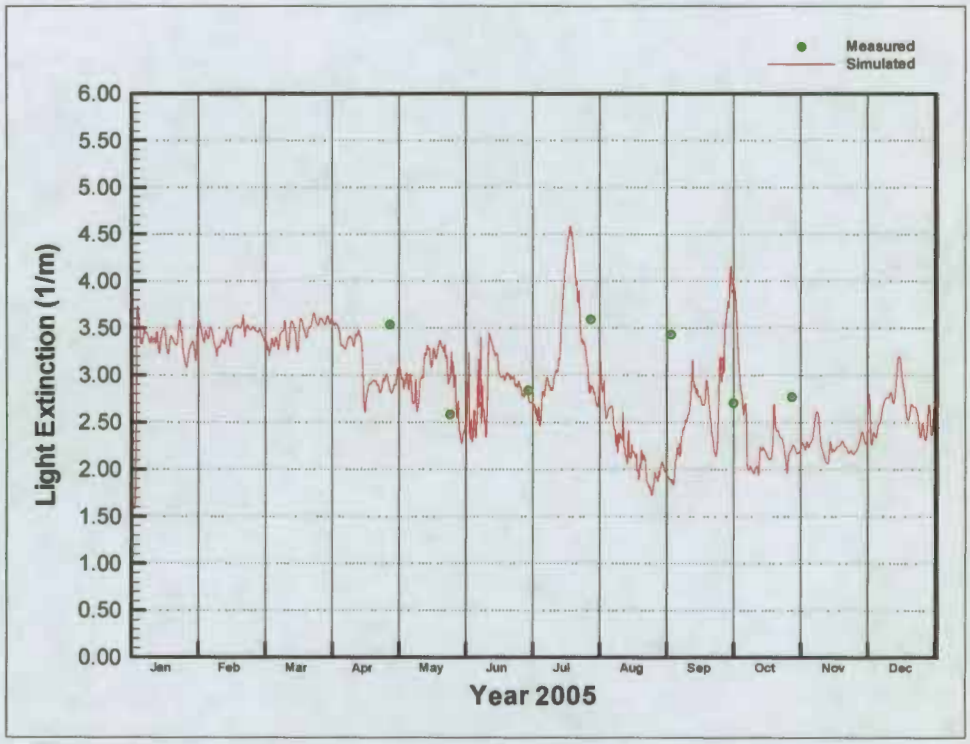

Figure 7-31 Light Extinction Comparison at Station Weiss 4.

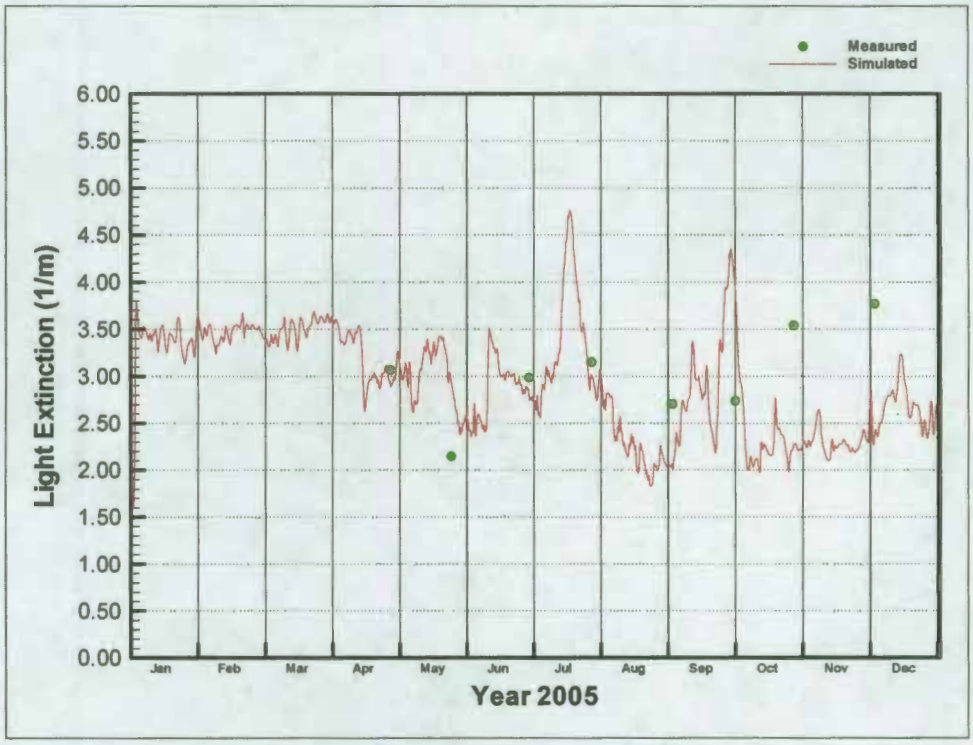

Figure 7-32 Light Extinction Comparison at Station Weiss 12.

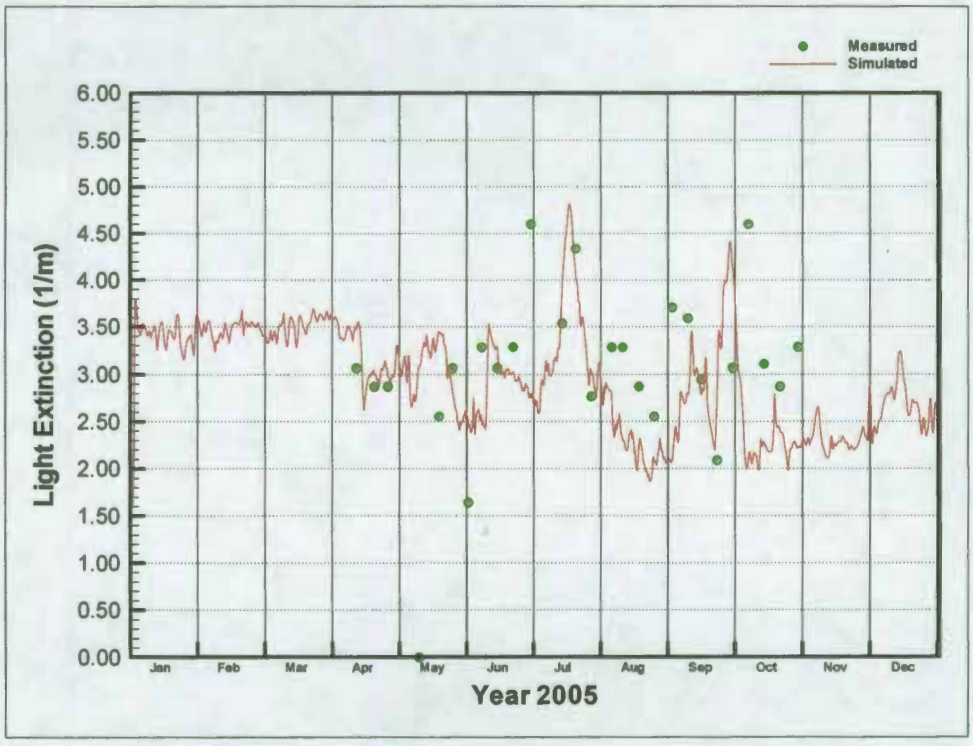

Figure 7-33 Light Extinction Comparison at Coosa River at Georgia-Alabama border.

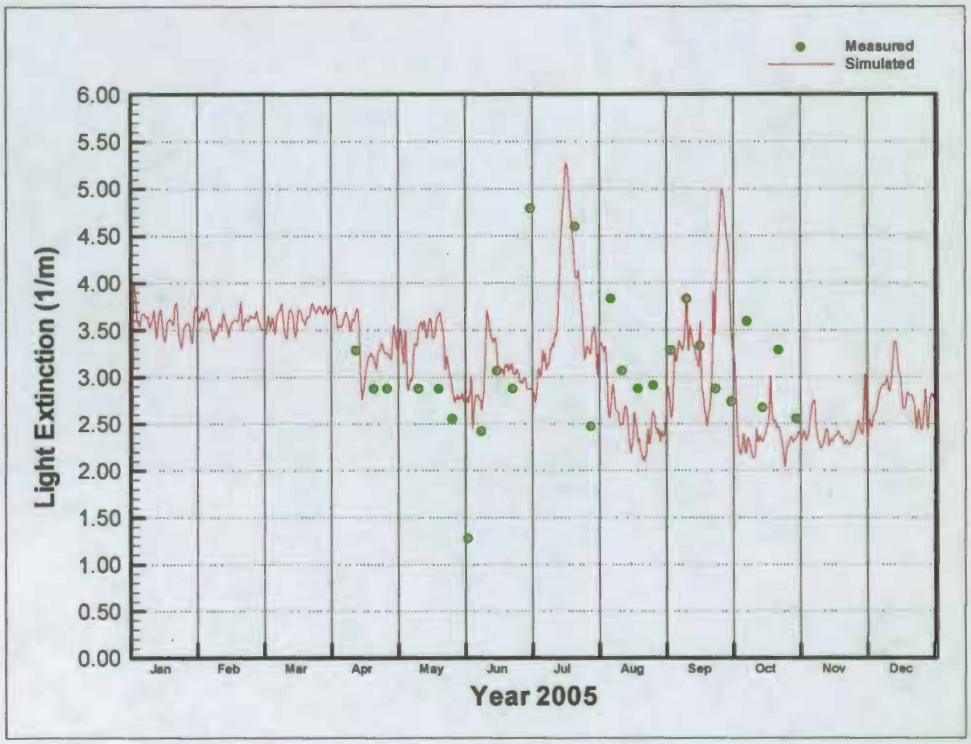

Figure 7-34 Light Extinction Comparison at Coosa River at River Mile 262 for the year 2005.

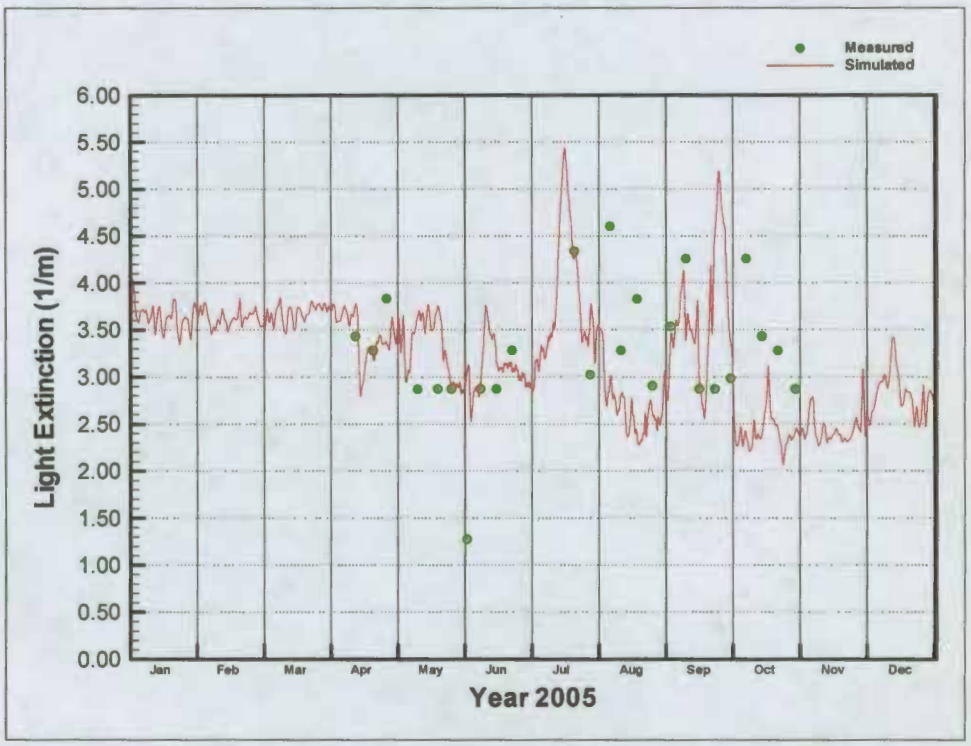

Figure 7-35 Light Extinction Comparison at Coosa River at River Mile 267 for the year 2005.

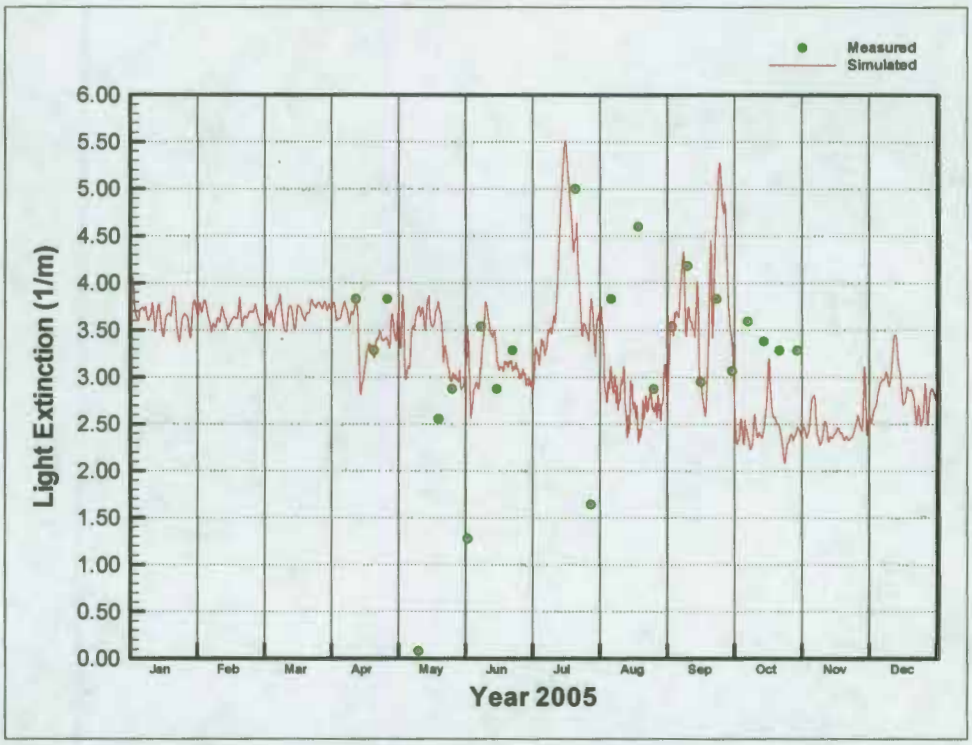

Figure 7-36 Light Extinction Comparison at Coosa River at State Road 100 for the year 2005.

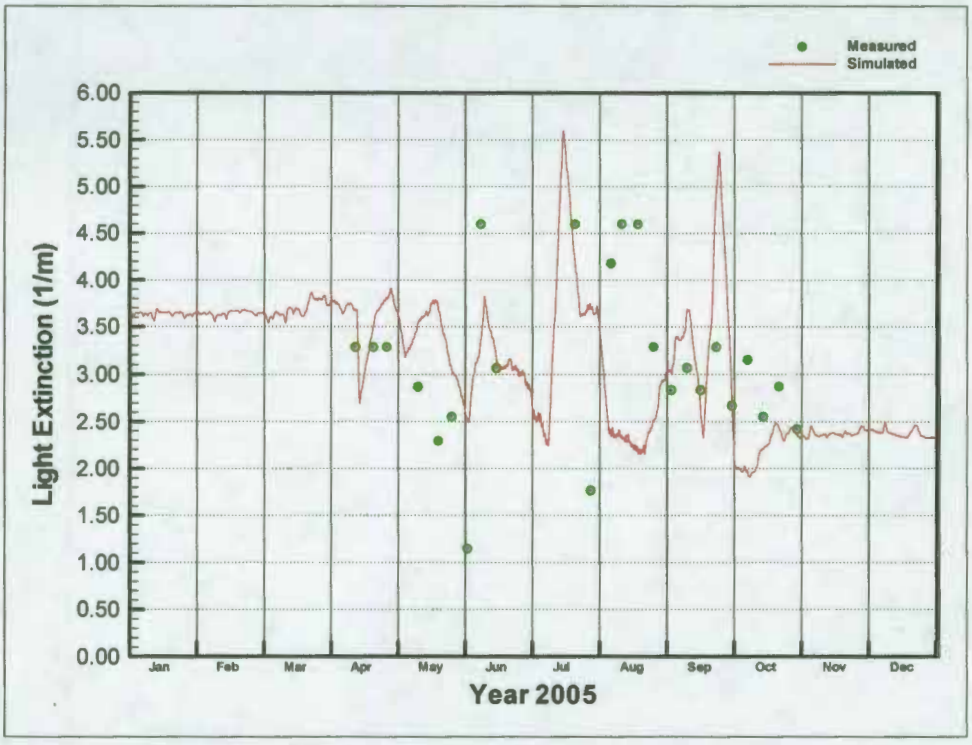

Figure 7-37 Light Extinction Comparison at Coosa River at Beech Creek for the year 2005.

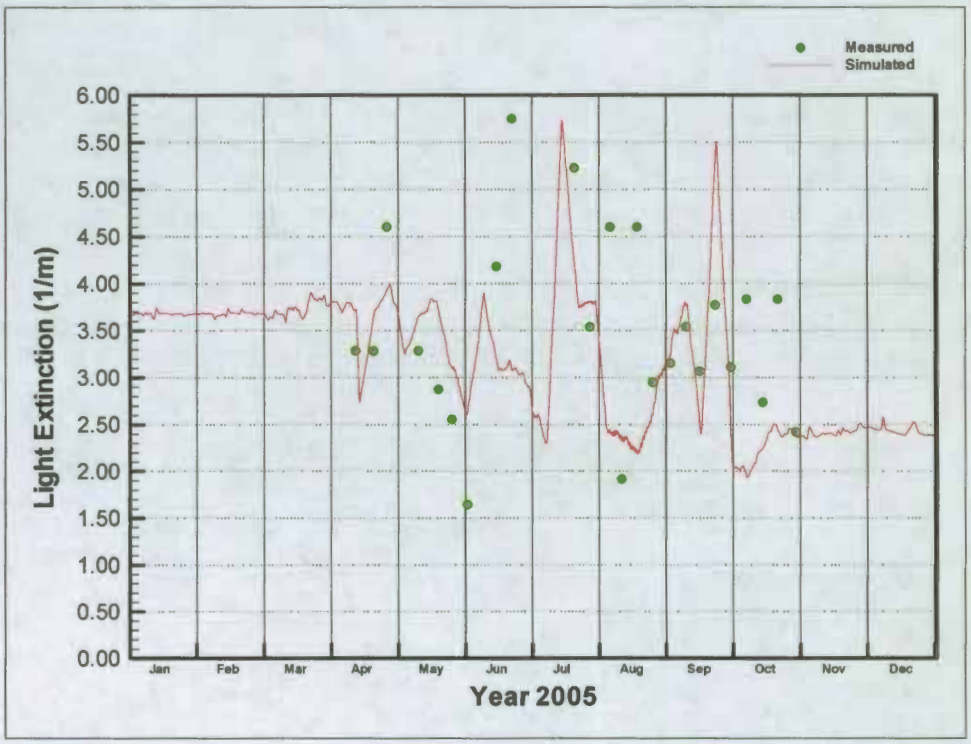

Figure 7-38 Light Extinction Comparison at Coosa River at Blacks Bluff Rd for the year 2005.

7.6 Chlorophyll-a

Simulated chlorophyll-a were compared to measured chlorophyll-a data collected by ADEM and the USGS. Data were collected monthly at the ADEM stations during the growing season (April through October). Data were collected hourly at the USGS Station from April 4 through December 31, 2005. Sampling summary information for ADEM stations are presented in Table 7-12, and information for the USGS station is presented in Table 7-13. This includes the number of observations, minimum, and maximum.

Figures 7-39 through 7-43 present the chlorophyll-a comparisons at the ADEM stations. Figure 7-44 presents the chlorophyll-a comparison at the USGS station. Figure 7-45 presents the simulated chlorophyll-a at the Georgia-Alabama border against the USGS station (02397530) and Weiss 12.

Table 7-12 Weiss Lake Chlorophyll-a Sampling Stations (ADEM)

Station	No. of Obs.	Mean (ug/l)	Min (ug/l)	Max (ug/l)	First Date	Last Date
WEISS0	11	13.66	0.100	28.30	25-April-01	25-Oct-05
WEISS1	10	17.06	0.10	34.71	27-April-05	24-Oct-05
WEISS1A	46	25.42	6.41	55.00	5-May-92	18-Aug-04
WEISS2	54	28.74	6.41	51.40	5-May-92	24-Oct-05
WEISS3	53	12.77	0.10	31.33	6-May-93	24-Oct-05
WEISS4	52	11.90	1.10	28.80	6-May-93	24-Oct-05
WEISS5	12	19.66	4.54	59.27	18-April-00	25-Oct-05
WEISS6	11	33.33	5.34	47.53	18-April-00	25-Oct-05
WEISS7	10	33.22	2.14	65.15	18-April-00	25-Oct-05
WEISS8	10	26.84	3.20	39.00	18-April-00	25-Oct-05
WEISS9	10	25.27	2.67	45.92	18-April-00	25-Oct-05
WEISS12	22	11.33	0.50	25.56	23-April-02	24-Oct-05

Table 7-13 Weiss Lake Chlorophyll-a Sampling Stations (USGS)

Station	No. of Obs.	Mean (ug/l)	Min (ug/l)	Max (ug/l)	First Date	Last Date
02397530	6517	5.94	0.15	62.2	4/4/2005	12/31/2005

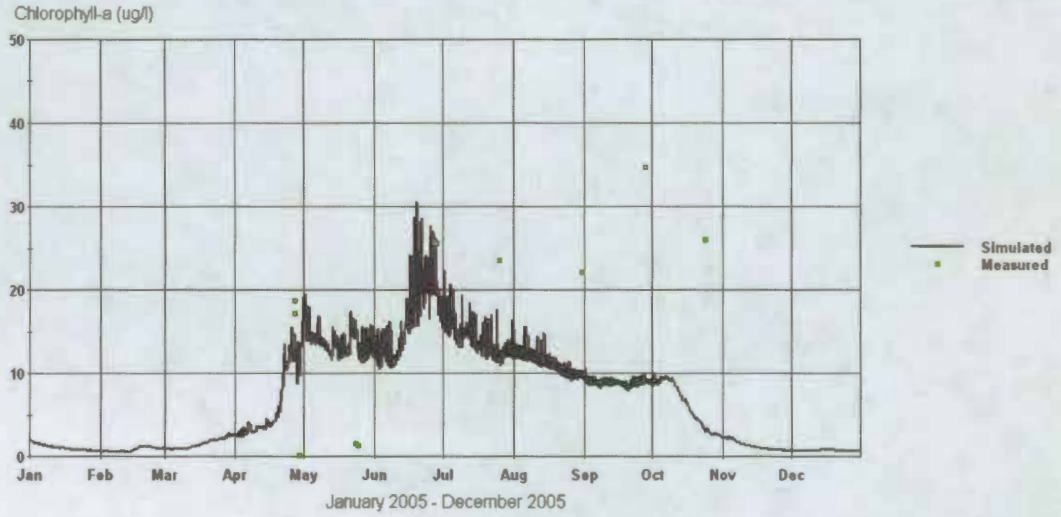

Figure 7-39 Simulated vs. Measured Chlorophyll-a at Station Weiss 1.

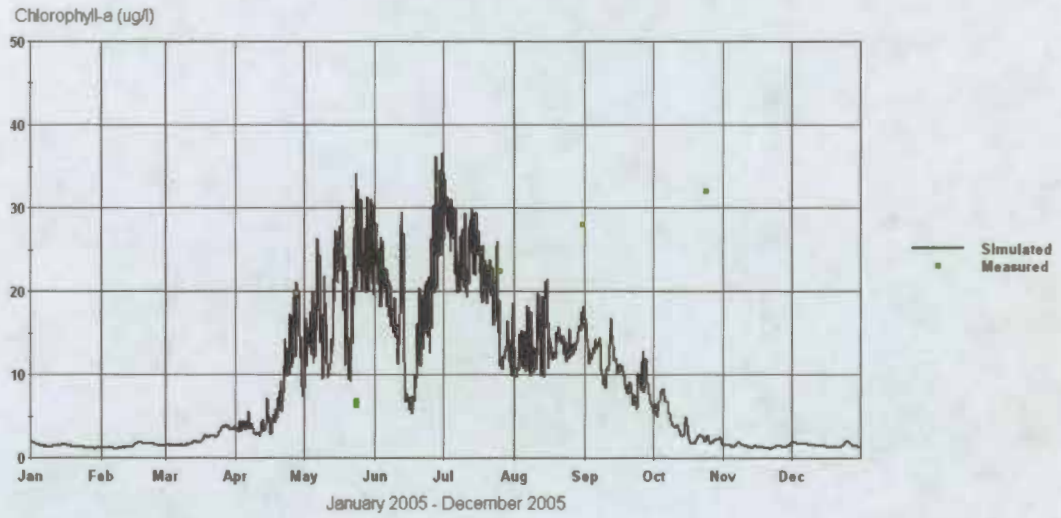

Figure 7-40 Simulated vs. Measured Chlorophyll-a at Station Weiss 2.

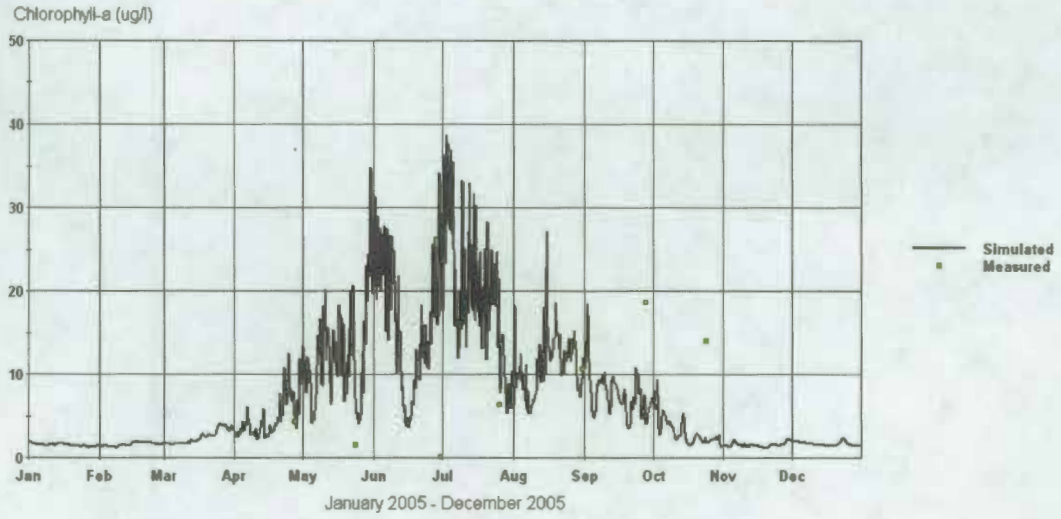

Figure 7-41 Simulated vs. Measured Chlorophyll-a at Station Weiss 3.

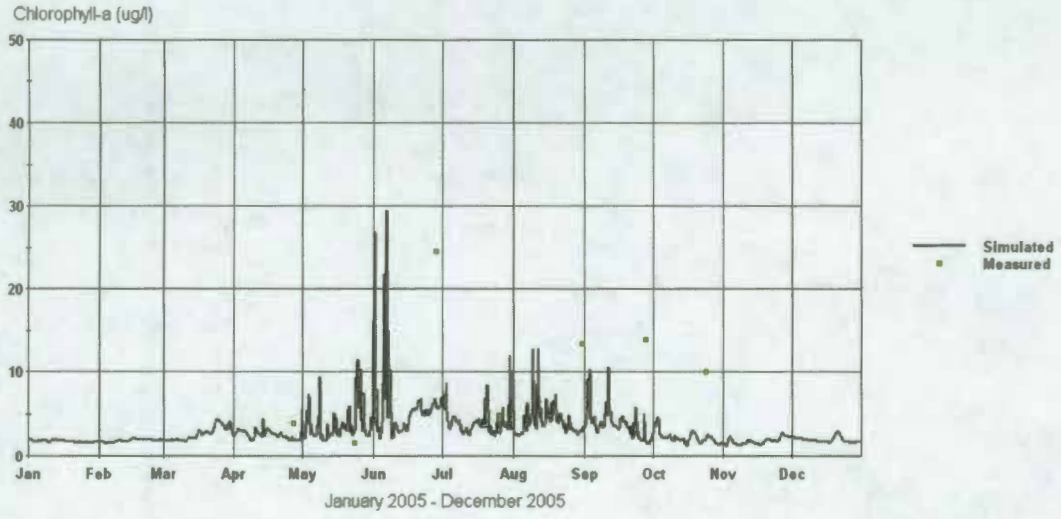

Figure 7-42 Simulated vs. Measured Chlorophyll-a at Station Weiss 4.

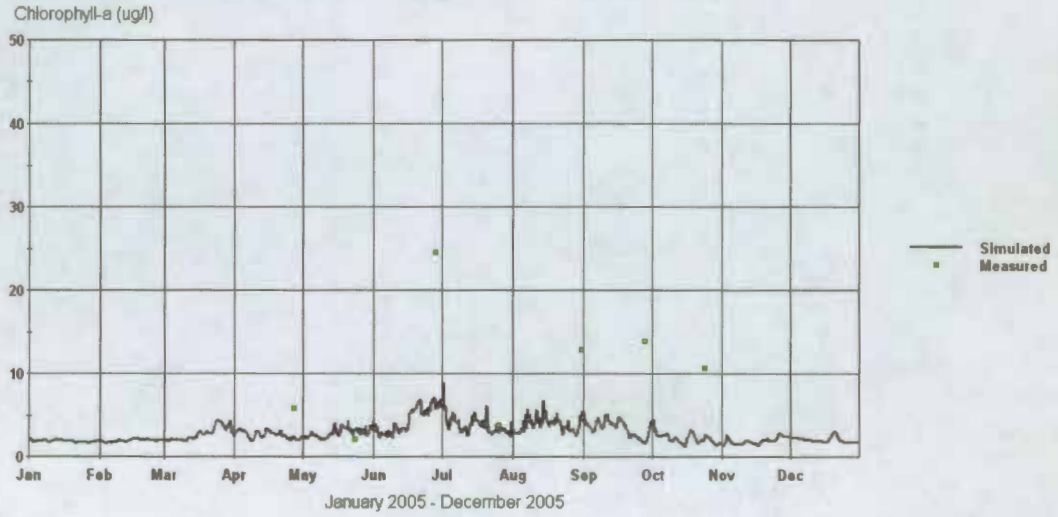

Figure 7-43 Simulated vs. Measured Chlorophyll-a at Station Weiss 12.

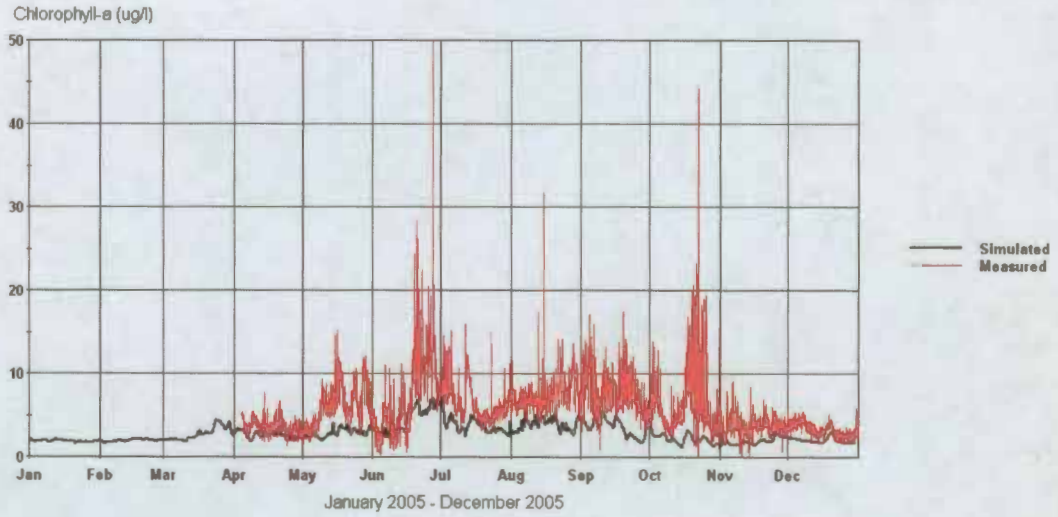

Figure 7-44 Simulated vs. Measured Chlorophyll-a at USGS Station 02397530.

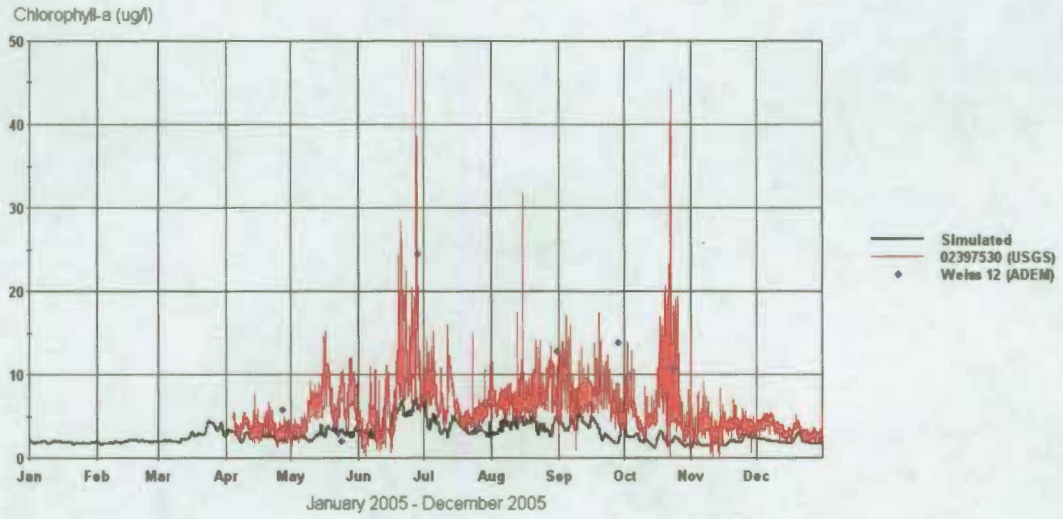

Figure 7-45 Simulated vs. Measured Chlorophyll-a at USGS Station 02397530 and ADEM Station Weiss 12.

7.7 Dissolved Oxygen

Simulated dissolved oxygen values were compared to measured dissolved oxygen profile data collected by ADEM and GAEPD. Data were collected monthly at the ADEM stations during the growing season (April through October). Data were collected approximately weekly from April through October at the GAEPD stations. Sampling summary information for ADEM stations are presented in Table 7-14, and information for GAEPD stations are presented in Table 7-15. This includes the number of observations, minimum, and maximum.

Table 7-14 Weiss Lake Dissolved Oxygen Sampling Stations (ADEM)

Station	Unique Sampling Dates	No. of Obs.	Mean (mg/l)	Min (mg/l)	Max (mg/l)	First Date	Last Date
WEISS0	7	34	6.84	4.93	9.87	25-Apr-01	30-Oct-01
WEISS1	7	100	7.01	0.80	9.63	27-Apr-05	24-Oct-05
WEISS1A	53	701	5.96	0.14	11.09	5-May-92	24-Oct-05
WEISS2	53	705	6.48	0.01	11.70	5-May-92	24-Oct-05
WEISS3	51	565	6.80	0.00	11.23	6-May-93	24-Oct-05
WEISS4	51	607	6.80	1.04	10.52	6-May-93	24-Oct-05
WEISS5	9	91	6.64	0.23	9.42	18-Apr-00	25-Oct-05
WEISS6	9	82	6.80	0.10	13.00	18-Apr-00	25-Oct-05
WEISS7	9	74	7.05	0.12	11.91	18-Apr-00	25-Oct-05
WEISS8	9	108	5.69	0.03	10.84	18-Apr-00	25-Oct-05
WEISS9	9	76	7.15	0.17	10.33	18-Apr-00	25-Oct-05
WEISS12	25	366	7.24	0.15	10.83	23-Apr-02	1-Mar-06

Table 7-15 Weiss Lake Dissolved Oxygen Sampling Stations (GAEPD)

Station	Unique Sampling Dates	No. of Obs.	Mean (mg/l)	Min (mg/l)	Max (mg/l)	First Date	Last Date
Stateline[A,1]	24	291	7.31	4.65	10.39	12-Apr-05	26-Oct-05
RM 262[B,1]	25	253	7.10	4.73	9.14	12-Apr-05	26-Oct-05
RM 267[B,1]	25	238	7.24	4.96	10.28	12-Apr-05	26-Oct-05
SR 100[B,1]	25	229	7.24	4.93	9.74	12-Apr-05	26-Oct-05
Beech Creek[B,1]	25	221	7.38	5.04	9.66	12-Apr-05	26-Oct-05
Blacks Bluff[B,1]	25	202	7.45	4.95	9.64	12-Apr-05	26-Oct-05

[A] Statistics include data collected at 25%, 50%, 75% and 95% of the cross section.
[B] Statistics include data collected at 50% of the cross section.
[1] Does not include data from 5/19/2005 or 5/25/2005.

7.7.1 Time Series

Figures 7-46 through 7-48 present the dissolved oxygen time series comparisons at the GAEPD stations.

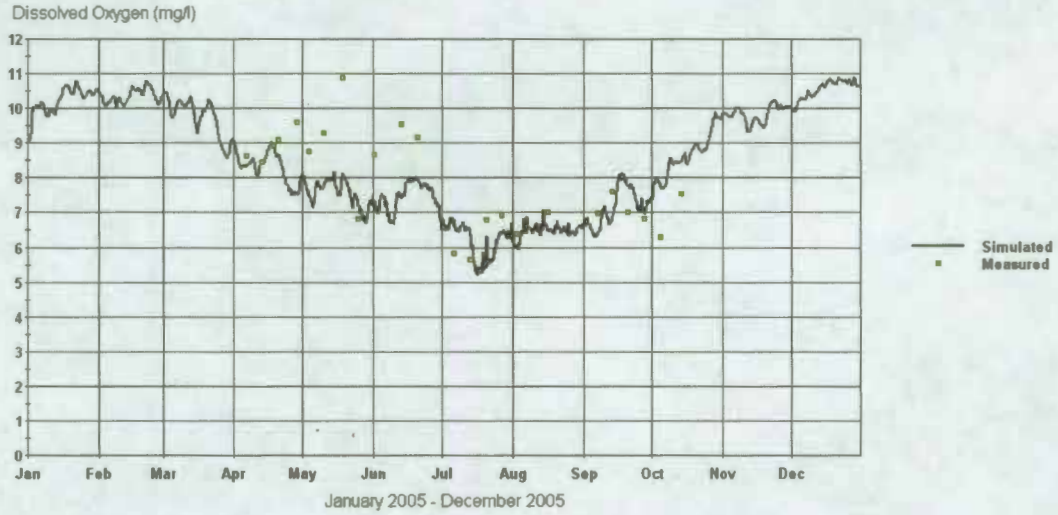

Figure 7-46 Simulated vs. Measured Dissolved Oxygen at Coosa River at Georgia-Alabama border (5COO-530).

Figure 7-47 Simulated vs. Measured Dissolved Oxygen at Coosa River at State Road 100 (5COO-410).

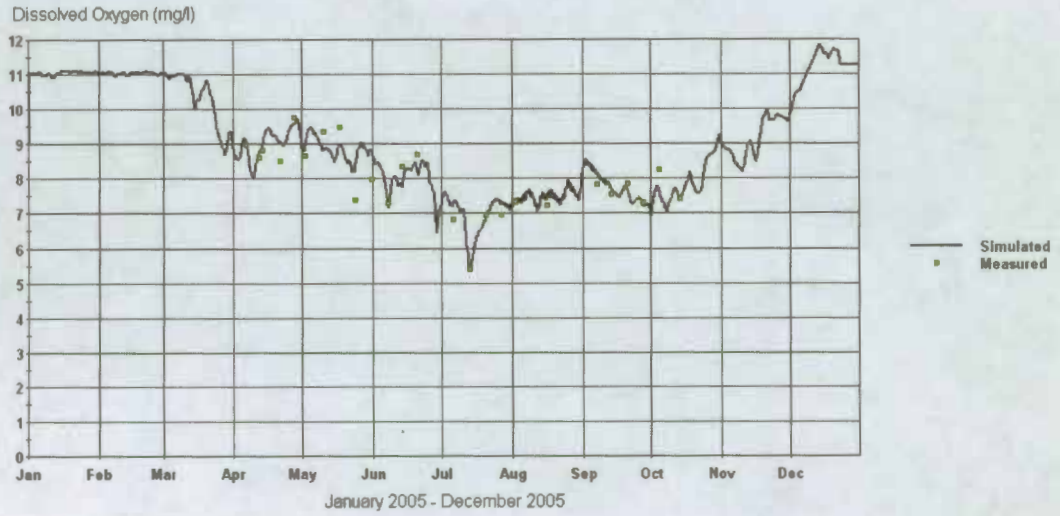

Figure 7-48 Simulated vs. Measured Dissolved Oxygen at Coosa River at Blacks Bluff (5COO-340).

7.7.2 Vertical Profiles

Figures 7-49 through 7-53 present the dissolved oxygen profile comparisons at the ADEM stations. Figures 7-54 through 7-59 present the dissolved oxygen profile comparisons at the GAEPD stations.

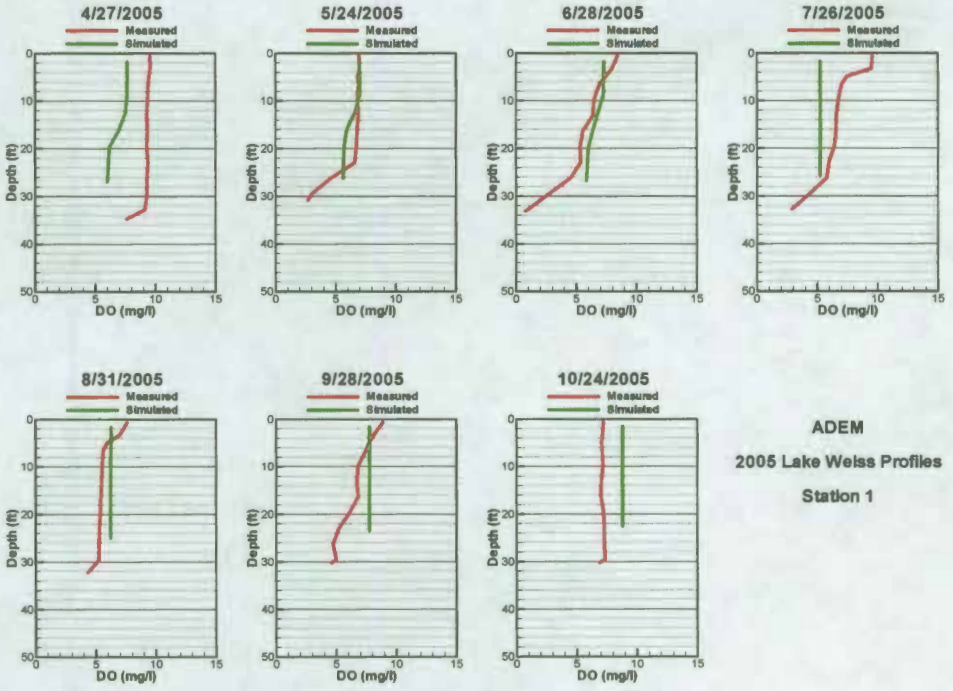

Figure 7-49 Dissolved Oxygen Profile Comparisons at Station Weiss 1.

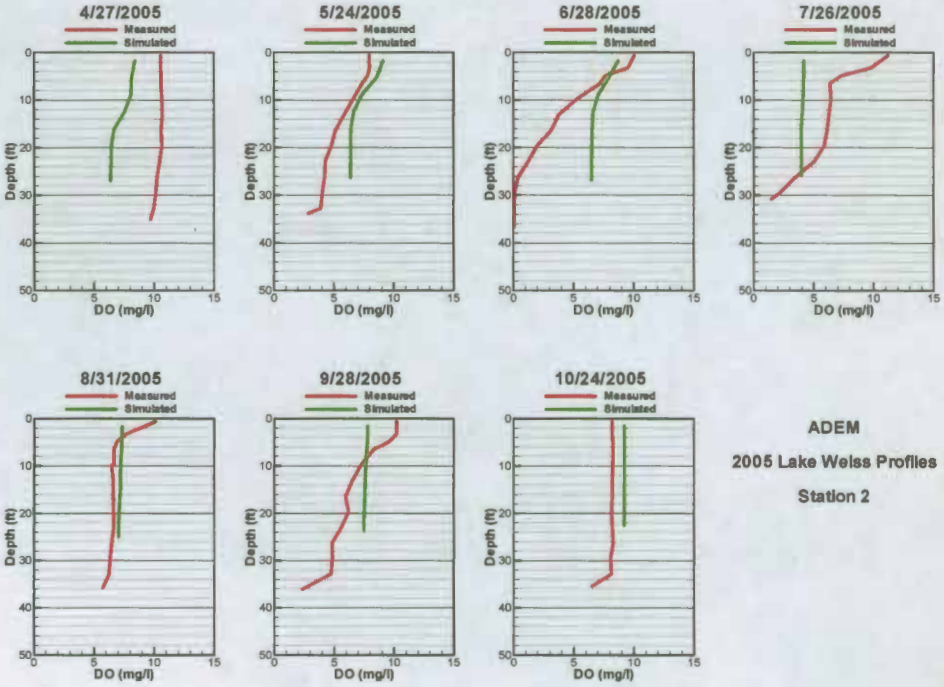

Figure 7-50 Dissolved Oxygen Profile Comparisons at Station Weiss 2.

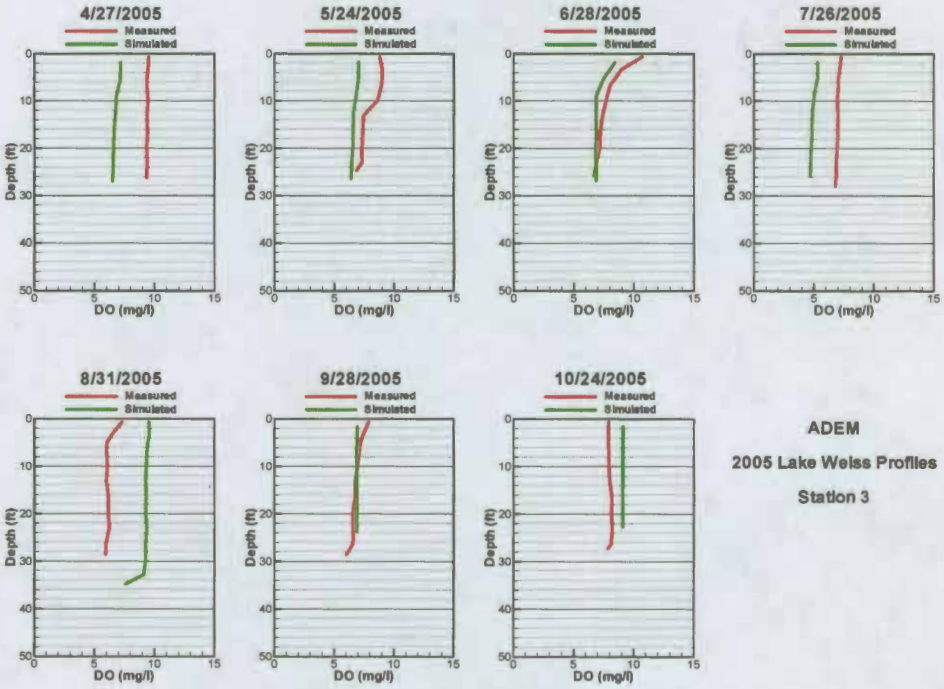

Figure 7-51 Dissolved Oxygen Profile Comparisons at Station Weiss 3.

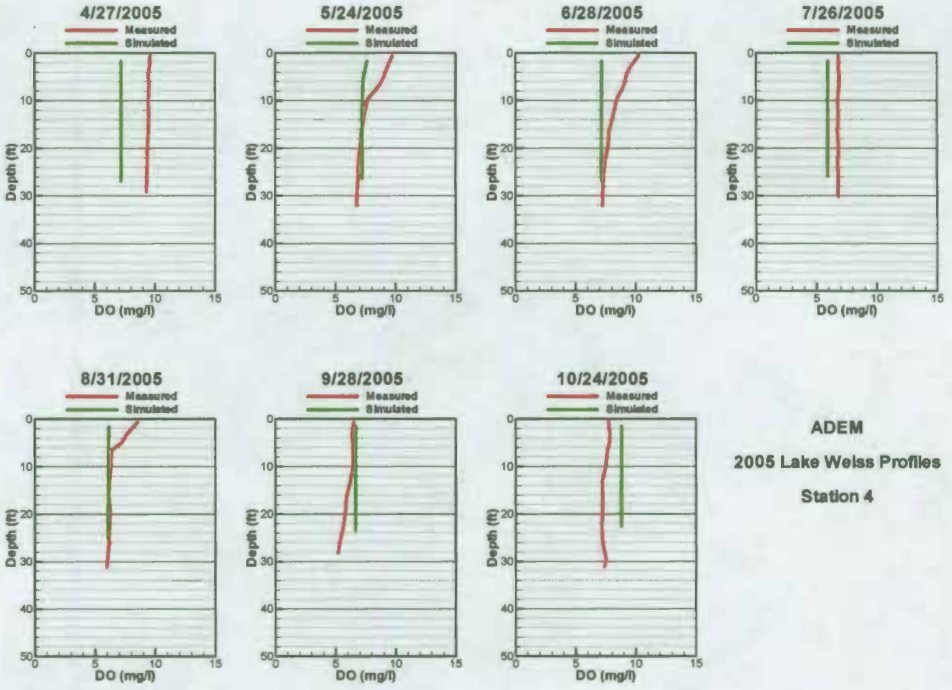

Figure 7-52 Dissolved Oxygen Profile Comparisons at Station Weiss 4.

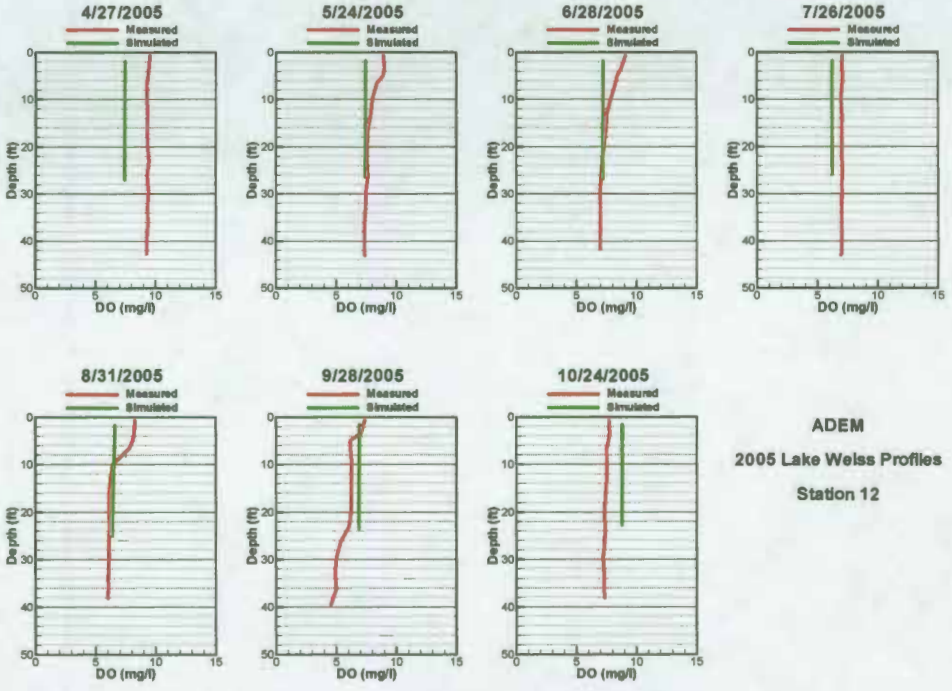

Figure 7-53 Dissolved Oxygen Profile Comparisons at Station Weiss 12.

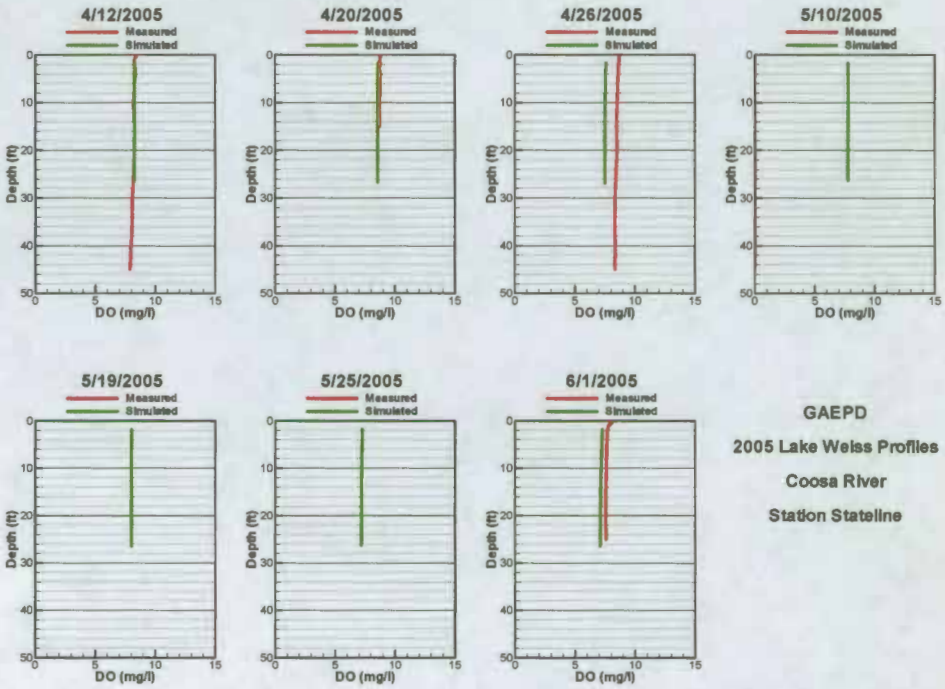

Figure 7-54 Dissolved Oxygen Profile Comparisons at Coosa River at Georgia-Alabama border.

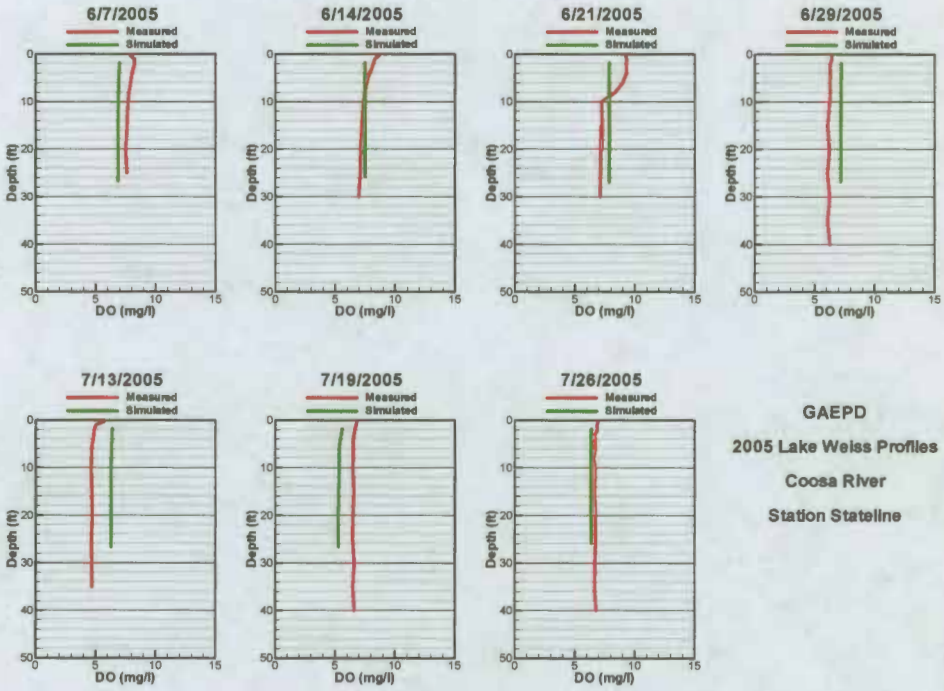

Figure 7-54 Dissolved Oxygen Profile Comparisons at Coosa River at Georgia-Alabama border (cont).

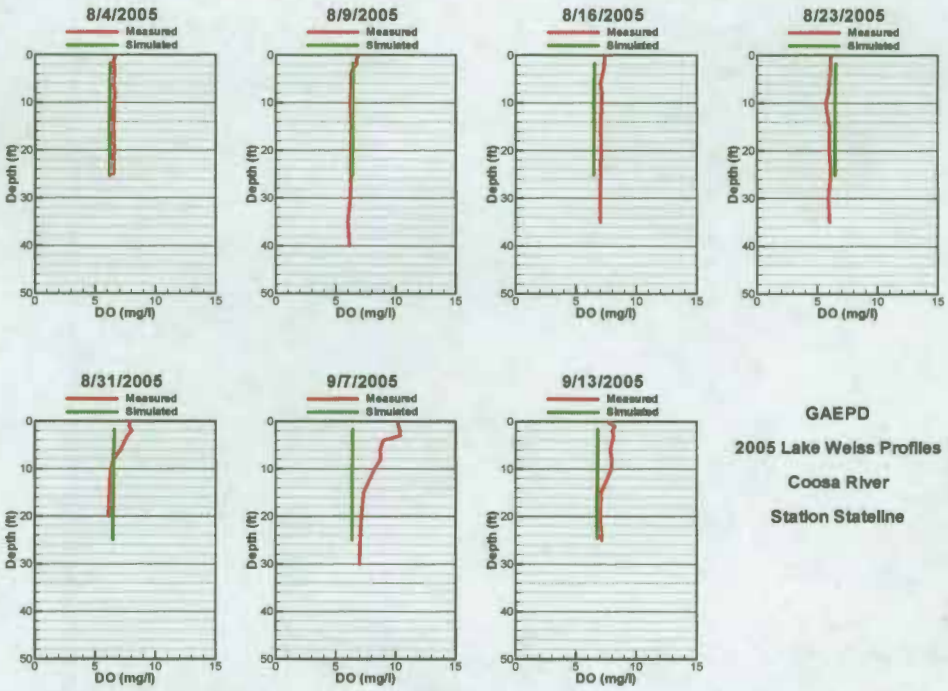

Figure 7-54 Dissolved Oxygen Profile Comparisons at Coosa River at Georgia-Alabama border (cont).

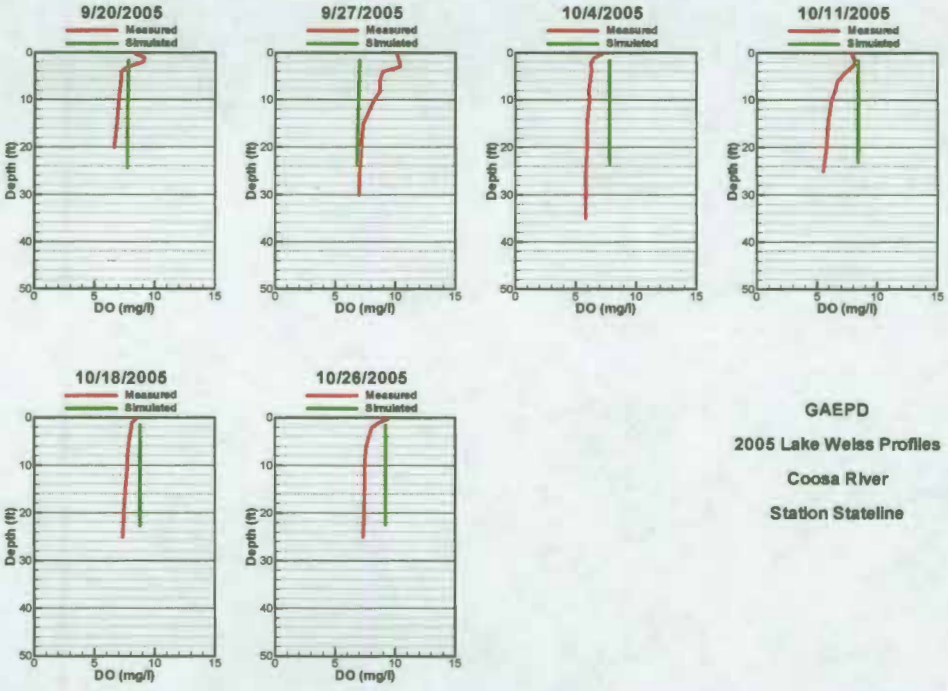

Figure 7-54 Dissolved Oxygen Profile Comparisons at Coosa River at Georgia-Alabama border (cont).

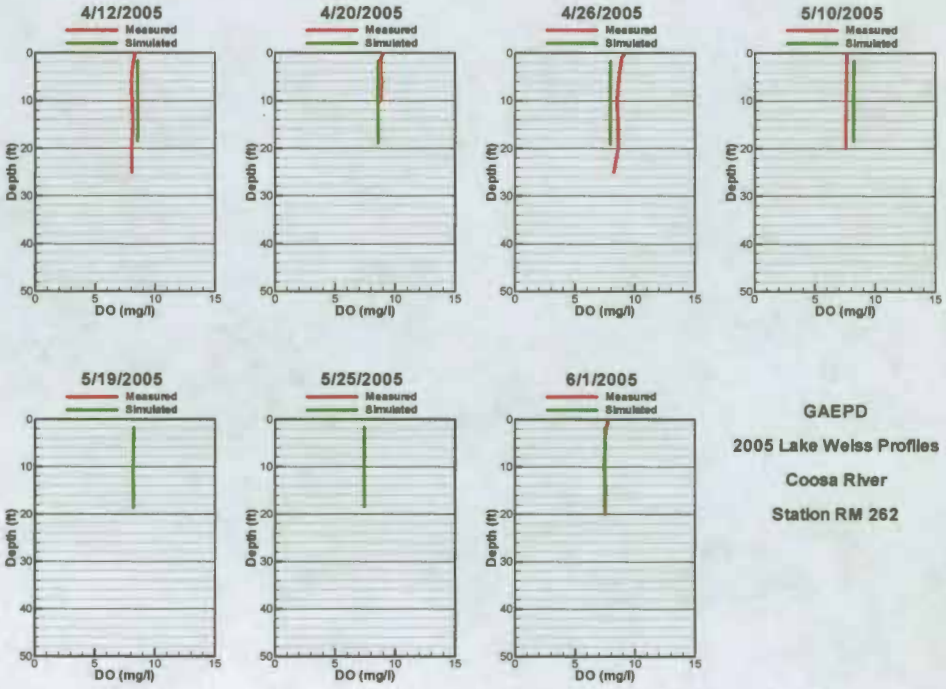

Figure 7-55 Dissolved Oxygen Profile Comparisons at Coosa River at RM 262.

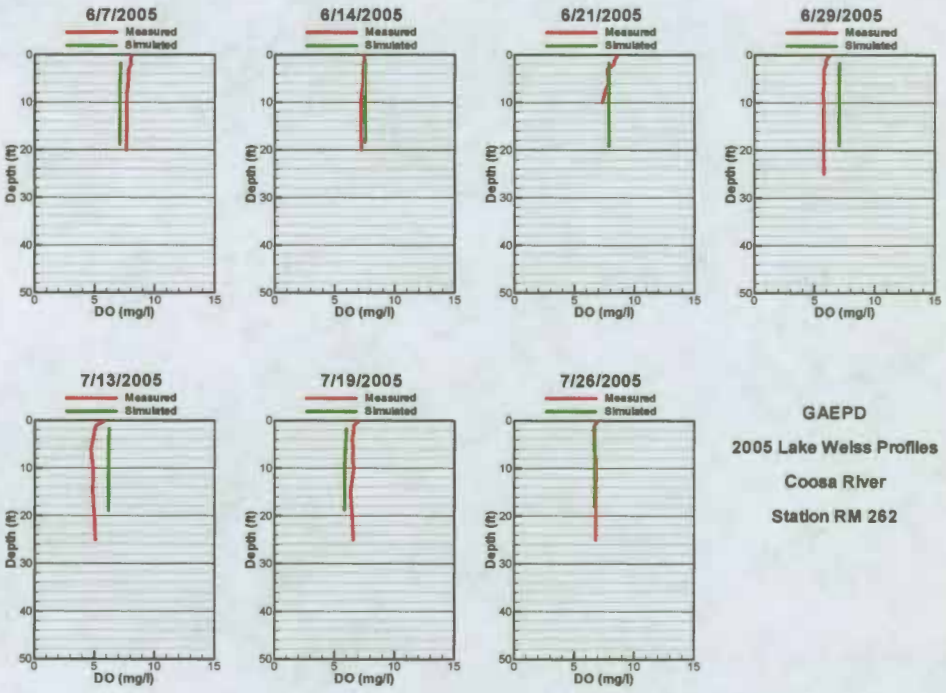

Figure 7-55 Dissolved Oxygen Profile Comparisons at Coosa River at RM 262 (cont).

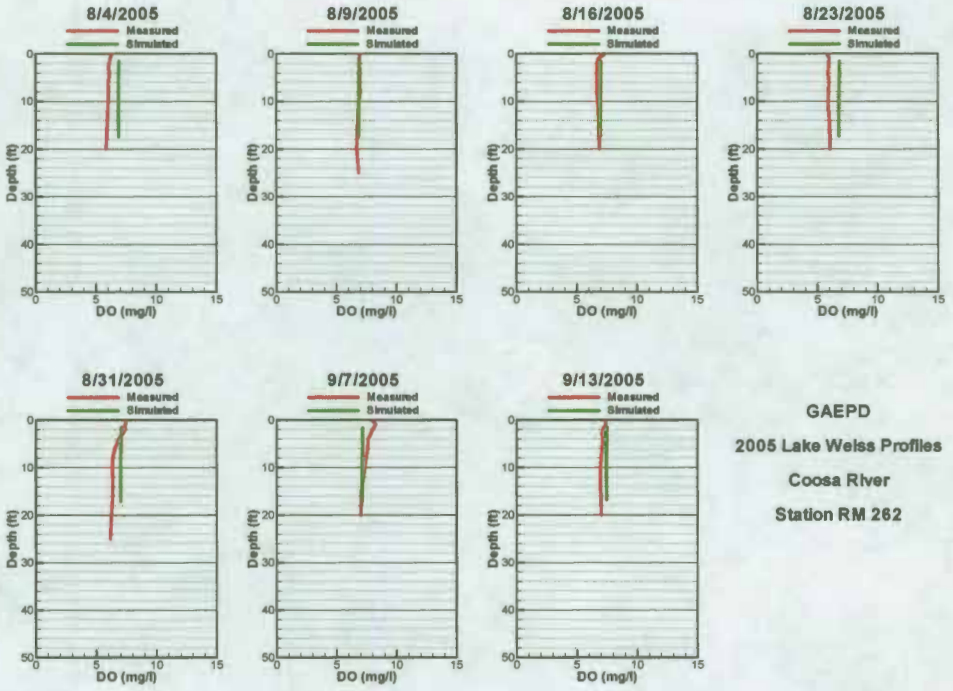

Figure 7-55 Dissolved Oxygen Profile Comparisons at Coosa River at RM 262 (cont).

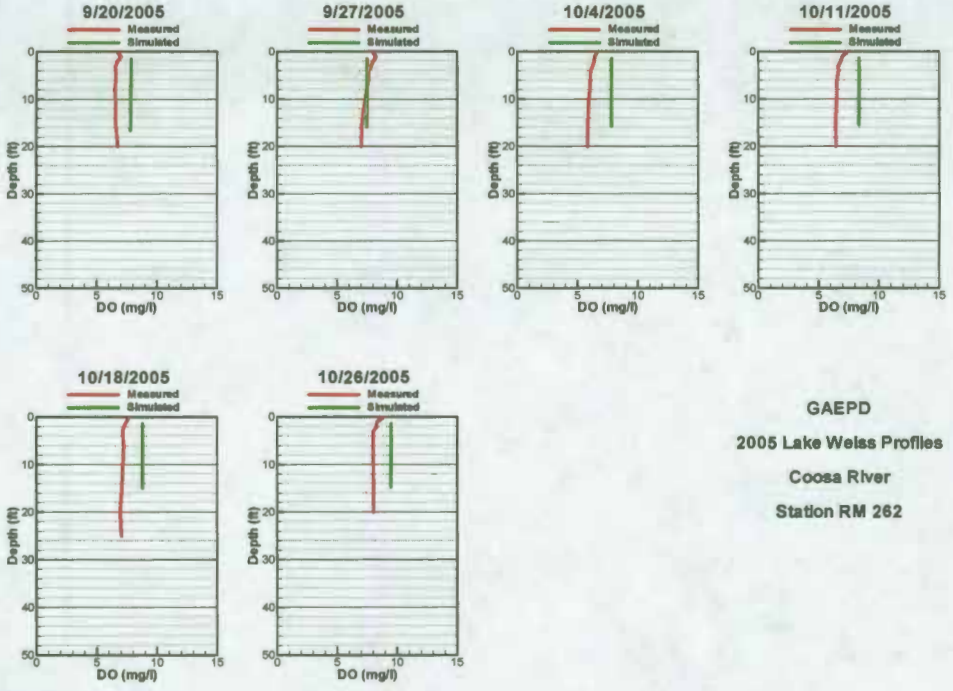

Figure 7-55 Dissolved Oxygen Profile Comparisons at Coosa River at RM 262 (cont).

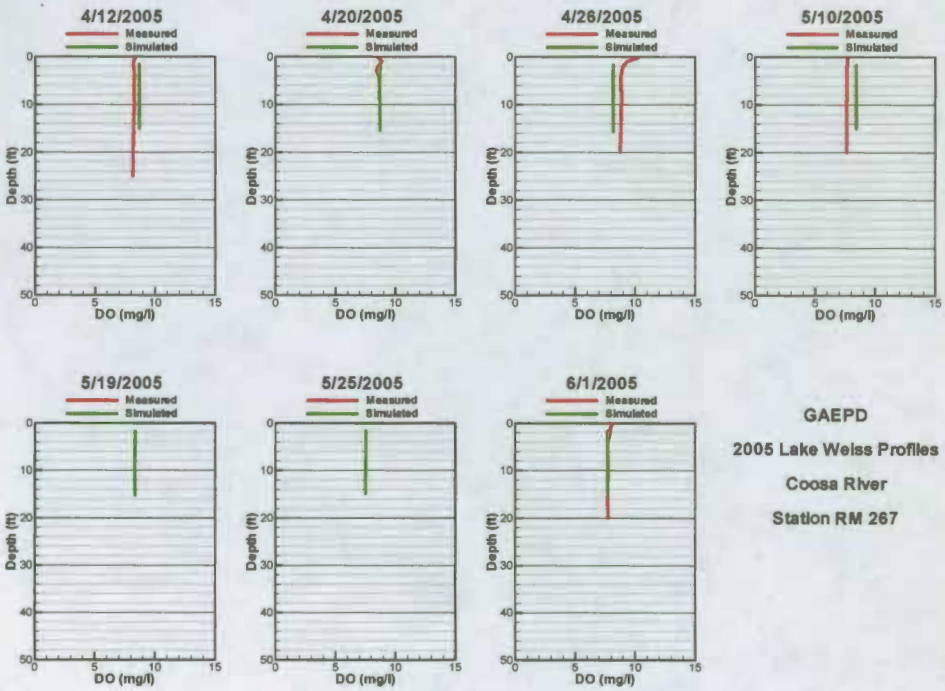

Figure 7-56 Dissolved Oxygen Profile Comparisons at Coosa River at RM 267.

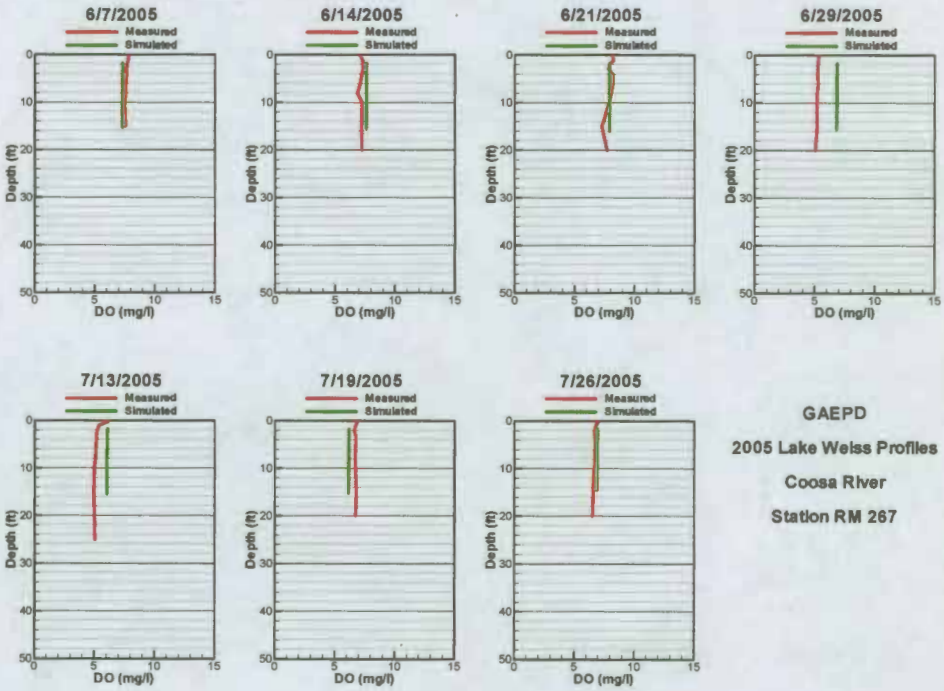

Figure 7-56 Dissolved Oxygen Profile Comparisons at Coosa River at RM 267 (cont).

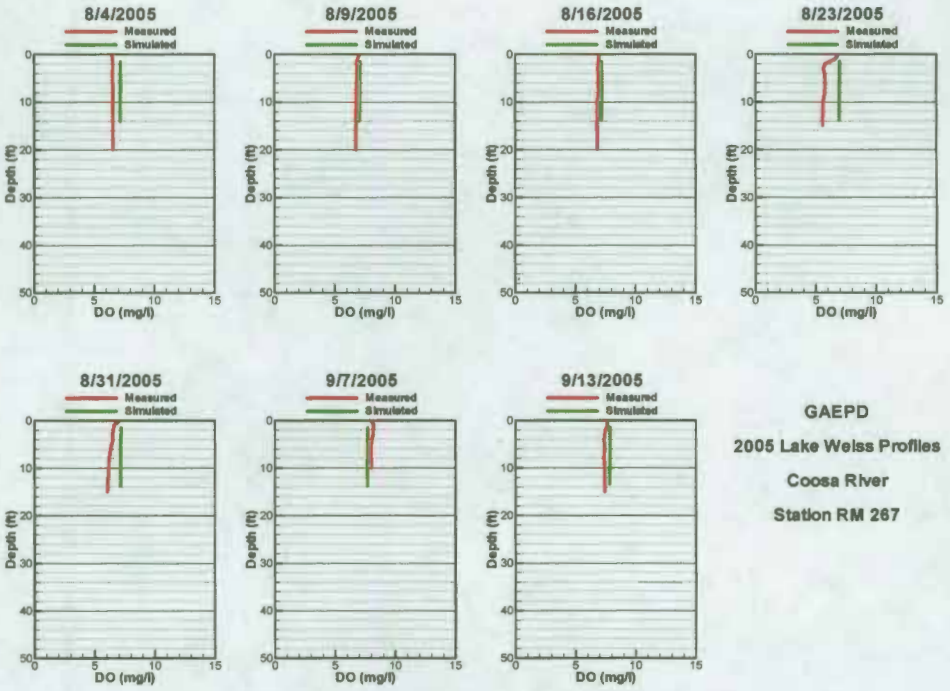

Figure 7-56 Dissolved Oxygen Profile Comparisons at Coosa River at RM 267 (cont).

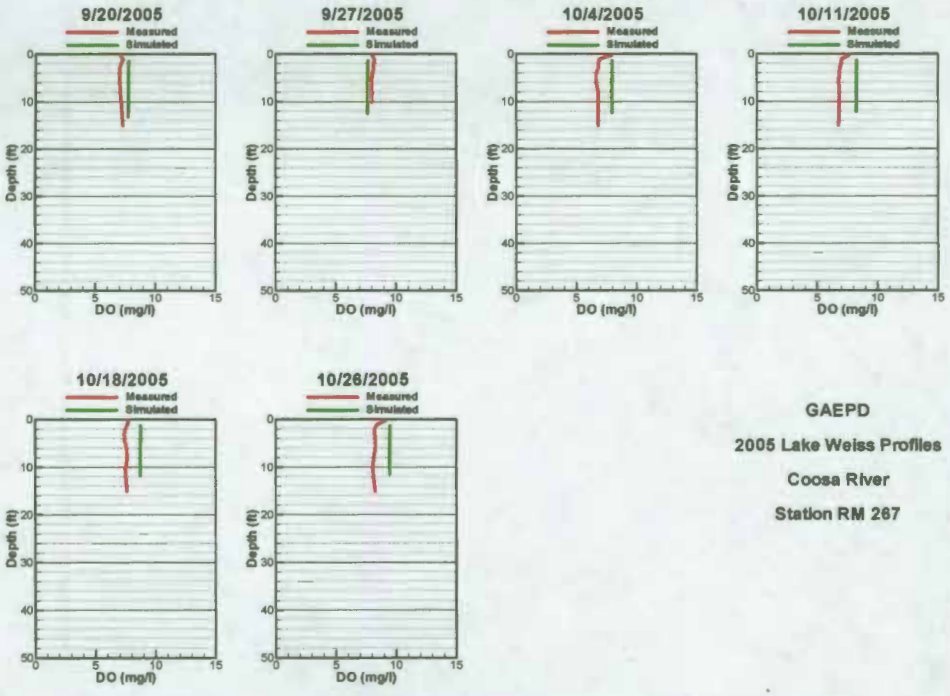

Figure 7-56 Dissolved Oxygen Profile Comparisons at Coosa River at RM 267 (cont).

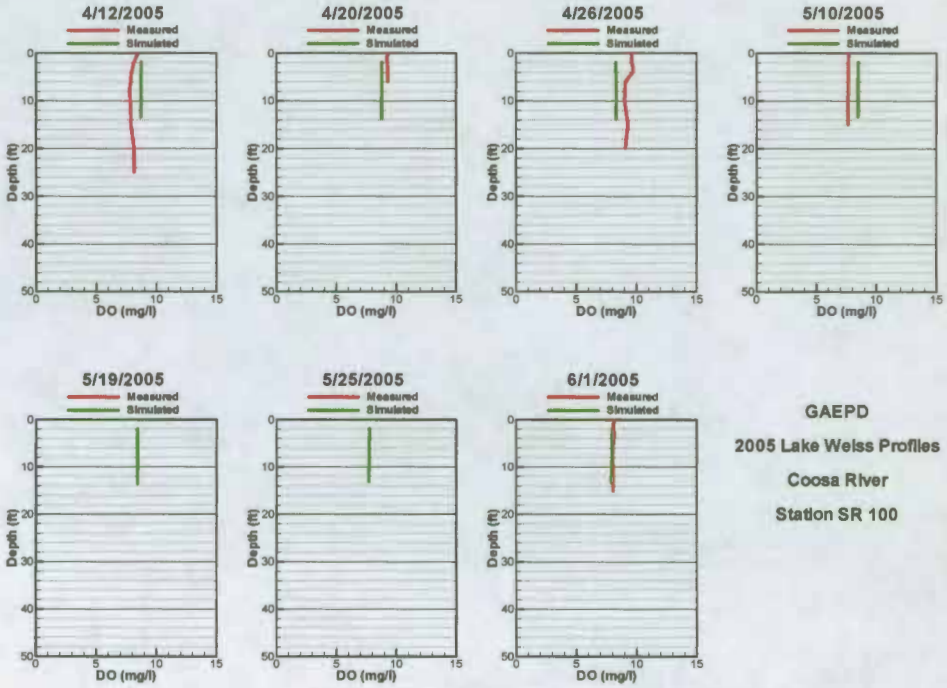

Figure 7-57 Dissolved Oxygen Profile Comparisons at Coosa River at State Road 100.

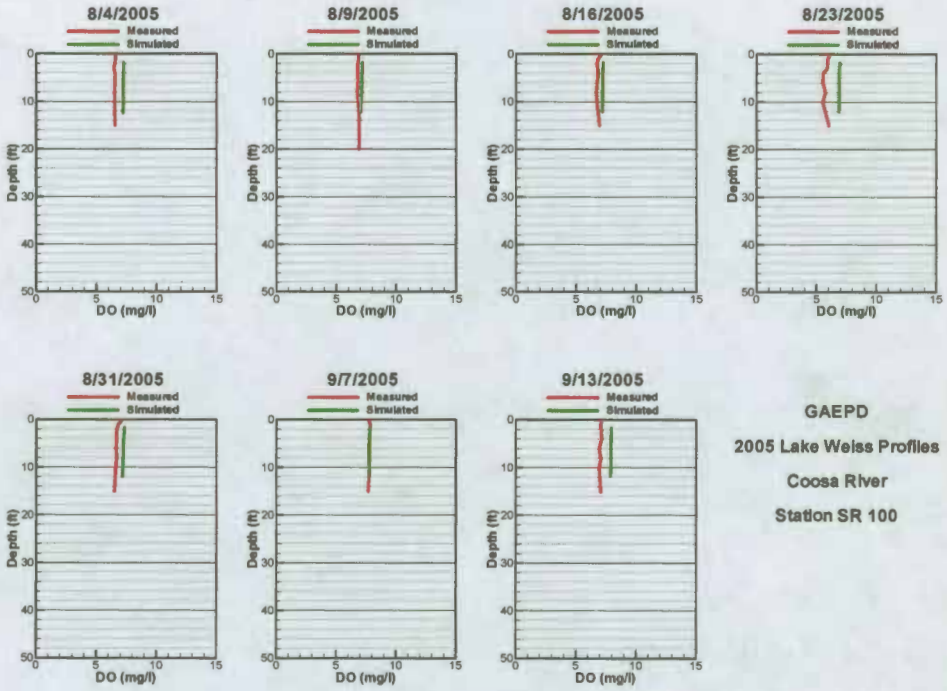

Figure 7-57 Dissolved Oxygen Profile Comparisons at Coosa River at State Road 100 (cont).

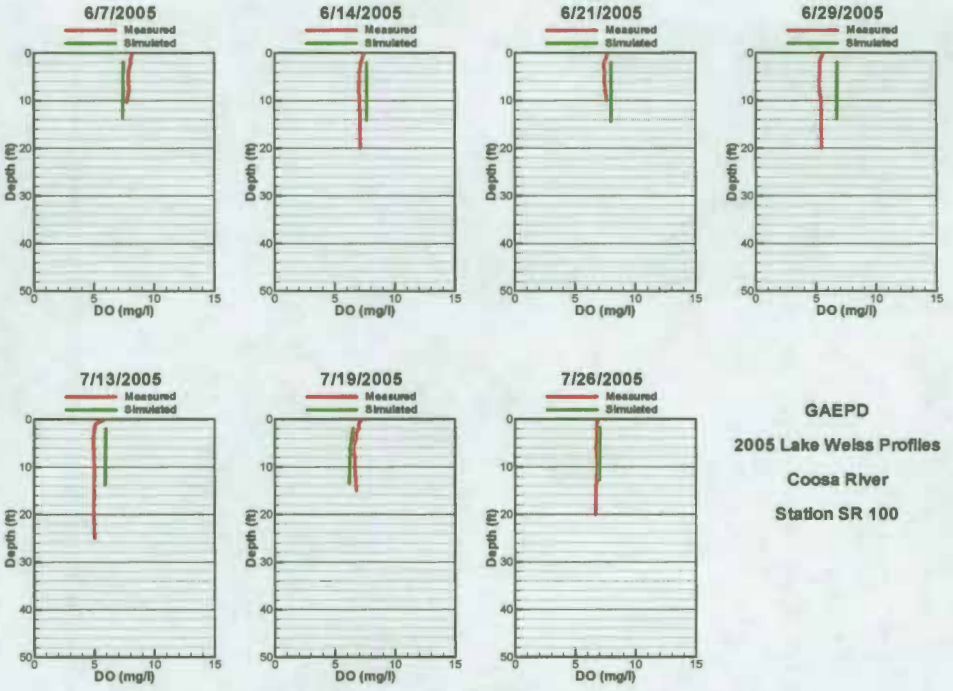

Figure 7-57 Dissolved Oxygen Profile Comparisons at Coosa River at State Road 100 (cont).

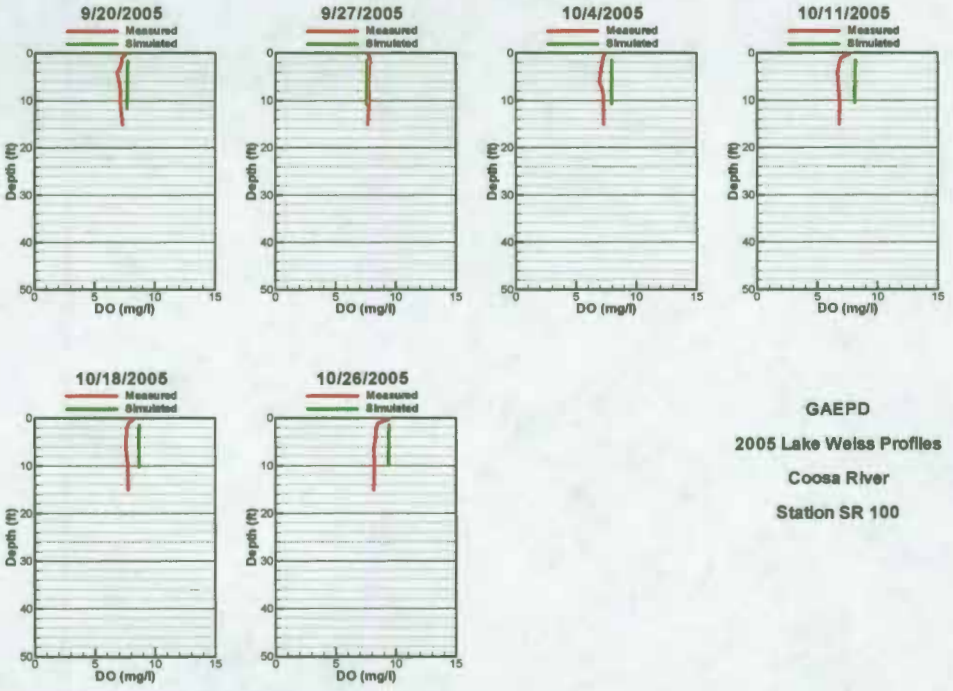

Figure 7-57 Dissolved Oxygen Profile Comparisons at Coosa River at State Road 100 (cont).

Figure 7-58 Dissolved Oxygen Profile Comparisons at Coosa River at Beech Creek.

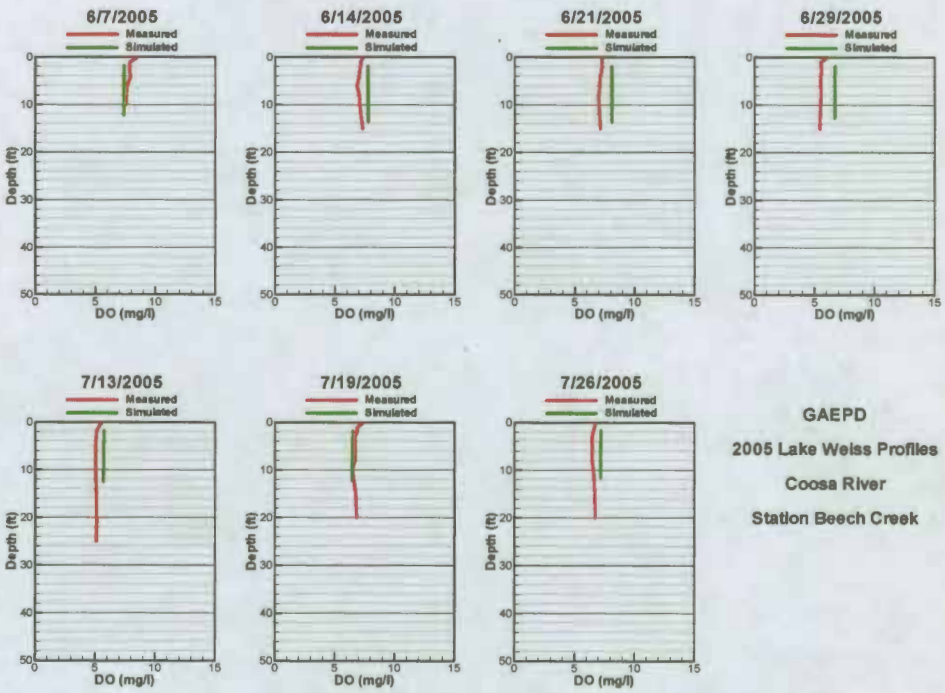

Figure 7-58 Dissolved Oxygen Profile Comparisons at Coosa River at Beech Creek (cont).

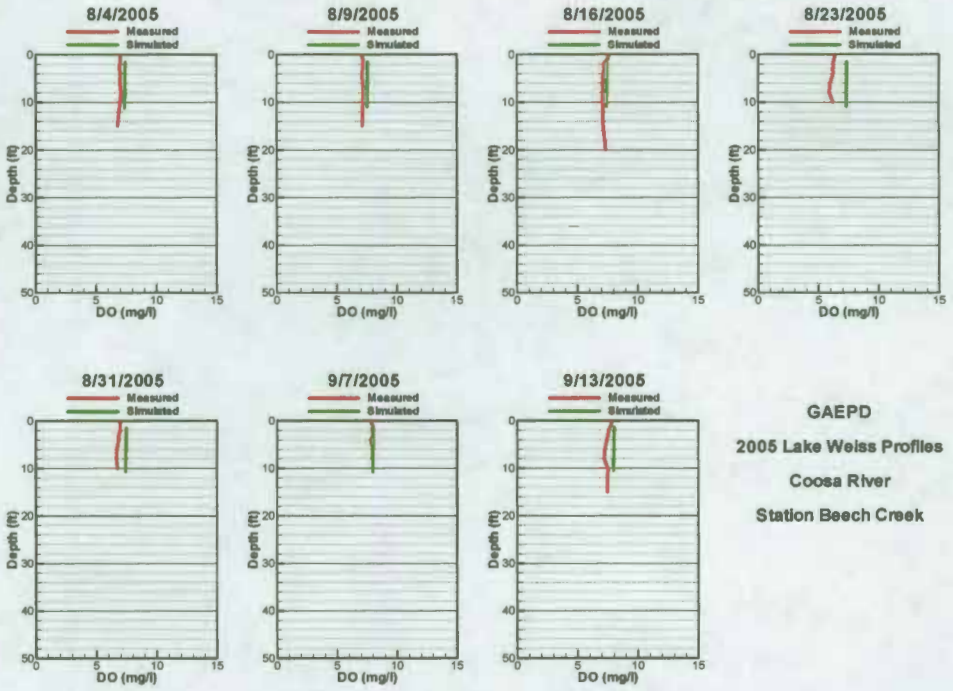

Figure 7-58 Dissolved Oxygen Profile Comparisons at Coosa River at Beech Creek (cont).

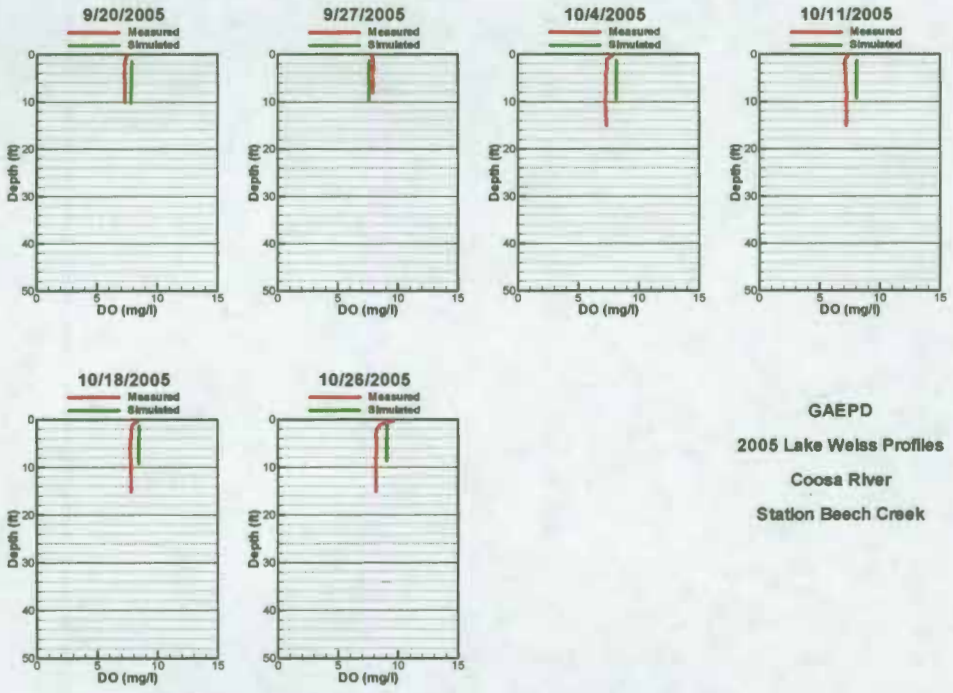

Figure 7-58 Dissolved Oxygen Profile Comparisons at Coosa River at Beech Creek (cont).

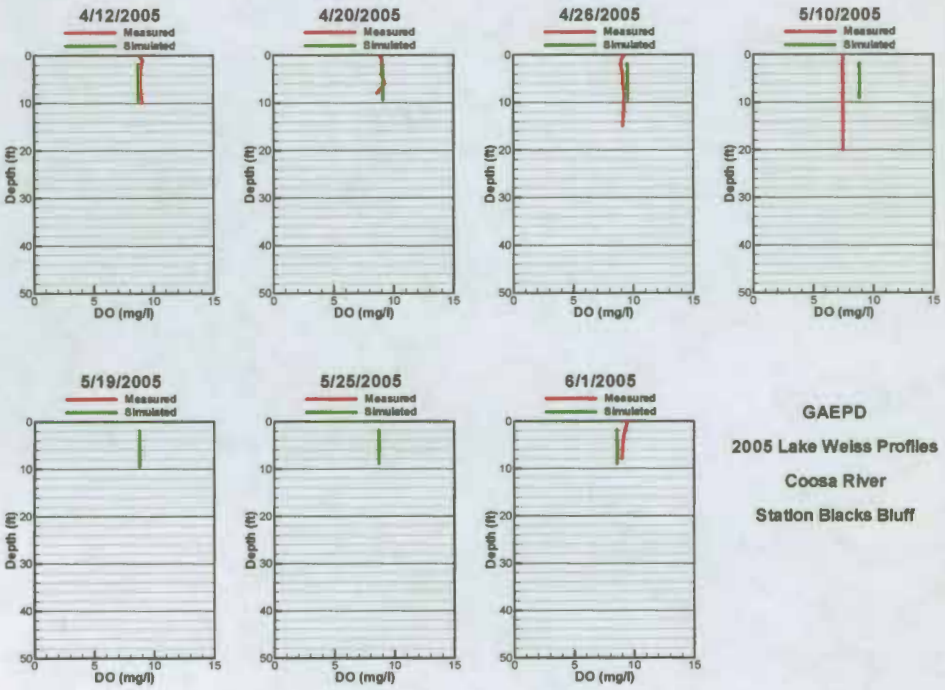

Figure 7-59 Dissolved Oxygen Profile Comparisons at Coosa River at Blacks Bluff Road.

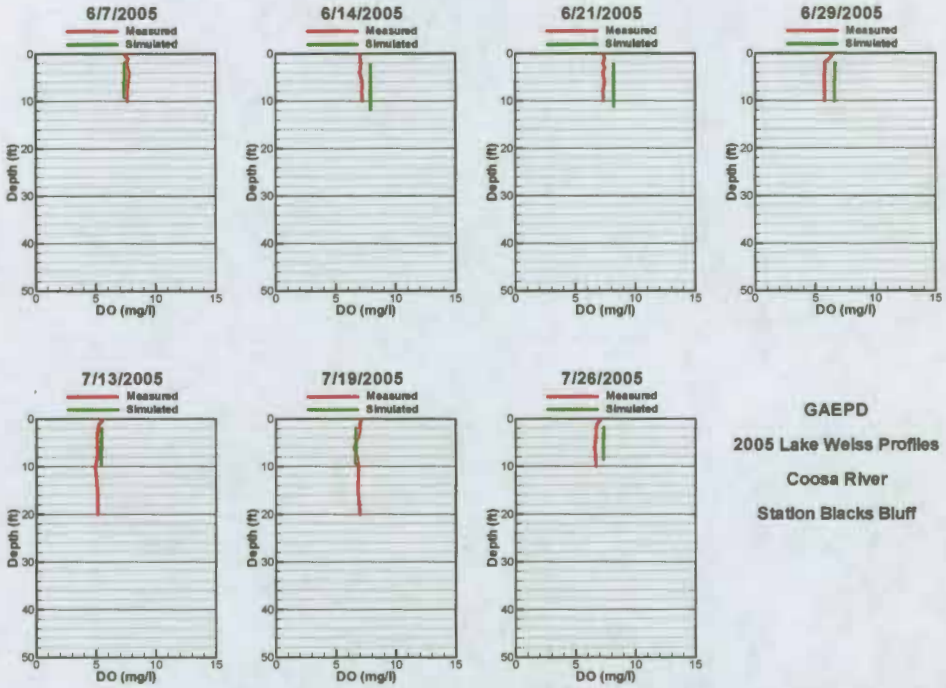

Figure 7-59 Dissolved Oxygen Profile Comparisons at Coosa River at Blacks Bluff Road (cont).

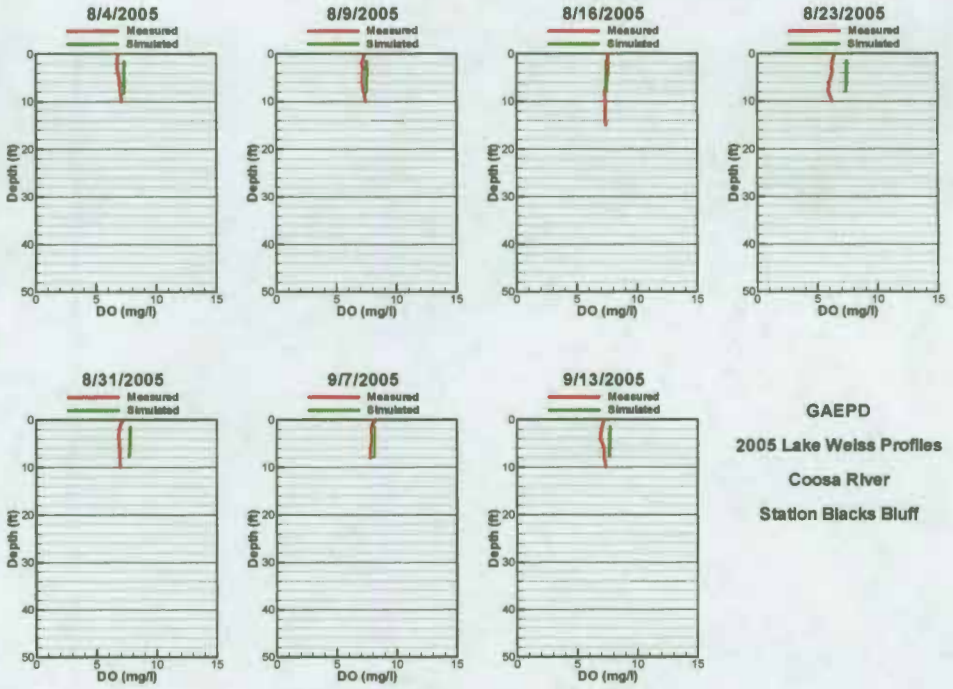

Figure 7-59 Dissolved Oxygen Profile Comparisons at Coosa River at Blacks Bluff Road (cont).

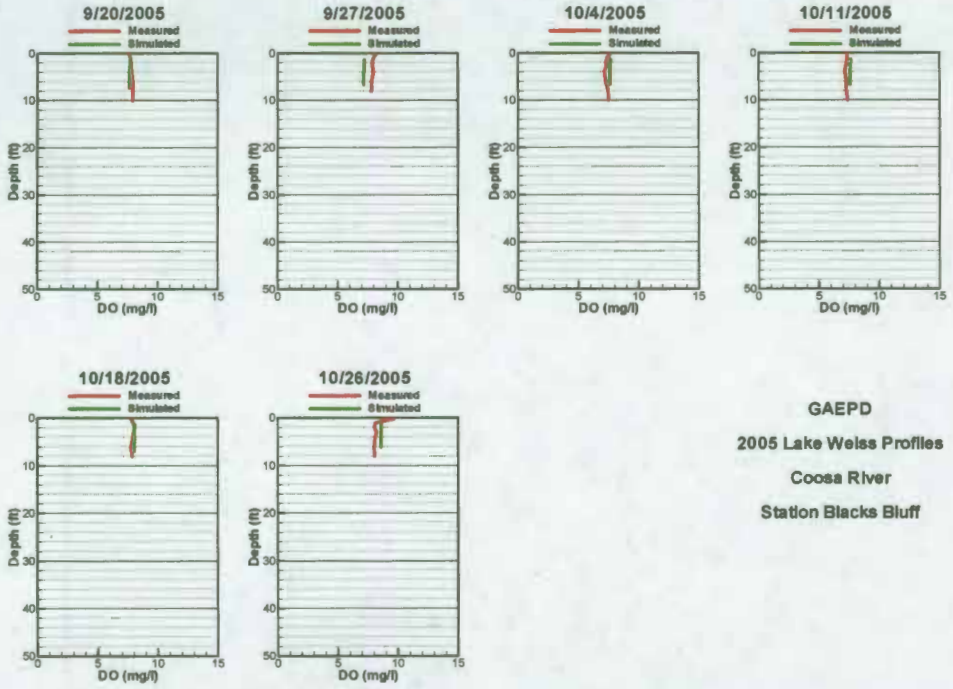

Figure 7-59 Dissolved Oxygen Profile Comparisons at Coosa River at Blacks Bluff Road (cont).

7.8 Water Quality Validation

Once the water quality model was calibrated to data collected during 2005, it was validated to 2000 data. The validation was performed by comparing simulated data to measured nutrient data collected by ADEM at 4 stations (Weiss 1A, 2, 3, and 4). Data collected efforts at station Weiss 12 did not begin until 2002, and therefore, nutrient data were not reviewed at this location for the validation.

7.8.1 Ammonia

Simulated ammonia data were validated to measurements taken at the four ADEM stations. Figures 7-60 through 7-63 present the ammonia validation at the four ADEM stations.

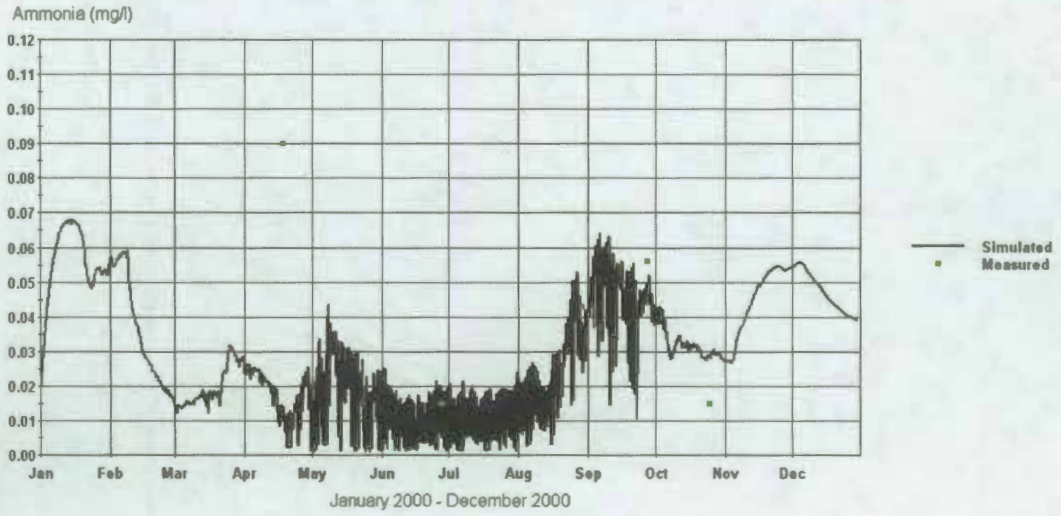

Figure 7-60 Simulated vs. Measured Ammonia at Station Weiss 1A.

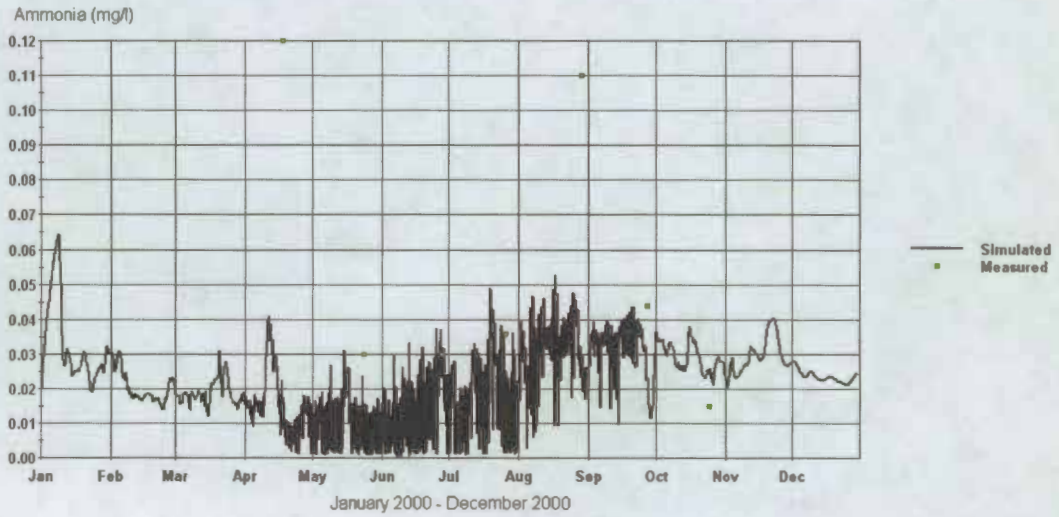

Figure 7-61 Simulated vs. Measured Ammonia at Station Weiss 2.

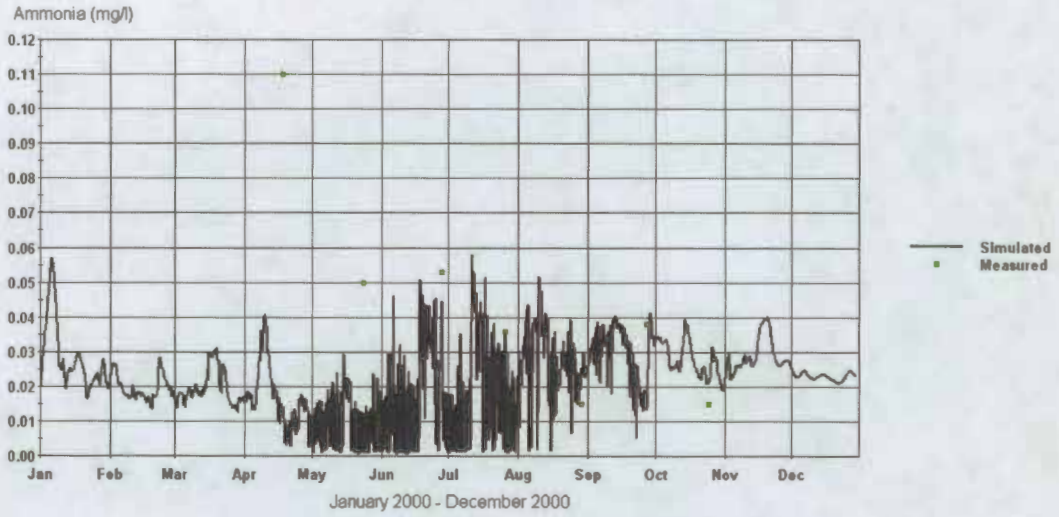

Figure 7-62 Simulated vs. Measured Ammonia at Station Weiss 3.

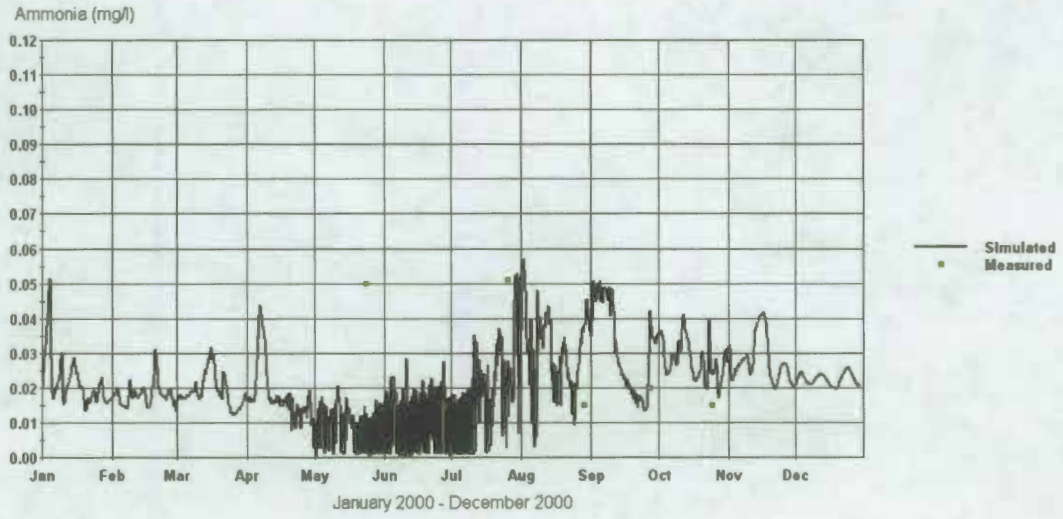

Figure 7-63 Simulated vs. Measured Ammonia at Station Weiss 4.

7.8.2 Nitrate+Nitrite

Simulated nitrate+nitrite data were validated to measurements taken at the four ADEM stations. Figures 7-64 through 7-67 present the nitrate+nitrite validation at the four ADEM stations.

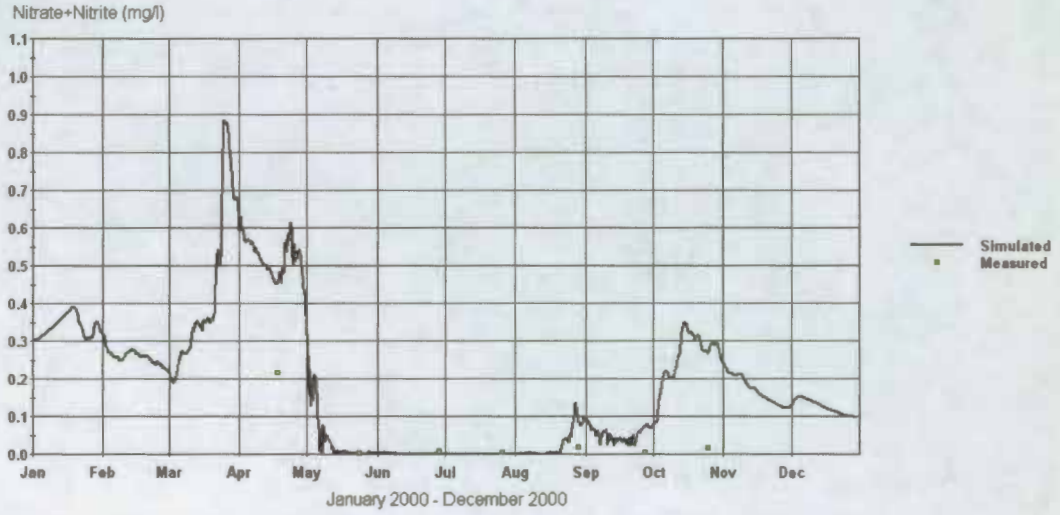

Figure 7-64 Simulated vs. Measured Nitrate+Nitrite at Station Weiss 1A.

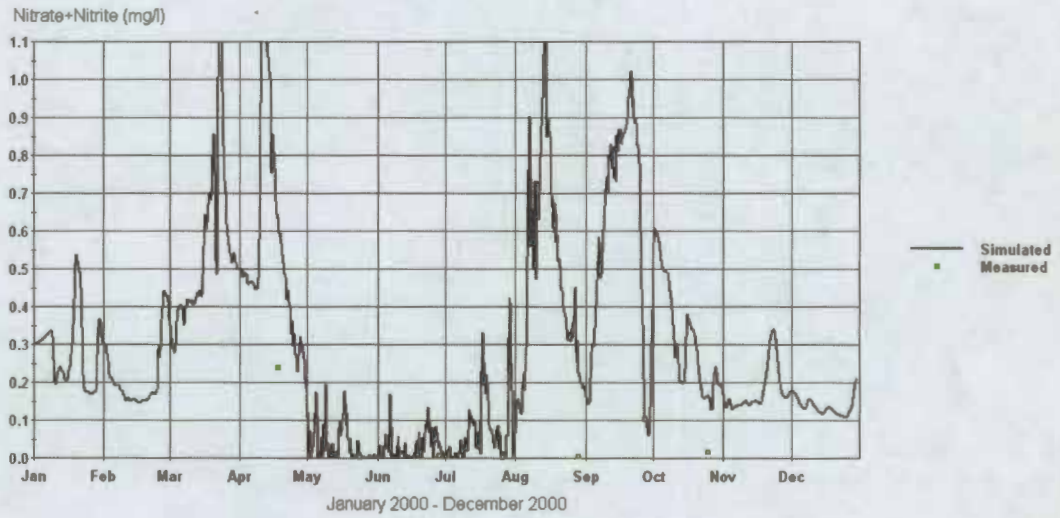

Figure 7-65 Simulated vs. Measured Nitrate+Nitrite at Station Weiss 2.

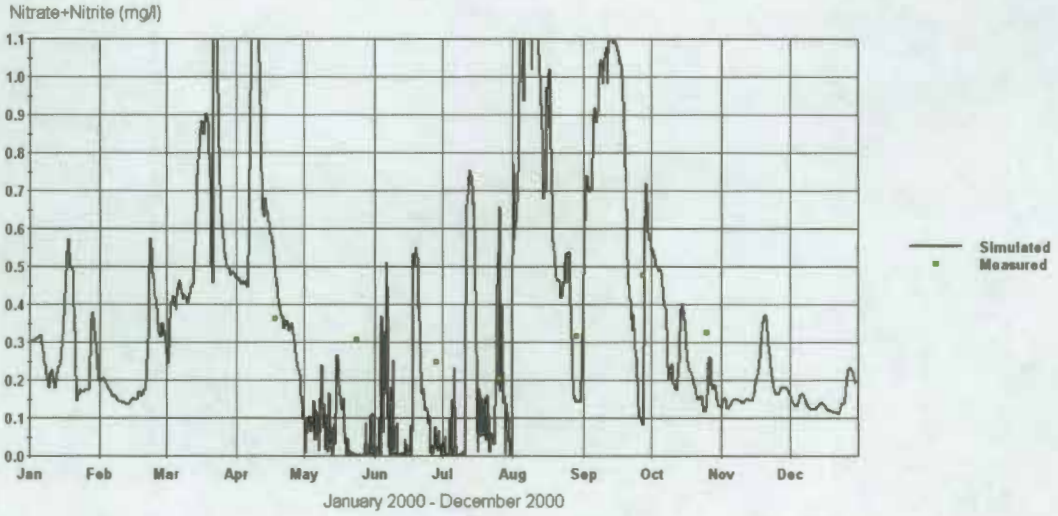

Figure 7-66 Simulated vs. Measured Nitrate+Nitrite at Station Weiss 3.

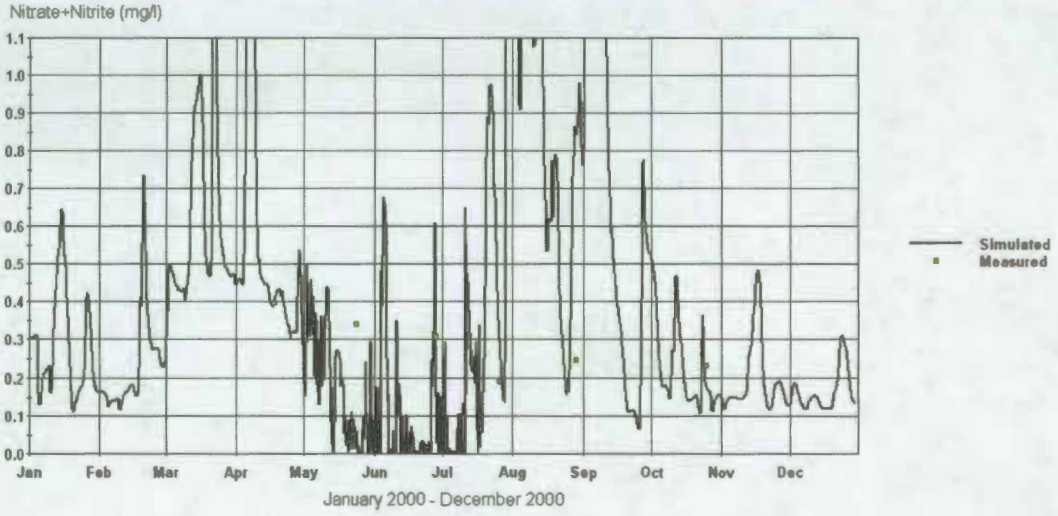

Figure 7-67 Simulated vs. Measured Nitrate+Nitrite at Station Weiss 4.

7.8.3 Total Phosphorus

ADEM did not collect orthophosphate data during 2000, however; total phosphorus data were collected. Simulated total phosphorus data were validated to measurements taken at the four ADEM stations. Figures 7-68 through 7-71 present the total phosphorus validation at the four ADEM stations.

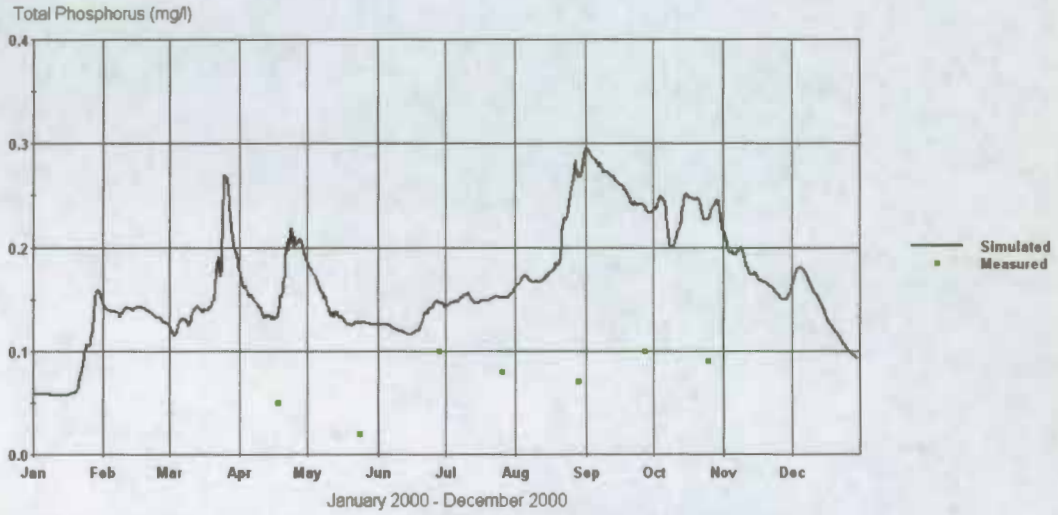

Figure 7-68 Simulated vs. Measured Total Phosphorus at Station Weiss 1A.

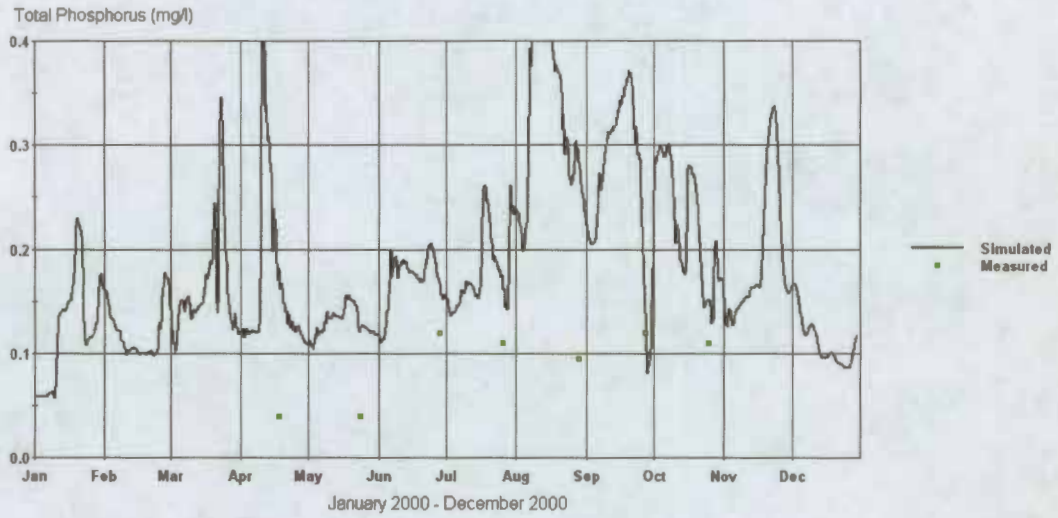

Figure 7-69 Simulated vs. Measured Total Phosphorus at Station Weiss 2.

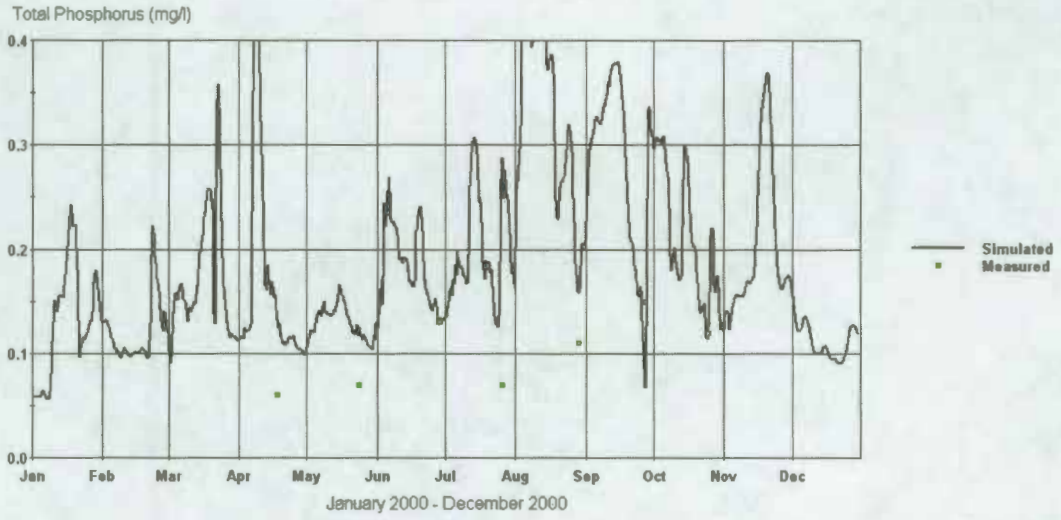

Figure 7-70 Simulated vs. Measured Total Phosphorus at Station Weiss 3.

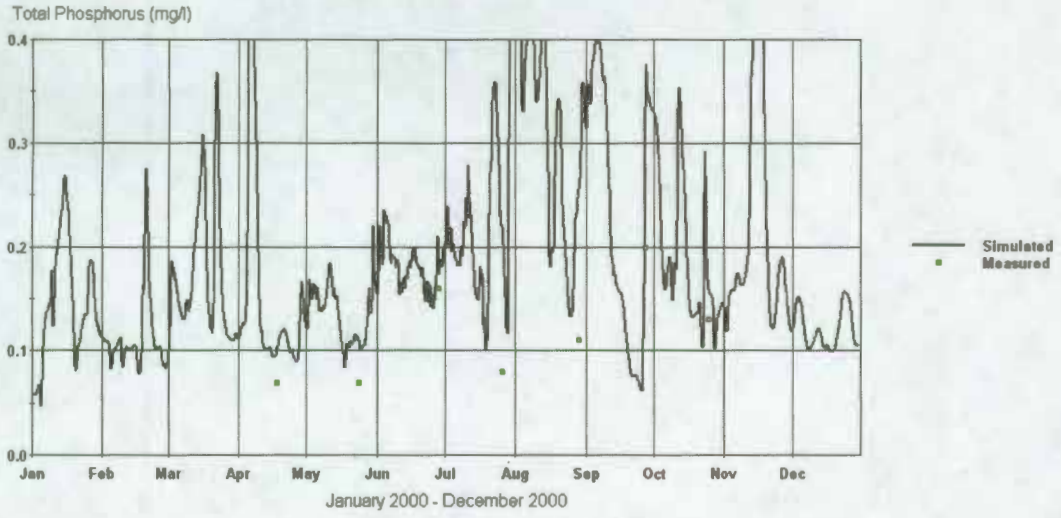

Figure 7-71 Simulated vs. Measured Total Phosphorus at Station Weiss 4.

7.8.4 Light Extinction

Simulated light extinction coefficient data were validated to calculated values determined from measurements taken at the four ADEM stations. Refer to section 7.5 on how the light extinction values were calculated. Table 7-16 presents statistics for the calculated light extinction values from the ADEM stations for year 2000 data. Data were collected monthly during the growing season (April through October). Figures 7-72 through 7-75 present the total phosphorus validation at the four ADEM stations.

Table 7-16 Light Extinction Coefficient for 2000 Weiss Lake Sampling Stations (ADEM)

Station	No. of Obs.	Mean (1/m)	Min (1/m)	Max (1/m)
WEISS1A	7	2.918	2.150	3.833
WEISS2	7	4.072	2.447	5.750
WEISS3	7	3.491	2.191	4.894
WEISS4	7	3.244	1.917	6.216

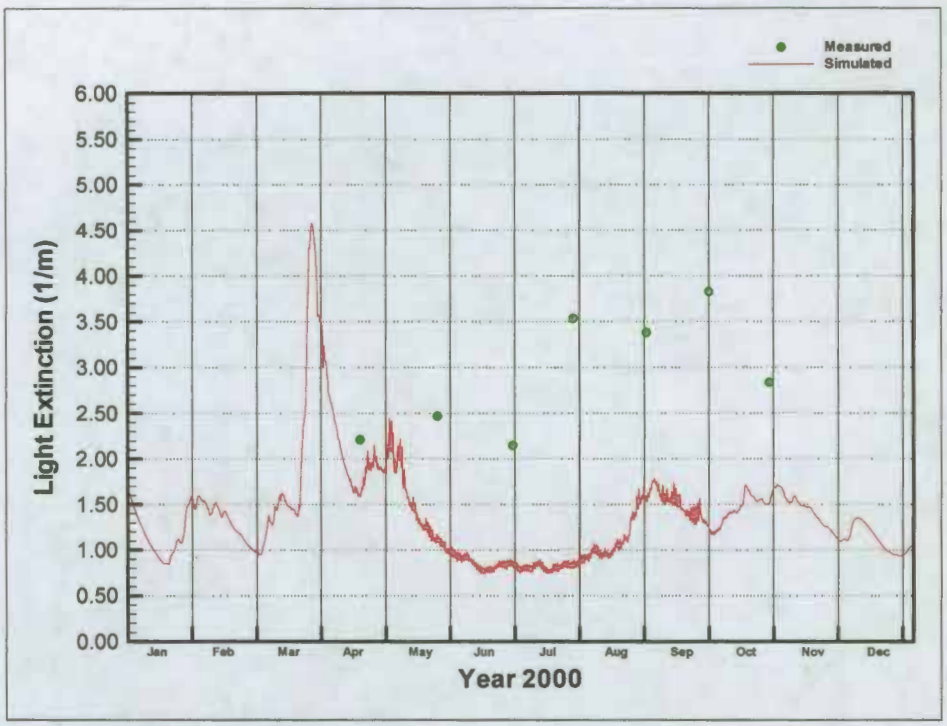

Figure 7-72 Light Extinction Comparison at Station Weiss 1A.

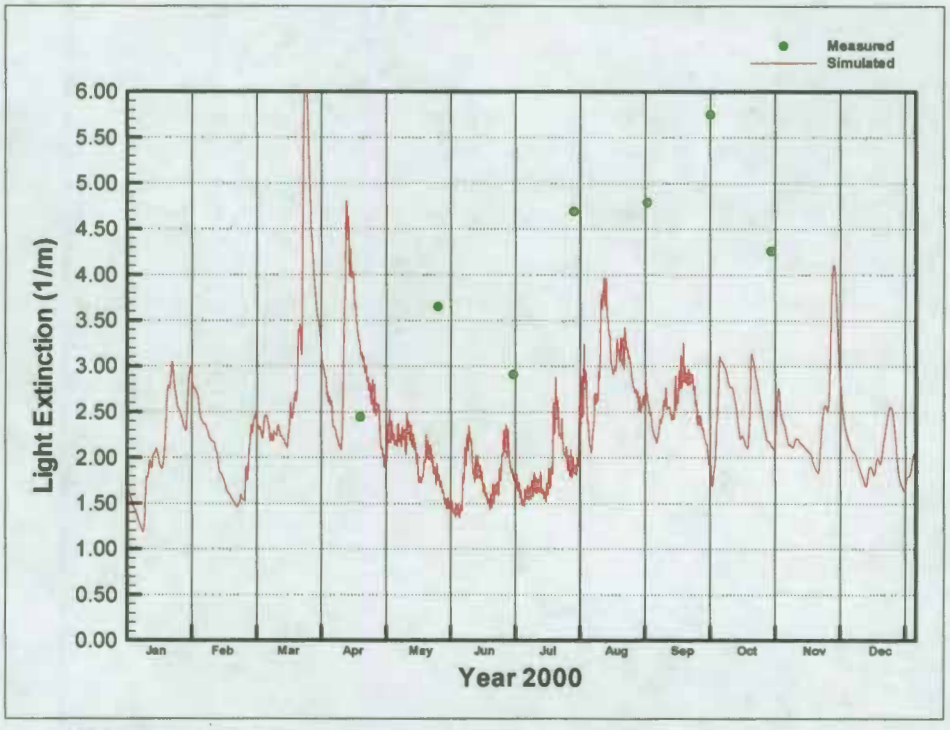

Figure 7-73 Light Extinction Comparison at Station Weiss 2.

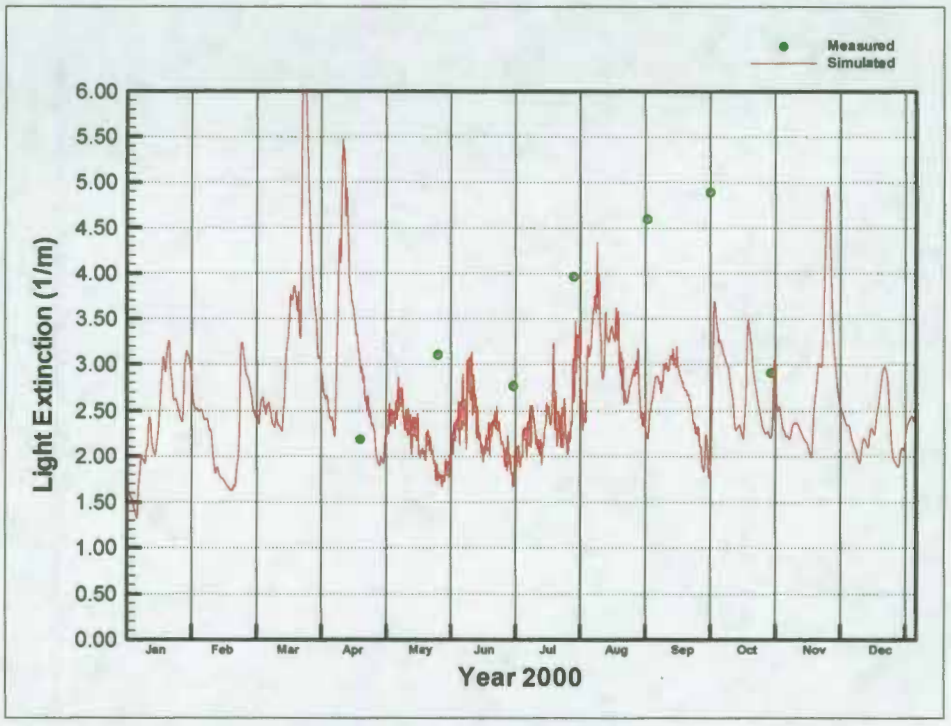

Figure 7-74 Light Extinction Comparison at Station Weiss 3.

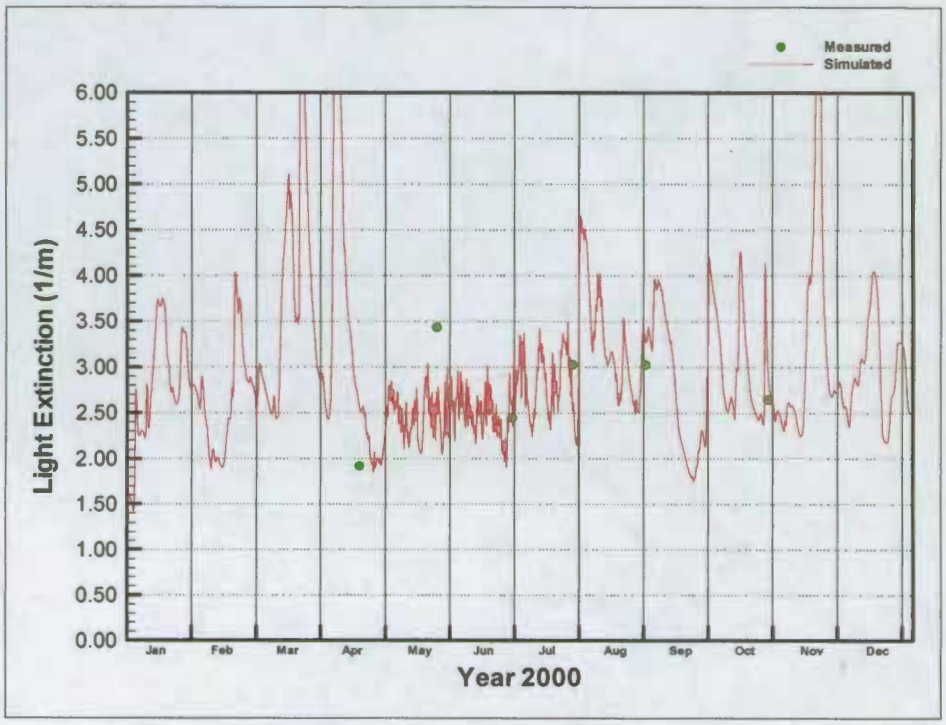

Figure 7-75 Light Extinction Comparison at Station Weiss 4.

7.8.5 Chlorophyll-a

Simulated chlorophyll-a data were validated to measurements taken at the four ADEM stations. Figures 7-76 through 7-79 present the chlorophyll-a validation at the four ADEM stations.

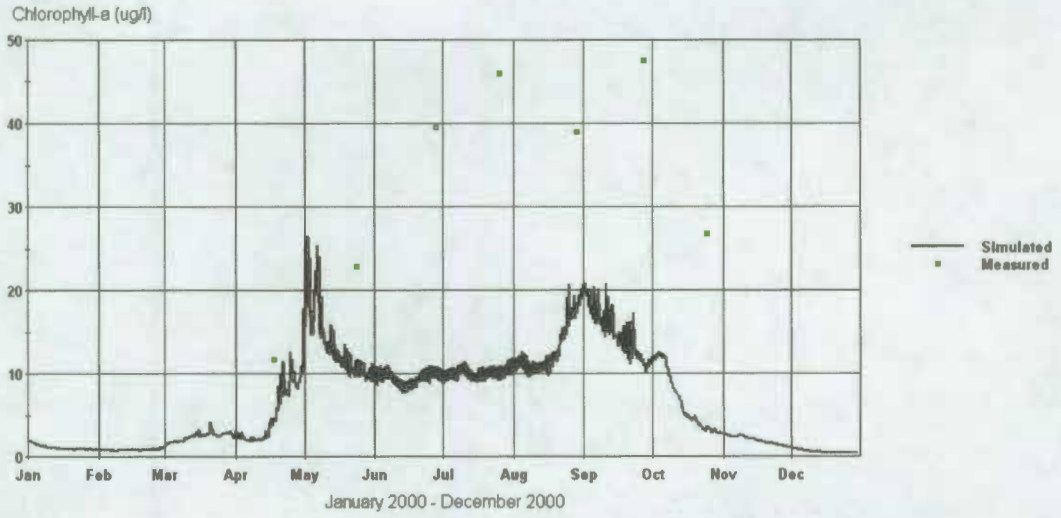

Figure 7-76 Simulated vs. Measured Chlorophyll-a at Station Weiss 1A.

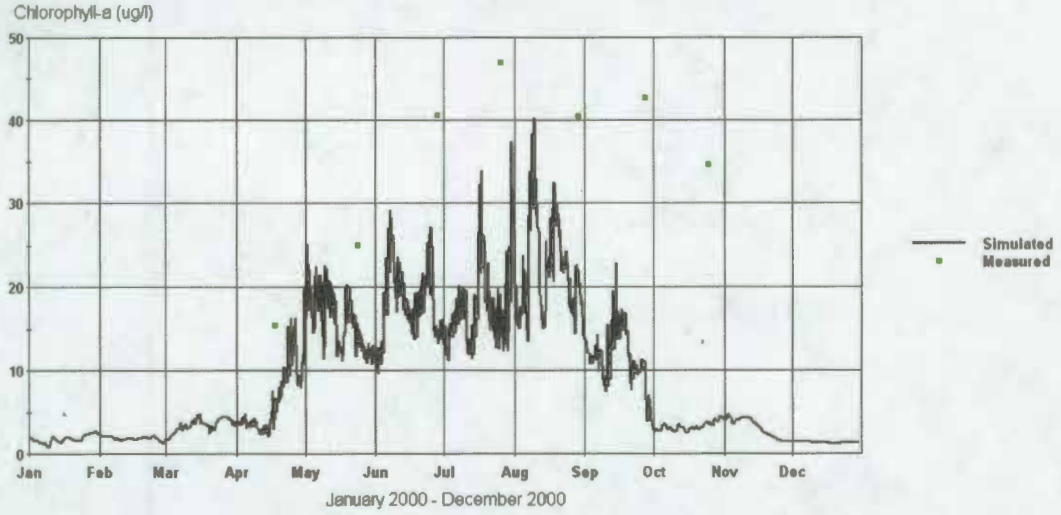

Figure 7-77 Simulated vs. Measured Chlorophyll-a at Station Weiss 2.

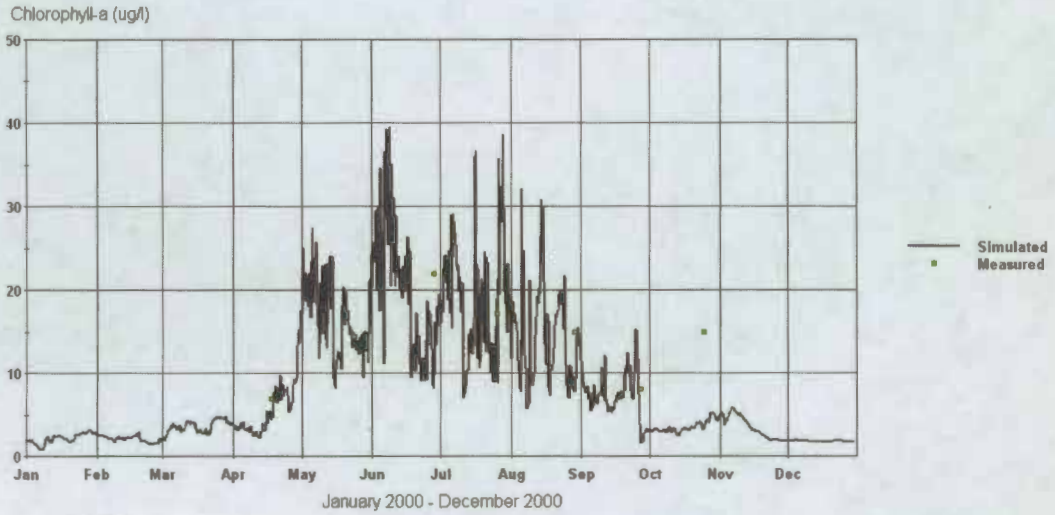

Figure 7-78 Simulated vs. Measured Chlorophyll-a at Station Weiss 3.

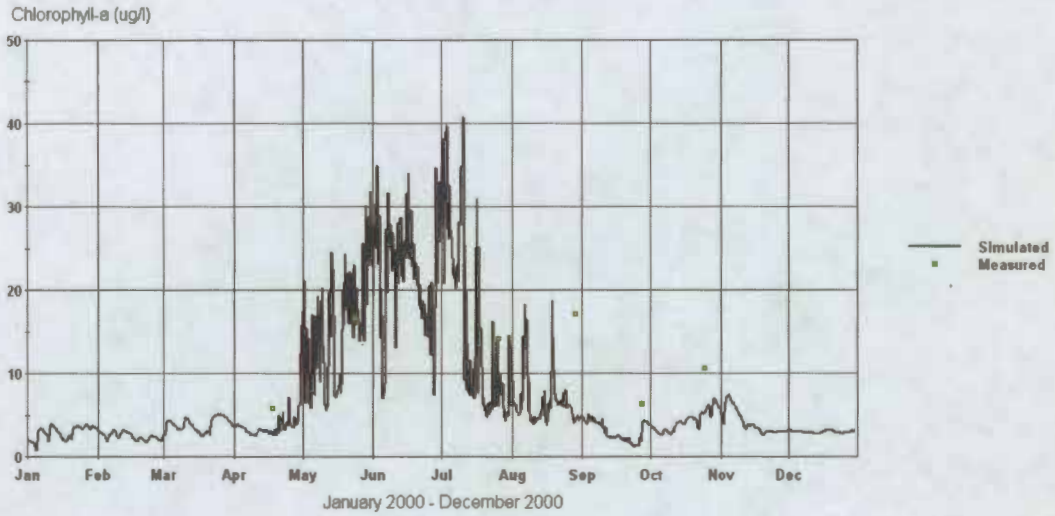

Figure 7-79 Simulated vs. Measured Chlorophyll-a at Station Weiss 4.

7.8.6 Dissolved Oxygen

Simulated dissolved oxygen values were validated to measured dissolved oxygen profile data collected monthly by ADEM. Figures 7-80 through 7-83 present the dissolved oxygen validation at the four ADEM stations.

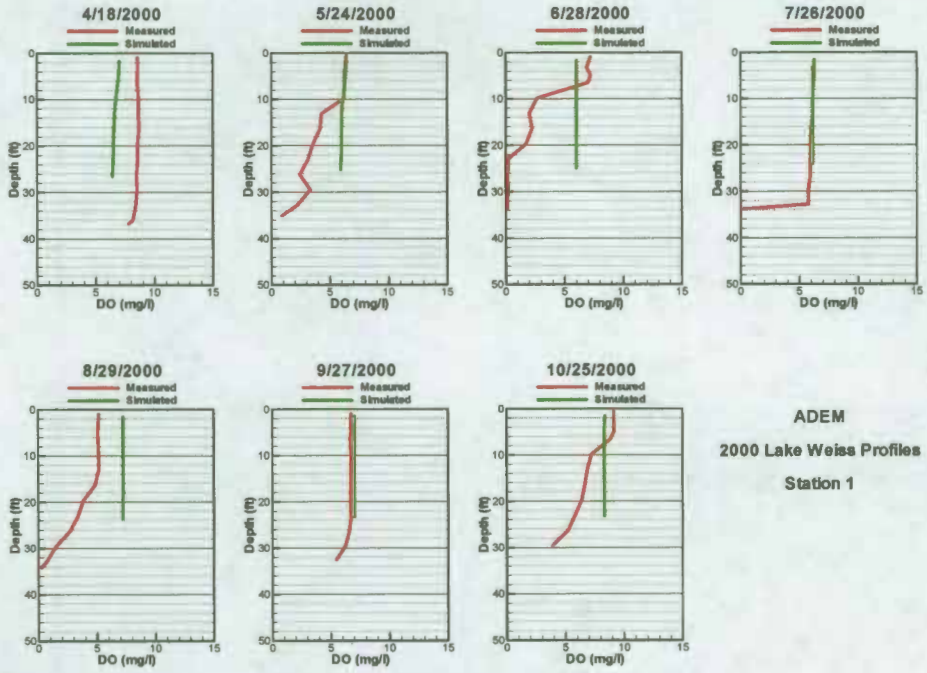

Figure 7-80 Dissolved Oxygen Profile Comparisons at Station Weiss 1A.

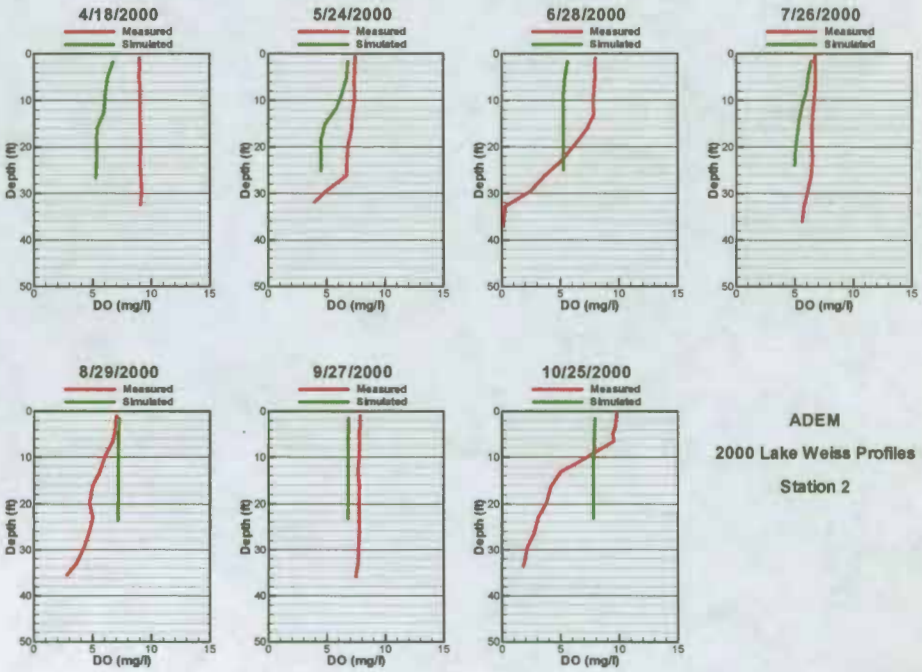

Figure 7-81 Dissolved Oxygen Profile Comparisons at Station Weiss 2.

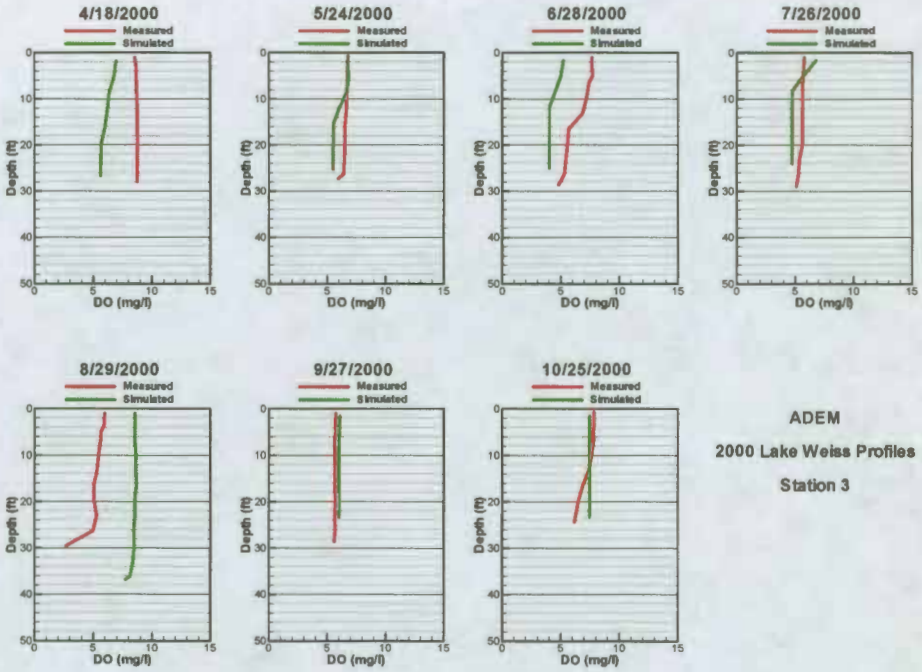

Figure 7-82 Dissolved Oxygen Profile Comparisons at Station Weiss 3.

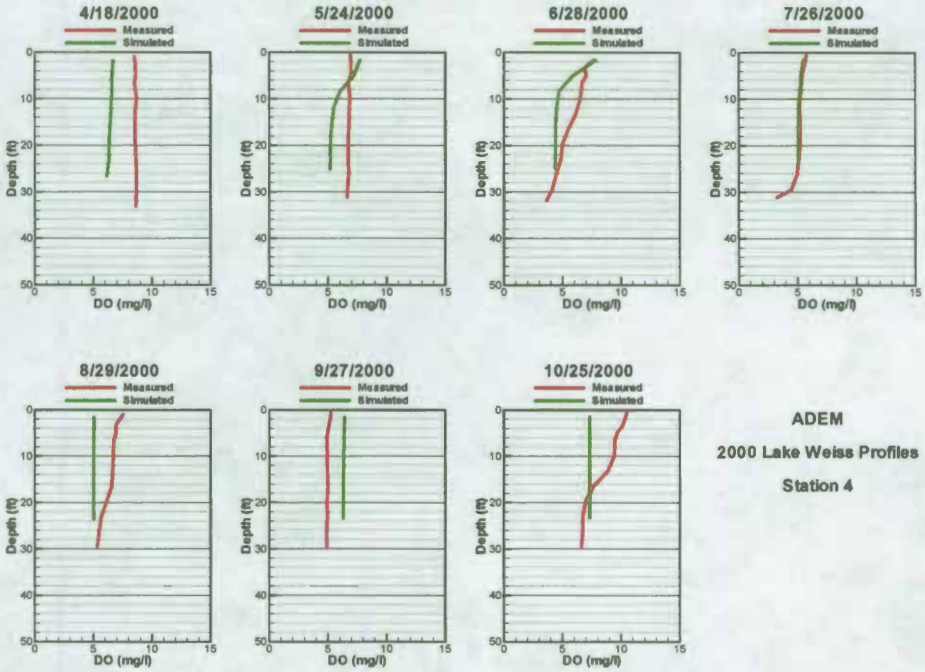

Figure 7-83 Dissolved Oxygen Profile Comparisons at Station Weiss 4.

8.0 STATISTICS

8.1 Chlorophyll-a

Tables 8-1 and 8-2 present statistics for the simulated chlorophyll-a during the 2005 and 2000 growing season, respectively. The data represents the top layer in the model.

Table 8-1 Growing Season Statistics of Simulated Chlorophyll-a for 2005

Station	Minimum (ug/l)	Maximum (ug/l)	Average (ug/l)
WEISS1[A]	2.31	30.49	11.16
WEISS2[A]	1.42	36.67	13.58
WEISS3[A]	1.28	38.73	10.77
WEISS4[A]	1.16	29.52	3.74
WEISS12[A]	1.17	8.99	3.27
Stateline[B]	1.21	7.20	3.32
RM 262[B]	1.29	7.59	3.59
RM 267[B]	1.33	8.15	3.74
SR 100[B]	1.37	8.93	3.79
Beech Creek[B]	1.49	11.17	4.83
Blacks Bluff[B]	1.50	11.49	4.84

[A] – ADEM Stations
[B] – GAEPD Stations

Table 8-2 Growing Season Statistics of Simulated Chlorophyll-a for 2000

Station	Minimum (ug/l)	Maximum (ug/l)	Average (ug/l)
WEISS1[A]	1.86	26.46	10.41
WEISS2[A]	2.08	40.22	13.53
WEISS3[A]	1.51	39.54	12.31
WEISS4[A]	1.19	40.77	10.18
WEISS12[A]	1.21	42.51	7.50
Stateline[B]	1.31	27.23	6.36
RM 262[B]	1.67	18.87	7.16
RM 267[B]	1.80	16.64	7.53
SR 100[B]	0.61	15.82	7.55
Beech Creek[B]	5.14	26.13	13.19
Blacks Bluff[B]	5.55	22.29	13.21

[A] – ADEM Stations
[B] – GAEPD Stations

8.2 Dissolved Oxygen

Statistics were calculated for the simulated dissolved during the 2005 and 2000 growing seasons. Tables 8-3 and 8-4 present the statistics for Layer 1 (top layer) and Layer 2 during the 2005 growing season. Table 8-5 presents the statistics calculated over the entire water column for the 2005 growing season. Tables 8-6 and 8-7 present the statistics for Layer 1 (top layer) and Layer 2 during the 2000 growing season. Table 8-8 presents the statistics calculated over the entire water column for the 2000 growing season.

Table 8-3 Growing Season Statistics of Simulated Dissolved Oxygen for 2005 (Layer 1)

Station	Average Depth for Layer (feet)	Minimum (ug/l)	Maximum (ug/l)	Average (ug/l)
WEISS1[A]	3.40	5.12	10.14	6.94
WEISS2[A]	3.40	3.97	10.72	7.58
WEISS3[A]	3.40	4.78	10.92	7.59
WEISS4[A]	3.40	4.80	10.86	7.26
WEISS12[A]	3.40	5.12	9.87	7.36
Stateline[B]	3.40	5.20	9.88	7.40
RM 262[B]	3.22	5.58	9.84	7.65
RM 267[B]	3.18	5.66	9.70	7.77
SR 100[B]	3.62	5.63	9.59	7.83
Beech Creek[B]	3.28	5.60	9.51	7.98
Blacks Bluff[B]	3.48	5.47	9.70	7.99

[A] – ADEM Stations
[B] – GAEPD Stations

Table 8-4 Growing Season Statistics of Simulated Dissolved Oxygen for 2005 (Layer 2)

Station	Average Depth for Layer (feet)	Minimum (ug/l)	Maximum (ug/l)	Average (ug/l)
WEISS1[A]	3.40	5.12	9.65	6.88
WEISS2[A]	3.40	3.57	10.00	7.32
WEISS3[A]	3.40	4.63	9.93	7.31
WEISS4[A]	3.40	4.79	9.86	7.20
WEISS12[A]	3.40	5.07	9.87	7.32
Stateline[B]	3.40	5.20	9.87	7.38
RM 262[B]	3.22	5.52	9.83	7.63
RM 267[B]	3.18	5.64	9.69	7.76
SR 100[B]	3.62	5.59	9.57	7.81
Beech Creek[B]	3.28	5.57	9.50	7.97
Blacks Bluff[B]	3.48	5.41	9.74	7.97

[A] – ADEM Stations
[B] – GAEPD Stations

Table 8-5 Growing Season Statistics of Simulated Dissolved Oxygen for 2005 (Calculated over Entire Water Column)

Station	Minimum (ug/l)	Maximum (ug/l)	Average (ug/l)
WEISS1[A]	5.26	9.59	6.74
WEISS2[A]	3.84	9.97	6.91
WEISS3[A]	4.08	9.90	6.99
WEISS4[A]	4.82	9.83	7.17
WEISS12[A]	5.11	9.79	7.30
Stateline[B]	5.22	9.82	7.36
RM 262[B]	5.56	9.77	7.63
RM 267[B]	5.68	9.66	7.76
SR 100[B]	5.63	9.54	7.80
Beech Creek[B]	5.66	9.47	7.96
Blacks Bluff[B]	5.46	9.65	7.97

[A] – ADEM Stations
[B] – GAEPD Stations

Table 8-6 Growing Season Statistics of Simulated Dissolved Oxygen for 2000 (Layer 1)

Station	Average Depth for Layer (feet)	Minimum (ug/l)	Maximum (ug/l)	Average (ug/l)
WEISS1[A]	1.00	5.69	9.74	6.86
WEISS2[A]	1.00	5.09	9.63	6.85
WEISS3[A]	1.00	3.58	10.31	6.74
WEISS4[A]	1.00	4.46	10.38	6.58
WEISS12[A]	1.00	4.38	10.83	6.32
Stateline[B]	1.00	4.44	9.53	6.15
RM 262[B]	0.93	4.25	7.89	6.02
RM 267[B]	0.91	3.41	7.86	5.64
SR 100[B]	1.02	2.40	7.79	5.24
Beech Creek[B]	0.91	6.43	9.43	7.89
Blacks Bluff[B]	0.92	6.70	9.49	7.88

[A] – ADEM Stations
[B] – GAEPD Stations

Table 8-7 Growing Season Statistics of Simulated Dissolved Oxygen for 2000 (Layer 2)

Station	Average Depth for Layer (feet)	Minimum (ug/l)	Maximum (ug/l)	Average (ug/l)
WEISS1[A]	1.00	5.64	9.59	6.81
WEISS2[A]	1.00	5.06	8.61	6.72
WEISS3[A]	1.00	3.57	9.10	6.52
WEISS4[A]	1.00	4.46	9.01	6.33
WEISS12[A]	1.00	4.37	9.63	6.16
Stateline[B]	1.00	4.36	8.70	6.06
RM 262[B]	0.93	4.06	7.88	5.94
RM 267[B]	0.91	3.37	7.85	5.57
SR 100[B]	1.02	1.78	7.79	5.16
Beech Creek[B]	0.91	6.39	9.42	7.86
Blacks Bluff[B]	0.92	6.66	9.47	7.85

[A] – ADEM Stations
[B] – GAEPD Stations

Table 8-8 Growing Season Statistics of Simulated Dissolved Oxygen for 2000 (Calculated over Entire Water Column)

Station	Minimum (ug/l)	Maximum (ug/l)	Average (ug/l)
WEISS1[A]	5.76	8.68	6.73
WEISS2[A]	4.68	8.15	6.20
WEISS3[A]	3.68	8.25	5.95
WEISS4[A]	4.55	7.78	5.91
WEISS12[A]	4.41	7.79	5.95
Stateline[B]	4.39	7.78	5.94
RM 262[B]	4.29	7.83	5.92
RM 267[B]	3.71	7.79	5.56
SR 100[B]	2.78	7.76	5.21
Beech Creek[B]	6.44	9.12	7.86
Blacks Bluff[B]	6.72	9.26	7.85

[A] – ADEM Stations
[B] – GAEPD Stations

9.0 SUMMARY AND CONCLUSIONS

The following goals were defined for the hydrodynamic and water quality models for Weiss Lake:

- The model needs to be able to simulate the hydrodynamic conditions in the lake.
- Longitudinal and vertical gradients of temperature affect residual transport; as such, the hydrodynamic model must be able to handle the degree of stratification within the lake.
- The water quality model needs to predict dissolved oxygen (DO) in the Coosa River and the upper lake area (especially around the Georgia-Alabama border).
- The water quality model needs to predict chlorophyll-a at the main stem ADEM monitoring stations.

In general, the models presented within this report meets the goals outlined above.

9.1 Hydrodynamic Calibration

During 2005, the temperature time series comparisons match very well in the upstream part of Weiss Lake, but down by the forebay, the simulated temperatures tend to simulate higher than the measured data. From the State Road 100 station down to Weiss 3, there appears to be a significant temperature load in late August through early October that is not being simulated. Attempts were made during the calibration to look at different solar radiation stations, but this did not help. The only significant point source temperature load, Georgia Power – Hammond Plant, was input with measured data, giving the impression that there is some unknown heat load.

In general, the temperatures profile comparisons look good at all stations. The exception to this is during late August through early October, where the simulated profiles are approximately 2-4°C warmer from Weiss 4 up to Blacks Bluff Road.

From about June through September, the measured temperature profiles show that within the first 10 feet that data show some stratification. This stratification is about 1-3°C. Some of the simulated profiles show this stratification, and other do not, particularly from the Weiss 12 station up to the State Road 100 station.

9.2 Hydrodynamic Validation

During the 2000 simulation, the temperature time series comparisons are under predicting temperatures from the Georgia-Alabama border to Weiss 4. The temperature time series comparisons match well at stations Weiss 2 and Weiss 3. At the forebay (Weiss 1), the simulated temperatures are warmer than the measured data.

The temperature profile comparisons show that the simulated data and the measured data are well mixed.

9.3 Water Quality Calibration

The water quality calibration for Weiss Lake was performed in three parts, 1) nutrients, 2) light extinction, and 3) chlorophyll-a and dissolved oxygen.

For the nutrient calibration, the ammonia and nitrate+nitrite comparisons look very good at all stations. The total phosphorus comparisons look good from the Weiss 3 station up to the Blacks Bluff station. At

Weiss 1 and Weiss 2, the simulated total phosphorus is higher than the measured. The BOD5 comparisons look good at the three GAEPD stations.

The light extinction calibration matches very well at all stations except Weiss 1 and 2. At Weiss 2, the simulated light extinction is low from August through October, and at Weiss 1, the simulated light extinction is generally low. Even though the light extinction comparisons are low at Weiss 1 and 2, they are still in the same range.

The chlorophyll-a comparison at the forebay looks good from April through July, but then under simulates from September through October. The calibration at stations Weiss 2 and Weiss 3 look very good. The chlorophyll-a comparison from station Weiss 4 to the Georgia-Alabama border shows that the model is under simulating. In all of the measured data, there appears to be a late summer bloom of chlorophyll-a. None of the simulated data shows this bloom. This needs to be investigated further.

The dissolved oxygen time series comparisons match very well at the three GAEPD stations. Overall the dissolved oxygen profiles comparisons are similar to the measured profiles. The measured profile data tends to show more stratification than the simulated data, especially at Weiss 2.

9.4 Water Quality Validation

The water quality validation for Weiss Lake focused on getting the right boundary conditions. Unlike 2005, there was not much measured data that could be used to generate inputs. Therefore, the LSPC watershed model was utilized to not only generate all watershed inputs but the upstream boundary (Mayo's Bar) as well.

In reviewing the water quality validation, the water quality model is under predicting chlorophyll-a at Weiss 1 and 2 by 5 to 35 ug/l. The model is indicating that at Weiss 1, chlorophyll-a is being limited by nitrogen. This appeared to be the case when the nitrate+nitrite comparisons were examined, particularly at Weiss 4. Since the majority of the nitrate+nitrate load at Weiss 4 is coming from the upstream boundary, it is believed that the watershed model is under predicting nitrate+nitrite. Therefore, for the water quality validation, the upstream boundary time series was multiplied by 6 to generate a nitrate+nitrite comparison at Weiss 4 that compared well. This needs to be investigated further.

The light extinction validation matches very well at Weiss 4 and is in the same range at Weiss 1, 2, and 3. The ammonia and nitrate+nitrite comparisons are similar at all stations. The total phosphorus comparisons show that the simulated values are generally over predicting more at Weiss 1 than at Weiss 4. This is in part due to the nitrogen limitation on chlorophyll-a.

Overall the dissolved oxygen profiles comparisons are similar to the measured profiles. The measured profile data tends to show more stratification than the simulated data.

10.0 REFERENCES

Adcroft, A. and J.M. Campin, 2004: Rescaled height coordinates for accurate representation of free-surface flows in ocean circulation models. *Ocean Modelling*, **7**, 269-284.

Bennett, A. F., 1976: Open boundary conditions for dispersive waves. *J. Atmos. Sci.*, **32**, 176-182.

Bennett, A. F., and P. C. McIntosh, 1982: Open ocean modeling as an inverse problem: tidal theory. *J. Phys. Ocean.*, **12**, 1004-1018.

Blumberg, A. F., and L. H. Kantha, 1985: Open boundary condition for circulation models. *J. Hydr. Engr.*, **111**, 237-255.

Blumberg, A. F., and G. L. Mellor, 1987: A description of a three-dimensional coastal ocean circulation model. In: *Three-Dimensional Coastal Ocean Models, Coastal and Estuarine Science,* Vol. 4. (Heaps, N. S., ed.) American Geophysical Union, pp. 1-19.

Ezer, T. and G. L. Mellor, 2004: A generalized coordinate ocean model and a comparison of the bottom boundary layer dynamics in terrain-following and in z-level grids. *Ocean Modelling*, **6**, 379-403.

Galperin, B., L. H. Kantha, S. Hassid, and A. Rosati, 1988: A quasi-equilibrium turbulent energy model for geophysical flows. *J. Atmos. Sci.,* **45**, 55-62.

Hamrick, J. M., 1992: A Three-Dimensional Environmental Fluid Dynamics Computer Code: Theoretical and Computational Aspects. The College of William and Mary, Virginia Institute of Marine Science. Special Report 317, 63 pp.

Hamrick, J. M., 1994: Linking hydrodynamic and biogeochemical transport models for estuarine and coastal waters. *Estuarine and Coastal Modeling, Proceedings of the 3rd International Conference*, M. L. Spaulding *et al*, Eds., American Society of Civil Engineers, New York, 591-608.

Johnson, B.H., K.W. Kim, R.E. Heath, B.B. Hsieh, and H.L. Butler, 1993: Validation of three-dimensional hydrodynamic model of Chesapeake Bay. *J.Hyd. Eng.*, **119**, 2-20.

Martin, P. J., 2000: A description of the Navy Coastal Ocean Model version 1.0. Naval Research Laboratory Report NRL/FR?7322-00-9962. Naval Research Laboratory, Stennis Space Center, MS, 42 pp.

Mellor, G.L., and T. Yamada, 1982: Development of a turbulence closure model for geophysical fluid problems. Rev. Geophys. Space Phys., **20**, 851-875.

Mellor, G. L., T. Ezer and L.-Y. Oey, 1994: The pressure gradient conundrum of sigma coordinate ocean models. *J. Atmos. and Oceanic Tech.*, **11**, 1126-1134.

Mellor, G. L., L.-Y. Oey and T. Ezer, 1998: Sigma coordinate pressure gradient errors and the seamount problem, *J. Atmos. Ocean. Tech.*, **15**, 1122-1131.

Smolarkiwicz, P.K., and L.G. Margolin, 1993: On forward-in-time differencing for fluids: extension to a curvilinear framework. Mon. Weather Rev., **121**, 1847-1859.

Stacey, M. W., S. Pond, and Z. P. Nowak, 1995: A numerical model of circulation in Knight Inlet, British Columbia, Canada. *J. Phys. Oceanogr.* **25**, 1037-1062.