Appendix D

HEC-5Q Water Quality Modeling Report

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DRAFT REPORT

HEC-RESSIM AND HEC-5Q SIMULATION OF WATER QUALITY IN THE ALABAMA-COOSA-TALLAPOOSA RIVER BASIN

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1 INTRODUCTION

An HEC-5Q model was developed for the Alabama-Coosa-Tallapoosa (ACT) Basin, in support of the Environmental Impact Statement (EIS) for the Water Control Manual Update Study. The purpose of the HEC-5Q model was to evaluate the impacts of proposed alternative water management plans on long-term, system-wide, stream and reservoir water quality.

The water quality model was created to serve as a defensible screening tool to make relative comparisons of the impacts among various water management alternatives. The central focus of this effort was to enable the EIS team to evaluate the differences in water quality between alternatives over a growing season. The decision to model 70 years of record allows insight regarding the frequency and duration of water quality situations resulting from water management operations. The water quality model was evaluated for the 2000 – 2008 period to best capture the effects of recent population, water usage, and land use on pollution levels. The evaluation also ensured that the model exhibited the tendencies seen in the observed data and that it was sufficient to provide reasonable long-term estimates of water quality through the ACT system. The 2000 – 2008 period encompassed years where hydrologic conditions were representative of “normal” in-stream flows, as well as years with high flow or drought conditions. Point (wastewater) and non-point (tributary streams) inflow quality was developed from database information compiled during this analysis.

Time and budget constraints, the physical and temporal scale of this analysis, and limitations of observed data required simplifying assumptions and methodologies to be adopted, as outlined in the Chapter 2 of this report. HEC-5Q was selected as a logical choice for the water quality model because it is compatible with HEC-ResSim and has been used for previous analyses of the ACT. HEC-5Q was aligned to work seamlessly with the HEC-ResSim model used to evaluate the water management alternatives.

HEC-5Q follows well-known solutions for key water quality values and does not attempt to simulate the concentration changes or transport of every type of constituent. Its one-dimensional nature limits the amount of input data and detail of results at sites. Although these limitations restrict the depth of analysis possible from its results, they also relieve heavy burdens regarding prohibitively long computation time and large input data requirements. The simplified inputs and calculation, and connection to HEC-ResSim, make possible relative comparisons of the water quality impacts of water management alternatives broadly across the basin.

The 1999 Comprehensive Study used HEC-5 to generate the flows that were input into HEC-5Q (HEC, 1999). These were used to model water quality of the streams in the ACT basin, using a daily time step. The current analysis uses ResSim to generate all flows. A “plug-in” was developed to allow HEC-5Q to be operated from ResSim and facilitate input of ResSim-generated flows into the HEC-5Q model.

The HEC-5Q modeling software used for the 1999 EIS was updated to implement a 6-hour time step to capture diurnal variations, which are often important. Then the 1999 HEC-5Q model of the ACT was extended to simulate the reservoirs as well as the rivers. The ACT HEC-5Q model was then adjusted to approximate the 2000 – 2008 observed data, followed by verification with additional observations at key locations.

The revised HEC-5Q model was used to make preliminary observations using present-day water quality loading parameters applied to water levels and flows for four proposed water management alternatives. This work was performed in close coordination with water quality and water management technical staff members from Mobile District, Tetra Tech, the Hydrologic Engineering Center (HEC), and Resource Management Associates (RMA).

Below is a summary of the various model specifics for the current (2001-2008) study.

1.1 DEMONSTRATION OF HEC-5Q MODEL PERFORMANCE

The HEC-5Q water quality models previously developed have been extended and updated. When the original model was developed there were limited data for the reservoirs. For the current qualitative assessment of the water quality model, performed for the period of 2000 – 2008, data are available for all reservoirs except Carters Rereg. Thus the assessment has been extended to the reservoirs. Model coefficients were adjusted so that the temporal and spatial variation of the water quality parameters is reasonably represented.

To ensure a consistent approach across the full time period of the analysis, using a consistent set of model parameters, the HEC-5Q model was adjusted to produce reasonable results under a range of conditions experience over the period of record. Therefore, it is not expected or required that the model will reproduce particular historical observations.

The modeled flows computed by ResSim reasonably approximated the observed flows over the analysis period. However, there were periods where modeled flows did not match observed flows. This is due to required exceptions to normal operations in the field. This analysis did not require that these special operations or conditions be approximated by the model.

Water quality, both modeled and observed, is sensitive to the amount of flow. The hydrology of the ResSim model for Baseline (No Action) conditions was used in the model performance demonstration. The Baseline flows are not historical discharges, and in situations where they differ substantially, it becomes very difficult to make calibration assessments. Furthermore, since the flows associated with observed concentrations do not always closely match the Baseline flows, careful apportioning of the modeled flows is required to avoid unreasonable mass loadings. Because historical data were not used, this effort does not represent a true calibration. Rather, it is an attempt to represent the current operations strategies and reproduce the global response.

Since meteorological data were not available for all locations, and there were data gaps in existing records, extrapolated meteorology was used to drive the water quality model. Only maximum and minimum air temperatures were available for the simulated periods. The extrapolation process used maximum and minimum air temperatures to select meteorological data from the historical record to derive meteorological forcing for each location for the analysis period. While the imposition of a generalized daily meteorological pattern can sometimes interfere with exactly reproducing historical observations, it allows a consistent approach and enables the model to reproduce general trends of the observed data. This process is described in greater detail in Section 2.2.3. With this method, model results were intended to reproduce the general trends in observed data and focus on water quality responses from changes in water management operations rather than changes in the weather.

The daily timestep of the HEC-ResSim model is too coarse for water quality modeling and must be adapted to a shorter interval. The water quality modeling team chose a six hour timestep for the water quality modeling to better capture the water temperature changes throughout a day, while remaining manageable for computing 70 years of record. Shorter computation times allow the flexibility to make incremental improvements to the model and facilitate recomputing the period of record as plan formulations change, which require the water quality to be recomputed with new sets of flows.

For model performance demonstration, the point and non-point water quality described in Sections 2.2.1 and 2.2.2 was assumed. Constituents chosen for presentation of model demonstration results include temperature, dissolved oxygen, nitrate (NO3), ammonia (NH3), phosphate (PO4) and Chlorophyll *a*. Nutrient and Chlorophyll *a* data are typically available at monthly intervals during the spring, summer and fall months (growing season) and represent conditions in the photic zone.

1.2 MODEL LOADINGS

The non-point water quality inputs (tributary streams) to the ResSim/HEC-5Q model were developed from observed data in conjunction with BASINS model loadings that were developed during previous ACT modeling efforts (Tetra Tech, August 1998). The BASINS model computes flow and water quality (BOD, total nitrogen, and total phosphorus) as a function of precipitation, land use, antecedent conditions, and other factors. During that effort, BASINS model outputs were produced using 1995 land use conditions and anticipated 2020 and 2050 land use conditions for the 1984 – 1989 period using that period's precipitation record. The primary use of the BASINS model output was to develop extrapolation functions that relate hydrograph dynamics to concentration. The 2020 BASINS model output was used for developing these functions.

Default loading values were assumed, as outlined below, where these were not available from municipal or industrial dischargers. When point source data were available, these consisted of one value per month. These monthly data provided a seasonal pattern to the inflow quality but day-to-day variations are not captured. Since constant loading values were used instead of time series of the actual values, and modeled instead of observed flows were used as inputs, the HEC-5Q model was not expected or required to replicate individual historic concentration values. Adjusting the model to replicate individual extreme values and particular times and locations can harm the ability of the model to provide reasonable estimates for the majority of time periods throughout the system. Therefore, the focus of this analysis was to achieve reasonable responses over the system for the entire analysis period, using a consistent set of model coefficients.

1.3 ALTERNATIVE OPERATING PLANS

To analyze the range of potential impacts of water allocation, a matrix of alternative flow options, representing a range of high, moderate, and low in-stream flows were examined together under each of four operating plans. These are referred to as:

1. No Action Alternative
2. Plan D
3. Plan F
4. Proposed Action Alternative

1.3.1 NO ACTION ALTERNATIVE

The No Action Alternative (also known as "Baseline") represents current water control operations at each of the projects in the ACT Basin. Baseline flows, however, are not representative of observed flows, due to differences between simulated operations and real operations implemented in the field. A more detailed explanation is given in HEC (2011b). The No Action alternative includes targets to meet minimum in-stream flow requirements on the Alabama River at Claiborne. A minimum environmental target flow of 4640 cfs was established at "JBT Goal," below the confluence of the Coosa and Tallapoosa Rivers, upstream of Montgomery. When the flow meets or exceeds this level, the minimum flow at Claiborne is 6600 cfs. If the flow drops below 4640 cfs at JBT goal, the minimum flow at Claiborne is 4200 cfs.

1.3.2 PLAN D

Plan D includes a navigation operation to support a 9-ft or 7.5-ft channel and drought operations with the revised 20% reduction of 7Q10 flow (4,640 cfs), the DIL calculated semi-monthly, and the USFWS enhancement. The 7Q10 flow is defined as the 7-day average low flow that has a return period of 10 years. Carters operations are changed with a seasonally varying minimum flow requirement, the addition of Zone 2, and a defined guide curve. Allatoona operations are changed with the addition of Zones 3 and 4 and the revised peaking hydropower demand that ranges from 0-4 hours. This alternative uses the Revised Drought Plan with the USFWS enhancement.

1.3.3 PLAN F

Plan F includes a navigation operation to support a 9-ft or 7.5-ft channel and drought operations with the revised 20% reduction of 7Q10 flow (4,640 cfs), the DIL calculated semi-monthly, and the USFWS enhancement. Carters operations are changed with a seasonally varying minimum flow requirement, the addition of Zone 2, and a defined guide curve. Allatoona operations are changed with the addition of Zones 3 and 4 and the revised peaking hydropower demand that ranges from 0-4 hours and the Phased Drawdown guide curve. This alternative uses the Revised Drought Plan with the USFWS enhancement.

1.3.4 PROPOSED ACTION ALTERNATIVE

The Proposed Action Alternative (also known as "RPlan G") alternative includes a navigation operation to support a 9-ft or 7.5-ft channel and drought operations with the revised 20% reduction of 7Q10 flow (4,640 cfs), the DIL calculated semi-monthly, and the USFWS enhancement. Carters operations are changed with a seasonally varying minimum flow requirement, the addition of Zone 2, and a defined guide curve. Allatoona operations are changed with the addition of Zones 3 and 4 and the revised peaking hydropower demand that ranges from 0-4 hours, reduced during September-October period, and the Phased Drawdown guide curve (see ResSim modeling report). This alternative is the same as Plan F, except that it uses the reduction in hydropower from September to October.

1.4 HYDROLOGIC CONDITIONS

To evaluate the effects of the four operating plans on the water quality of the ACT watershed, three types of hydrologic conditions were selected for analysis. The year 2002 was selected to represent normal hydrologic conditions. The year 2003 was selected to represent flood ("wet") conditions. The year 2007 was selected to represent drought ("dry") conditions. These selections were based on an analysis of 2000 – 2008 flow data recorded on the Coosa River at the Alabama-Georgia state line, the Tallapoosa River at JBT Goal, and at ARP. The year 2002 corresponded to the median flow levels, while 2003 and 2007 corresponded to the highest and lowest flow levels, respectively, during the 2000 – 2008 model evaluation period. In addition, the 2001 – 2008 period was summarized, plotting composite longitudinal river profiles of each water quality parameter. These analysis periods are shown in Table 1-1.

Table 1-1 Annual hydrologic conditions evaluated in this analysis, and the year(s) selected from the model results to represent these conditions.

Hydrologic Conditions	Representative Year
Normal	2002
Flood ("Wet")	2003
Drought ("Dry")	2007
Composite	2001 – 2008

Each of these options was evaluated using the HEC-5Q water quality model. The evaluation utilized non-point source pollutant loads developed from observed data in conjunction with BASINS model loadings that were developed during previous ACT modeling efforts (Tetra Tech, August 1998).

1.5 Project Objectives

The purpose of this analysis was to evaluate the impacts of proposed alternative water management plans on long-term, system-wide, stream and reservoir water quality of the ACT river and reservoir system. An HEC-5Q (HEC, 1998) water quality model ACT system was constructed and evaluated to ensure that it exhibited the tendencies seen in the observed data and that it was sufficient to provide reasonable long-term estimates of water quality through the ACT system. The central focus of this effort was to enable the EIS team to evaluate the differences in water quality between alternatives over a growing season. Time and budget constraints, the physical and temporal scale of this analysis, and limitations of observed data required simplifying assumptions and methodologies to be adopted, as outlined in the report. The principal water quality constituents simulated were temperature, ammonia, nitrate, phosphate, phytoplankton (reported as chlorophyll *a*), dissolved oxygen, and 5-day Uninhibited Biochemical Oxygen Demand (BOD5U). In addition, the percentage of flow consisting of municipal or industrial wastewater was modeled. These constituents are consistent with impact assessment guidance from the U.S. Fish and Wildlife Service (USFWS) in their April 2010 Planning Aid Letter (PAL).

1.6 Report Organization

Modifications made in the 1998 version of HEC-5Q, updated from the version described in HEC (1986a), are described in this report. A description of the model is presented in Chapter 2 including a discussion of representation of the physical system with the model, input provided to the model, and water quality constituents simulated. A demonstration of model performance results is presented in Chapter 3. Results of the water quality model runs are presented in Chapter 4. References are provided in Chapter 5.

2 MODEL DESCRIPTION

HEC-5Q, was developed so that temperature and selected conservative and non-conservative constituents could be readily included as a consideration in system planning and management. Using computed reservoir operation and system flows generated by ResSim, the water quality simulation model computes the distribution of temperature and other constituents in the reservoirs and in the associated downstream reaches. For those constituents modeled, the water quality model can be used in conjunction with ResSim to determine concentrations resulting from operation of the reservoir system for flow and storage considerations, or alternately, flow rates necessary to meet water quality objectives.

HEC-5Q can be used to evaluate options for coordinating reservoir releases among projects to examine the effects on flow and water quality at specified locations in the system. Examples of applications of the flow simulation model include examination of reservoir capacities for flood control and hydropower and reservoir release requirements to meet water supply and irrigation diversions. The model may be used in applications including evaluation of in-stream temperatures and constituent concentrations at critical locations in the system or examination of the potential effects of changing reservoir operations or water use patterns on temperature or water quality constituent concentrations. Reservoirs equipped with selective withdrawal structures may be simulated using HEC-5Q to determine operations necessary to meet water quality objectives downstream.

HEC-5Q can be used to simulate concentrations of various combinations of a wide range of water quality constituents. For the ACT analysis, the following parameters were modeled.

- Temperature
- Point source tracer
- Dissolved oxygen
- Ammonia (NH_3) - Nitrogen
- Nitrate (NO_3) – Nitrogen
- Phosphate (PO_4) – Phosphorus
- Phytoplankton – Chlorophyll *a*[1]
- Point source dissolved organics (BOD)
- Non-point source dissolved organics (BOD)
- Particulate Organic Matter (POM)

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[1] The relationship between phytoplankton biomass and Chlorophyll *a* (CHLA) is quite variable by speciation, available light and other environmental factors. All tabular and plot references to phytoplankton or CHLA assume a ratio of 10 ug/L CHLA to 1 mg/L phytoplankton biomass (dry weight). This 1:100 ratio corresponds to a CHLA to carbon ratio of 1:45 assuming a 45% carbon ratio for phytoplankton. Nutrient interactions with phytoplankton assume a chemical composition of 0.01 and 0.08 for phosphorus (P) and nitrogen (N) respectively or CHLA:P and CHLA:N of 1 and 8 respectively. These values are in line with CE-QUAL-R1 (WES, 1986) guidelines.

All of these parameters are assumed passively transported by advection and diffusion. All rate coefficients regulating the parameter kinetics are temperature dependent. A brief description of the processes affecting each of these parameters is provided below. Additional documentation of hydrodynamics, transport and water quality kinetics are presented in various reports (HEC, 1996, 1999 a & b).

Temperature

The external heat sources and sinks that are considered in HEC-5Q are assumed to occur at the air-water interface and with the bed. The exchange with the bed through conductance moderates diurnal temperatures variations. The bed heat capacity is expressed as an equivalent water thickness. The method used to evaluate the net rate of heat transfer utilizes the concepts of equilibrium temperature and coefficient of surface heat exchange. The equilibrium temperature is defined as the water temperature at which the net rate of heat exchange between the water surface and the overlying atmosphere is zero. The coefficient of surface heat exchange is the rate at which the heat transfer process proceeds. All heat transfer mechanisms, except short-wave solar radiation, are applied at the water surface. Short-wave radiation penetrates the water surface and may affect water temperatures several meters below the surface. The depth of penetration is a function of adsorption and scattering properties of the water.

Point Source Tracer

The point source tracer is a tag assigned to all point discharges. A value of 100 is assigned so that the concentration of the tracer translates to the percentage of point discharge water at any location. For this analysis, no distinction is made between the types of point discharges.

Ammonia - Nitrogen

Ammonia is a plant nutrient and is consumed with phytoplankton growth. The remaining ammonia sink is decay. Sources of ammonia include phytoplankton respiration, POM and DOM decay and aerobic and anaerobic release from bottom sediments.

Nitrate - Nitrogen

Nitrate is a plant nutrient and is consumed with phytoplankton growth. The remaining nitrate sink is denitrification associated with suboxic processes. Decay of ammonia provides a source of nitrate (nitrite formation phase is ignored).

Phosphate - Phosphorus

Phosphorus is the third plant nutrient considered in the model and is consumed with phytoplankton growth. Phosphates tend to sorb to suspended solids and are subject to loss by settling. Sources of phosphorus include phytoplankton respiration, POM and DOM decay and aerobic and anaerobic release from bottom sediments.

Phytoplankton – Chlorophyll *a*

Photosynthesis acts as a phytoplankton source that is dependent on phosphate, ammonia, and nitrate. (Carbon limitation was not considered.) Photosynthesis is therefore a sink for these nutrients. Conversely, phytoplankton respiration releases phosphate and ammonia. Phytoplankton is an oxygen source during photosynthesis and an oxygen sink during respiration. Phytoplankton growth rates are a function of the limiting nutrient (or light) as determined by the Michaelis-Menten formulation. Respiration, settling and mortality are phytoplankton sinks.

Dissolved Oxygen

Exchange of dissolved oxygen (DO) at the water surface is a function of the surface exchange (reaeration) rate that is determined by wind speed in reservoirs and hydraulic characteristics in streams. Phytoplankton photosynthesis is a source of DO. Sinks for DO include BOD and ammonia decay, phytoplankton respiration and benthic uptake. Oxygen consumption associated with the decay of DOM and POM is represented by BOD, therefore these parameters are not explicitly linked to DO.

Dissolved organics (BOD)

Dissolved organic material represents all materials that exert an oxygen demand (BOD) during decay and transformation to their chemical components. Thus they contribute to dissolved nitrogen and phosphorus. The dissolved material is subdivided into point and non-point origin to add flexibility in assigning decay rates. It is also a measure of point source influence that considers decay and source quality.

Particulate Organic Matter (POM)

Sources of POM include a component of phytoplankton mortality. POM also exerts an oxygen demand (BOD) during decay and transformation to its chemical components. POM sinks include decomposition to phosphate and ammonia. POM is also subject to settling. Oxygen uptake associated with POM decay is represented by BOD.

2.1 MODEL REPRESENTATION OF THE PHYSICAL SYSTEM

Rivers and reservoirs comprising the ACT system were represented as a network of reservoirs and streams and discretized into sections, as shown in Table 2-1.

Flow and water quality were simulated by ResSim and HEC-5Q respectively. In HEC-5Q, stream elements are assumed well mixed. Stream reaches are typically partitioned into computational elements of approximately one mile or less in length. Because of the simplified geometry, lateral cross-stream variations cannot be evaluated and longitudinal variations are limited to the element length.

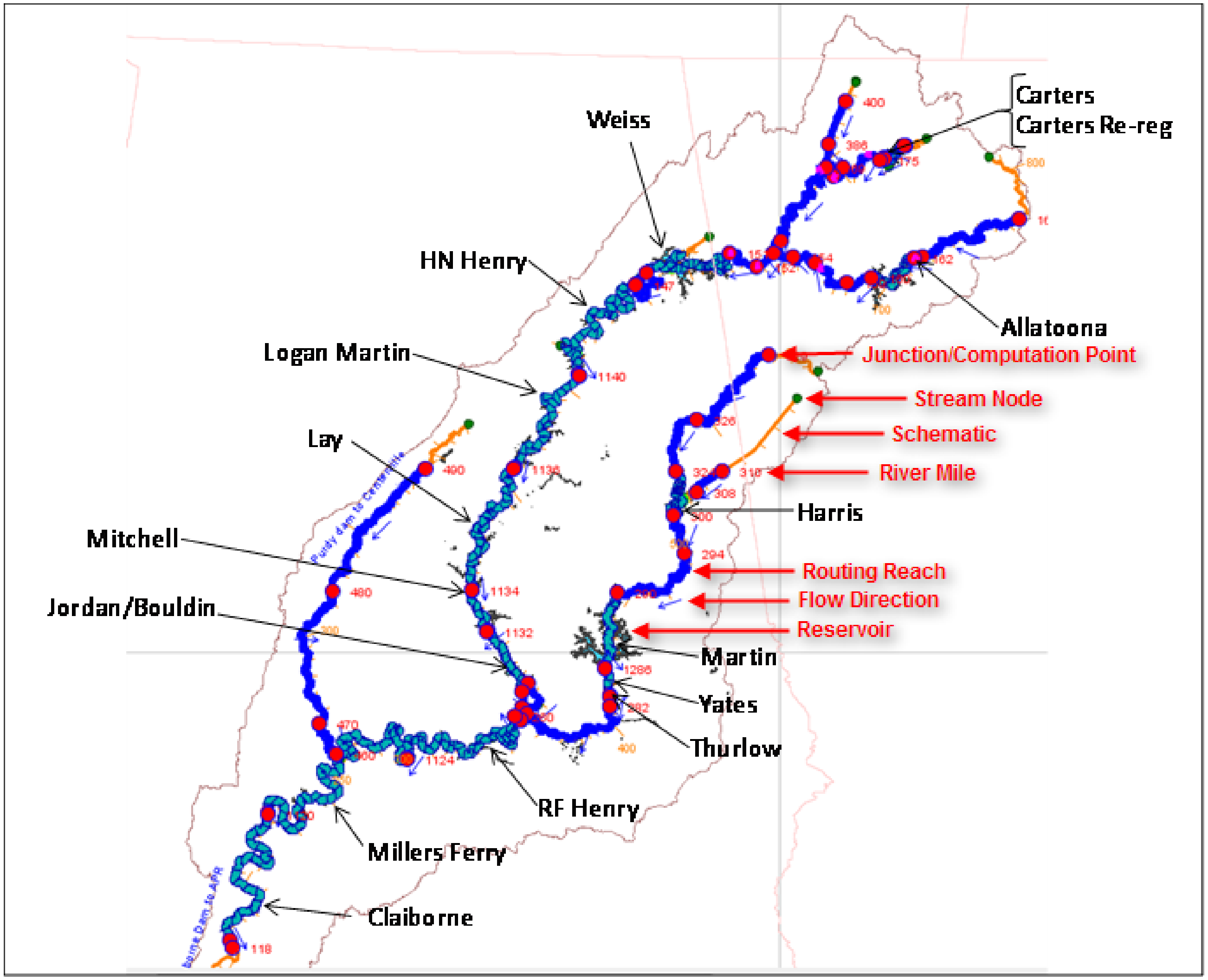

Figure 2-1 HEC-5 and HEC-5Q Model Schematic of ACT Basin showing reservoirs.

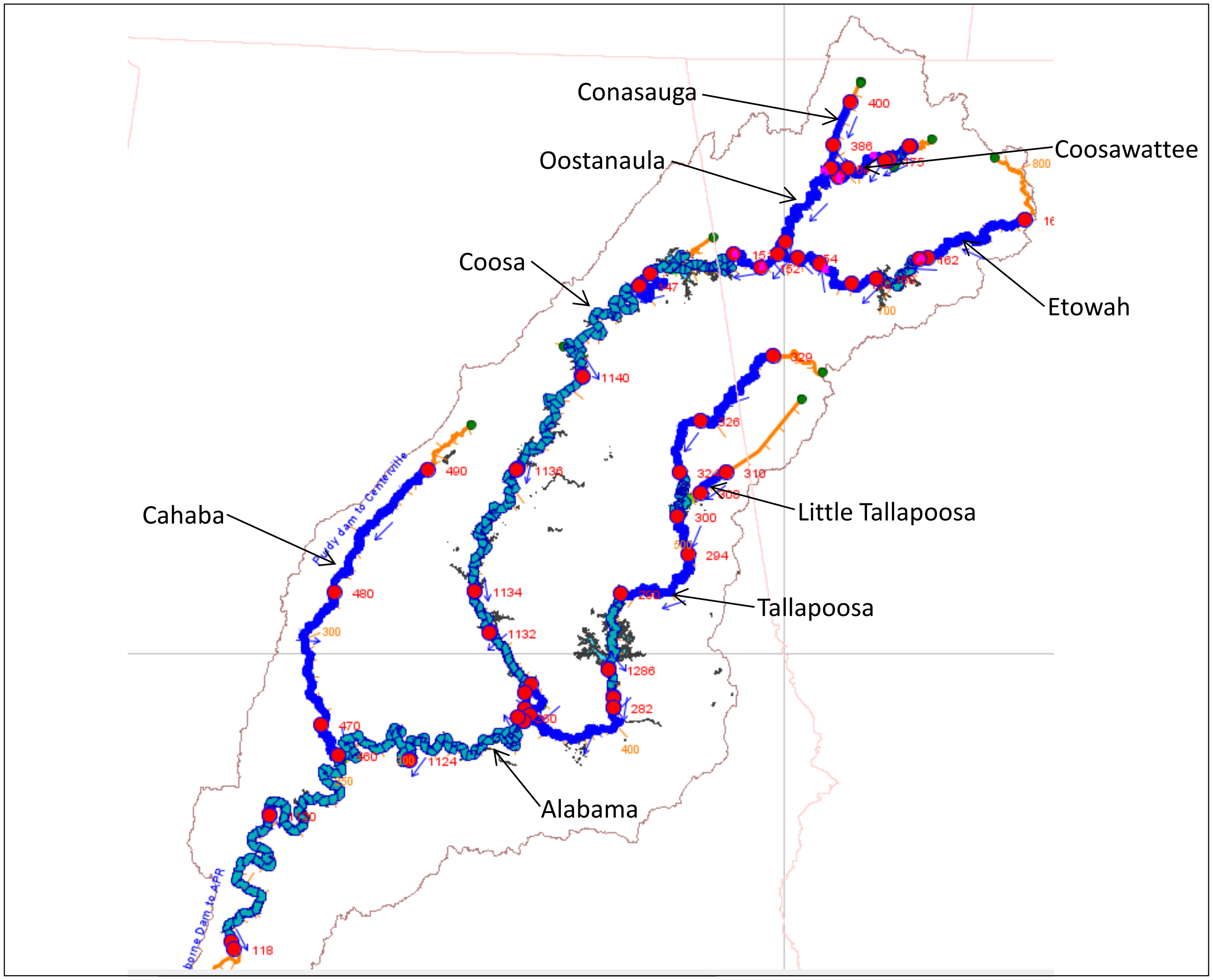

Figure 2-2 HEC-5 and HEC-5Q Model Schematic of ACT Basin showing rivers. See Figure 2-1 for definition of model elements.

2.1.1 MODEL REPRESENTATION OF RESERVOIRS

For water quality simulations, each reservoir was geometrically discretized and represented as either a vertically segmented, longitudinally segmented, or a vertically layered and longitudinally segmented water body. A description of the different types of reservoir representation follows. A list of all reservoirs, the geometric representation, inflows and tributaries is presented as an appendix to this report.

Area-capacity curves come from ResSim output. Other geometry (outlets, etc.) were taken from the 1998 model.

2.1.1.1 Vertically Segmented Reservoirs

Vertically stratified reservoirs are represented conceptually by a series of one-dimensional horizontal slices or layered volume elements, each characterized by an area, thickness, and volume. In the aggregate the assemblage of layered volume elements is a geometrically discretized representation of the prototype reservoir. Within each horizontal layer (or 'element') of a vertically segmented reservoir, the water is assumed to be fully mixed with all isopleths parallel to the water surface both laterally and longitudinally. External inflows and withdrawals occur as sources or sinks within each element and are instantaneously dispersed and homogeneously mixed throughout the layer from the headwaters of the impoundment to the dam. Consequently, simulation results are most representative of conditions in the main reservoir body and may not accurately describe flow or quality characteristics in shallow regions or near reservoir banks. It is not possible to model longitudinal variations in water quality constituents using the vertically segmented configuration.

Vertical advection is one of two transport mechanisms used in HEC-5Q to simulate transport of water quality constituents between elements in a vertically segmented reservoir. Vertical transport is defined as the inter-element flow that results in flow continuity and is calculated as the algebraic sum of inflows to and outflows from each layer beginning with the lowest layer in the reservoir. Any flow imbalance is accounted for by vertical advection into or out of the layer above, a process that is repeated for all layers in the reservoir. At the surface layer, an increase or decrease in reservoir volume accounts for any resulting flow imbalance.

An additional transport mechanism used to distribute water quality constituents between elements is effective diffusion, representing the combined effects of molecular and turbulent diffusion, and convective mixing or the physical movement of water due to density instability. Wind and flow-induced turbulent diffusion and convective mixing are the dominant components of effective diffusion in the epilimnion of most reservoirs.

The outflow component of the model incorporates the selective withdrawal techniques developed by Bohan (1973) for withdrawal through a dam outlet or other submerged orifice, or for flow over a weir. The relationships developed for the 'WES Withdrawal Allocation Method' describe the vertical limits of the withdrawal zone and the vertical velocity distribution throughout the water column. The withdrawal zone limits and the corresponding velocity profile are calculated as a function of the water temperature distribution with depth in a stratified reservoir. In HEC-5Q, the approach velocity profile is approximated as an average velocity in each layer just upstream of a submerged weir or a dam with a submerged orifice. The computed velocity distribution is then used to allocate withdrawals from each layer. Detailed descriptions of the WES Withdrawal Allocation Method and weir formulation are provided in the HEC-5 Appendix on Water Quality (HEC, 1998).

Carters, Allatoona, Harris and Martin Lakes are examples of vertically segmented reservoirs in the ACT model.

2.1.1.2 Longitudinally Segmented Reservoirs

Longitudinally segmented reservoirs are represented conceptually as a linear network of a specified number of segments or volume elements. Length and the relationship between width and elevation characterize the geometry of each reservoir segment. The surface areas, volumes and cross-sections are computed from the width relationship. Longitudinally segmented reservoir may be subdivided into vertical elements with each element assumed fully mixed in the vertical and lateral directions. Branching of reservoirs is allowed. For reservoirs represented as layered and longitudinally segmented, all cross-sections contain the same number of layers and each layer is assigned the same fraction of the reservoir cross-sectional area. The model performs a backwater computation to define the water surface profile as a function of the hydraulic gradient based on flow and Manning's equation.

External flows such as withdrawals and tributary inflows occur as sinks or sources. Inflows to the upstream ends of reservoir branches are allocated to individual elements in proportion to the fraction of the cross-section assigned to each layer. Other inflows to the reservoir are distributed in proportion to the local reservoir flow distribution. External flows may be allocated along the length of the reservoir to represent dispersed, or non-point, source inflows including agricultural drainage or groundwater accretions.

The longitudinally segmented reservoirs of the ACT contain up to eight layers. The layered representation was utilized for all reservoirs that had the potential for both horizontal and vertical gradients in flow, temperature and water quality.

Vertical variations in constituent concentrations are computed for each cell of the layered and longitudinally segmented reservoir model. Mass transport between vertical layers is represented by net flow determined by mass balance and by diffusion.

Vertical flow distributions at dams are based on weir or orifice withdrawal. The velocity distribution within the water column is calculated as a function of the water density and depth using the WES weir withdrawal or orifice withdrawal allocation method. HEC-5Q uses an elemental average of the approach velocity for each layer in the reservoir.

A uniform vertical flow distribution is specified at the upstream end of each reservoir and at any intermediate location. Linear interpolation of flow is performed for reservoir segments without specifically defined flow fields (e.g., interpolation between flows at the dam face and the defined intermediate location).

Table 2-1 summarizes the discretization of all reservoirs in the ACT model, listing the number of segments and layers in each longitudinally segmented reservoir and the layer thickness of each vertically segmented reservoir.

Table 2-1 Summary of reservoir discretization.

***River*/Reservoir**	**Reservoir Type**	**# of Segments/ Layer Thickness (ft)**	**# of Layers**
Etowah River			
Allatoona	Vertical	3’	varies
Coosawattee River			
Carters	Vertical	3’	varies
Carters re-reg	Longitudinal	6	1
Coosa River			
Weiss	Branched Longitudinal	28	8
H. N. Henry	Branched Longitudinal	27	5
Logan Martin	Longitudinal	21	5
Lay	Longitudinal	23	5
Mitchell	Longitudinal	7	5
Jordan/Bouldin	Longitudinal	7	5
Tallapoosa River			
Harris	Vertical	3’	varies
Martin	Vertical	3’	varies
Yates	Longitudinal	4	4
Thurlow	Longitudinal	2	4
Alabama River			
R. F. Henry	Longitudinal	30	5
Millers Ferry	Branched Longitudinal	40	5
Claiborne	Longitudinal	19	5

2.1.2 MODEL REPRESENTATION OF STREAMS

In HEC-5Q, a reach of a river or stream is represented conceptually as a linear network of segments or volume elements. Each element is characterized by its length, width and cross-sectional area as a function flow and depth. Stream flow, diversion and incremental inflow rates are provided by ResSim at stream control points. The total incremental local inflow is divided into components and placed at the actual inflow locations of the non-point (tributary) inflow. The diversion defined by ResSim represents the net point inflow above the control point. The individual point inflows and withdrawals are assigned to the location of the discharge or diversion. A flow balance is used to determine the flow rate at element boundaries. Once inter-element flows are established, the water depth, surface width and cross sectional area are defined at each element boundary as a function of the user specified flow-depth relationship. A list of all stream reaches and point and non-point source inflows and water quality is provided in the appendix in Table A-1 (tributaries) and Table A-2 (municipal and industrial discharges).

2.2 WATER QUALITY BOUNDARY CONDITIONS AND INPUT DATA

HEC-5Q requires that in-stream flows, tributary flows and water quality, withdrawals, reservoir operations, and other point and non-point source flows and water quality loads to the system be specified for simulation of water quality.

ResSim incremental inflows are determined by difference from available and/or synthesized river flows, reservoir operation and point source inflows. This process may result in computed inflows that are negative. This approach assumes that the observed/synthesized flows are the best depiction of historical inflow conditions. Negative inflows do not present a problem for ResSim.

Negative inflows are a problem, however, from a water quality perspective in that the inflow quality must be defined while the negative inflow removes ambient water quality. As an example, if a -100 cfs is followed by a +100 cfs to represent an inflow of near zero, an artificial tributary load is introduced on the +100 cfs day. To mitigate this affect, the water quality load is computed from an inflow rate that is constrained as positive. An example of 7-day average (with negative flows) and constrained Weiss reservoir inflows is provided in Figure 2-3, with a detail view of 2001 in Figure 2-4. In some instances, the constrained inflow is developed by aggregating two or more sets of ResSim incremental inflows. The rate of decrease is further limited to 67% of the previous day's flow. Residual negative inflows are allocated to future positive inflow. Aggregation is done when adjacent control points have erratic local flows or when one of the local flows has extensive negative inflows. An example of this approach is shown in Figure 2-5 where the inflow to H. Neely Henry (H. N. Henry) has extensive negative inflow periods. The inflows to HN Henry and Logan Martin are combined and then constrained to the 67% decrease. The scaled flows are then allocated to individual tributaries proportional to tributary inflow as computed by BASINS.

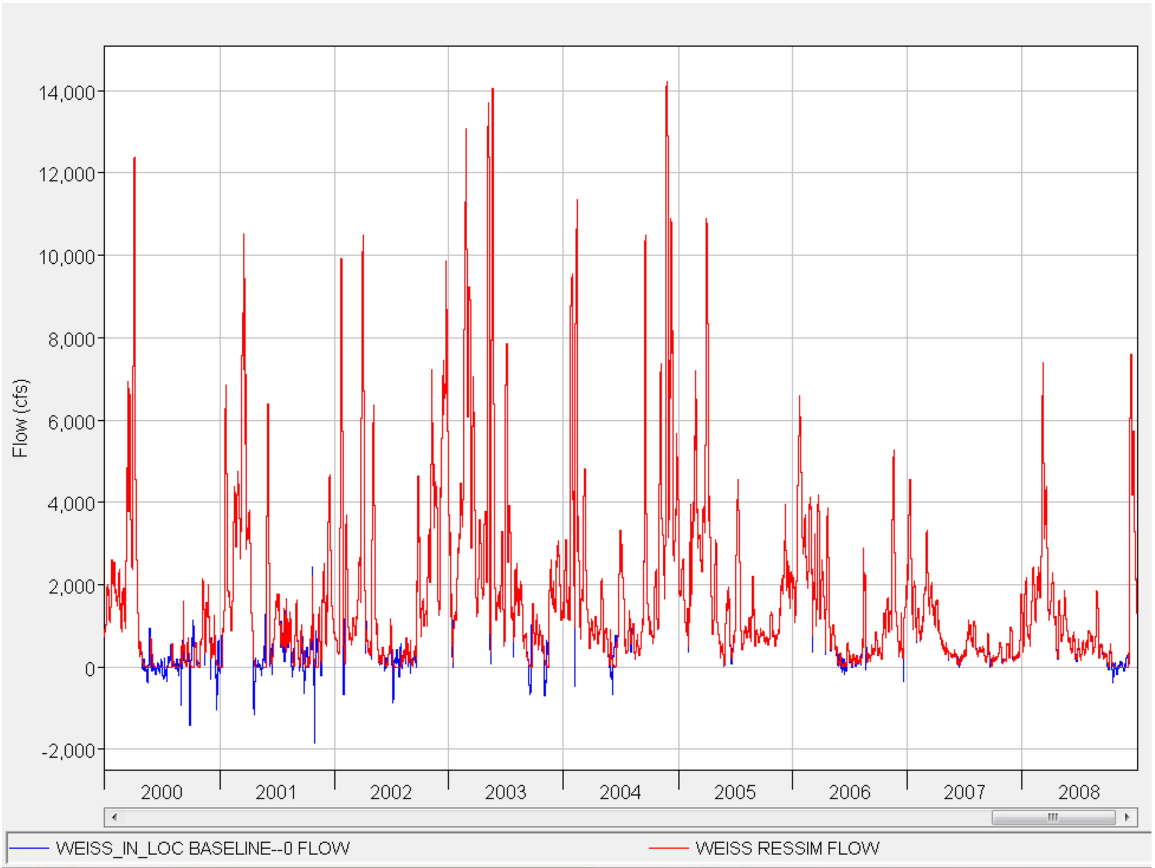

Figure 2-3 Comparison of 7-day average and constrained Weiss reservoir inflows.

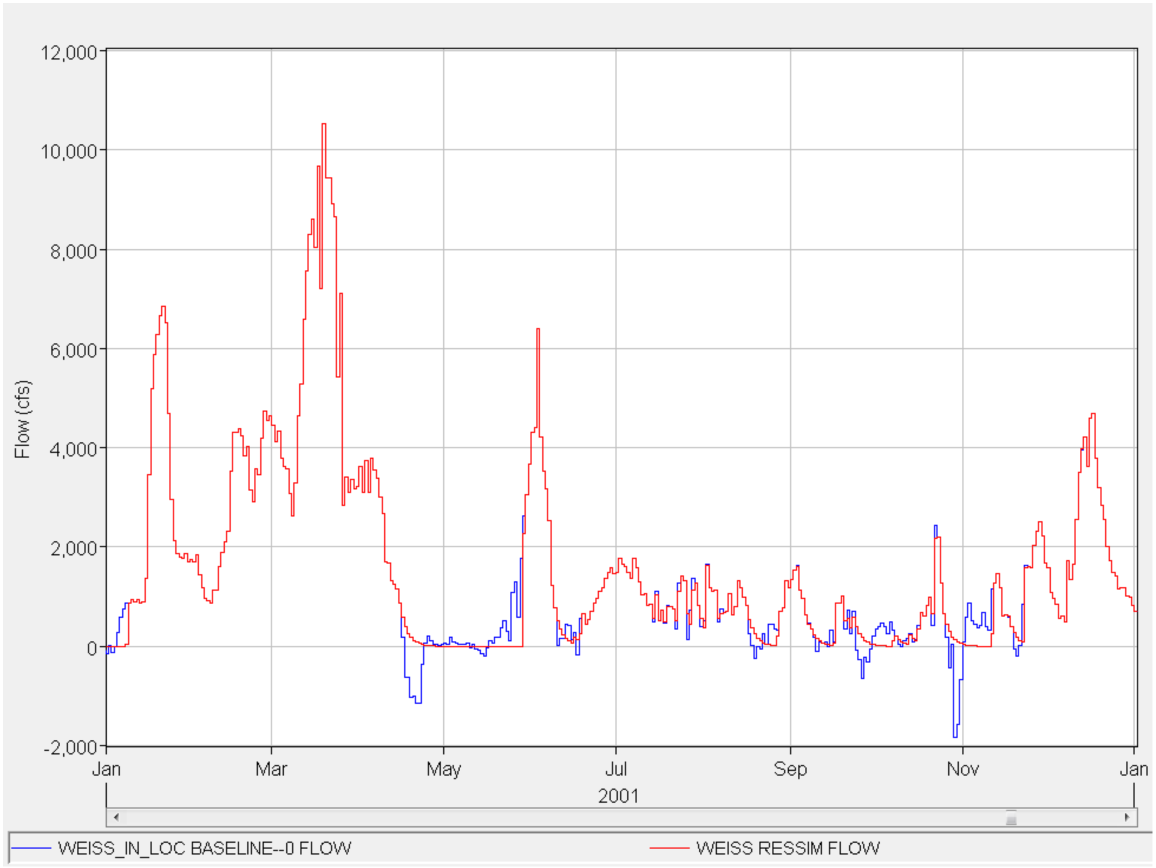

Figure 2-4 Comparison of 7-day average and constrained Weiss reservoir inflows (detail view of 2001).

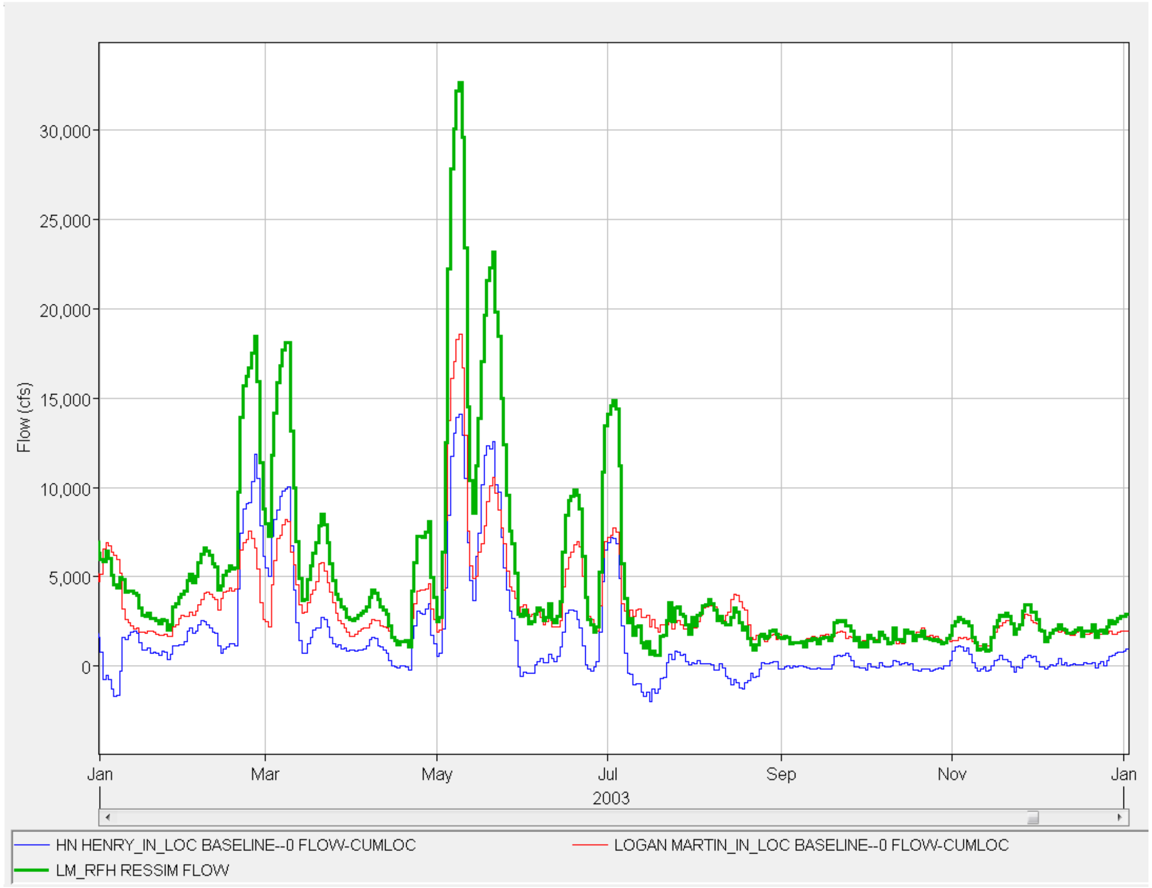

Figure 2-5 Inflows to H. N. Henry reservoir (blue) and Logan Martin reservoir (red) and combined and constrained H. N. Henry and Logan Martin ResSim flows (green).

2.2.1 NON-POINT SOURCE FLOW AND WATER QUALITY DATA

The non-point (tributary streams) water quality inputs to the ResSim/HEC-5Q model were developed from observed data in conjunction with BASINS model loadings that were developed during previous ACT modeling efforts (Tetra Tech, August 1998). The BASINS model computes flow and water quality (BOD, total nitrogen, and total phosphorus) as a function of precipitation, land use, antecedent conditions, and other factors. During that effort, BASINS model outputs were produced for the 1984 – 1989 period using that period's precipitation record, in conjunction with 1995 land use conditions and anticipated 2020 and 2050 land use conditions The primary use of the BASINS model output was to develop extrapolation functions that relate hydrograph dynamics to concentration. The 2020 BASINS model output was used for developing these functions. Output for 200 ACT BASINS watersheds was available. These watersheds were consolidated to define 102 non-point tributary inflows for the current HEC-5Q modeling effort. The watersheds/stream names and corresponding stream / inflow locations are listed in the appendix (Table A-1).

ResSim-computed flows for the 1939 – 2008 period were utilized. The tributary flows and water quality computed by BASINS for the 1984 – 1989 period served as a basis for estimating the response of water quality parameters to tributary stream flow dynamics and for extrapolating a comparable record for the 1939 – 2008 ResSim simulation period.

The intent of the extrapolation was to establish the shape of the water quality response to flow. The extrapolation assumed that the inflowing concentration is influenced by the rate of change in flow. On the rising hydrograph, the concentration was computed as:

$$C = C_o + K_1 * (\log Q_t - \log Q_{t-1})$$

- C = Concentration
- C_o = Minimum concentration
- K_1 = Scaling factor
- Q_t = Flow for current day
- Q_{t-1} = Flow for previous day

On the falling hydrograph, the concentration was computed as a fraction of the previous day's concentration. For example:

$$C = C_o + K_2 * (C_{t-1} - C_o)$$

- C = Concentration
- C_o = Minimum concentration
- K_2 = Scaling factor
- C_{t-1} = Concentration for previous day

The extrapolated water quality was computed as a function of ResSim based flows to align the inflow concentration with the ResSim inflow hydrographs. The C and K values were selected such that the concentration range, magnitude and response to flow dynamics were in line with those predicted by the BASINS model.

Water quality field data for eight tributaries to the upper ACT Basin Rivers were compared with the BASINS-based water quality for the 2000 – 2008 period. The fraction of total nitrogen allocated to nitrate and ammonia was based on these observations.

Tributaries to the upper ACT:

- Mountaintown Creek (15)[2]
- Armuchee Creek (25)
- Shoal Creek (6)
- Little River (8)
- Raccoon Creek (11)
- Euharlee Creek (12)
- Beech Creek (27)
- Chattooga River (30)

The observed data for these tributaries include the following water quality parameters:

- BOD5U: 5-Day uninhibited BOD
- DO: Dissolved Oxygen
- NH3: Ammonia -nitrogen
- NO2NO3: Nitrite + Nitrate-nitrogen
- TOTALP: Total Phosphorus
- SOLIDTSS: Suspended Solids (POM)
- TEMP: Temperature
- Chlorophyll *a*

Table 2-2 provides a summary of available observed data, including number of samples and average, maximum, minimum and median values for the above listed tributaries and parameters. The ratio of average to the median value is also included to identify those parameters where the average is overly weighted by a few extreme measurements. Parameters such as PO4-P and TSS (POM) are examples of parameters where the average concentration is elevated relative to the median value. The sample weighted averages for the eight tributaries is also included. Average tributary stream inputs to the model are provided in Table 2-3. Full tables of maximum, minimum and average values can be found in the appendix in Table A-1. Non-point flow allocation percentages and point discharge rates are shown in Figure 2-6.

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[2] The numbers in parentheses correspond to the tributary numbers within the HEC-5Q data set.

Table 2-2 Summary of available observed data for inflow water quality.

	BOD5U (mg/L)	OXYGEN (mg/L)	NH3-N (mg/L)	NO2+NO3-N (mg/L)	Total P (mg/L)	TSS (POM) (mg/L)	Temp. (C)	Chlorophyll *a* (ug/L)
Mountaintown Creek at State Road 282 (US Hwy 76) near Ellijay, Ga.								
Samples	94	147	79	91	89	65	147	18
Avg	1.50	10.14	0.033	0.110	0.052	16.00	14.44	2.63
Min	0.10	7.64	0.010	0.040	0.012	1.00	2.40	0.80
Max	2.85	14.32	0.100	0.260	0.720	506.00	25.99	9.70
Median	2.00	9.88	0.030	0.101	0.020	6.00	15.08	2.10
Avg/Median	1.33	0.98	0.919	0.921	0.381	0.38	1.05	0.80
Armuchee Creek at Old Dalton Road near Rome, Ga.								
Samples	43	62	35	35	35	37	62	15
Avg	1.18	8.18	0.035	0.253	0.031	15.47	19.81	3.41
Min	0.00	6.06	0.010	0.050	0.020	1.00	4.80	1.00
Max	7.38	24.57	0.120	0.980	0.185	130.00	27.10	21.10
Median	0.83	7.56	0.030	0.240	0.020	11.50	21.86	1.90
Avg/Median	0.70	0.92	0.853	0.947	0.645	0.74	1.10	0.56
Shoal Creek at State Road 108 (Fincher Rd.) near Waleska, Ga.								
Samples	91	156	76	88	87	59	156	18
Avg	1.41	9.37	0.036	0.154	0.043	13.91	14.79	2.52
Min	0.10	5.67	0.010	0.020	0.015	1.00	2.02	0.70
Max	3.50	13.60	0.100	0.320	0.700	362.00	25.54	5.60
Median	1.45	9.21	0.030	0.170	0.020	5.00	15.10	2.20
Avg/Median	1.03	0.98	0.823	1.105	0.462	0.36	1.02	0.87
Little River at Georgia Highway 5 near Woodstock, Ga.								
Samples	91	156	76	88	86	91	156	18
Avg	1.65	8.88	0.113	0.843	0.080	25.83	15.73	3.59
Min	0.10	5.50	0.020	0.100	0.020	1.00	1.90	1.30
Max	6.30	13.20	0.530	6.800	0.660	240.00	25.90	11.90
Median	1.85	8.70	0.076	0.430	0.060	14.00	16.40	2.80
Avg/Median	1.12	0.98	0.672	0.510	0.750	0.54	1.04	0.78
Raccoon Creek at State Road 113 near Stilesboro, Ga.								
Samples	12	45	12	12	12	12	45	1
Avg	0.53	7.92	0.025	0.415	0.026	14.50	18.49	2.00
Min	0.20	5.40	0.010	0.160	0.020	1.00	4.10	2.00
Max	1.20	12.10	0.030	0.540	0.080	100.00	25.93	2.00
Median	0.40	7.54	0.030	0.450	0.020	7.00	19.52	2.00
Avg/Median	0.75	0.95	1.200	1.084	0.774	0.48	1.06	1.00

Euharlee Creek at County Road 32 near Stilesboro, Ga.								
Samples	42	35	36	36	36	37	35	14
Avg	1.09	8.14	0.038	0.690	0.116	24.38	18.28	2.41
Min	0.30	6.70	0.010	0.236	0.020	3.00	8.10	0.70
Max	2.85	10.30	0.160	1.440	0.410	112.00	24.14	11.30
Median	0.98	7.90	0.030	0.660	0.100	15.50	19.72	1.50
Avg/Median	0.90	0.97	0.794	0.957	0.859	0.64	1.08	0.62
Beech Creek at Mays Bridge Road SW near Rome, Ga.								
Samples	64	68	48	56	57	58	68	12
Avg	1.48	5.44	0.043	0.150	0.037	9.85	18.47	3.36
Min	0.00	2.14	0.018	0.020	0.019	1.00	7.80	1.10
Max	5.14	10.20	0.110	0.303	0.120	36.00	25.13	6.90
Median	1.29	5.20	0.032	0.150	0.028	9.50	19.62	2.50
Avg/Median	0.87	0.96	0.746	1.003	0.756	0.97	1.06	0.74
Chattooga River at Holland-Chattoogaville Road (FAS1363) near Lyerly,								
Samples	90	156	76	90	88	91	157	24
Avg	1.78	8.60	0.065	0.421	0.266	16.77	17.23	3.49
Min	0.36	4.40	0.020	0.050	0.020	2.50	3.90	0.70
Max	3.91	15.85	0.370	1.160	0.950	94.00	29.59	11.10
Median	2.00	8.34	0.050	0.410	0.210	12.50	18.00	2.60
Avg/Median	1.13	0.97	0.775	0.974	0.790	0.75	1.05	0.75
Sample Weighted								
Samples	527	825	438	496	490	450	826	120
Avg	0.00	0.00	0.000	0.000	0.000	0.00	0.00	0.00
Min	0.00	0.00	0.000	0.000	0.000	0.00	0.00	0.00
Max	0.00	0.00	0.000	0.000	0.000	0.00	0.00	0.00
Median	0.00	0.00	0.000	0.000	0.000	0.00	0.00	0.00
Avg/Median	0.00	0.00	0.000	0.000	0.000	0.00	0.00	0.00

Table 2-3 Summary of average inflow and quality for tributaries.

Location	Flow (cfs)	Temp (C)	NO3-N (mg/L)	PO4-P (mg/L)	Chlorophyll a (mg/L)	NH3-N (mg/L)	DO (mg/L)	diss. org (mg/L)	org solids (mg/L)
upstream Etowah R.	98.0	17.6	0.189	0.017	0.000	0.018	8.44	2.01	1.18
Amicaloa Cr.	96.0	17.6	0.200	0.017	0.000	0.019	8.43	2.02	1.27
Settingdown Cr.	173.7	17.6	0.232	0.018	0.000	0.022	8.43	2.02	1.27
Long Swamp Cr.	263.7	17.6	0.227	0.018	0.000	0.021	8.43	2.02	1.25
Mountain Cr.	372.7	17.6	0.236	0.019	0.000	0.022	8.43	2.03	1.32
Shoal Cr.	30.2	17.6	0.202	0.018	0.000	0.019	8.38	2.04	1.35
Noonday & Allatonna Cr.	147.0	17.6	0.283	0.025	0.000	0.025	8.38	2.23	1.80
Little R.	231.0	17.6	0.282	0.026	0.000	0.025	8.38	2.23	1.80
Pumpkinvine Cr.	107.4	17.6	0.330	0.017	0.000	0.019	8.43	2.02	1.28
Pettit Cr.	188.4	17.6	0.440	0.019	0.000	0.024	8.43	2.03	1.36
Raccoon Cr.	226.1	17.6	0.435	0.019	0.000	0.023	8.43	2.03	1.37
Euharlee Cr.	366.5	17.6	0.438	0.018	0.000	0.023	8.43	2.02	1.32
Two Run Cr.	77.0	17.6	0.437	0.018	0.000	0.023	8.43	2.01	1.24
Dikes Cr.	133.7	17.6	0.446	0.018	0.000	0.024	8.43	2.01	1.23
Coosawattee R.	616.2	17.6	0.182	0.016	0.000	0.018	8.43	2.01	1.23
Talking Rock Cr.	195.9	17.6	0.250	0.021	0.000	0.023	8.43	2.06	1.48
Salacoa Cr.	296.3	17.6	0.257	0.052	0.000	0.024	8.43	2.06	1.34
Conasauga R	255.6	17.6	0.258	0.024	0.000	0.024	8.43	2.04	1.28
Coahulla R.	265.8	17.6	0.346	0.037	0.000	0.030	8.43	2.20	1.61
Holly Cr.	468.5	17.6	0.319	0.035	0.000	0.028	8.43	2.24	1.68
Polecat Cr.	47.4	17.6	0.248	0.020	0.000	0.023	8.43	2.10	1.43
Oostanaula Tribs.	97.1	17.6	0.275	0.020	0.000	0.025	8.43	2.09	1.40
Oothkalooga Cr.	70.7	17.6	0.302	0.021	0.000	0.027	8.43	2.09	1.59
Johns Cr.	66.3	17.6	0.278	0.019	0.000	0.025	8.43	2.04	1.43
Armuchee Cr.	205.2	17.6	0.254	0.018	0.000	0.023	8.43	2.03	1.34
Silver Cr.	221.5	17.6	0.440	0.019	0.000	0.024	8.43	2.03	1.38
Coosa R. Tribs	16.0	17.6	0.274	0.020	0.000	0.025	8.43	2.11	1.59
Big Cedar Cr.	178.6	17.6	0.253	0.017	0.000	0.023	8.43	2.07	1.35
Spring Cr.	267.9	17.6	0.257	0.017	0.000	0.023	8.43	2.07	1.36
Chattooga R.	520.2	17.6	0.247	0.017	0.000	0.023	8.43	2.06	1.33
Weiss Lake	702.3	17.6	0.241	0.017	0.000	0.022	8.43	2.05	1.29
Terrapin Cr.	177.8	17.6	0.242	0.016	0.000	0.022	8.43	2.01	1.33
Big Willis Cr.	350.0	17.6	0.243	0.016	0.000	0.022	8.43	2.01	1.36
Big Canoe Cr.	516.3	17.6	0.237	0.015	0.000	0.022	8.43	2.00	1.31
Beaver Cr.	554.7	17.6	0.235	0.015	0.000	0.022	8.43	2.00	1.30
Ohatchee Cr.	174.5	17.6	0.183	0.015	0.000	0.018	8.43	2.00	1.17
Cane Cr.	251.4	17.6	0.182	0.015	0.000	0.018	8.43	2.00	1.19
Broken Arrow Cr.	366.4	17.6	0.175	0.015	0.000	0.017	8.43	2.00	1.17
Choccolocco Cr.	895.5	17.6	0.181	0.015	0.000	0.018	8.43	2.00	1.19
Kelley Cr.	85.7	17.6	0.225	0.017	0.000	0.021	8.43	2.06	1.31
Talladega Cr.	204.9	17.6	0.236	0.017	0.000	0.022	8.43	2.07	1.38
Upper Yellowleaf Cr.	284.3	17.6	0.230	0.017	0.000	0.021	8.43	2.07	1.34
Peckerwood Cr.	331.4	17.6	0.235	0.017	0.000	0.022	8.43	2.07	1.35
Waxahatchee Cr.	414.3	17.6	0.229	0.017	0.000	0.021	8.43	2.07	1.36
Lower Yellowleaf Cr.	59.1	17.6	0.170	0.016	0.000	0.017	8.43	2.03	1.19
Walnut Cr.	509.3	17.6	0.172	0.016	0.000	0.017	8.43	2.04	1.21
Chestnut Cr.	154.9	17.6	0.186	0.015	0.000	0.018	8.43	2.02	1.13
Weoka Cr.	398.4	17.6	0.176	0.015	0.000	0.018	8.43	2.02	1.12
Tallapoosa R.	162.6	17.6	0.245	0.019	0.000	0.023	8.43	2.03	1.39
Little Cr.	38.9	17.6	0.262	0.020	0.000	0.024	8.43	2.04	1.41

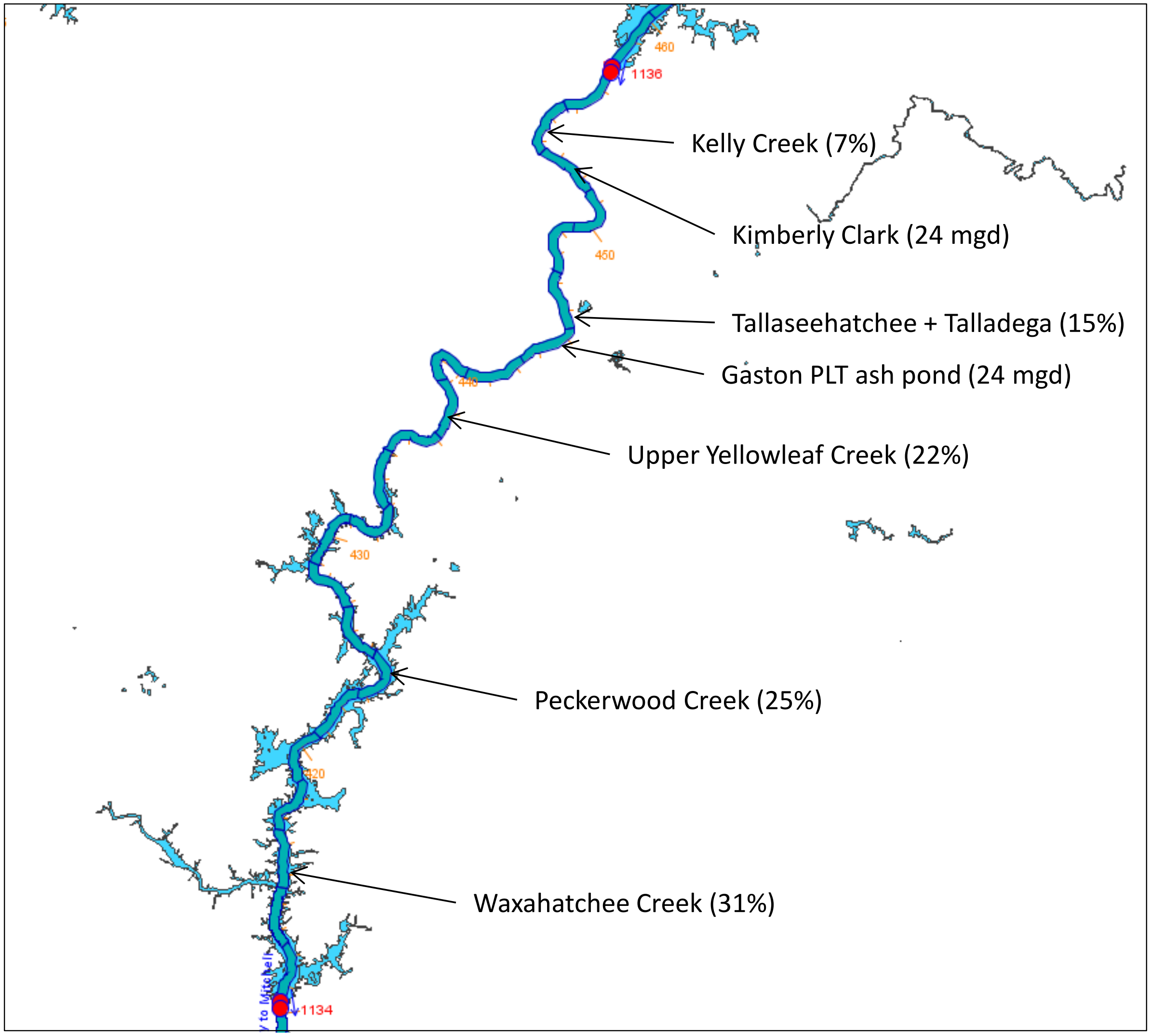


Figure 2-6 HEC-5 and HEC-5Q Model Schematic of Lay Reservoir with inflows. Non-point flow allocation percentages and point discharge rates are indicated.

2.2.2 POINT SOURCE FLOW AND WATER QUALITY DATA

Point source inflows represent non tributary inflows and include municipal and industrial discharges and cooling water returns. Agricultural returns and groundwater inflows were not considered. Discharge rate and water quality were defined seasonally for each discharge where sufficient data were available

The seasonal discharge rates and quality were based on point source discharge data provided by Tetra Tech for the 2000 – 2008 period. Monthly average flow and quality characteristics were defined as the average of all the available measurements without regard to the time of month.

If insufficient data were available, default values or relationships between parameters were used. The following assumptions were used for those discharges and parameters that could not be defined monthly.

- Temperature - Available water temperature data were used to develop a relationship with equilibrium temperature that defined daily average inflow temperature.

- Dissolved oxygen – a uniform concentration ranging from of 5 mg/L for BOD < 10 mg/L to 2 mg/L for BOD > 50 mg/L.

- Total Nitrogen (municipal) – A uniform NO3-N concentration of 10 mg/L was specified for advanced treatment facilities. Smaller NO3-N and larger NH3-N concentrations were assumed for plants without nitrification.

- Total Nitrogen (Industrial) – Uniform NO3-N and NH3-N concentrations were assigned based on the industry. Of special interest is the NH3-N concentration of 4 mg/L assigned for pulp mills. This value is considered conservative and results in elevated ammonia levels in the model predictions. Sensitivity to pulp mill NH3 is evaluated in Chapter 3.

- Total Phosphorus – A uniform concentration of 0.7 mg/L was assigned to Georgia dischargers and discharger specific concentrations were assigned for Alabama dischargers.

Observed BOD data were used as inputs to the model at municipal and industrial discharge locations, where available, to represent the total dissolved organic material (BOD*2.5). Where measured BOD datra were not available, TSS (Total Suspended Solids) measurements were generally available. The organic fraction of TSS measured at these locations is large enough that TSS and POM (Particulate Organic Matter) are approximately equivalent, indicating that a strong relationship exists between these TSS measurements and BOD. Regression analysis of the BOD and TSS (POM) data recorded at municipal and industrial sites showed that BOD is significantly correlated with TSS (POM) at these locations. For both municipal and industrial dischargers, BOD was estimated as the equivalent of TSS (POM). Furthermore, the TSS:BOD relationship was primarily applied to small discharge sites (flows less than 5 MGD), which have a minor impact on the system. There were 9 dischargers with permitted flows greater than 5 MGD and 6 dischargers with flows greater than 10 MGD. For flows greater than 5 MGD, 82% of reported measurements (255 out of 311) contained BOD. For flows greater than 10 MGD, 93% of reported measurements (216 out of 232) had BOD. The remainder of these measurements contained TSS (POM) only. The BASINS model provided the organic matter values for the tributary streams.

Average point-source inputs are summarized in Table 2-4. Full tables of maximum, minimum, and average values can be found in the appendix in Table A-2. Analysis of the observed data indicates that there is an unidentified source of approximately 750 lb/day of NO_3-N near river mile 675 on the Etowah River. This assessment is based on the greatly increased measured NO_3-N concentrations between this location and the nearest upstream measuring site. Therefore, the 750 lb/day source was added to the model at Etowah River mile 675, as shown in Figure 2-7. This corresponds to a concentration of 90 mg/L at 1 MGD (1.547 cfs), as listed in Table 2-4.

Table 2-4 Summary of average point source inflow and quality for municipal and industrial discharges[3].

Location	Flow (cfs)	Temp (C)	NO3-N (mg/L)	PO4-P (mg/L)	Chlorophyll *a* (ug/l)	NH3-N (mg/L)	DO (mg/L)	diss. org (mg/L)	org solids (mg/L)
Cartersville WPCP	13.0	21.6	10.000	3.720	0.000	1.336	3.92	17.16	9.55
Calhoun WPCP	11.5	21.6	10.000	3.720	0.000	0.566	4.66	26.36	16.58
City of Chatsworth	2.2	21.6	10.000	3.720	0.000	0.312	6.37	7.20	4.27
Cobb County Noonday Cree	15.1	21.6	10.000	0.264	0.000	0.155	6.43	3.75	1.39
Canton WPCP	2.4	21.6	10.000	4.605	0.000	2.426	4.37	16.25	11.13
Cherokee County Rose Cre	5.9	21.6	10.000	0.175	0.000	0.381	5.75	6.25	2.07
Cobb County Northwest WP	10.7	21.6	10.000	0.102	0.000	0.106	6.52	2.50	1.06
Inland Paperboard	35.1	21.6	1.000	0.300	0.000	4.000	3.90	41.33	94.05
Etowah River mile 675 NO3-N Source	1.5	-	*90	-	-	-	-	-	-
Rome WPCP	16.9	21.6	10.000	2.085	0.000	0.439	4.69	14.35	7.03
Rome - Coosa WPCP	1.3	21.6	10.000	1.524	0.000	0.204	5.45	2.68	3.51
Gadsden East WWTP	4.9	21.6	2.945	2.220	0.000	8.863	3.90	41.42	17.76
Gadsden West WWTP	8.3	21.6	4.303	1.942	0.000	6.921	4.01	21.70	10.62
Attalla Lagoon	3.3	21.6	0.686	1.048	0.000	3.657	3.59	53.71	43.38
Tyson Foods	1.6	21.6	10.000	6.500	0.000	1.000	6.24	22.63	11.31
Goodyear Tire and Rubber	12.8	24.4	1.000	0.300	0.000	4.000	3.73	35.00	13.77
Pell City Dye Creek WWTP	2.5	21.6	4.758	1.500	0.000	0.159	8.22	16.53	2.74
Kimberley-Clark Corporat	37.1	21.6	1.000	0.300	0.000	4.000	3.90	50.06	25.07
APCO Gaston PLT ash pond	38.5	21.6	0.220	0.060	0.000	0.050	6.24	9.00	3.60
Tallassee Lagoon	1.0	21.6	10.000	2.374	0.000	1.834	3.90	26.95	22.57
Tuskegee South WWTP (Cal	1.6	21.6	10.000	0.700	0.000	1.074	6.47	20.00	9.32
Tuskegee North WWTP	2.2	21.6	10.000	0.700	0.000	1.551	5.46	5.84	5.74
Alexander City Coley Cre	12.4	21.6	8.449	1.051	0.000	0.314	7.11	5.48	4.83
Wetumka City of Water Wo	3.2	21.6	10.000	2.700	0.000	0.250	6.24	6.25	6.22
International Paper Comp	44.5	21.6	1.000	0.300	0.000	4.000	0.86	88.42	45.69
International Paper	41.5	21.6	1.000	0.300	0.000	4.000	0.86	83.34	62.00
General Electric WWTP	4.1	21.6	0.100	0.300	0.000	0.100	5.85	17.45	10.65
Prattville Pine Creek	3.2	21.6	10.000	0.800	0.000	6.000	5.85	12.75	12.10
Montgomery Econchate	26.3	20.3	2.500	1.000	0.000	7.399	3.44	56.25	16.50
Montgomery Towassa	3.9	20.3	2.500	1.000	0.000	7.399	3.44	56.25	16.50
Catoma Creek WWTPg	25.4	21.6	10.000	0.700	0.000	0.200	5.19	6.40	2.89
Macmillan Bloedel Packin	27.8	21.6	1.000	1.200	0.000	1.400	2.34	104.79	62.13
Alabama River Pulp Compa	35.8	20.3	1.000	0.300	0.000	4.000	0.86	148.26	77.00
Selma Valley Creek WWTP	5.6	21.6	10.000	0.700	0.000	5.386	3.90	59.23	16.52
Leeds	1.7	22.0	14.250	5.000	0.000	1.000	5.93	37.50	6.70
Birminghan Area discharges	3.7	20.3	12.000	5.000	0.000	3.000	5.16	22.50	8.40
Jefferson Co. + Hoover RC	7.3	20.3	13.897	5.000	0.000	1.106	6.15	8.27	3.85
Pelham	1.5	19.0	14.000	5.000	0.000	1.000	6.34	30.00	11.20

[3] The asterisk denotes the location of a 750 lb/day load of NO_3-N that was input to the model to account for an unidentified source, based on the observed data, as described in the text. This corresponds to a concentration of 90 mg/L at a flow of 1 MGD (1.547 cfs).

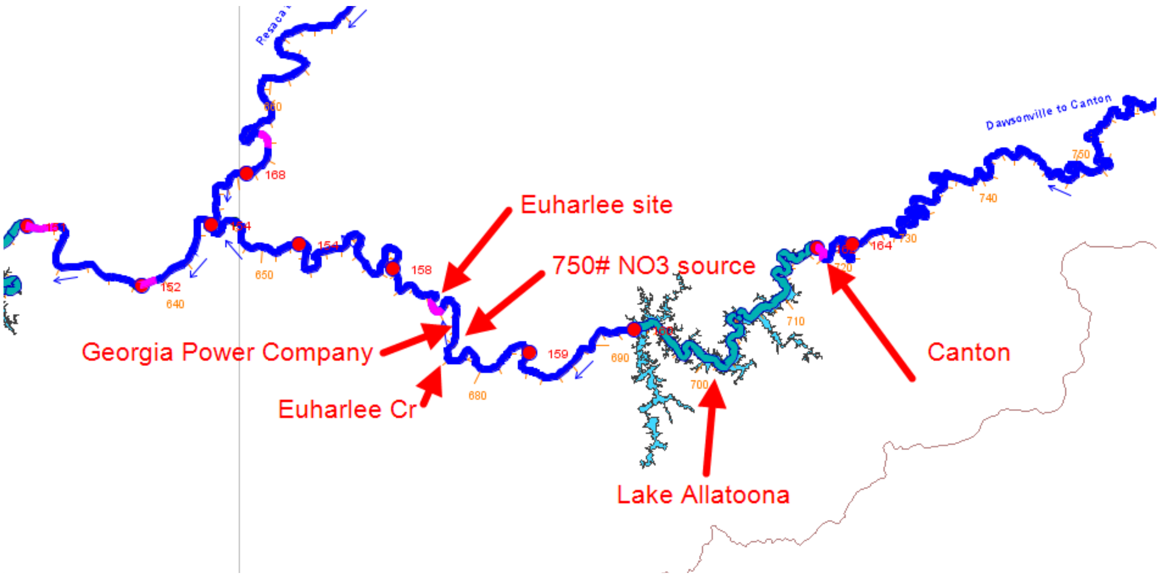


Figure 2-7 Location of the unidentified source of 750 lb/day NO_3-N (90 mg/L at 1 MGD), which was assigned to river mile 675 in the model.

2.2.3 METEOROLOGICAL DATA AND TRIBUTARY WATER TEMPERATURES

Meteorological data for the 1984-88 model performance demonstration period were developed using 3-hour observations of wind speed, cloud cover, air temperature and dew point (or wet bulb) temperature., etc.). These data were provided for Class A National Weather Service (NWS) stations throughout the ACT watershed. Daily average equilibrium temperature, heat exchange rate, wind speed and solar radiation were computed for nine data zones for model input. During the previous "Proof of Concept" effort, these daily values were downscaled to 6-hour values using typical diurnal variations because diurnal variations are often important and daily time steps (used in previous ACT applications) cannot capture these variations. Therefore, a six hour time step data set was developed that included 6-hour meteorology data (heat exchange parameters) and revised model coefficients.

Normally, 6-hour heat exchange inputs are generated from short interval air temperature, relative humidity, wind speed and solar radiation. However, because 6-hour data are unavailable, the 24-hour average heat exchange parameters were downscaled based on typical diurnal variations. Figure 2-8 is an example of the typical and downscaled equilibrium temperature, a measure of radiative balance. Equilibrium temperature is defined as the water temperature at which the net heat flux across the air-water interface is zero. The exchange rate was downscaled such that the 24-hour and 6-hour produced the same end of day computed water temperature.

The evaluation of water quality focused on the 2000 – 2008 period, to best capture the effects of recent population, water usage, and land use on pollution levels. However, the HEC-5Q model of the ACT was constructed to allow analyses for the 1939 – 2008 hydrologic period of record, corresponding to the hydrologic analyses performed by HEC-ResSim. Detailed meteorological data of the type required to compute model inputs were not consistently available with enough coverage for the entire period to ensure a consistent approach across the watershed. Extensive extrapolation of the meteorological data is required to model earlier periods, and many shorter-term synthetic data records would be required for a number of stations for any given period, introducing differing amounts of uncertainties throughout the model. To achieve reasonable and consistent coverage, the modeling team chose to use a consistent synthetic meteorological data creation approach across the ACT basin, followed by adjustment of the model to replicate observed water temperatures. This approach allowed HEC-5Q to achieve modeled water temperatures that were generally in very good agreement with observed water temperatures throughout the basin.

Extrapolation of model inputs for the entire analysis period was based on 1939 – 2008 National Weather Service (NWS) daily maximum and minimum air temperature and precipitation data. This approach assigns model inputs for each day of the extrapolation period based on the similarity of the temperature extremes and precipitation in the 1984-88 record. As an example, data with the best match of the temperature extremes and precipitation within 2 calendar days before or after the NWS calendar date could be selected. Thus up to 5 days from each of the 5 years of model input data (a total of 25 days) would be available for assignment to each day of evaluation period.

Specification of water surface heat exchange data requires designation of 'meteorological zones' within an area. Meteorological zones may represent data from a single weather station or a combination of two or more stations. Each control point within the system or sub-system used in temperature or water quality simulation must be associated with one of the defined meteorological zones. Within a river basin, it may be appropriate to apply different atmospheric conditions over different regions. Reasons for defining more than one meteorological zone within a system include availability of data, and variations in topography and vegetation within a region.

Data from five meteorological zones in the ACT basin were used to compute water temperatures in tributary streams in each basin, as shown in Table 2-5. Water temperatures were approximated based on an equilibrium temperature assumption.

Table 2-5. Meteorological data sources for the ACT basin

Met Zone	River	Latitude of Met data application	Met station data source (specified by location)
1	Alabama River	up to Latitude 32.2°	Average of Mobile and Montgomery, AL
2	Alabama, Cahaba, Coosa and Tallapoosa Rivers	Latitude 32.2° - 33°	Montgomery, AL
3	Coosa, Cahaba and Tallapoosa Rivers	Latitude 33° to 34°	Birmingham, AL
4	Coosa River	above Latitude 34°	Average of Huntsville and Birmingham, AL
5	ACT above Weiss Reservoir		Average of Chattanooga, TN and Atlanta, GA

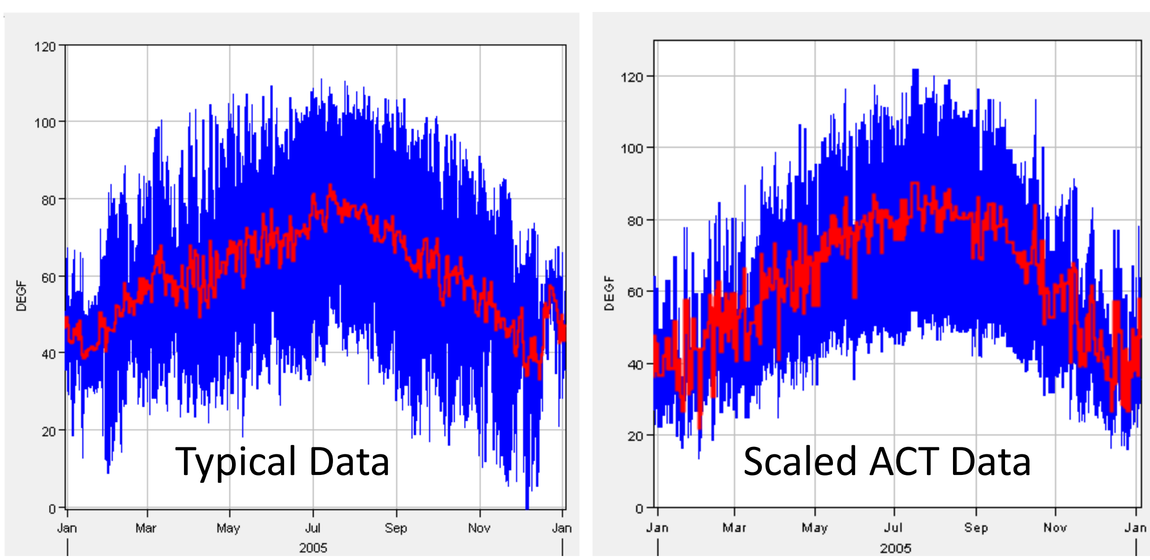


Figure 2-8 Typical and downscaled 6-hour equilibrium temperature (red line is the 24-hour data). Equilibrium temperature is defined in the text.

3 DEMONSTRATION OF MODEL PERFORMANCE

The HEC-5Q water quality models developed during previous studies have been extended and updated. When the original model was developed there were limited data for the reservoirs. For the current qualitative assessment of the water quality model, performed for the period of 2000 – 2008, data are available for all reservoirs except Carters Rereg. Thus the assessment has been extended to the reservoirs. Model coefficients were adjusted so that the temporal and spatial variation of the water quality parameters is reasonably represented.

To ensure a consistent approach across the full time period of the analysis, using a consistent set of model parameters, the HEC-5Q model was adjusted to produce reasonable results under a range of conditions over the analysis period. Therefore, it is not expected or required that the model will reproduce particular historical observations.

Water quality, both modeled and observed, is sensitive to the amount of flow. The hydrology of the ResSim model for Baseline (No Action) conditions was used in the model performance demonstration. The Baseline flows are not historical discharges, and in situations where they differ substantially, it becomes very difficult to make calibration assessments. Furthermore, since the flows associated with observed concentrations do not always closely match the Baseline flows, careful apportioning of the modeled flows is required to avoid unreasonable mass loadings. Because historical data were not used, this effort does not represent a true calibration. Rather, it is an attempt to represent the current operations strategies and reproduce the global response.

Since meteorological data were not available for all locations, and there were data gaps in existing records, extrapolated meteorology was used to drive the water quality model. Only maximum and minimum air temperatures were available for the simulated periods. The extrapolation process used maximum and minimum air temperatures to select meteorological data from the historical record to derive meteorological forcing for each location for the analysis period. While the imposition of a generalized daily meteorological pattern can sometimes interfere with exactly reproducing historical observations, it allows a consistent approach and enables the model to reproduce general trends of the observed data. This process is described in greater detail in Section 2.2.3. With this method, model results were intended to reproduce the general trends in observed data.

The daily timestep of the HEC-ResSim model is too coarse for water quality modeling and must be adapted to a shorter interval. The water quality modeling team chose a six hour timestep for the water quality modeling to better capture the water temperature changes throughout a day, while remaining manageable for computing the full period of record (1939 – present). Shorter computation times allow the flexibility to make incremental improvements to the model and facilitate recomputing the period of record as plan formulations change, which require the water quality to be recomputed with new sets of flows.

For model performance demonstration, the point and non-point water quality described in Sections 2.2.1 and 2.2.2 was assumed. Constituents chosen for presentation of model demonstration results include temperature, dissolved oxygen, nitrate (NO3), ammonia (NH3), phosphate (PO4) and Chlorophyll *a*. Nutrient and Chlorophyll *a* data are typically available at monthly intervals during the spring, summer and fall months (growing season) and represent conditions in the photic zone.

3.1 Reservoirs

Model performance demonstration results for reservoirs are shown in Figure 3-1 through Figure 3-20. Computed and observed temperature and dissolved oxygen profiles are provided for Carters, Allatoona, Weiss, Lay, Robert F. Henry (R. F. Henry), Harris, Martin and Yates reservoirs. Representative profiles are provided in each reservoir for either 2004 or 2005.

For the 1-D vertically segmented reservoirs (Carters, Allatoona, Harris and Martin) there is only one profile result to compare with observed data. Observed data, however, are often available at multiple locations within a reservoir for the same date.

For longitudinally segmented reservoirs (Weiss, Lay, R. F. Henry and Yates) computed data are plotted at the dam and mid-lake locations to give the best comparison with data from multiple locations. The observations and model results that extend to the greatest depths are closest to the dam.

Each figure contains 6 vertical profiles with the earliest profile representing conditions in April. The sequence of the remaining profiles shows a typical seasonal progression.

Observations in Carters reservoir (Figure 3-1 and Figure 3-2) are available near the surface (to a depth of 75 ft +/-). Therefore we cannot evaluate the model performance in the lower 250 ft. Computed temperatures during April through June 2004 are in reasonable agreement with observed data, although tending to under predict right at the water surface. The computed thermocline seems to drop more rapidly than observed, resulting in poor agreement with observed data during July and August; however by September the agreement is excellent. The DO plots indicate that the model is producing similar levels of DO near the surface, and a similar trend over time, but the model may progress more quickly. Without measurements of Carters Rereg discharge, it is difficult to assess the model's capability to represent the pumpback/discharge operation. However, the primary areas of interest are the euphotic zone (surface) of the reservoir and the stream section downstream of the reservoir. The modeled and observed surface values are in reasonable agreement. Furthermore, temperature data were available in the Coosawattee River downstream of Carters Rereg for short periods in 2001, 2005, and 2006, which indicate good agreement between the modeled and observed temperatures downstream of Carters Reservoir. Therefore, either the mixing of the bottom 250 ft of the water column was reasonably captured by the model or this portion of the water column had a negligible impact on the downstream water quality.

At Allatoona, in Figure 3-3, surface temperatures are well represented during most months plotted for 2004. The thermocline is somewhat lower than observed during April through June. Bottom temperatures are under predicted for all months; however results are otherwise quite good for July through September. Computed dissolved oxygen, shown in Figure 3-4, is in good agreement with observed data during April through August. In September, the model shows that anoxic conditions at depth are beginning to improve, whereas the data still show very low DO values, indicating a difference in timing of lake overturn and the influence of oxygenated inflows.

Temperature profiles for Weiss Reservoir are shown in Figure 3-5 for 2005. Model results and observed data show minimal stratification and good agreement between the two. The model shows less difference between the dam and mid-lake locations than is seen among the observed data locations. DO profiles are shown in Figure 3-6. Computed DO is lower than observed in April. In May, computed surface DO is higher than observed, but in good agreement at depth. The model is in reasonable agreement with observed data during June and July, and slightly lower than observed at depth during August and September. Variation in model DO between the dam and mid-lake locations tends to be less than the variation among observed data at different locations. Surface variations seen in the observed data are often in response to the timing and location of algal blooms while the model tends to represent a more global response. The computed hypolimnion DO tends to be less than observed which may translate to lower discharge concentrations. The lower DO will accentuate differences in reservoir operational impacts and thus contribute to a more conservative assessment. These results are typical of those for the reservoirs of the upper Coosa River chain of reservoirs.

In Lay reservoir, computed temperatures are in good agreement with observed data during April through September, 2005 (Figure 3-7). Data show more variation by location than is seen between the computed dam and mid-lake temperatures. The cooler profile near the surface (above elevation 380') shows the influence of a cooler water source other than the upstream main stem Coosa River that has a temperature of approximately 27°C. This profile is in a branch to the reservoir and no attempt was made to identify this source. Computed DO profiles in Figure 3-8 show generally good agreement with observed data and reproduce surface values throughout the plotted period. Computed DO near the bottom does not go quite as low as observed during April through June, and is slightly lower than observed during August. During August and September, computed DO values at depth are as much as 3 ppm higher than observed, not approaching the anoxic conditions seen in the data. The computed and observed temperature profile for September shows virtually no stratification. The model cannot prevent mixing of dissolved parameters under this condition. These results are typical of those for the reservoirs of the mid and lower Coosa River chain of reservoirs.

Figure 3-9 shows 2005 temperature profiles in R. F. Henry reservoir. During April the model result is in good agreement with the limited observed data. During May through September, the model result tends to show slightly more stratification than observed, with lower temperatures in the hypolimnion. DO profiles in Figure 3-10 show again that the model tends to be more stratified than observed, with lower than observed values in the hypolimnion throughout the plotted period. These results are typical of those for the reservoirs of the Alabama River chain of reservoirs.

Temperature profiles in Harris reservoir show good agreement with observed data during 2004 (Figure 3-11). Surface temperatures and thermocline are generally well represented, however hypolimnion temperatures are lower than observed. The model does an excellent job of reproducing DO observations, as shown in Figure 3-12. The outlet centerline elevation of 775' would access near surface waters so it appears that there would be limited effects of the anoxic hypolimnion. However, in the absence of downstream ambient data, this cannot be confirmed.

Martin reservoir temperature profiles are plotted in Figure 3-13 for 2005. The model results show slightly more stratification than observed at times and computed temperatures tend to be higher than observed. DO profiles in Figure 3-14 show generally good agreement with observed data. There are at times large variations in observed DO by location. The model results in anoxic conditions earlier than two of the three observed data locations, but falls within a reasonable range using the vertically segmented reservoir.

Temperature profiles in Yates reservoir are plotted for 2005 in Figure 3-15. The model is in good agreement with observed data during April. Surface temperatures are higher than observed during May and temperatures are overall higher than observed during June through September. This is a result of the temperatures coming out of Martin reservoir and is consistent with the 2C +/- difference between the computed and observed temperature at elevation 430' in Lake Martin. DO profiles in Figure 3-16 show good agreement with observed data in April. During May, June and September, computed surface DO is slightly higher than observed. During June through September DO in the hypolimnion is lower than observed. These differences in DO are also consistent with the Lake Martin DO profiles (Figure 3-24).

3.2 Streams

Time series of computed and observed temperature, dissolved oxygen, nitrate, ammonia and phosphate are provided at locations (shown in Figure 3-17) in the upper ACT basin where data are available. Model results are plotted at 6-hour intervals. Additionally, longitudinal profiles of computed and observed nutrients and Chlorophyll *a* (growing season values) are plotted along the Coosa and Alabama Rivers.

The 5, 25, 50, 75 and 95% occurrence levels of the observed data were computed from near surface (growing zone) measurements at two locations in the Reservoir. Measurements were typically made monthly during the April through November period. The corresponding computed profiles are for the surface element and represent various depth/thicknesses computed as a fraction of the total cross-sectional area (e.g., the surface element thickness in Weiss Reservoir would represent 1/8 of the total cross section at each reservoir segment). There were limited data available to plot profiles in the other rivers, however the data that do exist are available for plotting in the DSS file that accompanies this report. This profile plot format was used for comparison of alternatives.

Computed and observed temperatures in the Oostanaula River at Resaca are plotted in Figure 3-18. The model reproduces the seasonal trends and maximum and minimum values seen in the data. Dissolved oxygen, in Figure 3-19, shows that the model reproduces the observed seasonal trends. Winter time peaks tend to be slightly lower than observed. Nitrate, ammonia and phosphate time series are shown in Figure 3-20 through Figure 3-22. The model results are within range of observed data for each nutrient. Noise in the model result is due to weekday/weekend variation in flows, which affects the dilution of the nutrient inputs. To achieve the dissolved oxygen results seen in Figure 3-19, a benthic demand (3 $g/m^2/day$), approximately three times the rate assigned to the other river's reach, was specified. The intent of this demand was to represent the diffuse source of oxygen consuming material related to chicken production and processing.

Temperature time series in Coosawattee River at Calhoun are plotted in Figure 3-23. The model produces somewhat higher seasonal minimums than observed during 2001 and 2002, but the seasonal variations are otherwise well represented. DO times series (Figure 3-24) show that the model tends to under-predict seasonal peak DO values, but otherwise reproduces the seasonal trends. Nitrate time series in Figure 3-25 show that seasonal minimums are lower than observed, but model results are otherwise within reasonable range of observed data. With the exception of two observed outliers, both the computed and observed ammonia nitrogen levels (Figure 3-26) are within a narrow range of 0.02 and 0.06 mg/L.

Computed phosphate (Figure 3-27) tends to be higher than observed, with the model noise resulting from flow variations. Differences between modeled and observed values could be due to either default discharge concentrations that are too high or depletion that is not represented in the model. For example, HEC-5Q does not model benthic algae. Another possible contribution to the differences between the modeled and observed growing season phosphate values is the difference between observed flows and the modeled flows input into the HEC-5Q model from HEC-ResSim. The modeled flows computed by HEC-ResSim reasonably approximated the observed flows over the study period. However, there were periods where modeled flows did not match observed flows, due to required exceptions to normal operations in the field.

The occasional major spikes (fall 2007) result for near-zero flow. The spikes are also somewhat dependent on the BASINS-generated non-point inflow quality. However, the predicted phosphorous levels are on the conservative side, ensuring availability to algae. These spikes were not considered a problem since our evaluation of alternatives is limited to the 5% and 95% occurrence while the erroneous spikes represent <1% or >99% of the computed values. Since the focus of this study was to provide reasonable long-term, system-wide, approximations of water quality concentrations, the ability to predict individual values was not emphasized. Instead, we focused on reproducing reasonable dissolved oxygen and chlorophyll results. For example, the dissolved oxygen time series at Calhoun (Figure 3-24) indicate good agreement between the modeled and observed values.

In the Etowah River near Canton computed temperatures (Figure 3-28) are higher than observed during the winter (very cold versus very, very cold), but are otherwise in good agreement with the data. Computed DO (Figure 3-29) is also in good agreement with data, although some of the seasonal highs and lows are missed. Nitrate (Figure 3-30) is generally in the range of observed data, but the lowest observed concentrations are not reproduced. Ammonia (Figure 3-31) is within the range of observed concentrations with the majority of both the computed and observed falling below 0.05 mg/L. Phosphate (Figure 3-32) tends to be higher than observed. Results at this location are primarily affected by the inflows rather than any adjustment of model parameters and serve as an indication of the accuracy and uncertainty associated with the specification of point and non-point inflows discussed in Sections 2.2.1 and 2.2.2.

Computed temperatures in Etowah River near Euharlee are in good agreement with observed data, as shown in Figure 3-33. Computed DO (Figure 3-34) tends to have lower seasonal low values than observed, but otherwise matches observed data well. Computed Nitrate, shown in Figure 3-35, is generally within range of observed data, although computed values during 2000 are overall higher than observed. The spike in computed nitrate during 2005 (higher than the plot scale at 3.4 mg/l) is the result of near zero flows in the river. This location appears to be impacted by an upstream power plant. Although no data were available to quantify the impact of the power plant, observed values could not be reproduced by the model without the addition of 750 lb/day of nitrate to represent the load from the power plant. A comparison of computed values with and without this additional nitrate load is provided in Figure 3-36 to show that the load was required to bring average computed values closer to average observed data. Ammonia concentrations, shown in Figure 3-37, are well-represented by the model.

Both the computed temperatures and DO in the Oostanaula River at the Rome water intake (Figure 3-38 and Figure 3-39) are well represented throughout the year. Nitrate (Figure 3-40) concentrations are in the range of observed data except for the low observed values during the summers of 2002 and 2007, Ammonia (Figure 3-41) is within the range of observed concentrations with the majority of both the computed and observed falling below 0.10 mg/L. Phosphate (Figure 3-42) is within the range of the observed data, however there is a tendency for more elevated observed concentrations.

Observed temperatures in Coosa River near Rome are reproduced by the model as shown in Figure 3-43. In the Coosa River above State Line, computed temperatures reproduce the seasonal trends of the observed data (Figure 3-44). DO results, plotted in Figure 3-45, do not show as much variation as observed. This monitoring station is located within the upstream end of Weiss Reservoir. The scatter seen in the observed data is likely a result of primary productivity that is more dynamic than predicted by the model. Additionally, the time of day of the measurement would impact DO concentration due to the active algal growth/respiration cycle. Computed nitrate and phosphate (Figure 3-46 and Figure 3-47) are in the range of observed data, although minimum nitrate values are not as low as observed.

A longitudinal profile of computed and observed temperature along the Coosa River by river mile is plotted in Figure 3-48. Solid lines are the 5%, 25%, 50%, 75% and 95% occurrence computed values during the 2001 through 2008 May through October growing seasons. The same percentile values are shown as blue squares for observed data. Maximum computed temperatures are a few degrees below observed, but otherwise the model is generally in reasonable agreement with observed data. At the upstream locations, computed 5% values are not as low as observed by as much as 5° C. These profile results demonstrate the thermal uniformity of the surface waters of the Coosa lakes.

The Coosa River dissolved oxygen profile is shown in Figure 3-49 for the same May through October growing season. Minimum computed oxygen concentrations are in the observed range, while maximums are under predicted. The model is not capturing the episodes of super-saturation. This is possibly due to too much reaeration in the physical system or because of the time of day measurements are taken (during peak algal production), or the location in the water column. Furthermore, the model is performing conservatively by focusing on capturing low dissolved oxygen values.

A longitudinal profile of computed and observed nitrate along the Coosa River by river mile is plotted in Figure 3-50. Solid lines are the 5%, 25%, 50%, 75% and 95% occurrence computed values during the 2001 through 2008 April through November growing seasons. The same percentile values are shown as blue squares for observed data. At any location where only three squares are visible, the 5 and 25 percentile values are both 0.003 mg/l. The profile plot indicates that computed values are higher than observed. The 95% occurrence observed value tends to fall between the average and 75 percentile computed value. It is to be expected that the 95% computed concentration would be higher than observed since the computed includes the first and last weeks of April and November respectively. These periods are characterized by little biological activity and nutrient uptake. April and November measurements tend to be taken towards the end and beginning of the month respectively when biological activity is greater. Additionally, early and late season monitoring is omitted if conditions are not conducive to primary production, hence further reducing the biologic active period data.

The Coosa River ammonia nitrogen plot is shown in Figure 3-51 for the April through November growing season. Computed ammonia tends to be higher than observed. The spike at mile 628 is due to the TIN incorporated paper mill discharge. The ammonia default a concentration of 4 mg/L was assigned to all paper / pulp mills. A sensitivity analysis was performed by setting these discharges lower to 1 mg/L ammonia. With this change, the 95% concentration is reduced from 0.24 to 0.15 and results in concentrations more in line with the observed.

The Coosa River phosphate profile is shown in Figure 3-52. Computed concentrations match reasonably well with observed data at the downstream locations. At the upstream locations the 95% occurrence values are higher than observed. The data show a general decrease in phosphate from upstream to downstream, and this is reproduced by the model.

Again, observed data are biased to the middle of the growing season when nutrient concentrations are lower, whereas model results represent the entire period equally. Because of this, the computed nutrients tend to be higher than observed.

A profile of Chlorophyll *a* in Coosa River is plotted in Figure 3-53. Model results are generally a good match with observed data. At the furthest upstream locations, the model result falls below the 95% occurrence values. The model tends to under predict spikes in algal production in the river below Rome. A time series of Chlorophyll *a* in the Coosa River and Weiss reservoir is plotted in Figure 3-54. Observed data are collected at two locations within the reservoir and computed time series are shown at the Weiss dam and at mid-lake just downstream of Weiss at Stateline. The observed data from the two stations were combined and ranked so the percentages may have a preponderance of a particular station. The combining is in keeping with the model demonstration approach. The model reproduces the seasonal trends and the variation between the upstream and downstream reservoirs.

A longitudinal profile of computed and observed temperature along the Alabama River by river mile is plotted in Figure 3-55. Results are plotted for the 2001 through 2008 May through October growing seasons. Maximum computed temperatures are two to three degrees below observed and minimum temperatures are two to three degrees above observed.

The Alabama River dissolved oxygen profile is shown in Figure 3-56 for the same May through October growing season. Results vary by location. At the downstream end, maximum values are in agreement with observed but minimum values are higher than observed. The middle location is the reverse and the upstream location does not have as much variation as observed.

A longitudinal profile of nitrate nitrogen in the Alabama River is plotted in Figure 3-57. Computed values are higher than observed. The 95% occurrence observed value tends to fall between the average and 75% computed value. A profile of Ammonia nitrogen is plotted in Figure 3-58. Computed values are within the range of observed data. The pulp mill default ammonia concentration of 4 mg/L impacts the results. As discussed previously, a sensitivity analysis with the pulp mill ammonia concentration set at 1 mg/L reduces the 95% concentration from 0.09 to 0.07.

The Alabama River phosphate profile is plotted in Figure 3-59. Observed data show an increase in phosphate from upstream to downstream. This increase is only apparent in the 75% and 95% occurrence model result. The 5%, 25% and 50% occurrence results are close to observed, while the 75% and 95% results are higher than observed. The observed data bias towards the middle of the period affects both the phosphate and the nitrate results.

A profile of Chlorophyll *a* in the Alabama River is plotted in Figure 3-60. Computed values show a greater range than observed. A time series plot of computed and observed Chlorophyll *a* in Alabama River at Millers Ferry reservoir is plotted in Figure 3-61. Computed values at the Dam and mid-lake are very similar and match reasonably well with data observations. During some years, the modeled peaks are higher than observed. The general trend of slightly higher computed than observed Chlorophyll *a* is considered conservative since it accentuates the sensitivity to operational alternatives.

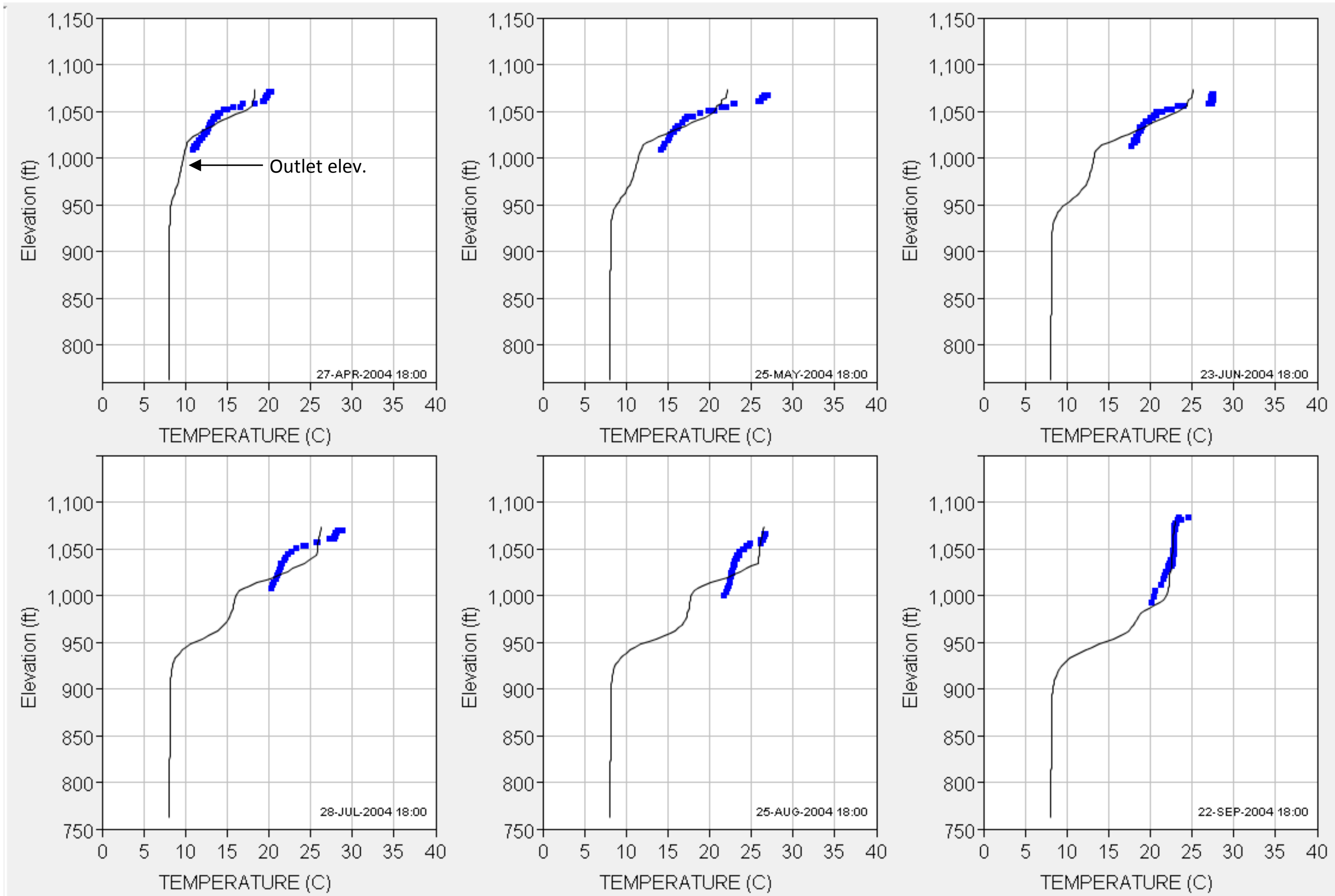


Figure 3-1 Typical computed and observed temperature profiles in Carters Reservoir for dates between April and September 2004. Multiple profile locations were measured on each day.

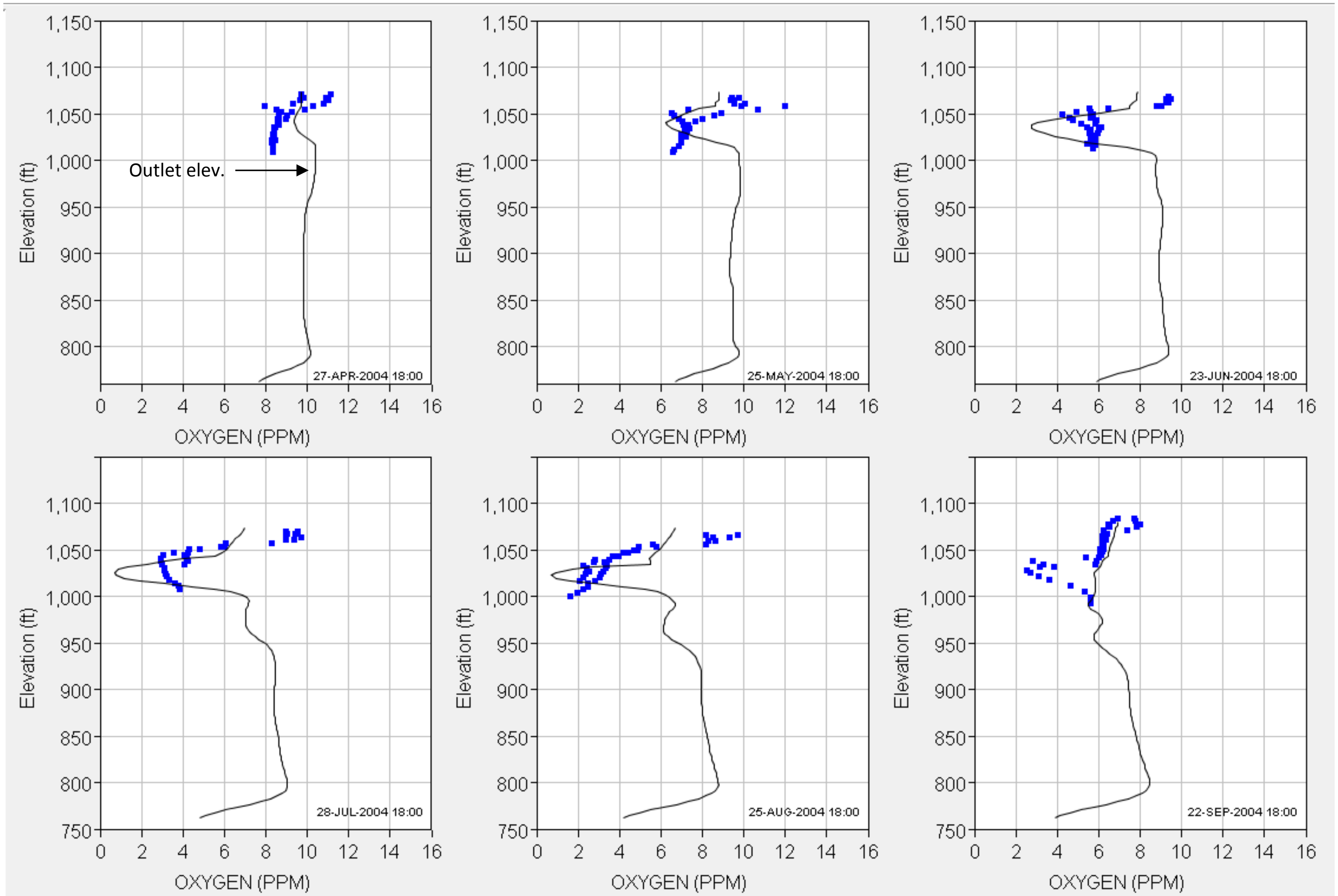


Figure 3-2 Typical computed and observed oxygen profiles in Carters Reservoir for dates between April and September 2004. Multiple profile locations were measured on each day.

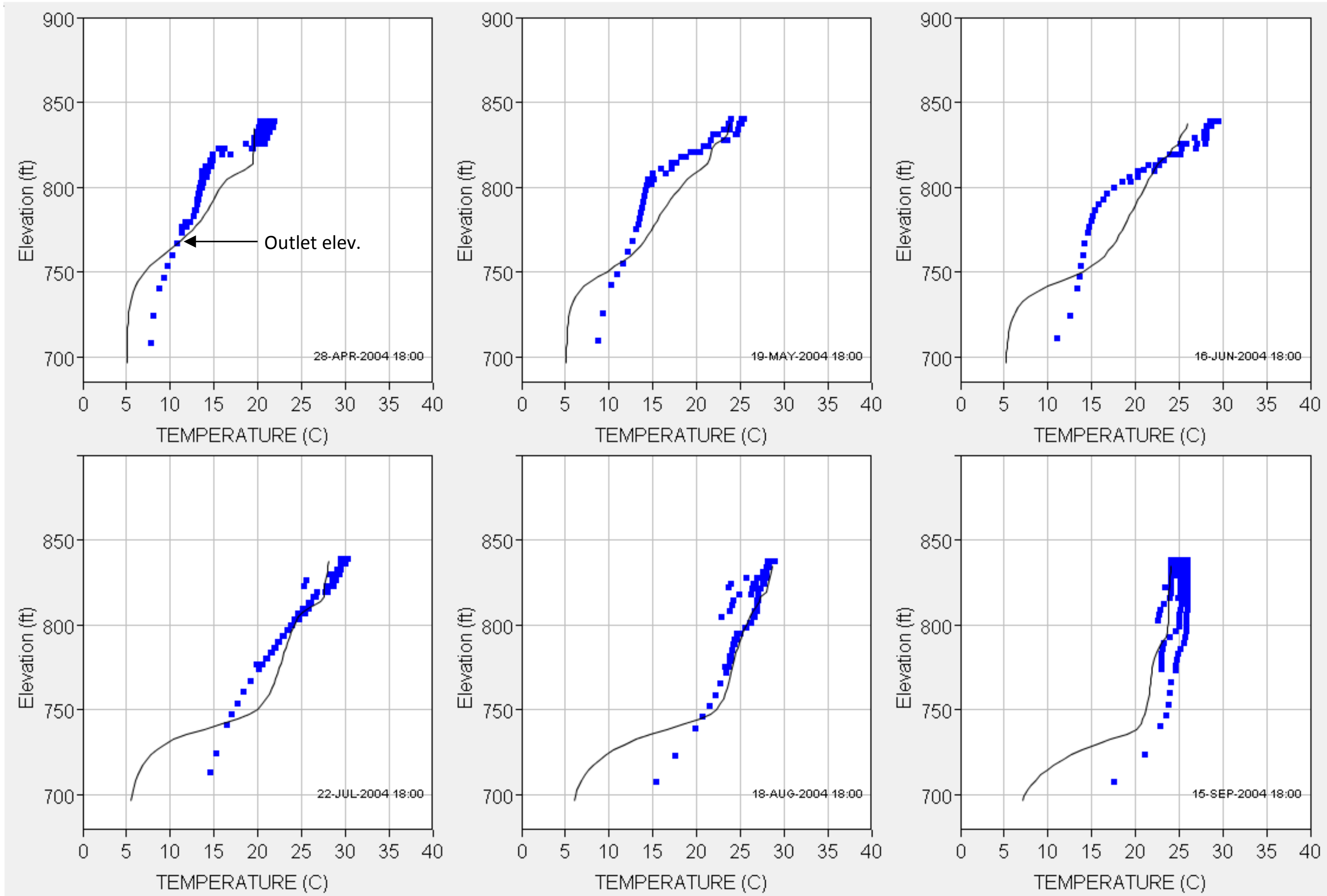


Figure 3-3 Typical computed and observed temperature profiles in Allatoona Reservoir for dates between April and September 2004. Multiple profile locations were measured on each day.

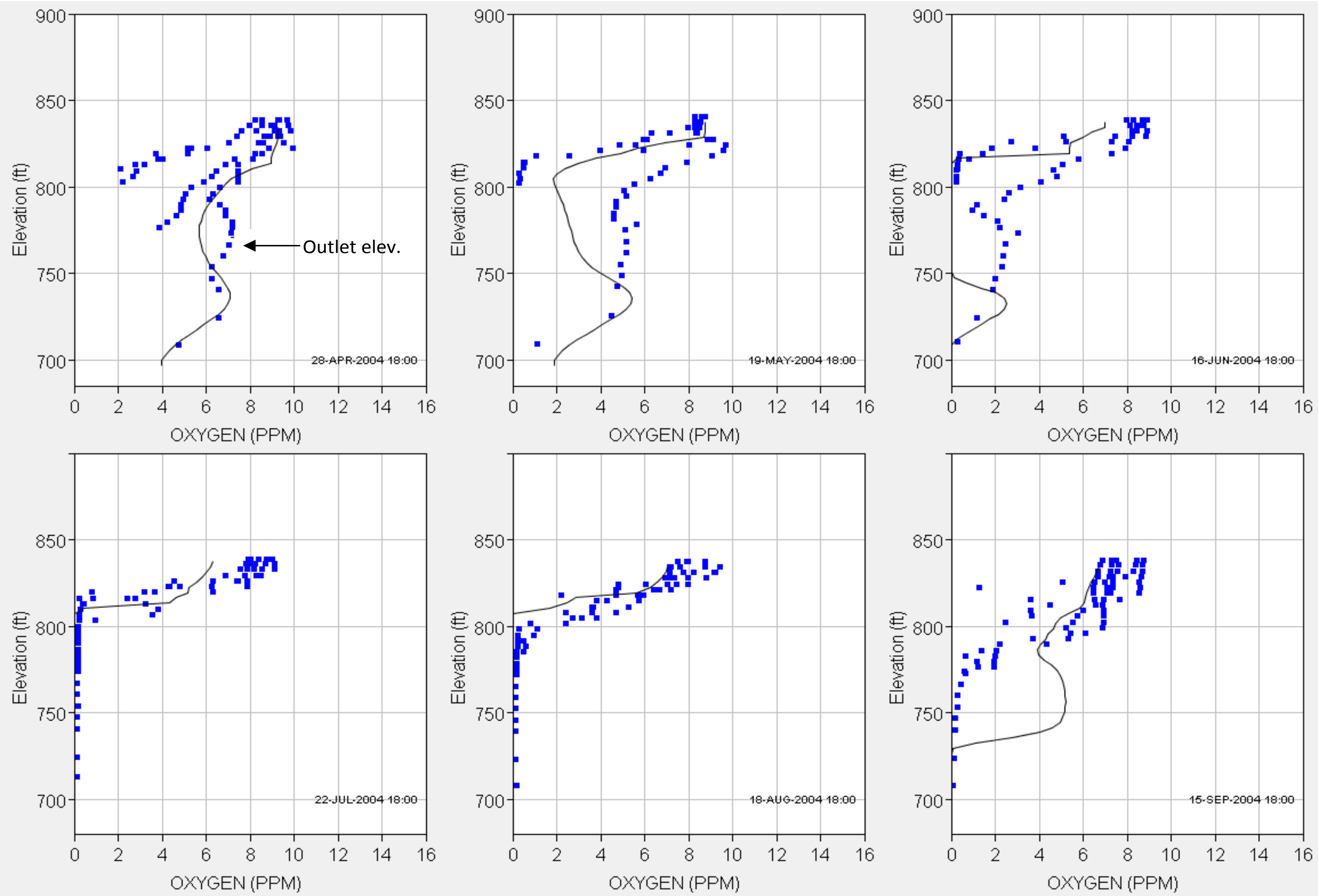


Figure 3-4 Typical computed and observed oxygen profiles in Allatoona Reservoir for dates between April and September 2004. Multiple profile locations were measured on each day.

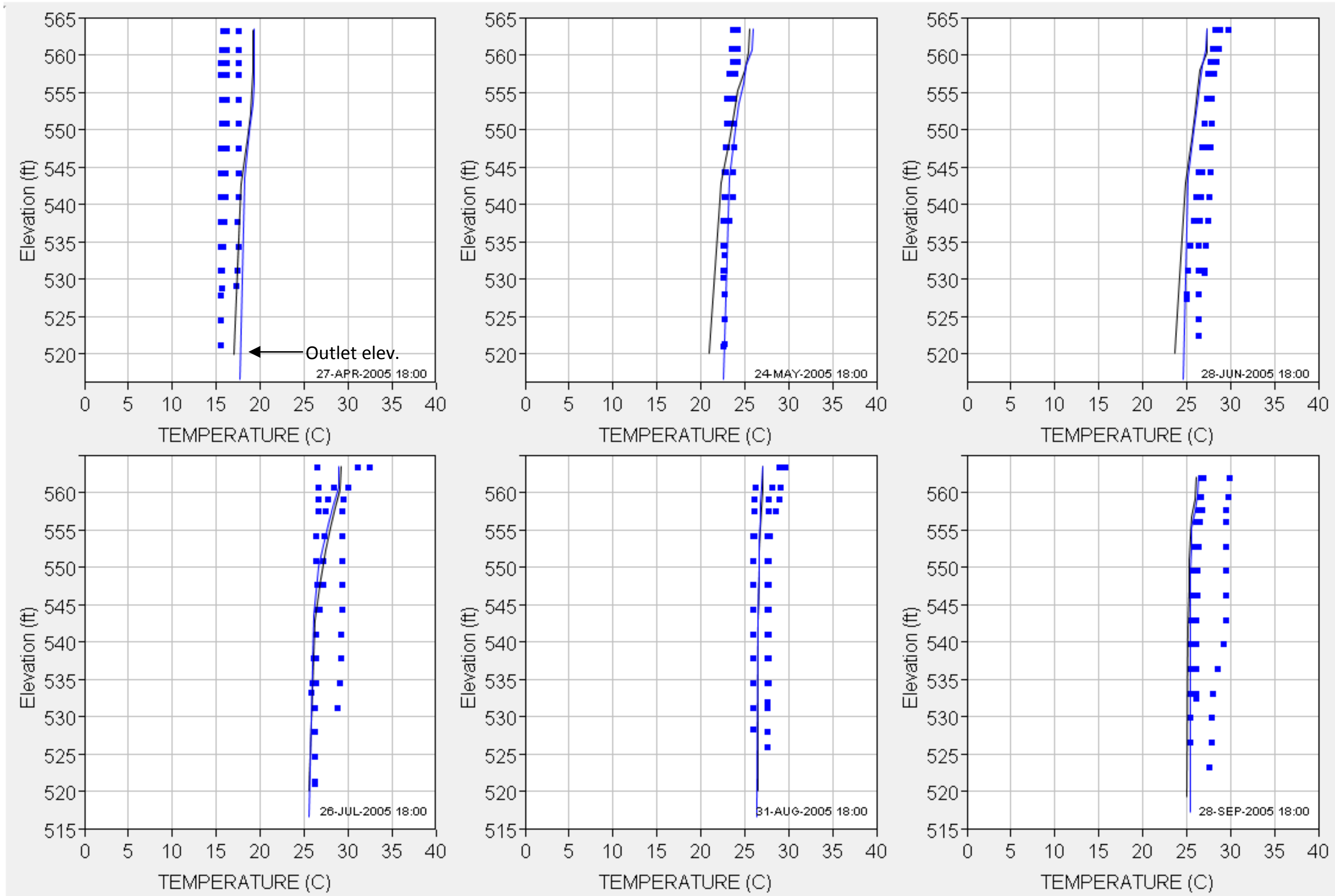


Figure 3-5 Typical computed and observed temperature profiles in Weiss Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day.

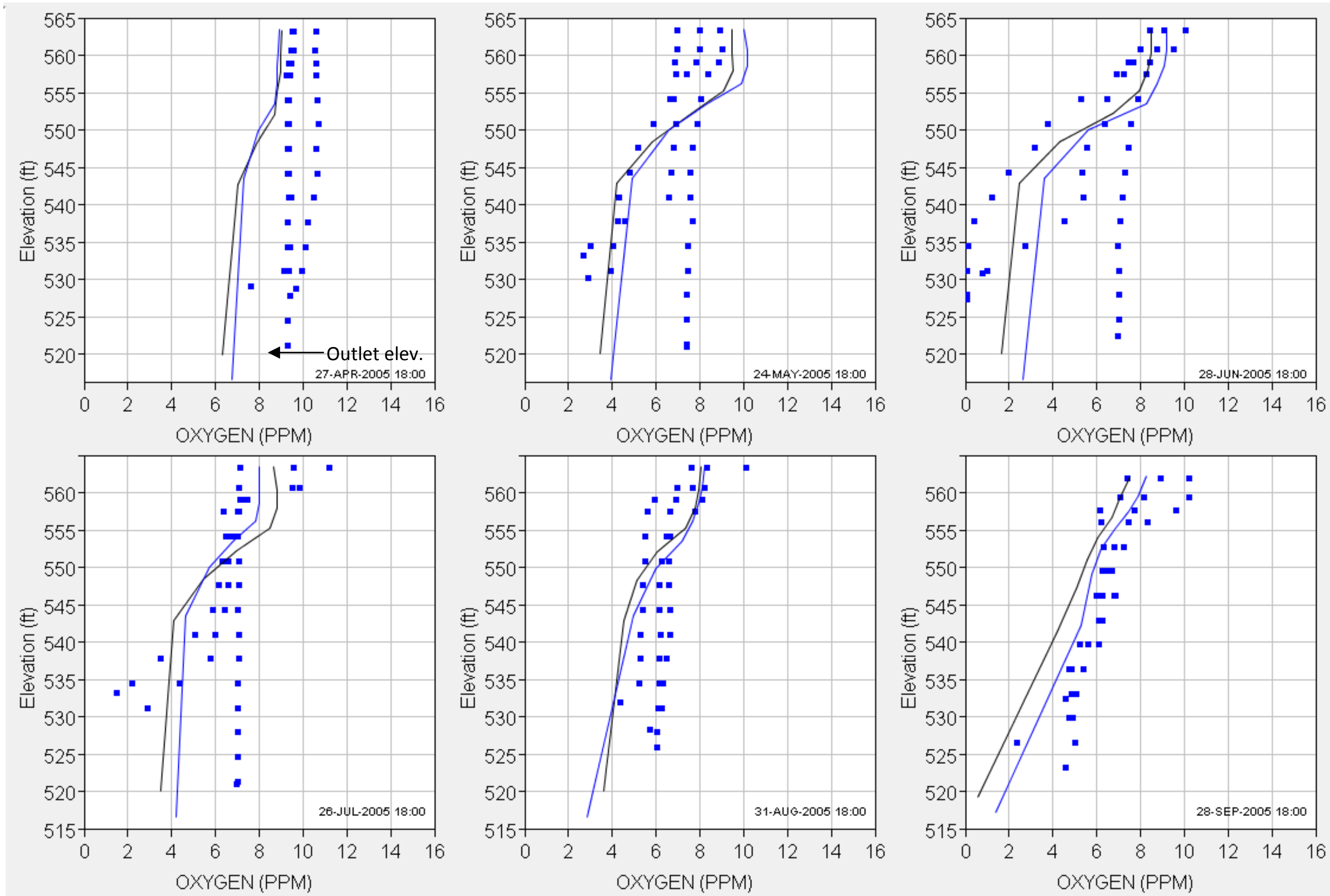


Figure 3-6 Typical computed and observed oxygen profiles in Weiss Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day.

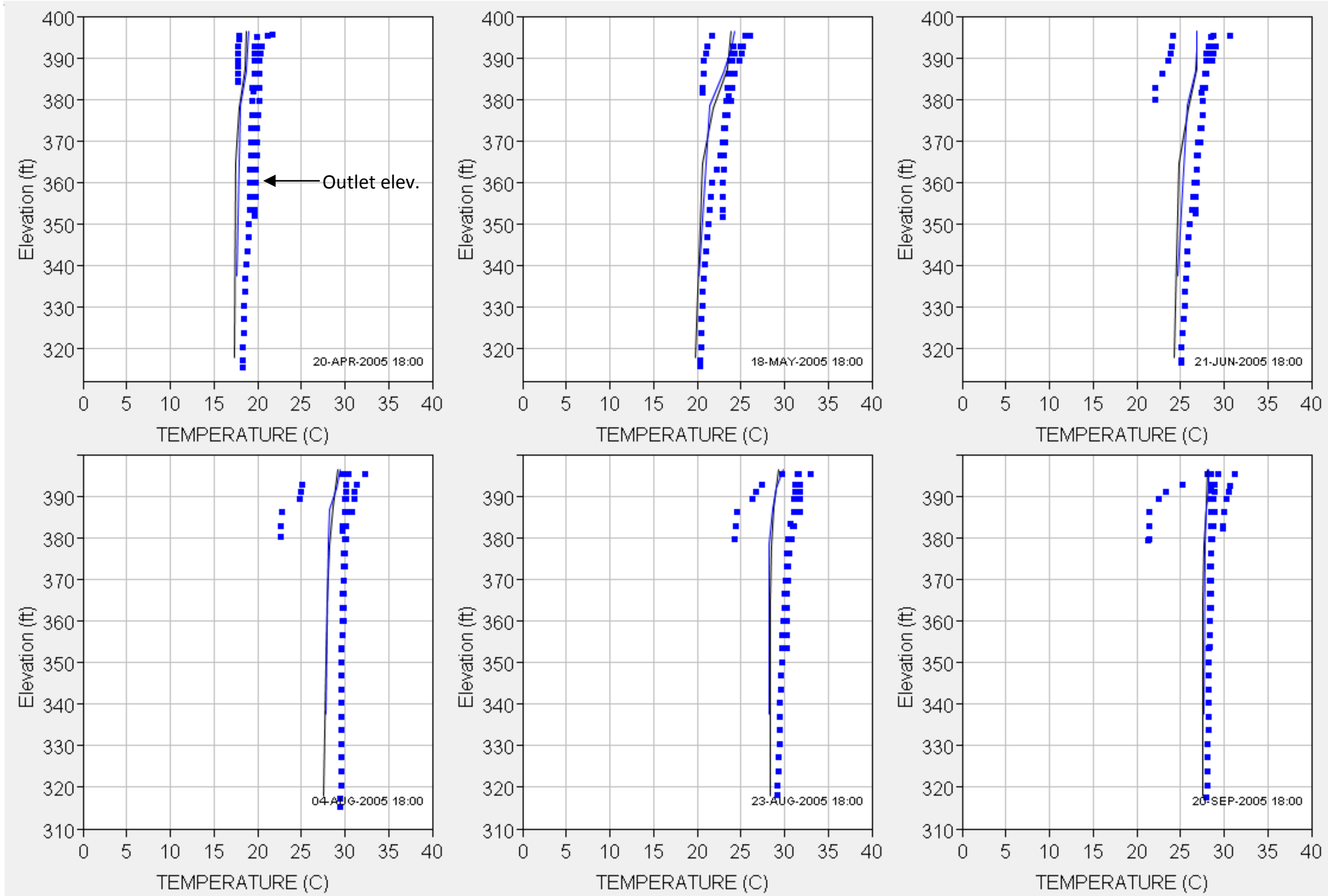


Figure 3-7 Typical computed and observed temperature profiles in Lay Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day.

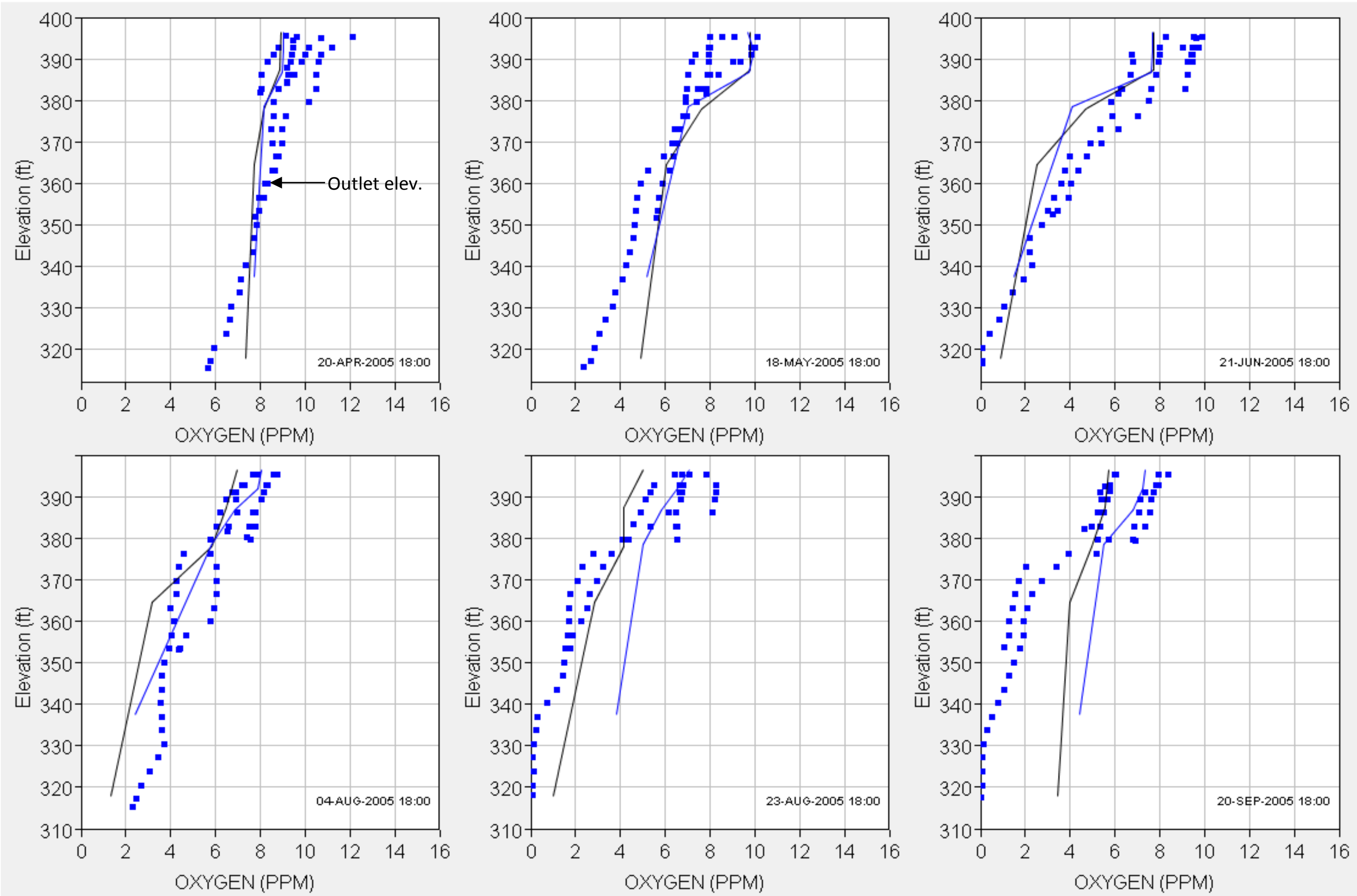


Figure 3-8 Typical computed and observed oxygen profiles in Lay Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day.

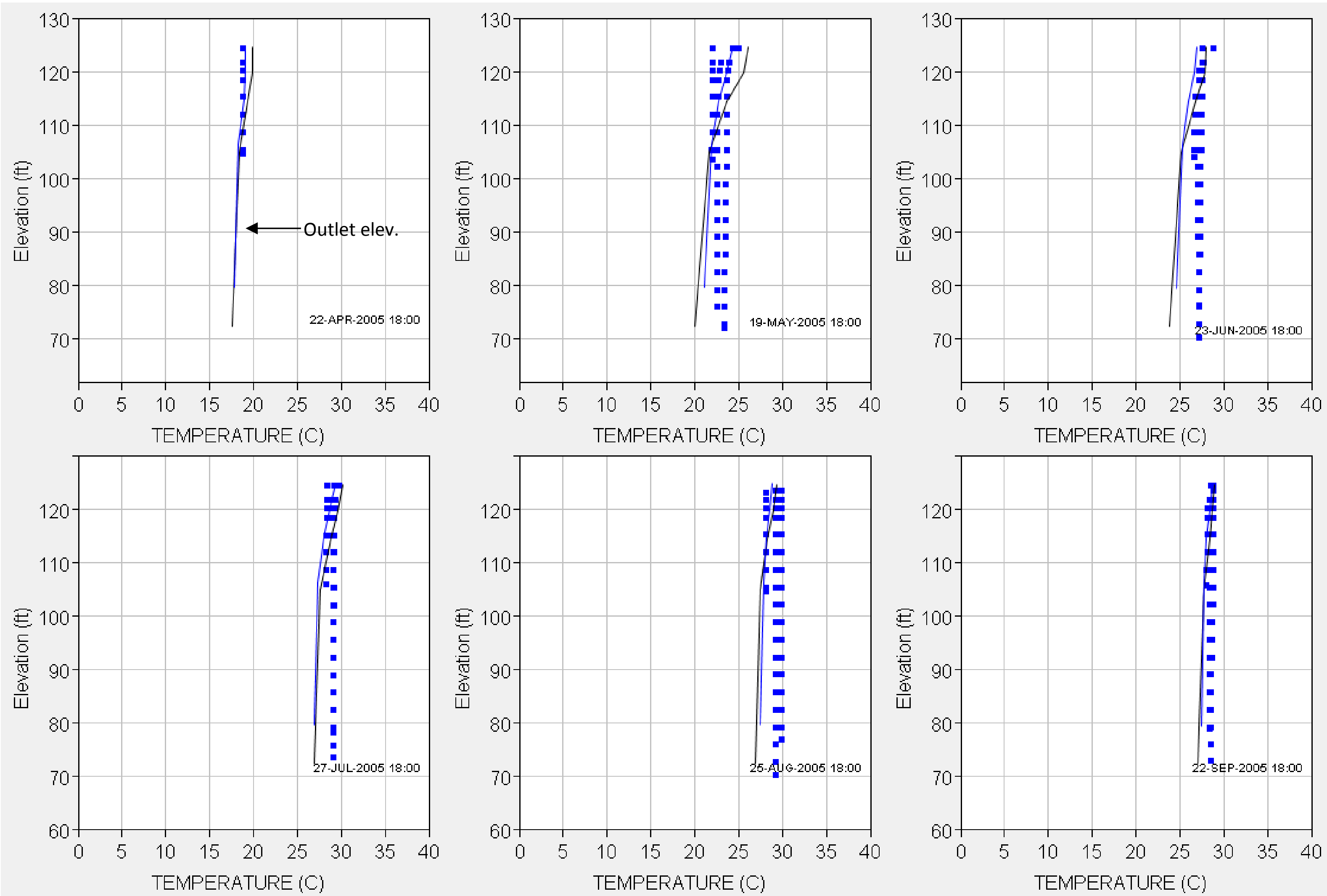


Figure 3-9 Typical computed and observed temperature profiles in R. F. Henry Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day.

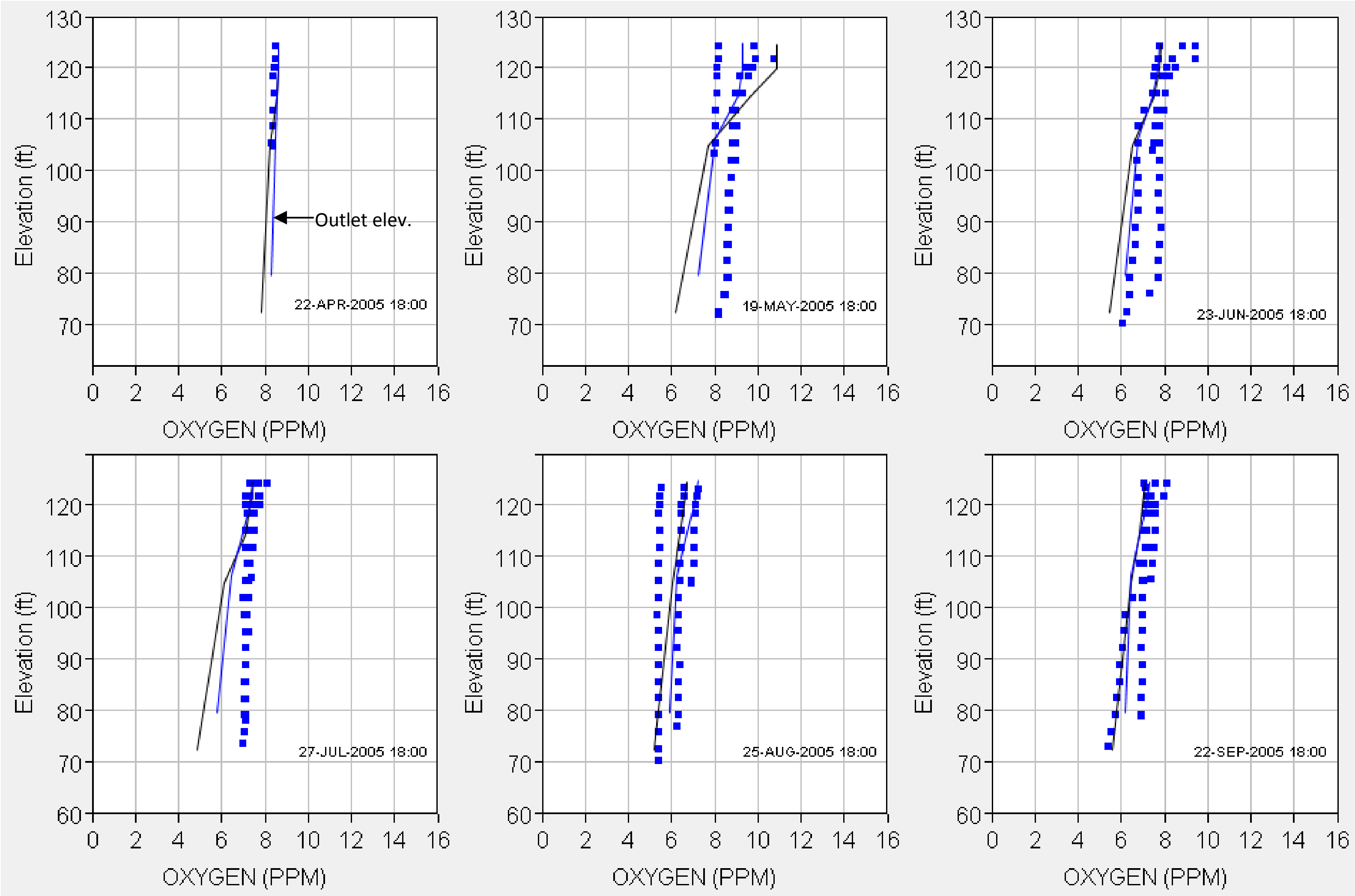


Figure 3-10 Typical computed and observed oxygen profiles in R. F. Henry Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day.

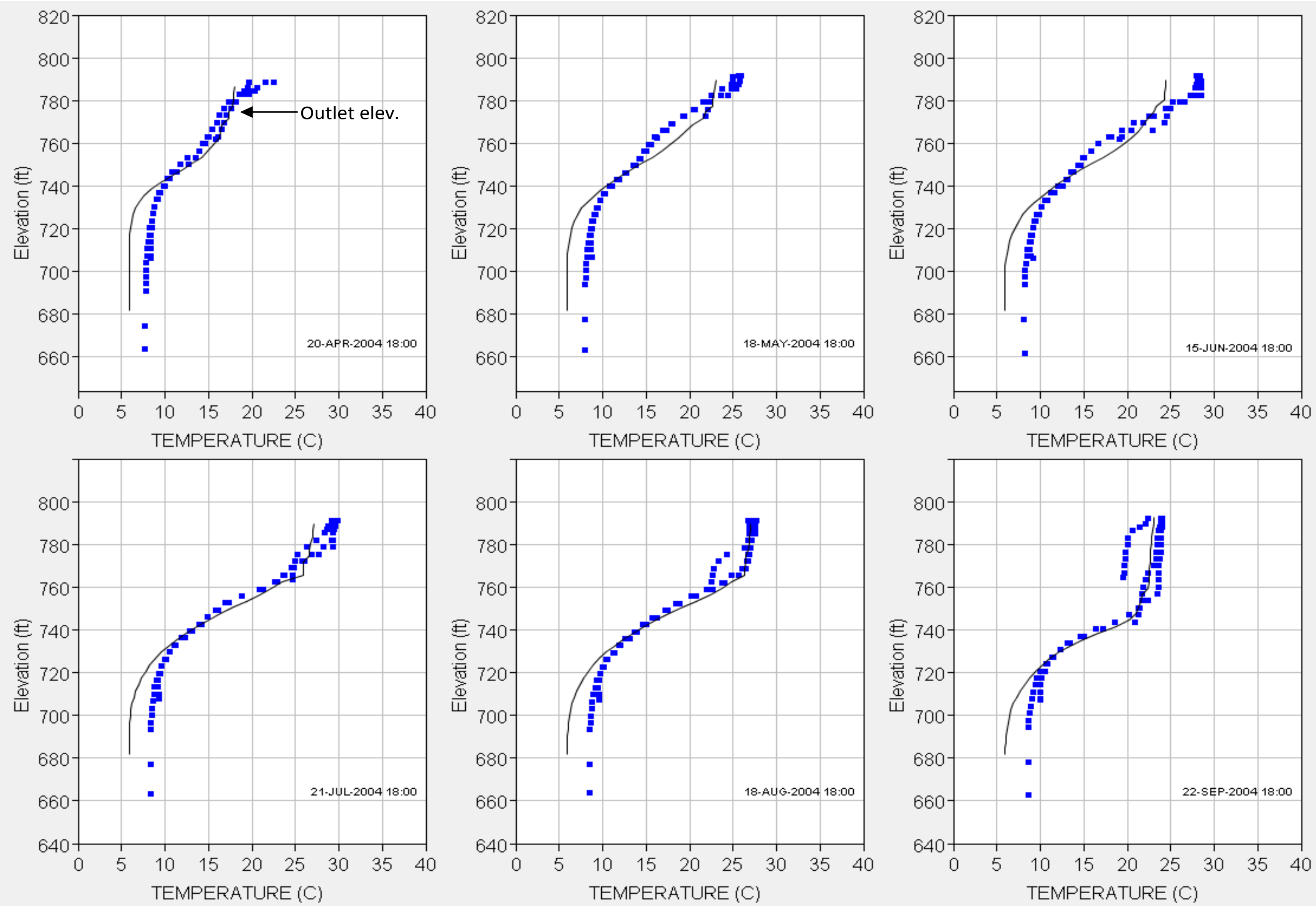


Figure 3-11 Typical computed and observed oxygen profiles in Harris Reservoir for dates between April and September 2004. Multiple profile locations were measured on each day.

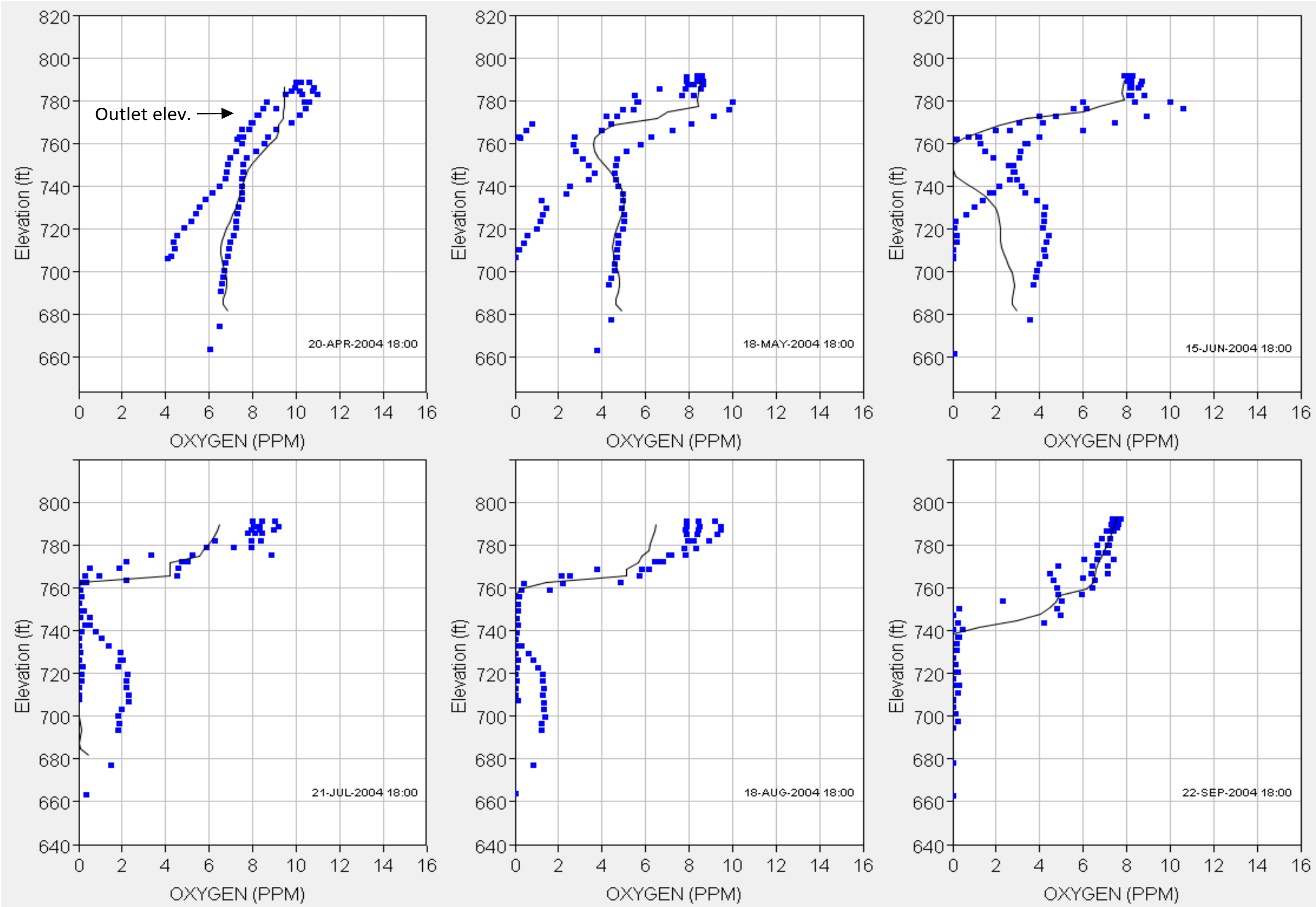


Figure 3-12 Typical computed and observed oxygen profiles in Harris Reservoir for dates between April and September 2004. Multiple profile locations were measured on each day.

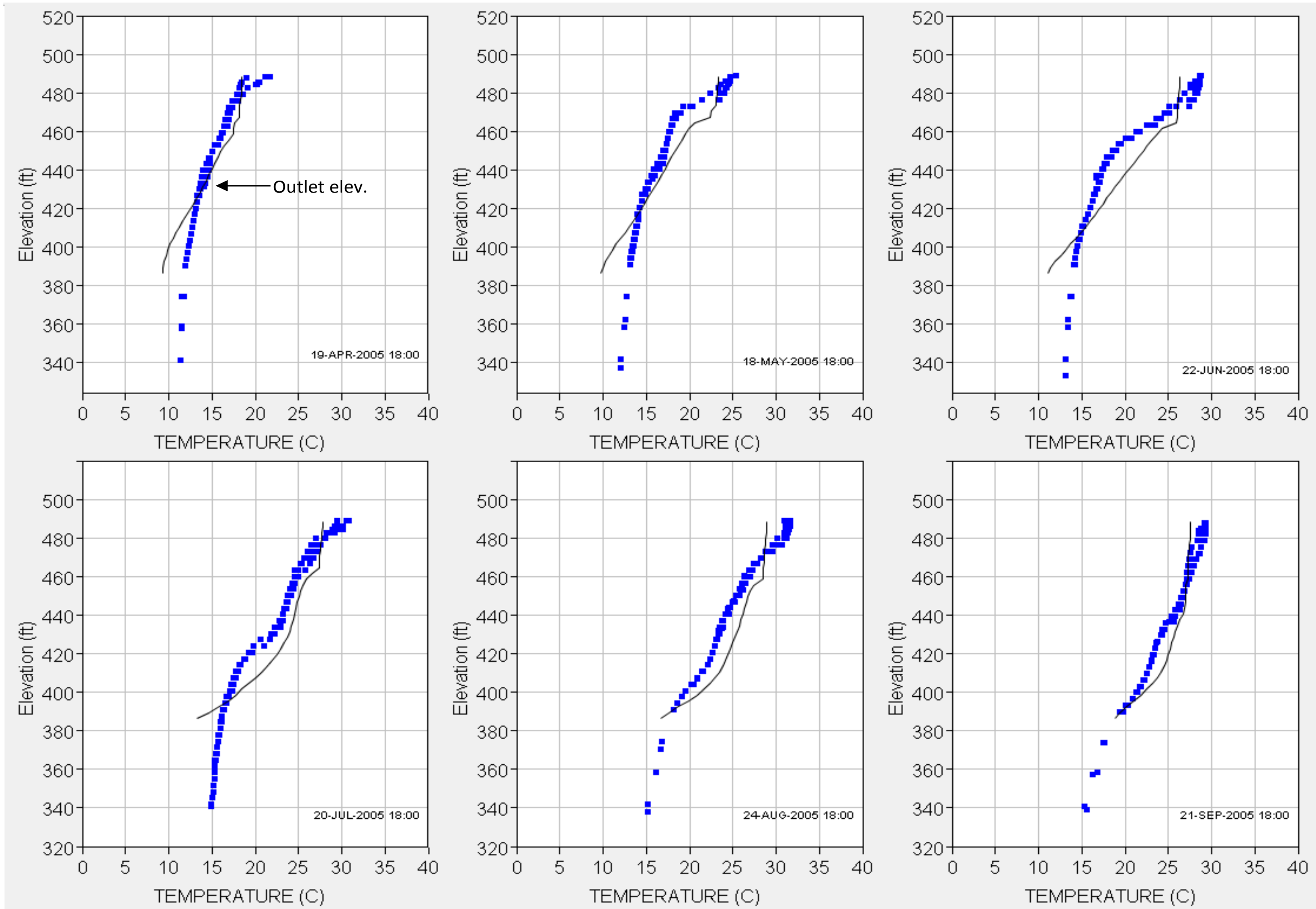


Figure 3-13 Typical computed and observed oxygen profiles in Martin Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day.

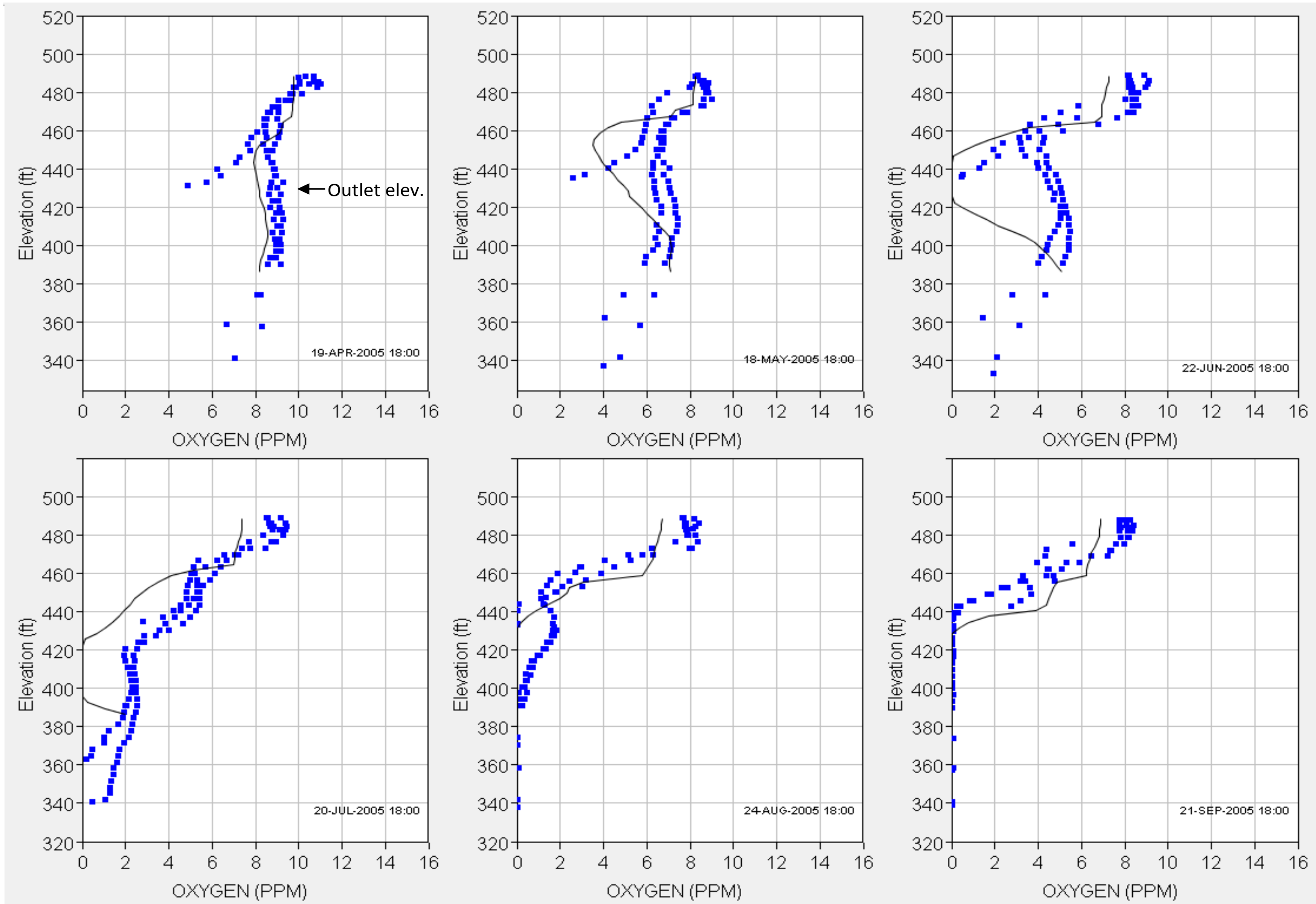


Figure 3-14 Typical computed and observed oxygen profiles in Martin Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day.

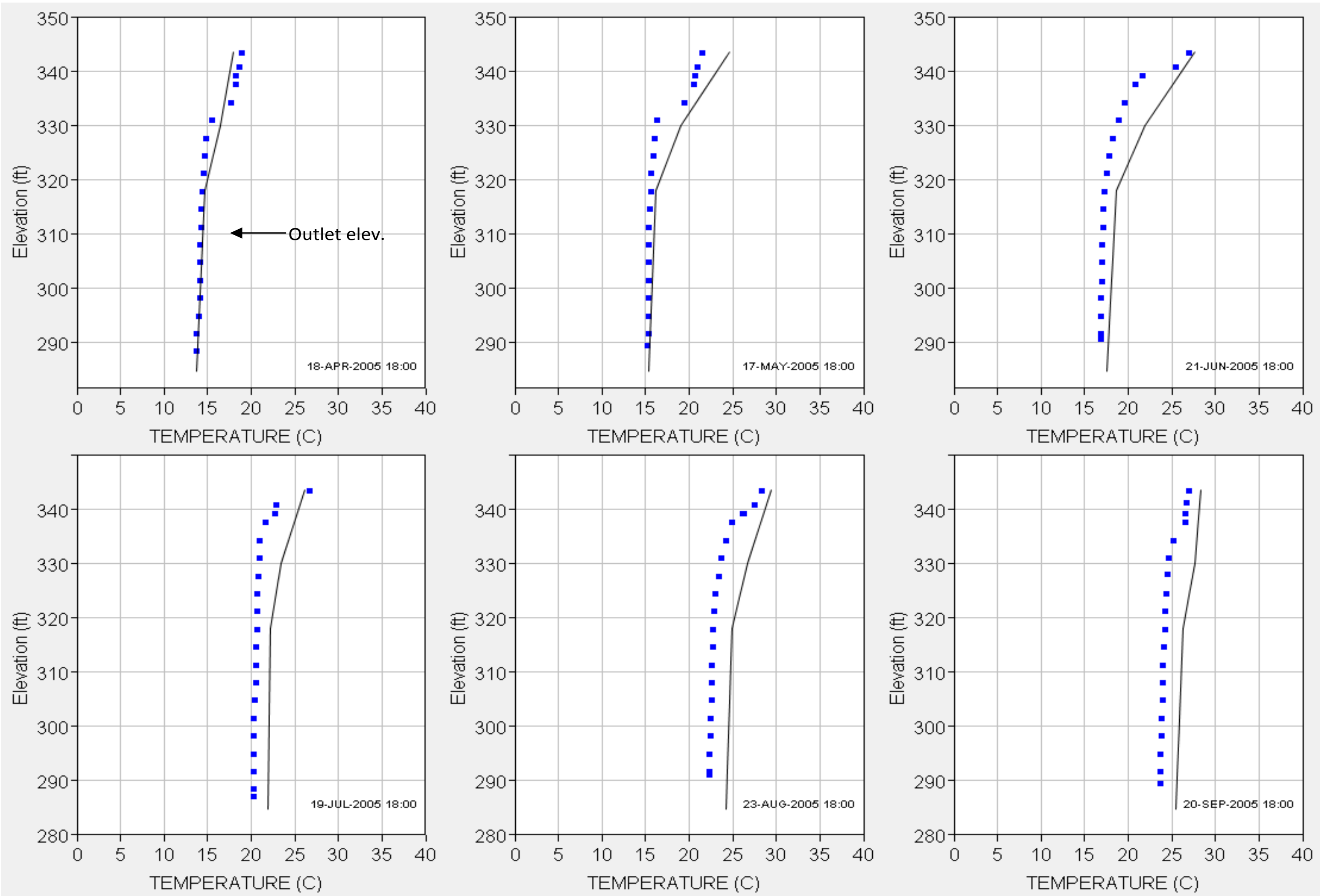


Figure 3-15 Typical computed and observed oxygen profiles in Yates Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day.

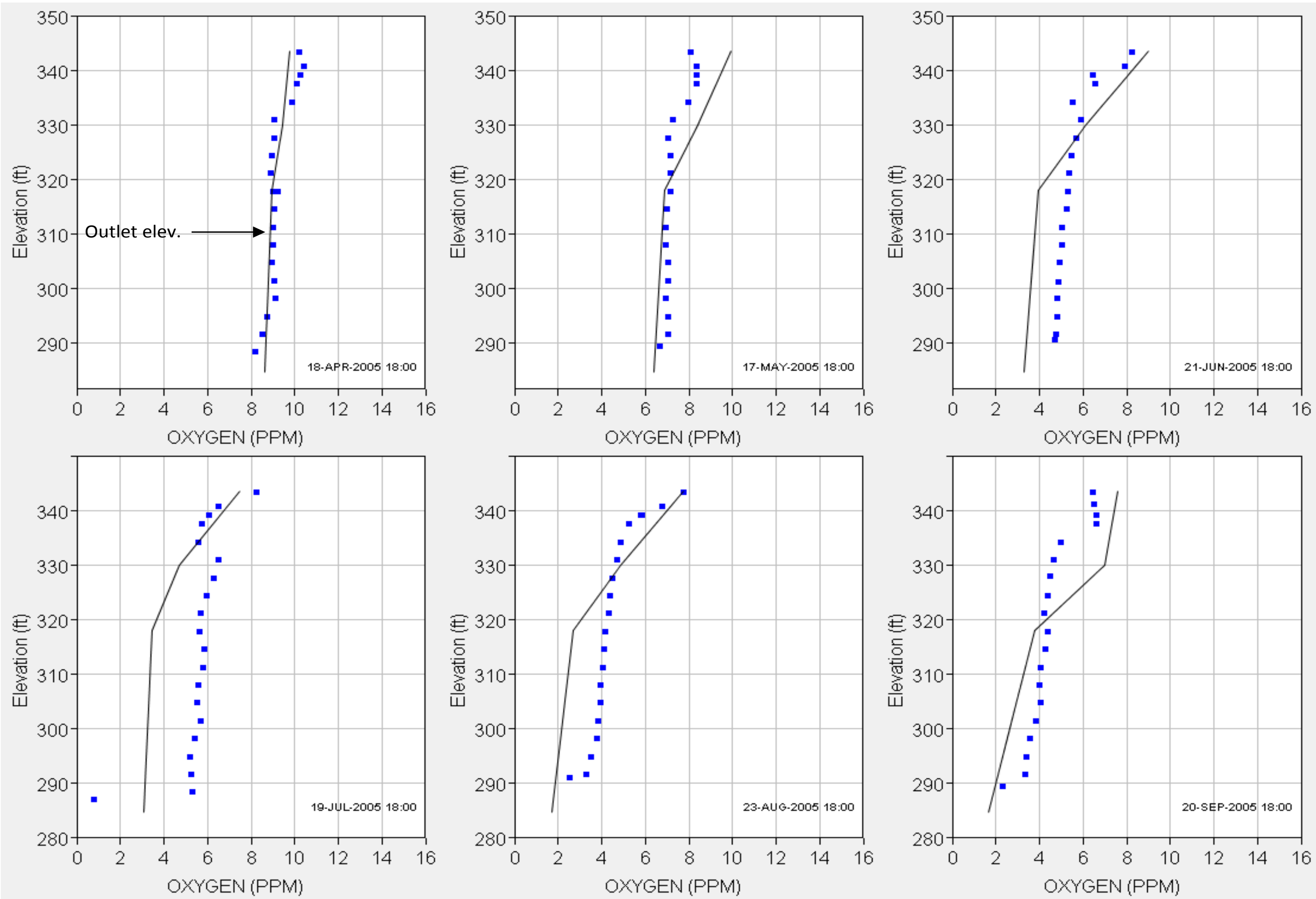


Figure 3-16 Typical computed and observed oxygen profiles in Yates Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day.

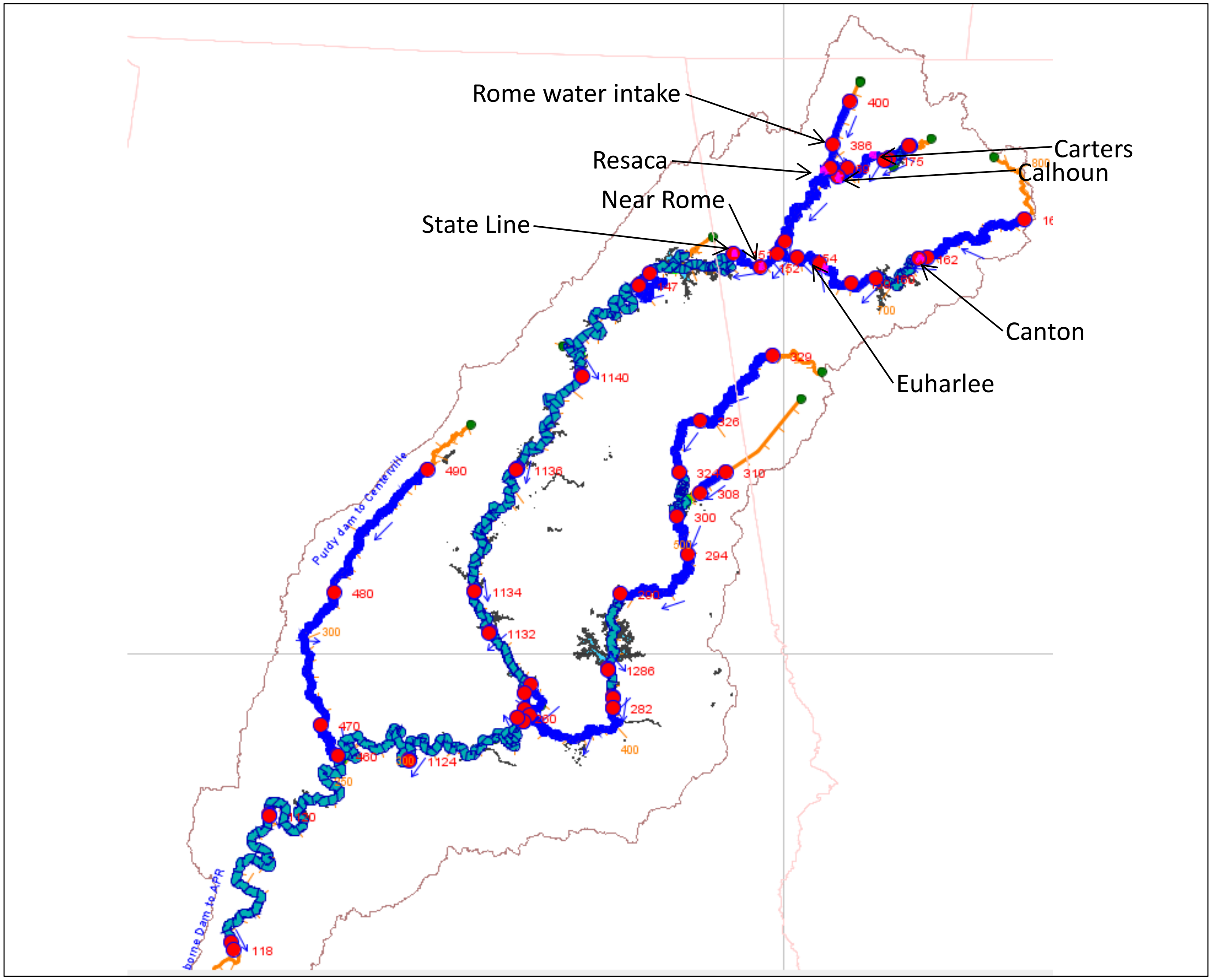


Figure 3-17 HEC-5 and HEC-5Q Model Schematic of ACT Basin showing time series plot locations.

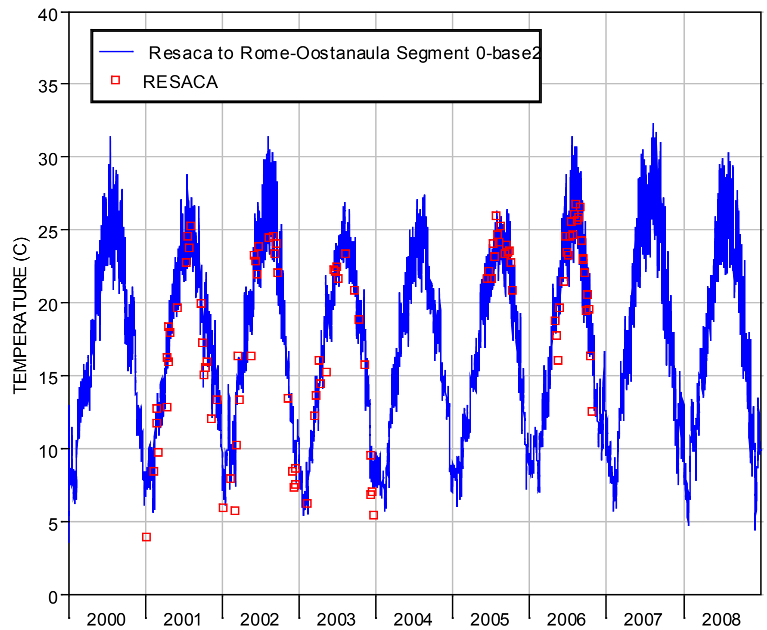


Figure 3-18 Time series of computed and observed temperature in Oostanaula River at Resaca.

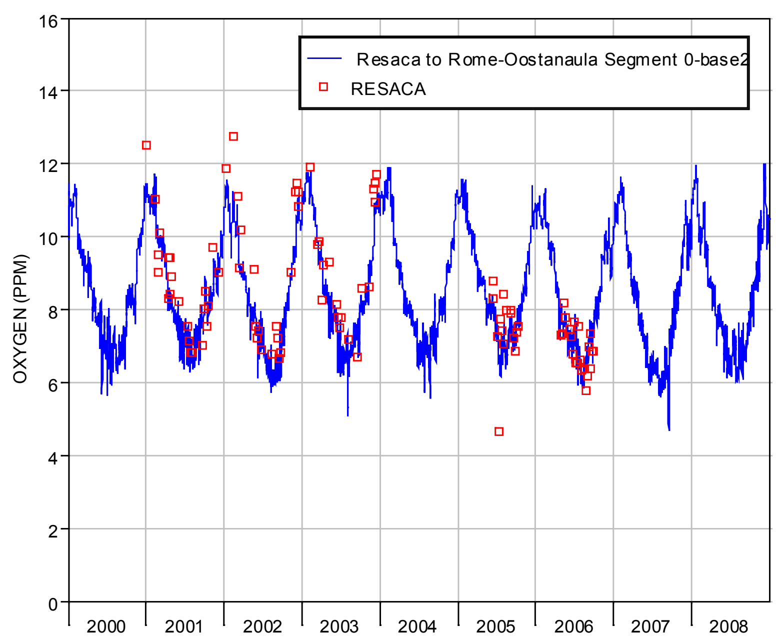


Figure 3-19 Time series of computed and observed oxygen in Oostanaula River at Resaca.

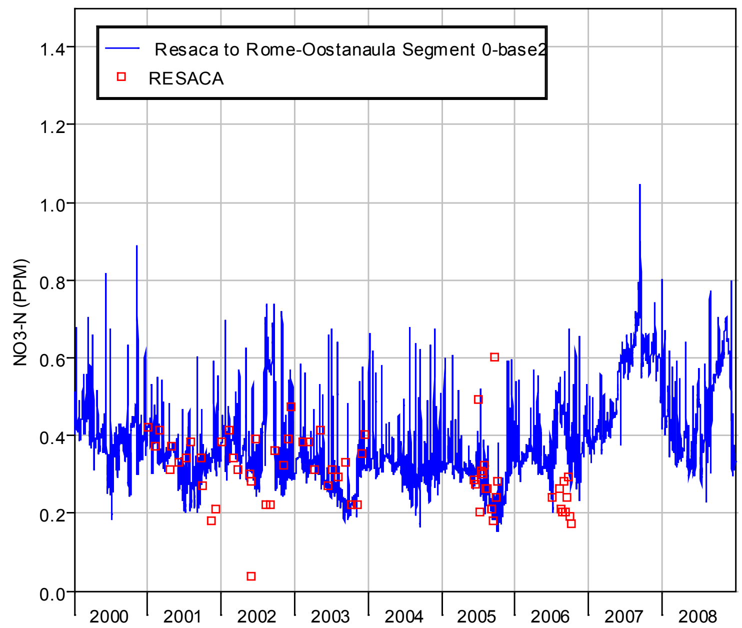


Figure 3-20 Time series of computed and observed nitrate in Oostanaula River at Resaca.

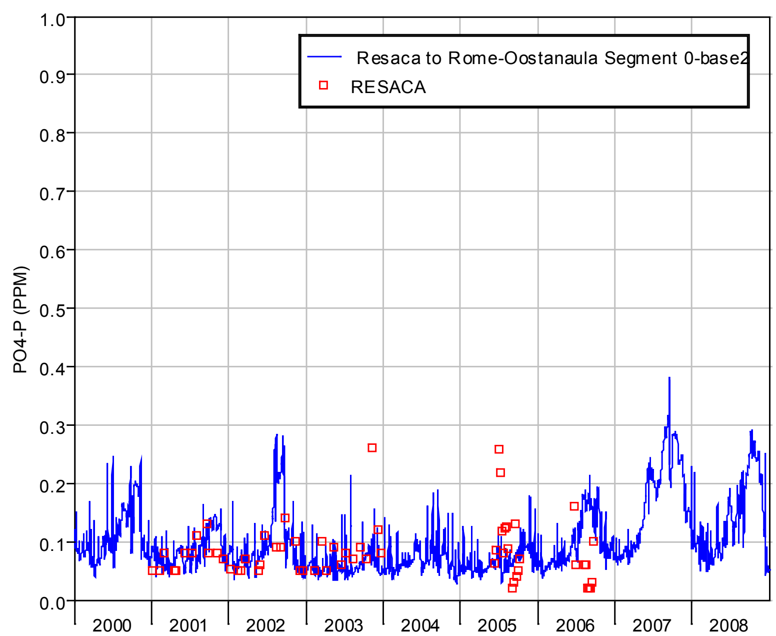


Figure 3-21 Time series of computed and observed phosphate in Oostanaula River at Resaca.

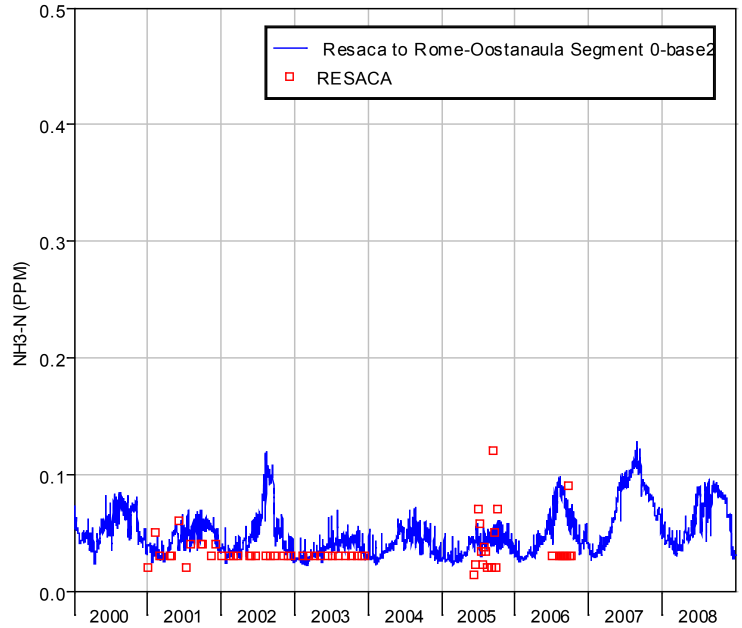


Figure 3-22 Time series of computed and observed ammonia in Oostanaula River at Resaca.

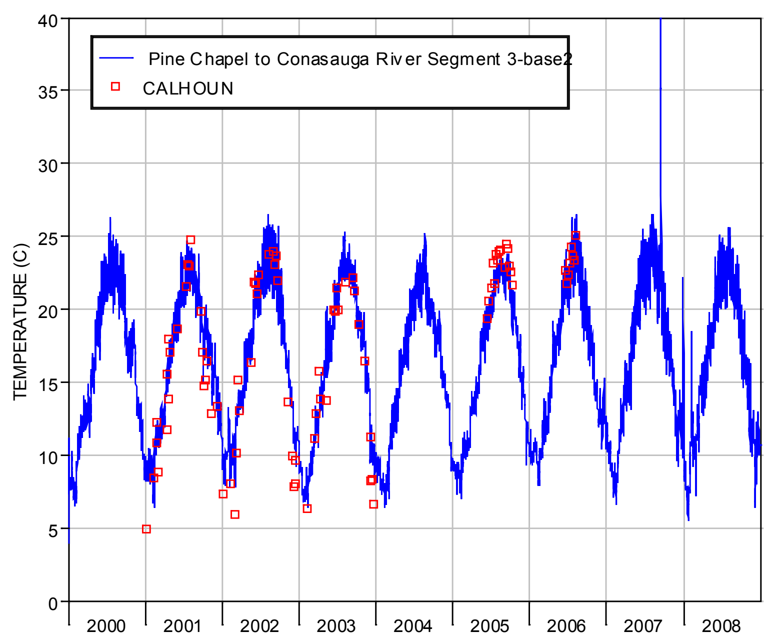


Figure 3-23 Time series of computed and temperature in Coosawattee River at Calhoun.

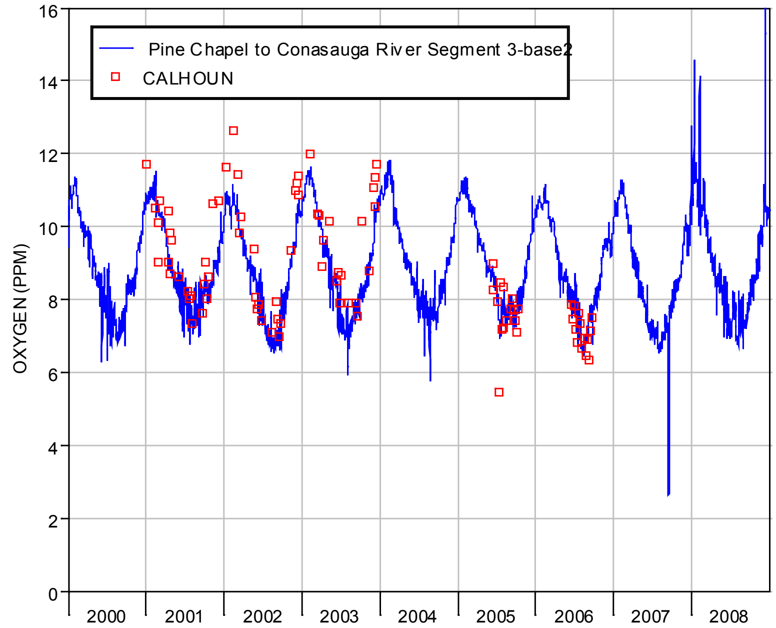


Figure 3-24 Time series of computed and observed oxygen in Coosawattee River at Calhoun.

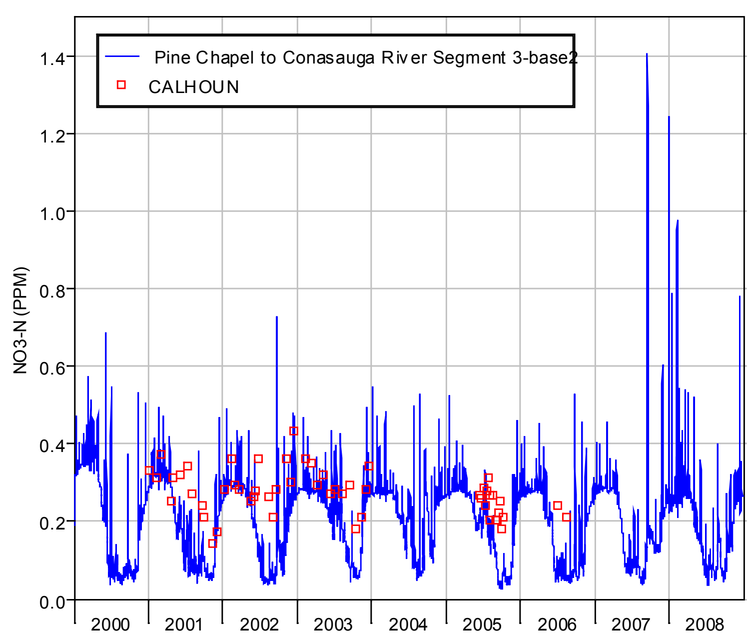


Figure 3-25 Time series of computed and observed nitrate in Coosawattee River at Calhoun.

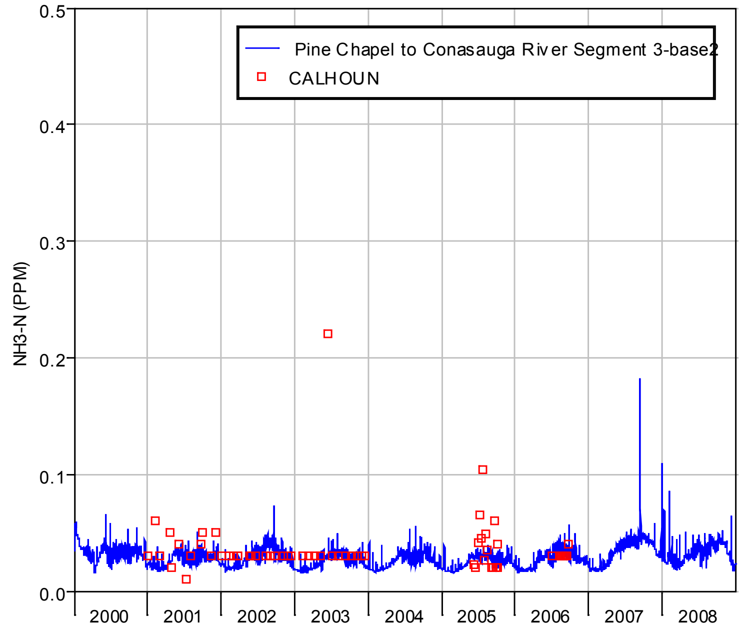


Figure 3-26 Time series of computed and observed ammonia in Coosawattee River at Calhoun.

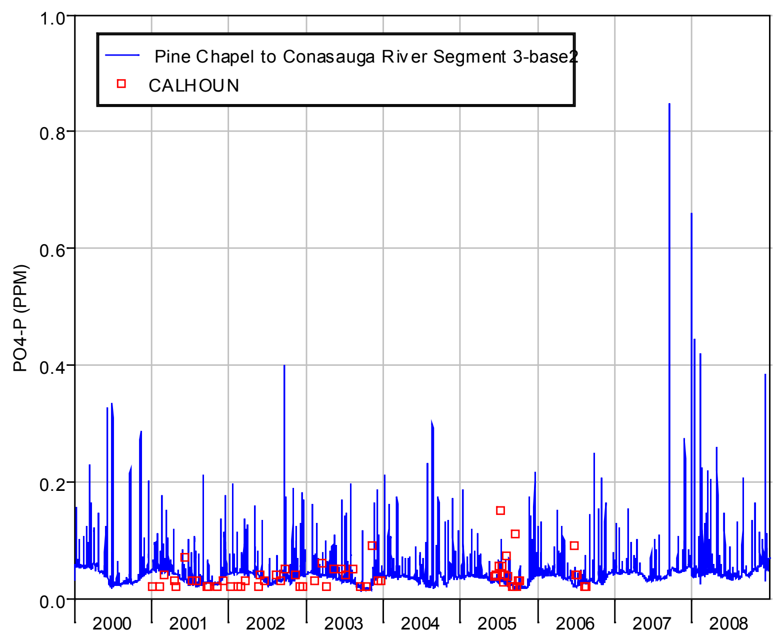


Figure 3-27 Time series of computed and observed phosphate in Coosawattee River at Calhoun.

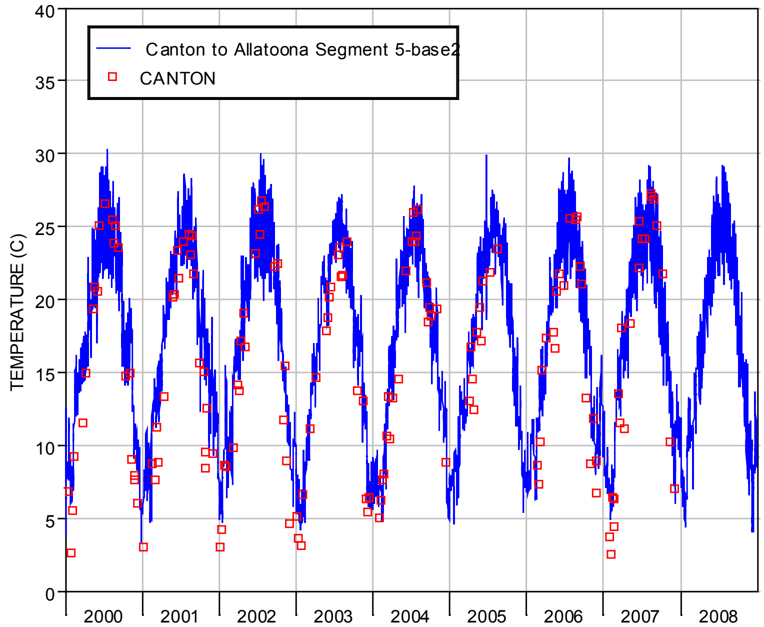


Figure 3-28 Time series of computed and observed temperature in Etowah River near Canton.

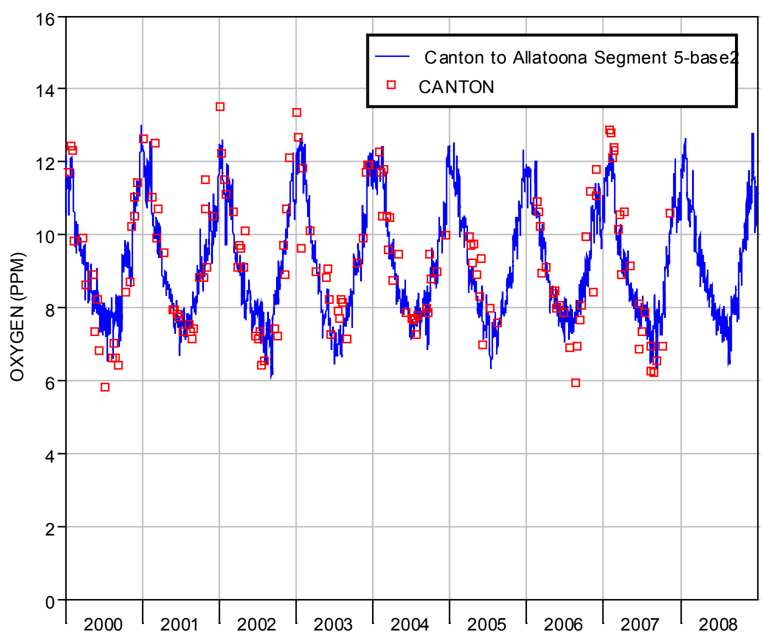


Figure 3-29 Time series of computed and observed oxygen in Etowah River near Canton.

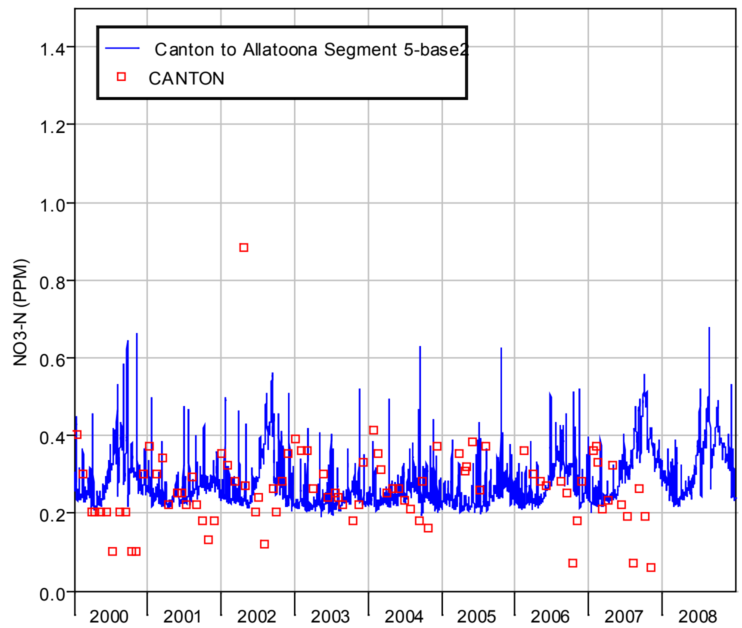


Figure 3-30 Time series of computed and observed nitrate in Etowah River near Canton.

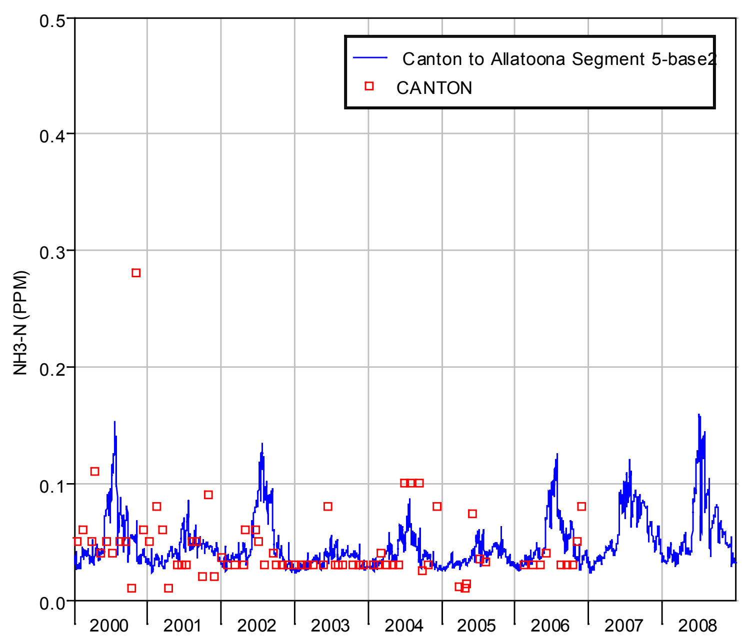


Figure 3-31 Time series of computed and observed ammonia in Etowah River near Canton.

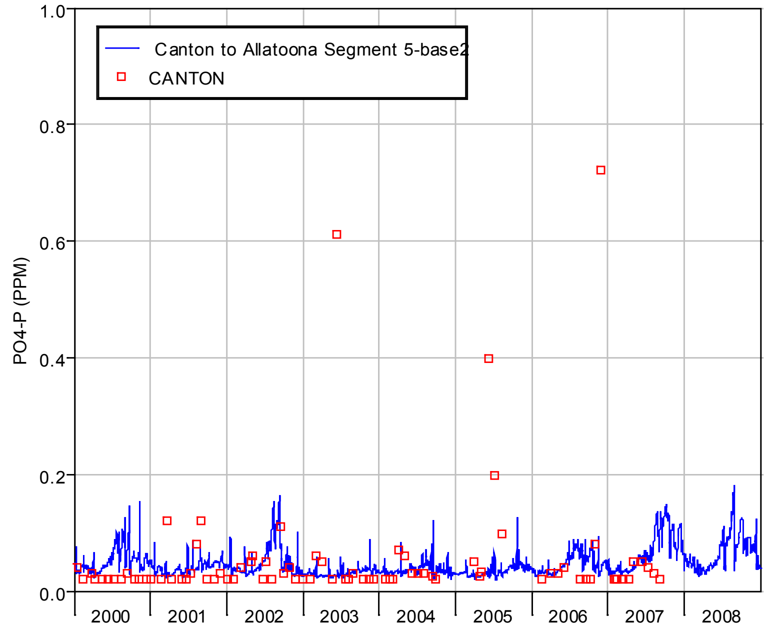


Figure 3-32 Time series of computed and observed phosphate in Etowah River near Canton.

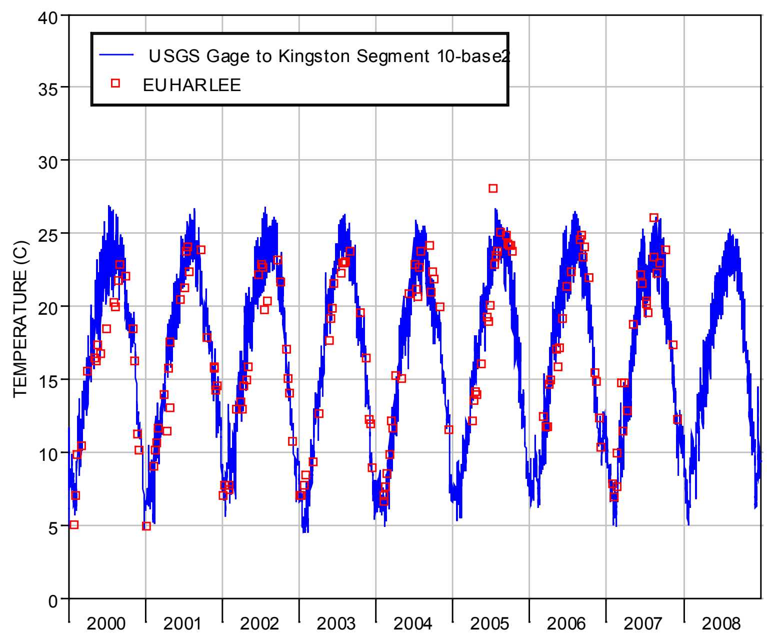


Figure 3-33 Time series of computed and observed temperature in Etowah River near Euharlee.

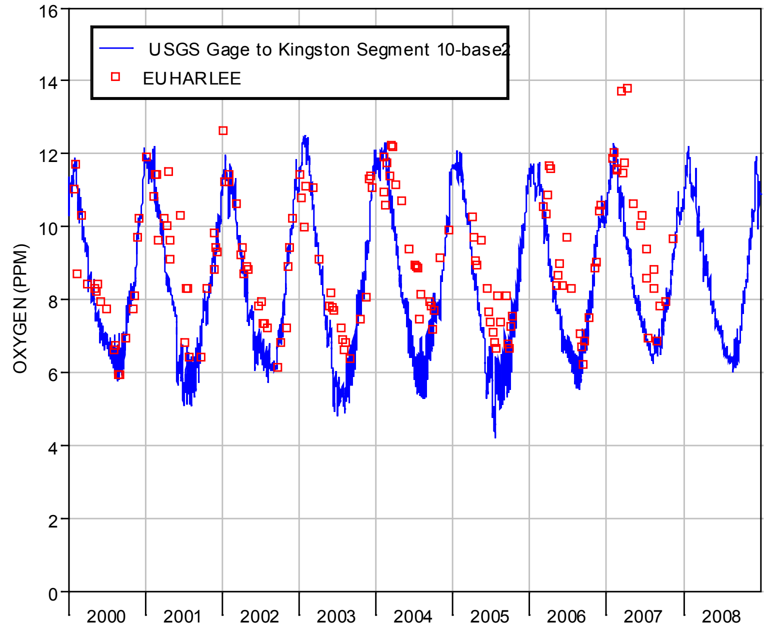


Figure 3-34 Time series of computed and observed oxygen in Etowah River near Euharlee.

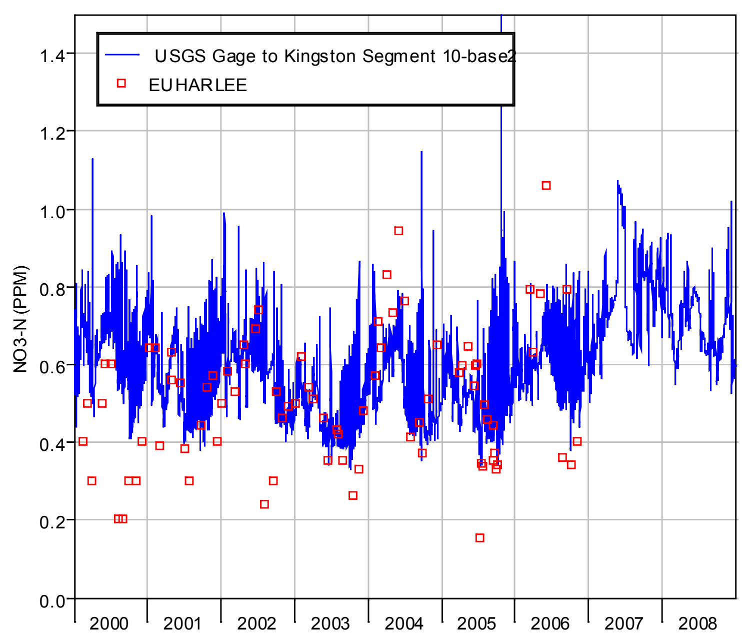


Figure 3-35 Time series of computed and observed nitrate in Etowah River near Euharlee.

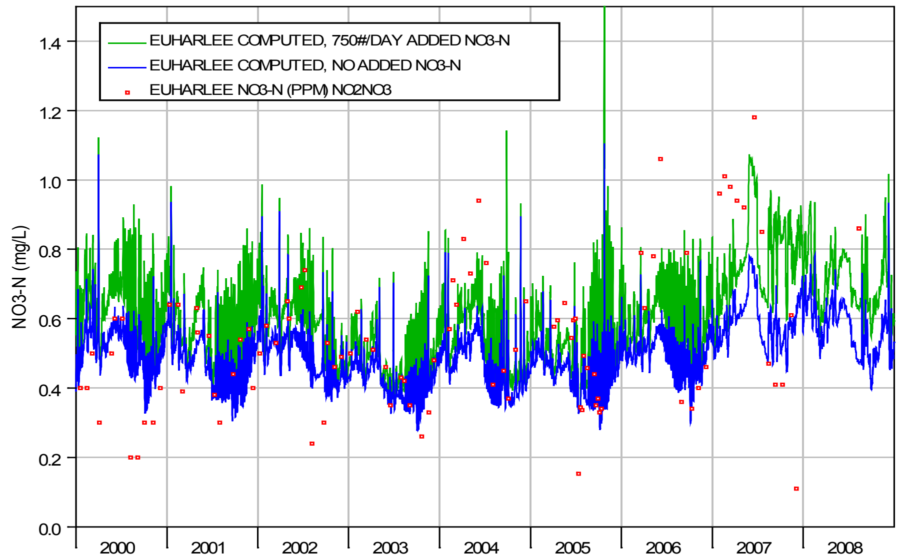


Figure 3-36 Time series of computed nitrate in Etowah River near Euharlee with and without 750 lb/day NO3-N added at river mile 675.

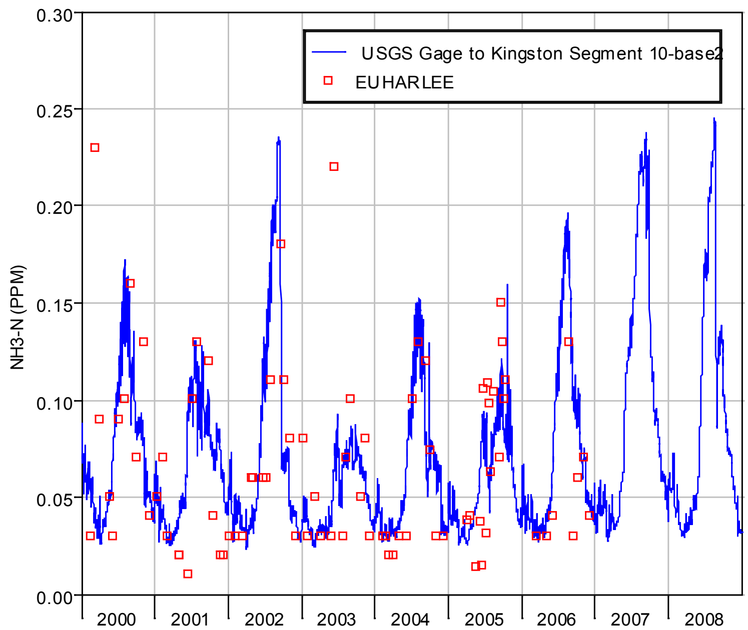


Figure 3-37 Time series of computed and observed ammonia in Etowah River near Euharlee.

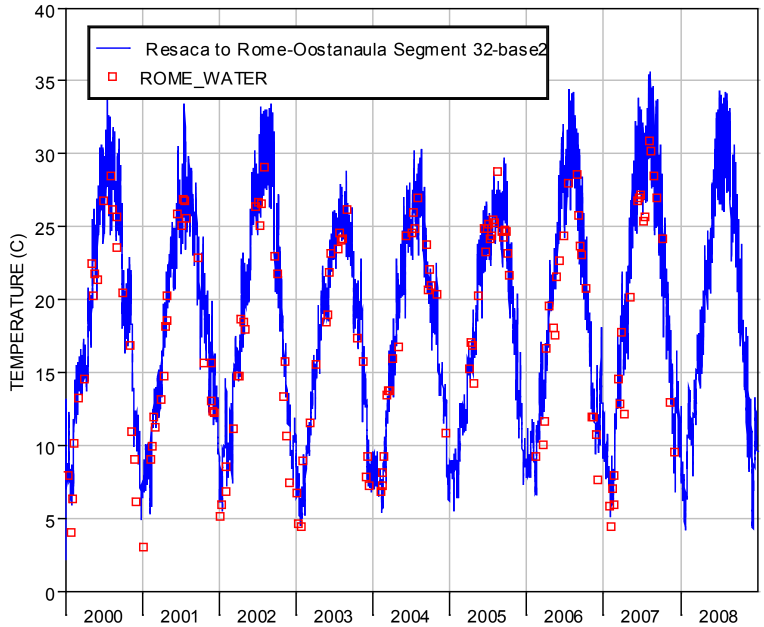


Figure 3-38 Time series of computed and observed temperature in Coosa River at Rome water intake.

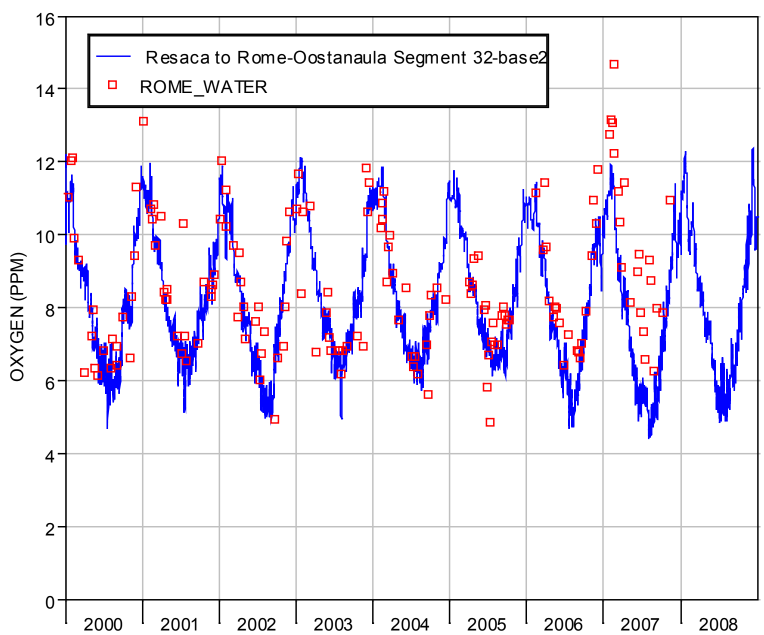


Figure 3-39 Time series of computed and observed oxygen in Coosa River at Rome water intake.

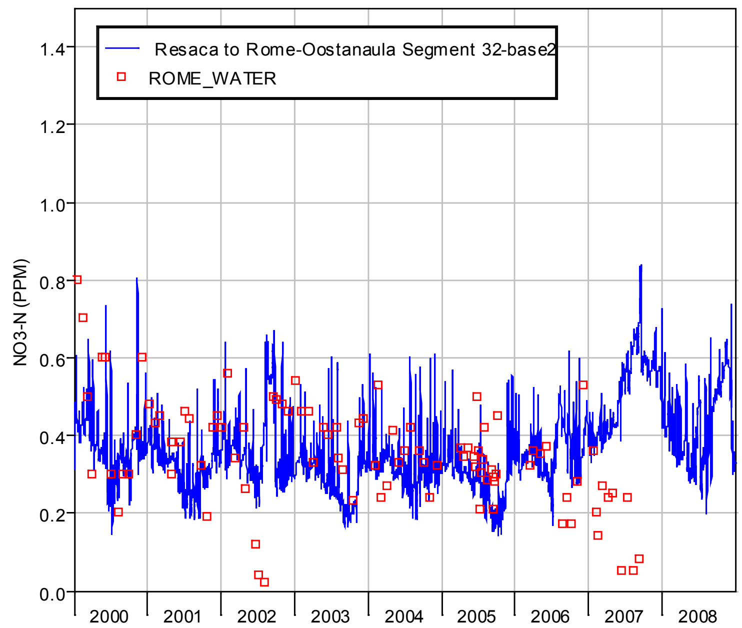


Figure 3-40 Time series of computed and observed nitrate in Coosa River at Rome water intake.

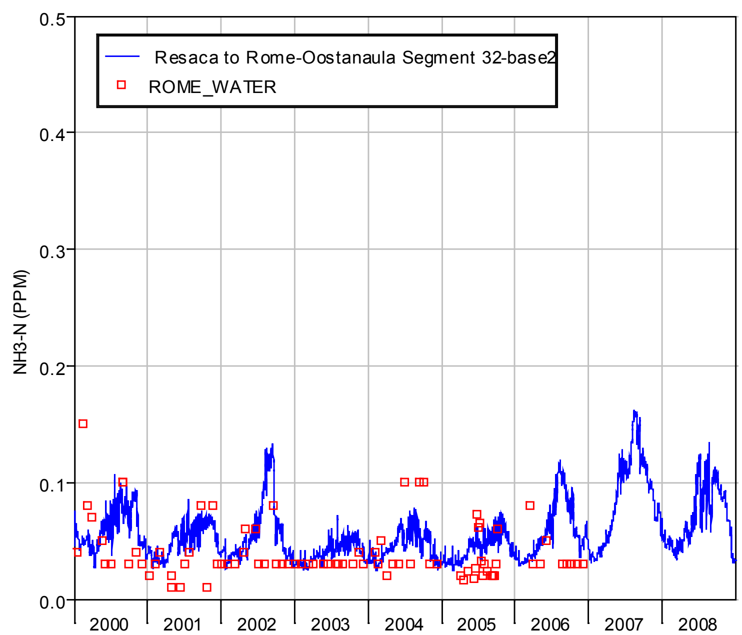


Figure 3-41 Time series of computed and observed ammonia in Coosa River at Rome water intake.

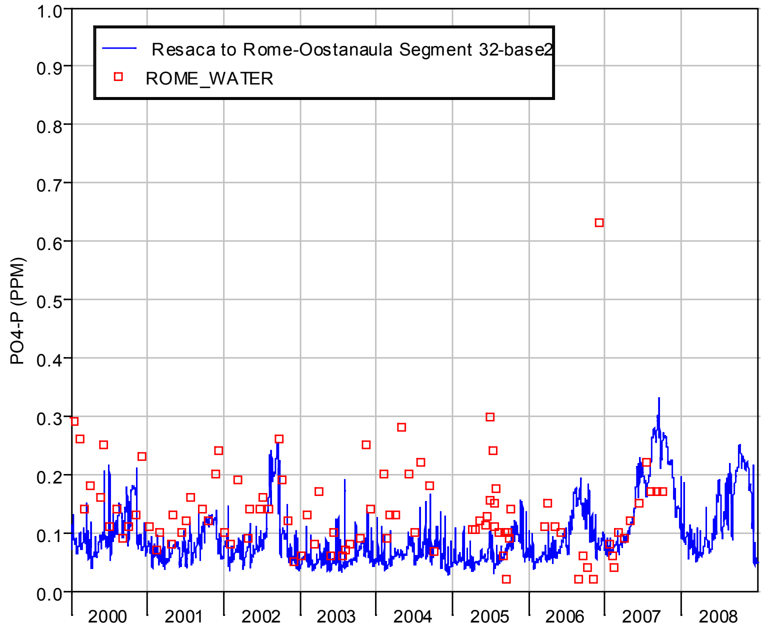


Figure 3-42 Time series of computed and observed phosphate in Coosa River at Rome water intake.

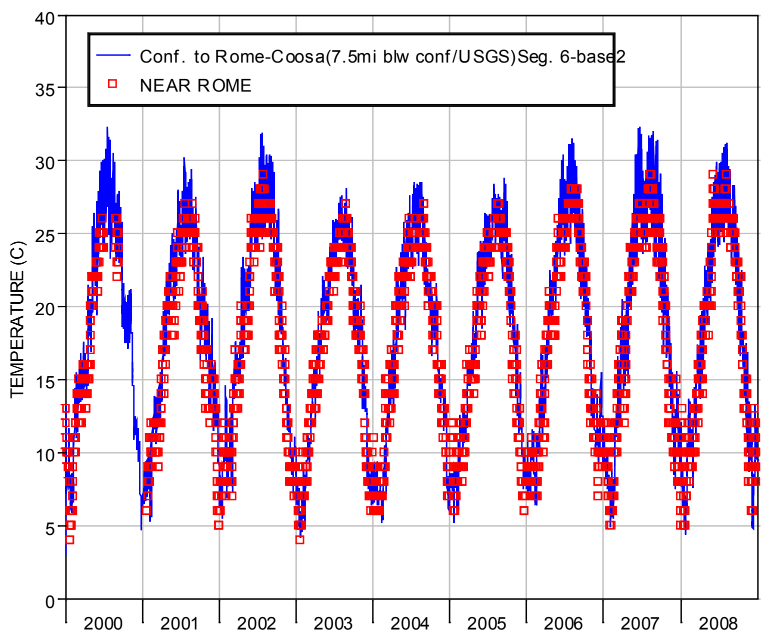


Figure 3-43 Time series of computed and observed temperature in Coosa River near Rome.

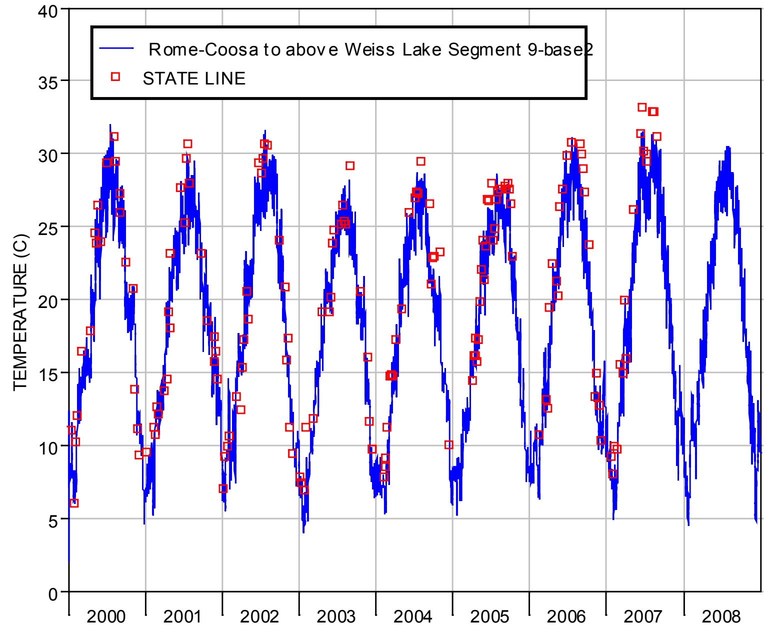


Figure 3-44 Time series of computed and observed temperature in Coosa River above State Line.

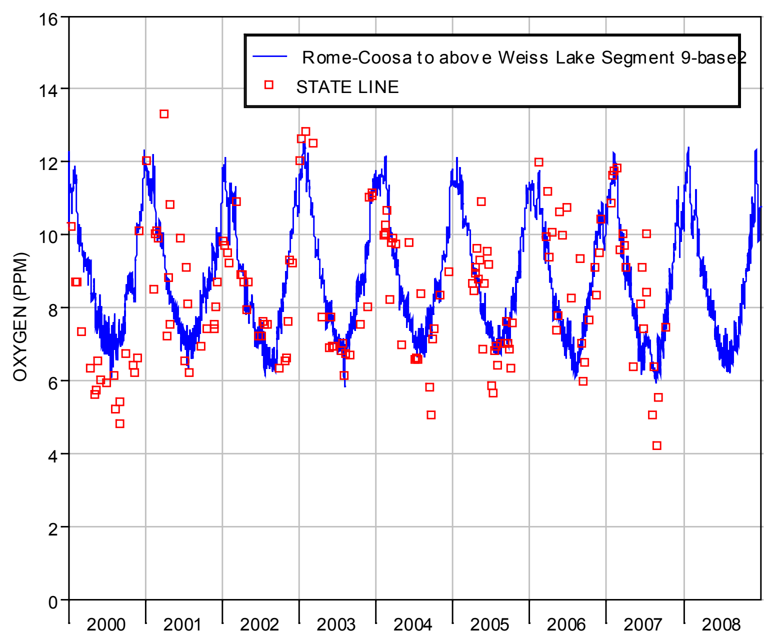


Figure 3-45 Time series of computed and observed oxygen in Coosa River above State Line.

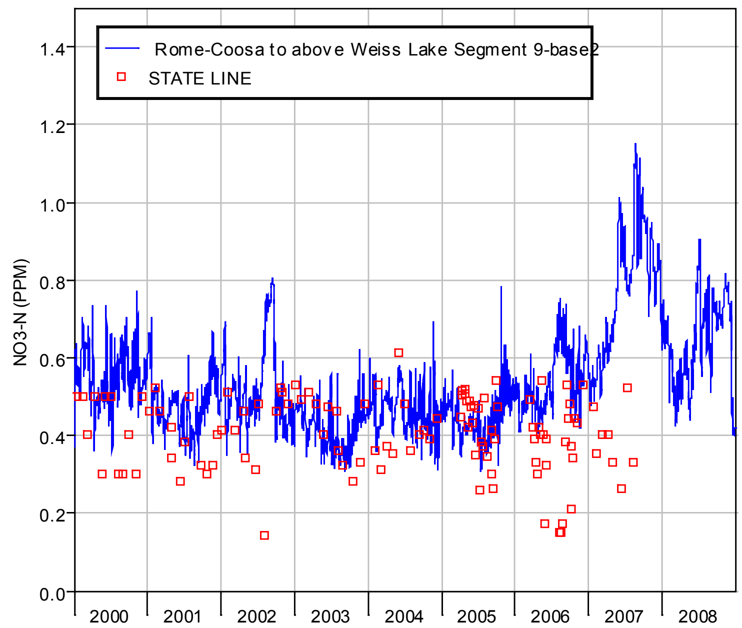


Figure 3-46 Time series of computed and observed nitrate in Coosa River above State Line.

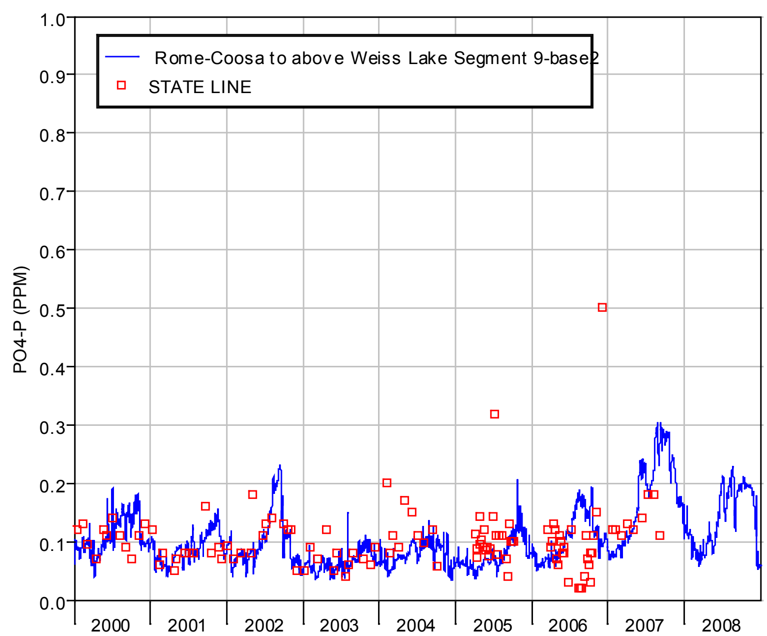


Figure 3-47 Time series of computed and observed phosphate in Coosa River above State Line.

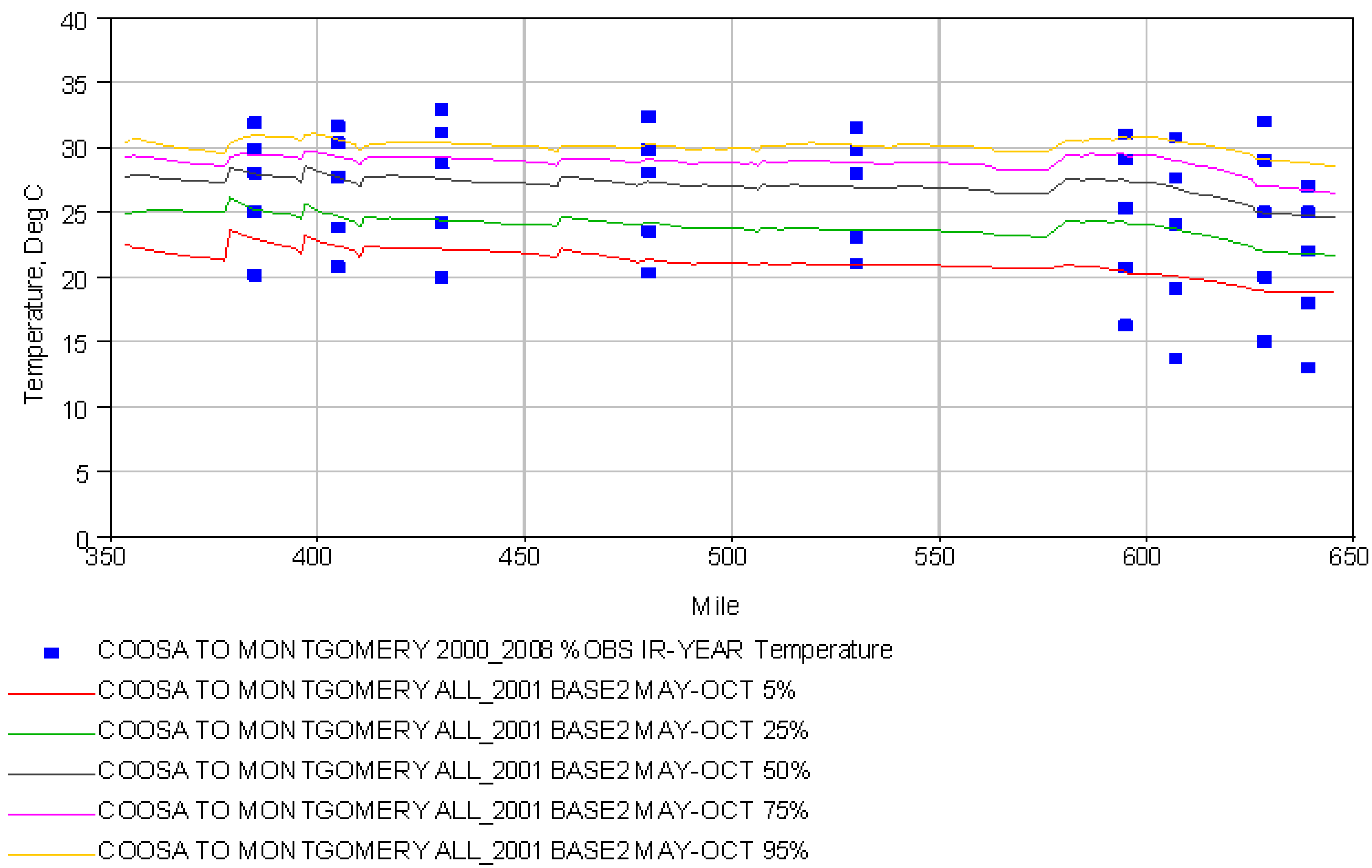


Figure 3-48 Longitudinal profile of observed and computed temperature in Coosa River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (May-October) values.

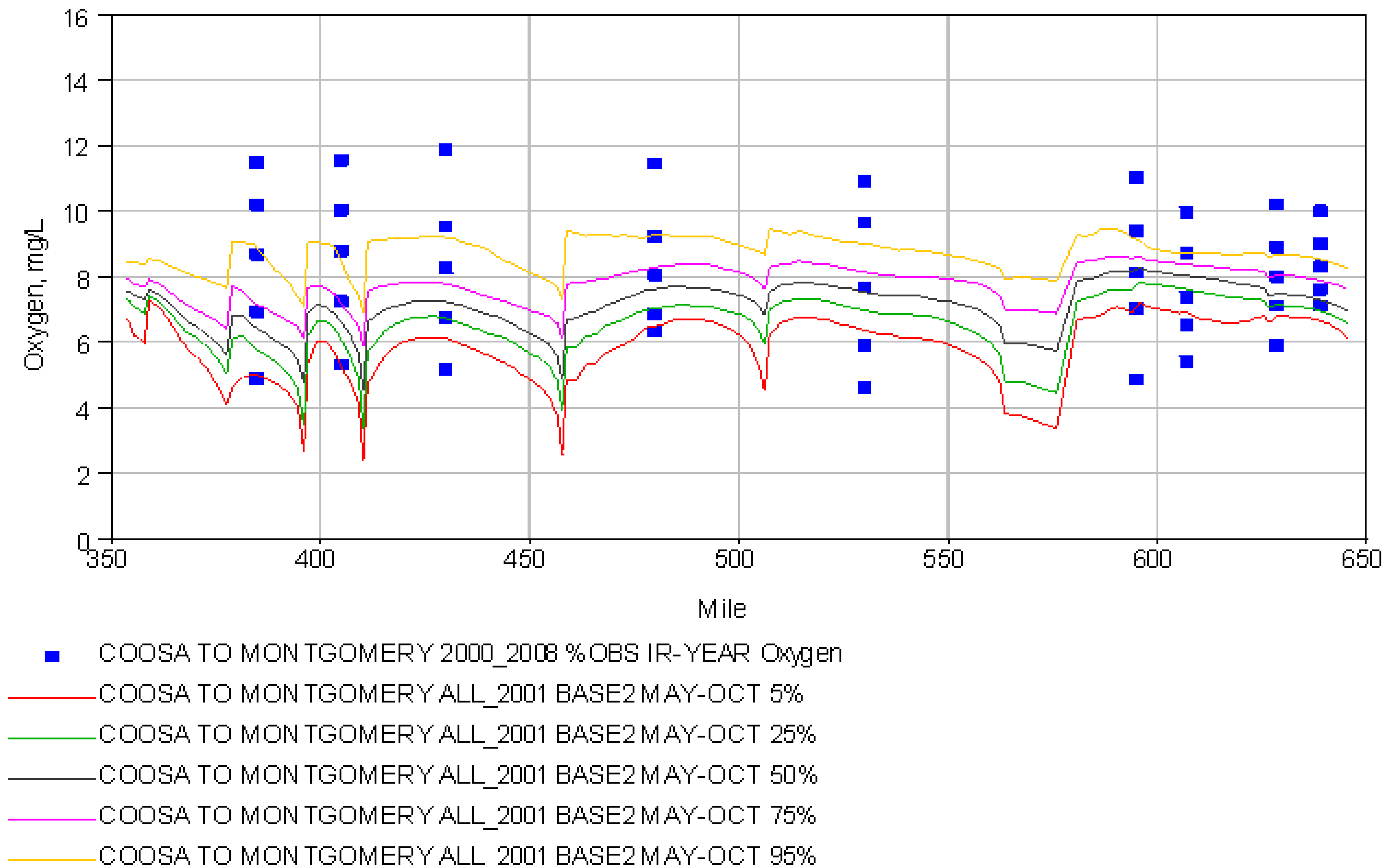


Figure 3-49 Longitudinal profile of observed and computed oxygen in Coosa River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (May-October) values.

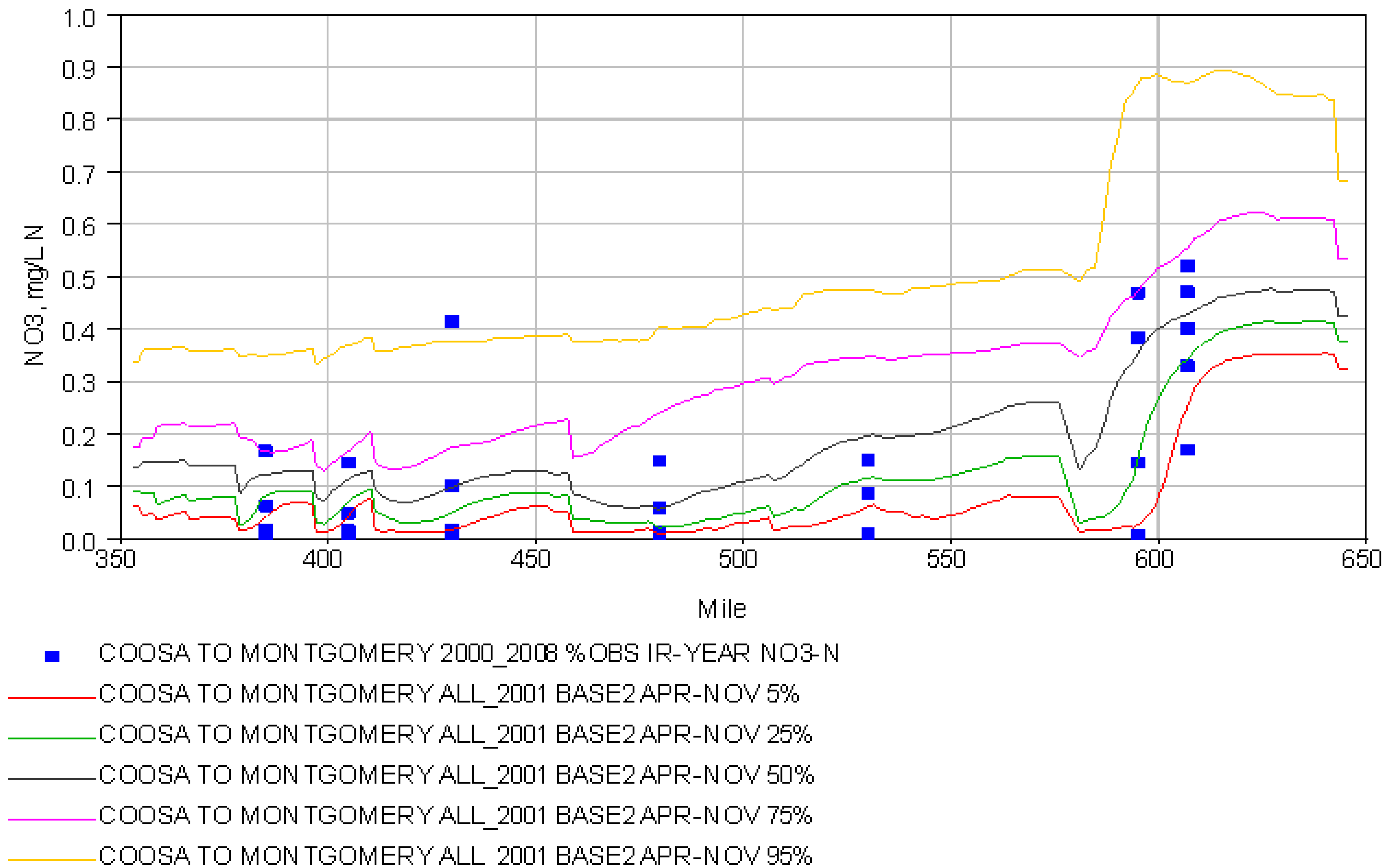


Figure 3-50 Longitudinal profile of observed and computed nitrate nitrogen in Coosa River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (April – November) values.

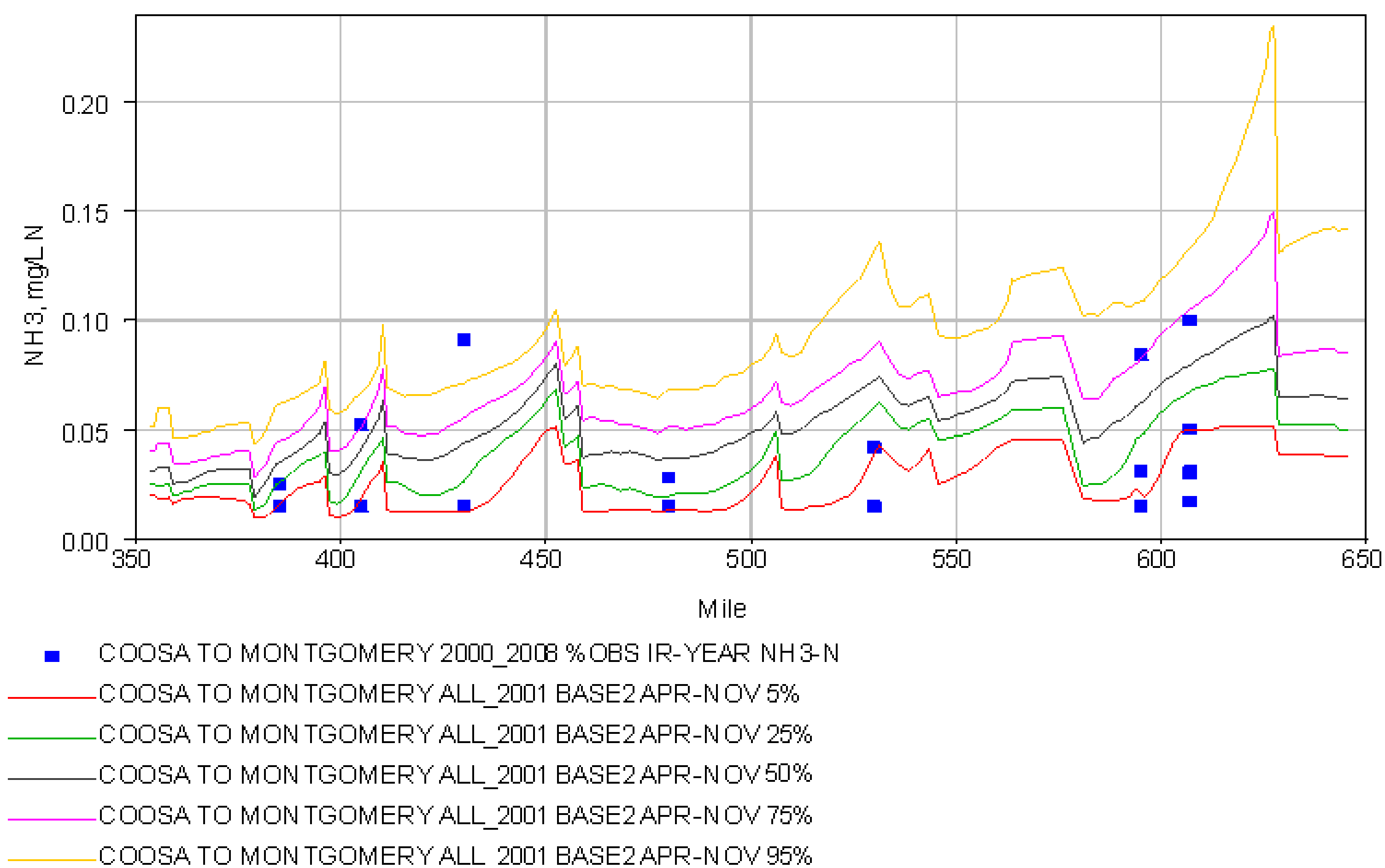


Figure 3-51 Longitudinal profile of observed and computed ammonia nitrogen in Coosa River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (April – November) values.

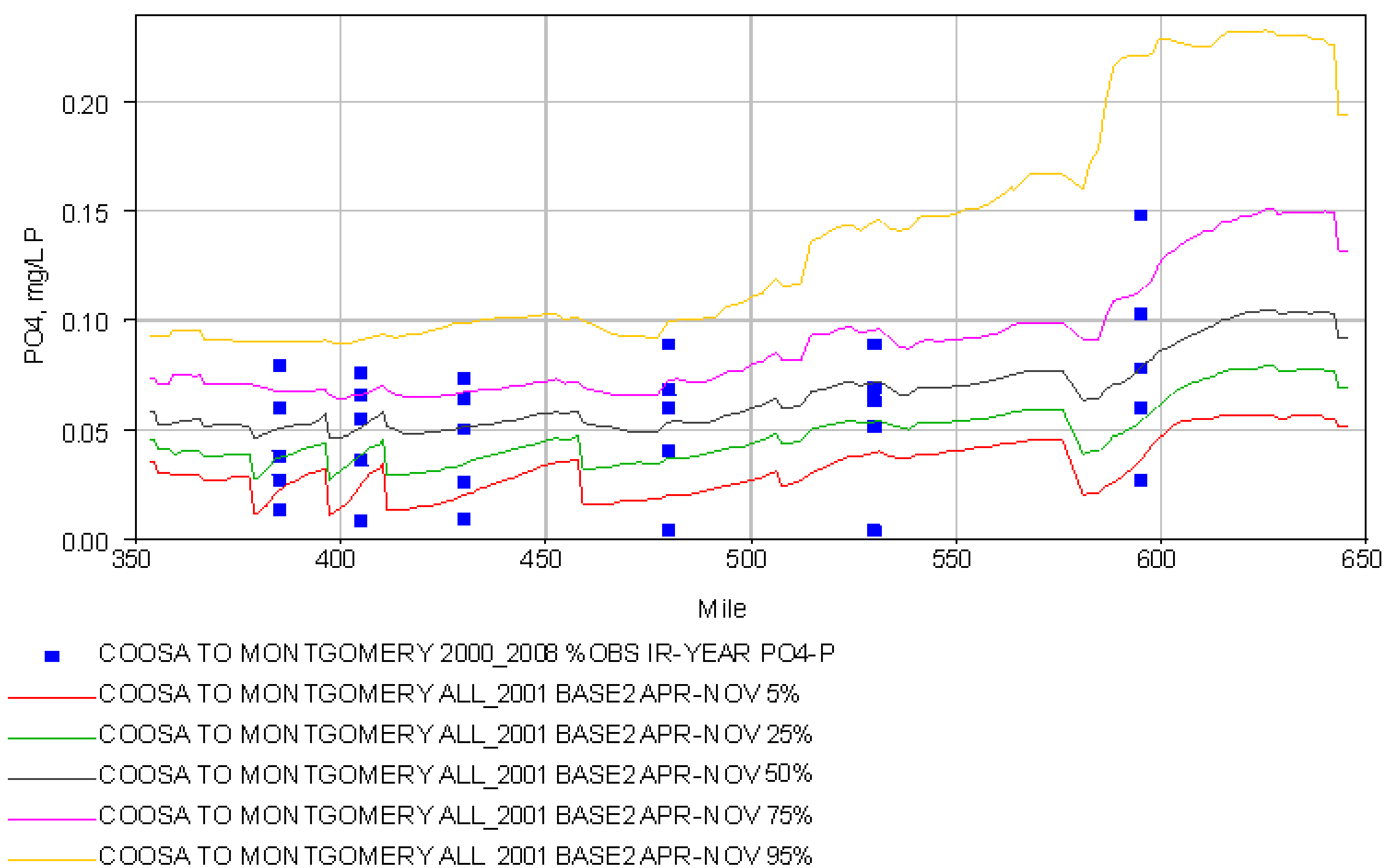


Figure 3-52 Longitudinal profile of observed and computed phosphate phosphorus in Coosa River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (April – November) values.

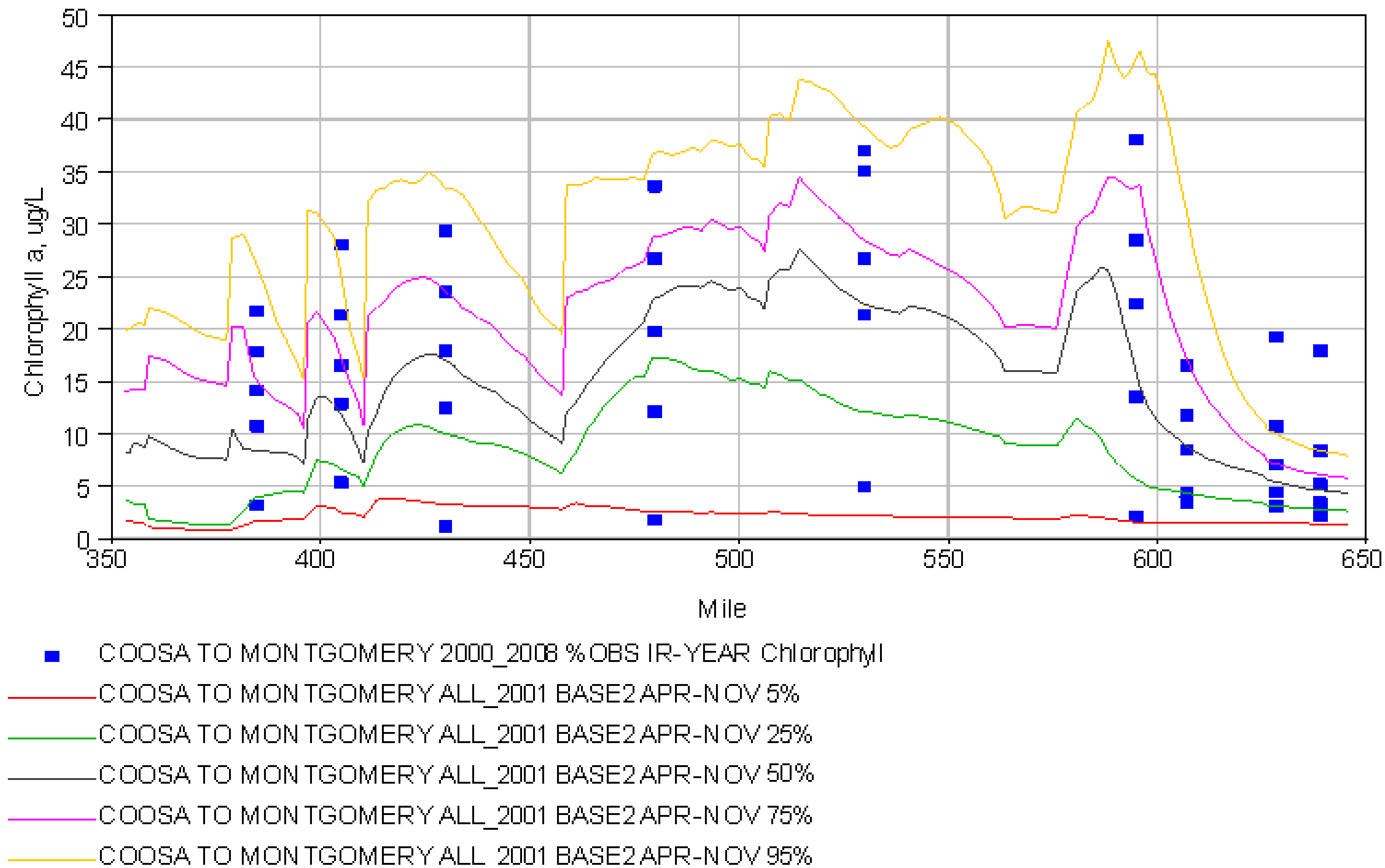


Figure 3-53 Longitudinal profile of observed and computed Chlorophyll *a* in Coosa River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (April – November) values.

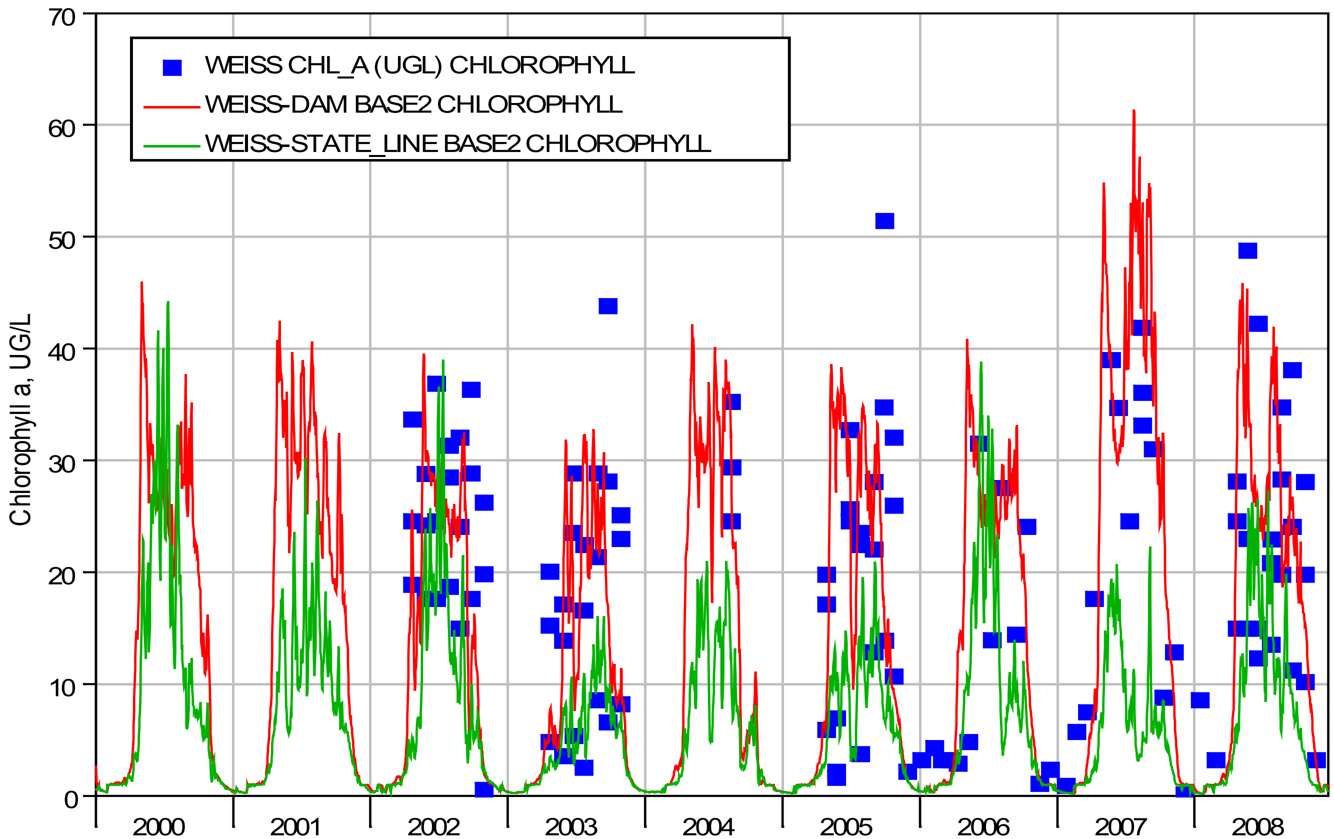


Figure 3-54 Observed and computed Chlorophyll *a* in Weiss reservoir.

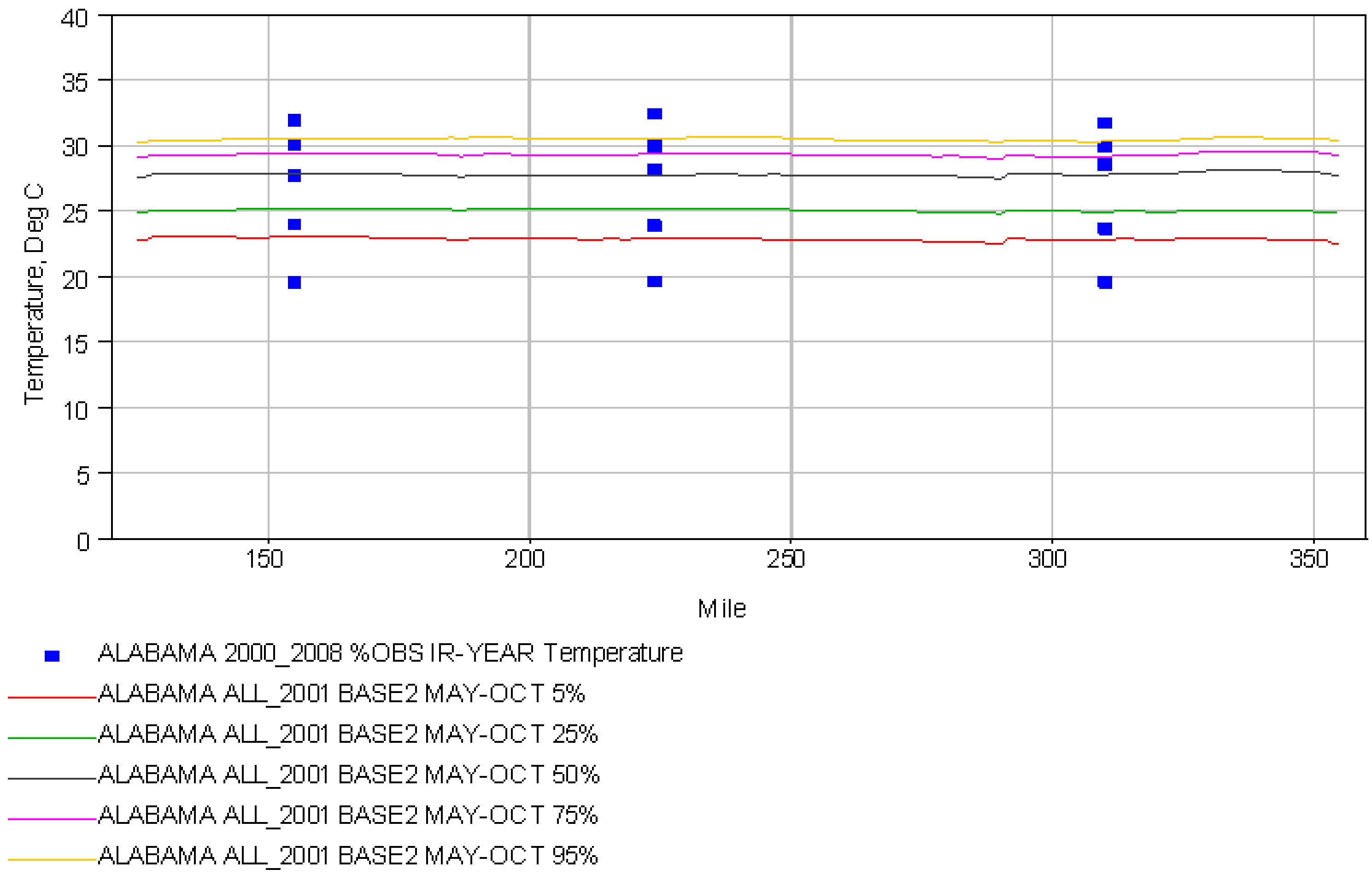


Figure 3-55 Longitudinal profile of observed and computed temperature in Alabama River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (May - October) values.

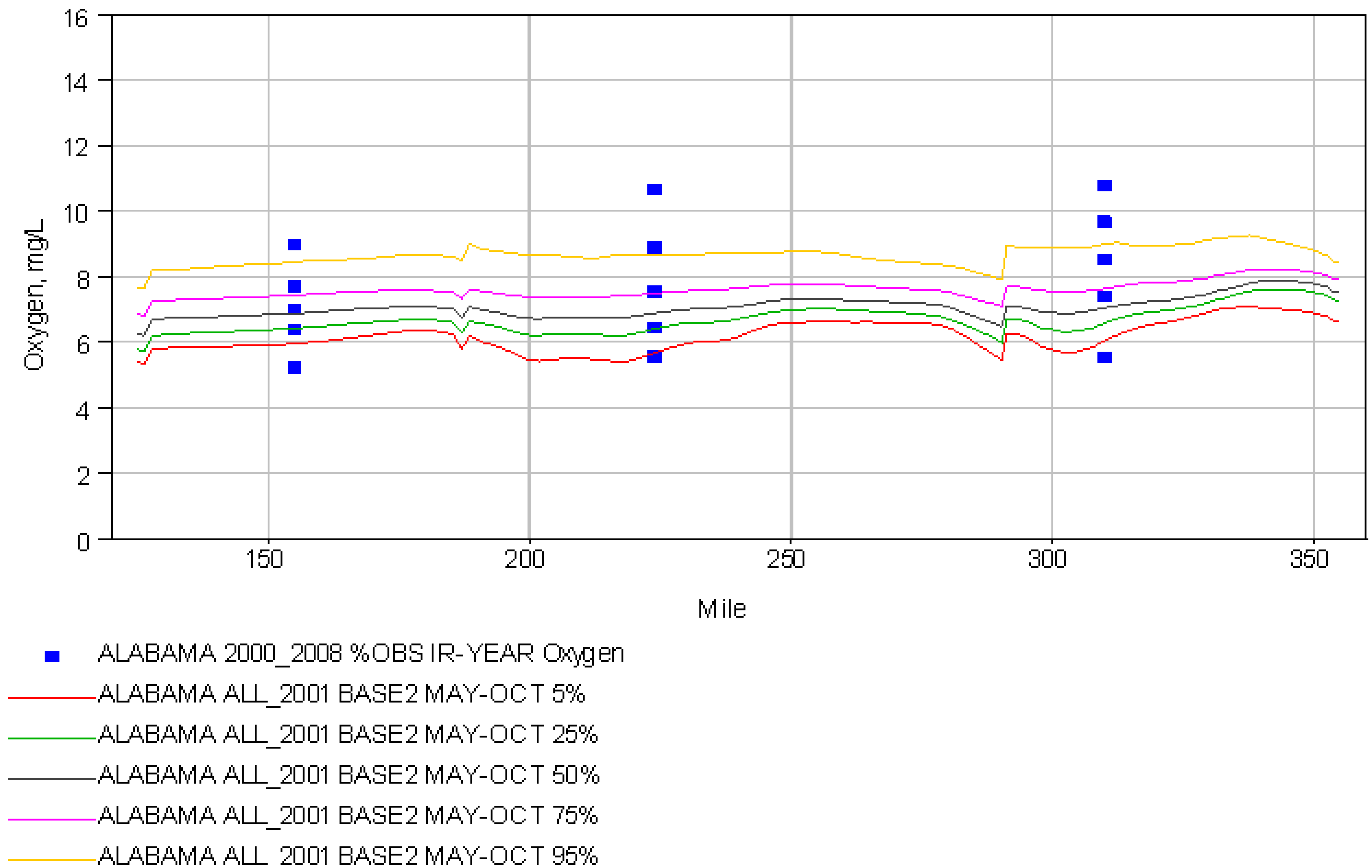


Figure 3-56 Longitudinal profile of observed and computed oxygen in Alabama River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (May - October) values.

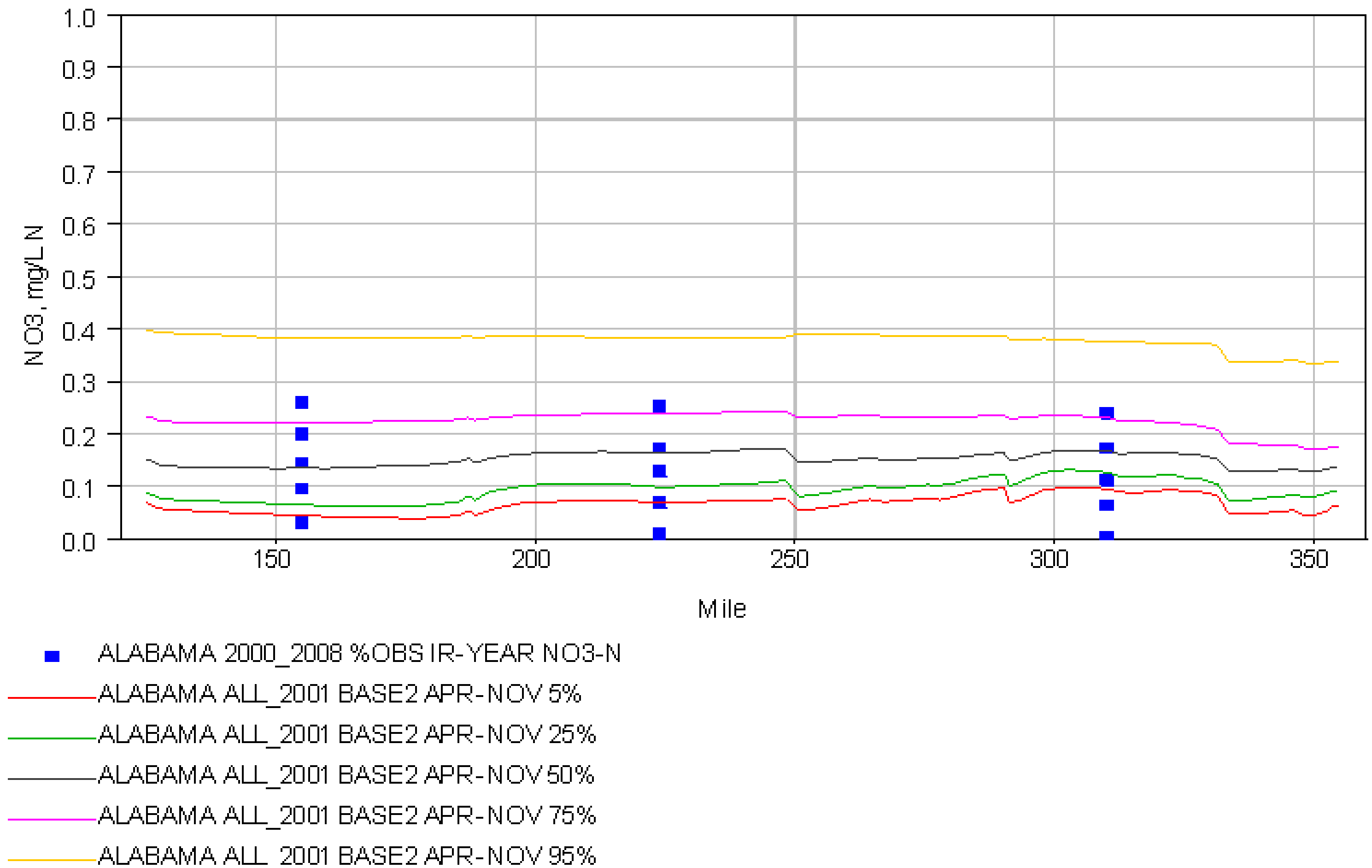


Figure 3-57 Longitudinal profile of observed and computed nitrate nitrogen in Alabama River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (April – November) values.

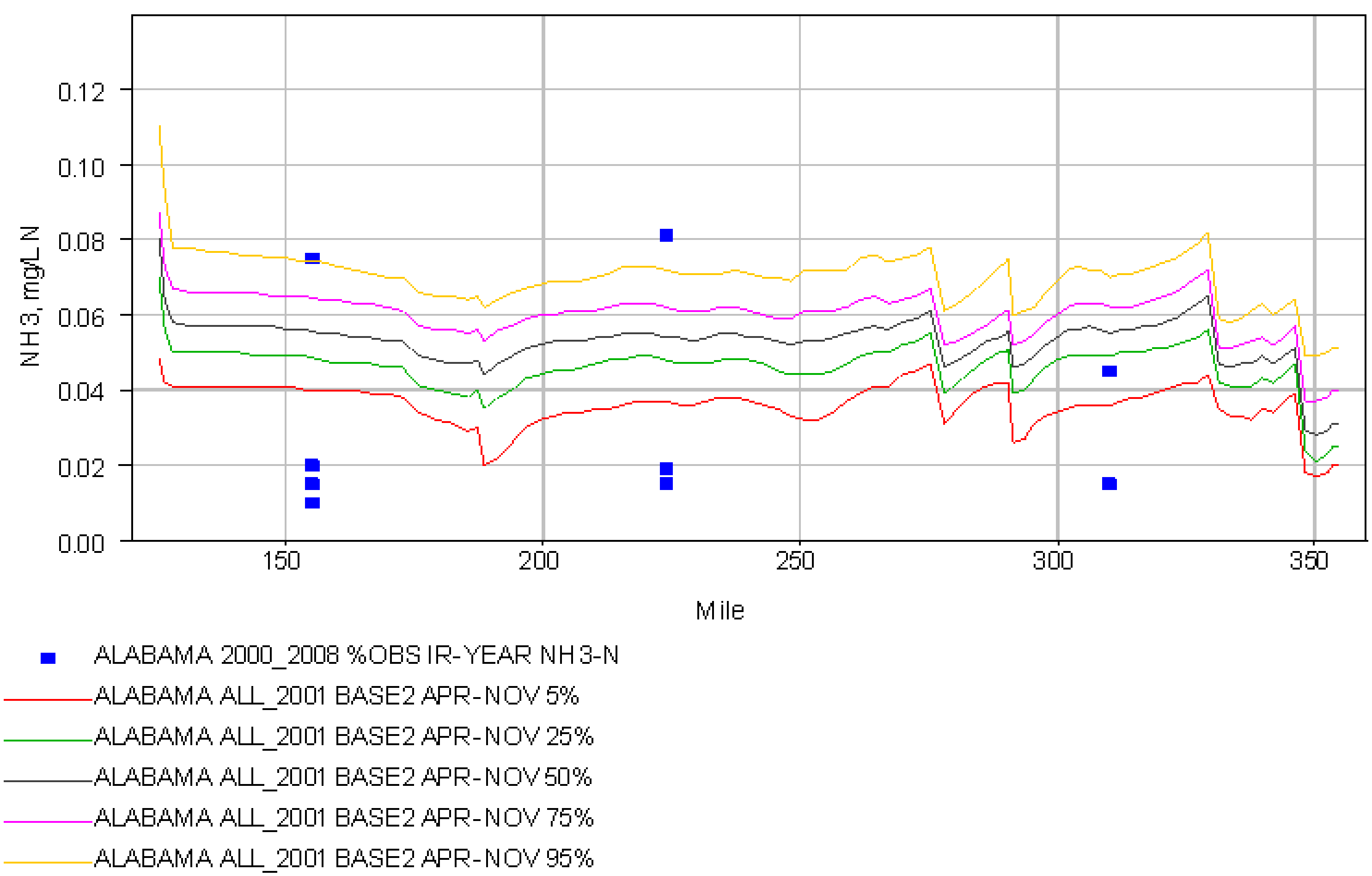


Figure 3-58 Longitudinal profile of observed and computed ammonia nitrogen in Alabama River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (April – November) values.

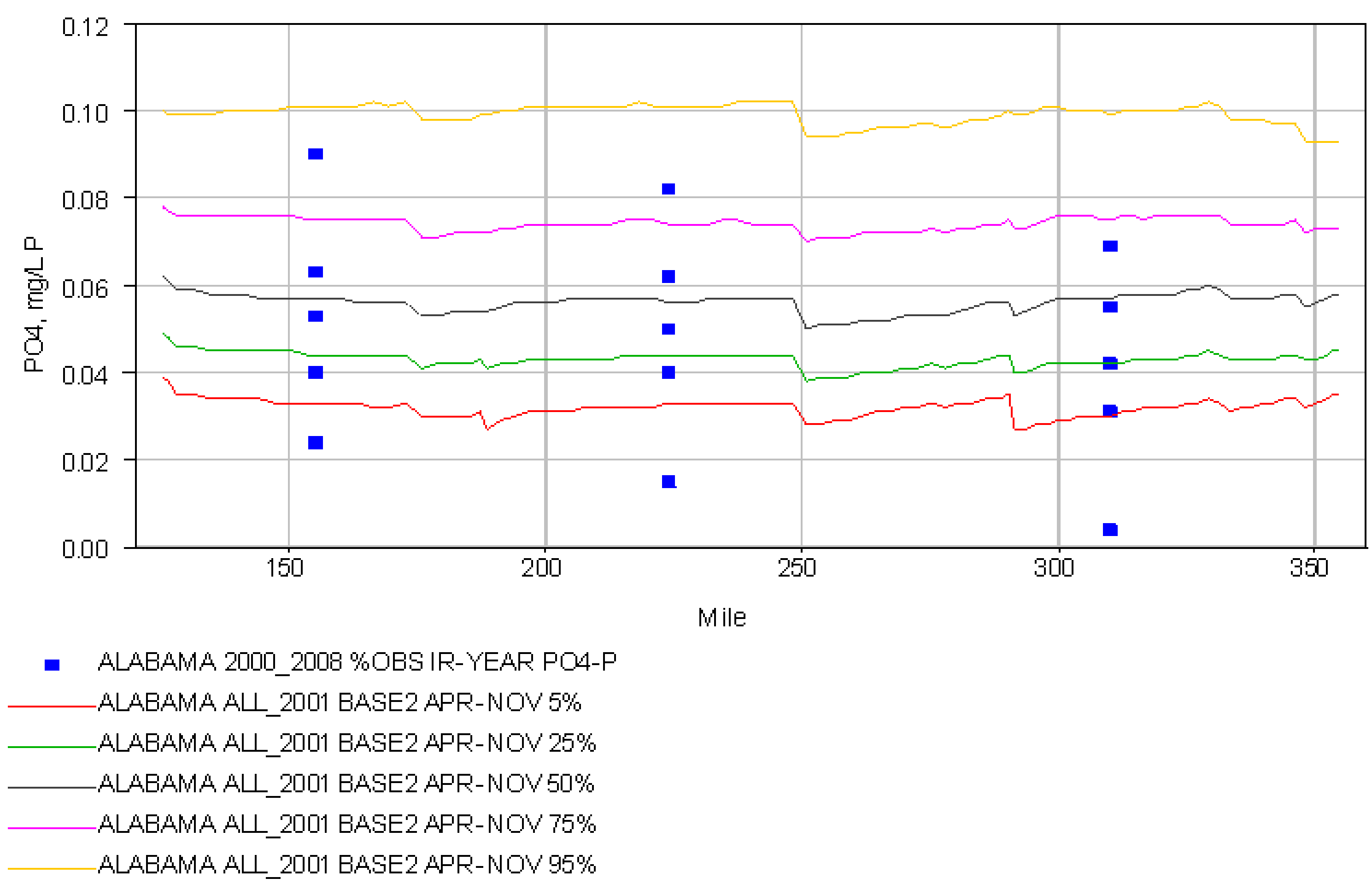


Figure 3-59 Longitudinal profile of observed and computed phosphate phosphorus in Alabama River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (April – November) values.

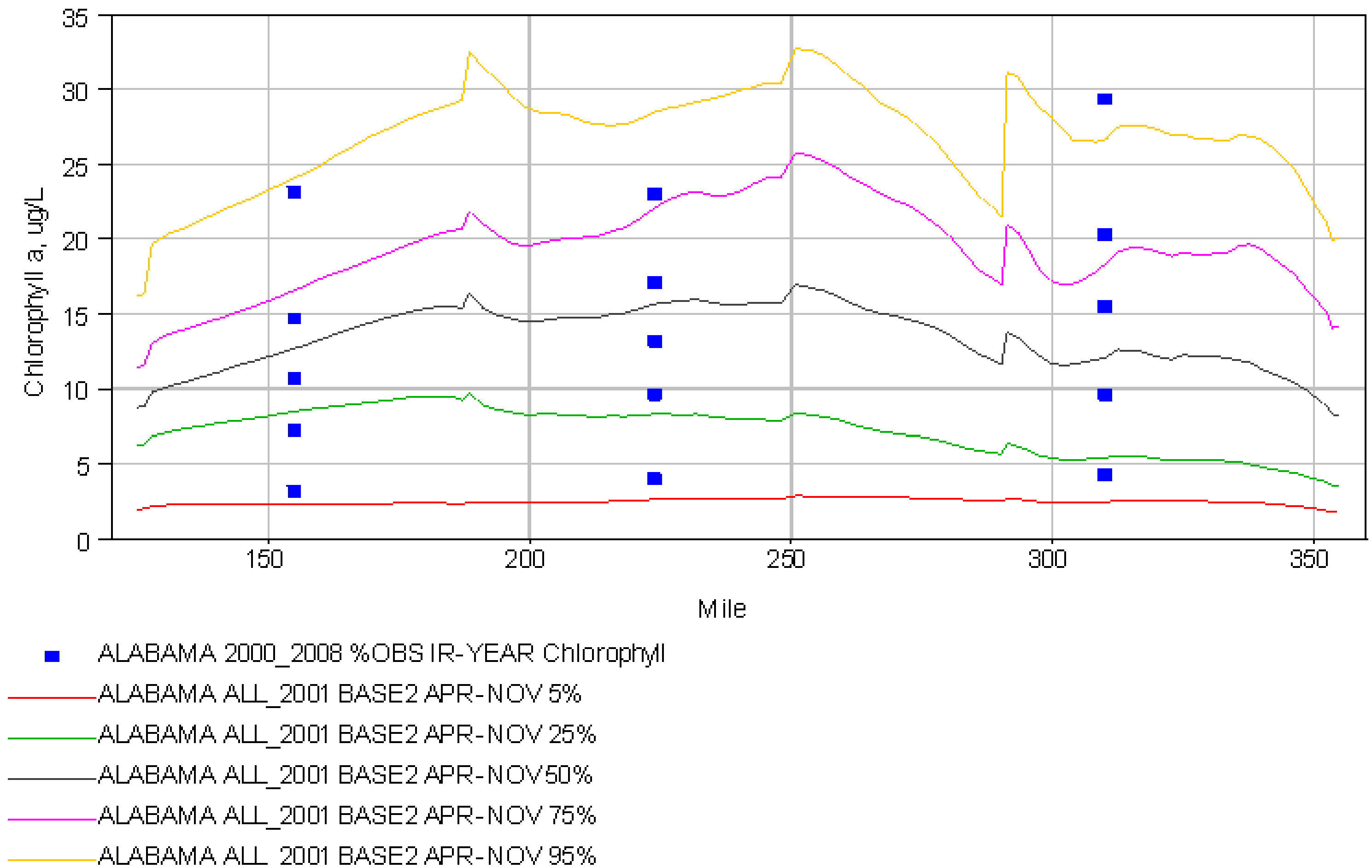


Figure 3-60 Longitudinal profile of observed and computed Chlorophyll *a* in Alabama River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (April – November) values.

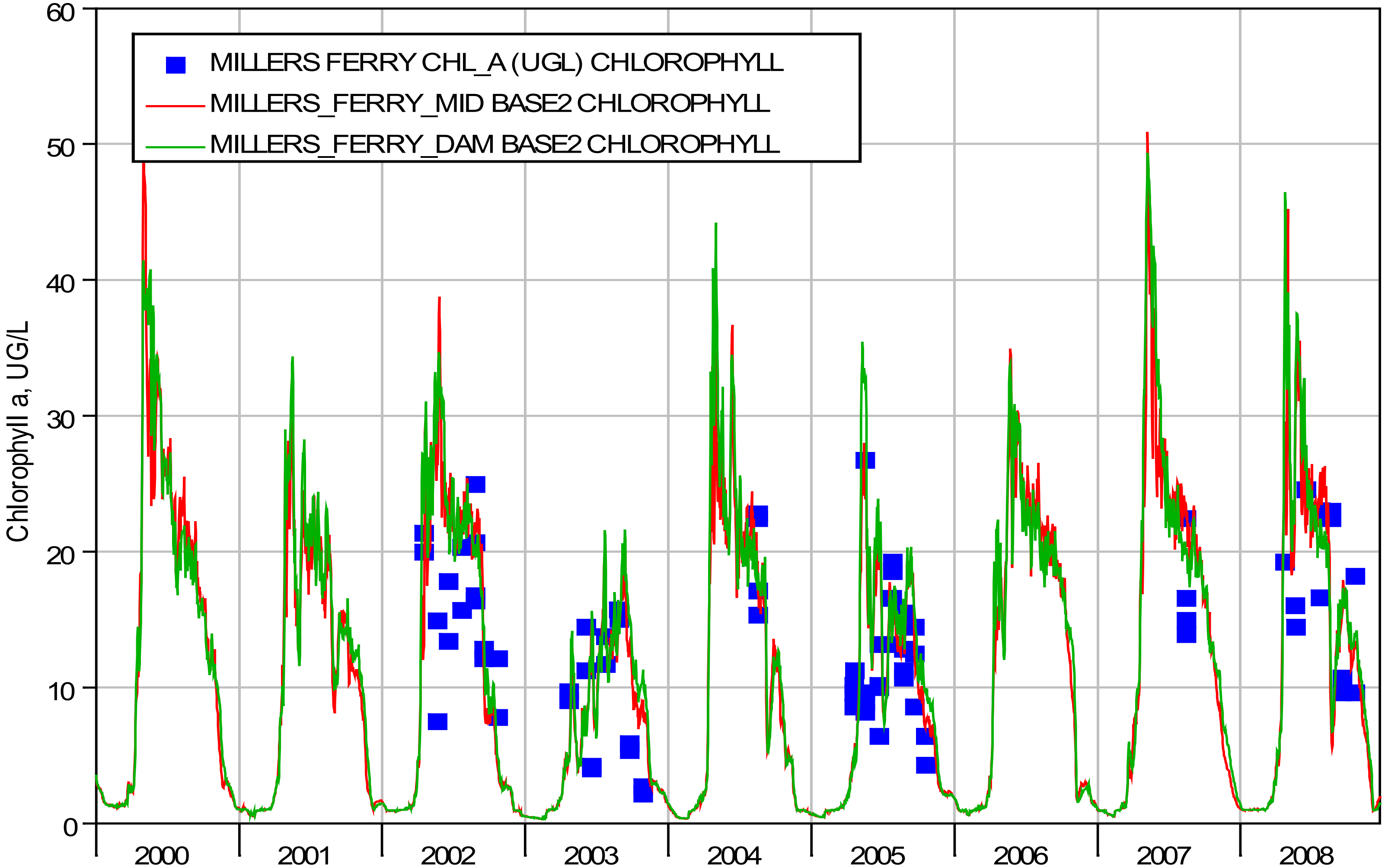


Figure 3-61 Observed and computed Chlorophyll *a* in Alabama River at Millers Ferry.

4 RESULTS

HEC-5Q was used to simulate water quality in the ACT basin under four alternative reservoir operation scenarios. The simulation results are included in the companion DVD for this report. These results consist of time series, cumulative occurrence profiles, and longitudinal river profiles of occurrence of each water quality parameter. The details of these results are outlined below, and representative plots are shown. All plots are available on the companion DVD to this report, along with HEC-DSS files used to create the plots. The model output in the DSS files may be viewed in tabular form or plotted using HEC-DSSVue.

The simulation results for stream sections represent the average of each water quality parameter at each river mile. In the reservoirs, the simulation results represent the average concentration in the approximate euphotic zone (top 5 to 10 feet) of each reservoir.

Time series were output for several model locations along the Alabama, Coosa, Tallapoosa, Etowah, and Coosawattee Rivers. These locations are shown in Table 4-1. The time series were used to compute the cumulative occurrence of each water quality parameter shown in Table 4-2. Then occurrence was computed for several different annual, seasonal, and weekly periods and plotted by river mile to create longitudinal occurrence profiles for each parameter. The definition of each plot type and the various computation intervals applied to derive each set of plots are detailed in the following sections.

Table 4-1 Time Series Output Locations (Upstream to Downstream)

River Mile	River	River Profile	Time Series Location
730.85	Coosawattee	Coosawattee to Weiss	Carters - Pumpback
720.00	Coosawattee	"	Carters - Lake
719.05	Coosawattee	"	Carters
718.51	Coosawattee	"	Carters Rereg
701.51	Coosawattee	"	Pine Chapel
695.87	Coosawattee	"	Oostanaula
688.80	Oostanaula	"	Resaca
668.87	Oostanaula	"	Oostanaula - River Mile 669
651.02	Oostanaula	"	Rome-Oostanaula
723.64	Etowah	Etowah to Weiss	Canton
717.50	Etowah	"	Above Allatoona
694.00	Etowah	"	Allatoona - Lake
692.48	Etowah	"	Allatoona - Outflow
684.12	Etowah	"	Cartersville
667.17	Etowah	"	Kingston
653.10	Etowah	"	Rome

River Mile	River	River Profile	Time Series Location
646.55	Etowah	"	Oostanaula
639.04	Oostanaula	"	Rome-Coosa
645.46	Coosa	Coosa to Montgomery	Oostanaula-Etowah-Coosa
625.59	Coosa	"	Weiss - Inflow
603.26	Coosa	"	Weiss - Mid-lake
580.93	Coosa	"	Weiss - Dam
584.25	Coosa	"	Weiss - Spillway
533.69	Coosa	"	H. N. Henry - Mid-lake
507.35	Coosa	"	H. N. Henry - Dam
481.95	Coosa	"	Logan Martin - Mid-lake
459.00	Coosa	"	Logan Martin - Dam
434.05	Coosa	"	Lay - Mid-lake
411.38	Coosa	"	Lay - Dam
403.20	Coosa	"	Mitchell - Mid-lake
397.16	Coosa	"	Mitchell - Dam
386.85	Coosa	"	Jordan - Mid-lake
378.96	Coosa	"	Jordan - Dam
355.44	Coosa	"	Coosa
522.60	Tallapoosa	Tallapoosa to Montgomery	Above Harris
498.00	Tallapoosa	"	Harris - Lake
497.83	Tallapoosa	"	Harris - Outflow
484.15	Tallapoosa	"	Wadley
465.40	Tallapoosa	"	Tallapoosa - River Mile 465
445.55	Tallapoosa	"	Above Martin
498.00	Tallapoosa	"	Martin - Lake
419.95	Tallapoosa	"	Martin - Outflow
413.03	Tallapoosa	"	Yates - Dam
409.51	Tallapoosa	"	Thurlow - Dam
407.90	Tallapoosa	"	Tallassee
390.76	Tallapoosa	"	Tallapoosa - River Mile 391
375.74	Tallapoosa	"	Tallapoosa - River Mile 376
355.50	Tallapoosa	"	Above JBT Goal
522.01	Little Tallapoosa	"	Above Harris
353.50	Alabama	Alabama	Above R. F. Henry
331.38	Alabama	"	Montgomery
310.31	Alabama	"	R. F. Henry - Mid-lake
291.35	Alabama	"	R. F. Henry - Dam
290.10	Alabama	"	R. F. Henry - Outflow
258.94	Alabama	"	Selma
223.72	Alabama	"	Millers Ferry - Mid-lake
188.50	Alabama	"	Millers Ferry - Dam
187.15	Alabama	"	Millers Ferry - Outflow

River Mile	River	River Profile	Time Series Location
156.68	Alabama	"	Claiborne - Mid-lake
127.90	Alabama	"	Claiborne - Dam
125.30	Alabama	"	ARP
248.01	Cahaba	"	Above Millers Ferry

Table 4-2 Water quality parameters modeled by HEC-5Q.

Water Quality Parameter
Water temperature
Dissolved Oxygen (D.O.)
5-Day Uninhibited BOD (BOD5U)
Nitrate-Nitrogen (NO_3-N)
Ammonia-Nitrogen (NH_3-N)
Phosphate-Phosphorous (PO_4-P)
Municipal and Industrial Wastewater as Percent of Flow
Phytoplankton (Algae) reported as Chlorophyll *a*[4]

Three categories of plots were created from the HEC-5Q model output to summarize the results: Time Series, Cumulative Occurrence, and River Profiles. These are described in following sections.

[4] All references to Chlorophyll *a* assume a ratio of 10 ug/L Chlorophyll *a* to 1 mg/L phytoplankton biomass (dry weight).

4.1 TIME SERIES

Time series are shown for each parameter computed for the 2001 – 2008 model period. A time series plot was created for each location (Table 4-1) along the Alabama, Coosa, Tallapoosa, Etowah, and Coosawattee Rivers. Each of the water quality parameters shown in Table 4-2 was plotted. The full set of plots was provided to Mobile District via FTP transfer will be provided on the companion DVD to this report.

Representative plots of Chlorophyll *a*, dissolved oxygen, and temperature are shown in Figure 4-1 – Figure 4-6 at two sample stations from both the Coosa and Alabama Rivers. The two sample stations for the Coosa River are Weiss – State Line and Jordan – Mid-lake. The two sample stations for the Alabama River are Above R. F. Henry and Claiborne – Mid-lake.

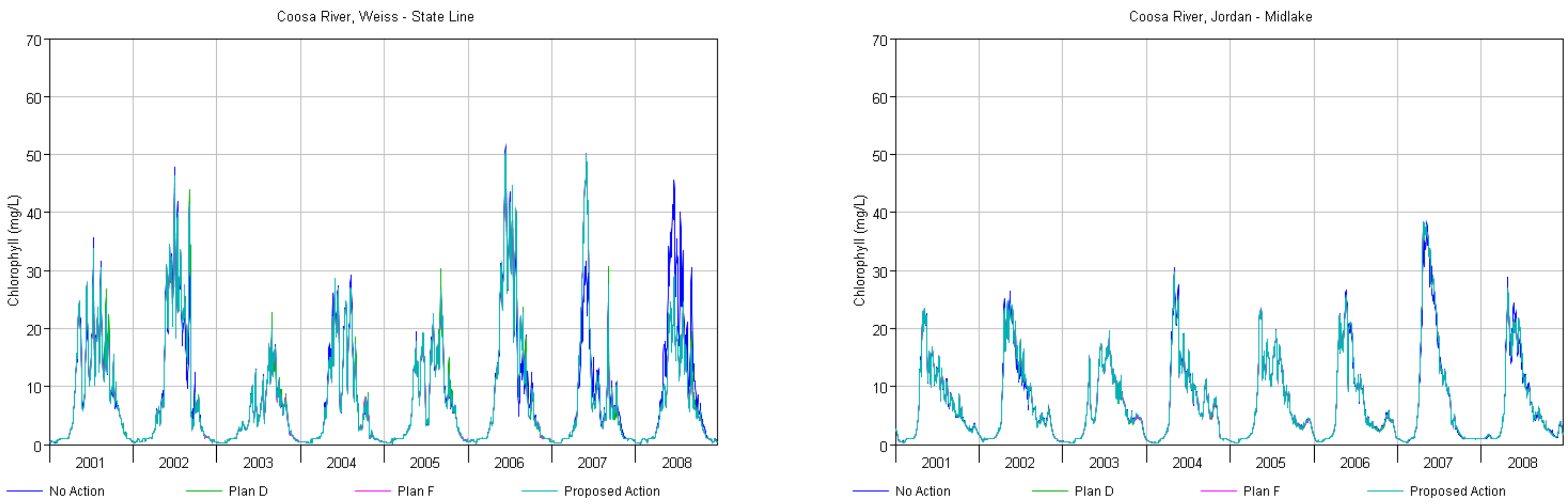


Figure 4-1 Time series of chlorophyll computed for the Coosa River at two stations, Weiss – State Line and Jordan – Mid-lake, during the 2001-2008 modeling period.

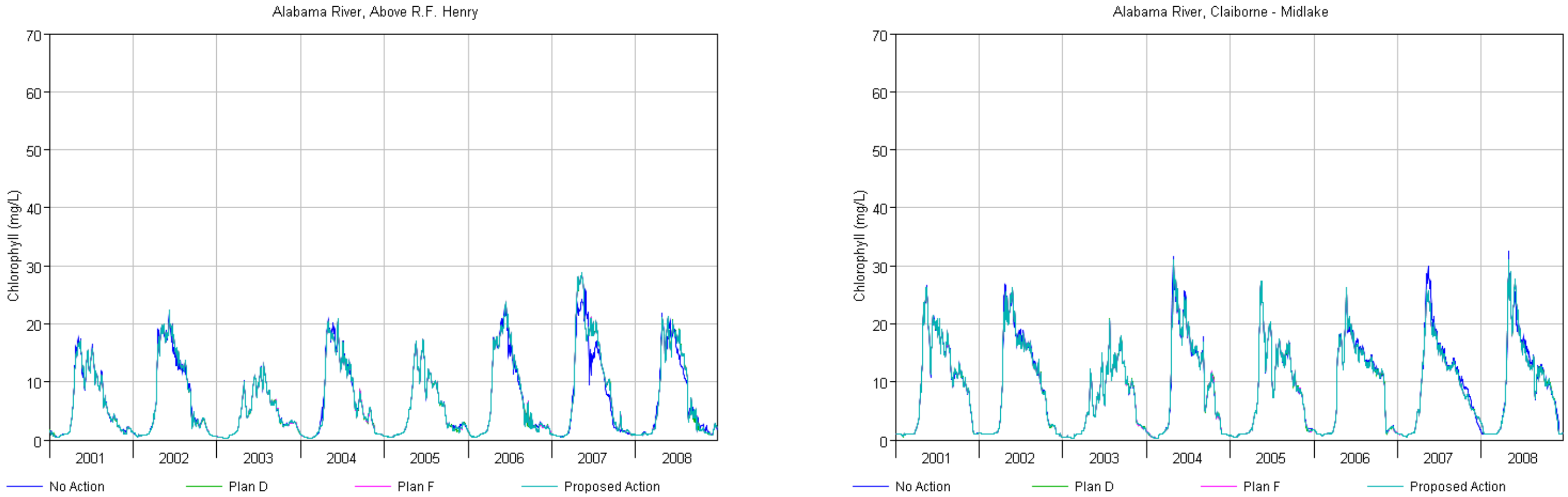
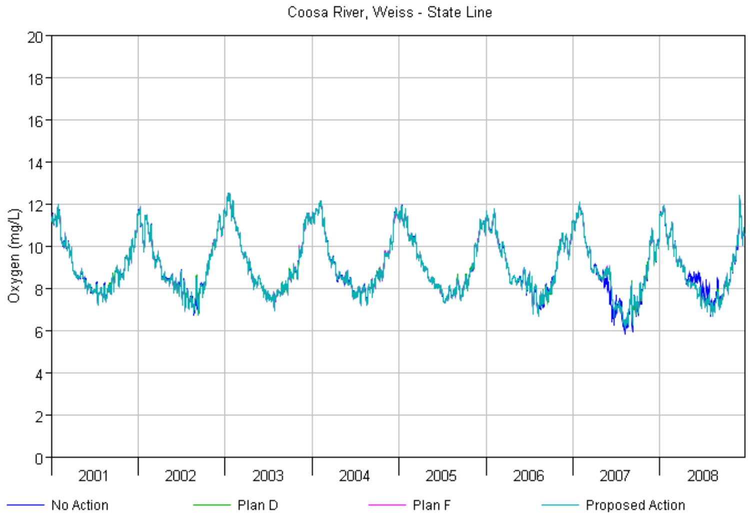


Figure 4-2 Time series of chlorophyll computed for the Alabama River at two stations, Above R. F. Henry and Claiborne - Mid-lake, during the 2001-2008 modeling period.



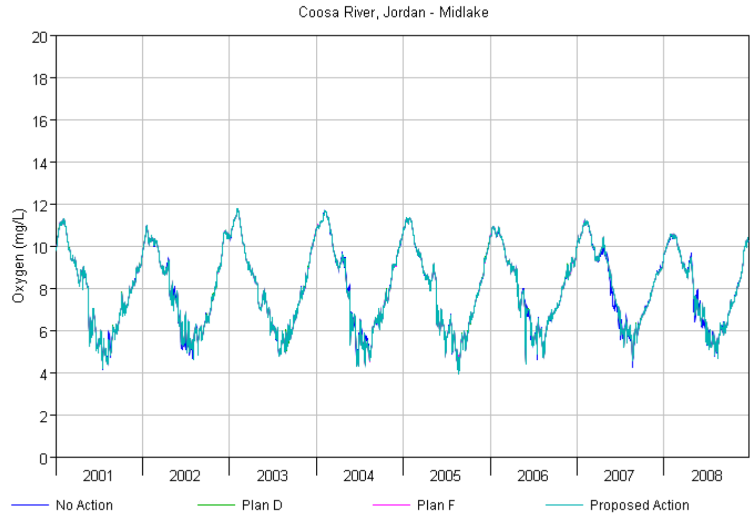
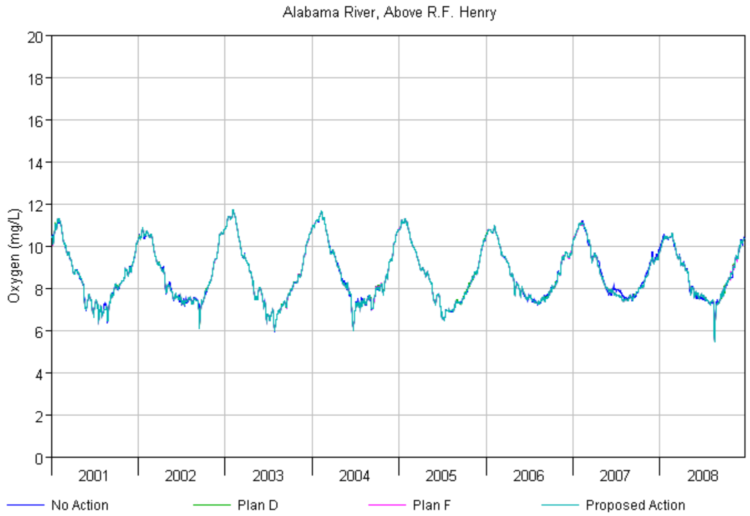


Figure 4-3 Time series of dissolved oxygen computed for the Coosa River at two stations, Weiss – State Line and Jordan – Mid-lake, during the 2001-2008 modeling period.



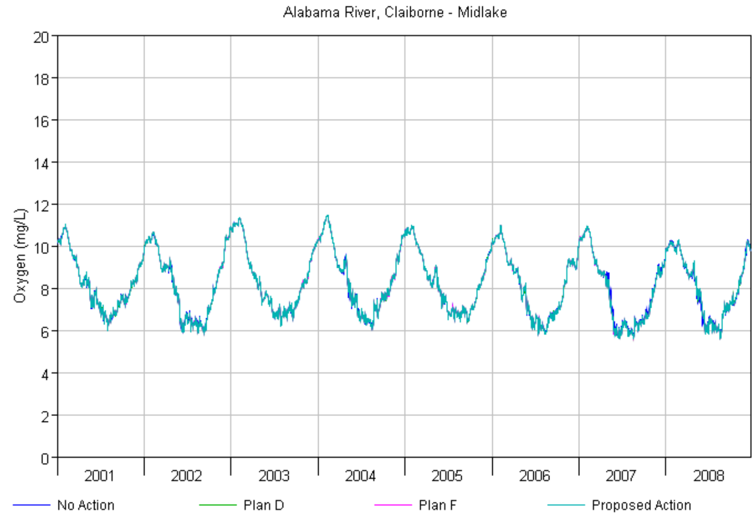


Figure 4-4 Time series of dissolved oxygen computed for the Alabama River at two stations, Above R. F. Henry and Claiborne - Mid-lake, during the 2001-2008 modeling period.

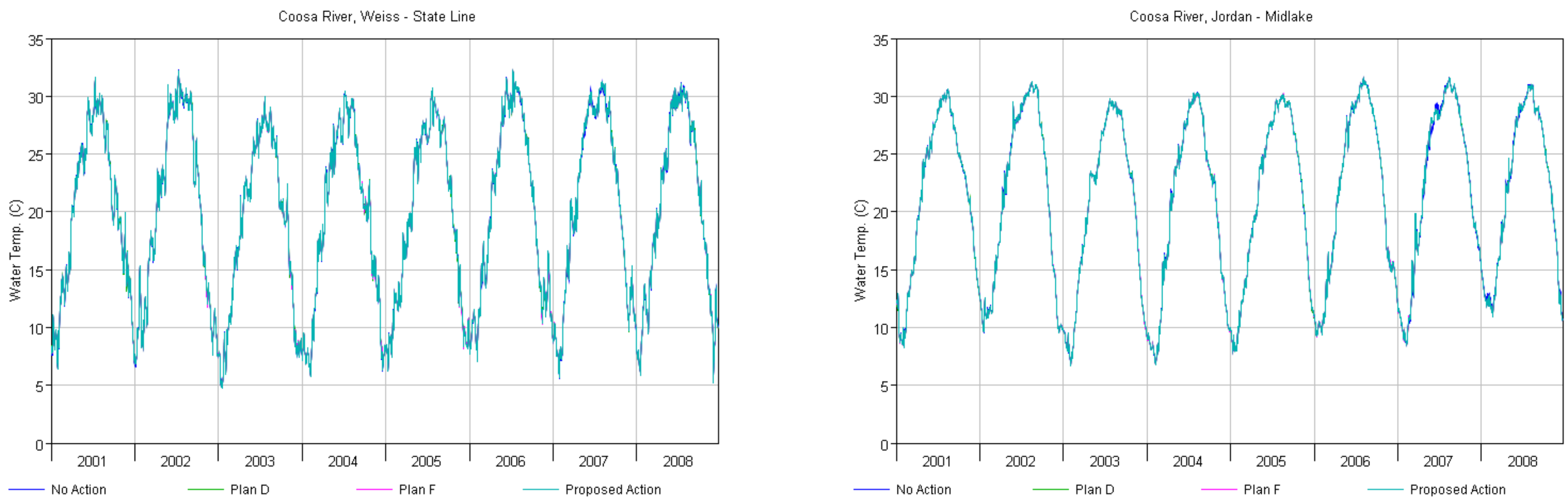


Figure 4-5 Time series of water temperature in degrees Celsius computed for the Coosa River at two stations, Weiss – State Line and Jordan – Mid-lake, during the 2001-2008 modeling period.

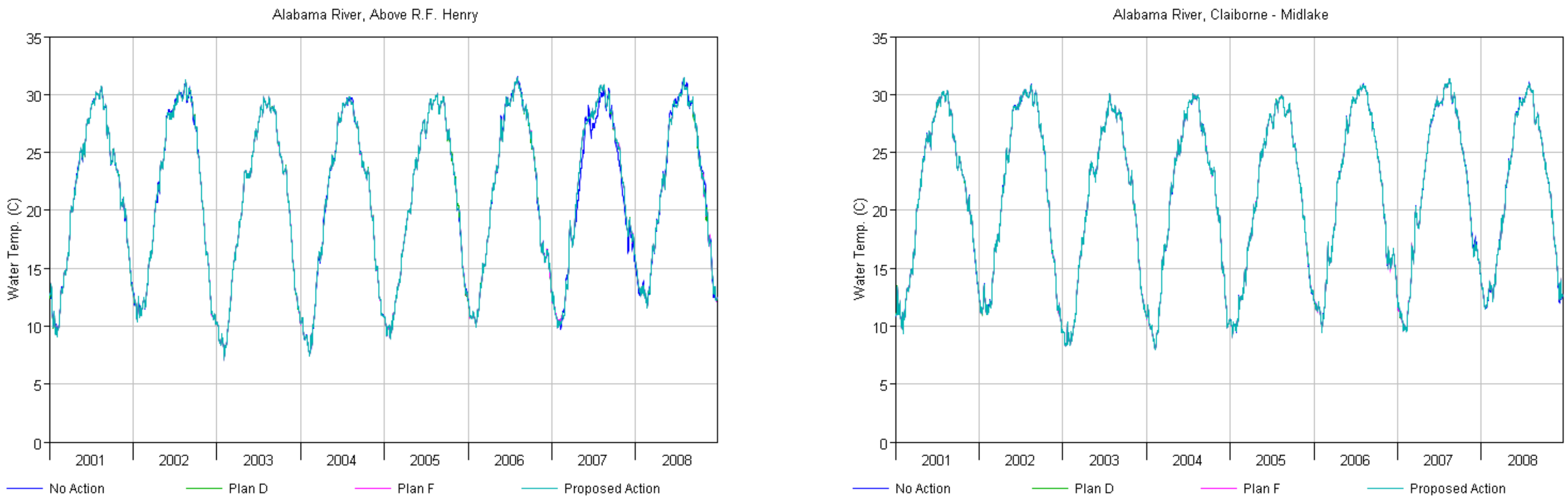


Figure 4-6 Time series of water temperature in degrees Celsius computed for the Alabama River at two stations, Above R. F. Henry and Claiborne - Mid-lake, during the 2001-2008 modeling period.

4.2 Cumulative Occurrence

The Cumulative percentage of occurrence of each water quality parameter shown in Table 4-2 was computed for the 2001 – 2008 modeling period using the time series from each time series location shown in Table 4-1 along the Alabama, Coosa, Tallapoosa, Etowah, and Coosawattee Rivers. The cumulative occurrence plots show the percentage of time each parameter was lower than a certain concentration level. For example, if a dissolved oxygen plot shows a 10% occurrence level at 6 mg/L, then 5% of the observations were lower than this level. An occurrence level of 100% at 12 mg/L shows that 95% of model values fell below 12 mg/L. Conversely, this would indicate that 5% of the model values were higher than 12 mg/L. The 0% and 100% levels represent the minimum and maximum values, respectively. In the longitudinal river profiles shown below, the 5%, 50%, and 95% occurrence levels are plotted to show the lower, median, and upper range of concentration values.

The dissolved oxygen plots indicate the D.O. standard specified by the U.S. Fish and Wildlife Service (USFWS). The USFWS D.O. standard for fish habitat in pristine water bodies is 6 mg/L, while the USFWS standard for the rest of the ACT system is 5 mg/L. The point where the cumulative occurrence curve intersects the top of the zone shows the percentage of time this standard is violated. If the curve does not cross this zone, then the standard was never exceeded during the modeling period. All locations modeled and plotted in this analysis, except one station (above Lake Allatoona at Canton, GA), required the 5 mg/L standard. The station above Allatoona must meet the 6 mg/L D.O. standard. This station was only included to verify the inflow water quality of the tributaries above Allatoona.

Representative plots of Chlorophyll *a*, dissolved oxygen, and temperature are shown in Figure 4-7 – Figure 4-12 at two sample stations from both the Coosa and Alabama Rivers. The two sample stations for the Coosa River are Weiss – State Line and Jordan – Mid-lake. The two sample stations for the Alabama River are Above R. F. Henry and Claiborne – Mid-lake.

All of the plots in Figure 4-7 – Figure 4-12 represent the cumulative occurrence over the 2001 – 2008 modeling period. Figure 4-7 – Figure 4-8 show the cumulative occurrence of Chlorophyll *a* at Weiss – State Line and Jordan – Mid-lake along the Coosa River and at Above R. F. Henry and Claiborne – Mid-lake along the Alabama River.

Figure 4-9 and Figure 4-10 show the cumulative occurrence for dissolved oxygen (D.O.) at Weiss – State Line and Jordan – Mid-lake along the Coosa River and at Above R. F. Henry and Claiborne – Mid-lake along the Alabama River. The zone where this standard would be violated is indicated on each figure. The D.O. plot of Jordan at Mid-lake shows that the USFWS D.O. standard is violated less than 2% of the time, according to HEC-5Q model predictions. The other plots show that HEC-5Q model predicts no violation of the D.O. standard.

Finally, Figure 4-11 – Figure 4-12 show the cumulative occurrence for water temperature over the 2001-2008 modeling period.

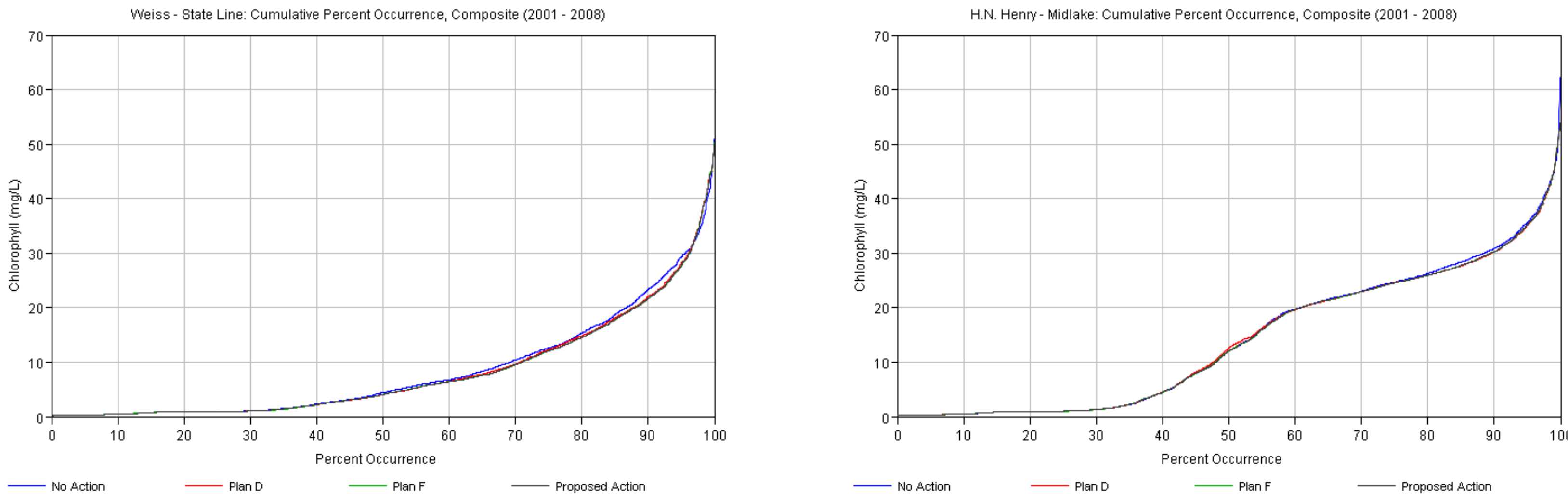


Figure 4-7 Cumulative occurrence of chlorophyll computed for the Coosa River at two stations, Weiss – State Line and Jordan – Mid-lake, during the 2001-2008 modeling period.

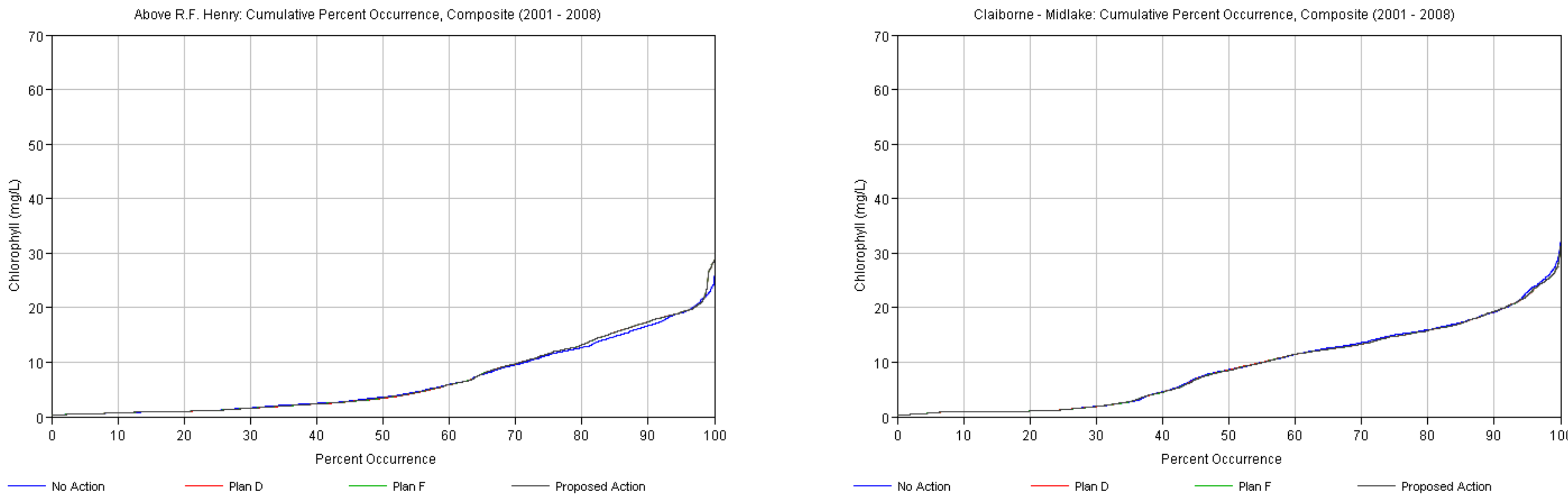


Figure 4-8 Cumulative occurrence of chlorophyll computed for the Alabama River at two stations, Above R. F. Henry and Claiborne - Mid-lake, during the 2001-2008 modeling period.

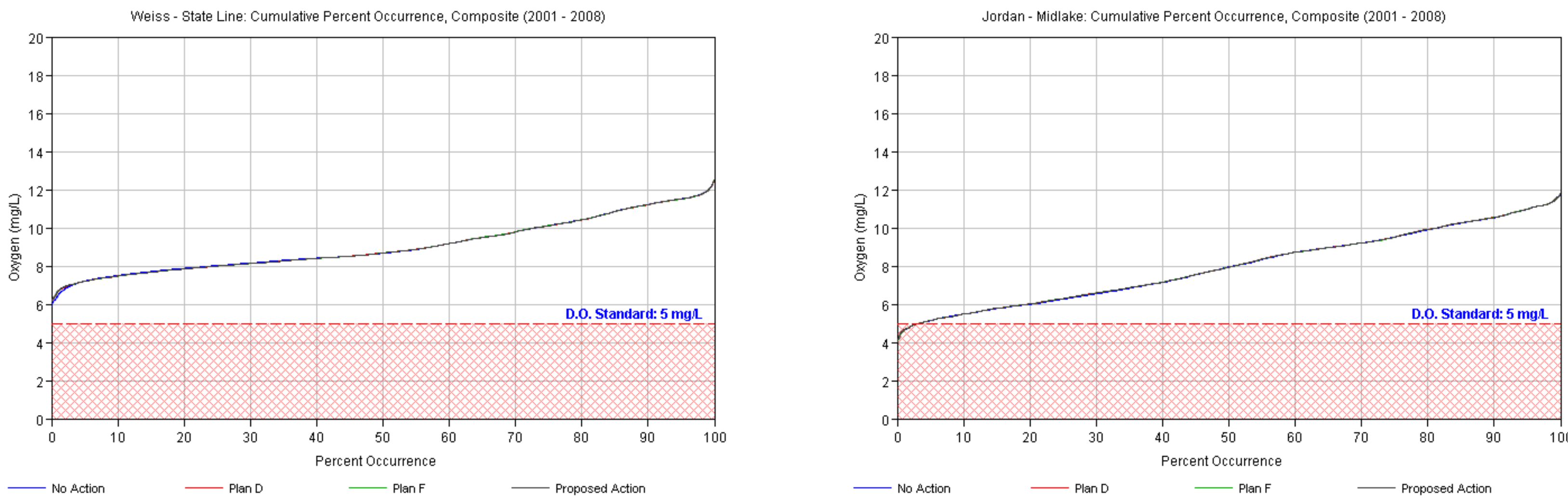


Figure 4-9 Cumulative occurrence of dissolved oxygen computed for the Coosa River at two stations, Weiss – State Line and Jordan – Mid-lake, during the 2001-2008 modeling period. The USFWS standard of 5 mg/L is denoted by the red shaded zone.

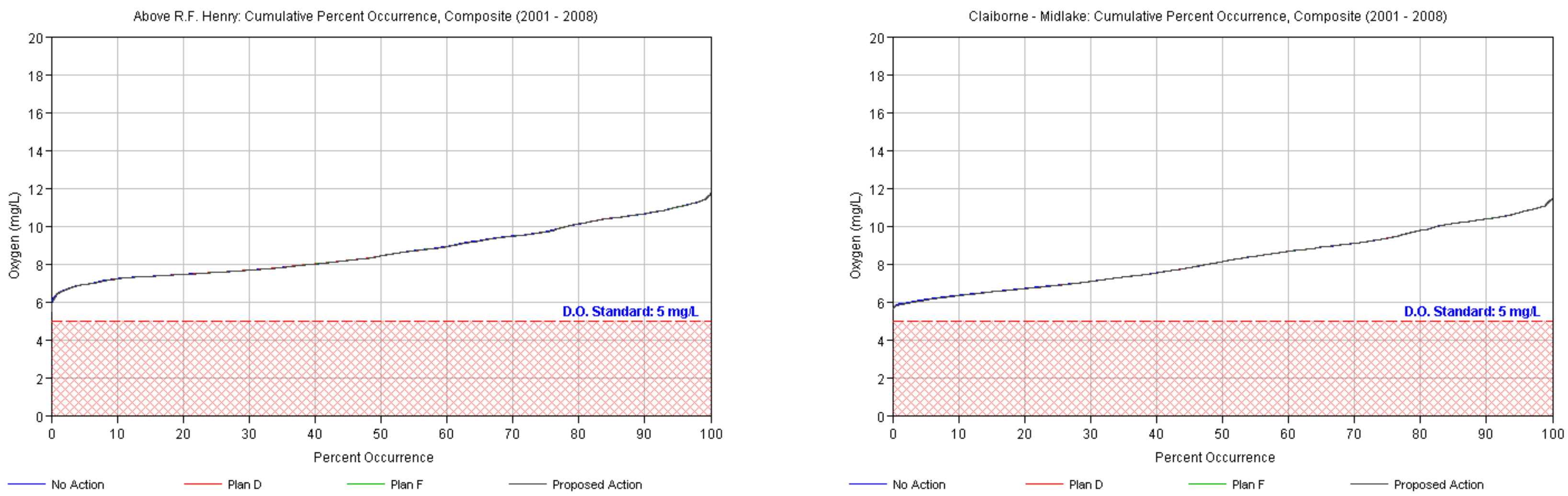


Figure 4-10 Cumulative occurrence of dissolved oxygen computed for the Alabama River at two stations, Above R. F. Henry and Claiborne - Mid-lake, during the 2001-2008 modeling period. The USFWS standard of 5 mg/L is denoted by the red shaded zone.

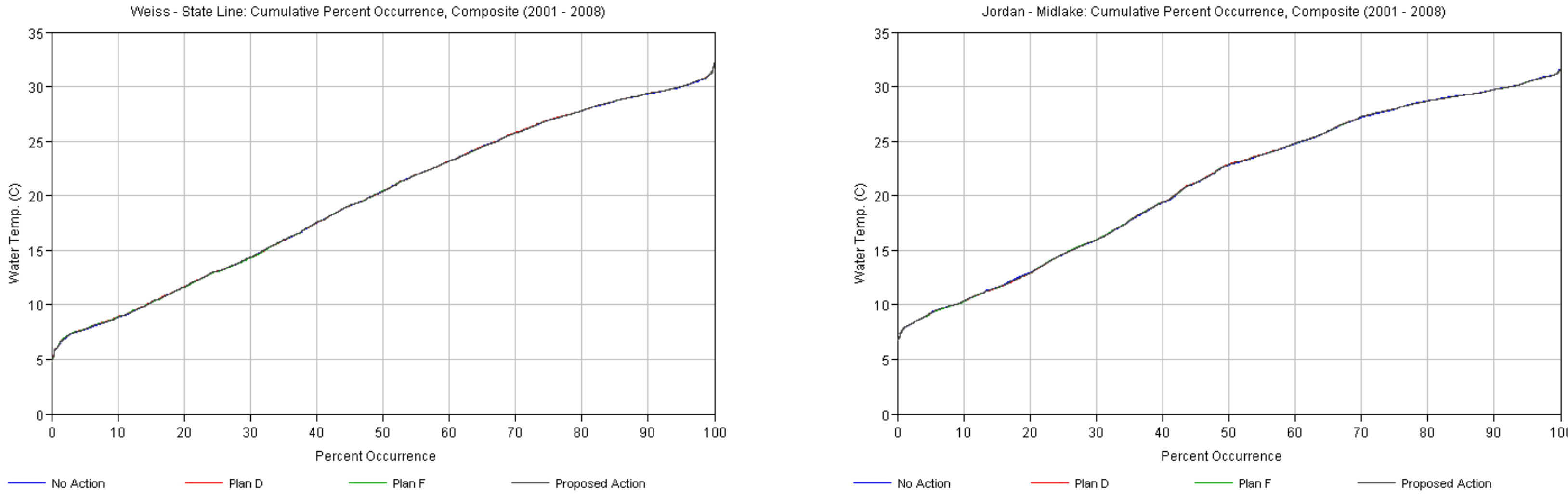


Figure 4-11 Cumulative occurrence of water temperature computed for the Coosa River at two stations, Weiss – State Line and Jordan – Mid-lake, during the 2001-2008 modeling period.

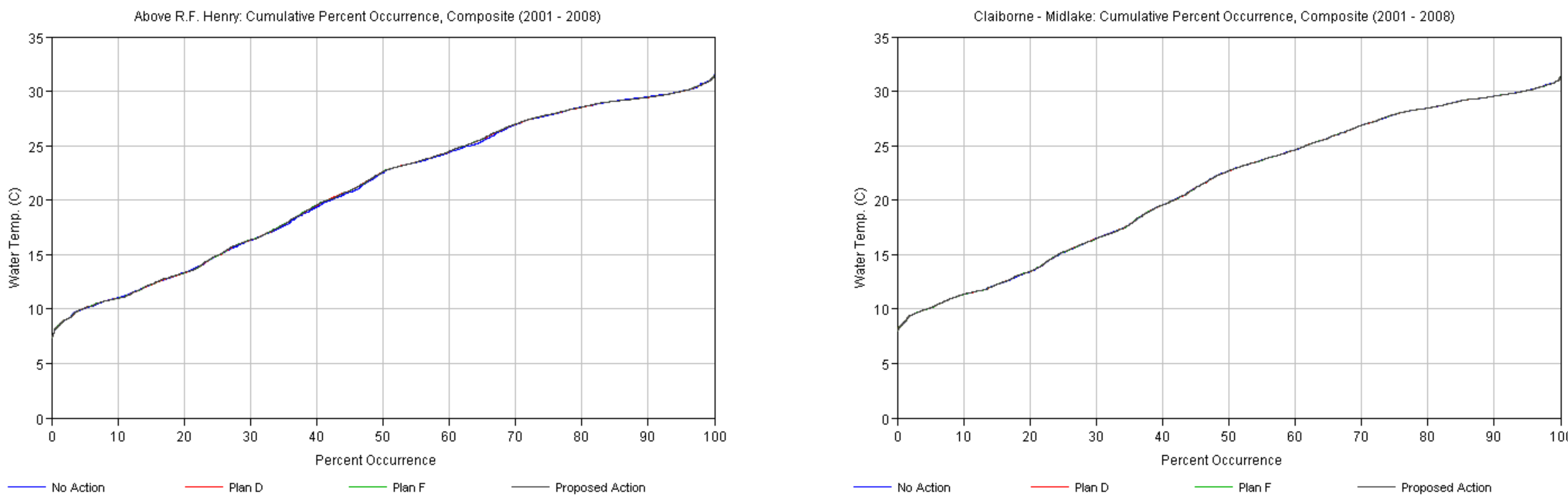


Figure 4-12 Cumulative occurrence of water temperature computed for the Alabama River at two stations, Above R. F. Henry and Claiborne - Midlake, during the 2001-2008 modeling period.

4.3 RIVER PROFILES

Cumulative occurrence levels of each water quality parameter shown in Table 4-2 were computed for each river mile along the Chattahoochee and Flint Rivers for Baseline conditions and each of the alternatives. The occurrence levels were plotted by river mile to show longitudinal profiles of occurrence for each parameter. Occurrence profiles were plotted to show how water quality varies along each reach, and how it may be affected by dams, other structures, or discharges (point-source and non-point-source). Peak values may shift longitudinally during a drought ("dry") year vs. a flood ("wet") year. Therefore, these can serve as validation of the model accuracy.

The 50% occurrence level shows the median concentration of each parameter. The 5% and 95% occurrence were selected as proxies of the minimum and maximum values, respectively. A minimum/maximum value computed by the model may not be representative of the true minimum/maximum, but instead may be a function of minor model error due to missing data or other factors. The 5% and 95% occurrence levels are expected to be better representations of the lower and upper bounds of concentration in the ACT basin.

4.3.1 COMPUTATION

A post-processing program was used to compute the percentage exceedance of each parameter at multiple exceedance levels. The exceedance shows the percentage of time a parameter exceeded a particular concentration. To avoid confusion with the water quality definition of exceedance as a violation of a standard, the percentage of occurrence is shown instead. This was computed by subtracting the exceedance level from 100%. While a 95% exceedance level indicates that 95% of values are greater than the concentration at that level, the 5% occurrence indicates that 5% of values are less than that level.

4.3.2 COMPUTATION PERIODS

While cumulative occurrence was computed for the entire model period in Section 4.2, several different weekly, seasonal, and annual model periods were computed and shown as longitudinal occurrence profiles.

To show how the ACT system functions during different annual hydrologic conditions, three different years were selected from the 2001 – 2008 model period to represent normal, flood ("wet"), and drought ("dry") hydrologic conditions. The years 2002, 2003, and 2007 were selected to represent "normal", "wet", and "dry" hydrologic conditions, respectively. These are plotted along with profiles of the composite of the 2001 – 2008 modeling period.

In addition to showing the annual percentage of occurrence of each parameter, the functioning of the ACT system is particularly important during the growing season.

There are two major definitions of growing season in the ACT basin. Three growing season definitions had to be considered for the ACT basin to address requirements by the States of Georgia and Alabama as well as the U.S. Fish and Wildlife Service. These definitions are as follows:

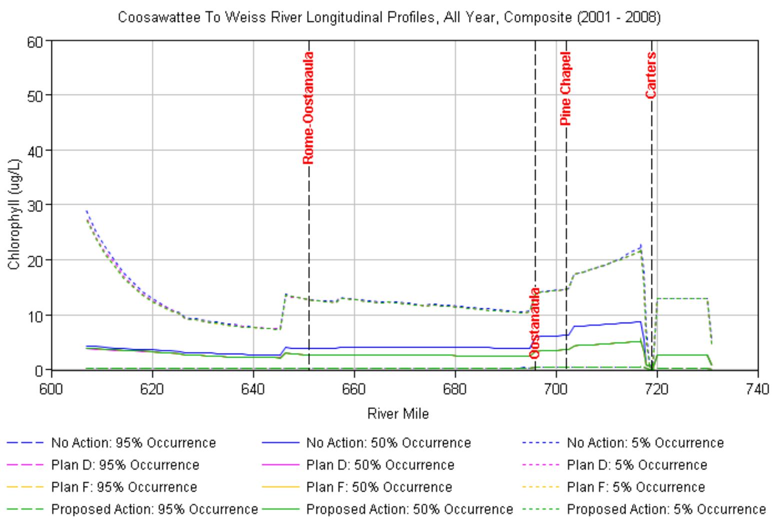
1. State of Georgia: April – October
2. State of Alabama: April – November
3. USFWS: May – October

Occurrence profiles were computed for each of these growing seasons.

To investigate whether the changes in power plant operations and water resource demands during the weekend have an effect on water quality, occurrence profiles were computed for weekly (7-day), weekday (Monday - Friday), and weekend (Saturday – Sunday) time intervals.

Occurrence profiles were computed for every combination of the annual, seasonal, and weekly time periods outlined above. However, weekday and weekend intervals are not included in this report. These results are available in the HEC-DSS model output files, which are available in the companion DVD or upon request. Several samples of the weekly intervals are shown below.

Composite Period: The following occurrence profile plots were computed for nine different parameters: chlorophyll, dissolved oxygen, wastewater percent of flow, 5-day uninhibited biochemical oxygen demand, ammonia - nitrogen, nitrate - nitrogen, total-N, phosphate, and total-P.



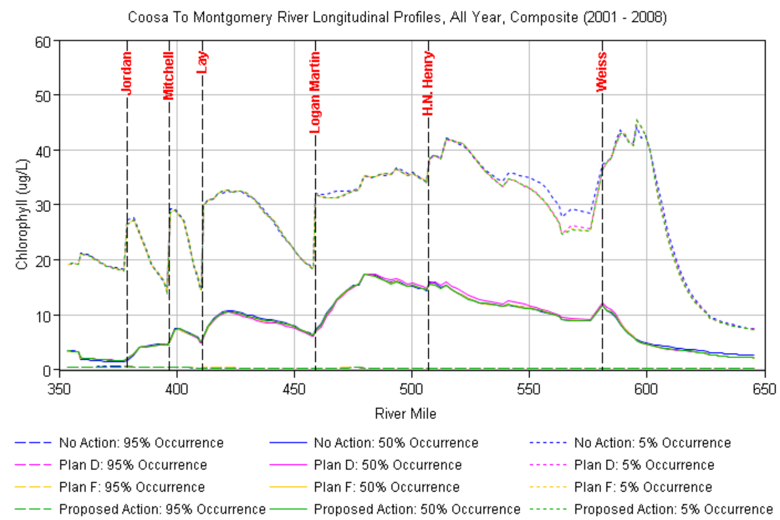


Figure 4-13 Longitudinal occurrence profiles of chlorophyll computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001-2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

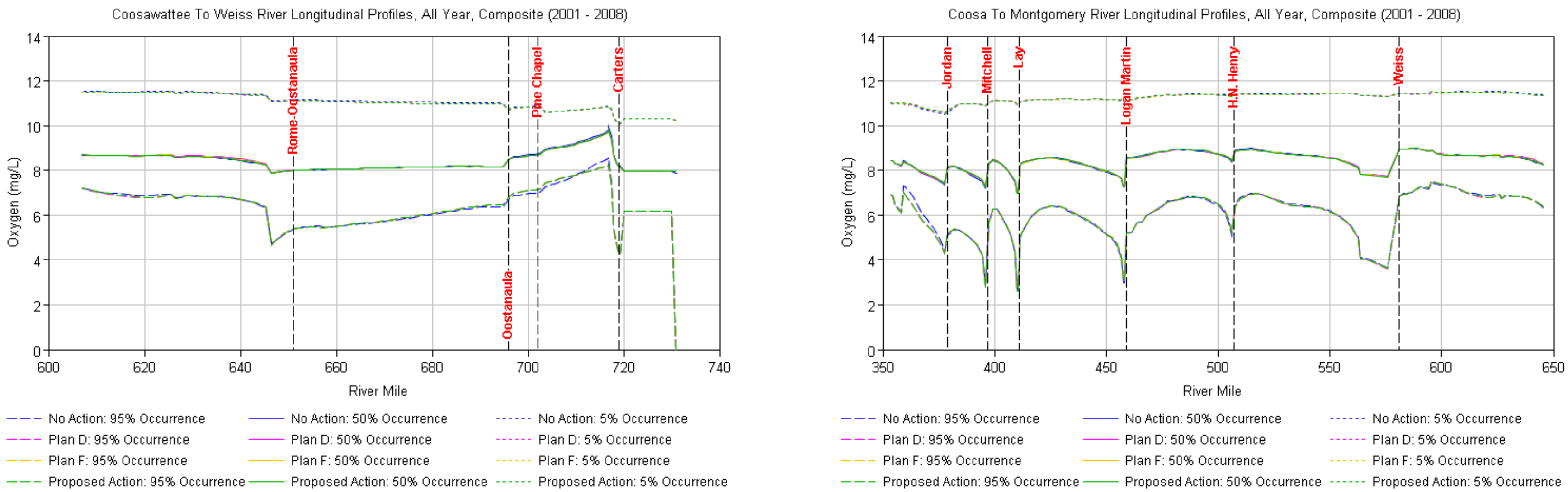


Figure 4-14 Longitudinal occurrence profiles of dissolved oxygen computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001-2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

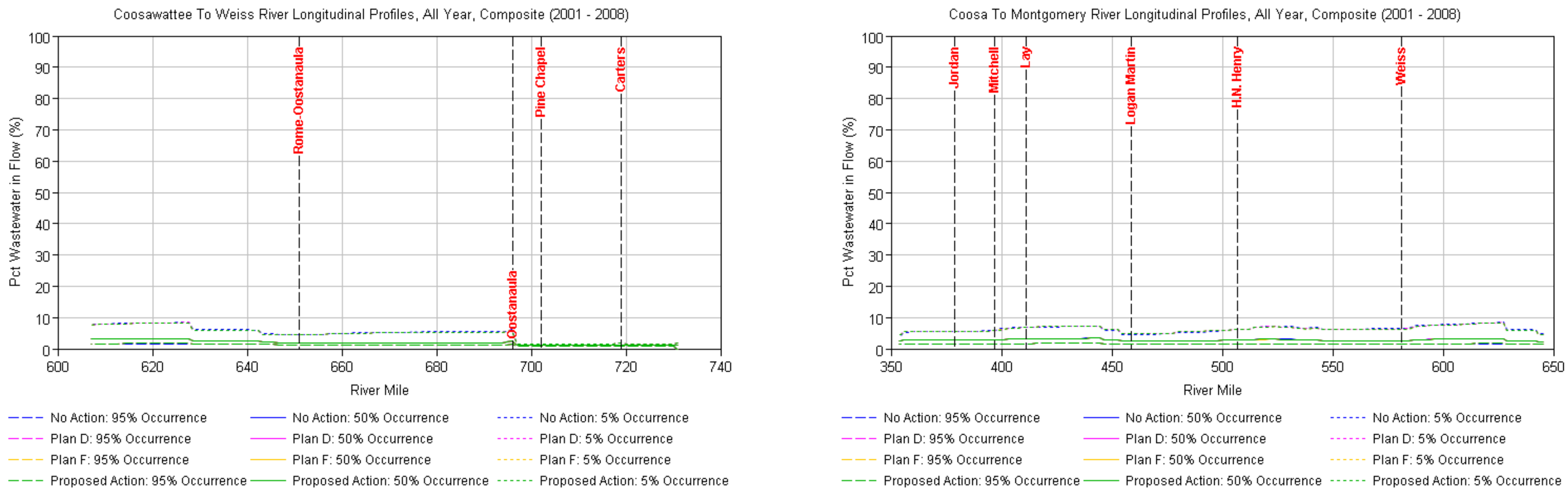
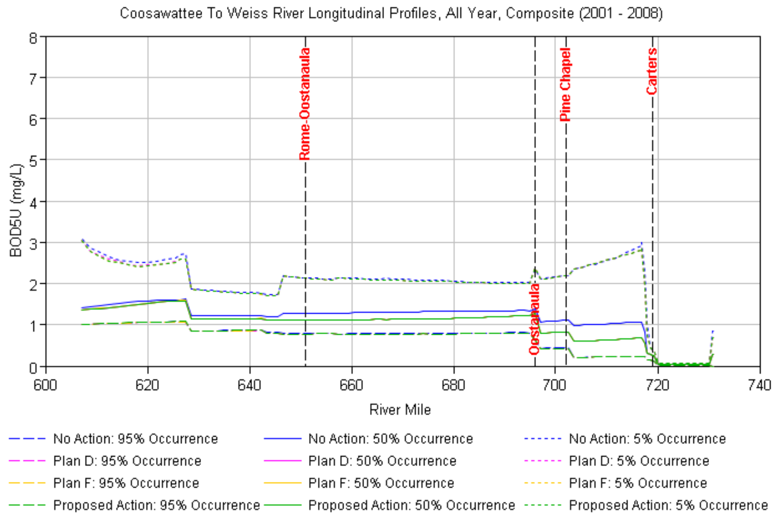


Figure 4-15 Longitudinal occurrence profiles of wastewater computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001-2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.



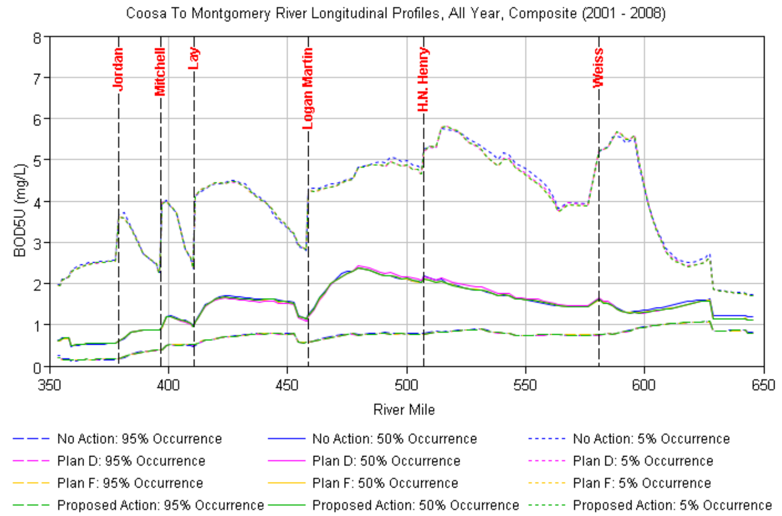
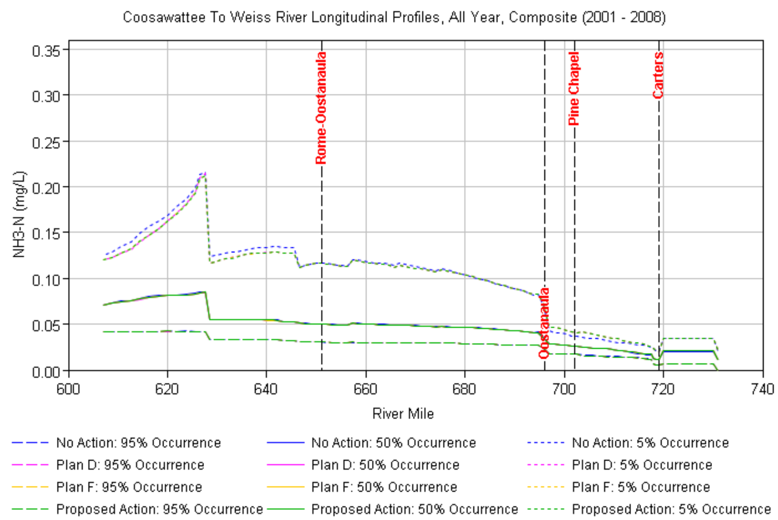


Figure 4-16 Longitudinal occurrence profiles of 5-Day uninhibited biochemical oxygen demand (BOD5U) computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001-2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.



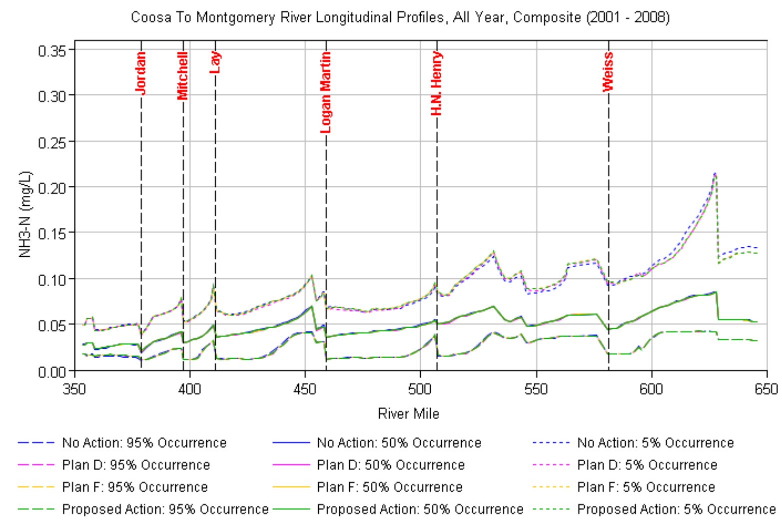


Figure 4-17 Longitudinal occurrence profiles of ammonia-nitrogen (NH3-N) computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001-2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

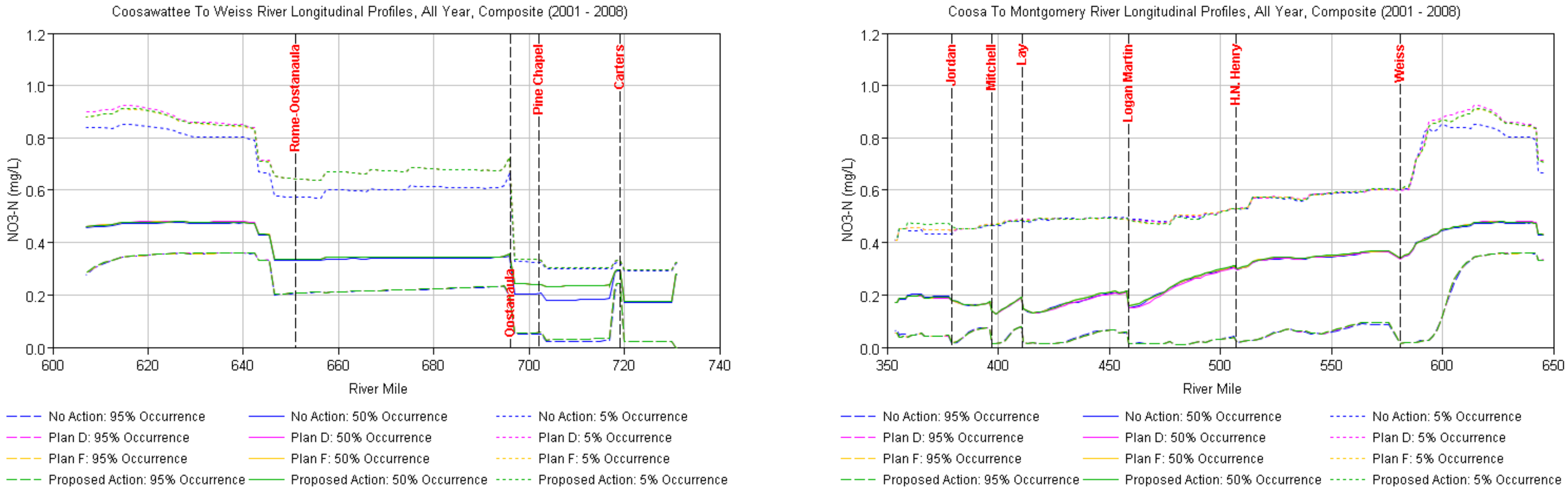
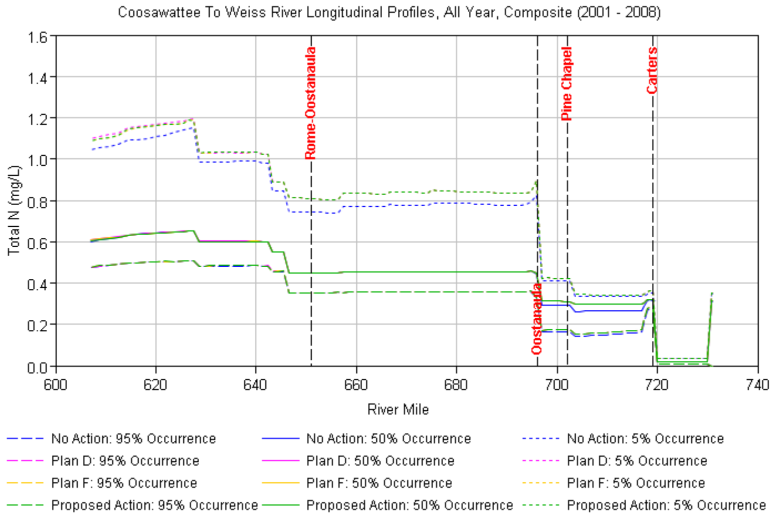


Figure 4-18 Longitudinal occurrence profiles of nitrate-nitrogen (NO3-N) computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001-2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.



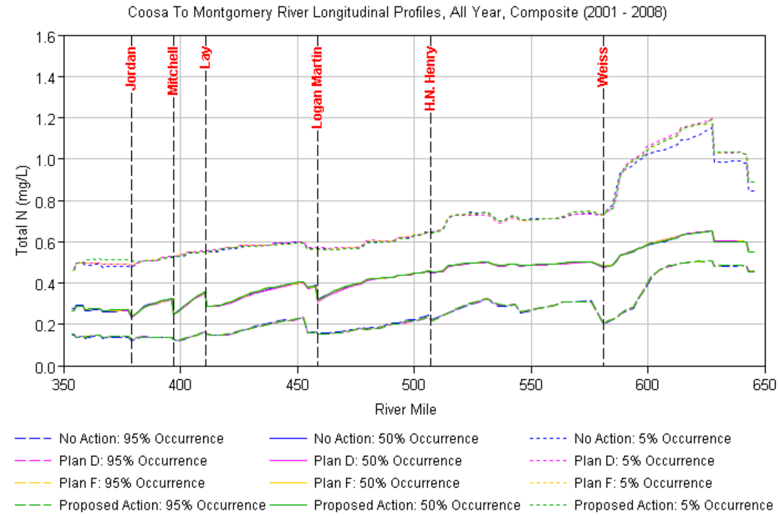


Figure 4-19 Longitudinal occurrence profiles of total-N computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001-2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

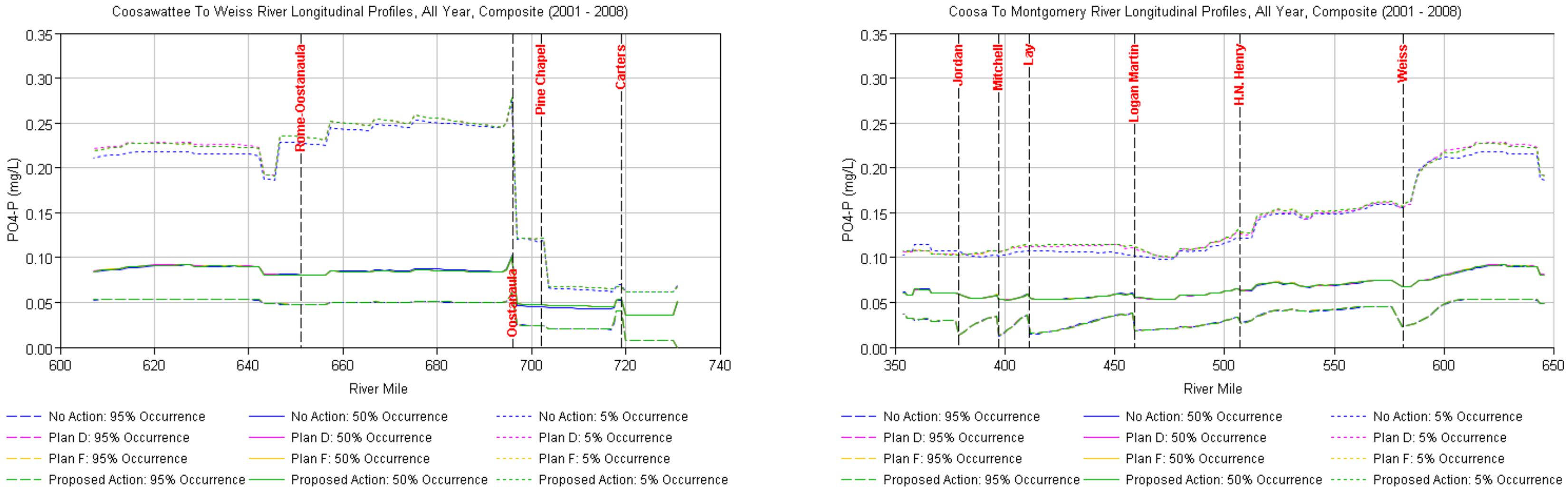


Figure 4-20 Longitudinal occurrence profiles of phosphate (PO4-P) computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001-2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

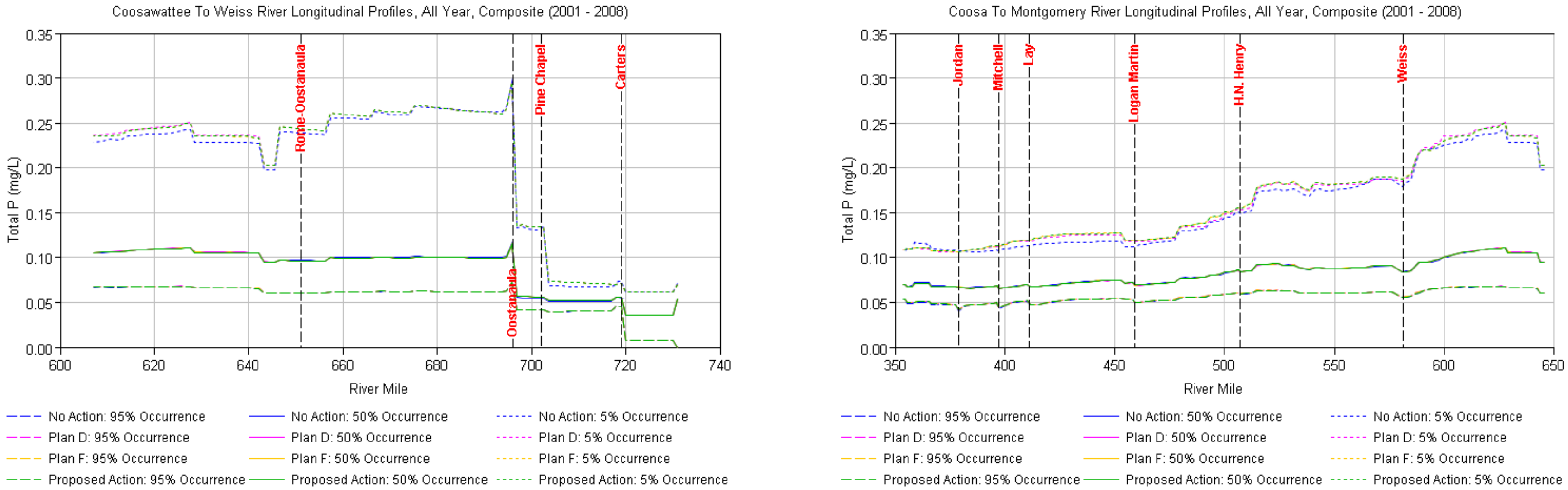


Figure 4-21 Longitudinal occurrence profiles of total-P computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001-2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

Annual Hydrologic Periods: The following plots show the wet, normal, and dry years during the 2001-2008 modeling period. 2002 represents a normal year, 2003 represents a wet year, and 2007 represents a dry year. Dissolved oxygen was chosen to highlight these representative years in the plots below.

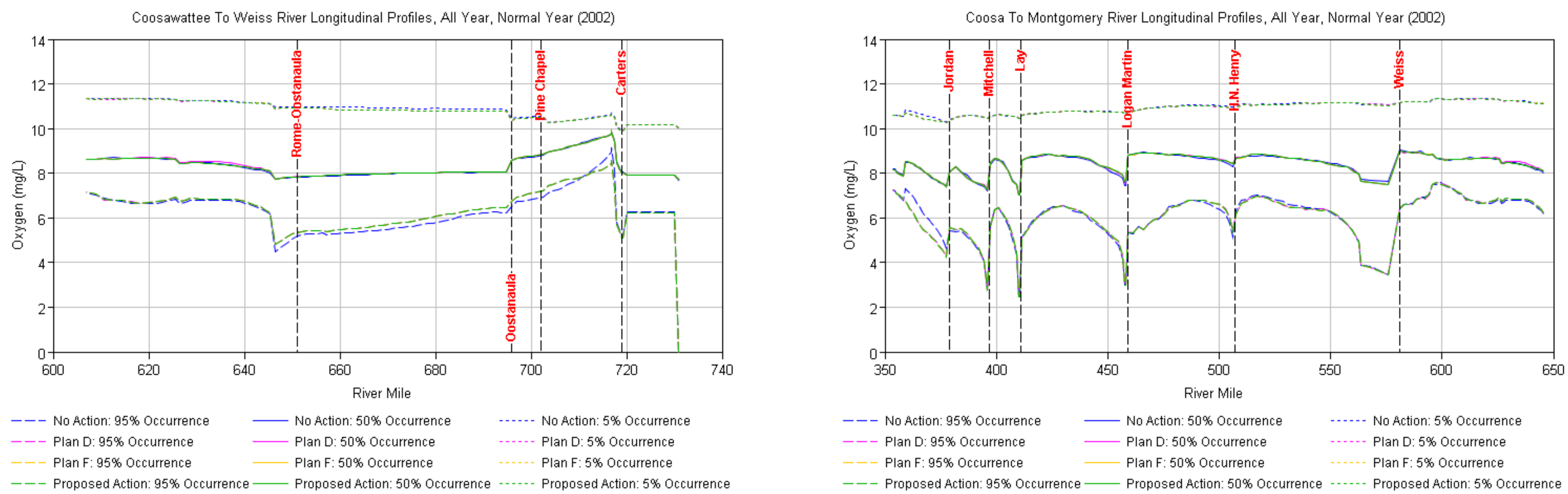


Figure 4-22 Longitudinal occurrence profiles of dissolved oxygen computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during a "normal" year (2002). The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

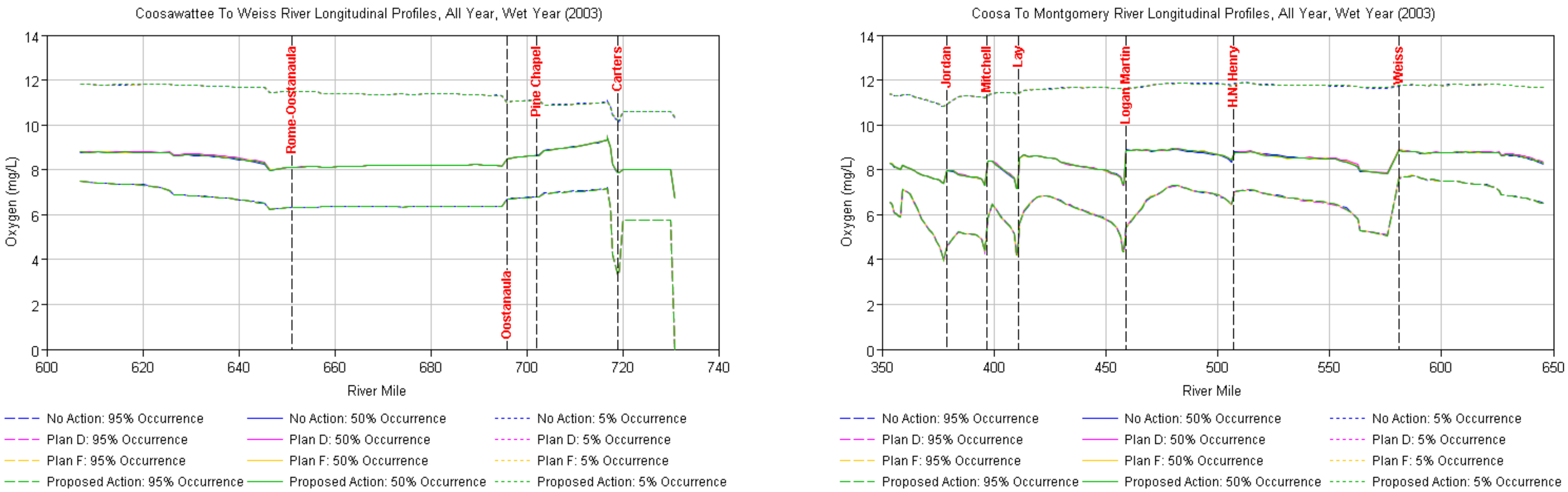


Figure 4-23 Longitudinal occurrence profiles of dissolved oxygen computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during a "wet" year (2003). The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

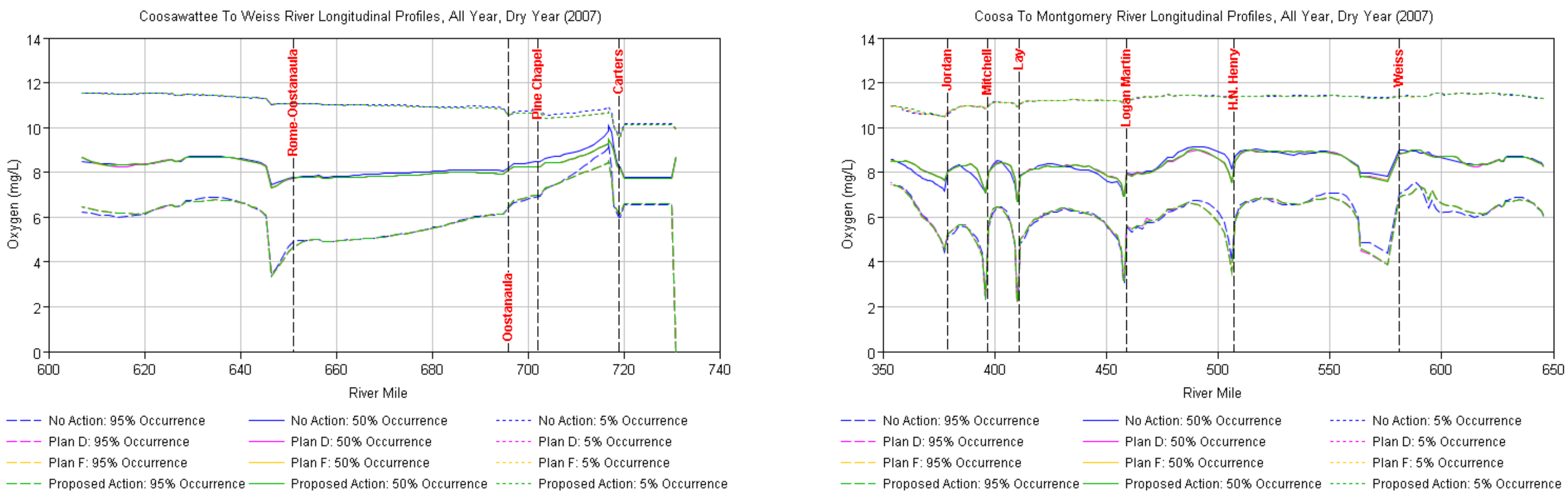
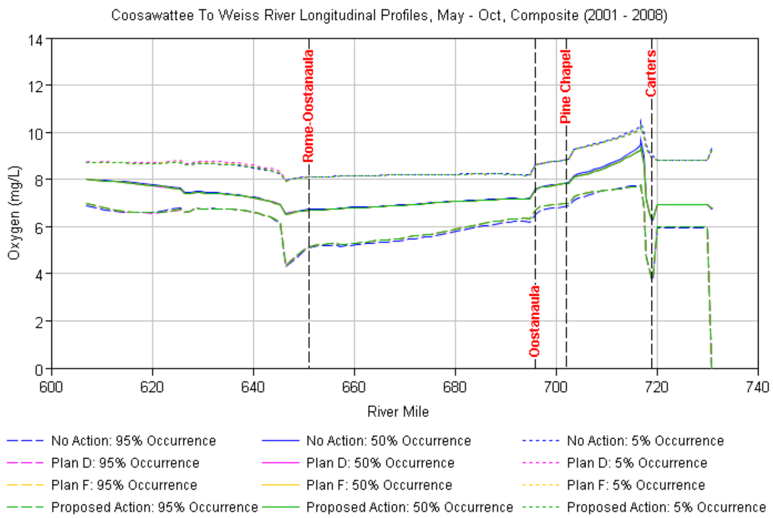


Figure 4-24 Longitudinal occurrence profiles of dissolved oxygen computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during a "dry" year (2007). The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

Growing Seasons: The following plots represent the three major growing seasons outlined in this report: the U.S. Fish and Wildlife Service (May-Oct). the State of Georgia (Apr-Oct), and the state of Alabama (Apr-Nov).



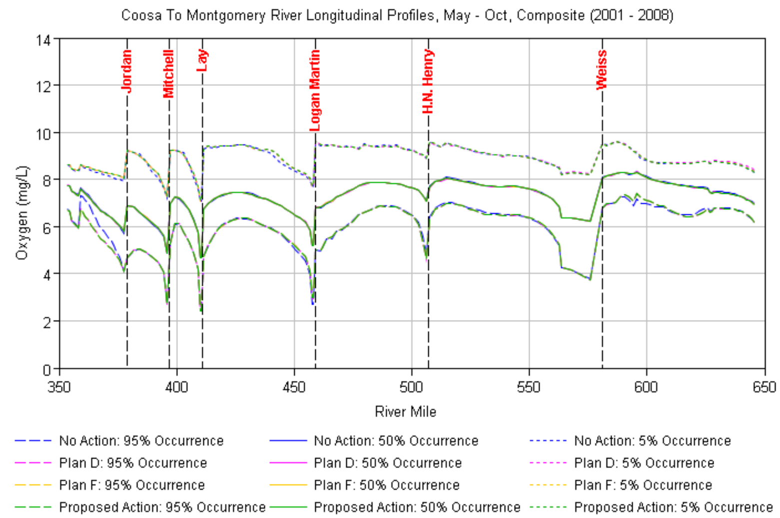


Figure 4-25 To address the standards of the U.S. Fish and Wildlife Service, dissolved oxygen was computed for the months of May-October along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001-2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

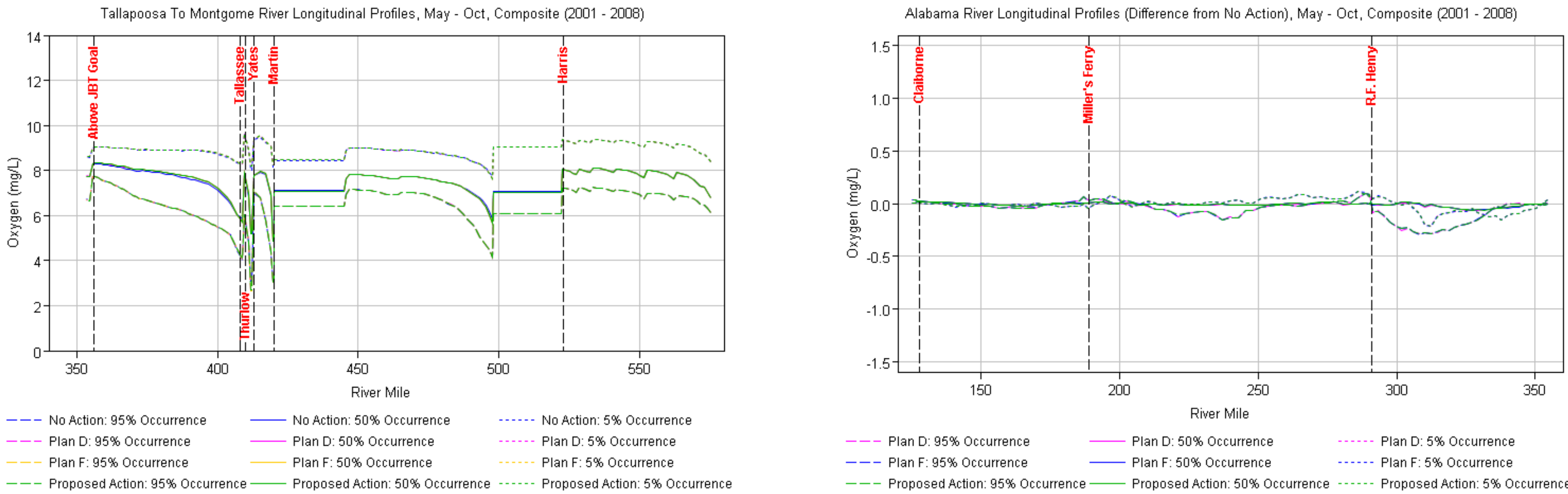


Figure 4-26 To address the standards of the U.S. Fish and Wildlife Service, dissolved oxygen was computed for the months of May-October along the Tallapoosa to Montgomery River and the Alabama River during the 2001-2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

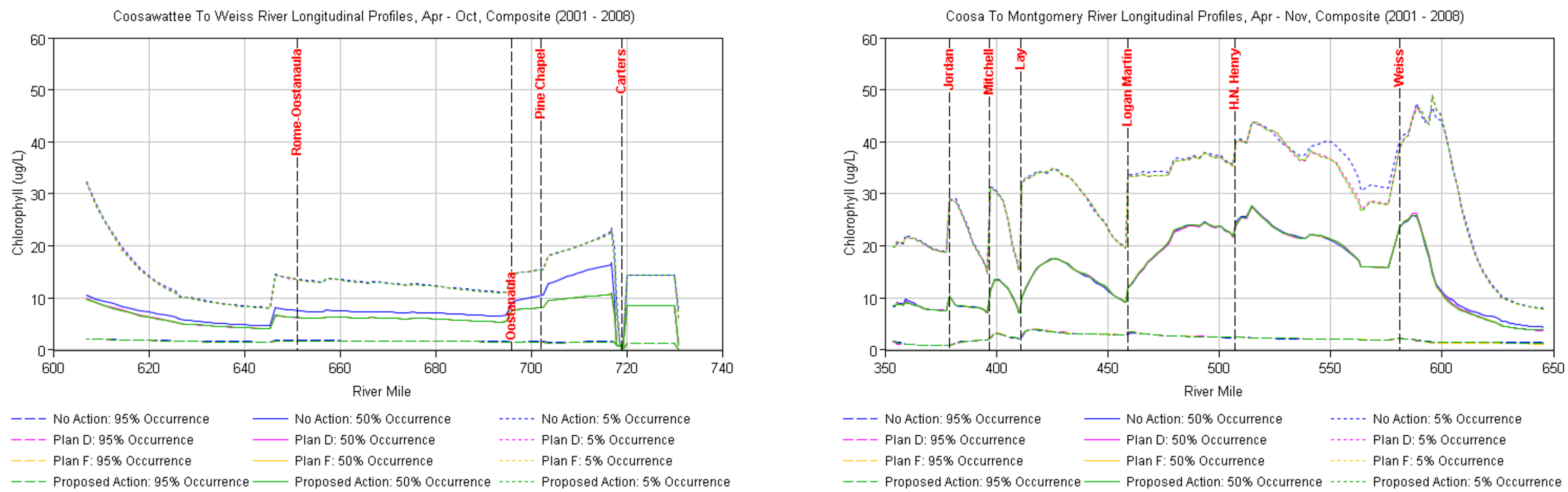


Figure 4-27 To address the standards of the states of Georgia and Alabama, chlorophyll was computed for the months of April-October along the Coosawattee to Weiss River according to Georgia's growing season, and chlorophyll was also computed for the months of April-November along the Coosa to Montgomery River according to Alabama's growing season. Both profiles were computed during the 2001-2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

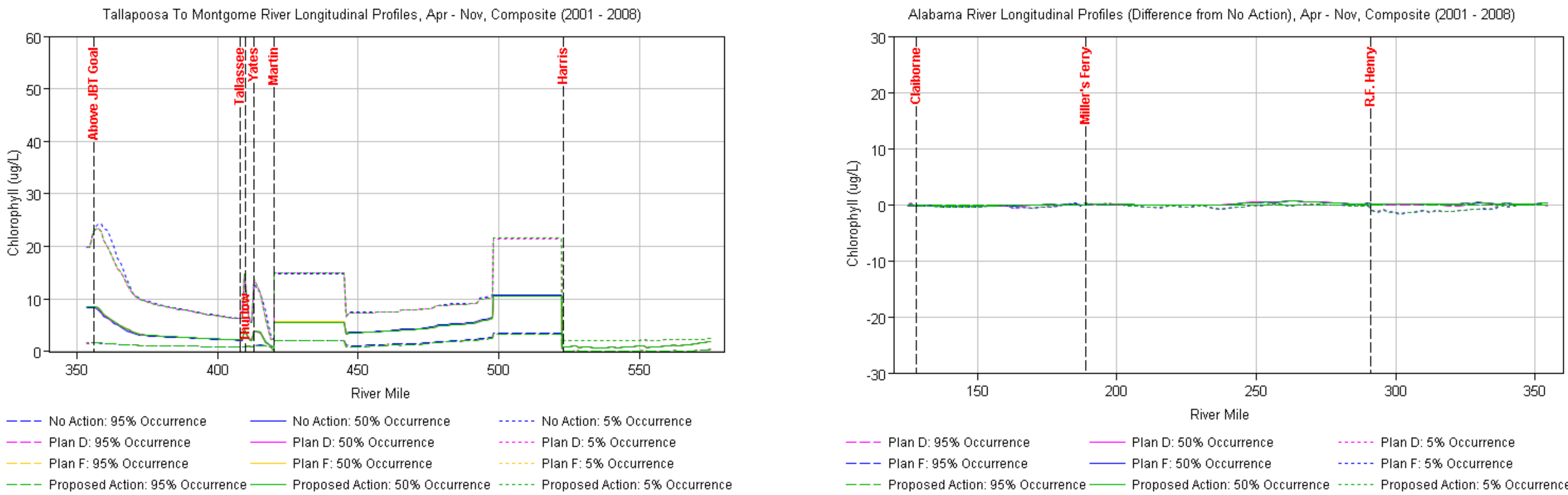


Figure 4-28 To address the standards of the state of Alabama, chlorophyll was computed for the months of April-November along the Tallapoosa to Montgomery River and the Alabama River during the 2001-2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

5 CONCLUSIONS

An HEC-5Q model was developed for the Alabama-Coosa-Tallapoosa (ACT) Basin, in support of the Environmental Impact Statement (EIS) for the Water Control Manual Update Study. The purpose of the HEC-5Q model was to evaluate the impacts of proposed alternative water management plans on long-term, system-wide, stream and reservoir water quality. The HEC-5Q model was adjusted to provide reasonable long-term, system-wide, assessments of the differences of water quality between model alternatives.

The same meteorological forcing, precipitation, point-source discharges, and model coefficients were used for each alternative to ensure a consistent approach. Only the system operations modeled by HEC-ResSim differed between alternatives. The modeled flows computed by HEC-ResSim reasonably approximated the observed flows over the 2001 – 2008 evaluation period. There were periods where modeled flows did not match observed flows, due to required exceptions to normal operations in the field. This project did not require that these conditions be approximated by the model. Since HEC-5Q used the modeled flows output by HEC-ResSim, the modeled water quality concentrations can differ from individual observed concentrations.

Default point-source loading values were assumed, where these values were not available from the dischargers. When point source data were available, it consisted of one value per month. These monthly data provided a seasonal pattern to the inflow quality, but day to day variations were not captured by the observed data. Non-point source and tributary stream loadings were provided by the BASINS model.

Model performance of the reservoir and river systems was evaluated for temperature, dissolved oxygen, chlorophyll *a*, and nutrients. The euphotic zone of the reservoir was emphasized over the hypolimnion, where data were limited. Temperature, dissolved oxygen, and chlorophyll *a* were emphasized over nutrients, particularly where nutrient levels were low, near detection limits. Since constant loadings and modeled instead of observed flows were used as inputs, the HEC-5Q model was not expected or required to replicate individual observed concentration values, particularly extreme values. Instead, the focus of this study was to ensure reasonable responses over the system for the 2001 – 2008 evaluation period and the full period of record, using a consistent set of model coefficients.

The consistency of the modeling approach and evaluation of the model's performance indicate that only minor differences in water quality between alternatives are to be expected. Therefore, the modeling approach used for this study was determined to be adequate to compare the differences between alternatives.

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APPENDIX A

Table A-1 Average, maximum and minimum tributary flow and water quality inputs.

Location/River/River Mile	Avg/ Max/Min	Flow (cfs)	Temp (C)	NO3-N (mg/l)	PO4-P (mg/l)	Chlorophyll *a* (ug/l)	NH3-N (mg/l)	DO (mg/l)	diss. org (mg/l)	org solids (mg/l)
upstream Etowah R.	Avg	98.0	17.6	0.189	0.017	0.155	0.018	8.44	2.01	1.18
Etowah R.	Min	0.0	6.0	0.151	0.015	0.050	0.016	5.51	2.00	1.09
Mile 774	Max	1344.1	28.1	0.687	0.144	0.250	0.055	12.35	4.17	4.04
Amicaloa Cr.	Avg	96.0	17.6	0.200	0.017	0.155	0.019	8.43	2.02	1.27
Etowah R.	Min	1.6	6.0	0.159	0.015	0.050	0.016	3.09	2.00	1.13
Mile 767	Max	1317.0	28.1	0.746	0.167	0.387	0.060	12.35	5.71	5.52
Settingdown Cr.	Avg	173.7	17.6	0.232	0.018	0.155	0.022	8.43	2.02	1.27
Etowah R.	Min	2.9	6.0	0.180	0.015	0.050	0.018	3.09	2.00	1.13
Mile 751	Max	2382.2	28.1	0.913	0.209	0.387	0.072	12.35	5.65	5.47
Long Swamp Cr.	Avg	263.7	17.6	0.227	0.018	0.155	0.021	8.43	2.02	1.25
Etowah R.	Min	4.4	6.0	0.177	0.015	0.050	0.018	3.09	2.00	1.12
Mile 745	Max	3615.9	28.1	0.889	0.199	0.387	0.070	12.35	5.36	5.18
Mountain Cr.	Avg	372.7	17.6	0.236	0.019	0.155	0.022	8.43	2.03	1.32
Etowah R.	Min	6.3	6.0	0.182	0.015	0.050	0.018	3.09	2.00	1.15
Mile 738	Max	5111.1	28.1	0.934	0.226	0.387	0.074	12.35	6.52	6.30
Shoal Cr.	Avg	30.2	17.6	0.202	0.018	0.155	0.019	8.38	2.04	1.35
Allatoona - Etowah R.	Min	0.5	8.0	0.160	0.015	0.050	0.016	2.94	2.00	1.17
Mile 715	Max	414.5	24.0	0.756	0.190	0.387	0.060	11.77	7.14	6.90
Noonday & Allatonna Cr.	Avg	147.0	17.6	0.283	0.025	0.155	0.025	8.38	2.23	1.80
Allatoona - Etowah R.	Min	2.5	8.0	0.214	0.015	0.050	0.020	2.94	2.00	1.37
Mile 708	Max	2016.2	24.0	1.189	0.401	0.387	0.093	11.77	12.00	14.31
Little R.	Avg	231.0	17.6	0.282	0.026	0.155	0.025	8.38	2.23	1.80
Allatoona - Etowah R.	Min	3.9	8.0	0.213	0.015	0.050	0.020	2.94	2.00	1.38
Mile 694	Max	3168.6	24.0	1.183	0.406	0.387	0.092	11.77	12.00	14.41
Pumpkinvine Cr.	Avg	107.4	17.6	0.330	0.017	0.155	0.019	8.43	2.02	1.28
Etowah R.	Min	0.3	6.0	0.268	0.015	0.050	0.017	3.09	2.00	1.17
Mile 686	Max	1124.5	28.1	1.403	0.178	0.387	0.059	12.35	5.65	5.47
Pettit Cr.	Avg	188.4	17.6	0.440	0.019	0.155	0.024	8.43	2.03	1.36
Etowah R.	Min	0.6	6.0	0.352	0.015	0.050	0.020	3.09	2.00	1.22
Mile 683	Max	1972.2	28.1	1.978	0.279	0.387	0.081	12.35	7.14	6.89
Raccoon Cr.	Avg	226.1	17.6	0.435	0.019	0.155	0.023	8.43	2.03	1.37
Etowah R.	Min	0.7	6.0	0.349	0.015	0.050	0.020	3.09	2.00	1.22
Mile 679	Max	2367.3	28.1	1.954	0.270	0.387	0.079	12.35	7.22	6.97
Euharlee Cr.	Avg	366.5	17.6	0.438	0.018	0.155	0.023	8.43	2.02	1.32
Etowah R.	Min	1.1	6.0	0.351	0.015	0.050	0.020	3.09	2.00	1.19
Mile 675	Max	3836.4	28.1	1.968	0.244	0.387	0.080	12.35	6.33	6.12
Two Run Cr.	Avg	77.0	17.6	0.437	0.018	0.155	0.023	8.43	2.01	1.24
Etowah R.	Min	0.2	6.0	0.349	0.015	0.050	0.020	3.09	2.00	1.15
Mile 665	Max	805.9	28.1	1.959	0.220	0.387	0.080	12.35	5.05	4.88
Dikes Cr.	Avg	133.7	17.6	0.446	0.018	0.155	0.024	8.43	2.01	1.23
Etowah R.	Min	0.4	6.0	0.357	0.015	0.050	0.021	3.09	2.00	1.14
Mile 656	Max	1399.5	28.1	2.000	0.229	0.387	0.083	12.35	4.87	4.72
Coosawattee R.	Avg	616.2	17.6	0.182	0.016	0.155	0.018	8.43	2.01	1.23
Carters - Coosawattee R.	Min	67.5	6.0	0.150	0.015	0.050	0.016	3.09	2.00	1.14
Mile 730	Max	11652.1	28.1	0.680	0.092	0.387	0.055	12.35	3.95	3.83
Talking Rock Cr.	Avg	195.9	17.6	0.250	0.021	0.155	0.023	8.43	2.06	1.48
Carters Rereg - Coosawattee R.	Min	21.5	6.0	0.198	0.015	0.050	0.019	3.09	2.00	1.29
Mile 718	Max	3703.9	28.1	1.067	0.235	0.387	0.084	12.35	7.18	6.93
Salacoa Cr.	Avg	296.3	17.6	0.257	0.052	0.155	0.024	8.43	2.06	1.34
Coosawattee R.	Min	1.0	6.0	0.181	0.015	0.050	0.018	3.09	2.00	1.13
Mile 702	Max	5714.0	28.1	0.897	0.500	0.387	0.071	12.35	7.13	6.89

Conasauga R	Avg	255.6	17.6	0.258	0.024	0.155	0.024	8.43	2.04	1.28
Conasauga R.	Min	0.9	6.0	0.182	0.015	0.050	0.018	3.09	2.00	1.10
Mile 735	Max	4930.4	28.1	0.899	0.291	0.387	0.071	12.35	6.11	5.91
Coahulla R.	Avg	265.8	17.6	0.346	0.037	0.155	0.030	8.43	2.20	1.61
Conasauga R.	Min	0.9	6.0	0.233	0.015	0.050	0.022	3.09	2.00	1.22
Mile 723	Max	5126.3	28.1	1.297	0.500	0.387	0.101	12.35	12.00	11.56
Holly Cr.	Avg	468.5	17.6	0.319	0.035	0.155	0.028	8.43	2.24	1.68
Conasauga R.	Min	1.6	6.0	0.217	0.015	0.050	0.021	3.09	2.00	1.25
Mile 716	Max	9035.9	28.1	1.173	0.500	0.387	0.091	12.35	12.00	12.84
Polecat Cr.	Avg	47.4	17.6	0.248	0.020	0.155	0.023	8.43	2.10	1.43
Conasauga R.	Min	0.2	6.0	0.176	0.015	0.050	0.017	3.09	2.00	1.16
Mile 696	Max	913.2	28.1	0.853	0.204	0.387	0.068	12.35	8.72	8.42
Oostanaula Tribs.	Avg	97.1	17.6	0.275	0.020	0.155	0.025	8.43	2.09	1.40
Oostanaula R.	Min	0.3	6.0	0.192	0.015	0.050	0.019	3.09	2.00	1.15
Mile 694	Max	1873.4	28.1	0.979	0.203	0.387	0.077	12.35	8.26	7.97
Oothkalooga Cr.	Avg	70.7	17.6	0.302	0.021	0.155	0.027	8.43	2.09	1.59
Oostanaula R.	Min	0.2	6.0	0.247	0.015	0.050	0.023	3.09	2.00	1.35
Mile 673	Max	739.8	28.1	1.259	0.350	0.387	0.098	12.35	10.89	10.49
Johns Cr.	Avg	66.3	17.6	0.278	0.019	0.155	0.025	8.43	2.04	1.43
Oostanaula R.	Min	0.2	6.0	0.229	0.015	0.050	0.021	3.09	2.00	1.26
Mile 666	Max	694.5	28.1	1.132	0.290	0.387	0.088	12.35	8.24	7.95
Armuchee Cr.	Avg	205.2	17.6	0.254	0.018	0.155	0.023	8.43	2.03	1.34
Oostanaula R.	Min	0.6	6.0	0.211	0.015	0.050	0.020	3.09	2.00	1.21
Mile 657	Max	2148.0	28.1	1.007	0.239	0.387	0.079	12.35	6.79	6.56
Silver Cr.	Avg	221.5	17.6	0.440	0.019	0.155	0.024	8.43	2.03	1.38
Etowah R.	Min	0.7	6.0	0.352	0.015	0.050	0.020	3.09	2.00	1.23
Mile 646	Max	2318.6	28.1	1.977	0.255	0.387	0.081	12.35	7.36	7.11
Coosa R. Tribs	Avg	16.0	17.6	0.274	0.020	0.155	0.025	8.43	2.11	1.59
Weiss - Coosa R.	Min	0.0	6.0	0.235	0.015	0.050	0.022	3.09	2.00	1.38
Mile 621	Max	135.1	28.1	1.140	0.463	0.387	0.089	12.35	12.00	17.74
Big Cedar Cr.	Avg	178.6	17.6	0.253	0.017	0.155	0.023	8.43	2.07	1.35
Weiss - Coosa R.	Min	0.4	6.0	0.218	0.015	0.050	0.021	3.09	2.00	1.22
Mile 617	Max	1507.2	28.1	1.028	0.270	0.387	0.081	12.35	11.37	10.96
Spring Cr.	Avg	267.9	17.6	0.257	0.017	0.155	0.023	8.43	2.07	1.36
Weiss - Coosa R.	Min	0.6	6.0	0.222	0.015	0.050	0.021	3.09	2.00	1.23
Mile 600	Max	2260.8	28.1	1.051	0.272	0.387	0.082	12.35	11.55	11.13
Chattooga R.	Avg	520.2	17.6	0.247	0.017	0.155	0.023	8.43	2.06	1.33
Weiss - Coosa R.	Min	1.3	6.0	0.213	0.015	0.050	0.020	3.09	2.00	1.21
Mile 592	Max	4389.4	28.1	0.995	0.252	0.387	0.078	12.35	10.68	10.29
Weiss Lake	Avg	702.3	17.6	0.241	0.017	0.155	0.022	8.43	2.05	1.29
Weiss - Coosa R.	Min	1.7	6.0	0.209	0.015	0.050	0.020	3.09	2.00	1.19
Mile 588	Max	5926.5	28.1	0.964	0.224	0.387	0.076	12.35	9.65	9.30
Terrapin Cr.	Avg	177.8	17.6	0.242	0.016	0.155	0.022	8.43	2.01	1.33
Old Coosa R.	Min	1.3	6.0	0.211	0.015	0.050	0.020	3.09	2.00	1.25
Mile 564	Max	2072.5	28.1	0.480	0.065	0.387	0.040	12.35	3.52	3.42
Big Willis Cr.	Avg	350.0	17.6	0.243	0.016	0.155	0.022	8.43	2.01	1.36
H.N.Henry - Coosa R.	Min	2.5	6.0	0.212	0.015	0.050	0.020	3.09	2.00	1.27
Mile 530	Max	4079.9	28.1	0.483	0.069	0.387	0.040	12.35	3.73	3.62
Big Canoe Cr.	Avg	516.3	17.6	0.237	0.015	0.155	0.022	8.43	2.00	1.31
H.N.Henry - Coosa R.	Min	3.7	6.0	0.207	0.015	0.050	0.020	3.09	2.00	1.24
Mile 514	Max	6018.4	28.1	0.468	0.064	0.387	0.039	12.35	3.38	3.29
Beaver Cr.	Avg	554.7	17.6	0.235	0.015	0.155	0.022	8.43	2.00	1.30
H.N.Henry - Coosa R.	Min	4.0	6.0	0.205	0.015	0.050	0.020	3.09	2.00	1.23
Mile 511	Max	6466.6	28.1	0.463	0.062	0.387	0.039	12.35	3.29	3.20
Ohatchee Cr.	Avg	174.5	17.6	0.183	0.015	0.155	0.018	8.43	2.00	1.17
Logan Martin - Coosa R.	Min	1.2	6.0	0.163	0.015	0.050	0.016	3.09	2.00	1.13
Mile 505	Max	2034.2	28.1	0.336	0.026	0.387	0.029	12.35	2.26	2.21

Cane Cr.	Avg	251.4	17.6	0.182	0.015	0.155	0.018	8.43	2.00	1.19
Logan Martin - Coosa R.	Min	1.8	6.0	0.162	0.015	0.050	0.016	3.09	2.00	1.15
Mile 498	Max	2930.7	28.1	0.333	0.030	0.387	0.029	12.35	2.48	2.42
Broken Arrow Cr.	Avg	366.4	17.6	0.175	0.015	0.155	0.017	8.43	2.00	1.17
Logan Martin - Coosa R.	Min	2.6	6.0	0.156	0.015	0.050	0.016	3.09	2.00	1.13
Mile 484	Max	4271.5	28.1	0.317	0.026	0.387	0.028	12.35	2.32	2.27
Choccolocco Cr.	Avg	895.5	17.6	0.181	0.015	0.155	0.018	8.43	2.00	1.19
Logan Martin - Coosa R.	Min	6.4	6.0	0.161	0.015	0.050	0.016	3.09	2.00	1.15
Mile 475	Max	10439.3	28.1	0.332	0.029	0.387	0.029	12.35	2.47	2.41
Kelley Cr.	Avg	85.7	17.6	0.225	0.017	0.155	0.021	8.43	2.06	1.31
Lay - Coosa R.	Min	0.1	6.0	0.195	0.015	0.050	0.019	3.09	2.00	1.21
Mile 456	Max	1948.5	28.1	0.998	0.275	0.387	0.078	12.35	10.87	10.47
Talladega Cr.	Avg	204.9	17.6	0.236	0.017	0.155	0.022	8.43	2.07	1.38
Lay - Coosa R.	Min	0.3	6.0	0.204	0.015	0.050	0.020	3.09	2.00	1.26
Mile 445	Max	4657.5	28.1	1.065	0.336	0.387	0.083	12.35	12.00	12.77
Upper Yellowleaf Cr.	Avg	284.3	17.6	0.230	0.017	0.155	0.021	8.43	2.07	1.34
Lay - Coosa R.	Min	0.4	6.0	0.199	0.015	0.050	0.019	3.09	2.00	1.24
Mile 436	Max	6461.7	28.1	1.028	0.312	0.387	0.081	12.35	12.00	11.63
Peckerwood Cr.	Avg	331.4	17.6	0.235	0.017	0.155	0.022	8.43	2.07	1.35
Lay - Coosa R.	Min	0.4	6.0	0.203	0.015	0.050	0.019	3.09	2.00	1.24
Mile 422	Max	7533.1	28.1	1.056	0.316	0.387	0.083	12.35	12.00	11.69
Waxahatchee Cr.	Avg	414.3	17.6	0.229	0.017	0.155	0.021	8.43	2.07	1.36
Lay - Coosa R.	Min	0.6	6.0	0.198	0.015	0.050	0.019	3.09	2.00	1.25
Mile 415	Max	9415.0	28.1	1.020	0.313	0.387	0.080	12.35	12.00	12.00
Lower Yellowleaf Cr.	Avg	59.1	17.6	0.170	0.016	0.155	0.017	8.43	2.03	1.19
Mitchell - Coosa R.	Min	0.1	6.0	0.151	0.015	0.050	0.016	3.09	2.00	1.13
Mile 410	Max	1343.4	28.1	0.661	0.135	0.387	0.053	12.35	7.21	6.96
Walnut Cr.	Avg	509.3	17.6	0.172	0.016	0.155	0.017	8.43	2.04	1.21
Mitchell - Coosa R.	Min	0.7	6.0	0.153	0.015	0.050	0.016	3.09	2.00	1.14
Mile 402	Max	11574.5	28.1	0.673	0.148	0.387	0.054	12.35	7.67	7.40
Chestnut Cr.	Avg	154.9	17.6	0.186	0.015	0.155	0.018	8.43	2.02	1.13
Jordan - Coosa R.	Min	0.2	6.0	0.164	0.015	0.050	0.017	3.09	2.00	1.09
Mile 393	Max	3519.5	28.1	0.756	0.094	0.387	0.060	12.35	5.03	4.87
Weoka Cr.	Avg	398.4	17.6	0.176	0.015	0.155	0.018	8.43	2.02	1.12
Jordan - Coosa R.	Min	0.5	6.0	0.156	0.015	0.050	0.016	3.09	2.00	1.08
Mile 382	Max	9054.2	28.1	0.698	0.091	0.387	0.056	12.35	4.69	4.55
Tallapoosa R.	Avg	162.6	17.6	0.245	0.019	0.155	0.023	8.43	2.03	1.39
Tallapoosa R.	Min	1.9	6.0	0.190	0.015	0.050	0.019	3.09	2.00	1.23
Mile 576	Max	3354.4	28.1	0.851	0.233	0.387	0.067	12.35	7.63	7.37
Little Cr.	Avg	38.9	17.6	0.262	0.020	0.155	0.024	8.43	2.04	1.41
Tallapoosa R.	Min	0.4	6.0	0.201	0.015	0.050	0.019	3.09	2.00	1.24
Mile 574	Max	802.3	28.1	0.928	0.273	0.387	0.073	12.35	7.97	7.69
Muscadine Cr.	Avg	71.5	17.6	0.248	0.019	0.155	0.023	8.43	2.02	1.35
Tallapoosa R.	Min	0.8	6.0	0.192	0.015	0.050	0.019	3.09	2.00	1.21
Mile 572	Max	1475.3	28.1	0.864	0.247	0.387	0.068	12.35	6.90	6.66
Kelley + Norman Cr.	Avg	97.6	17.6	0.255	0.020	0.155	0.023	8.43	2.03	1.38
Tallapoosa R.	Min	1.1	6.0	0.196	0.015	0.050	0.019	3.09	2.00	1.22
Mile 563	Max	2013.7	28.1	0.897	0.262	0.387	0.071	12.35	7.40	7.15
Silas Cr.	Avg	138.3	17.6	0.262	0.020	0.155	0.024	8.43	2.03	1.38
Tallapoosa R.	Min	1.6	6.0	0.202	0.015	0.050	0.019	3.09	2.00	1.23
Mile 552	Max	2853.6	28.1	0.931	0.274	0.387	0.073	12.35	7.51	7.25
Cane Cr.	Avg	56.5	17.6	0.187	0.017	0.155	0.018	8.43	2.02	1.31
Tallapoosa R.	Min	0.6	6.0	0.151	0.015	0.050	0.016	3.09	2.00	1.19
Mile 544	Max	1165.7	28.1	0.587	0.149	0.387	0.048	12.35	6.32	6.11
Dyne Cr.	Avg	102.6	17.6	0.198	0.017	0.155	0.019	8.43	2.01	1.29
Tallapoosa R.	Min	1.2	6.0	0.158	0.015	0.050	0.016	3.09	2.00	1.17
Mile 535	Max	2116.0	28.1	0.636	0.148	0.387	0.052	12.35	5.90	5.70

Ketchepedrakee Cr.	Avg	151.1	17.6	0.194	0.016	0.155	0.019	8.43	2.01	1.25
Tallapoosa R.	Min	1.7	6.0	0.155	0.015	0.050	0.016	3.09	2.00	1.15
Mile 528	Max	3117.5	28.1	0.619	0.135	0.387	0.050	12.35	5.26	5.09
Little Tallapoosa R.	Avg	244.7	17.6	0.330	0.024	0.155	0.029	8.43	2.07	1.52
Little Tallapoosa R.	Min	2.8	6.0	0.248	0.015	0.050	0.023	3.09	2.00	1.30
Mile 540	Max	5047.7	28.1	1.241	0.396	0.387	0.096	12.35	9.77	9.42
Cohobadiah Cr.	Avg	83.6	17.6	0.287	0.019	0.155	0.026	8.43	2.00	1.20
Little Tallapoosa R.	Min	1.0	6.0	0.218	0.015	0.050	0.021	3.09	2.00	1.12
Mile 536	Max	1725.6	28.1	1.044	0.236	0.387	0.082	12.35	4.47	4.33
Tallapoosa R. Tribs	Avg	157.6	17.6	0.245	0.018	0.155	0.023	8.43	2.01	1.24
Harris - Tallapoosa R.	Min	1.8	6.0	0.190	0.015	0.050	0.019	3.09	2.00	1.14
Mile 512	Max	3252.1	28.1	0.854	0.193	0.387	0.068	12.35	4.99	4.83
Crooked Cr.	Avg	83.5	17.6	0.225	0.016	0.155	0.021	8.43	2.02	1.26
Tallapoosa R.	Min	0.2	6.0	0.189	0.015	0.050	0.018	3.09	2.00	1.20
Mile 498	Max	1183.4	28.1	0.771	0.177	0.387	0.062	12.35	7.16	6.91
Cornhouse Cr.	Avg	178.9	17.6	0.218	0.016	0.155	0.021	8.43	2.02	1.23
Tallapoosa R.	Min	0.5	6.0	0.184	0.015	0.050	0.018	3.09	2.00	1.18
Mile 492	Max	2534.5	28.1	0.738	0.171	0.387	0.059	12.35	6.41	6.19
High Pine Cr.	Avg	50.3	17.6	0.206	0.016	0.155	0.020	8.43	2.03	1.33
Tallapoosa R.	Min	0.1	6.0	0.175	0.015	0.050	0.017	3.09	2.00	1.26
Mile 482	Max	713.3	28.1	0.684	0.158	0.387	0.055	12.35	8.76	8.45
Chikasanoxee Cr.	Avg	146.7	17.6	0.201	0.016	0.155	0.019	8.43	2.02	1.24
Tallapoosa R.	Min	0.4	6.0	0.171	0.015	0.050	0.017	3.09	2.00	1.19
Mile 477	Max	2078.6	28.1	0.661	0.137	0.387	0.053	12.35	6.68	6.45
Chatahospee Cr.	Avg	275.1	17.6	0.210	0.016	0.155	0.020	8.43	2.02	1.23
Tallapoosa R.	Min	0.8	6.0	0.178	0.015	0.050	0.018	3.09	2.00	1.18
Mile 465	Max	3897.3	28.1	0.700	0.146	0.387	0.056	12.35	6.33	6.12
Hillabee Cr.	Avg	565.5	17.6	0.202	0.016	0.155	0.019	8.43	2.02	1.24
Tallapoosa R.	Min	1.6	6.0	0.172	0.015	0.050	0.017	3.09	2.00	1.19
Mile 445	Max	8012.0	28.1	0.663	0.144	0.387	0.054	12.35	6.63	6.40
Martin Lake Tribs	Avg	367.1	17.8	0.206	0.016	0.155	0.020	8.34	2.02	1.30
Martin - Tallapoosa R.	Min	1.1	10.0	0.175	0.015	0.050	0.017	2.81	2.00	1.23
Mile 430	Max	5201.2	26.6	0.684	0.172	0.387	0.055	11.23	8.05	7.77
Channahatchee Cr.	Avg	31.4	17.6	0.234	0.022	0.155	0.022	8.43	2.23	1.56
Yates - Tallapoosa R.	Min	0.3	6.0	0.160	0.015	0.050	0.016	3.09	2.00	1.16
Mile 420	Max	603.6	28.1	0.673	0.101	0.387	0.054	12.35	5.29	5.11
Tallapoosa R. Tribs	Avg	3.7	17.6	0.344	0.025	0.155	0.030	8.43	2.32	1.70
Tallapoosa R.	Min	0.0	6.0	0.218	0.015	0.050	0.021	3.09	2.00	1.19
Mile 408	Max	71.1	28.1	1.085	0.131	0.387	0.085	12.35	6.31	6.10
Upahee Cr.	Avg	29.3	17.6	0.321	0.033	0.155	0.028	8.43	2.47	1.91
Tallapoosa R.	Min	0.3	6.0	0.206	0.015	0.050	0.020	3.09	2.00	1.25
Mile 403	Max	561.8	28.1	1.002	0.201	0.387	0.079	12.35	7.95	7.67
Calebee Cr.	Avg	48.0	17.6	0.335	0.034	0.155	0.029	8.43	2.45	1.88
Tallapoosa R.	Min	0.5	6.0	0.214	0.015	0.050	0.020	3.09	2.00	1.24
Mile 396	Max	921.8	28.1	1.054	0.206	0.387	0.083	12.35	7.70	7.43
Cubahatchee Cr.	Avg	56.8	17.6	0.327	0.033	0.155	0.029	8.43	2.44	1.87
Tallapoosa R.	Min	0.6	6.0	0.209	0.015	0.050	0.020	3.09	2.00	1.24
Mile 389	Max	1090.7	28.1	1.022	0.200	0.387	0.080	12.35	7.60	7.34
Line Cr.	Avg	86.1	17.6	0.349	0.033	0.155	0.030	8.43	2.38	1.79
Tallapoosa R.	Min	0.9	6.0	0.221	0.015	0.050	0.021	3.09	2.00	1.22
Mile 387	Max	1653.4	28.1	1.104	0.201	0.387	0.086	12.35	6.99	6.75
Chubbehatchee Cr.	Avg	93.3	17.6	0.343	0.033	0.155	0.030	8.43	2.36	1.76
Tallapoosa R.	Min	1.0	6.0	0.218	0.015	0.050	0.021	3.09	2.00	1.21
Mile 383	Max	1791.2	28.1	1.084	0.195	0.387	0.085	12.35	6.73	6.50
Tallapoosa R. Tribs	Avg	104.5	17.6	0.361	0.035	0.155	0.031	8.43	2.38	1.79
Tallapoosa R.	Min	1.1	6.0	0.228	0.015	0.050	0.021	3.09	2.00	1.22
Mile 365	Max	2006.3	28.1	1.151	0.216	0.387	0.090	12.35	7.00	6.76

Coosa R. Tribs	Avg	9.9	17.6	0.473	0.048	0.155	0.040	8.43	2.36	1.76
Coosa R.	Min	0.1	6.0	0.288	0.015	0.050	0.026	3.09	2.00	1.21
Mile 357	Max	190.2	28.1	1.573	0.324	0.387	0.121	12.35	6.74	6.51
Autauga Cr.	Avg	530.1	17.6	0.354	0.025	0.155	0.031	8.43	2.26	1.72
R.F.Henry - Alabama R.	Min	0.7	6.0	0.276	0.015	0.050	0.025	3.09	2.00	1.30
Mile 328	Max	12947.3	28.1	0.854	0.196	0.387	0.068	12.35	8.77	8.46
Pintalla Cr.	Avg	798.2	17.6	0.350	0.024	0.155	0.030	8.43	2.19	1.59
R.F.Henry - Alabama R.	Min	1.1	6.0	0.273	0.015	0.050	0.025	3.09	2.00	1.24
Mile 323	Max	19497.5	28.1	0.842	0.179	0.387	0.067	12.35	7.35	7.10
Swift Cr.	Avg	991.5	17.6	0.338	0.023	0.155	0.030	8.43	2.15	1.52
R.F.Henry - Alabama R.	Min	1.3	6.0	0.265	0.015	0.050	0.024	3.09	2.00	1.21
Mile 310	Max	24217.4	28.1	0.811	0.166	0.387	0.065	12.35	6.61	6.38
Purdy Lake Tribs	Avg	23.5	17.6	0.238	0.021	0.155	0.022	8.43	2.14	1.47
Cahaba R.	Min	2.2	6.0	0.172	0.015	0.050	0.017	3.09	2.00	1.16
Mile 392	Max	562.0	28.1	0.975	0.136	0.387	0.077	12.35	5.21	5.04
Cahaba R.	Avg	65.7	17.6	0.220	0.023	0.155	0.021	8.43	2.14	1.46
Cahaba R.	Min	6.1	6.0	0.161	0.015	0.050	0.016	3.09	2.00	1.16
Mile 390	Max	1571.5	28.1	0.876	0.153	0.387	0.069	12.35	5.15	4.98
Little Shades Cr.	Avg	101.4	17.6	0.282	0.031	0.155	0.025	8.43	2.33	1.78
Cahaba R.	Min	9.4	6.0	0.197	0.015	0.050	0.019	3.09	2.00	1.27
Mile 385	Max	2426.2	28.1	1.217	0.273	0.387	0.095	12.35	7.97	7.69
Buck Cr.	Avg	155.0	17.6	0.275	0.029	0.155	0.025	8.43	2.28	1.70
Cahaba R.	Min	14.3	6.0	0.193	0.015	0.050	0.019	3.09	2.00	1.24
Mile 377	Max	3708.3	28.1	1.178	0.245	0.387	0.092	12.35	7.33	7.07
Pineywood Cr.	Avg	231.8	17.6	0.272	0.029	0.155	0.025	8.43	2.28	1.70
Cahaba R.	Min	21.4	6.0	0.191	0.015	0.050	0.019	3.09	2.00	1.24
Mile 362	Max	5545.6	28.1	1.158	0.238	0.387	0.090	12.35	7.27	7.02
Little Cahaba R.	Avg	391.1	17.6	0.292	0.029	0.155	0.026	8.43	2.23	1.63
Cahaba R.	Min	36.2	6.0	0.203	0.015	0.050	0.020	3.09	2.00	1.22
Mile 334	Max	9358.3	28.1	1.272	0.246	0.387	0.099	12.35	6.62	6.40
Shultz Cr.	Avg	438.2	17.6	0.284	0.028	0.155	0.026	8.43	2.21	1.59
Cahaba R.	Min	40.5	6.0	0.199	0.015	0.050	0.019	3.09	2.00	1.20
Mile 324	Max	10485.6	28.1	1.227	0.231	0.387	0.095	12.35	6.27	6.06
Affohee+Hayson+Blue Cr.	Avg	110.1	17.6	0.209	0.015	0.155	0.020	8.43	2.01	1.27
Cahaba R.	Min	0.6	6.0	0.182	0.015	0.050	0.018	3.09	2.00	1.21
Mile 312	Max	1450.1	28.1	1.155	0.228	0.387	0.090	12.35	8.41	8.12
Old Town + Wallace Cr.	Avg	193.4	17.6	0.210	0.016	0.155	0.020	8.43	2.01	1.29
Cahaba R.	Min	1.0	6.0	0.183	0.015	0.050	0.018	3.09	2.00	1.22
Mile 294	Max	2548.0	28.1	1.162	0.241	0.387	0.091	12.35	8.71	8.40
Waters Cr.	Avg	246.7	17.6	0.214	0.016	0.155	0.020	8.43	2.01	1.29
Cahaba R.	Min	1.2	6.0	0.187	0.015	0.050	0.018	3.09	2.00	1.22
Mile 280	Max	3249.6	28.1	1.198	0.244	0.387	0.093	12.35	8.71	8.40
Oakmulgee Cr.	Avg	414.4	17.6	0.213	0.015	0.155	0.020	8.43	2.01	1.27
Cahaba R.	Min	2.1	6.0	0.186	0.015	0.050	0.018	3.09	2.00	1.20
Mile 268	Max	5458.6	28.1	1.192	0.231	0.387	0.093	12.35	8.22	7.93
Cahaba R. Tribs	Avg	25.2	17.6	0.437	0.026	0.155	0.037	8.43	2.01	1.23
Cahaba R.	Min	0.1	6.0	0.366	0.015	0.050	0.032	3.09	2.00	1.17
Mile 256	Max	332.5	28.1	2.001	0.500	0.387	0.227	12.35	7.18	6.93
Big Swamp Cr.	Avg	115.9	17.6	0.390	0.034	0.155	0.033	8.43	2.18	1.54
Millers Ferry - Alabama R.	Min	-0.2	6.0	0.268	0.015	0.050	0.024	3.09	2.00	1.22
Mile 288	Max	1972.7	28.1	1.445	0.321	0.387	0.111	12.35	7.86	7.58
Mulberry Cr.	Avg	327.3	17.6	0.343	0.030	0.155	0.030	8.43	2.13	1.44
Millers Ferry - Alabama R.	Min	-0.4	6.0	0.239	0.015	0.050	0.022	3.09	2.00	1.18
Mile 276	Max	5572.2	28.1	1.240	0.262	0.387	0.096	12.35	6.64	6.41
Beach Cr.	Avg	375.6	17.6	0.344	0.030	0.155	0.030	8.43	2.15	1.49
Millers Ferry - Alabama R.	Min	-0.5	6.0	0.240	0.015	0.050	0.022	3.09	2.00	1.20
Mile 261	Max	6394.2	28.1	1.246	0.267	0.387	0.097	12.35	7.22	6.97

Cedar Cr.	Avg	575.7	17.6	0.332	0.030	0.155	0.029	8.43	2.17	1.52
Millers Ferry - Alabama R.	Min	-0.7	6.0	0.232	0.015	0.050	0.022	3.09	2.00	1.21
Mile 227	Max	9801.0	28.1	1.190	0.258	0.387	0.093	12.35	7.66	7.40
Bogue Chitto Cr.	Avg	685.6	17.6	0.339	0.029	0.155	0.030	8.43	2.16	1.50
Millers Ferry - Alabama R.	Min	-0.9	6.0	0.237	0.015	0.050	0.022	3.09	2.00	1.20
Mile 215	Max	11671.7	28.1	1.222	0.254	0.387	0.095	12.35	7.33	7.08
Chilatchee Cr.	Avg	849.1	17.6	0.328	0.029	0.155	0.029	8.43	2.16	1.52
Millers Ferry - Alabama R.	Min	-1.1	6.0	0.230	0.015	0.050	0.022	3.09	2.00	1.21
Mile 213	Max	14454.9	28.1	1.176	0.244	0.387	0.092	12.35	7.58	7.32
Beaver Cr.	Avg	48.6	17.6	0.251	0.025	0.155	0.023	8.43	2.32	1.80
Claiborne - Alabama R.	Min	-0.1	6.0	0.183	0.015	0.050	0.018	3.09	2.00	1.32
Mile 178	Max	827.6	28.1	0.839	0.182	0.387	0.067	12.35	11.24	10.83
Pursley Cr.	Avg	63.6	17.6	0.252	0.025	0.155	0.023	8.43	2.35	1.85
Claiborne - Alabama R.	Min	-0.1	6.0	0.183	0.015	0.050	0.018	3.09	2.00	1.34
Mile 167	Max	1082.7	28.1	0.843	0.191	0.387	0.067	12.35	11.83	11.40
Bear Cr.	Avg	78.9	17.6	0.250	0.025	0.155	0.023	8.43	2.35	1.84
Claiborne - Alabama R.	Min	-0.1	6.0	0.182	0.015	0.050	0.018	3.09	2.00	1.34
Mile 155	Max	1343.5	28.1	0.833	0.189	0.387	0.066	12.35	11.74	11.31
Tallahatchee Cr.	Avg	94.9	17.6	0.253	0.025	0.155	0.023	8.43	2.35	1.85
Claiborne - Alabama R.	Min	-0.1	6.0	0.184	0.015	0.050	0.018	3.09	2.00	1.34
Mile 145	Max	1615.6	28.1	0.847	0.193	0.387	0.067	12.35	11.86	11.42
Cane Cr.	Avg	113.9	17.6	0.249	0.025	0.155	0.023	8.43	2.33	1.82
Claiborne - Alabama R.	Min	-0.1	6.0	0.182	0.015	0.050	0.018	3.09	2.00	1.33
Mile 134	Max	1938.7	28.1	0.831	0.189	0.387	0.066	12.35	11.51	11.09

Table A-2 Average, maximum and minimum flow and water quality inputs from municipal and industrial discharges.

Location/River/River Mile	Avg/ Max/Min	Flow (cfs)	Temp (C)	NO3-N (mg/l)	PO4-P (mg/l)	Chlorophyll *a* (ug/l)	NH3-N (mg/l)	DO (mg/l)	diss. org (mg/l)	org solids (mg/l)
Cartersville WPCP	Avg	13.0	21.6	10.000	3.720	0.000	1.336	3.92	17.16	9.55
Etowah R.	Min	11.5	12.0	10.000	2.962	0.000	0.560	2.81	10.40	4.84
Mile 681	Max	15.1	28.0	10.000	5.086	0.000	2.720	5.11	32.40	17.54
Calhoun WPCP	Avg	11.5	21.6	10.000	3.720	0.000	0.566	4.66	26.36	16.58
Coosawattee R.	Min	10.3	12.0	10.000	2.962	0.000	0.471	3.59	19.73	13.11
Mile 693	Max	13.2	28.0	10.000	5.086	0.000	0.667	5.75	32.23	20.22
City of Chatsworth O	Avg	2.2	21.6	10.000	3.720	0.000	0.312	6.37	7.20	4.27
Conasauga R.	Min	1.7	12.0	10.000	2.962	0.000	0.125	4.41	5.48	2.96
Mile 713	Max	2.7	28.0	10.000	5.086	0.000	0.556	8.60	9.50	5.30
Cobb County Noonday Cree	Avg	15.1	21.6	10.000	0.264	0.000	0.155	6.43	3.75	1.39
Allatoona - Etowah R.	Min	14.1	12.0	10.000	0.183	0.000	0.114	4.93	3.75	1.21
Mile 710	Max	16.4	28.0	10.000	0.343	0.000	0.300	8.02	3.75	1.80
Canton WPCP	Avg	2.4	21.6	10.000	4.605	0.000	2.426	4.37	16.25	11.13
Etowah R.	Min	2.3	12.0	10.000	3.275	0.000	0.500	2.67	16.25	7.54
Mile 717	Max	2.5	28.0	10.000	6.873	0.000	7.160	6.68	16.25	24.67
Cherokee County Rose Cre	Avg	5.9	21.6	10.000	0.175	0.000	0.381	5.75	6.25	2.07
Allatoona - Etowah R.	Min	4.8	12.0	10.000	0.100	0.000	0.125	4.46	6.25	1.43
Mile 705	Max	6.5	28.0	10.000	0.300	0.000	0.933	7.10	6.25	2.60
Cobb County Northwest WP	Avg	10.7	21.6	10.000	0.102	0.000	0.106	6.52	2.50	1.06
Allatoona - Etowah R.	Min	9.8	12.0	10.000	0.100	0.000	0.100	4.86	2.50	1.00
Mile 700	Max	11.5	28.0	10.000	0.120	0.000	0.170	8.08	2.50	1.40
Inland Paperboard	Avg	35.1	21.6	1.000	0.300	0.000	4.000	3.90	41.33	94.05
Coosa R.	Min	31.6	12.0	1.000	0.300	0.000	4.000	1.36	32.03	74.82
Mile 628	Max	37.4	28.0	1.000	0.300	0.000	4.000	5.42	58.80	105.14
Georgia Power Company -	Avg	1.5	1.0	90.000	0.100	0.000	0.300	0.12	7.50	3.00
Etowah R.	Min	1.5	1.0	90.000	0.100	0.000	0.300	0.04	7.50	3.00
Mile 674	Max	1.5	1.0	90.000	0.100	0.000	0.300	0.14	7.50	3.00
Rome WPCP	Avg	16.9	21.6	10.000	2.085	0.000	0.439	4.69	14.35	7.03
Coosa R.	Min	12.9	12.0	10.000	1.333	0.000	0.262	3.38	9.45	5.44
Mile 643	Max	22.1	28.0	10.000	2.712	0.000	0.725	6.30	20.30	9.12
Rome - Coosa WPCP	Avg	1.3	21.6	10.000	1.524	0.000	0.204	5.45	2.68	3.51
Coosa R.	Min	0.8	12.0	10.000	0.900	0.000	0.129	3.87	2.50	2.00
Mile 640	Max	2.0	28.0	10.000	2.167	0.000	0.400	7.22	3.43	5.75
Gadsden East WWTP	Avg	4.9	21.6	2.945	2.220	0.000	8.863	3.90	41.42	17.76
H.N.Henry - Coosa R.	Min	3.6	12.0	1.457	1.632	0.000	7.420	1.36	36.40	12.94
Mile 526	Max	6.3	28.0	4.266	5.772	0.000	9.670	5.42	50.30	23.75
Gadsden West WWTP	Avg	8.3	21.6	4.303	1.942	0.000	6.921	4.01	21.70	10.62
H.N.Henry - Coosa R.	Min	5.0	12.0	2.390	1.150	0.000	4.820	2.58	18.48	7.61
Mile 524	Max	11.4	28.0	7.795	2.403	0.000	9.400	7.11	29.33	14.20
Attalla Lagoon	Avg	3.3	21.6	0.686	1.048	0.000	3.657	3.59	53.71	43.38
H.N.Henry - Coosa R.	Min	1.7	12.0	0.277	0.810	0.000	2.270	1.44	36.00	23.73
Mile 528	Max	4.6	28.0	1.225	1.782	0.000	6.640	8.04	95.90	61.60
Tyson Foods	Avg	1.6	21.6	10.000	6.500	0.000	1.000	6.24	22.63	11.31
H.N.Henry - Coosa R.	Min	1.3	12.0	10.000	6.500	0.000	1.000	2.17	5.00	2.63
Mile 518	Max	2.0	28.0	10.000	6.500	0.000	1.000	8.67	38.35	33.46
Goodyear Tire and Rubber	Avg	12.8	24.4	1.000	0.300	0.000	4.000	3.73	35.00	13.77
H.N.Henry - Coosa R.	Min	10.5	15.2	1.000	0.300	0.000	4.000	1.26	35.00	11.10
Mile 534	Max	17.2	33.1	1.000	0.300	0.000	4.000	5.06	35.00	23.60
Pell City Dye Creek WWTP	Avg	2.5	21.6	4.758	1.500	0.000	0.159	8.22	16.53	2.74
Logan Martin - Coosa R.	Min	1.7	12.0	0.657	0.720	0.000	0.130	5.31	15.18	2.01
Mile 481	Max	3.4	28.0	9.150	3.036	0.000	0.220	11.07	18.13	3.51
Kimberley-Clark Corporat	Avg	37.1	21.6	1.000	0.300	0.000	4.000	3.90	50.06	25.07
Lay - Coosa R.	Min	31.5	12.0	1.000	0.300	0.000	4.000	1.36	30.75	19.15
Mile 454	Max	47.4	28.0	1.000	0.300	0.000	4.000	5.42	72.60	38.00

APCO Gaston PLT ash pond	Avg	38.5	21.6	0.220	0.060	0.000	0.050	6.24	9.00	3.60
Lay - Coosa R.	Min	38.5	12.0	0.220	0.060	0.000	0.050	2.17	9.00	3.60
Mile 443	Max	38.5	28.0	0.220	0.060	0.000	0.050	8.67	9.00	3.60
Tallassee Lagoon	Avg	1.0	21.6	10.000	2.374	0.000	1.834	3.90	26.95	22.57
Tallapoosa R.	Min	0.8	12.0	10.000	1.183	0.000	0.470	1.36	14.60	11.20
Mile 407	Max	1.4	28.0	10.000	4.042	0.000	3.150	5.42	37.13	30.88
Tuskegee South WWTP (Cal	Avg	1.6	21.6	10.000	0.700	0.000	1.074	6.47	20.00	9.32
Tallapoosa R.	Min	1.1	12.0	10.000	0.700	0.000	0.240	4.49	20.00	5.11
Mile 401	Max	2.3	28.0	10.000	0.700	0.000	1.790	8.72	20.00	21.33
Tuskegee North WWTP	Avg	2.2	21.6	10.000	0.700	0.000	1.551	5.46	5.84	5.74
Tallapoosa R.	Min	1.8	12.0	10.000	0.700	0.000	0.190	1.90	4.33	3.55
Mile 399	Max	3.0	28.0	10.000	0.700	0.000	4.080	7.59	8.28	8.62
Alexander City Coley Cre	Avg	12.4	21.6	8.449	1.051	0.000	0.314	7.11	5.48	4.83
Martin - Tallapoosa R.	Min	12.4	12.0	5.440	0.650	0.000	0.220	5.16	3.75	3.33
Mile 430	Max	12.4	28.0	10.663	1.340	0.000	0.450	8.90	6.68	6.75
Wetumka City of Water Wo	Avg	3.2	21.6	10.000	2.700	0.000	0.250	6.24	6.25	6.22
Coosa R.	Min	1.8	12.0	10.000	2.700	0.000	0.250	2.17	6.25	2.07
Mile 366	Max	4.2	28.0	10.000	2.700	0.000	0.250	8.67	6.25	10.88
International Paper Comp	Avg	44.5	21.6	1.000	0.300	0.000	4.000	0.86	88.42	45.69
Millers Ferry - Alabama R.	Min	39.6	12.0	1.000	0.300	0.000	4.000	0.70	55.83	38.40
Mile 273	Max	48.3	28.0	1.000	0.300	0.000	4.000	1.00	121.83	53.76
International Paper	Avg	41.5	21.6	1.000	0.300	0.000	4.000	0.86	83.34	62.00
R.F.Henry - Alabama R.	Min	30.5	12.0	1.000	0.300	0.000	4.000	0.70	55.53	62.00
Mile 330	Max	55.5	28.0	1.000	0.300	0.000	4.000	1.00	143.30	62.00
General Electric WWTP	Avg	4.1	21.6	0.100	0.300	0.000	0.100	5.85	17.45	10.65
R.F.Henry - Alabama R.	Min	2.7	12.0	0.100	0.300	0.000	0.100	2.03	11.75	1.00
Mile 325	Max	5.1	28.0	0.100	0.300	0.000	0.100	8.13	25.25	40.20
Prattville Pine Creek	Avg	3.2	21.6	10.000	0.800	0.000	6.000	5.85	12.75	12.10
R.F.Henry - Alabama R.	Min	3.2	12.0	10.000	0.800	0.000	6.000	2.03	12.75	12.10
Mile 347	Max	3.2	28.0	10.000	0.800	0.000	6.000	8.13	12.75	12.10
Montgomery Econchate	Avg	26.3	20.3	2.500	1.000	0.000	7.399	3.44	56.25	16.50
R.F.Henry - Alabama R.	Min	26.3	2.6	2.500	1.000	0.000	7.400	2.80	56.25	16.50
Mile 344	Max	26.3	32.5	2.500	1.000	0.000	7.400	4.00	56.25	16.50
Montgomery Towassa	Avg	3.9	20.3	2.500	1.000	0.000	7.399	3.44	56.25	16.50
R.F.Henry - Alabama R.	Min	3.9	2.6	2.500	1.000	0.000	7.400	2.80	56.25	16.50
Mile 339	Max	3.9	32.5	2.500	1.000	0.000	7.400	4.00	56.25	16.50
Catoma Creek WWTPg	Avg	25.4	21.6	10.000	0.700	0.000	0.200	5.19	6.40	2.89
R.F.Henry - Alabama R.	Min	21.8	12.0	10.000	0.700	0.000	0.120	3.90	5.63	2.40
Mile 332	Max	32.4	28.0	10.000	0.700	0.000	0.300	6.57	7.50	3.50
Macmillan Bloedel Packin	Avg	27.8	21.6	1.000	1.200	0.000	1.400	2.34	104.79	62.13
Claiborne - Alabama R.	Min	24.2	12.0	1.000	1.200	0.000	1.400	0.81	88.75	45.67
Mile 171	Max	32.0	28.0	1.000	1.200	0.000	1.400	3.25	123.83	80.35
Alabama River Pulp Compa	Avg	35.8	20.3	1.000	0.300	0.000	4.000	0.86	148.26	77.00
Alabama R.	Min	30.5	2.6	1.000	0.300	0.000	4.000	0.70	138.00	65.20
Mile 125	Max	38.1	32.5	1.000	0.300	0.000	4.000	1.00	150.00	100.70
Selma Valley Creek WWTP	Avg	5.6	21.6	10.000	0.700	0.000	5.386	3.90	59.23	16.52
Millers Ferry - Alabama R.	Min	4.6	12.0	10.000	0.700	0.000	4.520	1.36	51.55	12.86
Mile 258	Max	6.8	28.0	10.000	0.700	0.000	6.120	5.42	66.25	19.62
Leeds	Avg	1.7	22.0	14.250	5.000	0.000	1.000	5.93	37.50	6.70
Cahaba R.	Min	1.7	2.7	14.250	5.000	0.000	1.000	2.59	37.50	6.70
Mile 389	Max	1.7	33.9	14.250	5.000	0.000	1.000	9.97	37.50	6.70
Birminghan Area discharges	Avg	3.7	20.3	12.000	5.000	0.000	3.000	5.16	22.50	8.40
Cahaba R.	Min	3.7	2.6	12.000	5.000	0.000	3.000	4.20	22.50	8.40
Mile 387	Max	3.7	32.5	12.000	5.000	0.000	3.000	6.00	22.50	8.40
Jefferson Co. + Hoover RC	Avg	7.3	20.3	13.897	5.000	0.000	1.106	6.15	8.27	3.85
Cahaba R.	Min	5.7	2.6	12.800	5.000	0.000	0.410	2.59	7.03	3.30
Mile 384	Max	11.4	32.5	14.600	5.000	0.000	2.210	10.20	10.98	5.19
Pelham	Avg	1.5	19.0	14.000	5.000	0.000	1.000	6.34	30.00	11.20
Cahaba R.	Min	1.5	2.0	14.000	5.000	0.000	1.000	2.59	30.00	11.20
Mile 372	Max	1.5	32.5	14.000	5.000	0.000	1.000	10.37	30.00	11.20