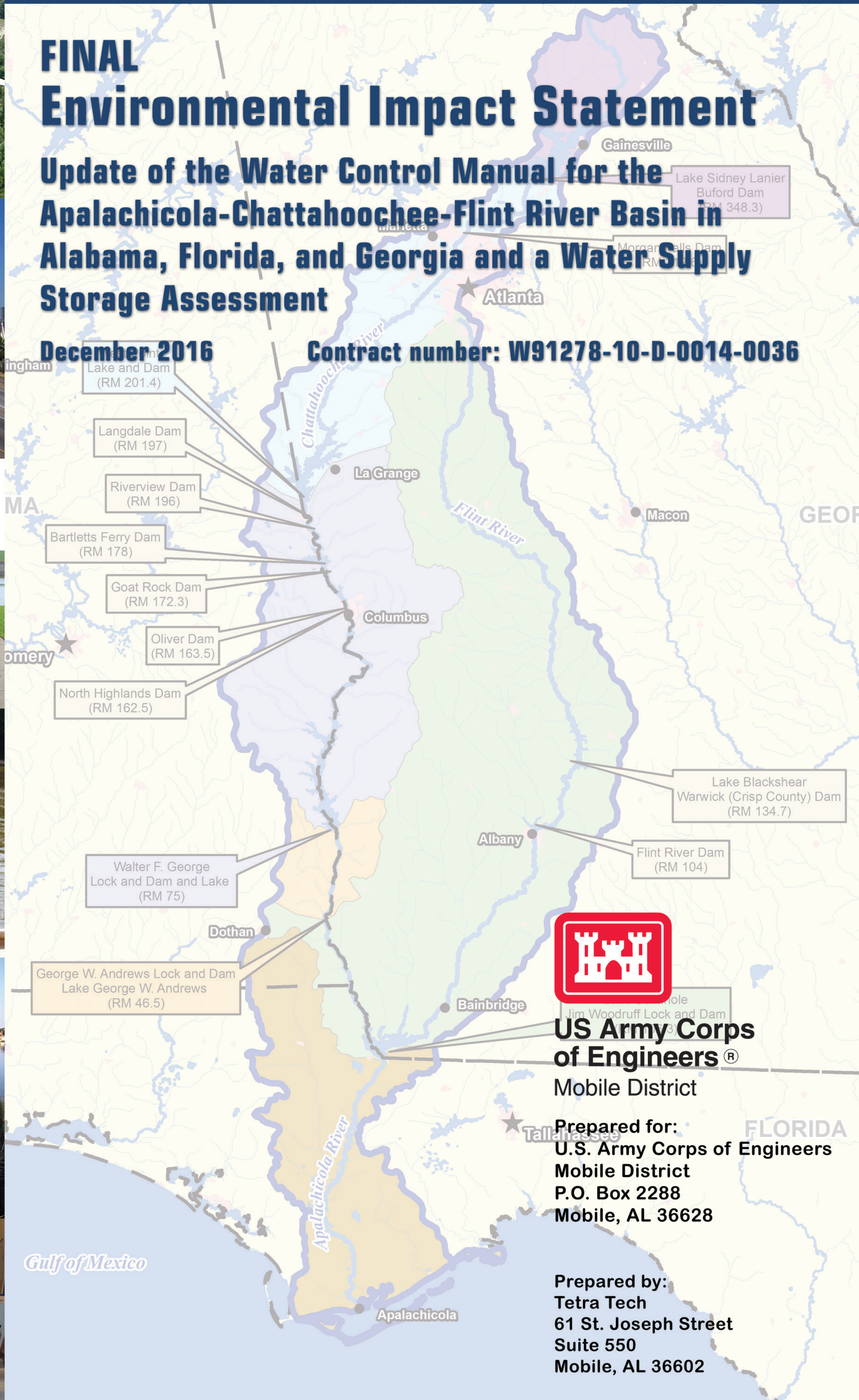





FINAL
Environmental Impact Statement

Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin in Alabama, Florida, and Georgia and a Water Supply Storage Assessment

December 2016 **Contract number: W91278-10-D-0014-0036**



US Army Corps of Engineers®
Mobile District

Prepared for:
U.S. Army Corps of Engineers
Mobile District
P.O. Box 2288
Mobile, AL 36628

Prepared by:
Tetra Tech
61 St. Joseph Street
Suite 550
Mobile, AL 36602

Appendix K

HEC-5Q Water Quality Modeling Report

This page intentionally left blank

FINAL REPORT

HEC-RESSIM AND HEC-5Q SIMULATION OF WATER QUALITY IN THE APALACHICOLA-CHATTAHOOCHEE-FLINT WATERSHED

Hydrologic Engineering Center (HEC)
U.S. Army Corps of Engineers
609 Second Street
Davis, CA 95616

&

Resource Management Associates, Inc.
1756 Picasso Avenue
Davis, CA 95618

Prepared for

U.S. Army Corps of Engineers, Mobile District

July 29, 2016

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

An HEC-5Q model was developed for the Apalachicola-Chattahoochee-Flint (ACF) Basin in support of the Environmental Impact Statement (EIS) for the Water Control Manual Update Study (HEC, 1998). It was developed to evaluate the impacts of proposed alternative water management plans on the long-term, system-wide, stream and reservoir water quality of the ACF watershed.

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 the algal growing season (spring, summer, and fall). The model was 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 ACF system.

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). These constituents are consistent with impact assessment guidance from the USFWS in their April 2010 Planning Aid Letter (PAL). In addition, the percentage of flow consisting of municipal or industrial wastewater (point source loads) was modeled.

The decision to model 70 years of record allows insight regarding the frequency and duration of water quality situations resulting from water management operations. In 2011, the model was evaluated for the 2001–2008 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 ACF system. In 2014, *the model was extended through 2011*. The 2001–2011 modeling period encompassed years where hydrologic conditions were representative of “normal” in-stream flows, as well as years with high flow (“wet”) or drought (“dry”) conditions. Point source (wastewater) and non-point source (tributary streams) inflow water quality loadings were 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 (ResSim) and has been used for previous analyses of the ACF. HEC-5Q was aligned to work seamlessly with the HEC-ResSim model that was 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 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 perform the reservoir operations modeling in the ACF basin. The flows that were computed by HEC-5 were then input into HEC-5Q (HEC, 1999). These were used to model water quality of the streams in the ACF basin, using a daily time step. The current analysis uses ResSim to generate all flows. A plug-in for ResSim was developed by HEC and RMA to allow HEC-5Q to be operated from ResSim and facilitate input of ResSim-generated flows into the HEC-5Q model.

The HEC-5Q ACF model used for the 1999 EIS was updated to implement a 6-hour time step to capture diurnal variations, which are often important. Then the HEC-5Q ACF model was extended to include modeling of the reservoirs themselves, was adjusted to approximate the 2001–2011 observed data, and was verified with additional observations in 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 the No Action plan and eight 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 (2001–2011) study.

1.1 HEC-5Q Model Assumptions and Limitations

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 assessment of the water quality of the ACF, performed for the 2001–2011 period, data are available for all reservoirs. Thus the assessment has been extended to the reservoirs. Model coefficients were adjusted so that the temporal and spatial variations of the water quality parameters are 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 experienced 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, such as temporary maintenance operations. This analysis did not require that these special operations or conditions be approximated by the ResSim or HEC-5Q models.

Water quality, both modeled and observed, is sensitive to the amount of flow. The hydrology of the ResSim model for No Action (baseline) conditions was used in the model performance demonstration. The No Action 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 No Action 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 for the period of record, and data gaps occurred in existing records, extrapolated meteorology was used to drive the water quality model. Only maximum and minimum air temperatures were available for the full period of record at all locations. 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. In other words, the air temperatures were used to associate all other meteorological parameters (e.g., dew point temperature) during the same time period as boundary conditions. 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 2.3.3. 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 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 HEC-5Q water quality model to better capture the diurnal temperature changes, while maintaining short enough computation times to be manageable for computing the period of record (currently 72 years). Shorter computation times facilitated making incremental improvements to the model and recomputing as plan formulations changed, which required the water quality to be recomputed with new sets of flows. Each daily flow value computed by the ResSim model was held constant throughout the day in the HEC-5Q model. The 6-hour computed water quality time series were averaged to daily values during post-processing.

The observed data represent the average over the euphotic zone, while the modeled data represent the surface layer. Rather than focus on replicating super-saturated values, the adjustment of the model was conservative, focusing on minimum dissolved oxygen values. Differences may also be due to differences in vertical location of the computed and observed values or the time of day measurements are taken (during peak algal production). The HEC-5Q model coefficients and parameters are within acceptable ranges, as reported in the literature. None of the model coefficients were skewed only to fit the data. Comparison with the observed data indicates that the model does a good job of predicting pollutant, DO, and chlorophyll *a* trends, as indicated by the data, which is important as the EIS evaluates how these trends will change with various flow release options.

No special adjustments were made to the HEC-5Q model for low flow conditions. However, non-point loadings were computed for all flows using the U.S. EPA's BASINS model, and measured point-source loadings were used, where available. One of the three hydrologic periods modeled in this analysis was a low flow period. The BASINS model provided 102 non-point source inflows and loadings for BOD, total nitrogen, and total phosphorous. The BASINS model computes tributary inflows and loadings for a wide range of flows, including low flows. Point source inflows include municipal and industrial discharges and cooling water returns. Agricultural returns and groundwater inflows were not considered as point-sources. 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 initial conditions of each reservoir were defined using the available data and the tendencies seen in the data. An initial stream quality was not defined, but was instead computed from the reservoir releases after the first time step. Each HEC-5Q model run was started in the winter, when growth rates were slow, which leads to improved accuracy of the model results.

1.2 MODEL LOADINGS

The non-point source water quality inputs to the HEC-5Q model were developed from observed data in conjunction with BASINS model loadings that were developed during previous ACF 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. BASINS model outputs were produced for three conditions: 1995 land use conditions, anticipated 2020 conditions, and anticipated 2050 conditions. Each of these was calculated using the 1984-1989 precipitation record. The 2020 BASINS model output was used to develop extrapolation functions that relate hydrograph dynamics and ResSim incremental local flows to concentrations. This model was selected since its time period is currently the closest of the three periods to present day conditions. The extrapolation functions were then applied to the 2001–2011 ResSim flows to generate the non-point source loadings for input to HEC-5Q.

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 observed concentration values. Events are captured based on setting appropriate boundary conditions and model coefficients to be able to predict all events during a simulation period. 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 HEC-ResSim ACF Model

This section describes the basic attributes of the ACF System model used to simulate the No Action Plan, Proposed Action Alternative, and several intermediate alternatives that resulted in the recommended plan. Figure 1.1 shows the complete ACF watershed model, which extends from the headwaters of the Chattahoochee River above Lake Lanier and the headwaters of the Flint River above Griffin through the confluence of the two rivers at Lake Seminole and down the Apalachicola River to Sumatra. Operations in the model extend from the proposed Glades reservoir above Lake Lanier through Buford dam to the tailwater of the Jim Woodruff Lock and Dam Project (represented by the USGS Chattahoochee gage 02358000). The watershed schematic shown in Figure 1.1 includes the location of the reservoirs, junctions, and diversions represented in the ACF system model by the 2016 network (used for modeling the intermediate and recommended plan alternatives). Further details can be found in HEC (2014) and HEC (2016).

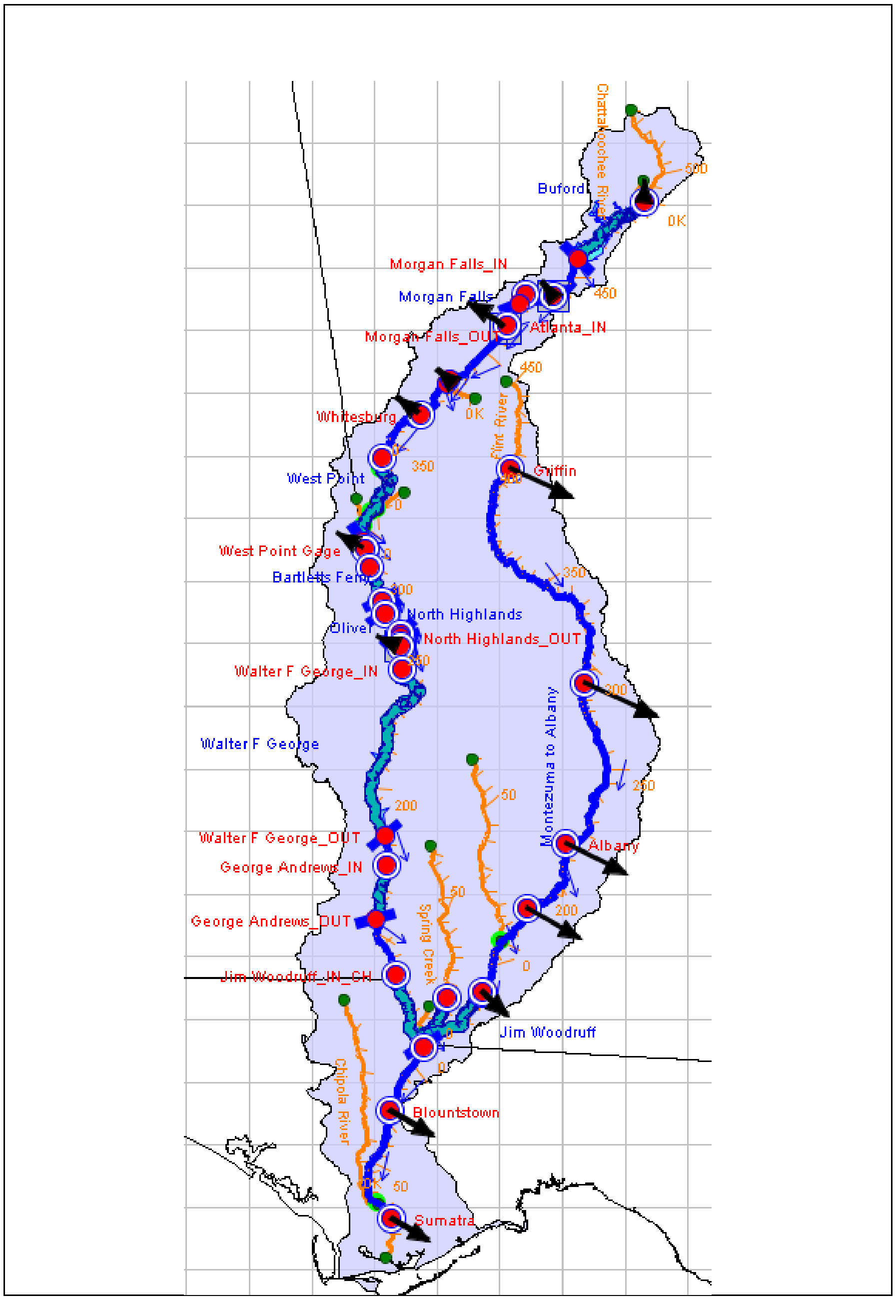


Figure 1.1. HEC-ResSim 2016 Network Schematic. The small blue arrows represent the direction of flow. The large black arrows represent withdrawals.

1.4 ACF STUDY ALTERNATIVES[1]

To analyze the range of potential impacts of water allocation, a matrix of alternative flow options, representing a range of high ("wet"), moderate ("normal"), and low ("dry") in-stream flows were examined together under the No Action plan and each of several study alternatives. Each study alternative consisted of a water management alternative paired with a water supply option. Seven water management alternatives and eight water supply options were evaluated by the PDT. These are described in Table 1.1 and Table 1.2, respectively. The No Action Alternative, Alternative 1, and Alternative 7 were the three water management alternatives selected by the PDT for final analysis by ResSim and HEC-5Q.

1.4.1 NO ACTION ALTERNATIVE

The No Action Alternative includes current operations and incorporates support for water supply as mandated by a 2012 Federal Court ruling. This alternative includes an 800 cfs minimum flow target at Peach Tree Creek (Atlanta) to support the water quality objective there and account for the water supply withdrawals taken from the river. The lake withdrawals are represented at the inflow to Buford and reflect the 2007 withdrawal levels. This alternative uses the action zones defined in the draft 1989 ACF WCM, current hydroelectric power generation schedules, and current fish and wildlife conservation practices such as spawning standard operating plan (SOP), and the Revised Interim Operating Plan (RIOP) for releases from Jim Woodruff Lock and Dam.

1.4.2 ALTERNATIVE 1

ResSim Alternative 1 modifies the conditions of the No Action alternative by adding the two proposed reservoirs, Glades and Bear Creek, to the network.

1.4.3 ALTERNATIVE 7

Alternative 7 modifies Alternative 1 by adding the management measures of revised action zones, modified hydroelectric power generation schedules, 4/5 month navigation, and seasonal minimum flow at Peach Tree Creek (summarized in Alternative 2), and then changing the drought operation trigger zone from zone 4 to zone 3.

---

[1] The HEC-ResSim model was revised in 2014, which included creating a new reservoir network that included Bear Creek and Glades Reservoirs. That network was used for all of the alternatives except the No Action Alternative. The operating plans and flows were altered for all alternatives. The HEC-5Q model was updated to incorporate these changes. The results presented in Chapter 4 were produced using the revised HEC-5Q model and revised ResSim flows. Comparison of the 2011 and 2014 model results for the No Action Alternative showed that the water quality differences between the two models were minor. Both models showed approximately equal agreement with the observed data. The flows used to adjust the 2011 HEC-5Q model better represent current and historical conditions under which the observed data were measured. These flows remain the logical choice for adjustment of the HEC-5Q model coefficients. Therefore, the plots in Chapter 3 have not been updated and reflect the 2011 HEC-5Q model comparisons.

1.4.4 PROPOSED ACTION ALTERNATIVE

Under the Proposed Action Alternative (PAA), the Corps would continue to operate projects in the ACF Basin in a balanced manner to achieve all authorized project purposes and would support water supply withdrawals in the river by operating to meet the minimum water quality objective at Peach Tree Creek. The PDT selected Alternative 7 as the recommended alternative.

Table 1.1 Summary of Water Management Alternatives

		Alternatives							
Measures		**NOAction***	**Alt1**	**Alt2**	**Alt3**	**Alt4**	**Alt5**	**Alt6**	**Alt7**
Action Zones	Current	X	X						
	Revised			X	X	X	X	X	X
Hydropower Generation	Current	X	X					X	
	Revised			X	X	X	X		X
Navigation	4/5 Month			X		X	X	X	X
	Tri-Rivers				X				
Basin Inflow	Current	X	X	X	X			X	X
	Florida					X			
	Georgia						X		
Drought Operation Trigger	Composite Storage Zone	4	4	4	4		4	4	3
Drought Operation Suspension	Composite Storage Zone	1	1	1	1		1	3	1
Peach Tree Creek minimum flow	Current	X	X						
	Seasonal Flow			X	X	X	X		X
	Monthly Flow							X	
Flow Target at Chattahoochee	Current	X	X	X	X				X
	Florida					X			
	Georgia						X		
	FWS							X	
Ramping Rate Suspension	Drought	X	X	X	X		X	X	X
	Prolonged Low Flow			X	X			X	X
	Pulse						X		

*NOAction alternative doesn't include Glades and Bear Creek reservoirs. It is based on "2014_Base" network. These reservoirs are included in the "2014" network which is used for all other alternatives.

Table 1.2 Water Supply Withdrawal Options. All flows values are in units of mgd.

Water Supply Option	Lake Lanier relocation (mgd)	Lake Lanier reallocation (mgd)	Lake Lanier total withdrawals (mgd)	Lake Lanier returns (mgd/% returned)	Glades Reservoir withdrawals (mgd)	Glades Reservoir returns (mgd/% returned)	Net withdrawals from Lake Lanier (mgd)	River withdrawals (mgd)	River returns (mgd/% returned
A - No Action	20	108	128	37/29%	0	0	91	277	227/82%
B – Relocation only	20	0	20	10/50%	0	0	10	277	227/82%
H - Projected return volume for 2035 w/Glades pumping	20	165	185	75/40.4%	40	16/40.4%	134	408	384/94%
I – Option H for Lanier w/o Glades, GA 2015 Request Downstream	20	225	225	91/40.4%	0	0	134	379	361/95%
J – Future without project condition	20	20	20	10/50%	0	0	10	379	361/95%
K – GA 2015 Request	20	242	242	104/43.2%	0	0	137.4	379	361/95%
L – Current Lake withdrawals (with GA 2015 downstream withdrawals)	20	128	128	?	0	0	?	379	361/95%
M – Increased Lanier (with GA 2015 downstream withdrawals)	20	185	185	?	0	0	?	379	361/95%

1.4.5 SELECTED STUDY ALTERNATIVES

For final analysis with ResSim and HEC-5Q, water management Alternative 1 was paired with two water supply options (A and L), and water management Alternative 7 was paired with eight water supply options (A, B, H, I, J, K, L, and M). The study alternative naming convention combines the number designating the water management alternative with the letter designating the water supply option. For example, the proposed action alternative, Alternative 7K, combines water management alternative "7" with water supply option "K". This will also be referred to as "Alt 7K" in the water quality plots presented in Chapter 4. The No Action plan and eight study alternatives were simulated by ResSim, and the computed flows were input into HEC-5Q to simulate water quality for each alternative for the period 2001–2011. The study alternatives simulated by HEC-5Q are:

1. Alternative 1A: No Action Alternative (NAA, also known as "Baseline")
2. Alternative 1L
3. Alternative 7A
4. Alternative 7B
5. Alternative 7H
6. Alternative 7I
7. Alternative 7J
8. Alternative 7K: Proposed Action Alternative (PAA)
9. Alternative 7L
10. Alternative 7M

1.5 HYDROLOGIC ANALYSIS PERIODS

To evaluate the effects of the nine operating plans on the water quality of the ACF watershed, three types of hydrologic conditions were selected for analysis. The years 2004, 2005, and 2007 were selected to represent normal, wet, and dry hydrologic conditions. These selections were based on an analysis of observed flow data recorded during the 2001–2011 modeling period. The precipitation in 2004 was the closest to the period-of-record average. The year 2004 corresponded to the median flow levels, while 2005 and 2007 corresponded to the highest and lowest flow levels, respectively, during the 2001–2011 model period. In addition, the 2001–2011 model period was summarized by plotting composite longitudinal river profiles of the percent occurrence of each water quality parameter. These analysis periods are shown in Table 1.3.

Table 1.3 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	2004
Flood (“Wet”)	2005
Drought (“Dry”)	2007
Composite	2001–2011

1.6 REPORT ORGANIZATION

Modifications made to 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 operations 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, 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 ACF 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*[2]
- Point source dissolved organics as Biochemical Oxygen Demand (BOD)
- Non-point source dissolved organics as Biochemical Oxygen Demand (BOD)
- Particulate organic matter (POM) as Total Suspended Solids (TSS)[3]

[2] HEC-5Q uses phytoplankton as a state variable. The relationship between phytoplankton biomass and Chlorophyll *a* (CHLA) is quite variable by speciation, available light and other environmental factors. The HEC-5Q model does not include assumptions of algal speciation. 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 0.009 and 0.05 for phosphorus (P) and nitrogen (N) respectively or CHLA:P and CHLA:N of 0.9 and 5 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.

---

[3] The Total Suspended Solids (TSS) levels recorded at major discharge locations in Alabama and Georgia were predominantly Particulate Organic Matter (POM). A strong relationship was found between TSS and BOD. Although there was some variability, the statistical linear fit was significant. All major discharge sites measured BOD. There were 9 dischargers with flows > 5 MGD and 6 dischargers with flows > 10 MGD. For flows > 5 MGD, 82% of reported measurements (255 out of 311) contained BOD. For flows > 10 MGD, 93% of reported measurements (216 out of 232) had BOD. The remainder of these measurements contained TSS only. Therefore, the TSS:BOD relationship was primarily applied to small discharge sites (flows less than 5 MGD), which have a minor impact on the system.

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, TSS and Dissolved Organic Matter (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, TSS 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.) Therefore, Photosynthesis is 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 TSS is represented by BOD. Therefore, these parameters are not explicitly linked to DO.

Dissolved organics (BOD)

Dissolved organic material represents all materials that exert a biochemical 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 origins to add flexibility in assigning decay rates. It is also a measure of point source influence that considers decay and source quality.

Organic Particulate (TSS)

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

2.1 INTERNAL LOADING AND NUTRIENT DYNAMICS

Internal loading was accounted for in the HEC-5Q model, to a limited degree. For each model element, when the average DO concentration in that element drops below 2.5 mg/L, conditions transition smoothly from aerobic to anaerobic, with corresponding effects on nitrate, ammonia, and phosphorus. It is assumed that nitrogen enters the system as ammonia.

2.2 MODEL REPRESENTATION OF THE PHYSICAL SYSTEM

Reservoirs and rivers comprising the ACF system were represented as a network of reservoirs and streams and discretized into sections, as shown in Figure 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. Area-capacity curves come from ResSim output. Other elements of the geometry (outlets, etc.) were taken from the 1998 HEC-5 model.

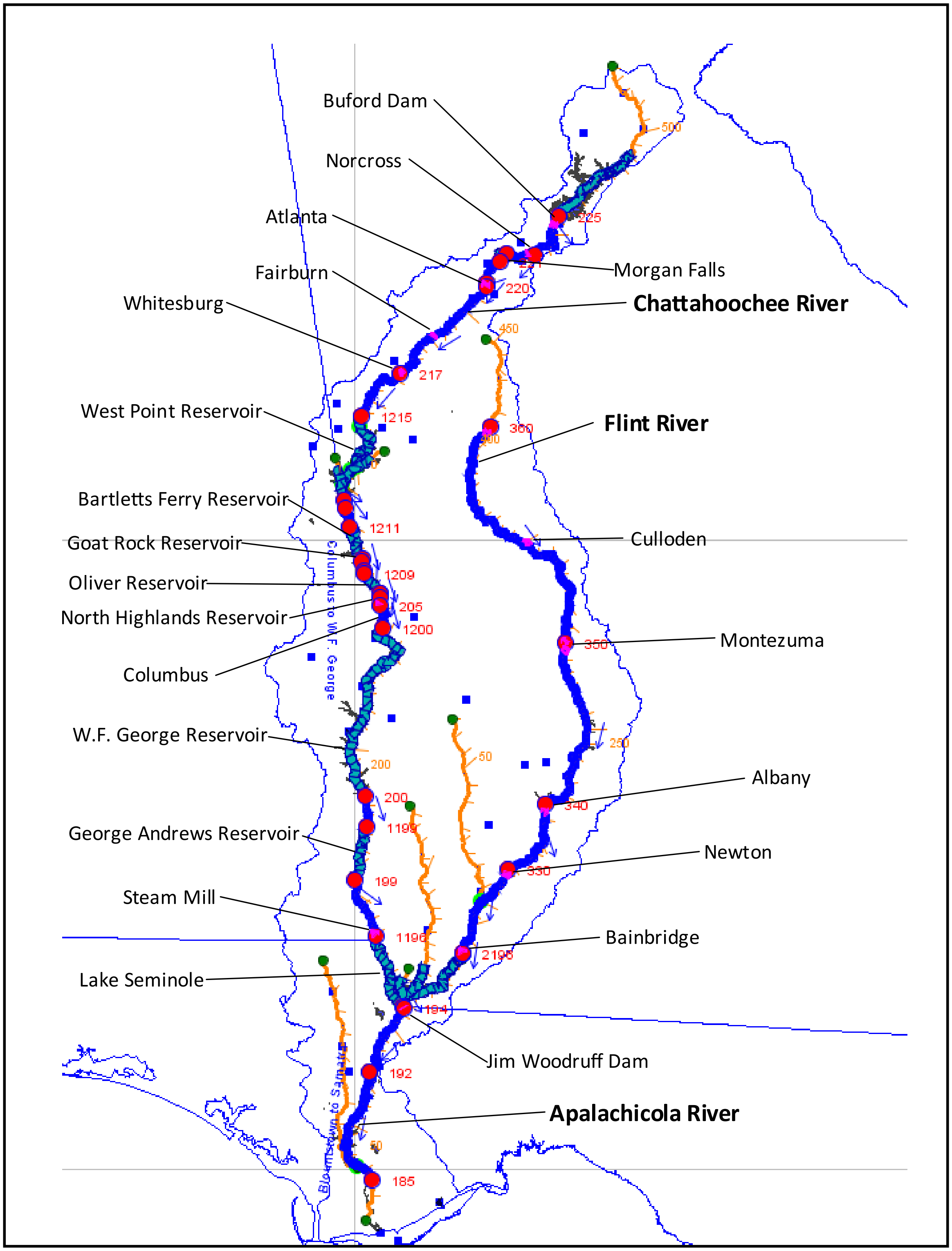


Figure 2.1 HEC-5 and HEC-5Q Model Schematic of ACF Basin. Note: the three straight blue lines indicate the state lines between Alabama, Georgia, and Florida.

2.2.1 MODEL REPRESENTATION OF RESERVOIRS

For water quality simulations, each reservoir was geometrically discretized and represented as either a vertically layered, longitudinally segmented, or a vertically layered and longitudinally segmented water body. Additionally, some of the run-of-the-river reservoirs along the Chattahoochee River extending from Langdale Reservoir to Eagle Reservoir were represented as stream reaches due to the short residence times. The reservoirs on the Flint River above Jim Woodruff were represented in this fashion. None of these small reservoirs and dams is represented in ResSim. A description of the different types of reservoir representation follows. Table 2.1 summarizes the geometric representation of the reservoirs. 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 elements of the geometry (outlets, etc.) were taken from the 1998 model.

Table 2.1 Geometric Representation of the ACF Reservoirs

Reservoir	Vertically Layered	Horizontally Segmented	Vertically Layered and Horizontally Segmented	Layer Thick-ness	# Layers	# Segments
Glades	X			1 m		
Lake Lanier	X			5 ft		
Morgan Falls		X			1	3
Bear Creek	X			1 m		
West Point			X		8	21
Bartletts Ferry			X		5	9
Goat Rock			X		4	3
Oliver			X		4	4
North Highlands			X		4	2
Walter F. George			X		9	30
George Andrews			X		5	8
Lake Seminole			X		8	38

2.2.1.1 Vertically Layered 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 layered reservoir, or layered volume element, 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 layered 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 layered 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).

Lake Lanier, above Buford Dam, Glades Reservoir, and Bear Creek Reservoir are the vertically segmented reservoirs in the ACF model. Lake Lanier is represented by 5-ft layers, while Glades and Bear Reservoirs are represented by one meter (1 m) layers.

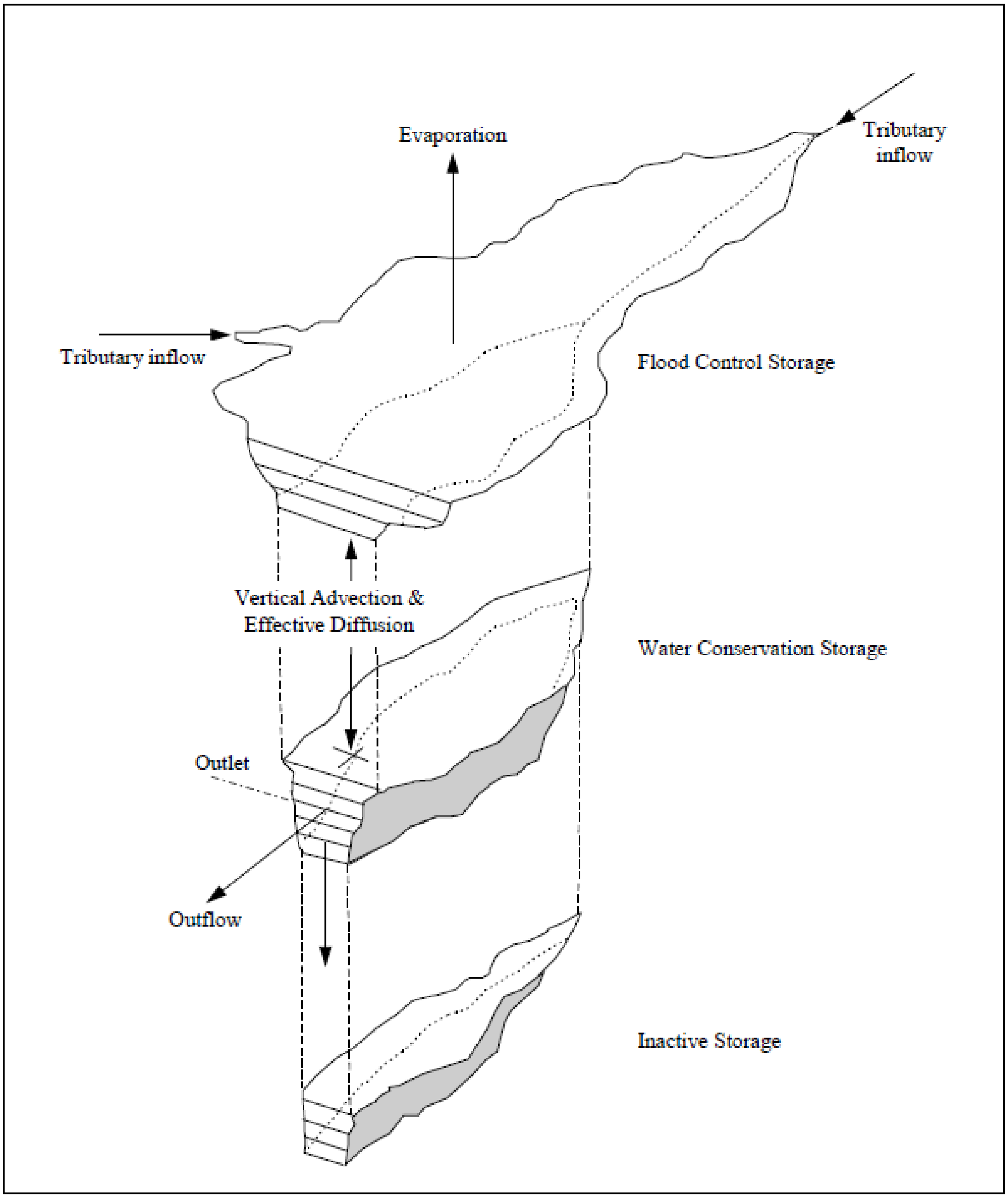


Figure 2.2 Schematic representation of a vertically layered reservoir (HEC, 1986).

2.2.1.2 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.

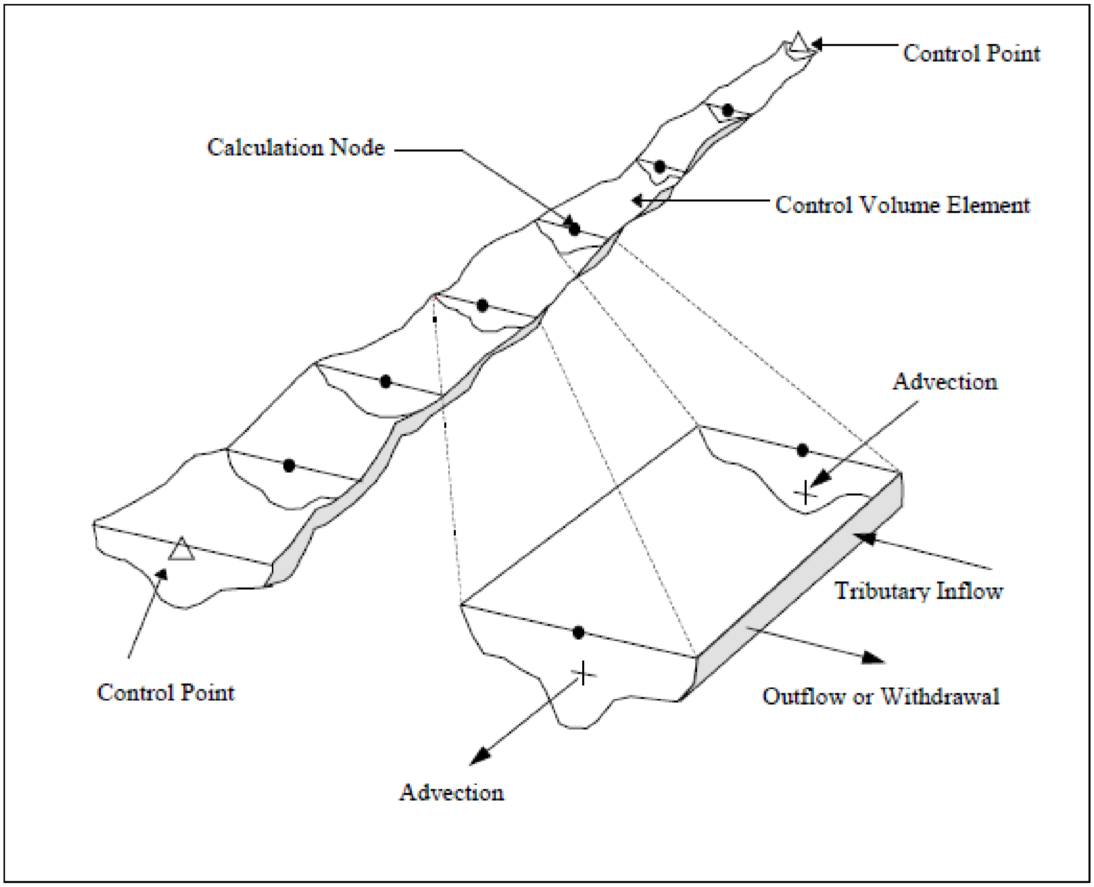


Figure 2.3 Schematic representation of a longitudinally stratified reservoir (HEC, 1986).

2.2.1.3 Vertically Layered and Longitudinally Segmented Reservoirs

Longitudinally segmented reservoirs may be subdivided into vertical elements with each element (layer) assumed fully mixed in the vertical and lateral directions. Branching of reservoirs is allowed. For reservoirs represented as vertically 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 vertically layered and longitudinally segmented reservoirs of the ACF contain up to nine 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 (Bohan, 1973). 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).

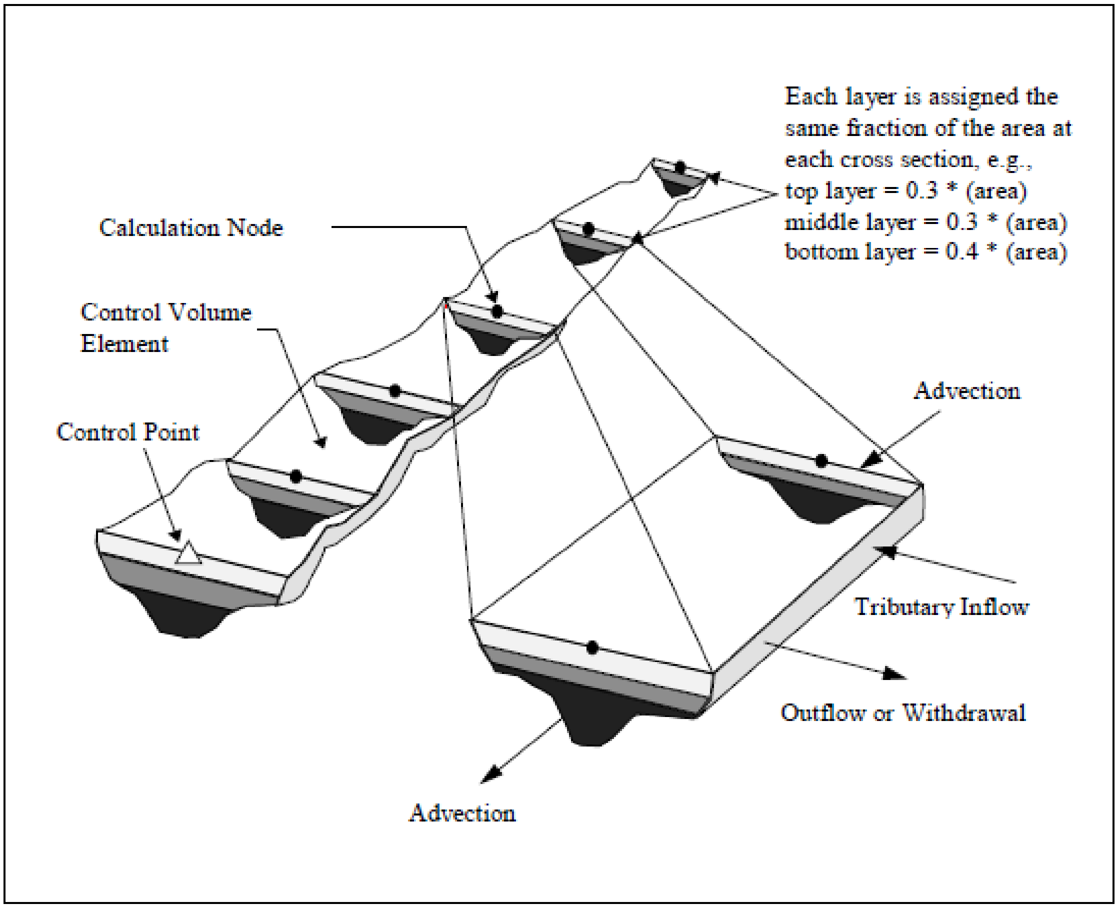


Figure 2.4 Schematic representation of a vertically layered and longitudinally segmented reservoir (HEC, 1986).

2.2.2 MODEL REPRESENTATION OF STREAMS

In HEC-5Q, a reach of a river or stream is represented conceptually as a linear network of segments or layered 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 source (tributary) inflow. The diversion defined by ResSim represents the net point source inflow above the control point. The individual point source 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. Lists of all stream reaches and point and non-point source inflows and water quality are provided in Appendix A in Table 7.1 (Chattahoochee River) and Table 7.2 (Flint River).

2.3 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, which assumes that the observed flows are the best depiction of historical inflow conditions, may result in computed inflows that are negative. Although negative inflows do not present a problem for ResSim, they are a problem from a water quality perspective. The issue is that the inflow quality must be defined, while the negative inflow removes ambient water quality. For example, if a -100 cfs flow is followed by a +100 cfs flow to represent an inflow of near zero, an artificial tributary load is introduced on the day of the +100 cfs flow. To mitigate this effect, the water quality load is computed from an inflow rate that is constrained as positive. Residual negative inflows are accumulated on the falling limb of the hydrograph and then allocated to future positive inflows. 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 (e.g., combined inflow between Buford Dam and Franklin above West Point Reservoir determines the shape of the Norcross tributary flow for defining the water quality load). Aggregation is done when adjacent control points have erratic local flows or when one of the local flows has extensive negative inflows. This constrained flow is then scaled to match the local inflow of the control point. The scaled flows are then allocated to individual tributaries above the control point proportional to tributary inflow as computed by BASINS. An example of 7-day average (with negative flows) and constrained reservoir inflows is provided in Figure 2.5 for Norcross. Since the 7-day average unconstrained flows contain negative flows, the constrained daily flows will often be higher than the 7-day average flows.

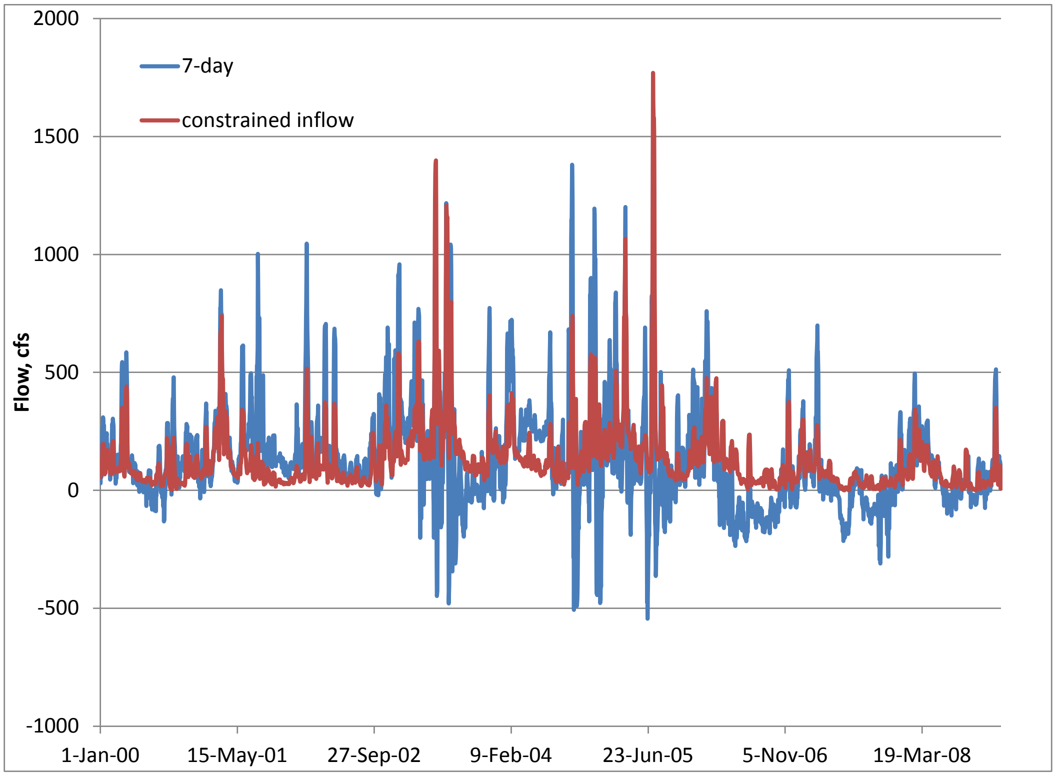


Figure 2.5 Comparison of 7-day average and constrained inflows at Norcross.

2.3.1 NON-POINT SOURCE FLOW AND WATER QUALITY DATA

The non-point source water quality inputs to the HEC-5Q model were developed from observed data in conjunction with BASINS model loadings that were developed during previous ACF 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. BASINS model outputs were produced for three conditions: 1995 land use conditions, anticipated 2020 conditions, and anticipated 2050 conditions. Each of these was calculated using the 1984-1989 precipitation record. The 2020 BASINS model output was used to develop extrapolation functions that relate hydrograph dynamics and ResSim incremental local flows to concentration. The 2020 BASINS model was selected since its time period is currently the closest of the three periods to present day conditions. The extrapolation functions were then applied to the 2001–2011 ResSim flows to generate the non-point-source loadings for input to HEC-5Q. Output for 133 ACF BASINS watersheds was available. These watersheds were consolidated to define 73 non-point source inflows for the current HEC-5Q modeling effort. The watersheds/stream names and corresponding stream / inflow locations are listed in Appendix A.

The HEC-5Q model of the ACF was designed to utilize flows computed by ResSim for the 1939–2011 period of record. The tributary flows and water quality computed by

BASINS for the 1984–1989 period served two purposes: 1) as a basis for estimating the response of water quality parameters to tributary stream flow dynamics, and 2) for extrapolating a comparable record for the 1939–2011 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:

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

1. C = Concentration
2. C_o = Minimum concentration
3. K_2 = Scaling factor
4. 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.

The concentrations of each parameter were then scaled to the average concentration for each tributary. The scaling factors developed from the analysis of the 1984–1989 period were applied to the entire 1939–2011 period.

Water quality field data for five tributaries to each of the Chattahoochee and Flint Rivers were compared with the BASINS-based water quality for the 2001–2011 period. The fraction of total nitrogen allocated to nitrate and ammonia was based on these observations.

Selected tributaries to the Chattahoochee River:

- Peachtree Creek (5)[4]
- Sweetwater Creek (6)
- Yellow Jacket Creek (14)
- Long Cane Creek (17)
- Pataula Creek (33)

Selected tributaries to the Flint River:

- Line Creek (39)
- Potato Creek (45)
- Patsiliga Creek (49)
- Muckalee Creek (60)
- Ichawaynochaway Creek (64)

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

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
- TEMP: Temperature
- TOC: Total Organic Carbon
- Chlorophyll *a* [5]

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 preponderance of data is for creeks tributary to the Chattahoochee River. The sample weighted averages for the eight tributaries is also included. 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 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 non-point source inputs to the model are provided in Table 2.3. Full tables of maximum, minimum and average values can be found in the Appendix A in Table 7.1.

.

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

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 (mg/L)	Temp. (deg C)	Chlorophyll *a* (ug/L)
	Ichawaynochaway Creek at State Road 91 near Newton, Ga.							
samples	12	19	12	12	12	12	19	0
avg	0.958	8.679	0.054	0.708	0.022	4.083	19.305	
min	0.400	6.700	0.020	0.400	0.020	1.000	7.000	
max	1.400	12.800	0.110	1.000	0.030	12.000	29.200	
median	0.800	7.900	0.050	0.700	0.020	2.000	20.800	
median/avg	0.835	0.910	0.923	0.988	0.923	0.490	1.077	
	Line Creek at State Road 16 near Digbey, Ga.							
samples	47	73	47	47	47	46	74	0
avg	1.779	7.905	0.066	0.466	0.138	9.817	16.634	
min	0.800	4.400	0.020	0.080	0.020	1.000	3.100	
max	2.100	12.500	0.380	1.100	0.370	38.000	26.600	
median	2.000	7.530	0.050	0.400	0.110	7.000	15.800	
median/avg	1.124	0.953	0.755	0.859	0.795	0.713	0.950	
	Long Cane Creek at State Road 50 near Georgetown, Ga.							
samples	48	76	48	47	48	48	76	0
avg	1.846	7.921	0.051	0.147	0.049	11.433	17.447	
min	0.600	4.800	0.020	0.020	0.020	1.000	3.290	
max	3.600	13.570	0.150	0.560	0.120	71.000	26.800	
median	2.000	7.420	0.030	0.120	0.050	6.300	18.200	
median/avg	1.084	0.937	0.584	0.819	1.013	0.551	1.043	
	Muckalee Creekat State Road 195 near Leesburg, Ga.							
samples	12	20	12	12	12	12	20	0
avg	0.850	7.635	0.055	0.442	0.065	5.333	18.255	
min	0.500	5.700	0.020	0.200	0.020	2.000	4.300	
max	1.300	10.600	0.090	0.900	0.130	14.000	26.400	
median	0.800	7.600	0.050	0.400	0.060	4.000	18.500	
median/avg	0.941	0.995	0.909	0.906	0.923	0.750	1.013	
	Pataula Creek at State Road 50 near Georgetown, Ga.							
samples	24	41	24	24	24	24	0	0
avg	1.495	8.960	0.039	0.109	0.034	8.779		
min	0.300	6.990	0.010	0.020	0.020	3.000		
max	5.000	12.400	0.090	0.200	0.160	28.000		
median	1.260	8.910	0.030	0.100	0.020	8.000		
median/avg	0.843	0.994	0.774	0.916	0.593	0.911		
	Patsiliga Creek (CR 128) near Reynolds, Ga.							
samples	10	19	11	11	11	11	19	0
avg	1.020	8.347	0.063	0.109	0.024	8.909	17.516	
min	0.600	6.200	0.030	0.100	0.020	2.000	6.500	
max	1.400	10.700	0.100	0.200	0.040	20.000	24.400	
median	1.100	8.100	0.060	0.100	0.020	7.000	17.900	
median/avg	1.078	0.970	0.957	0.917	0.846	0.786	1.022	

Table 2.2 Concluded

	BOD5U (mg/L)	Oxygen (mg/L)	NH3-N (mg/L)	NO2+NO3-N (mg/L)	Total P (mg/L)	TSS (mg/L)	Temp. (deg C)	Chlorophyll *a* (ug/L)
	Peachtree Creek at Northside Drive near Atlanta, Ga.							
samples	106	159	110	110	105	106	161	0
avg	2.387	8.531	0.080	0.527	0.070	24.116	17.519	
min	2.000	4.580	0.030	0.120	0.020	1.000	2.900	
max	7.700	14.650	0.740	1.100	0.530	300.000	27.710	
median	2.000	8.210	0.050	0.500	0.050	5.400	18.380	
median/avg	0.838	0.962	0.623	0.948	0.710	0.224	1.049	
	Potato Creek at State Road 74 near Thomaston, Ga.							
samples	12	20	12	12	12	12	20	0
avg	2.633	8.310	0.072	0.160	0.034	12.417	17.825	
min	0.700	4.900	0.040	0.020	0.020	4.000	5.000	
max	9.100	12.100	0.130	0.400	0.090	46.000	27.200	
median	1.500	7.800	0.060	0.100	0.030	7.000	15.800	
median/avg	0.570	0.939	0.837	0.625	0.878	0.564	0.886	
	Sweetwater Creek at Interstate Highway 20							
samples	106	160	110	110	104	106	161	0
avg	2.053	8.026	0.049	0.252	0.043	17.529	17.331	
min	2.000	4.730	0.030	0.030	0.020	1.000	2.580	
max	3.500	14.290	0.260	0.990	0.200	190.000	31.730	
median	2.000	7.620	0.040	0.260	0.030	8.000	18.130	
median/avg	0.974	0.949	0.813	1.031	0.699	0.456	1.046	
	Yellow Jacket Creek at Hammet Road near Hogansville, GA							
samples	102	173	89	98	98	96	173	20
avg	1.680	8.887	0.051	0.122	0.029	16.729	17.259	3.200
min	0.100	6.240	0.030	0.020	0.020	1.000	2.400	0.900
max	8.100	12.810	0.600	0.340	0.120	280.000	31.260	19.400
median	2.000	8.510	0.030	0.120	0.020	7.300	18.300	1.900
median/avg	1.191	0.958	0.589	0.980	0.692	0.436	1.060	0.594
	Sample Weighted							
samples	479	760	475	483	473	473	723	20
avg	1.907	8.377	0.059	0.302	0.055	16.049	17.392	3.200
min	1.113	5.256	0.027	0.067	0.020	1.226	3.070	0.900
max	5.346	13.401	0.412	0.778	0.251	181.252	29.147	19.400
median	1.871	8.010	0.041	0.285	0.042	6.703	18.005	1.900
median/avg	0.981	0.956	0.700	0.943	0.765	0.418	1.035	0.594

Table 2.3 Average, maximum and minimum flow and water quality inputs to the Chattahoochee River.

Stream Name	Flow	Temp	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM2 (BOD)	TSS (org)
	cfs	C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Chattahoochee River	1453	15.5	0.17	0.02	1.65	0.04	8.8	3	1.6
Swannee Creek	185	16.5	0.25	0.04	1.65	0.06	8.6	3.4	3.2
Big Creek	200	16.5	0.33	0.06	1.65	0.07	8.6	3.7	4.2
Sope Creek	141	16.5	0.55	0.13	1.65	0.12	8.6	5.3	8.1
Nancy and Peachtree Creek	311	16.5	0.46	0.1	1.65	0.1	8.6	4.5	6.3
Utoy Creek	396	16.5	0.38	0.08	1.65	0.08	8.6	4.1	5.3
Camp Creek	111	16.5	0.31	0.06	1.65	0.07	8.6	3.6	4.1
Bear Creek	84	16.5	0.23	0.03	1.65	0.05	8.6	3.2	2.4
Snake Creek	172	16.5	0.26	0.04	1.65	0.06	8.6	3.2	2.7
Chattahoochee: misc.trib-1	90	16.5	0.31	0.05	1.65	0.07	8.6	3.3	3
Centralhatchee Creek	27	16.5	0.32	0.05	1.65	0.07	8.6	3.2	2.6
Hillabatchee Creek	61	16.5	0.23	0.03	1.65	0.05	8.6	3.1	1.9
New River	140	16.5	0.26	0.03	1.65	0.05	8.6	3.2	2.2
Yellowjacket Creek	144	16.5	0.25	0.03	1.65	0.05	8.6	3.2	2.1
Wehadkee Creek	120	16.5	0.25	0.03	1.65	0.05	8.6	3.1	1.9
Oseligee Creek	345	16.5	0.22	0.02	1.65	0.04	8.6	3.1	1.8
Long Cane Creek	70	16.5	0.25	0.04	1.65	0.05	8.6	3.3	2.7
Flat Shoal Creek	243	16.5	0.22	0.02	1.65	0.04	8.6	3.2	2
Mountain Creek	162	16.5	0.21	0.02	1.65	0.04	8.6	3.1	1.8
Halawakee Creek	87	16.5	0.22	0.02	1.65	0.04	8.6	3.2	2
Mulberry Creek	312	16.5	0.21	0.02	1.65	0.04	8.6	3.2	2
Standing Boy Creek	31	16.5	0.21	0.02	1.65	0.04	8.6	3.1	2
Chattahoochee: misc.trib-2	88	16.5	0.3	0.05	1.65	0.07	8.6	3.5	3.4
Chattahoochee: misc.trib-3	68	16.5	0.37	0.07	1.65	0.08	8.6	4.2	5.1
Bull Creek	62	16.5	0.33	0.06	1.65	0.07	8.6	3.9	4.3
Upatoi Creek	301	16.5	0.28	0.05	1.65	0.06	8.6	3.7	3.8
Uchee Creek	207	16.5	0.24	0.03	1.65	0.05	8.6	3.2	2.4
Hichitee Creek	75	16.5	0.24	0.04	1.65	0.05	8.6	3.4	3
Hannahatchee Creek	175	16.5	0.22	0.04	1.65	0.05	8.6	3.4	2.9
Grass Creek	54	16.5	0.3	0.05	1.65	0.07	8.6	3.5	3.3
Cowikee Creek	353	16.5	0.24	0.04	1.65	0.05	8.6	3.4	3
Barbour Creek	128	16.5	0.25	0.04	1.65	0.06	8.6	3.4	3
Pataula Creek	367	16.5	0.26	0.05	1.65	0.06	8.6	3.5	3.2
Cemochechobee Creek	81	16.5	0.21	0.03	1.65	0.05	8.6	3.2	2.2

Table 2.3 Concluded

Stream Name	Flow	Temp	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM2 (BOD)	TSS (org)
	cfs	C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Kolomoki Creek	178	16.5	0.3	0.04	1.65	0.07	8.6	3.2	2.3
Sandy Creek	201	16.5	0.25	0.03	1.65	0.06	8.6	3.2	2.1
Omusee Creek	260	16.5	0.34	0.04	1.65	0.08	8.6	3.2	2.2
Sawhatchee Creek	67	16.5	0.27	0.05	1.65	0.06	8.6	3.4	3.5
Chattahoochee: misc.trib-4	635	16.5	0.29	0.02	1.65	0.07	8.6	3.1	2.1
Flint R.	286	16.5	0.31	0.04	1.65	0.07	8.6	3.1	2.4
Line Creek	157	16.5	0.18	0.02	1.65	0.04	8.6	3	1.6
White Oak Creek	194	16.5	0.18	0.02	1.65	0.04	8.6	3	1.5
Red Oak Creek	211	16.5	0.18	0.02	1.65	0.04	8.6	3	1.4
Elkins Creek	164	16.5	0.17	0.02	1.65	0.04	8.6	3	1.6
Pigeon Creek	102	16.5	0.16	0.02	1.65	0.03	8.6	3	1.6
Lazer Creek	192	16.5	0.19	0.02	1.65	0.04	8.6	3	1.7
Potato Creek	261	16.5	0.17	0.02	1.65	0.04	8.6	3	1.6
Swift Creek	218	6.5	0.17	0.02	1.65	0.04	8.6	3	1.8
Ulcohatchee Creek	171	16.5	0.21	0.03	1.65	0.05	8.6	3.1	2.2
Patsiliga Creek	271	16.5	0.23	0.02	1.65	0.05	8.6	3.1	2.1
Horse and Toteover Creek	93	16.5	0.17	0.02	1.65	0.04	8.6	3	1.7
Whitewater Creek	153	16.5	0.18	0.02	1.65	0.04	8.6	3	2
Montezuma WWTP	80	16.5	0.32	0.05	1.65	0.07	8.6	3.2	2.6
Buck Creek	127	6.5	0.31	0.03	1.65	0.07	8.6	3	2
Camp Creek	178	16.5	0.34	0.03	1.65	0.07	8.6	3	2.1
Turkey Creek	157	16.5	0.28	0.02	1.65	0.06	8.6	3	1.7
Lime Creek	39	16.5	0.4	0.05	1.65	0.09	8.6	3.1	2.2
Gum Creek	230	16.5	0.4	0.05	1.65	0.08	8.6	3	2
Swift Creek	123	16.5	0.38	0.05	1.65	0.08	8.6	3.1	2.2
Jones Creek	105	6.5	0.32	0.04	1.65	0.07	8.6	3.1	2.6
Abrams Creek	94	16.5	0.44	0.07	1.65	0.09	8.6	3.3	3.2
Piney Woods Creek	178	6.5	0.25	0.03	1.65	0.06	8.6	3.1	2.2
Kinchafoonee Creek	676	16.5	0.43	0.07	1.65	0.09	8.6	3.5	3.8
Dry Creek	190	6.5	0.37	0.04	1.65	0.08	8.6	3	1.9
Racoon Creek	178	16.5	0.23	0.02	1.65	0.05	8.6	3	1.6
Cooleewahee Creek	101	6.5	0.2	0.02	1.65	0.05	8.6	3	1.7
Ichawaynochaway Creek	1121	6.5	0.26	0.02	1.65	0.06	8.6	3	1.9
Flint: misc.trib-1	239	16.5	0.26	0.03	1.65	0.06	8.6	3.3	2.8

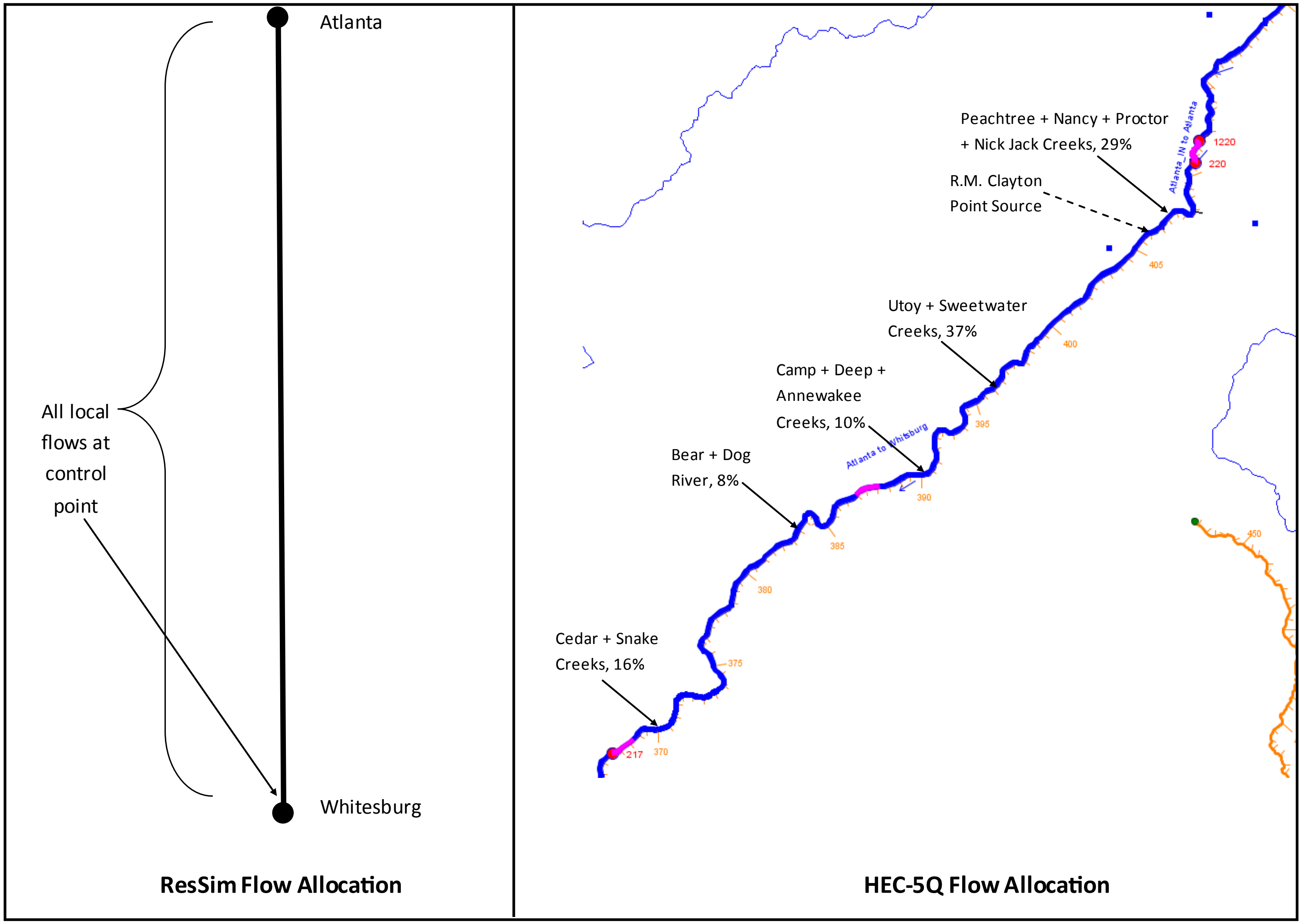


Figure 2.6 Example comparison between ResSim and HEC-5Q flow allocation.

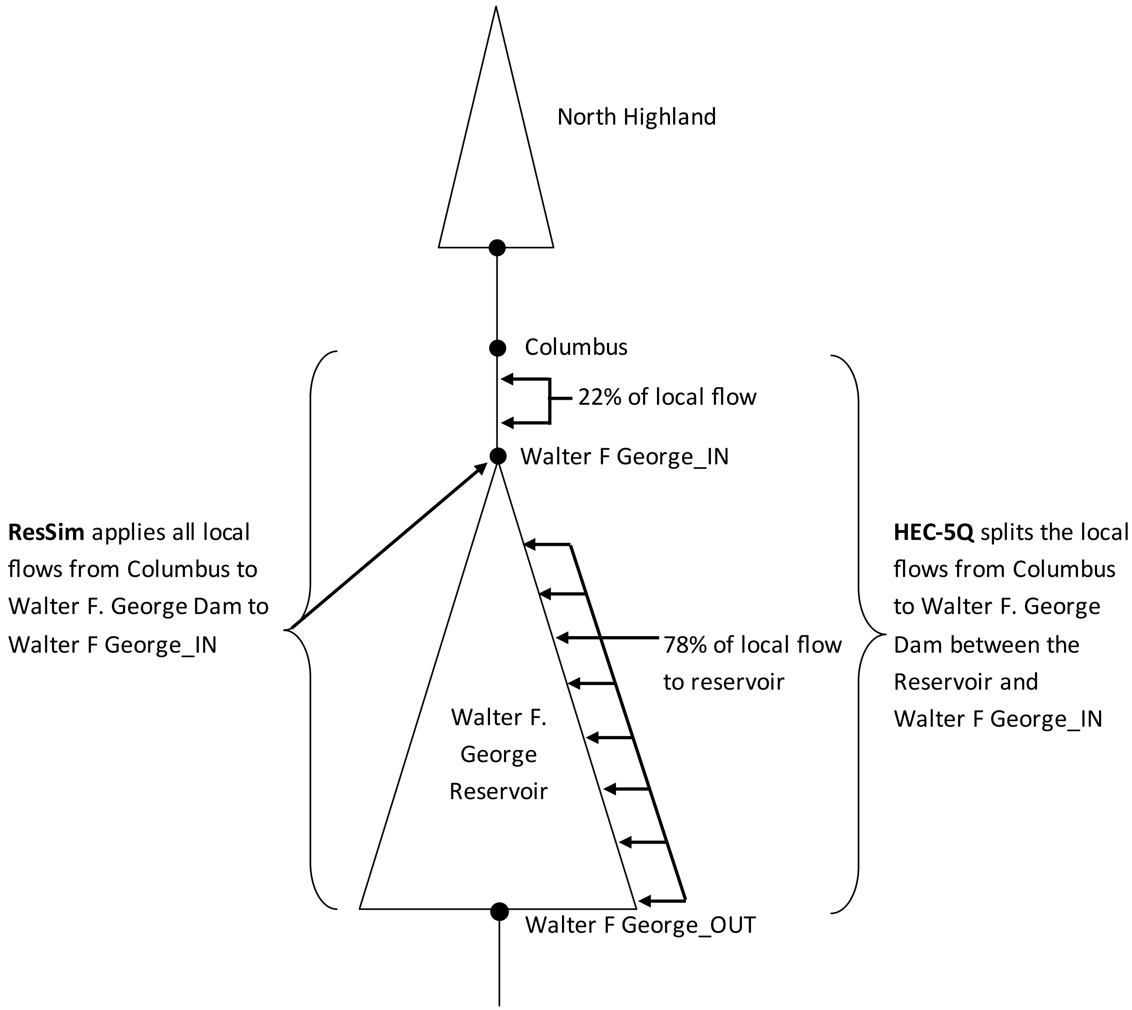


Figure 2.7 Illustration of ResSim versus HEC-5Q flow allocation at W.F. George Reservoir.

2.3.2 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 2001–2011 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[6].

- 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 5 mg/L for BOD < 10 mg/L to 2 mg/L for BOD > 50 mg/L was specified. Linear interpolation was used between these values.

- 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.

For DOM, either BOD or TSS data were generally available and so DOM was calculated from Uninhibited BOD as (BOD*2.5). For municipal dischargers, BOD was estimated as the equivalent of TSS. For industrial loads, the TSS to BOD ratio is 2 to 1. This ratio was based on correlations developed from discharge data where both parameters were available.

---

[6] Tables of the default loadings are available upon request.

Average point source inputs are summarized in Table 2.4. Inputs marked with a "*" were developed from 2000–2008 monitoring data. Data were averaged by month; for example, for each source, data for January of all years were averaged and applied to the model for January of each year. Those marked with "**" were also developed using this method, but data were very limited. The table values for "*" and "**" are the average of the 12 monthly values. An example of the actual monthly inputs for R. M. Clayton is provided in Table 2.5. Full tables of maximum, minimum and average values can be found in the appendix in Table 7.1 (Appendix A). Inputs marked with a "#" were updated based on most recent monitoring data because previous values appeared unrealistic. All other inputs are either default values or are referenced to values produced by an earlier analysis by the EIS team using the PIPES model. Some of the point inflows that were in the 1998 version of the model have been removed because their impacts were already included in the tributaries, and were therefore being double accounted. The impact of eliminating these sources was minimal, with a change on the order of 1%. The average, maximum and minimum concentrations are also summarized in Table 7.1 and Table 7.2 in Appendix A.

Table 2.4 Summary of point source inflow and quality.

CP - Location	flow (mgd)	NO3-N (mg/L)	total P (mg/L)	NH3-N (mg/L)	DO (mg/L)	5-day BOD (mg/L)	TSS (mg/L)
76 - GAINESVILLE FLAT CREEK	9.18*	10	0.28*	1.5	6.56*	4	3.47*
78 - FULTON COUNTY - CAULEY	4.28*	10	0.09*	0.20*	7.17*	3	3.08*
80 - FULTON COUNTY - JOHNS CR	5.97*	10	0.58*	1.17*	6.20*	6	7.28*
81 - FULTON CO. BIG CREEK WPCP	21.80*	10	0.46*	0.83*	6.06*	2	1.39*
83 - RM CLAYTON WPCP / MI = 407	78.49*	10	0.22*	0.86*	7.37*	4	3.75*
84 - ATLANTA SOUTH RIVER	31.95*	10	0.29*	0.58*	6.71*	3	2.67*
85 - ATLANTA CREEK WPCP / MI = 400	27.81*	10	0.18*	0.20*	6.75*	4	3.68*
86 - COBB COUNTY - SUTTON WPCP	30.86*	10	0.33*	0.43*	7.20*	2	2.21*
87 - SOUTH COBB WPCP / MILE = 403	23.57*	10	0.37*	1.13*	8.08*	7	6.95*
89 - DOUGLASVILLE DOUGLAS COU	1.46*	10	0.42*	1.29*	7.33*	4.83*	6.60*
90 - CAMP CREEK WPCP / MI = 392	14.22*	10	0.25*	2.77*	7.25*	5	5.07*
92 - LA GRANGE WPCP / MI = 302	5.72*	10	0.51*	0.08*	6.74*	3	2.90*
93 - COLUMBUS G42101	30.19*	10	2.24*	2.97*	7.31*	10	10.81*
94 - WEST POINT	0.65*	10	0.62*	2.58*	5.98*	10.92*	10.76*
95 - COLUMBUS - FORT BENNING	1.73*	1	8.12*	12.63*	3.48*	21.47*	20.35*
96 - EAST ALABAMA WWTP / MI = 300	2.49*	5.81*	1.73*	2.09*	4.45*	3.61*	16.17*
97 - LANETT WWTP / MI = 310	2.48*	10	0.7	0.59*	7.33*	2.70*	7.73*
98 - MEAD COATED BOARD / MI = 225	24.07*	0.26#	0.12#	5	0.91#	4.89*	11.10*
99 - EUFAULA WWTP / MILE = 218 (NO DATA) - USE LANETT WQ	2.48*	10	0.7	0.59*	7.33*	2.70*	7.73*
100 - PHENIX CITY (NO DATA) USE EAST ALABAMA WWTP	2.49*	5.81	1.73	2.09	4.45	3.61	16.17
105 – GRIFFIN	1.35*	10	1.77*	1.85*	7.18*	6.12*	7.51*
112 - ALBANY - JOSHUA ST	18.12*	10	0.99*	1.21*	6.17*	6.18*	7.61*
114 - DECATUR COUNTY INDUSTRIAL	0.55*	6.4#	0.45*	0.31*	3.67*	3.85*	4.22*
115 - MERC & CO.	1.34*	2.0#	5.1#	20.2#	2	57.95*	140.10*
116 - BAINBRIDGE WWTP / MILE = 148	1.12*	10	0.97*	7.65*	7.02*	10.53*	10.59*
117 - BLAKELY WPCP	1.17*	10	1.01*	0.48*	7.04*	3.80*	5.67*
118 - FLORIDA STATE HOSPITAL (OLD DATA)	0.62	10	0.7	1	5	5	5
119 - MONTEZUMA WWTP	0.84*	10	2.47*	0.73*	5.26*	22.39*	22.92*
120 - LOCKHEED	1.66*	8.6#	0.27*	0.03#	7.93*	2.87*	3
121 - FARLEY NUCLEAR PLANT	83.99*	0.5#	0.15#	0.2	5	4	4
124 - MILLER BREWERIES	1.86*	27.7#	7.2#	0.71#	7.24*	20.17*	10.48*
125 - OPELIKA EASTSIDE WWTP	0.69*	9.52*	9.24*	2.03*	7.90*	4	4.21*
126 - SOUTHERN POWER COMPANY	1.63*	4.7**	0.1**	0.6**	5	5	5.1#
127 - GREAT SOUTHERN PAPER CO.	47.31*	1	0.3	4	5	24.94*	30.98*

*Monthly averages used – overall average is listed
**Monthly averages of limited data used – overall average is listed
Based on most recent monitoring data
All other values default or referenced to original PIPES data

Table 2.5 Example monthly flow and water quality values for R. M. Clayton.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
Flow (mgd)	80.2	83.7	83.2	80.2	78.7	80.0	80.3	77.7	76.2	72.3	74.6	74.8	78.5
Total P, mg/L	0.270	0.277	0.181	0.205	0.181	0.211	0.194	0.227	0.187	0.194	0.227	0.239	0.217
NH3-N, mg/L	1.600	1.627	1.388	1.131	0.854	0.592	0.366	0.267	0.255	0.643	0.810	0.831	0.864
DO, mg/L	7.7	7.8	8.0	7.0	7.5	7.3	7.2	7.1	7.2	7.4	7.2	7.2	7.4
BOD5U/TSS, mg/L	4.85	5.08	3.76	4.47	2.84	3.28	3.19	3.29	3.26	3.08	4.45	3.46	3.75

2.3.3 METEOROLOGICAL DATA AND TRIBUTARY WATER TEMPERATURES

2.3.3.1 Water Quality Monitoring

Water quality in the ACF Basin is monitored by a number of federal, state, and local agencies as well as by industries for compliance with standards. Table 2.4 summarizes water quality conditions along the main-stem rivers in the ACF Basin using data collected by the states of Alabama, Georgia, and Florida as part of their monitoring efforts. States use their monitoring data to make decisions about violations of water quality standards. These data were used in this EIS to develop the HEC-5Q water quality model of the ACF Basin.

2.3.4 HISTORICAL METEOROLOGICAL DATA AND TRIBUTARY WATER TEMPERATURES

Meteorological data were developed for a five year period (1984–1989) during a previous effort using three-hour observations of wind speed, cloud cover, air temperature and dew point (or wet bulb) temperature. These data were provided for Class A National Weather Service (NWS) stations throughout the ACF watershed. Daily average equilibrium temperature, heat exchange rate, wind speed and solar radiation were computed for nine data zones for model input. 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 ACF 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, six-hour heat exchange inputs are generated from short interval air temperature, relative humidity, wind speed and solar radiation. However, because sufficient one-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. The exchange rate was downscaled such that the 24-hour and six-hour data produced the same end of day computed water temperature.

The current effort requires a water quality model that is capable of simulating part or all of the 1939–2011 hydrologic period. Detailed meteorological data of the type required to compute model inputs do not exist for the entire period.

Extrapolation of model inputs for the 2001–2011 study period was based on 2000–2011 National Weather Service (NWS) daily maximum and minimum air temperature 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 1984–1988 record. As an example, data with the best match of the temperature extremes and precipitation within two calendar days before or after the NWS calendar date could be selected. Thus up to seven days from each of the five years of model input data (a total of 35 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 four meteorological zones in the ACF basin were used to compute water temperatures in tributary streams in each basin, as shown in Table 2.6. Water temperatures were approximated based on an equilibrium temperature assumption, i.e., the water temperature at which the net heat flux across the air-water interface is zero.

Table 2.6. Meteorological data sources for the ACF basin

Met Zone	River	Latitude of Met data application	Met station data source (specified by location)
1	Apalachicola River	up to 30.6°	Average of Tallahassee, FL and Columbus, GA
2	Chattahoochee and Flint Rivers	up to Latitude 31.5°	Montgomery, AL
3	Chattahoochee and Flint Rivers	Latitude 31.5° to 33.2°	Columbus, GA
4	Chattahoochee and Flint Rivers	Latitude 33.2° and above	Atlanta, GA

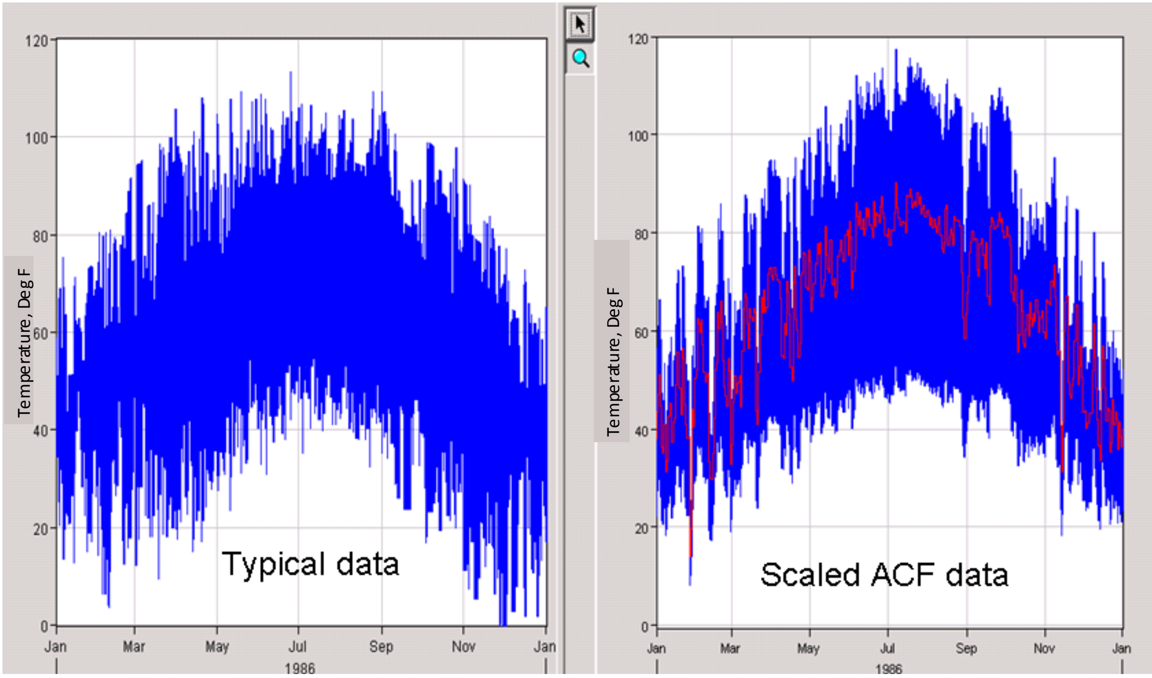


Figure 2.8 Typical and downscaled 6-hour equilibrium temperature (red line is the 24-hour data).

2.4 WATER QUALITY SIMULATIONS

Water quality simulations were performed using a six hour time step, with a 5-year simulation period for each of the demand levels specified, i.e., 1995, 2020, and 2050. The results were reported as daily averages. For each 5-year simulation, 1984–1988 meteorological and hydrologic data were used together with the point and non-point source data described previously. The following water quality constituents were simulated:

The following parameters were simulated for the ACF basin:

- Water temperature
- Dissolved oxygen (DO)
- 5-Day Uninhibited carbonaceous BOD (BOD5U)
- Nitrate as Nitrogen (NO_3-N)
- Ammonia as Nitrogen (NH_3-N)
- Phosphate as Phosphorous (PO_3-P)
- Municipal and Industrial Wastewater as Percent of Flow
- Phytoplankton reported as Chlorophyll *a*

2.4.1 CLIMATE CHANGE

The HEC-5Q ACF model was used to simulate water quality for the Proposed Action Alternative using climate-change-projected flows and air temperatures for three sets of hydrologic conditions. Projected incremental local flows were derived by the USACE Institute of Water Resources (IWR, 2014). The IWR climate analysis included a set of readily available hydrologic projection data developed by USACE in cooperation with the National Center for Atmospheric Research (NCAR), as well as utilizing and leveraging cooperative analysis performed with the Department of Interior Bureau of Reclamation and US Geological Survey, Lawrence Livermore National Laboratory, Santa Clara University, Climate Central, and Scripps Institution of Oceanography. The hydrologic projections utilized numerical model outputs from the Coupled Model Intercomparison Project, phase 5 (CMIP5) organized by the World Meteorological Organization.

Climate change impacts were projected for two time periods: 2021–2050 and 2060–2090. Delta values were calculated relative to the equivalent 30 year antecedent period 1970–1999. The comparison of projections to modeled antecedent conditions was the basis for assessing the impacts of the potential future hydrologic conditions of the ACF. The 10^{th}, 50^{th}, and 90^{th} (Q1, Q2, and Q3) quantiles were selected as analogs for the "Dry", "Median", and "Wet" hydrologic conditions for each future time period. Monthly scaling factors were developed for each month, each quantile, and each future time period. Therefore, six different monthly scaling factors were applied to the unimpaired incremental local flows (1978–2008) to estimate the climate change flows. Further details can be found in IWR (2014).

The 2021–2050 period was selected for analysis of the Proposed Action Alternative with HEC-ResSim and HEC-5Q. The ResSim ACF model was computed using the incremental local flows derived for the three hydrologic conditions (Q1, Q2, and Q3) for this period. These three scenarios are referred to as Dry (2050-Q1), Avg (2050-Q2), and Wet (2050-Q3). Climate model air temperature projections for the ACF were taken from the corresponding climate model output.

The input meteorological data set for the HEC-5Q ACF model was derived using an extrapolation procedure. For each climate scenario, the climate-change-projected air temperature for that day was used to locate the most similar record from the 1984–1988 period. The meteorology from that record was then used as input to the HEC-5Q ACF model. The rationale for this approach is that the meteorology can be characterized by the air temperature extremes. Through this process, different days are generally selected for the historical and climate change conditions.

This process results in a meteorological record that does not represent a uniform temperature increment. Many climate change studies suggest that future meteorological conditions will become more varied with larger extremes. This extrapolation approach adds variability (noise) to the model input data.

This climate change analysis did not use projected changes in radiation budget and wind forcing that could be associated with climate change. Full-scale climate modeling, analyzing multiple possible scenarios, may better characterize the overall response of water quality to the expected composite change in forcings in each of several scenarios.

3 DEMONSTRATION OF MODEL PERFORMANCE

Extensive comparison of modeled and observed time series (streams) and profiles (reservoirs) was performed on the HEC-5Q ACF model. Since ResSim flows differ from actual historical flows, this comparison is not referred to as model validation, but it represents the same process. In addition, a model sensitivity analysis was performed, as detailed in Appendix B. For model performance demonstration, the point source and non-point source water quality described in section 2.3 was assumed. Constituents chosen for presentation of model demonstration results include temperature, dissolved oxygen (DO), 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 3.21. Computed and observed temperature and DO profiles are provided for Lake Lanier (Buford), West Point Reservoir and W. F. George Reservoir. Observed data are available at mid-lake and forebay locations in each reservoir. Profiles are primarily provided for the years 2004, 2005, 2006 and 2007. Each figure contains six profiles. The year 2004 (“normal” hydrology) and 2006 figures begin with the first available profile (April) to demonstrate the stratification progression. The year 2007 (“dry” hydrology) figures end with the last available profile to demonstrate the stratification progression beyond September. Dissolved oxygen plots follow the temperature plots by reservoir to facilitate comparison of DO with temperature stratification.

For the 1-D vertically segmented reservoirs, 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. Lake Lanier was the only 1-D vertically segmented reservoir in the HEC-5Q model of the ACF.

For longitudinally segmented reservoirs, West Point and Walter F. George, 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.

Figure 3.1 through Figure 3.3 show the computed and observed temperature profiles for Lake Lanier (Buford). Computed temperatures tend to be slightly higher than observed in the hypolimnion, but otherwise the model does an excellent job of representing the seasonal progression of thermal stratification seen in the observed data.

Computed and observed DO profiles in Lake Lanier are plotted in Figure 3.4 through Figure 3.6. Observed data show large DO differences between the two observation locations. The two surface concentrations and model surface concentration are comparable at all times. Several plots exhibit characteristics of phytoplankton production and respiration. The July plot of Figure 3.4 shows two distinctly different observed profiles. The DO suppression at elevation 1,040' is typical of phytoplankton respiration below the photic zone while the other suggests photosynthesis at that level. The model exhibits the influence of respiration. The seasonal progression to anoxic conditions at the reservoir outlet elevation (940') is reasonably well represented. The resulting downstream DO, which is the primary focus, confirms the seasonal progression is adequately represented for the purposes of the modeling analysis.

Computed and observed temperature profiles in West Point Reservoir Figure 3.7 through Figure 3.9) are plotted at mid-lake and forebay locations. The mid-summer profiles consistently show less stratification than observed, however the date of destratification is approximated. Computed surface temperatures tend to be slightly less than observed. Both the model and observed data have approximately the same longitudinal variation. The cooler hypolimnion temperatures seen in the observed tends to delay destratification slightly (September 2006 and 2007).

Computed and observed DO profiles in West Point Reservoir (Figure 3.10 through Figure 3.12) are also plotted at mid-lake and forebay locations. The seasonal trends and computed DO profiles tend to be in reasonably good agreement with observed data. The earlier time of model destratification results in an earlier recovery of DO and a corresponding time of DO recovery in the computed release concentration.

W.F. George Reservoir temperature profile results (Figure 3.13 through Figure 3.15) are plotted at mid-lake and forebay locations to correspond with locations and timing of available data. Temperatures are reasonably well represented. Model results tend to show slightly more stratification than observed and also tend to show more variation between the mid-lake and forebay locations than observed. The seasonal trends are well represented.

W.F. George Reservoir DO profile results (Figure 3.16 through Figure 3.18) are plotted at mid-lake and forebay locations to correspond with locations of available data. In spring of 2004 the model results show more variation between the two lake locations than observed. The progression to anoxic conditions at the elevation of the dam outlet (155 ft) is well represented. The August profile shows the impact of thermal destratification timing. The modeled DO reflects weak stratification while the observed reflects a vertically mixed environment. By September 2004, both the model and data reflect a mixed environment. Observed mixing occurred before August 14 while the model mixing occurred after. Since the observed profiles represent snapshots in time, it is not possible to determine the time difference. During 2006, mixing occurred between August 23 and September 20 in both the data and model. During 2007, model mixing was delayed.

Both West Point and Walter F. George Reservoirs are weakly stratified and may destratify and then restratify as weather conditions change. Since the model meteorology was developed to represent seasonal variations and not actual data for a particular day, the focus is the general response of the reservoirs.

Time series of computed and observed chlorophyll *a* in Lake Lanier, West Point Reservoir and W.F. George Reservoir are plotted in Figure 3.19 through Figure 3.21. For each reservoir, observed data are the average of growing area concentrations at two locations within the reservoir.

In Lake Lanier, average computed concentrations in the upper 15 ft of the reservoir are plotted. Data are too sparse to discern clear seasonal trends, however the highest observed values do tend to occur during late summer, whereas the highest computed values occur during late April and early May and are somewhat higher than any observations. The initial computed algal bloom reflects the abundance of nutrients at the beginning of the growing season. Otherwise, the magnitude of computed chlorophyll *a* is in the general range of observed data.

In West Point Reservoir, computed chlorophyll *a* is plotted for the surface layer at mid-lake and forebay locations for comparison with observed data. Observed data are available April through October of each year. Computed values are generally within the range of observed values for most years. During 2003 and 2004 computed values tend to be somewhat lower than observed. 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.

In W.F. George Reservoir, computed chlorophyll *a* is plotted for the surface layer at mid-lake and forebay locations for comparison with observed data. Observed data are available April through October of each year. Results are similar to those for West Point. Computed values are generally within the range of observed values for most years. During 2003 and 2004 computed values tend to be somewhat lower than observed. Computed peaks tend to occur in the spring, whereas observed peaks tend to occur during the summer for several of the years.

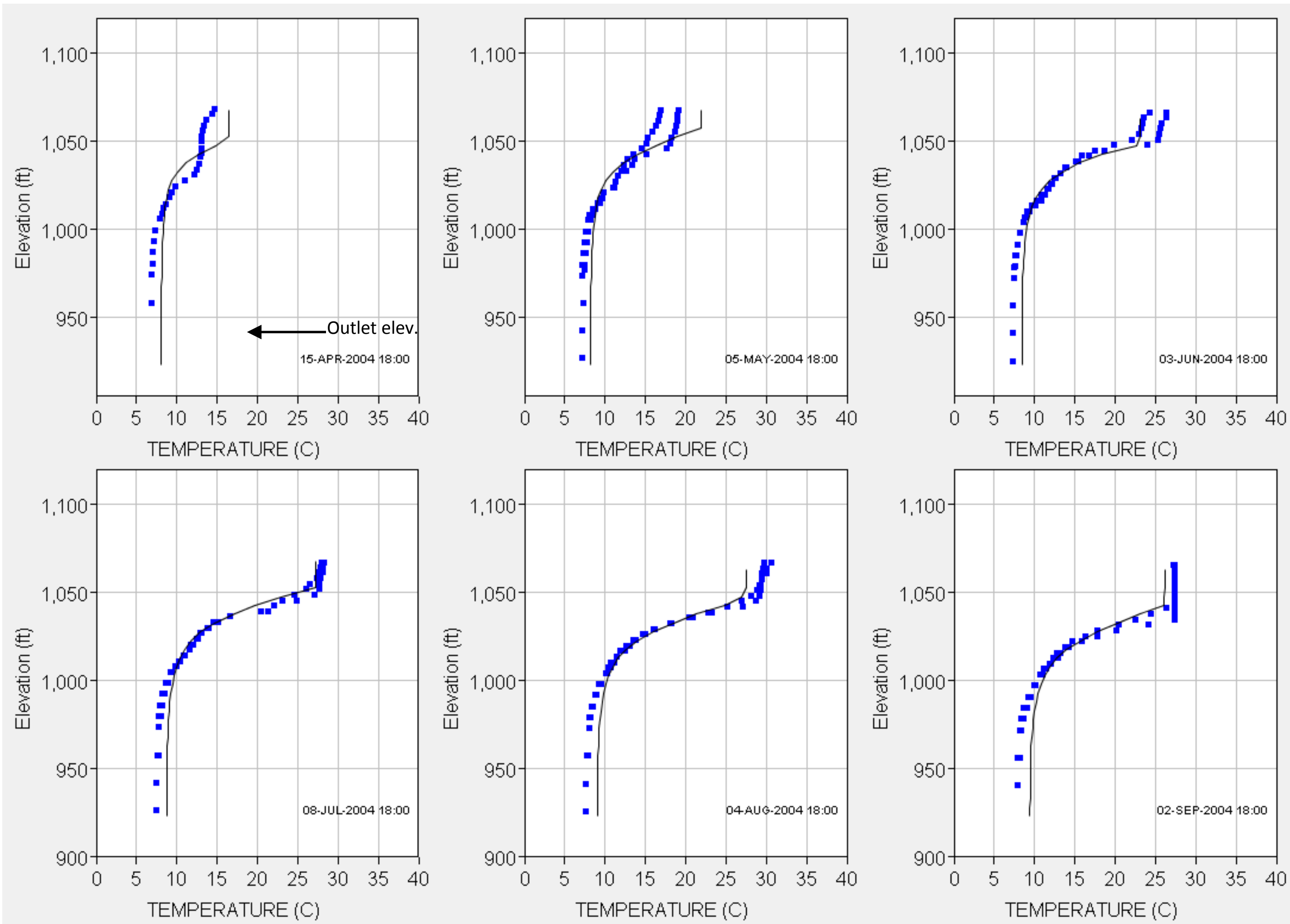


Figure 3.1 Computed and observed temperature profiles in Lake Lanier for dates between April - September 2004. Black line = computed; Blue dots = observed.

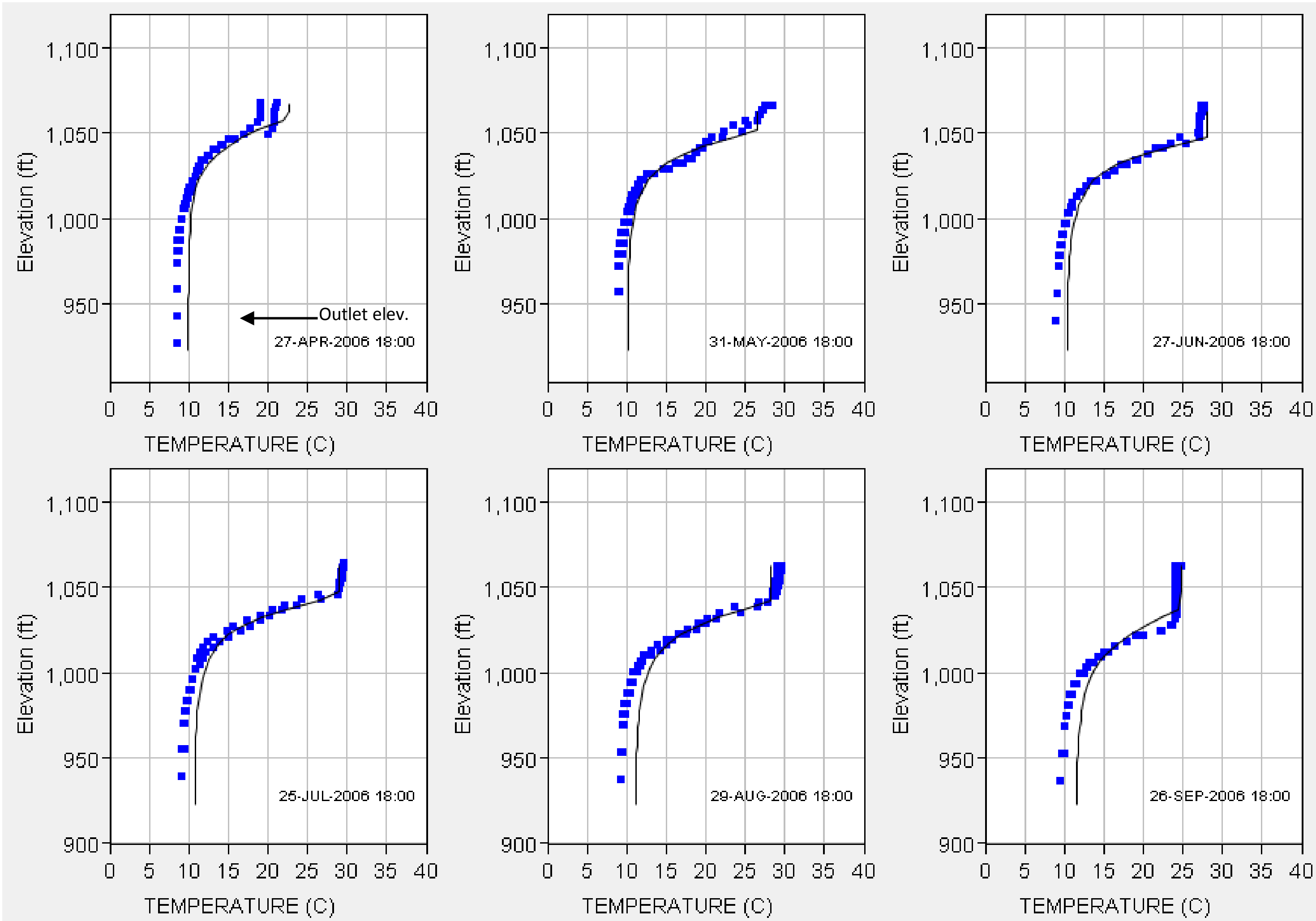


Figure 3.2 Computed and observed temperature profiles in Lake Lanier for dates between April–September 2006. Black line = computed; Blue dots = observed.

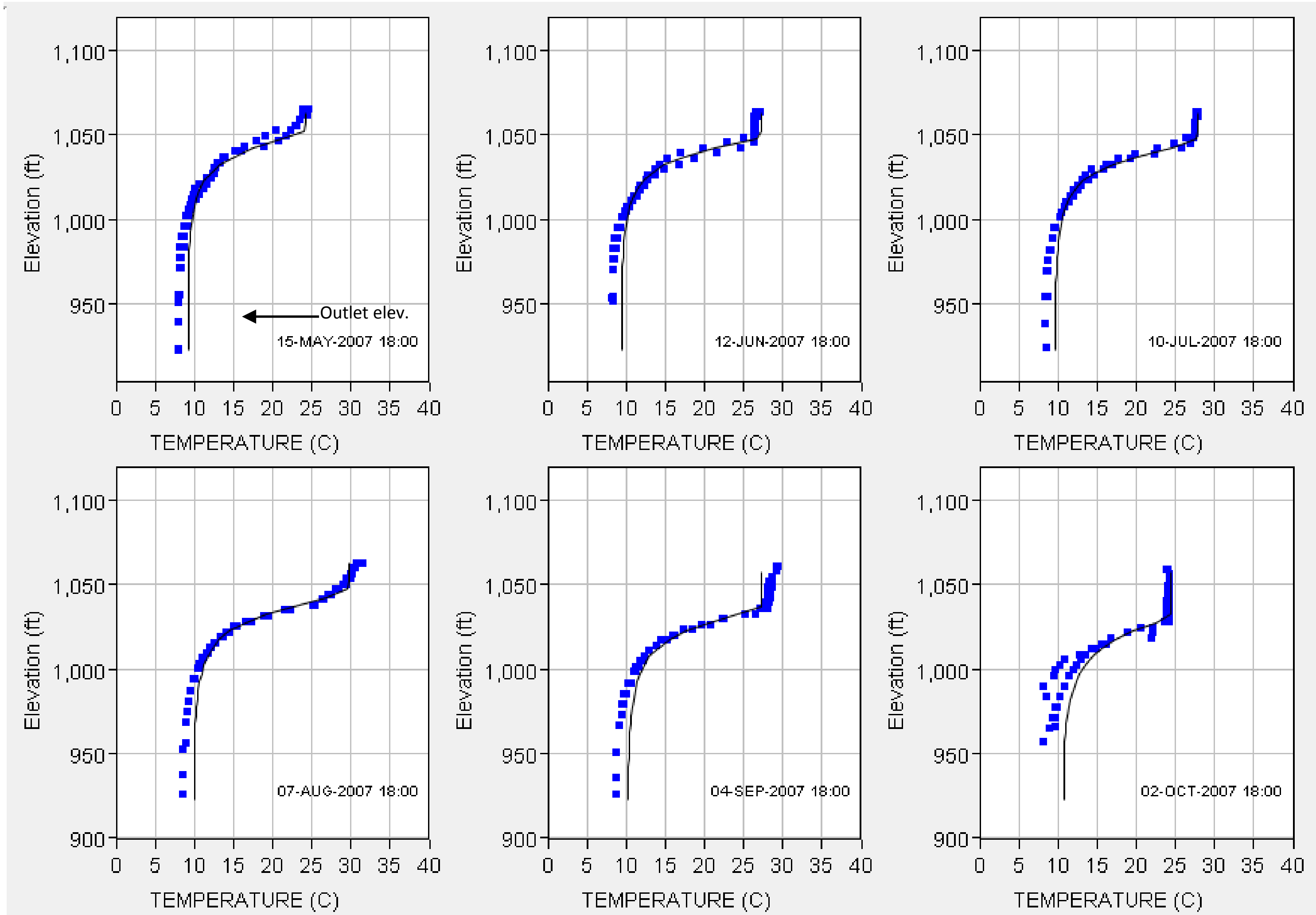


Figure 3.3 Computed and observed temperature profiles in Lake Lanier for dates between May–October 2007. Black line = computed; Blue dots = observed.

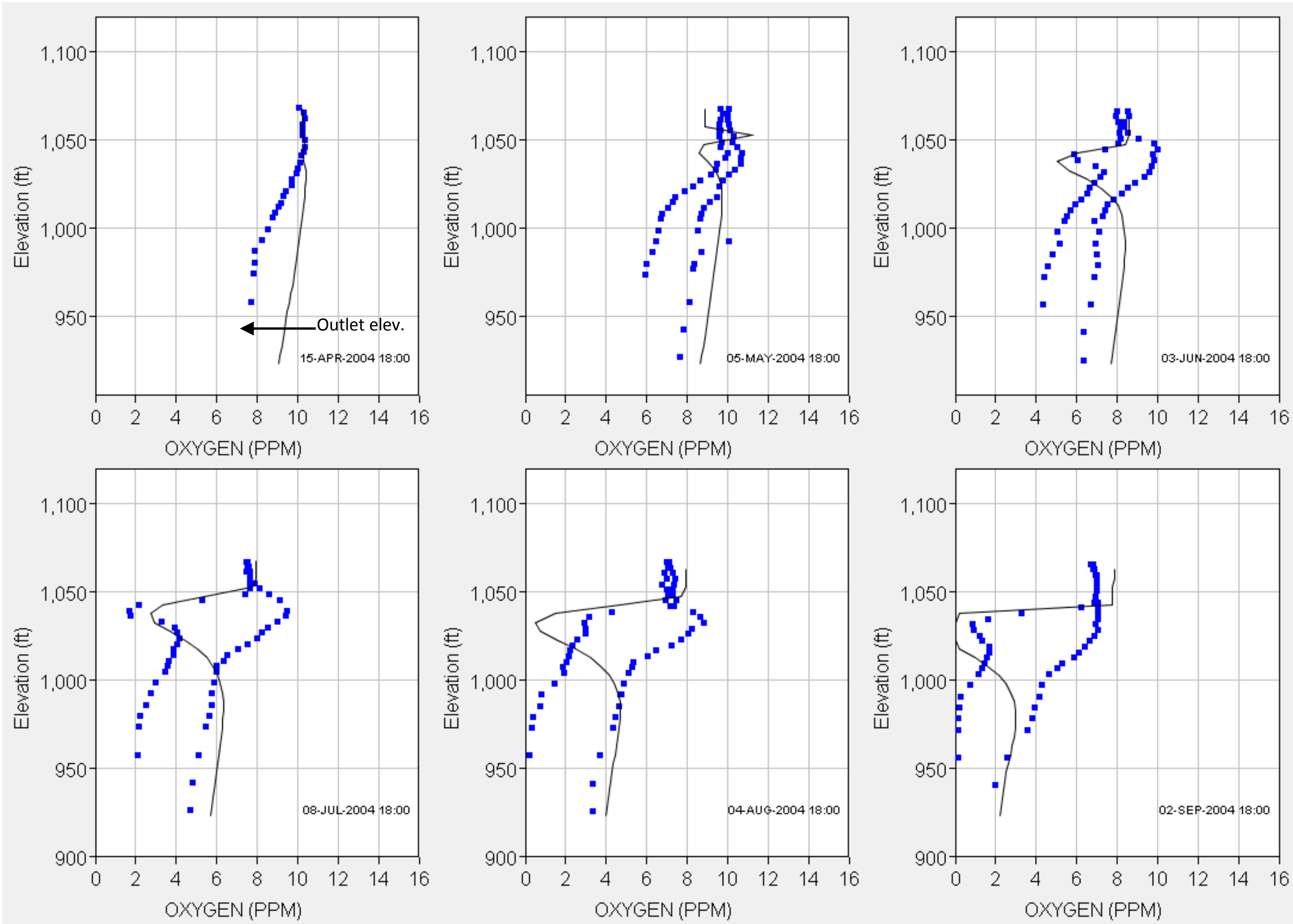


Figure 3.4 Computed and observed DO profiles in Lake Lanier for dates between April–September 2004. Black line = computed; Blue dots = observed.

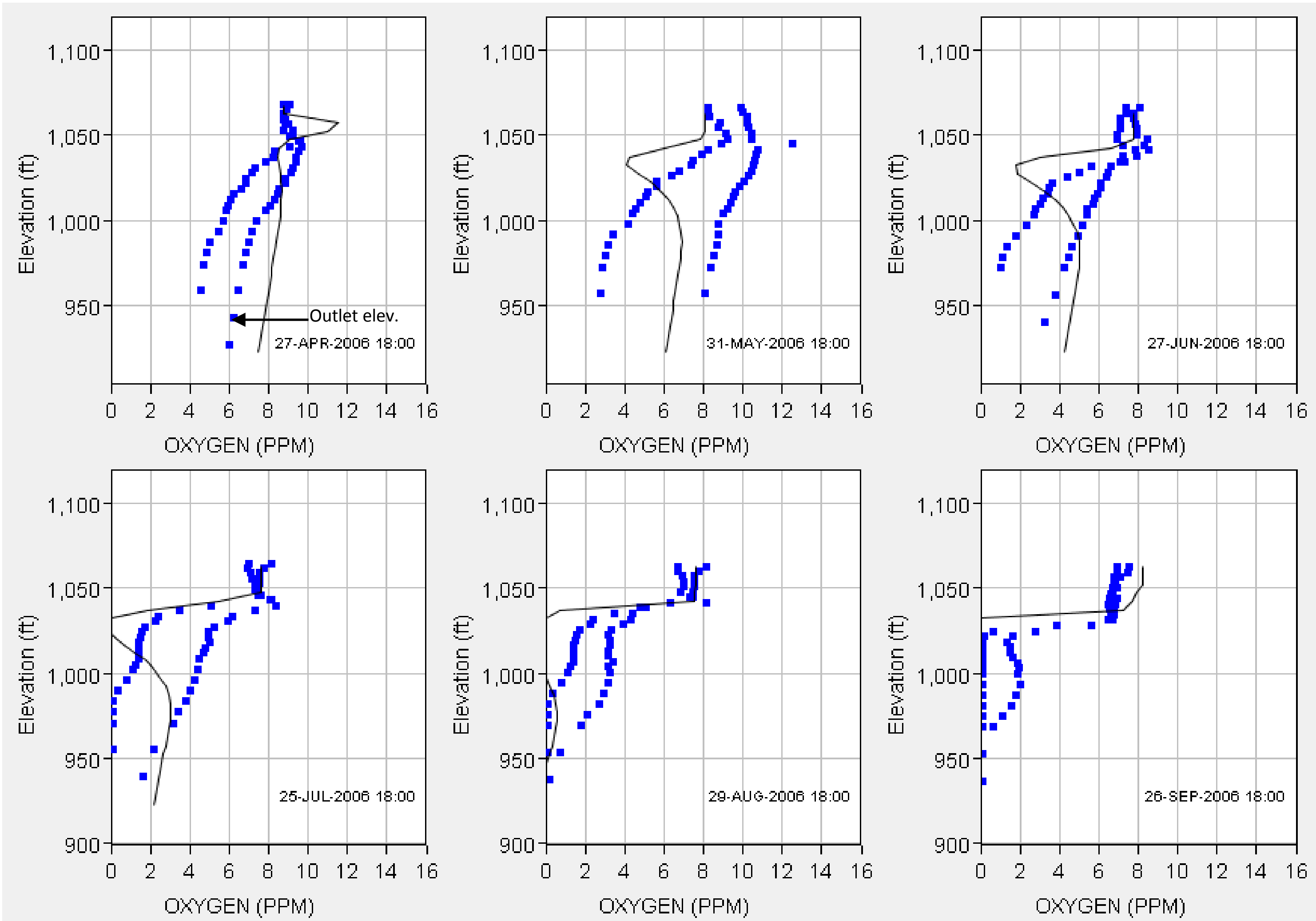


Figure 3.5 Computed and observed DO profiles in Lake Lanier for dates between April–September 2006. Black line = computed; Blue dots = observed.

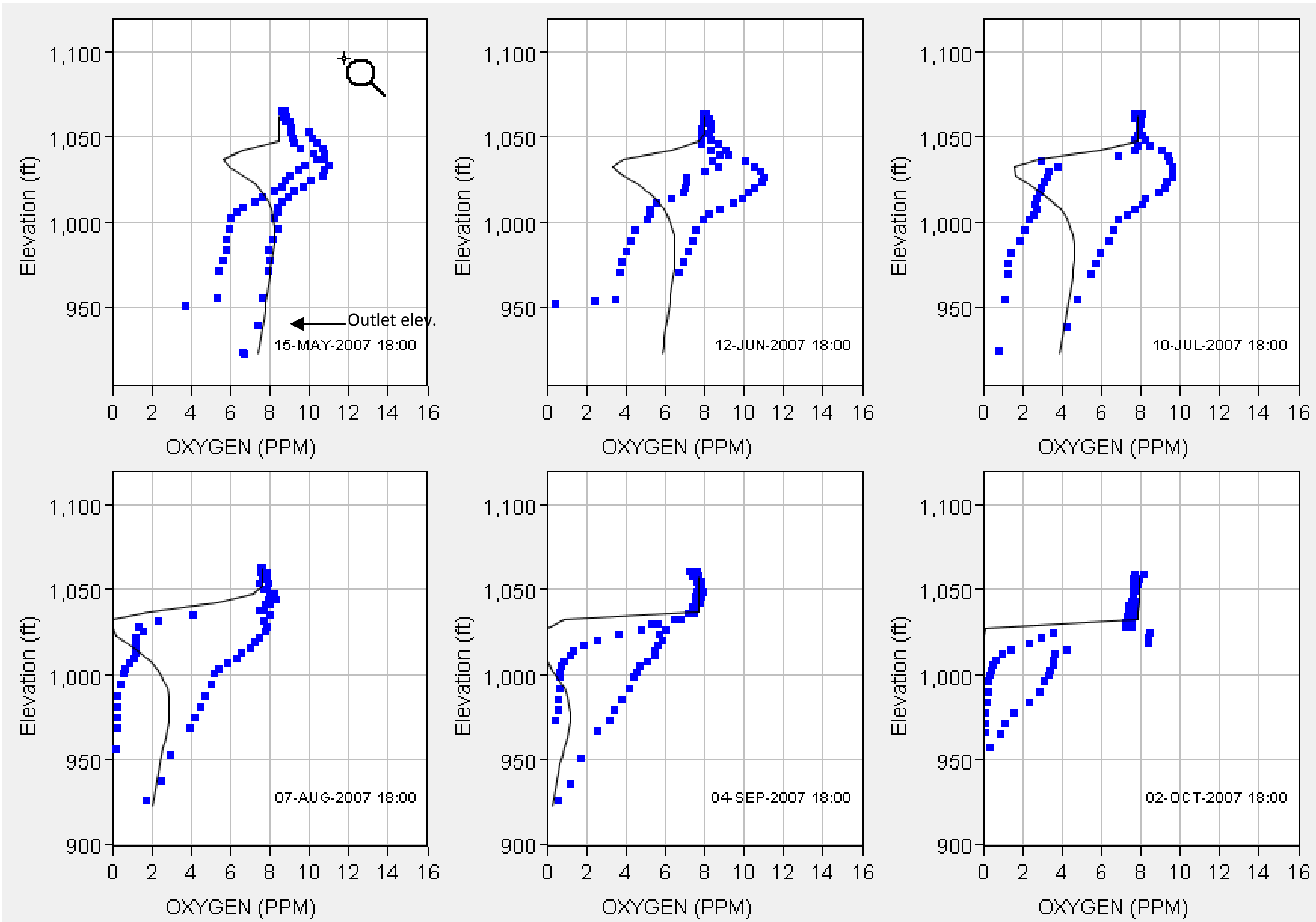


Figure 3.6 Computed and observed DO profiles in Lake Lanier for dates between May - October 2007. Black line = computed; Blue dots = observed.

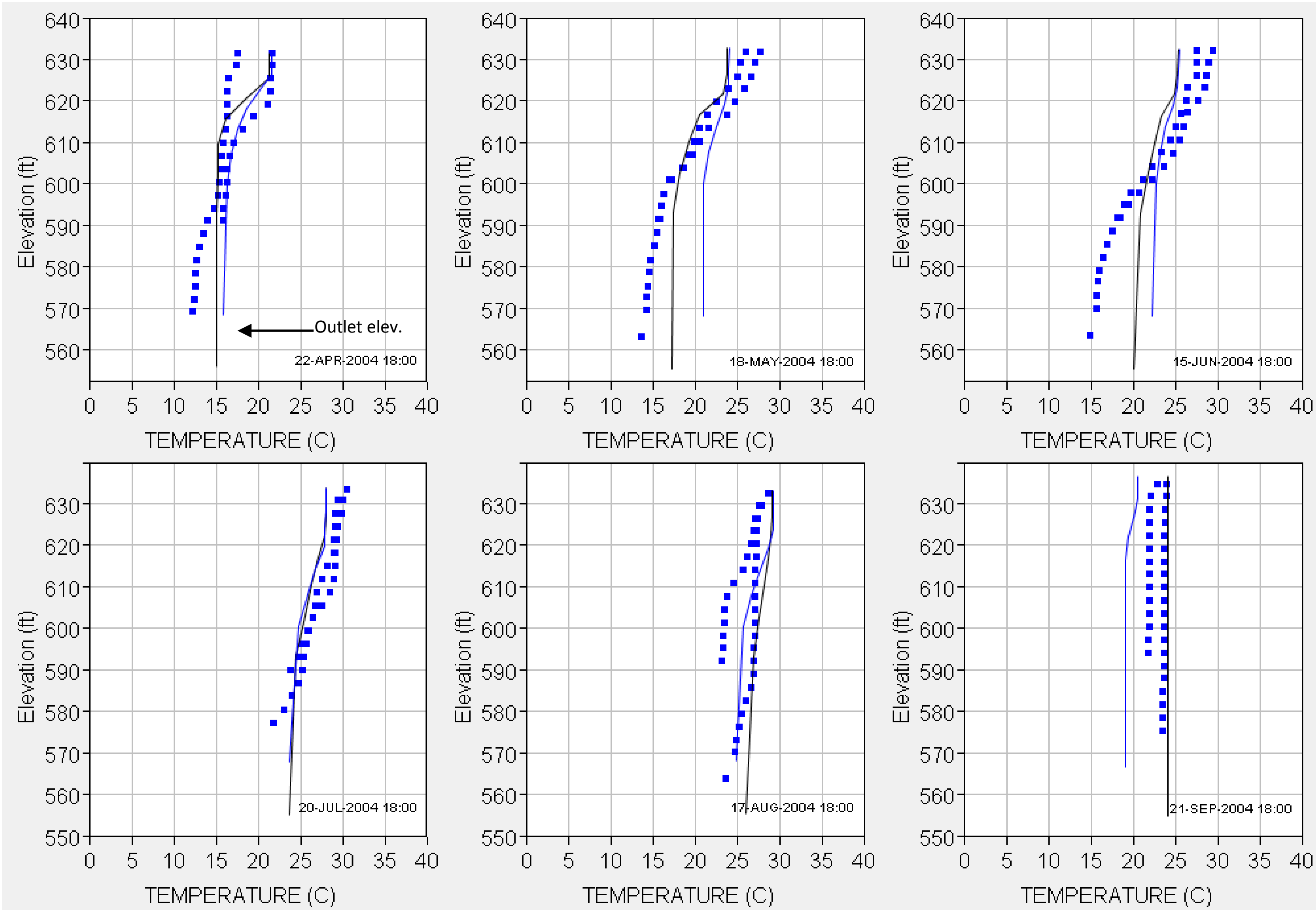


Figure 3.7 Computed and observed mid-lake and forebay temperature profiles in West Point Reservoir for dates between April–September 2004. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

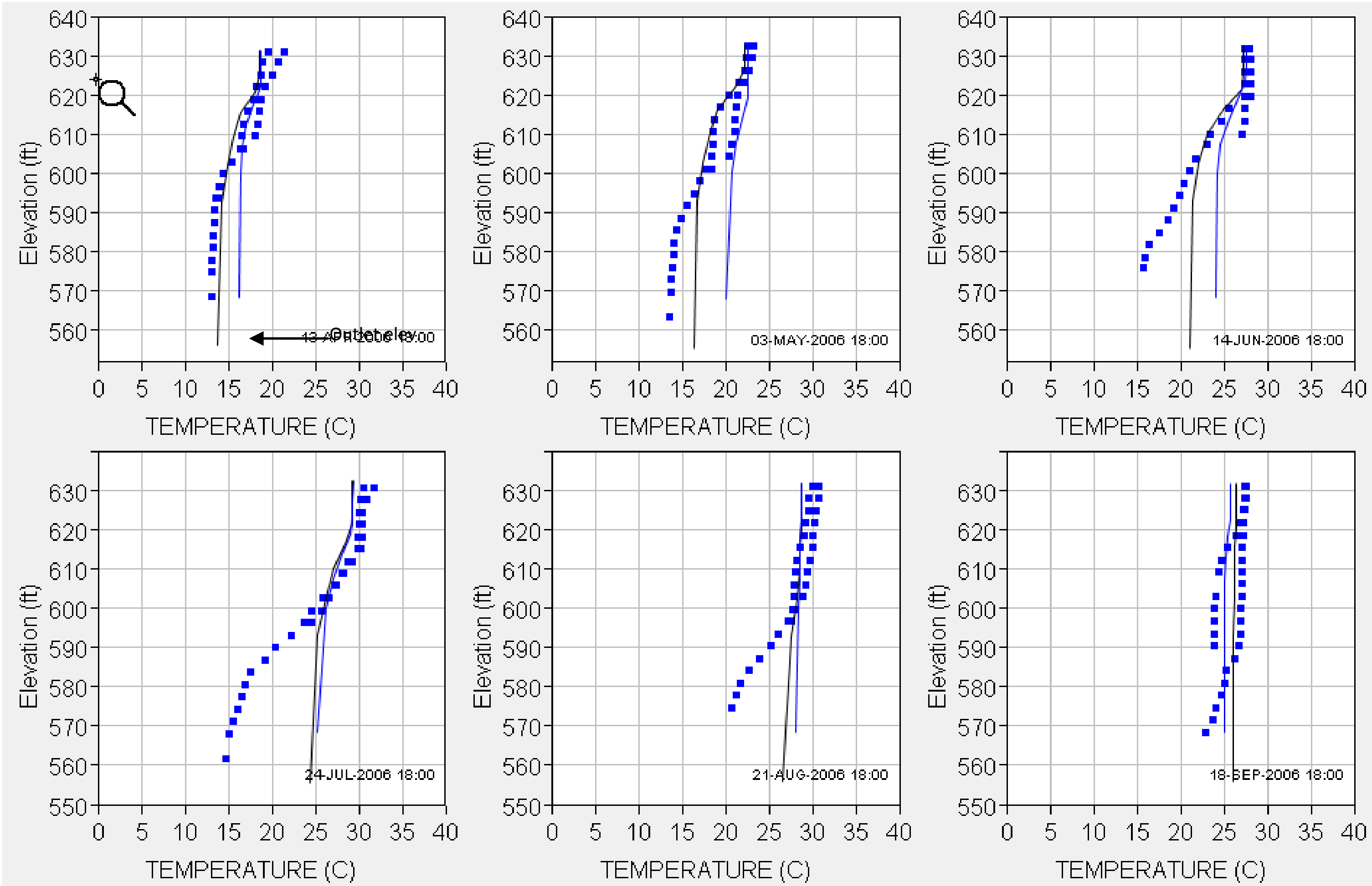


Figure 3.8 Computed and observed mid-lake and forebay temperature profiles in West Point Reservoir for dates between April–September 2006. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

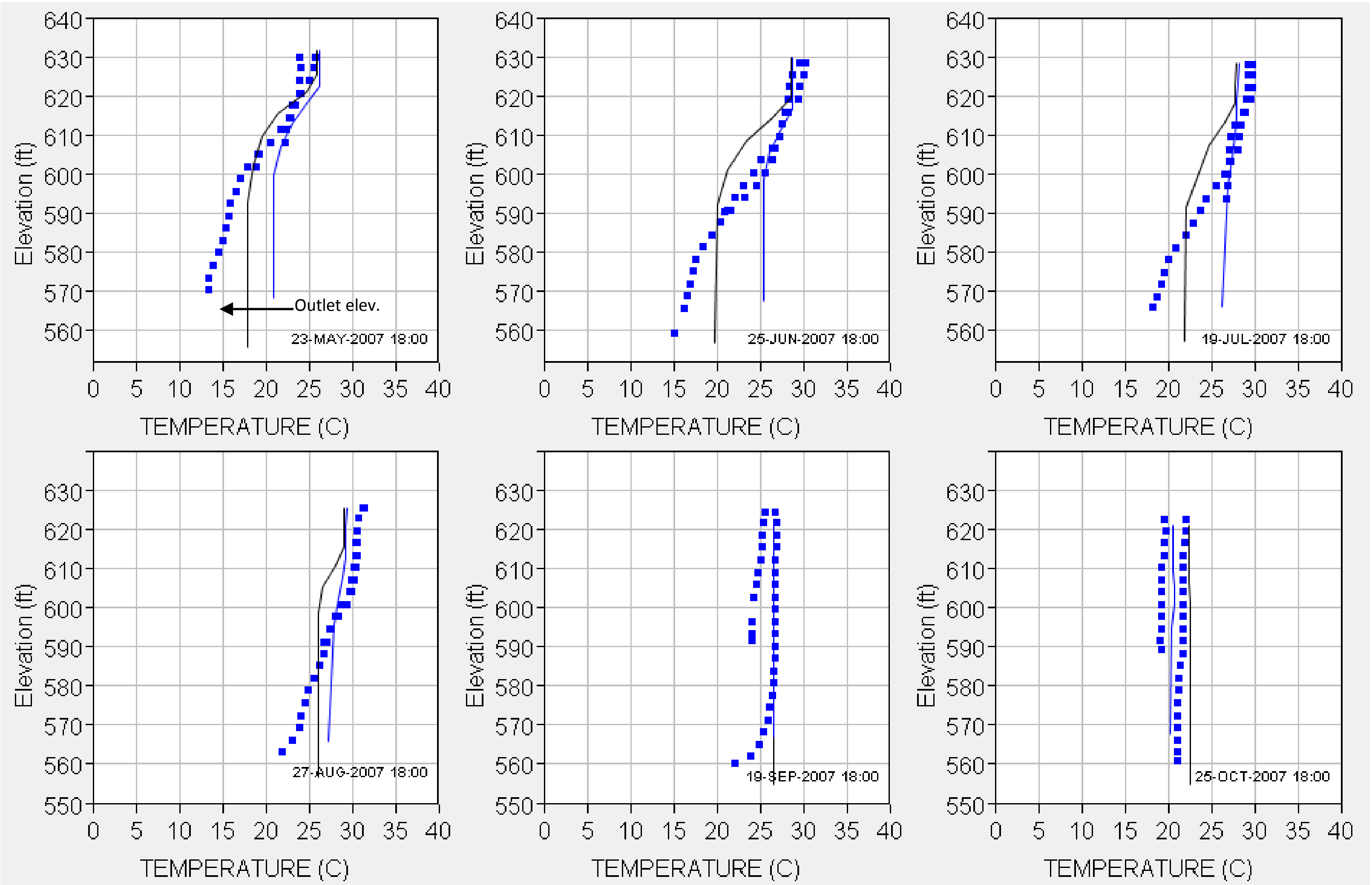


Figure 3.9 Computed and observed mid-lake and forebay temperature profiles in West Point Reservoir for dates between May - October 2007. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

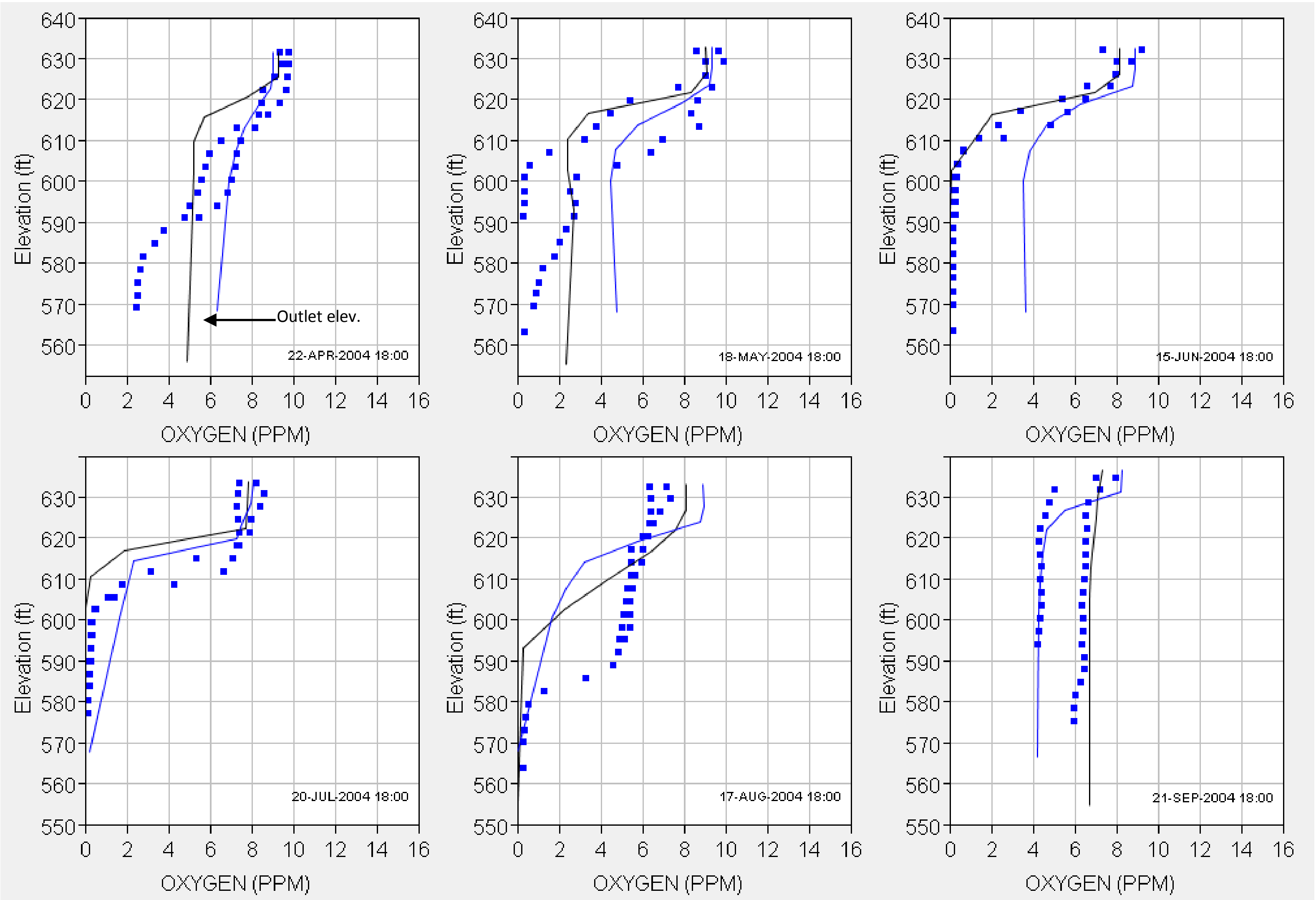


Figure 3.10 Computed and observed mid-lake and forebay DO profiles in West Point Reservoir for dates between April–September 2004. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

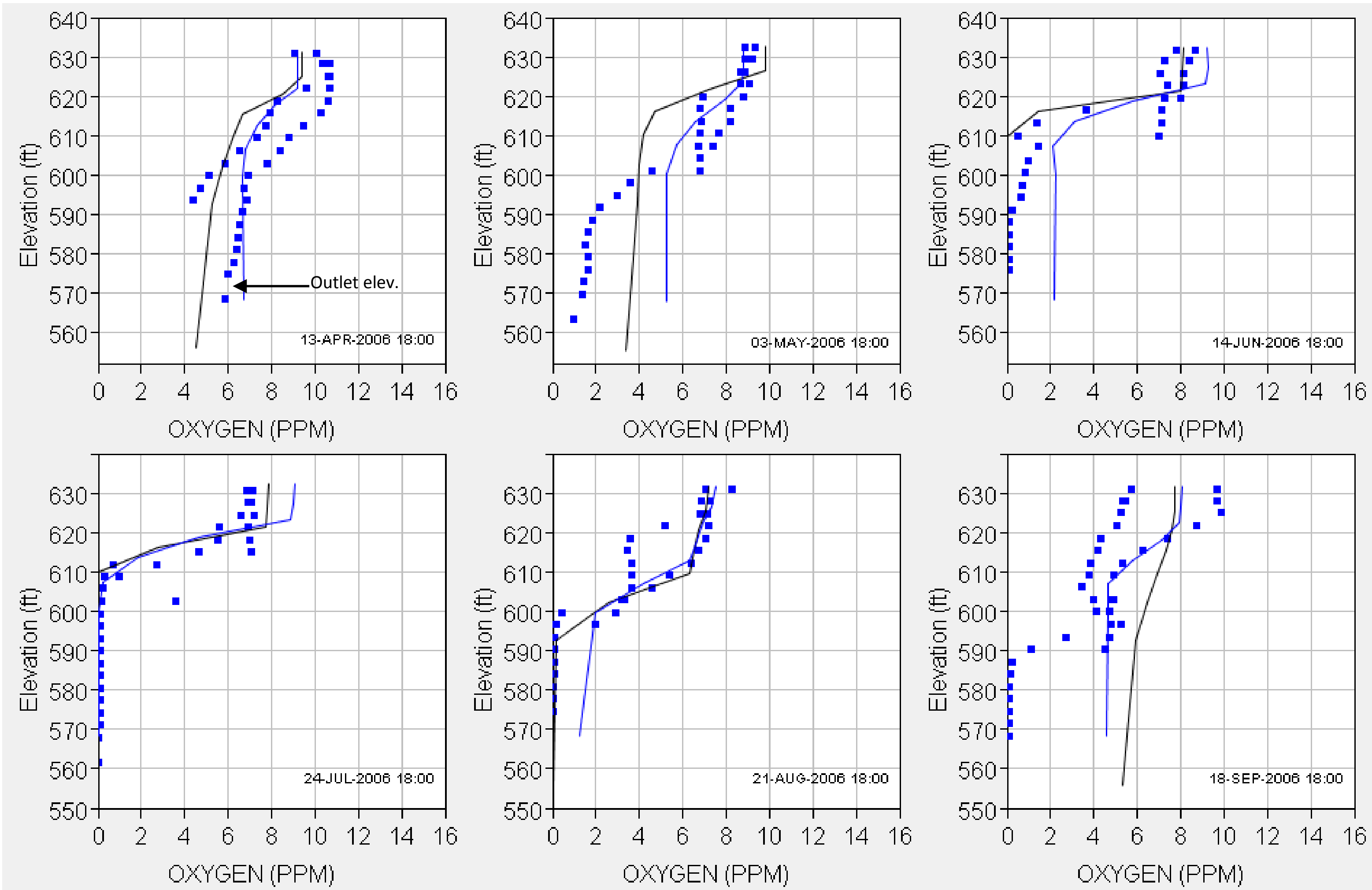


Figure 3.11 Computed and observed mid-lake and forebay DO profiles in West Point Reservoir for dates between April–September 2006. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

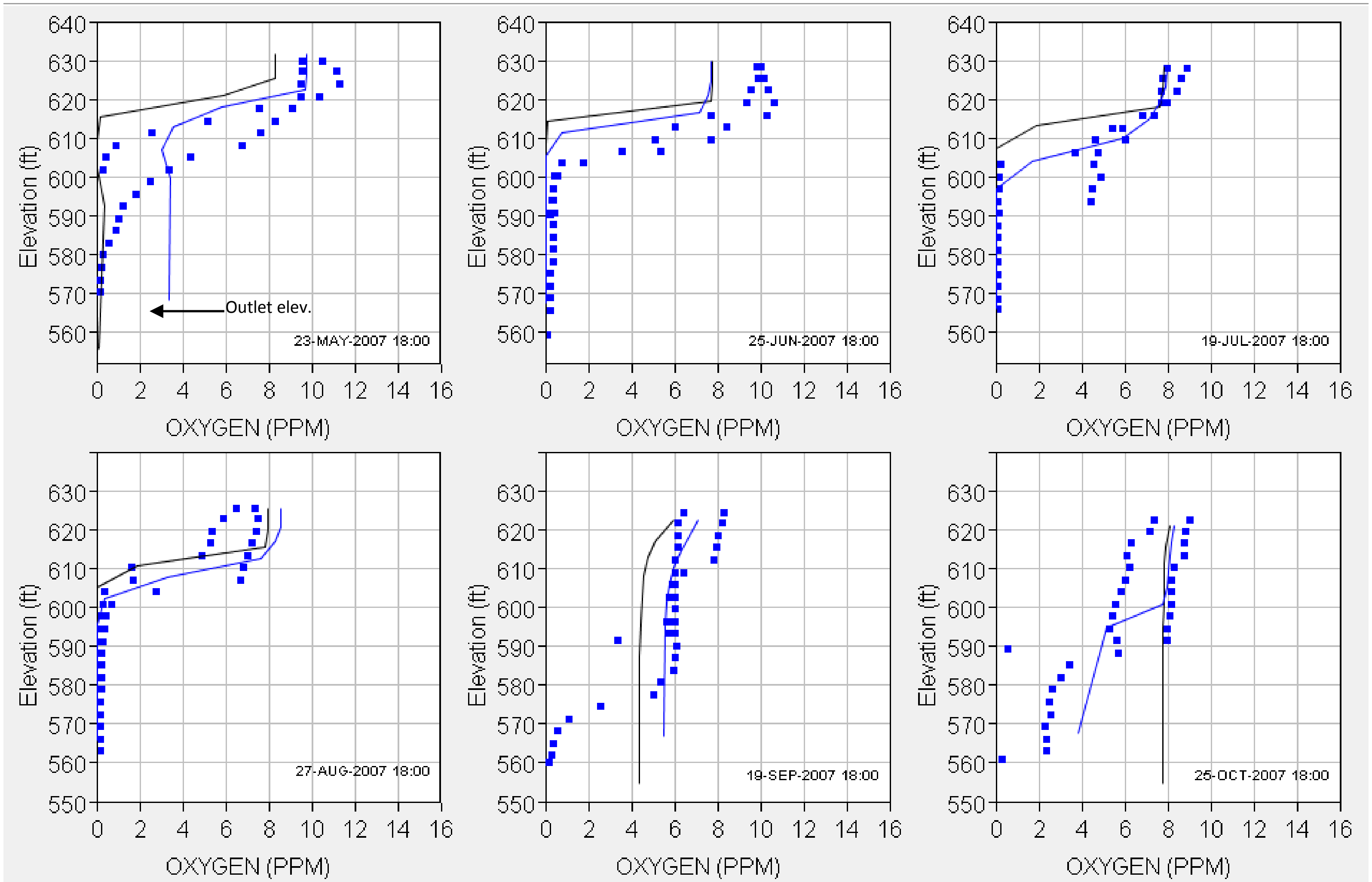


Figure 3.12 Computed and observed mid-lake and forebay DO profiles in West Point Reservoir for dates between May - October 2007. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

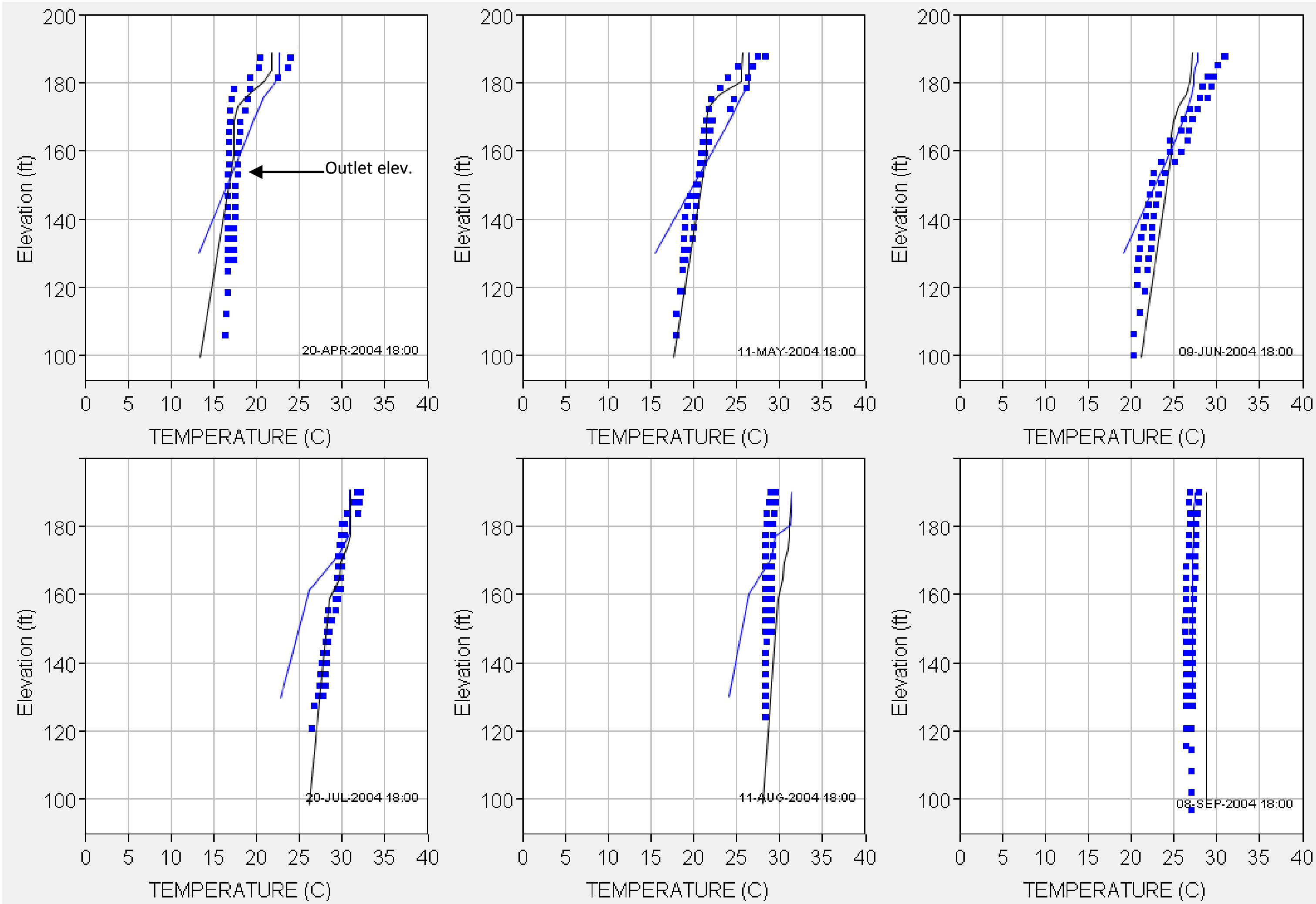


Figure 3.13 Computed and observed mid-lake and forebay temperature profiles in W.F. George Reservoir for dates between April–September 2004. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

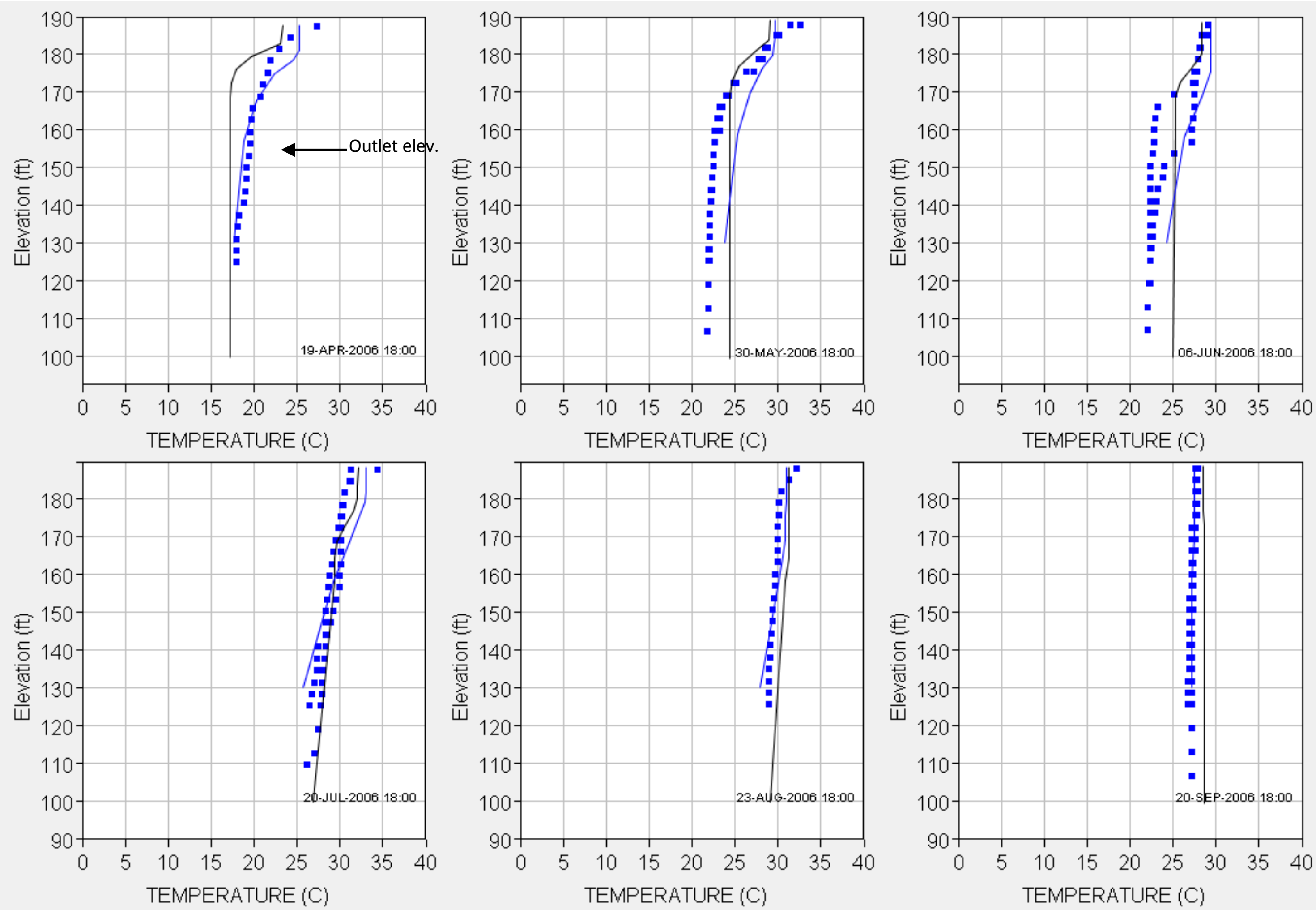


Figure 3.14 Computed and observed mid-lake and forebay temperature profiles in W.F. George Reservoir for dates between April–September 2006. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

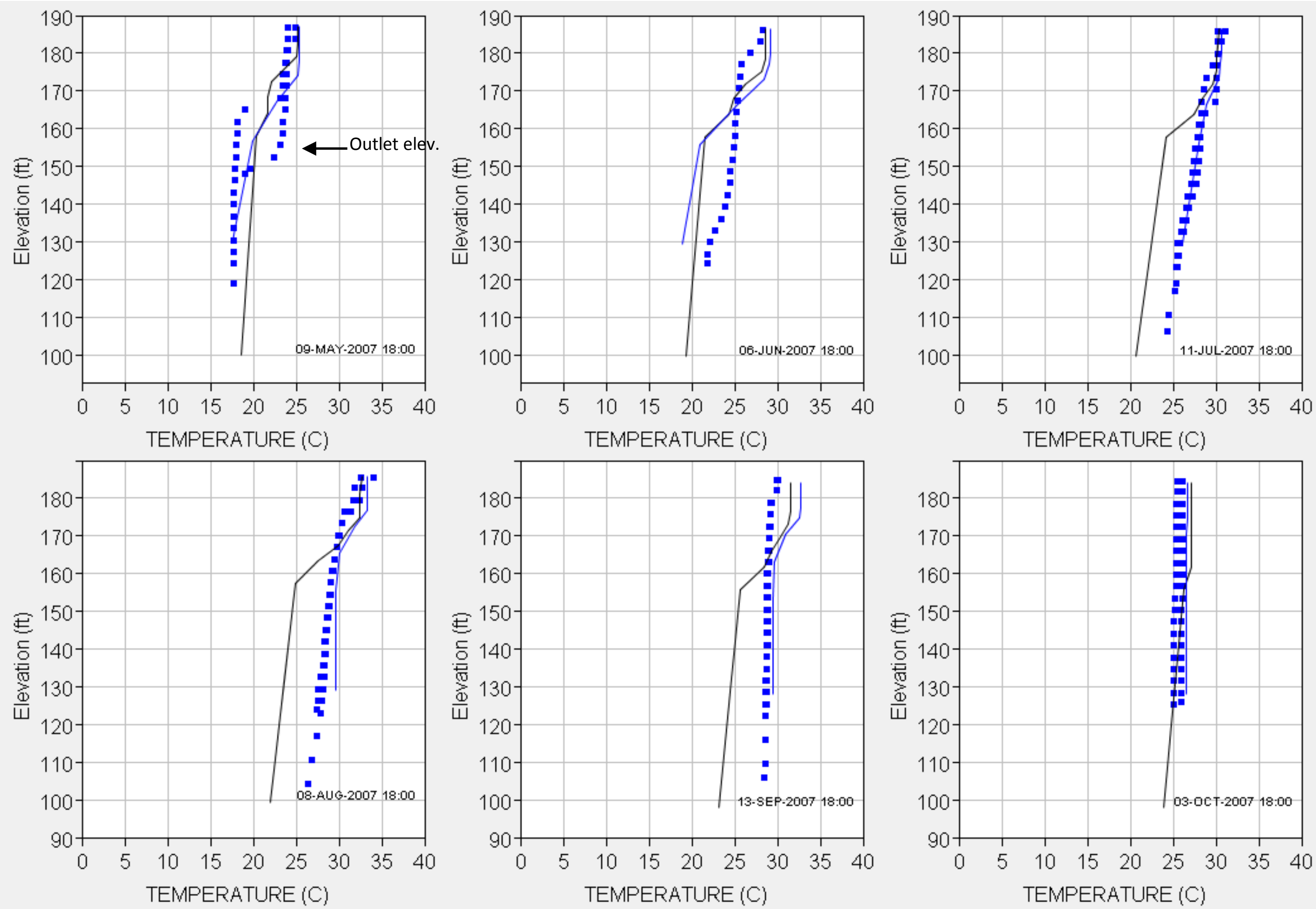


Figure 3.15 Computed and observed mid-lake and forebay temperature profiles in W.F. George Reservoir for dates between May - October 2007. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

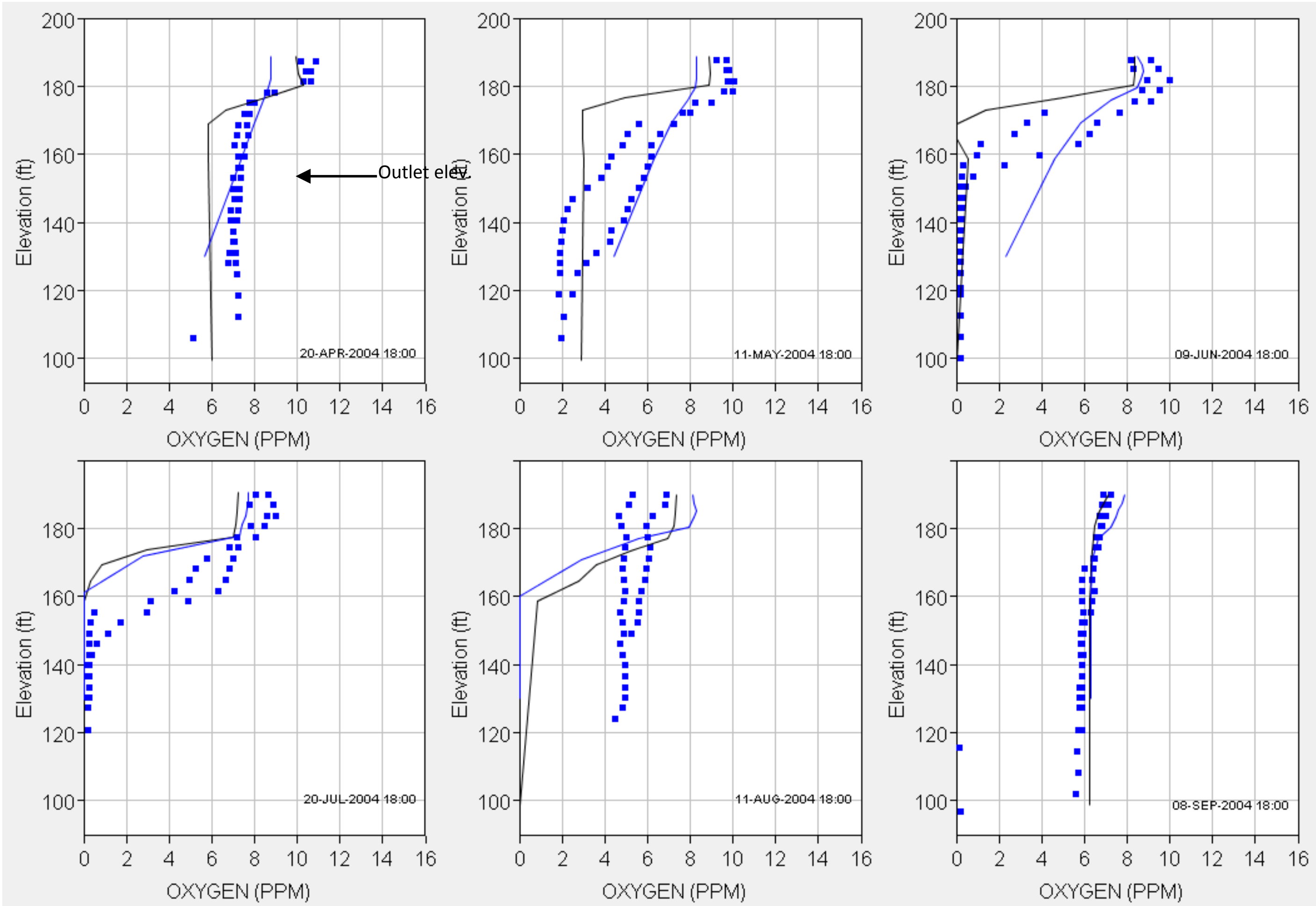


Figure 3.16 Computed and observed mid-lake and forebay DO profiles in W.F. George Reservoir for dates between April–September 2004. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

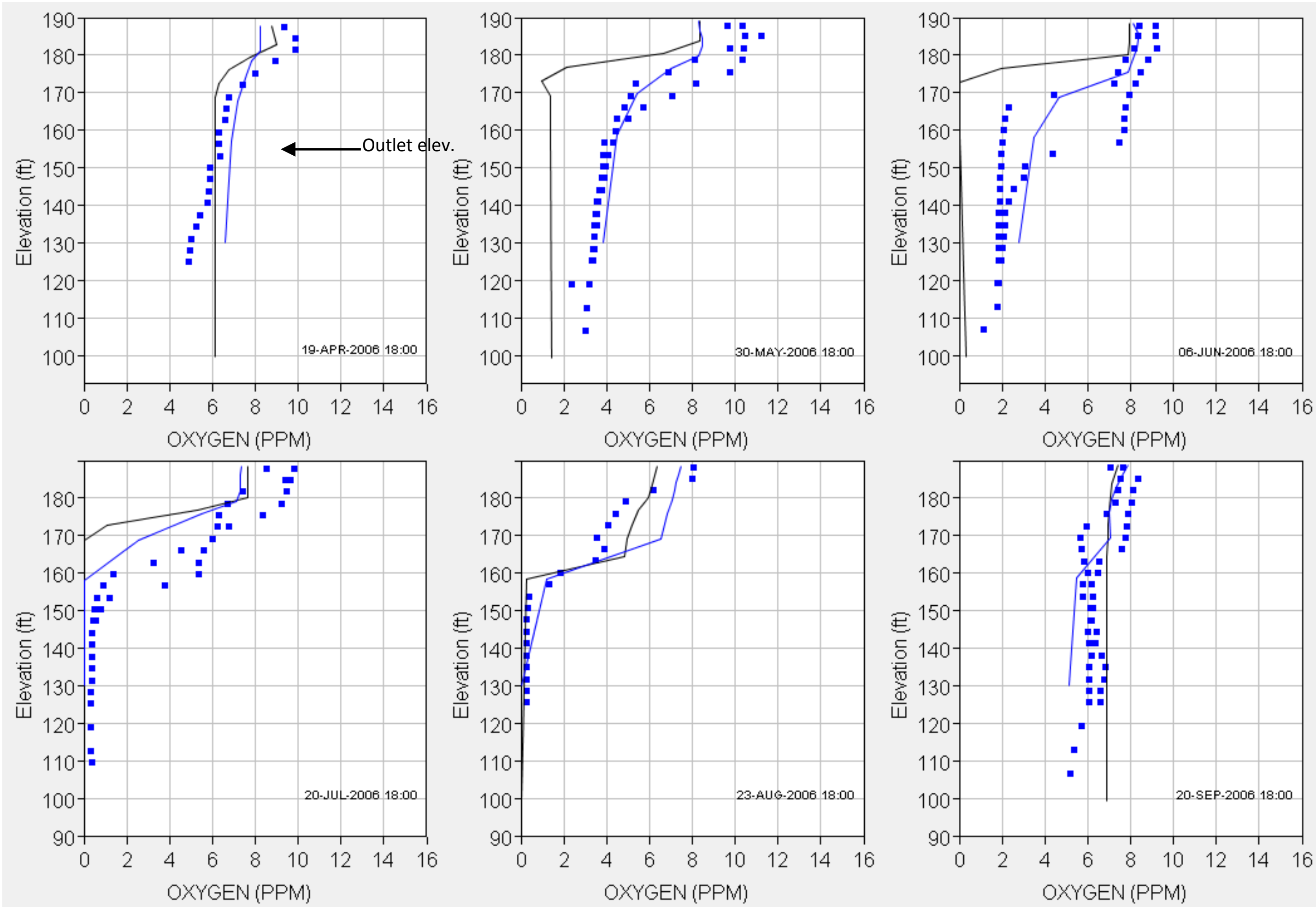


Figure 3.17 Computed and observed mid-lake and forebay DO profiles in W.F. George Reservoir for dates between April–September 2006. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

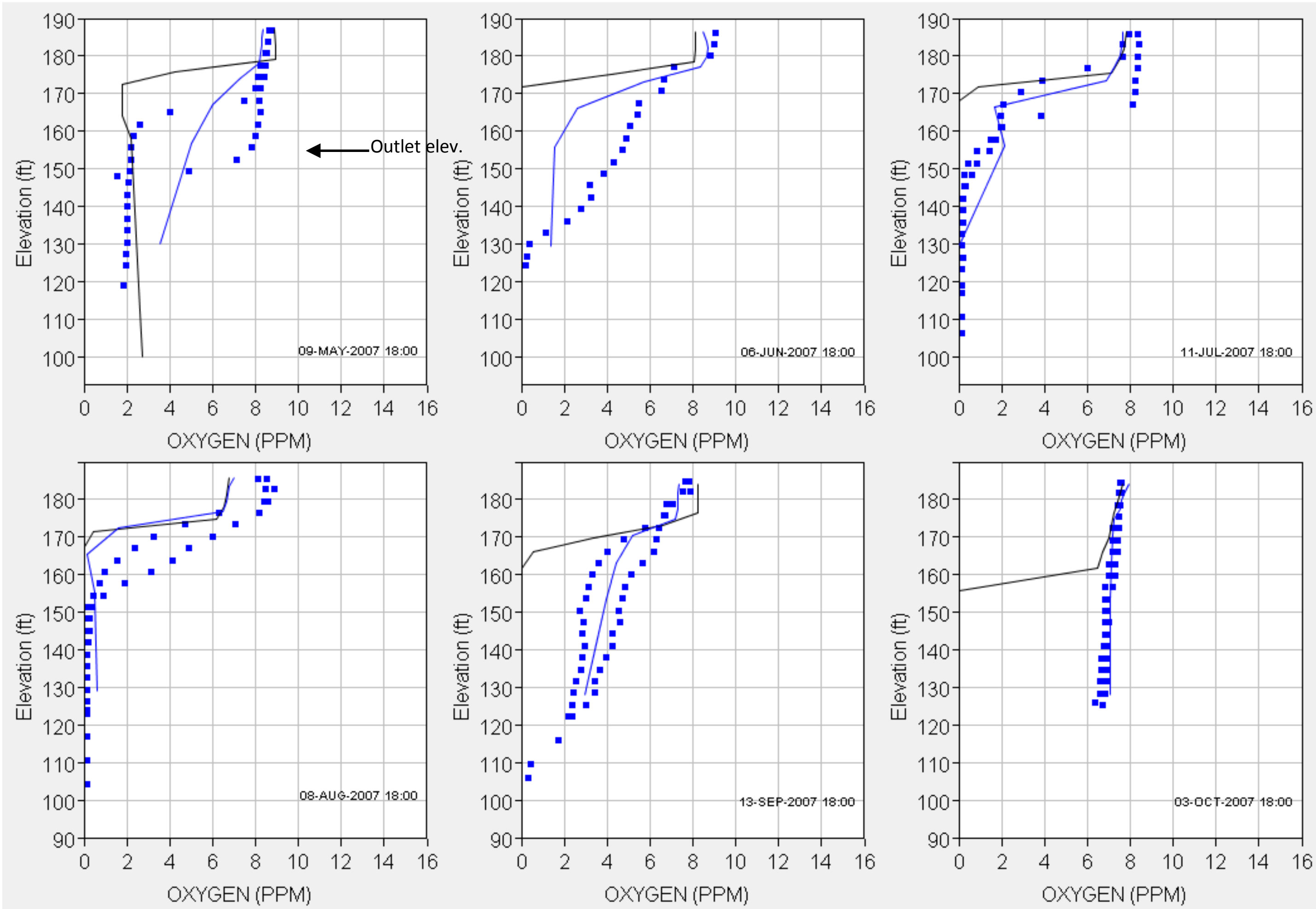


Figure 3.18 Computed and observed mid-lake and forebay DO profiles in W.F. George Reservoir for dates between May - October 2007. Black line = computed (dam); Blue line = computed (mid-lake); Blue dots = observed.

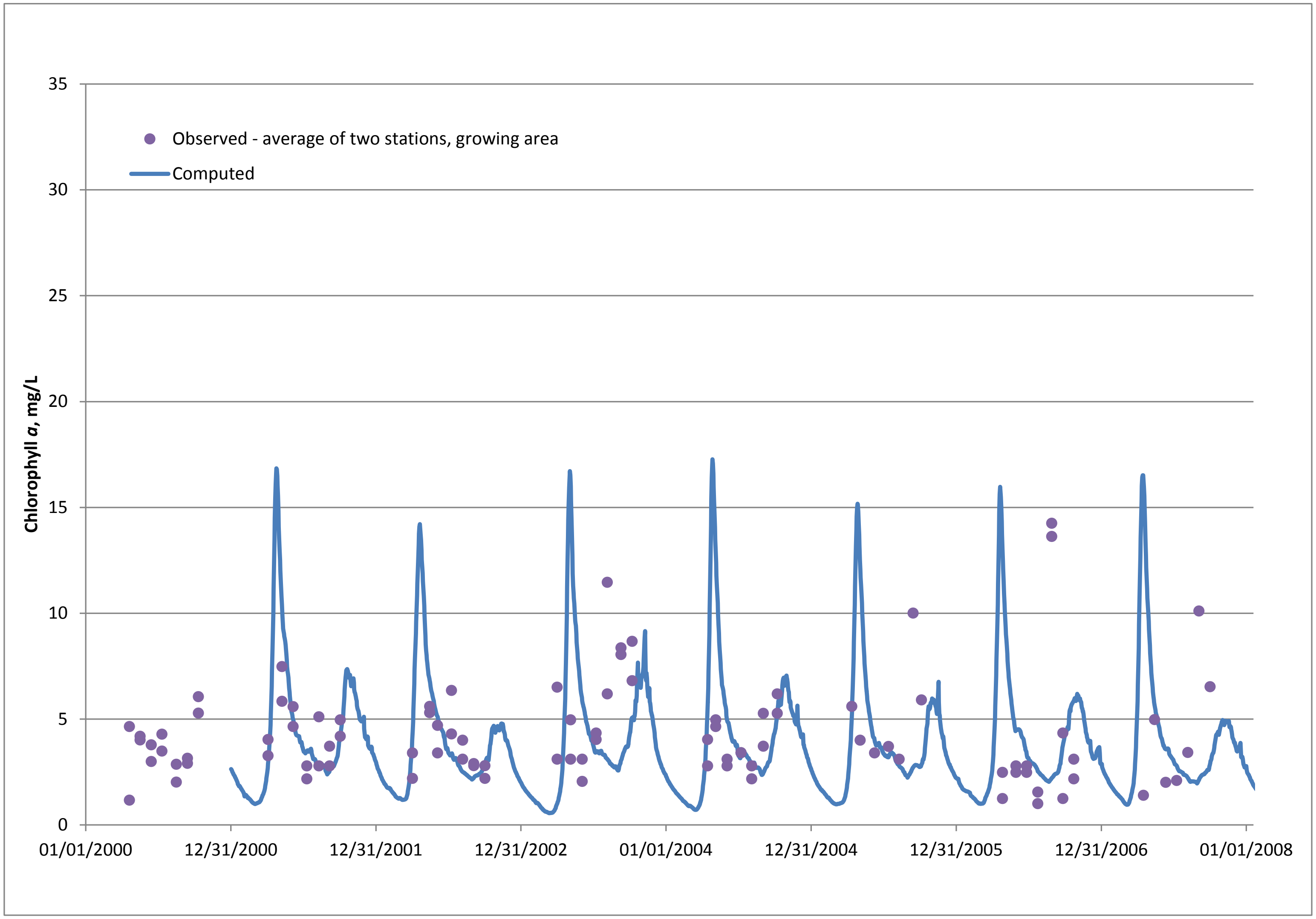


Figure 3.19 Time series of computed and observed chlorophyll *a* in Lake Lanier.

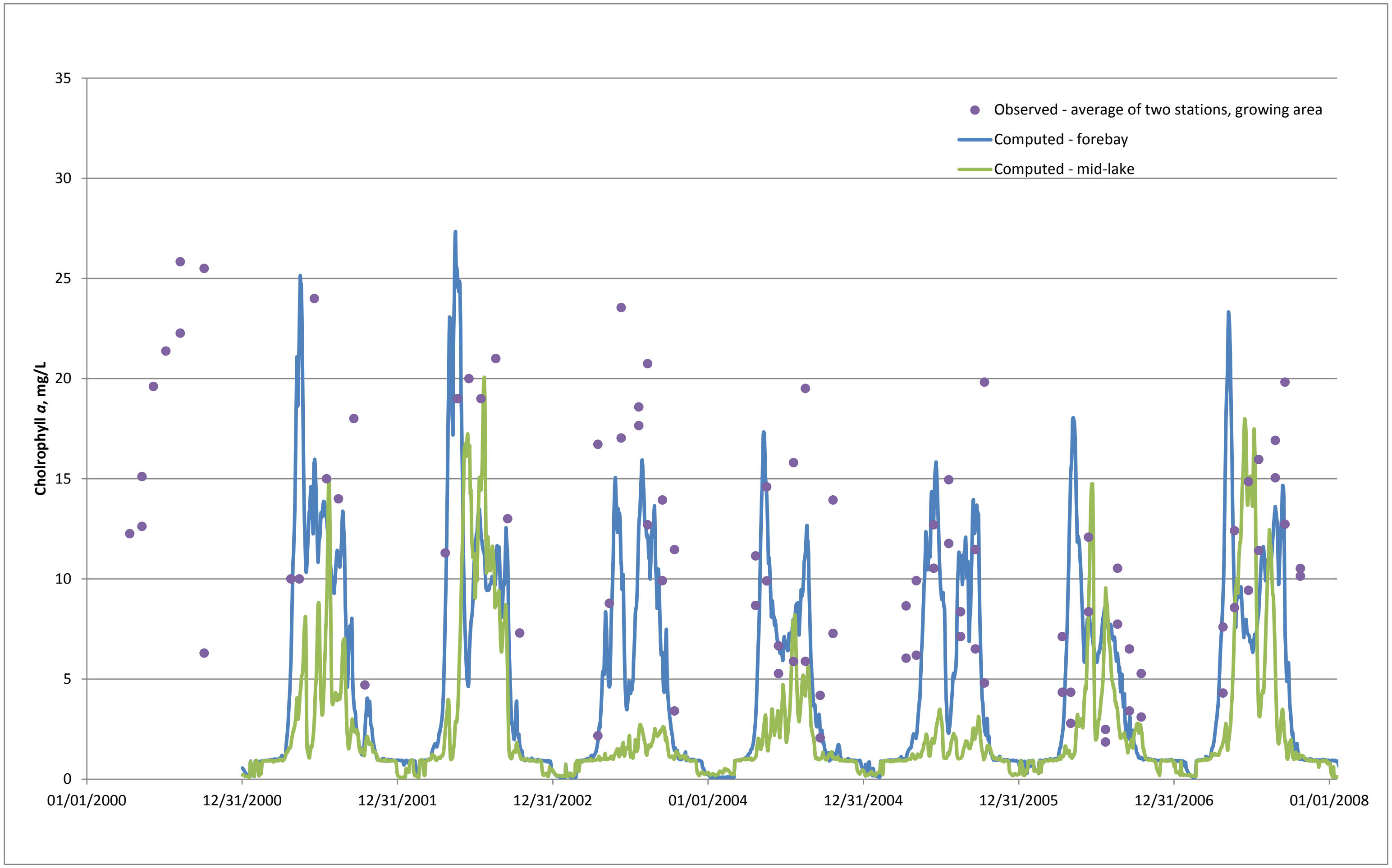


Figure 3.20 Time series of computed and observed chlorophyll *a* in West Point Reservoir.

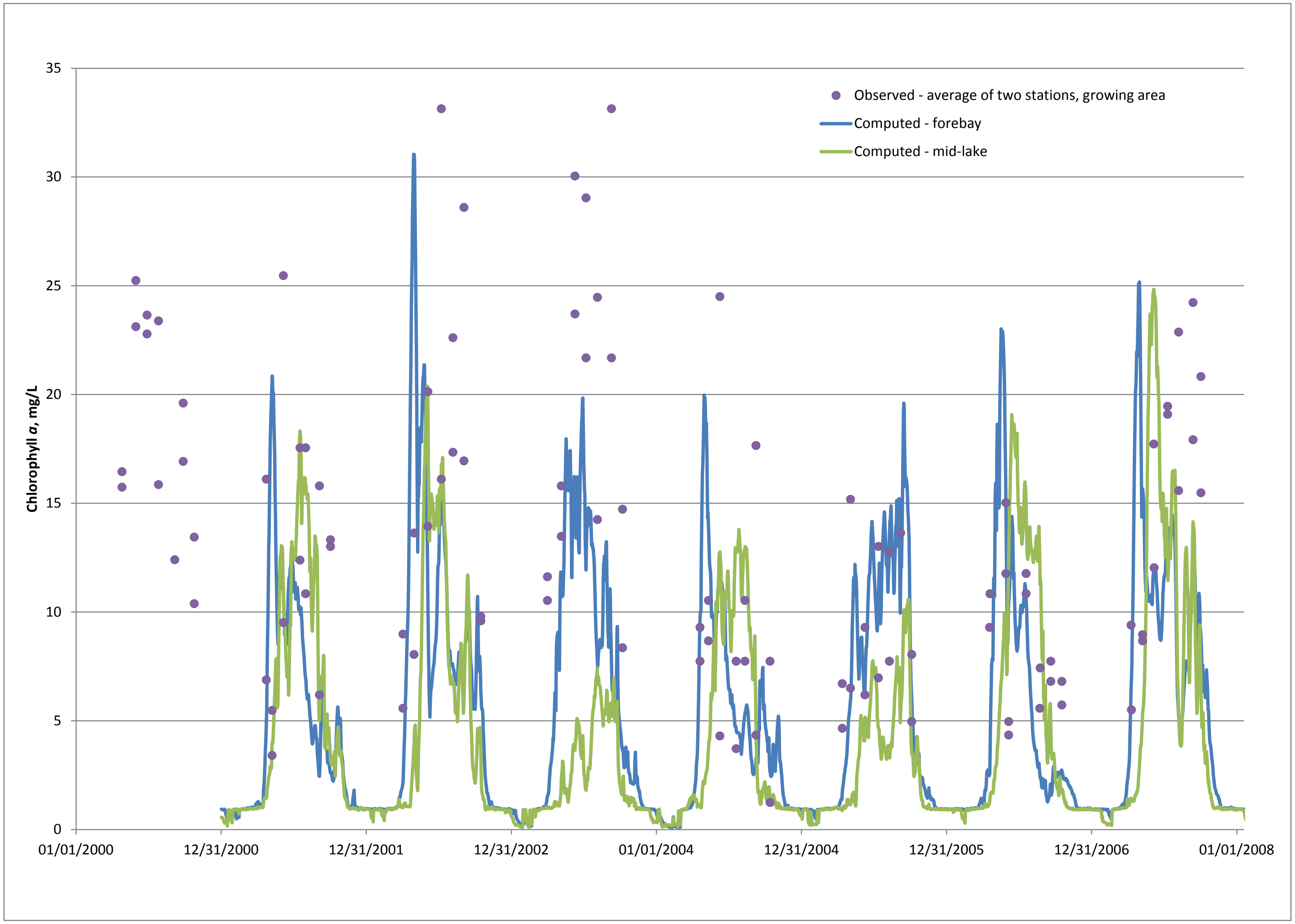


Figure 3.21 Time series of computed and observed chlorophyll *a* in W.F. George Reservoir.

3.2 STREAMS

Time series of computed and observed temperature, DO, NO3-N, NH3-N, and PO4-P are provided at locations (Figure 2.1) throughout the ACF basin where data are available. Model results are plotted at 6-hour intervals. Additionally, longitudinal profiles of computed and observed nitrate and ammonia nitrogen, phosphorus, and BOD (growing season values) are plotted from the Apalachicola River along the Chattahoochee River.

The 5, 25, 50 (median), 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 depths/thicknesses computed as a fraction of the total cross sectional area (e.g., the surface element thickness in West Point Reservoir would represent 1/8 of the total cross section at each reservoir segment). This profile plot format was used for comparison of alternatives.

In Figure 3.22 - Figure 3.55, the HEC-5Q computed values are daily averages. The observed temperature and DO values are often the daily minimum/maximum values. Sparse observations are spot samples.

Computed and observed temperatures at two locations below Buford Dam are plotted in Figure 3.22 and Figure 3.23, respectively. Model results are plotted at 6-hour intervals. Observed data are daily maximums and minimums. Large daily temperature fluctuations are the result of Buford Dam power peaking. Low temperatures occur during power generation. When power generation is minimal there is little flow and warming in the tailrace elevates temperatures. The model is run with daily average flows as though power generation is always occurring, and thus the results at Buford Dam should match the minimum observed temperatures. However, due to the slightly elevated hypolimnion temperatures in the reservoir, the tailwater temperatures are higher than the observed minimums.

This is seen downstream at Norcross (Figure 3.24) as well. The computed temperatures reflect average flow conditions and the diurnal variation is due solely to surface heat exchange. The observed temperatures reflect both surface heat exchange and variable flow and associated travel time. At peak power flows, the shorter travel time and increased water depth results in less heating. Model coefficients were selected to bias towards the maximum temperatures since this reach is a cold water fishery.

Computed temperatures at Atlanta (Figure 3.24 and Figure 3.25) have lower summertime peak temperatures than observed but are, otherwise, in agreement with the seasonal trends seen in the observed data. The impact of Buford Dam power peaking is considerably less at this location since flow rates are moderated within Morgan Falls Reservoir. This is similarly true at Fairburn (Figure 3.26) and Whitesburg (Figure 3.27), and Columbus (Figure 3.28). Excellent agreement between computed and observed temperature is achieved at Steam Mill (Figure 3.29). Below Jim Woodruff Dam (Figure 3.30), reasonable agreement between the computed and observed temperature is achieved during the short period data are available. The temperature reduction seen in the observed data in July could not be achieved since both the Chattahoochee and Flint River inflows to Lake Seminole are above 30° C.

Flint River computed and observed temperature time series at Bainbridge are plotted in Figure 3.31. The computed results are in good agreement with observed data at this location (inflow to Lake Seminole). Observed data are relatively sparse.

Computed and observed time series of DO are plotted in Figure 3.32 through Figure 3.37. In the Chattahoochee River below Buford Dam (Figure 3.32), the impacts of power peaking are also seen during the summer and fall. The low DO values occur during power production while the higher observations are influence by reaeration at off-peak times. Additionally, the power plant is occasionally offline for maintenance and flow is released from the sluice gates located at a higher elevation. This condition was not simulated since power plant maintenance schedules were not considered in the ResSim model.

In the Chattahoochee River at Fairburn (Figure 3.33) the computed seasonal DO fluctuations tend to be smaller than observed. In particular, winter time peak DO is lower than observed. At Whitesburg (Figure 3.34) the data are sparse, but the model results are in agreement with observed data. At Columbus (Figure 3.35), again data are sparse, but it appears that the model tends to not reach the peak winter time DO or the low summer time DO. This location is in the vicinity of the City Mills and Eagle & Phoenix Dams that are represented as equivalent stream sections. Since the observed DO generally exceeds the computed and also exceeds 6 mg/L, DO does not appear to be problematic and the lower computed DO results in a conservative analysis. At Steam Mill (Figure 3.36) computed seasonal peaks are low, but the model otherwise matches observed data reasonably well.

Flint River computed and observed DO time series at Bainbridge are plotted in Figure 3.37. The computed results are in good agreement with observed data at this location (inflow to Lake Seminole). Observed data are relatively sparse.

Nutrient time series at locations with available data and longitudinal profiles of computed and observed nutrients and BOD from the Apalachicola River along the Chattahoochee and Flint Rivers are plotted in Figure 3.38 through Figure 3.55. Longitudinal profiles of computed and observed nutrients and BOD start on the Apalachicola River and proceed up the Chattahoochee River to Lake Lanier. Computed values are plotted as the 5^{th} percentile, median and 95^{th} percentile of results for the entire simulation period at each location along the profile. Plotted observed values are similarly the 5^{th} percentile, median and 95^{th} percentile of available observed data; therefore, three data points are plotted at each sampling location. Where more than three data points are present, two observation locations are very close together.

Nitrate concentrations are impacted by the treatment plant inflows (point loads) which are set at a constant concentration of 10 mg/L. At locations most influenced by these inflows, computed concentrations tend to be higher than observed. Computed nitrate in the Chattahoochee River at Whitesburg does not drop as low as some of the observed data, but otherwise corresponds well with the range of observed values. The sensitivity to the point source default nitrate concentration is demonstrated in Figure 3.39. A 50 % reduction in load results in a nearly 50% reduction in computed nitrate concentration. Since the point load flows are relatively constant, the temporal variation in the computed nitrate is due to dilution of non-point inflows and reservoir release rates. Computed nitrate at Columbus ranges from about 0.2 to 2.4 mg/L, whereas observed data only range from about 0.3 to 1.1 mg/L. Seasonal trends are reasonably well represented. At Steam Mill the model produces seasonal trends and low values that are in agreement with observed data, however the seasonal peaks (winter months with minimal biological uptake) are at times more than twice as high as observed. In the Flint River at Bainbridge, model results correspond only with the lowest observed values. In all stream locations, there is ample nitrate for phytoplankton growth throughout the year. A longitudinal profile of computed and observed nitrate in Apalachicola and Chattahoochee Rivers is shown in Figure 3.43. Model results show generally good agreement with the longitudinal trend. Highest values occur between Morgan Falls and West Point. Lowest values occur upstream at Buford Dam and reflect Lake Lanier photic zone concentrations. Peak values from the model are higher than observed downstream of West Point. The 95% values are dominated by winter concentrations when biological uptake is minimal.

Computed ammonia in the Chattahoochee River at Whitesburg is in agreement with observed data in 2000, well above observed in 2001 and 2002 and slightly higher than observed in 2003. The nature of the point load assumption (same inflow assumption for all years) makes it difficult to approximate all years. Computed ammonia at Columbus is reasonably within the range of observed data, although tends to not drop as low as the minimum observed values. At Steam Mill the model results are overall higher than observed. Steam Mill is located below a pulp mill and is influenced by the default pulp mill ammonia concentration of 4 mg/L. The large fluctuation in the computed ammonia is due to weekday and weekend flow differences caused by reservoir operation. Figure 3.47 demonstrates the influence of the pulp mill discharge assumption. The minimum observed values are more closely approximated but the higher values are not. These sensitivity results suggest that the pulp mill discharge is variable in flow and quality. In the Flint River at Bainbridge (Figure 3.48), model results correspond well with observed values. Nearly all of the measured and observed data are less than 0.1 mg/L.

A longitudinal profile of computed and observed ammonia in Apalachicola and Chattahoochee Rivers is shown in Figure 3.49. The computed and observed results are in general agreement.

Computed phosphate in the Chattahoochee River at Whitesburg (Figure 3.50) is generally slightly higher than observed. The maximum observed values exceed the computed. The computed phosphate exceeds the observed throughout most of the simulation period at both Columbus (Figure 3.51) and Steam Mill (Figure 3.52), as well as in the Flint River at Bainbridge (Figure 3.53). The higher than observed computed phosphate concentration tends to accentuate phytoplankton production and accentuates the impacts of system operation resulting in a more conservative analysis when comparing alternatives.

A longitudinal profile of computed and observed phosphate in Apalachicola and Chattahoochee Rivers is shown in Figure 3.54. The observed and model concentrations exhibit the same general trends progressing downstream. The observed data show more variability than the computed values.

A longitudinal profile of computed and observed BOD in Apalachicola and Chattahoochee Rivers is shown in Figure 3.55. There are no strong trends in either the computed or observed data. Computed median and 95th percentile results tend to be lower than observed suggesting that the point load inflow characteristics do not capture the normal variability (as expected).

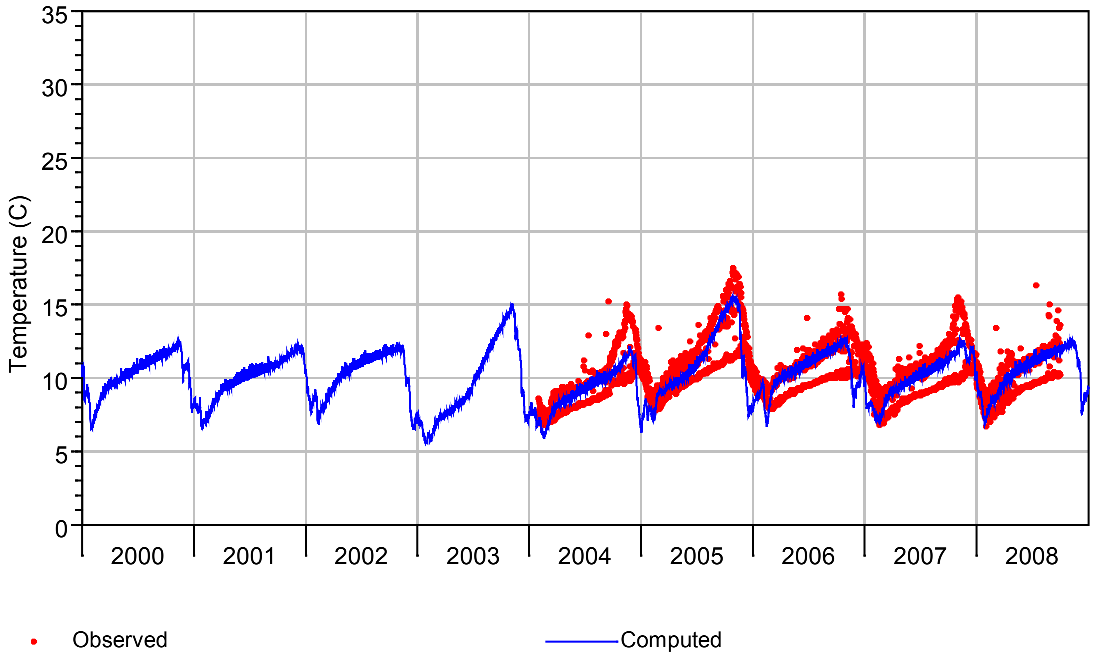


Figure 3.22 Computed and observed temperature time series on the Chattahoochee River at Buford dam tailwater.

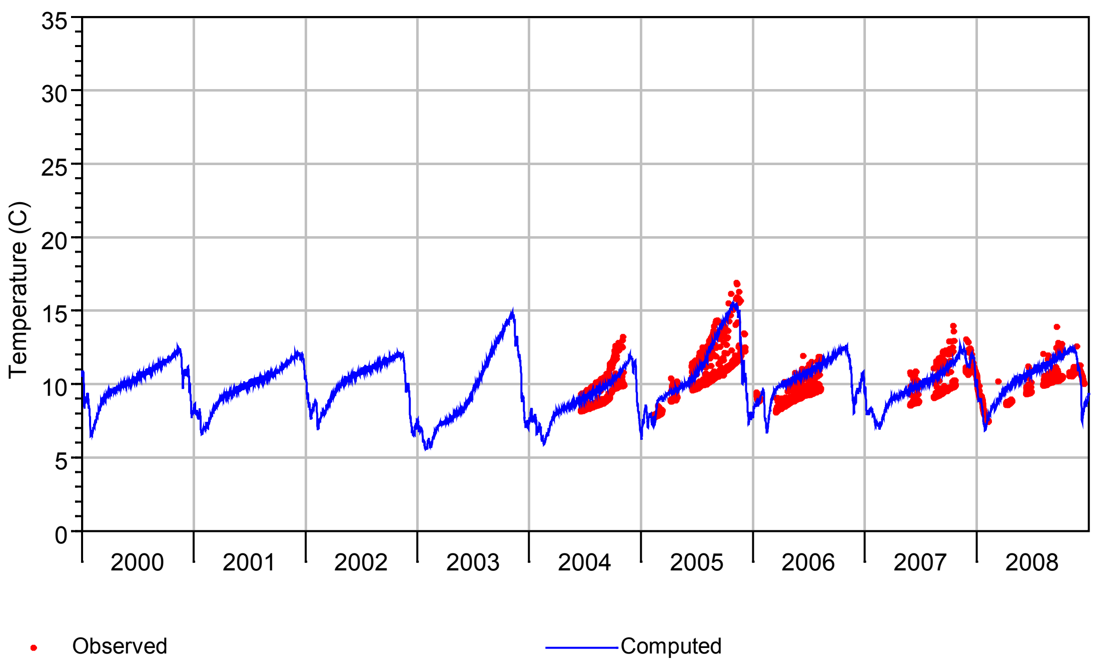


Figure 3.23 Computed and observed temperature time series on the Chattahoochee River at Buford.

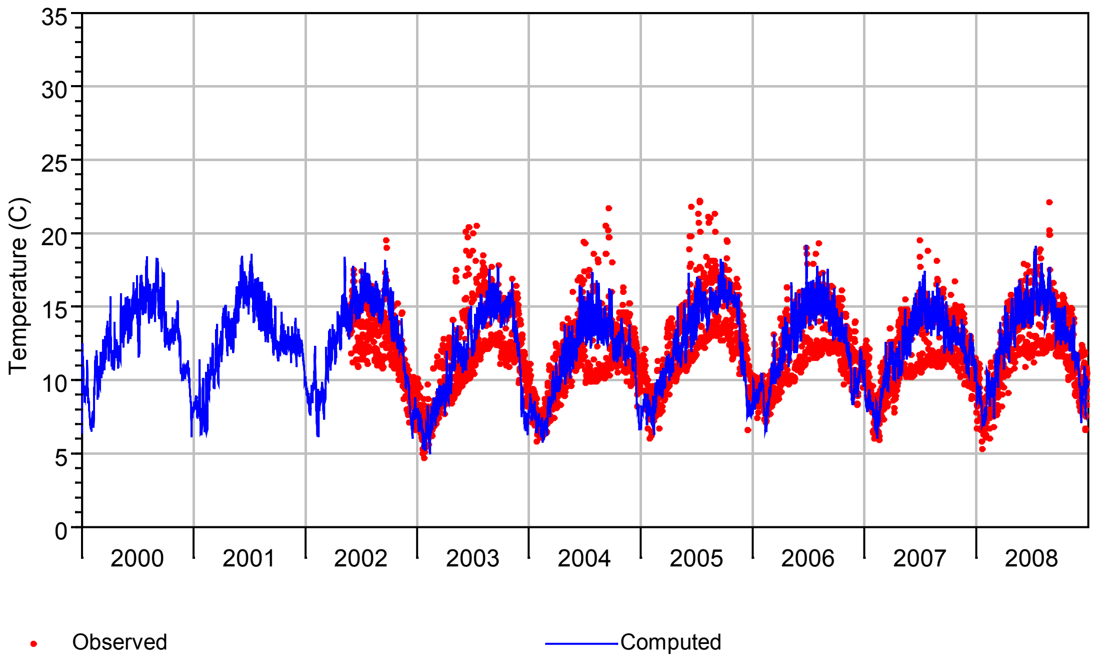


Figure 3.24 Computed and observed temperature time series on the Chattahoochee River at Norcross.

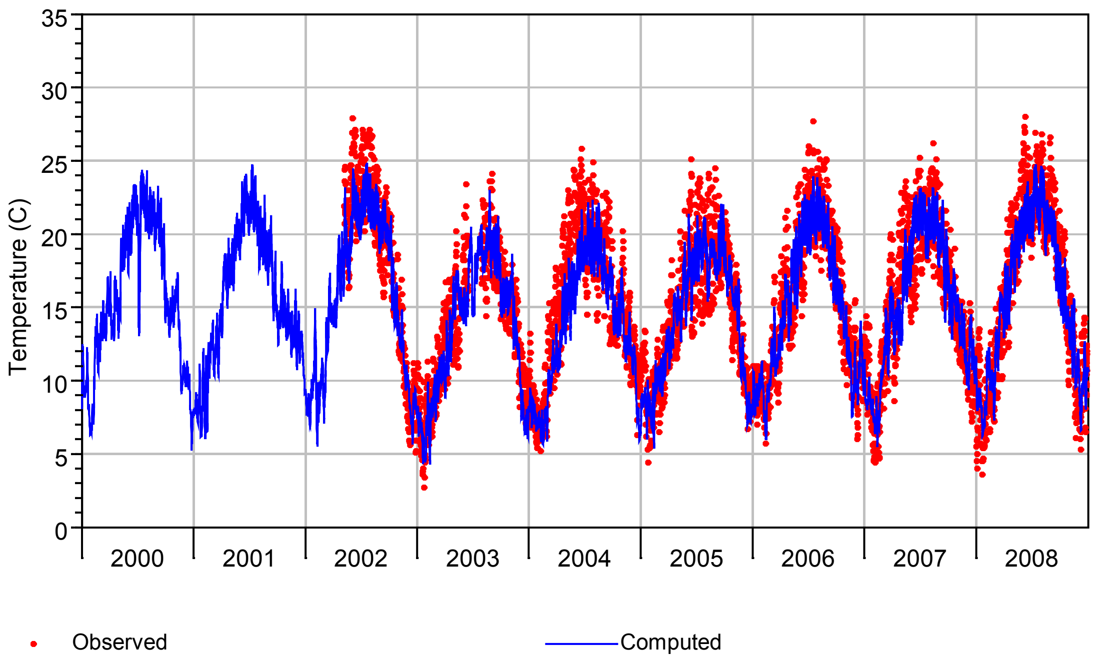


Figure 3.25 Computed and observed temperature time series on the Chattahoochee River at Atlanta.

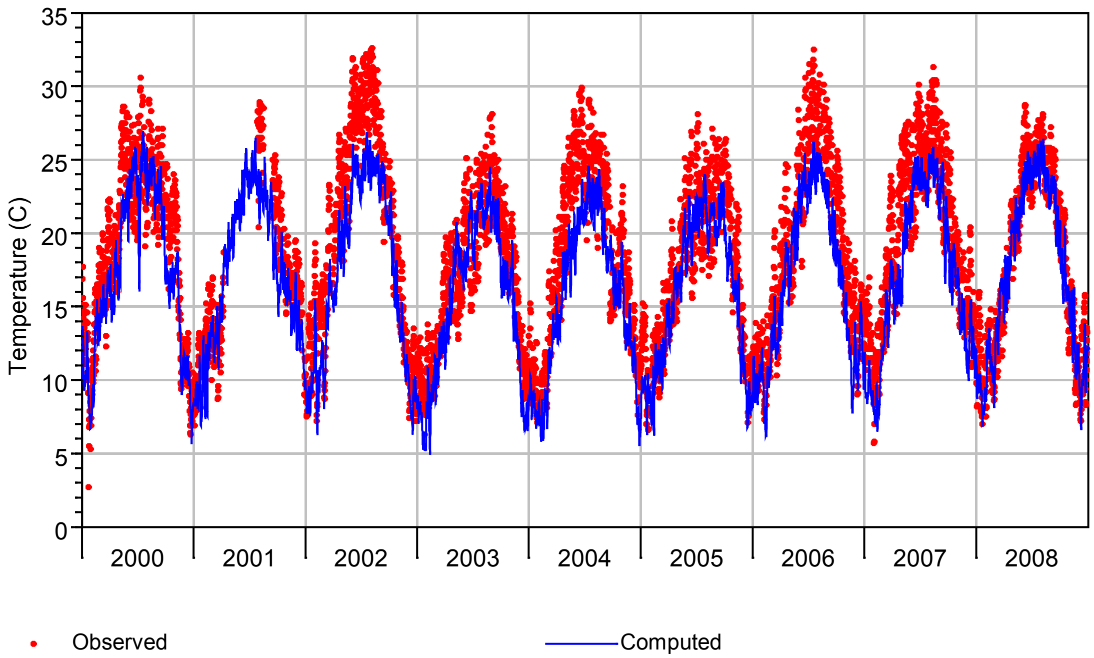


Figure 3.26 Computed and observed temperature time series on the Chattahoochee River at Fairburn.

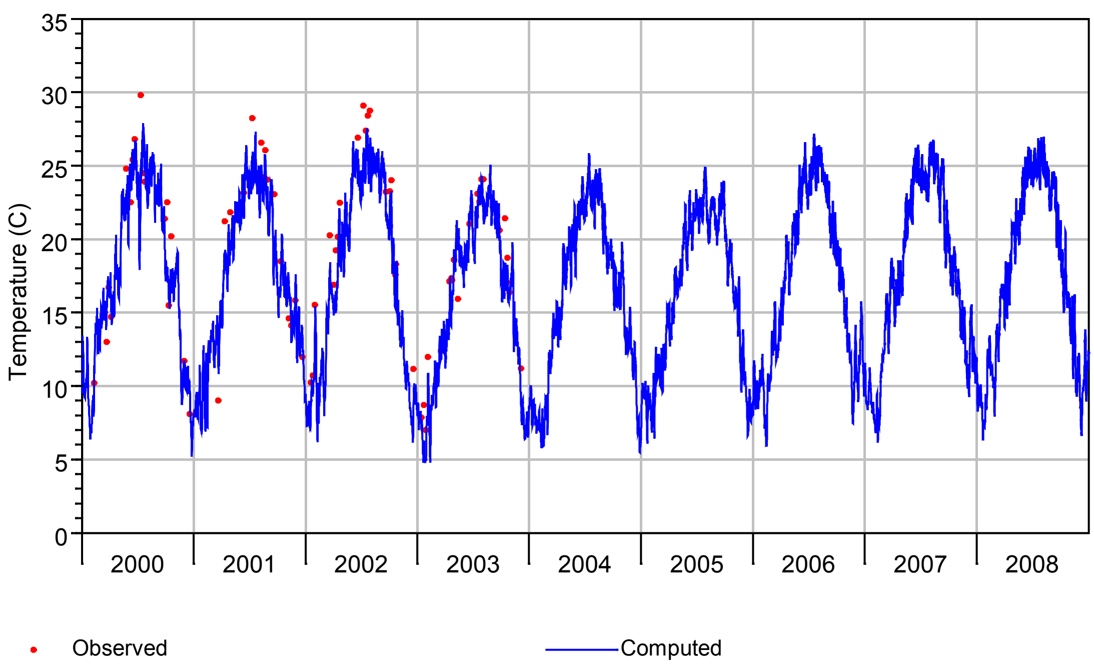


Figure 3.27 Computed and observed temperature time series on the Chattahoochee River at Whitesburg.

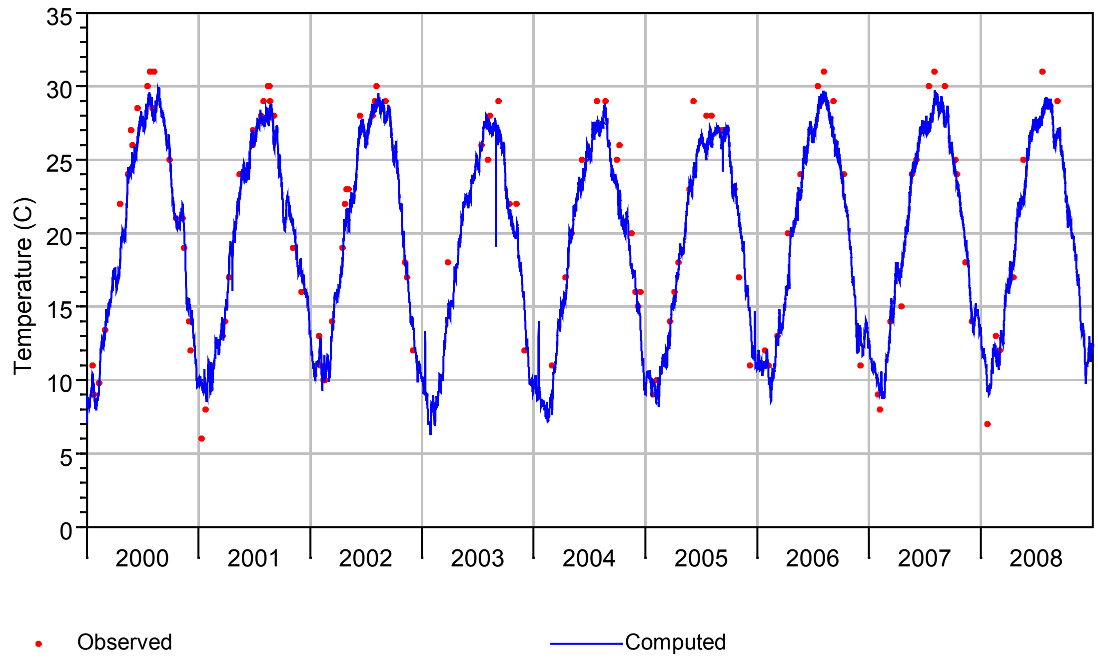


Figure 3.28 Computed and observed temperature time series on the Chattahoochee River at Columbus.

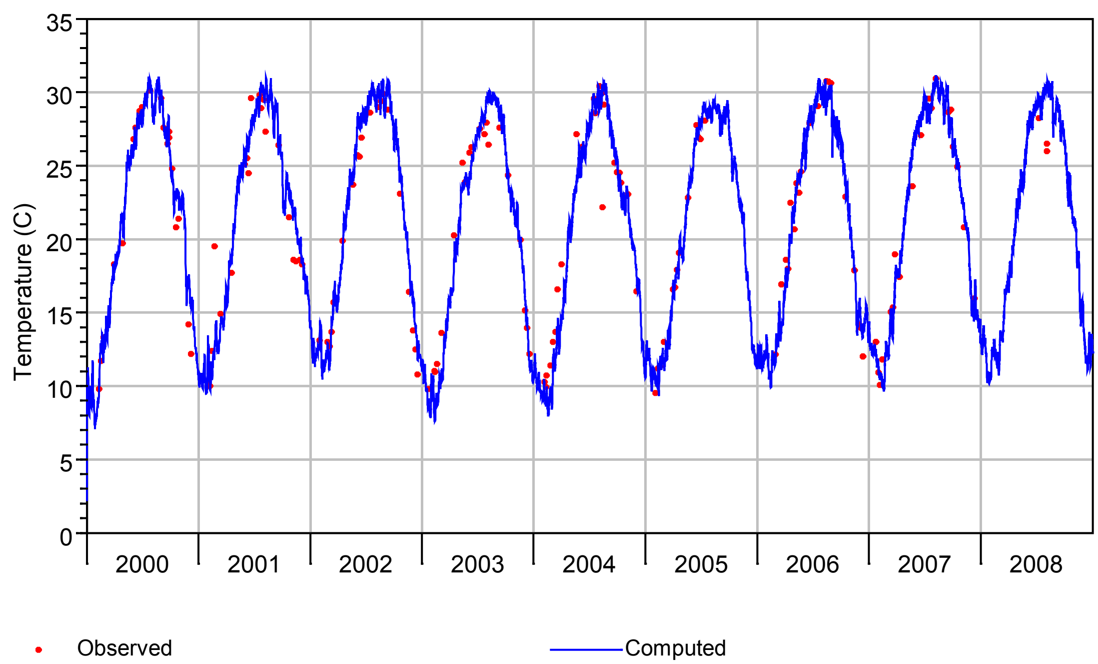


Figure 3.29 Computed and observed temperature time series on the Chattahoochee River at Steam Mill.

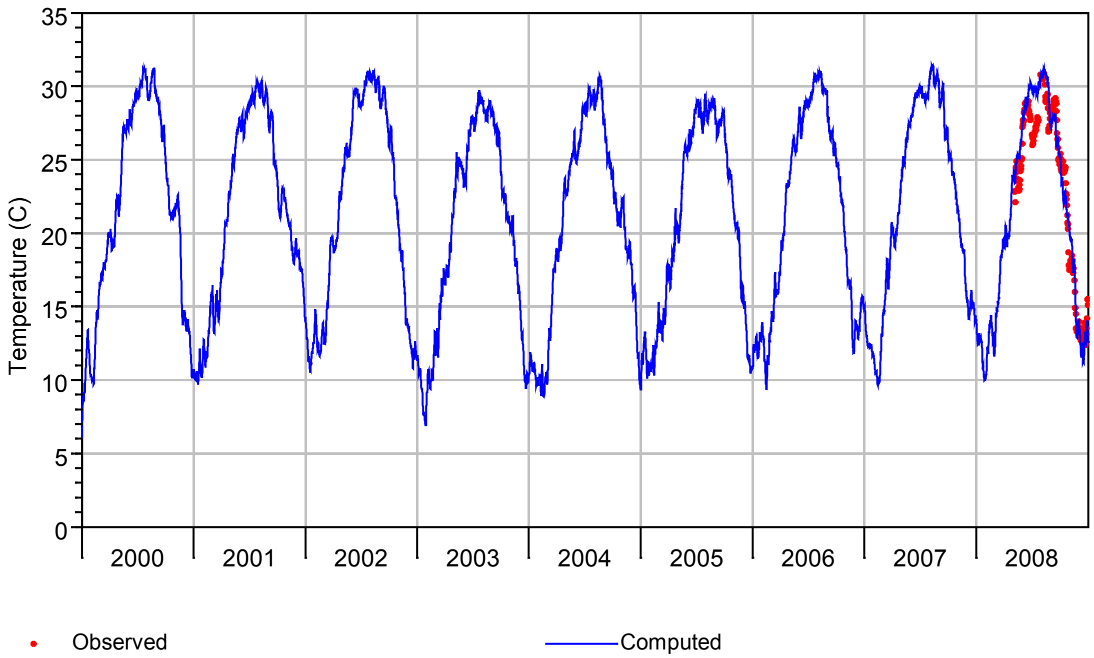


Figure 3.30 Computed and observed temperature time series on the Apalachicola River at Jim Woodruff Dam tailwater.

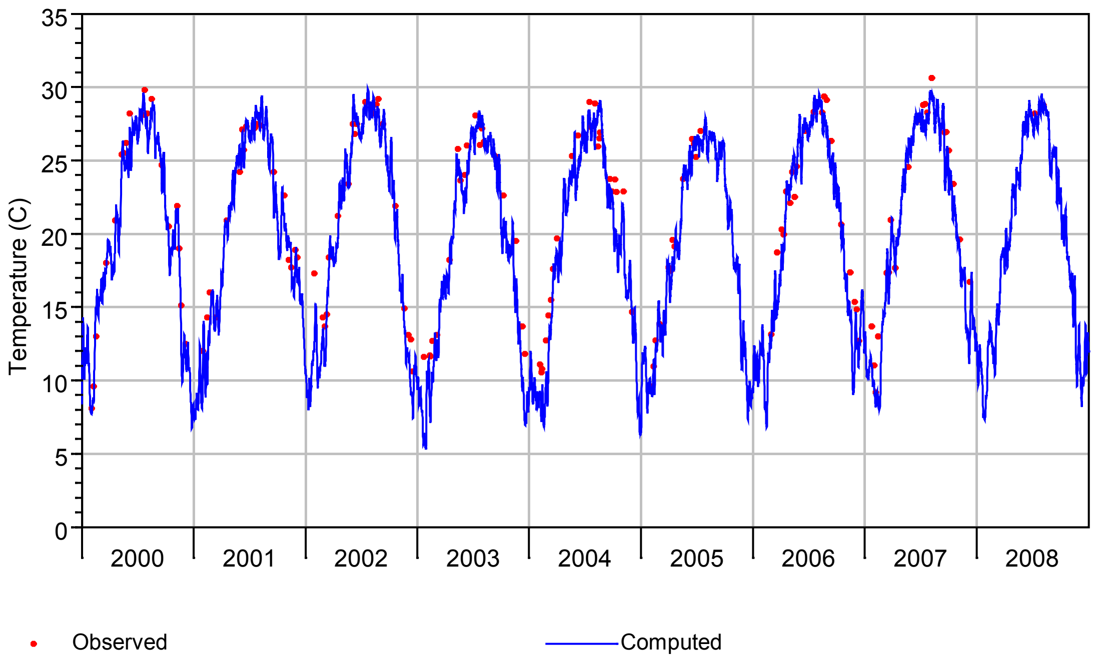


Figure 3.31 Computed and observed temperature time series on the Flint River at Bainbridge.

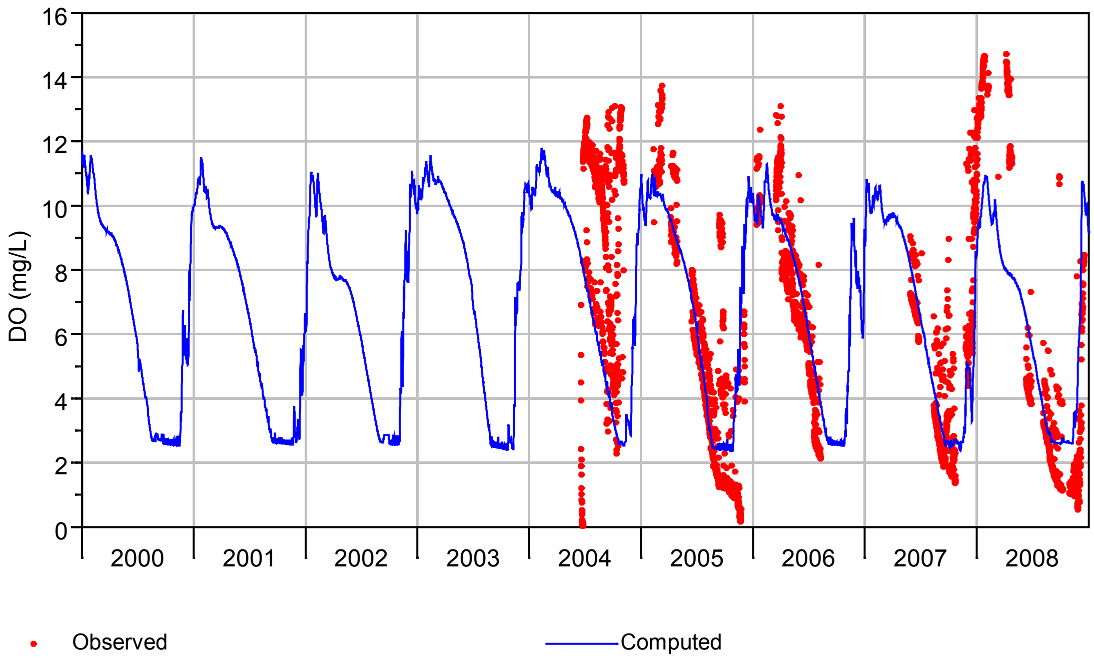


Figure 3.32 Computed and observed DO time series on the Chattahoochee River below Buford Dam.

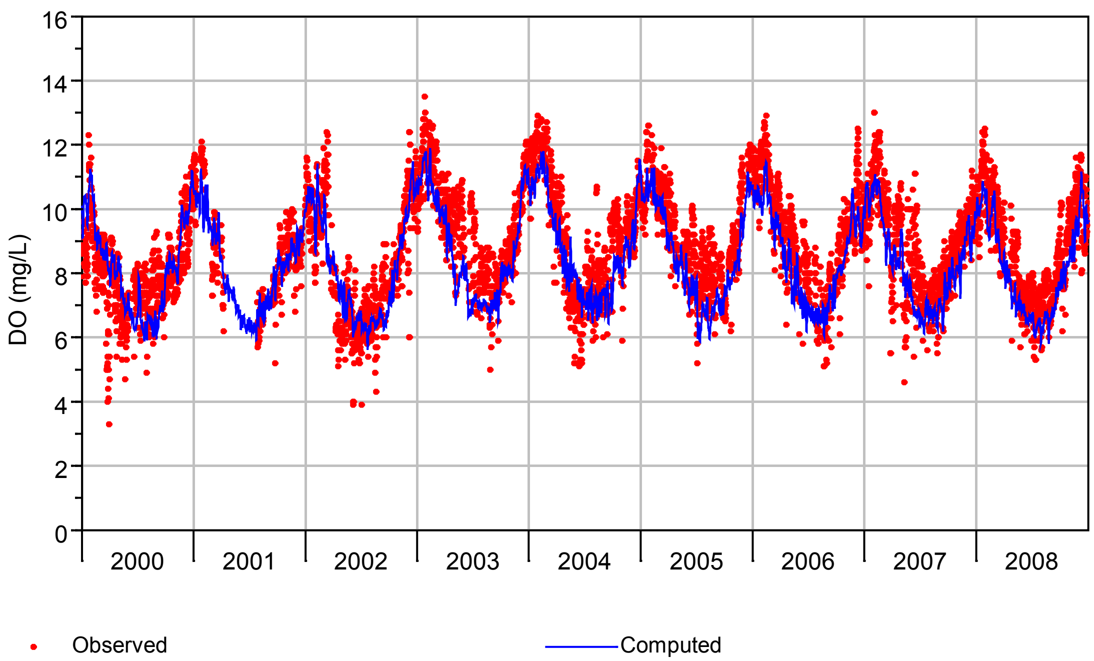


Figure 3.33 Computed and observed DO time series on the Chattahoochee River at Fairburn.

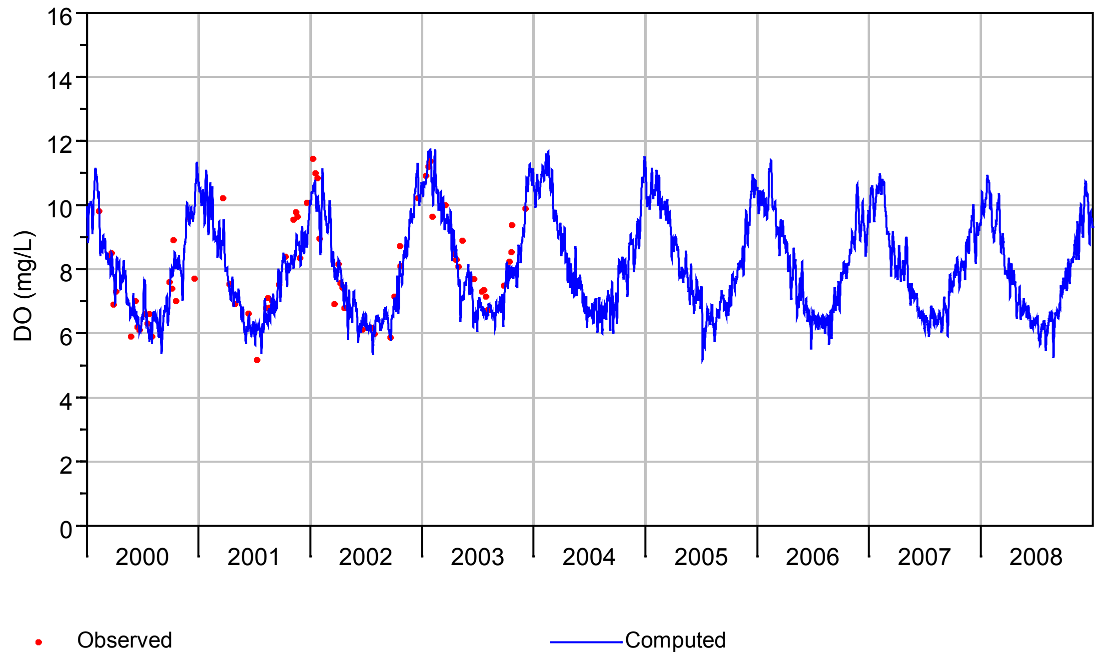


Figure 3.34 Computed and observed DO time series on the Chattahoochee River at Whitesburg.

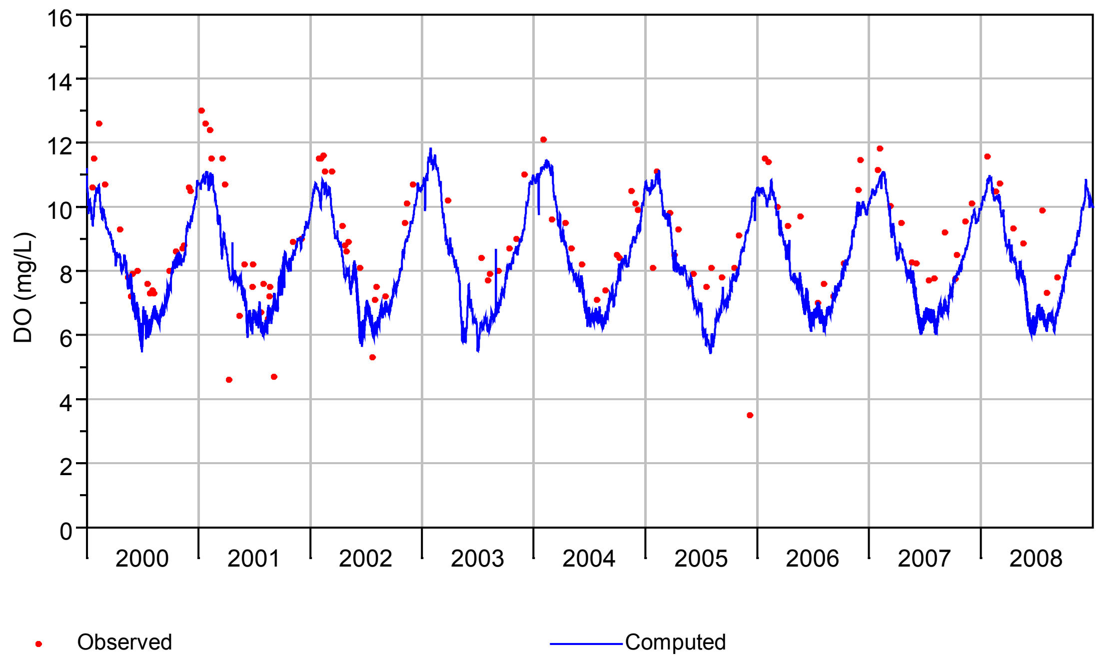


Figure 3.35 Computed and observed DO time series on the Chattahoochee River at Columbus.

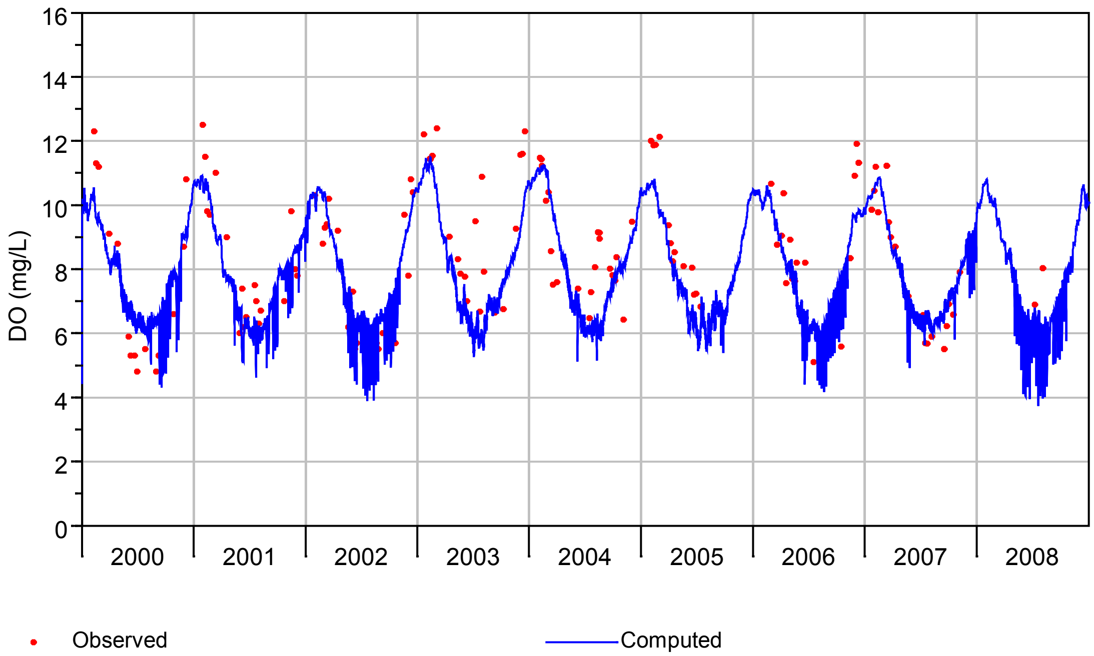


Figure 3.36 Computed and observed DO time series on the Chattahoochee River at Steam Mill.

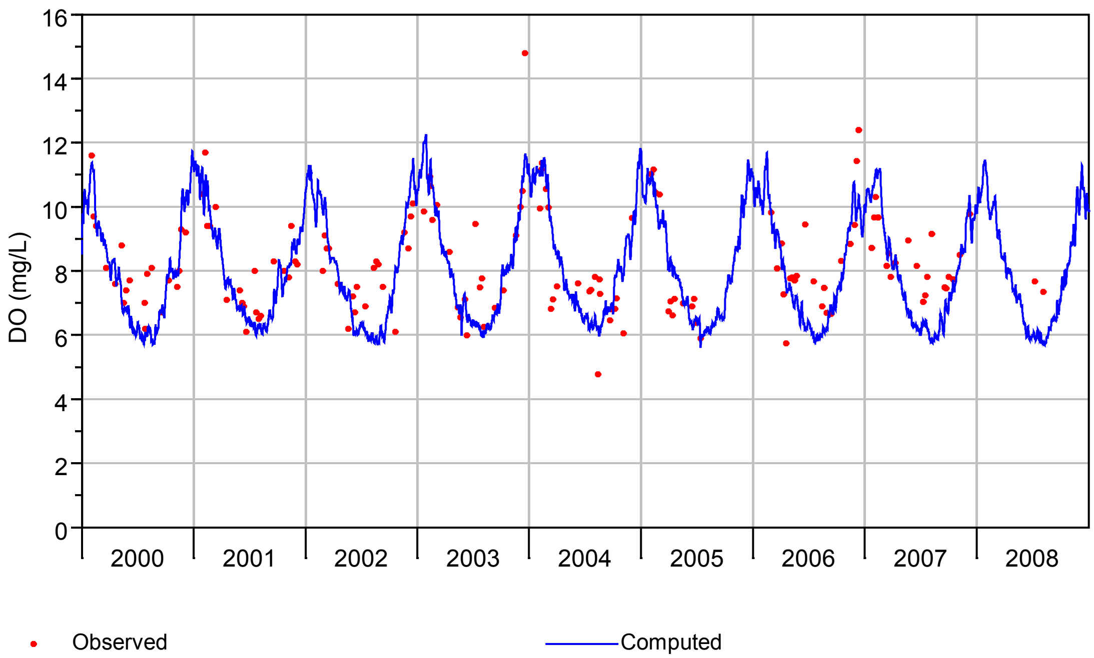


Figure 3.37 Computed and observed DO time series on the Flint River at Bainbridge.

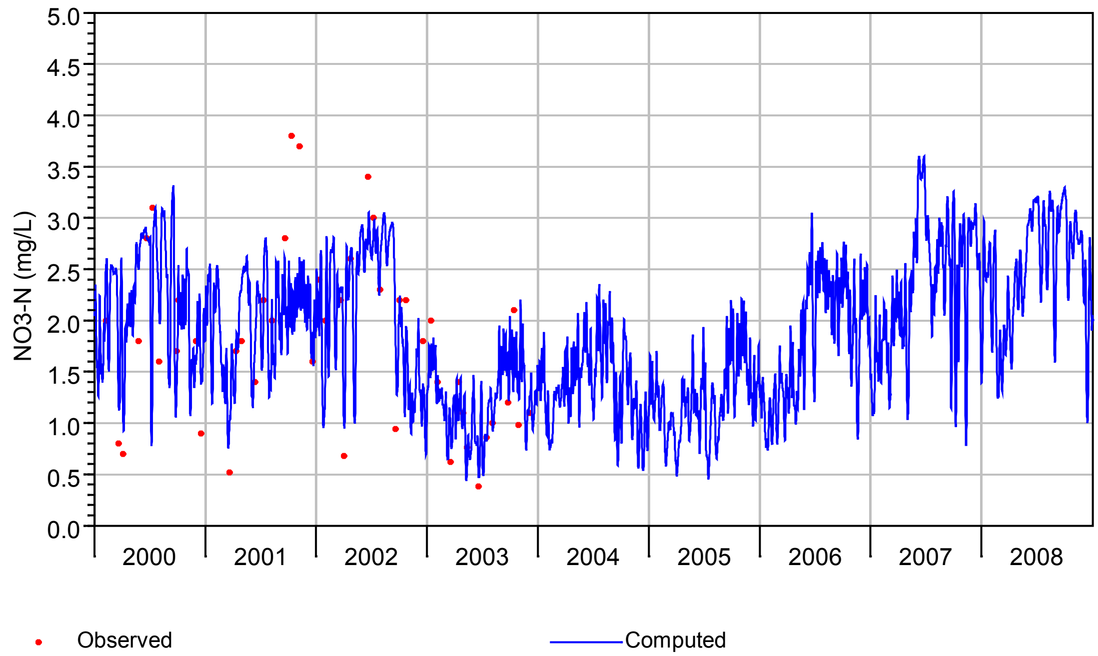


Figure 3.38 Computed and observed nitrate in the Chattahoochee River at Whitesburg.

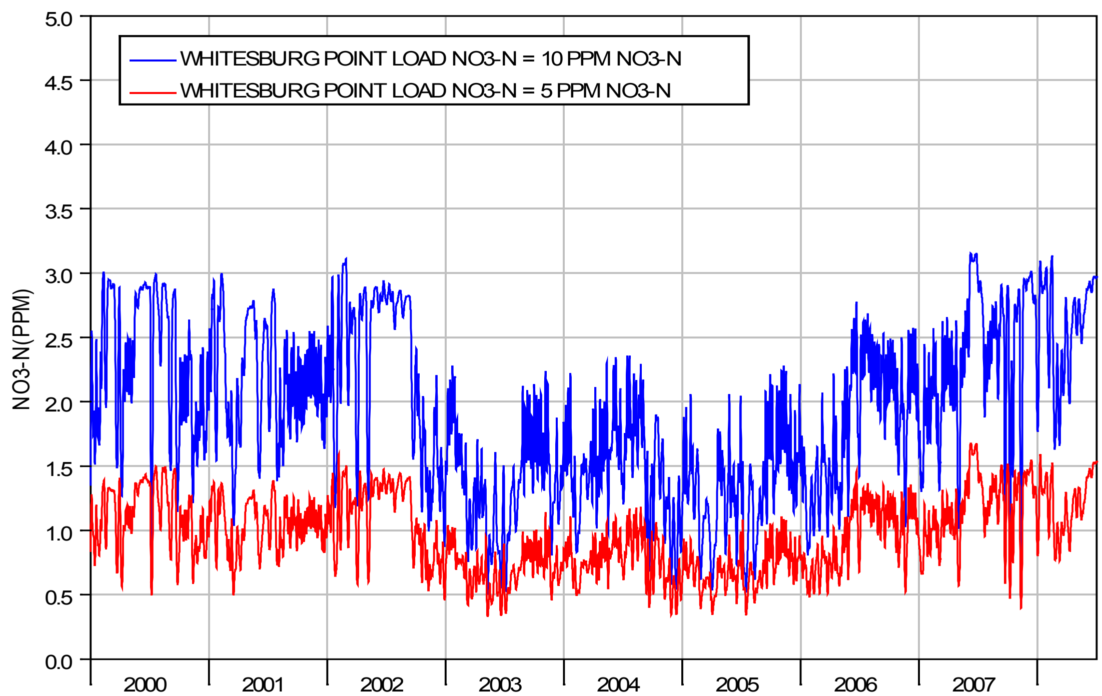


Figure 3.39 Time series of computed nitrate at Whitesburg Point illustrating sensitivity to point source NO3 default value – 5 mg/L versus 10 mg/L.

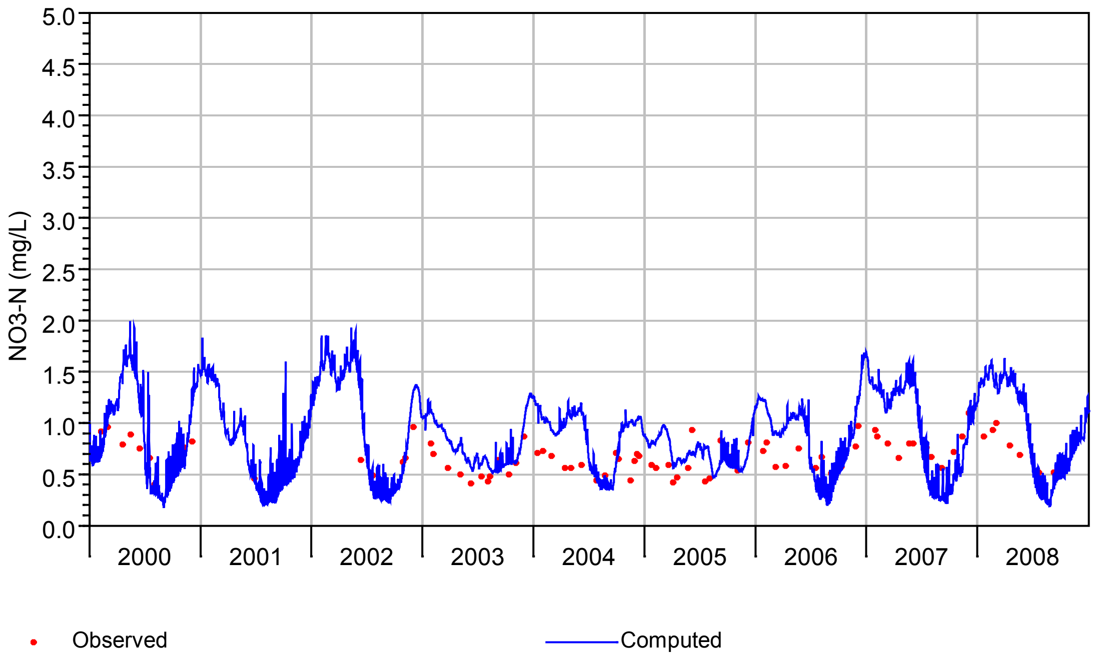


Figure 3.40 Computed and observed nitrate in the Chattahoochee River at Columbus.

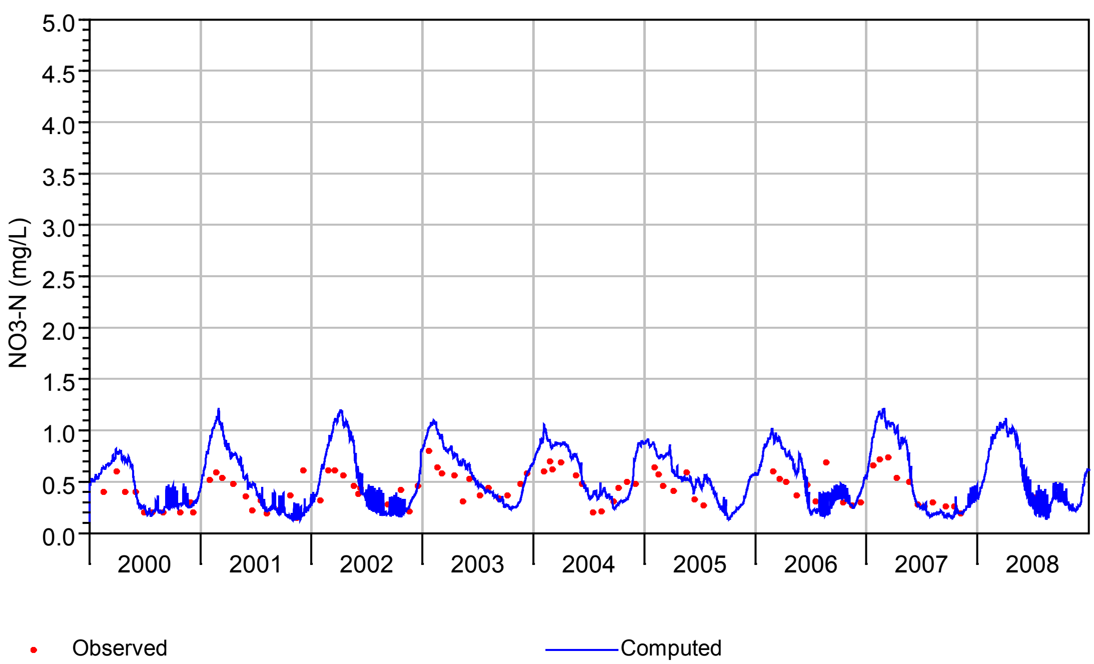


Figure 3.41 Computed and observed nitrate in the Chattahoochee River at Steam Mill.

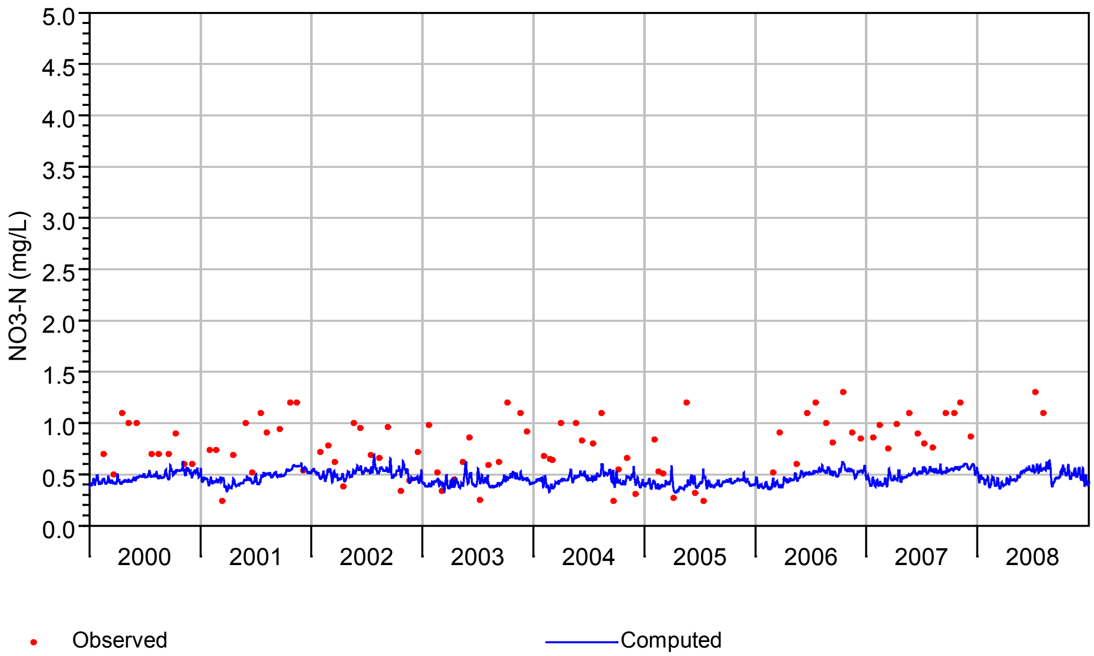


Figure 3.42 Computed and observed nitrate in the Flint River at Bainbridge.

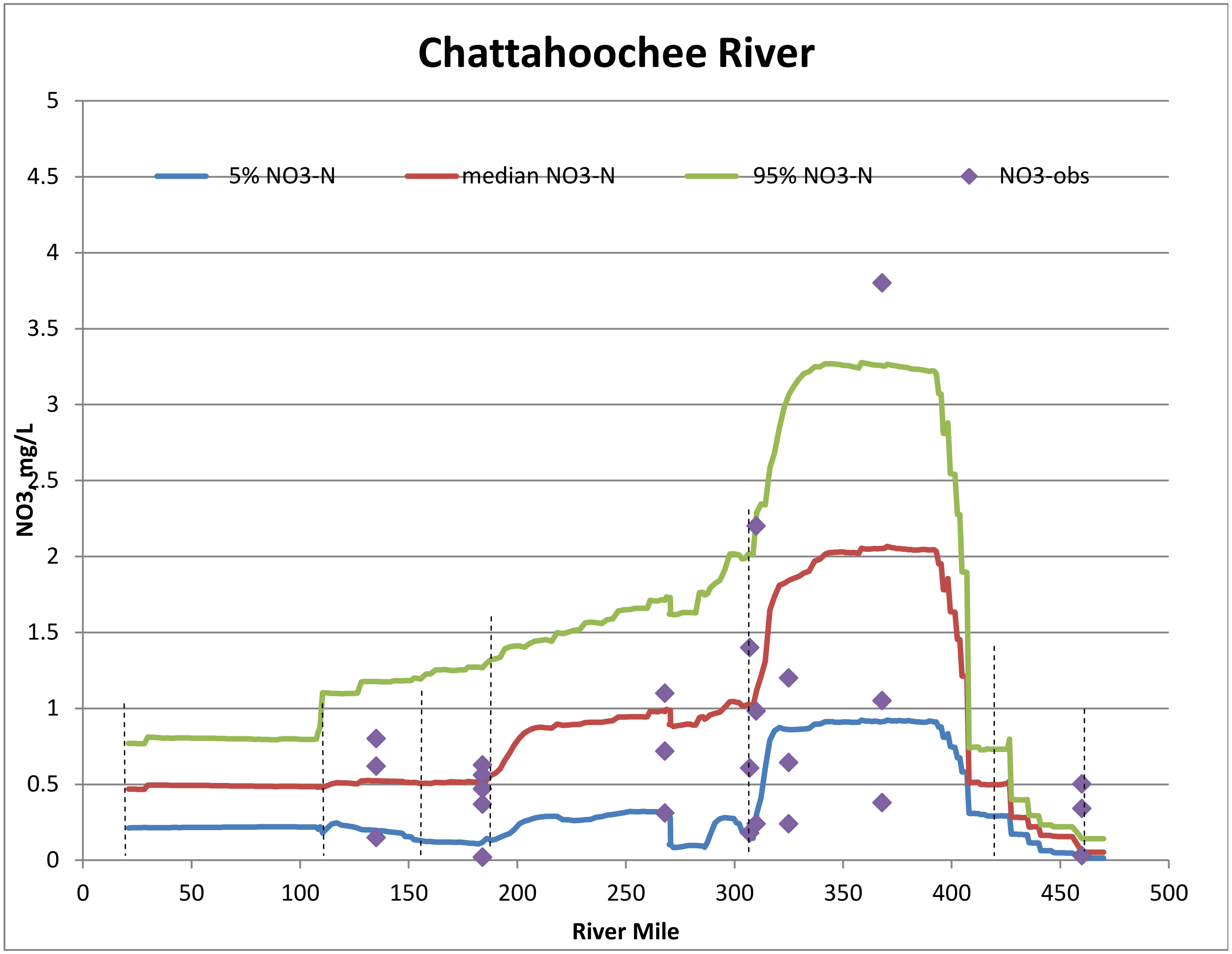


Figure 3.43 Longitudinal profile of observed and computed nitrate in Chattahoochee River up to river mile 460. All data are plotted as 5% occurrence, median and 95% occurrence.

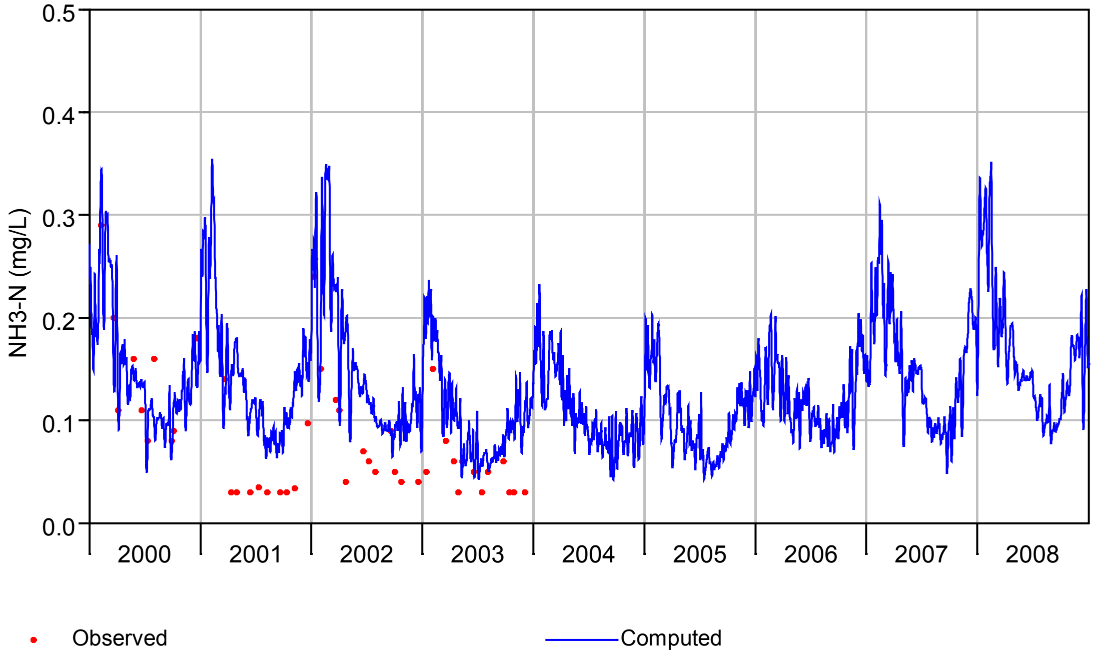


Figure 3.44 Computed and observed ammonia in the Chattahoochee River at Whitesburg.

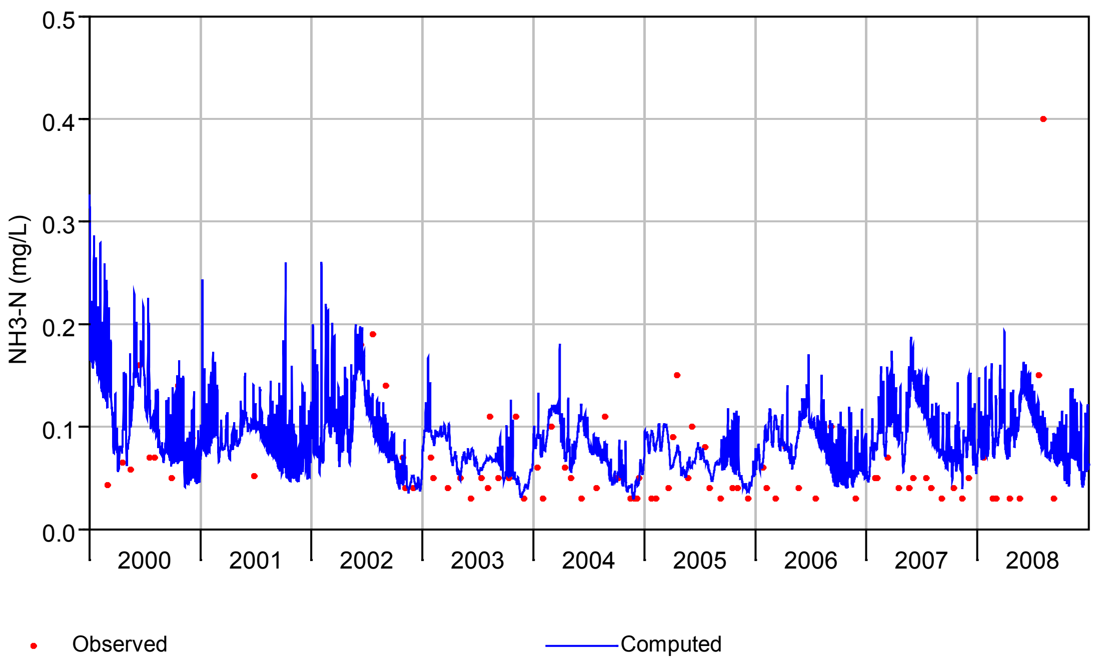


Figure 3.45 Computed and observed ammonia in the Chattahoochee River at Columbus.

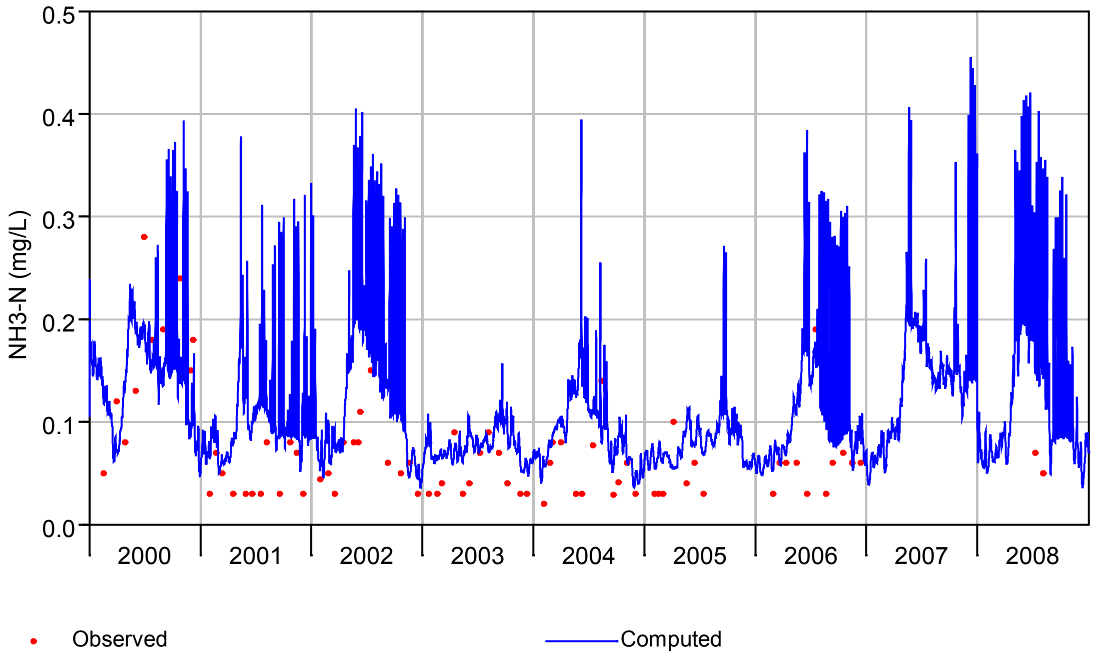


Figure 3.46 Computed and observed ammonia in the Chattahoochee River at Steam Mill.

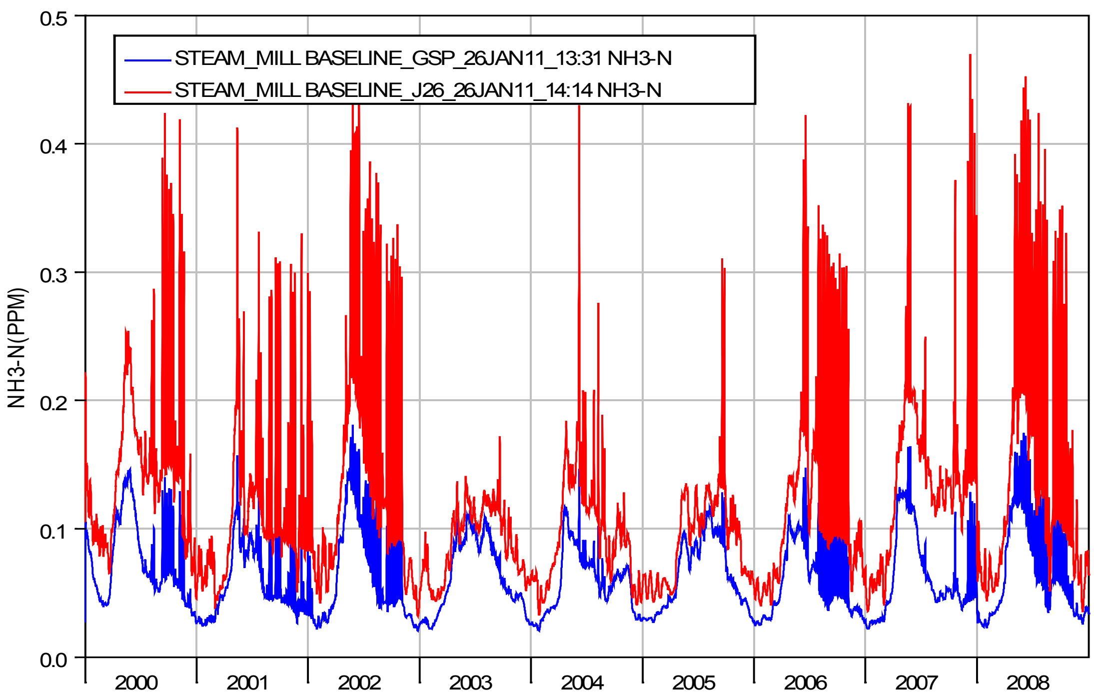


Figure 3.47 Time series of computed ammonia at Steam Mill illustrating sensitivity of ammonia to paper mill ammonia default value (4.0 mg/L versus 1.0 mg/L).

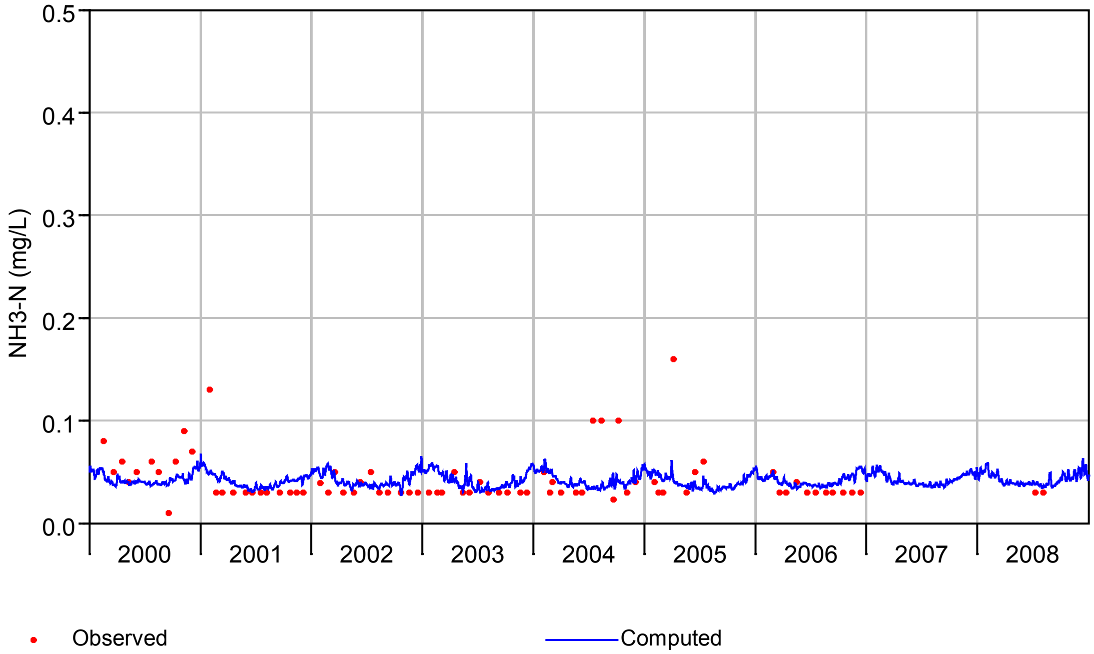


Figure 3.48 Computed and observed ammonia in the Flint River at Bainbridge.

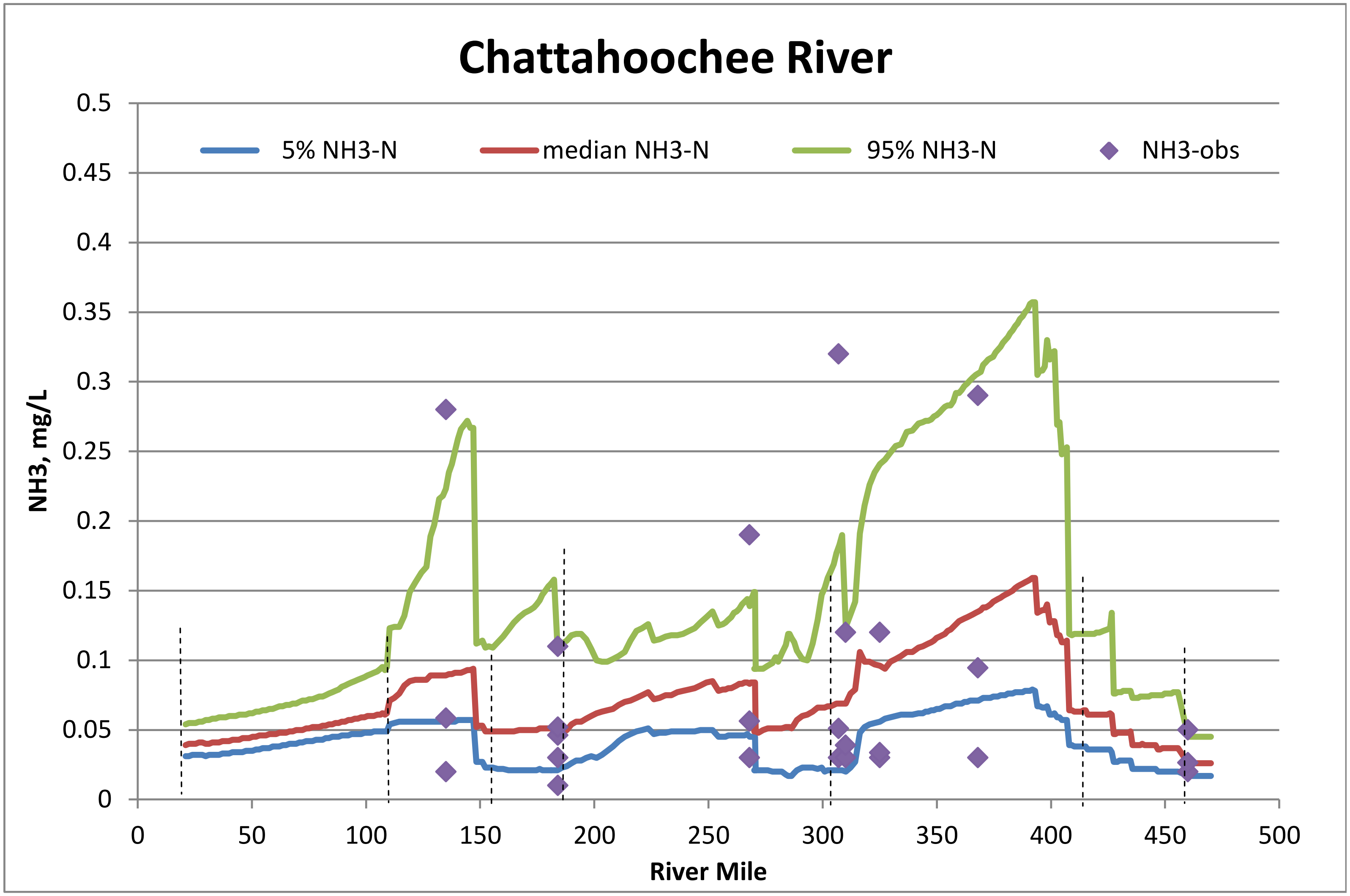


Figure 3.49 Longitudinal profile of observed and computed ammonia in Chattahoochee River up to river mile 460. All data are plotted as 5% occurrence, median and 95% occurrence.

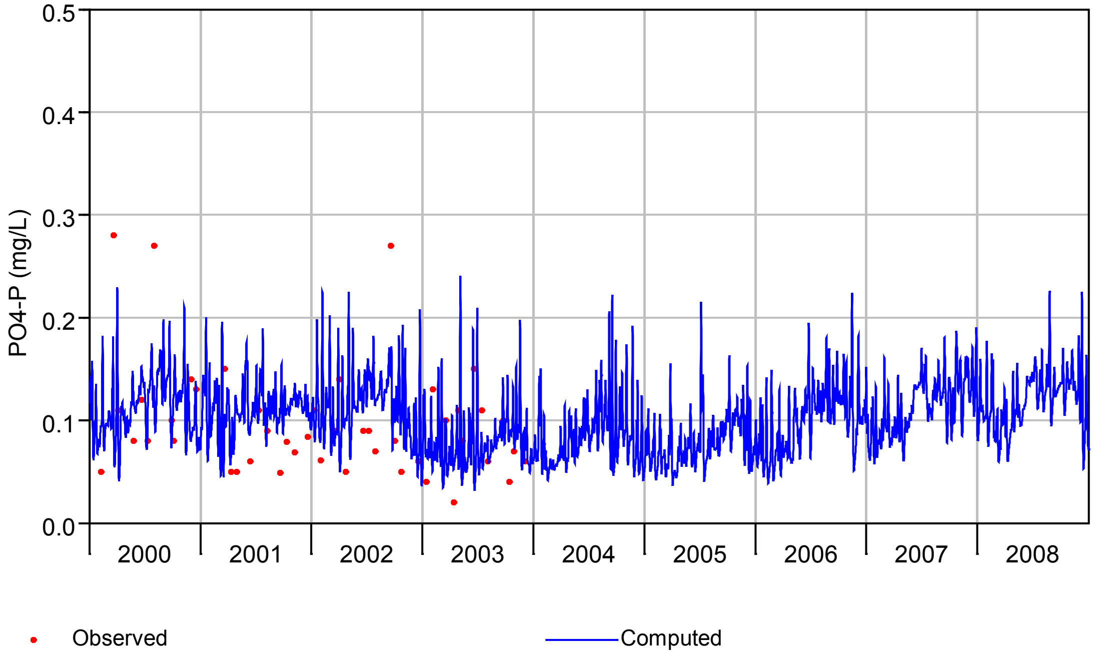


Figure 3.50 Computed and observed phosphate in Chattahoochee River at Whitesburg.

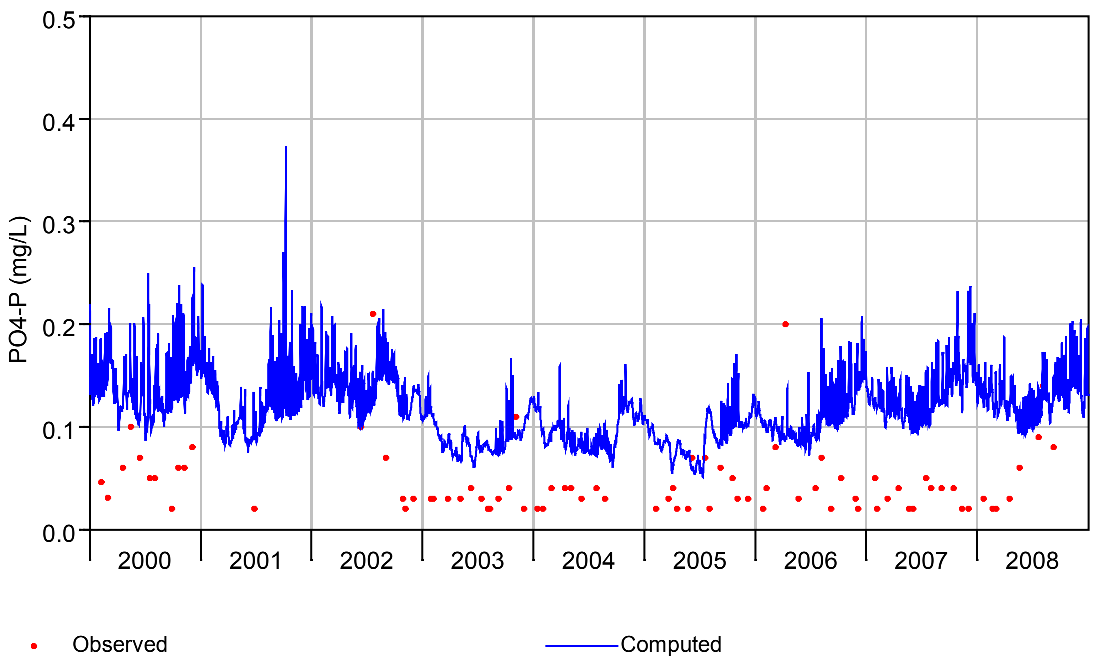


Figure 3.51 Computed and observed phosphate in Chattahoochee River at Columbus.

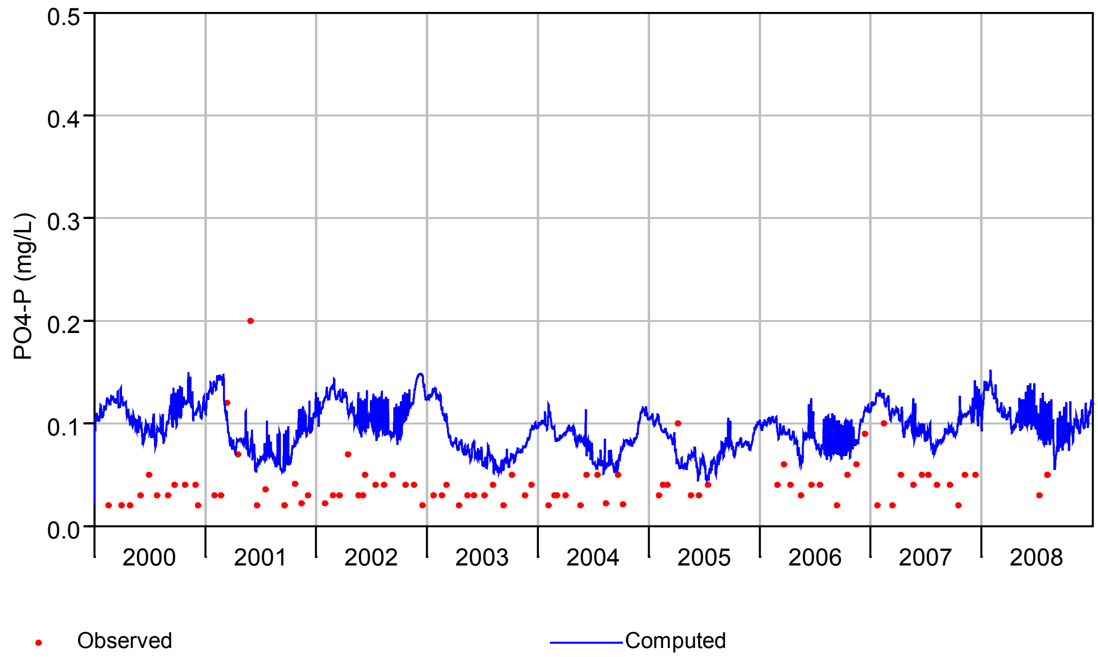


Figure 3.52 Computed and observed phosphate in Chattahoochee River at Steam Mill.

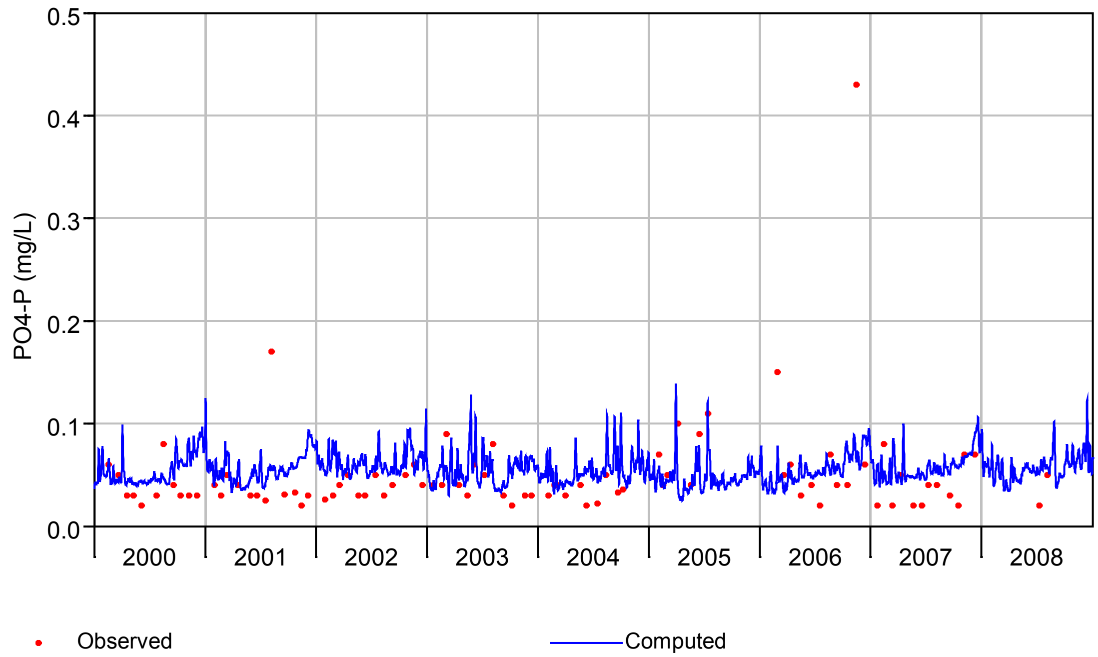


Figure 3.53 Computed and observed phosphate in the Flint River at Bainbridge.

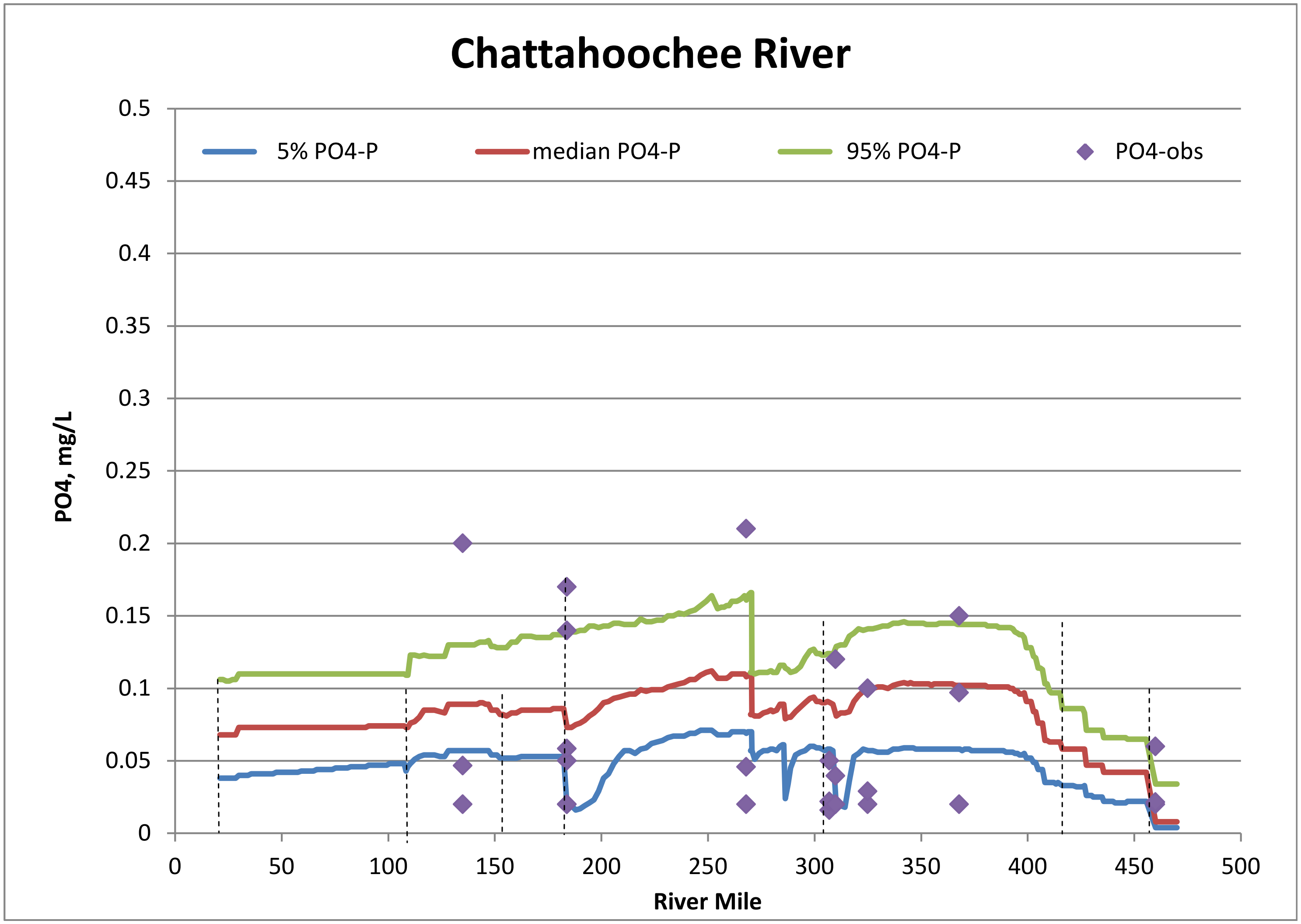


Figure 3.54 Longitudinal profile of observed and computed phosphate in Chattahoochee River up to river mile 460. All data are plotted as 5% occurrence, median and 95% occurrence.

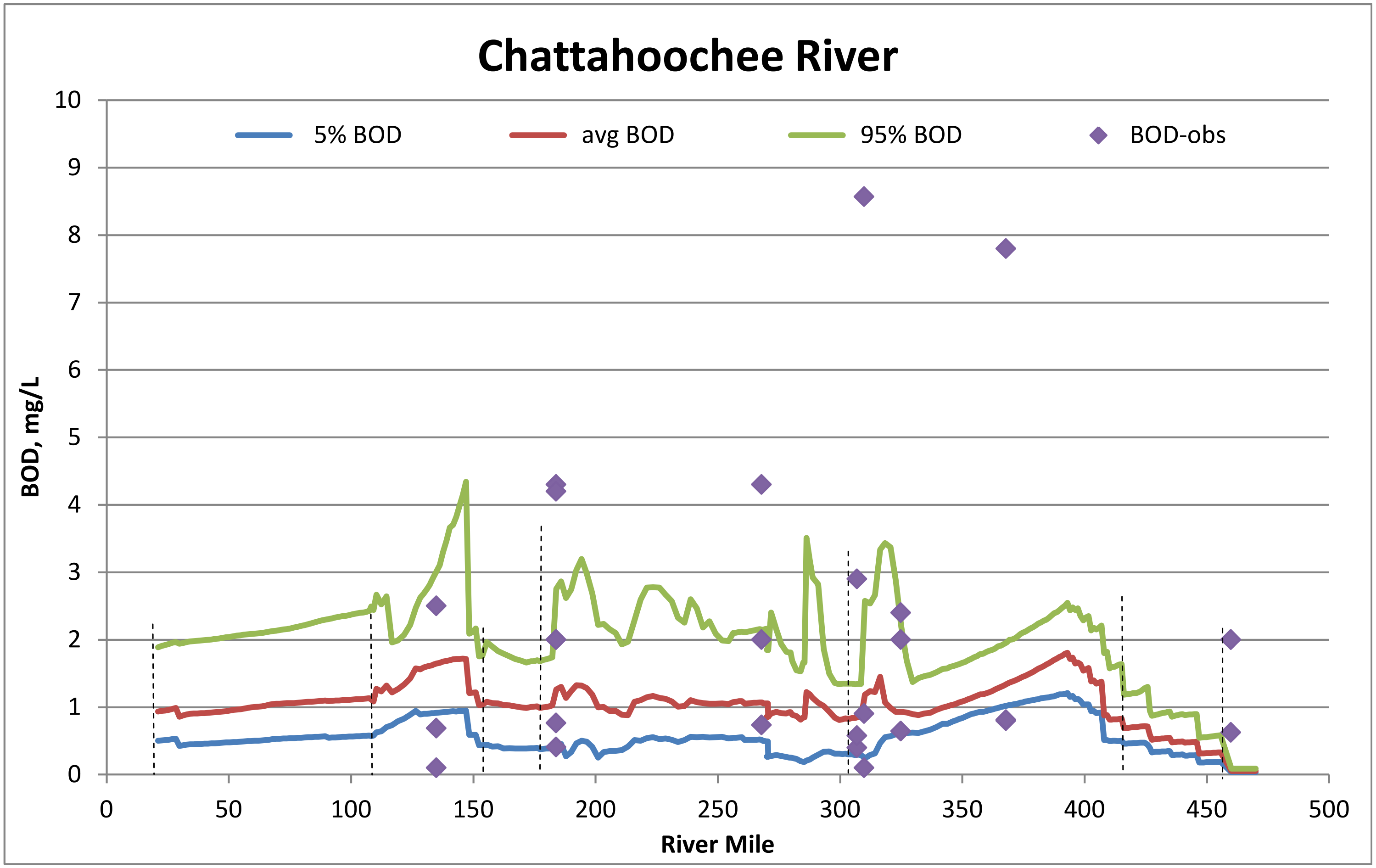


Figure 3.55 Longitudinal profile of observed and computed BOD in Chattahoochee River up to river mile 460. All data are plotted as 5% occurrence, median and 95% occurrence.

4 MODEL RESULTS

HEC-5Q was used to simulate water quality in the ACF basin for the No Action plan and each of eight study alternatives. These results consist of plots of time series, cumulative percentage occurrence by station, and longitudinal profiles of percent occurrence of each water quality parameter. The details of these results are outlined below, and representative plots are shown. All plots and the HEC-DSS files used to create the plots are available upon request. The model output in the DSS files may be viewed in tabular form or plotted using HEC-DSSVue. This program may be downloaded from: http://www.hec.usace.army.mil/software/hec-dssvue/downloads.aspx

The simulation results for stream sections represent the average concentration 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 ft) of each reservoir.

Time series were output for several model locations along the Chattahoochee, Flint, and Apalachicola 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 the percent occurrence was computed for several different annual and seasonal periods and plotted by river mile to create longitudinal occurrence profiles for each parameter. The definition of each plot type and the various computation periods applied to derive each set of plots are detailed in the following sections.

Table 4.1 Time Series Output Locations (Upstream to Downstream)

River (A Part)	River Mile (HEC-5Q)	Location	DSS Path Identifier
Chattahoochee	460.0	Lake Lanier (Buford Dam)	BUFORD_LAKE
Chattahoochee	455.6	Buford Outflow	BUFORD_OUT
Chattahoochee	438.1	Norcross	NORCROSS
Chattahoochee	419.9	Morgan Falls	MORGAN_FALLS
Chattahoochee	410.2	Atlanta	ATLANTA
Chattahoochee	368.2	Whitesburg	WHITESBURG
Chattahoochee	325.0	West Point Mid-lake	WEST_PT_MID
Chattahoochee	310.2	West Point Dam	WEST_PT_DAM
Chattahoochee	308.6	West Point Outflow	WEST_PT_OUT
Chattahoochee	286.3	Bartlett's Ferry Dam	BARTLETTS_DAM
Chattahoochee	285.5	Bartlett's Ferry Outflow	BARTLETTS_OUT
Chattahoochee	267.1	Columbus	COLUMBUS
Chattahoochee	218.4	W.F. George Mid-lake	WFGEORGE_MID
Chattahoochee	183.9	W.F. George Dam	WFGEORGE_DAM
Chattahoochee	182.3	W.F. George Outflow	WFGEORGE_OUT

Chattahoochee	155.5	George Andrews Dam	GEORGEAN_DAM
Chattahoochee	153.7	George Andrews Outflow	GEORGEAN_OUT
Chattahoochee	135.0	Jim Woodruff Inflow	JIM_WOOD_IN
Apalachicola	108.3	Jim Woodruff Dam	JIM_WOOD_DAM
Apalachicola	107.4	Jim Woodruff Outflow	JIM_WOOD_OUT
Apalachicola	78.1	Blountstown	BLOUNTSTOWN
Apalachicola	20.3	Sumatra	SUMATRA
Flint	288.4	Montezuma	MONTEZUMA
Flint	209.9	Albany	ALBANY
Flint	139.1	Bainbridge	BAINBRIDGE

Table 4.2 Water quality parameters modeled by HEC-5Q.

Water Quality Parameter
• Water Temperature
• Dissolved Oxygen (DO)
• 5-Day Uninhibited BOD (BOD5U)
• Nitrate as Nitrogen (NO3-N)
• Ammonia as Nitrogen (NH3-N)
• Orthophosphate as Phosphorous (PO4-P)
• Phytoplankton (Algae), reported as Chlorophyll a
• Municipal and Industrial (M&I) Wastewater as % of Flow

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.

4.1 TIME SERIES

Time series are shown for each parameter computed for the 2001–2011 model period. A time series plot was created for each location (Table 4.1) along the Chattahoochee, Flint, and Apalachicola Rivers. Each of the water quality parameters shown in Table 4.2 was plotted.

Representative time series plots of DO, Chlorophyll *a*, and temperature are shown in Figure 4.1 – Figure 4.6 at two sample stations (Lake Lanier and Whitesburg) along the Chattahoochee River. To improve the clarity of the plots, four sets were plotted. Each set contains the No Action Alternative (NAA). The first set contains all ten alternatives. The other three sets contain the NAA plus three alternatives each. The alternatives comprising each set are as follows:

Set 1: 1A (NAA), 1L, 7A, 7B, 7H, 7I, 7J, 7K (PAA), 7L, 7M

Set 2: 1A (NAA), 1L, 7A, 7B

Set 3: 1A (NAA), 7H, 7I, 7J

Set 4: 1A (NAA), 7K (PAA), 7L, 7M

Examples of the second and fourth sets are shown in Figure 4.1 – Figure 4.6. All plots were provided to the EIS team for analysis and are available by request.

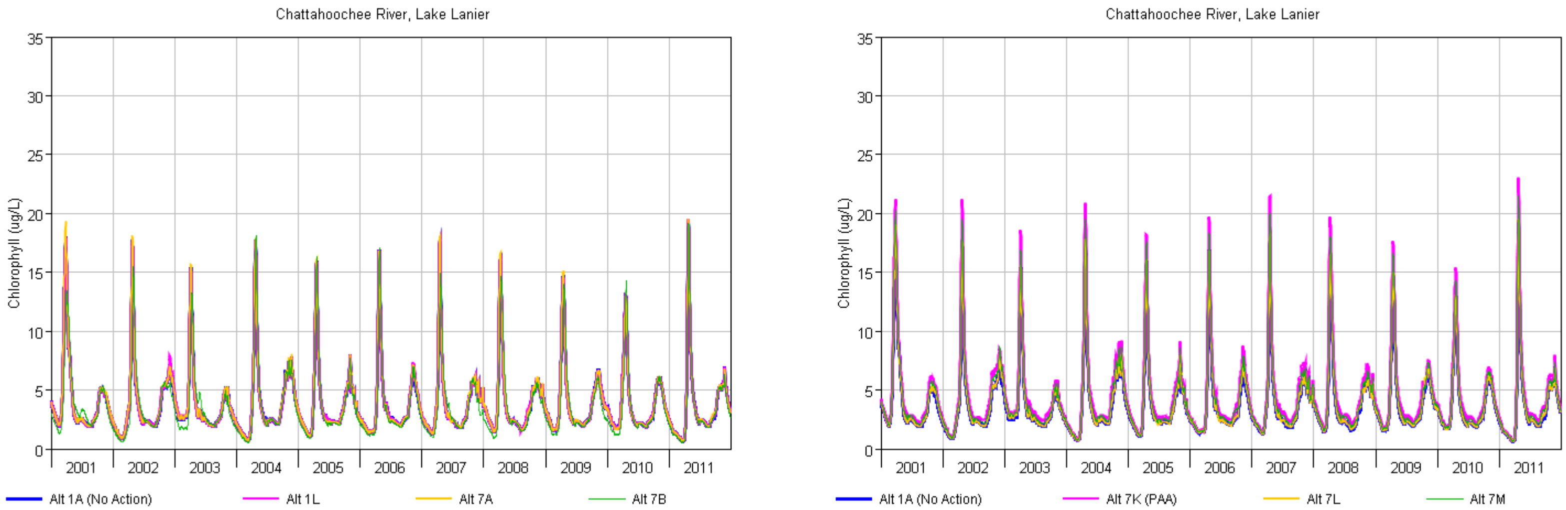


Figure 4.1 Time series of c*hlorophyll a* computed for the Chattahoochee River at Lake Lanier, above Buford Dam, during the 2001-2011 modeling period.

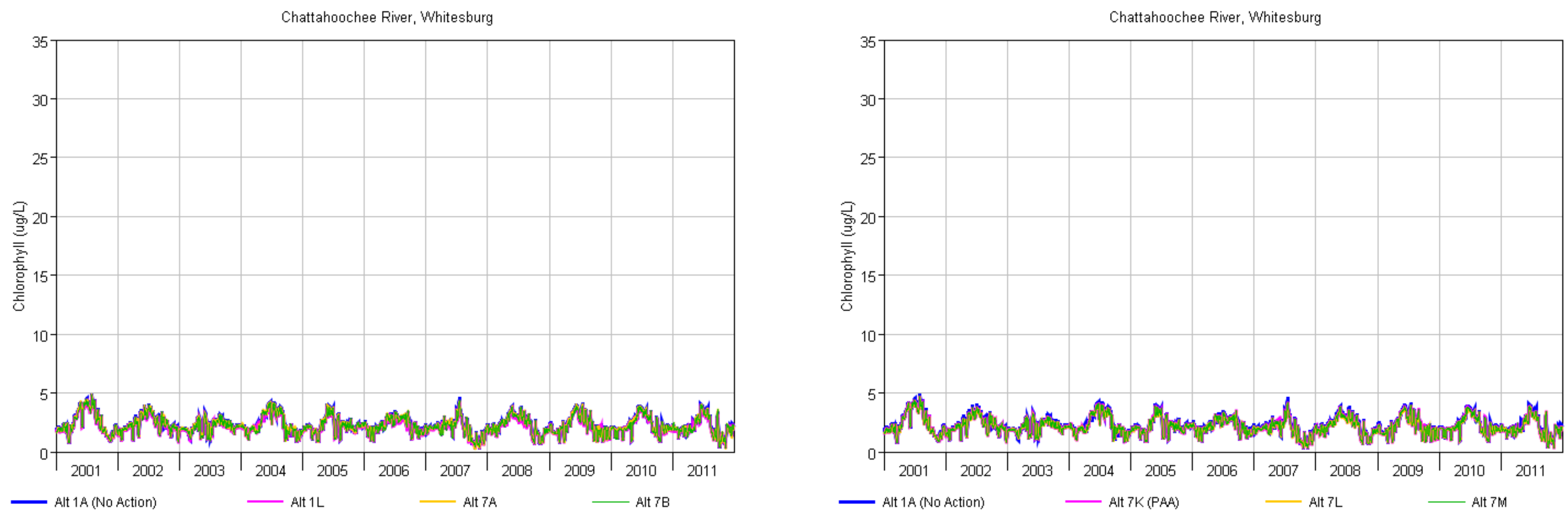
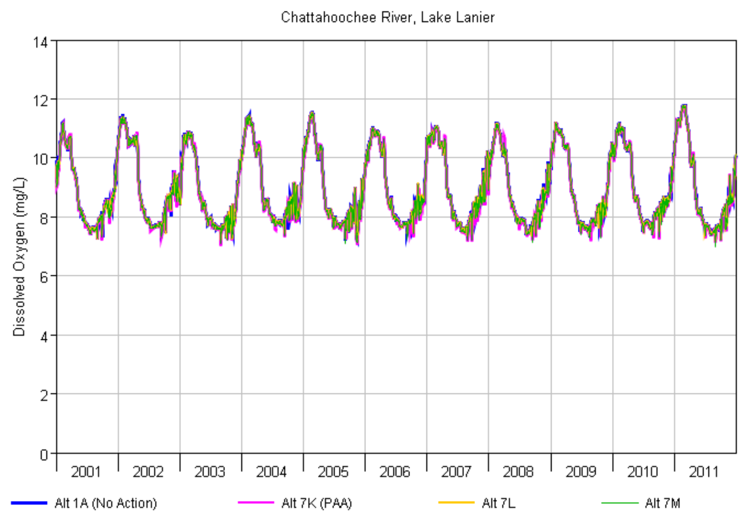


Figure 4.2 Time series of c*hlorophyll a* computed for the Chattahoochee River at Whitesburg during the 2001-2011 modeling period.



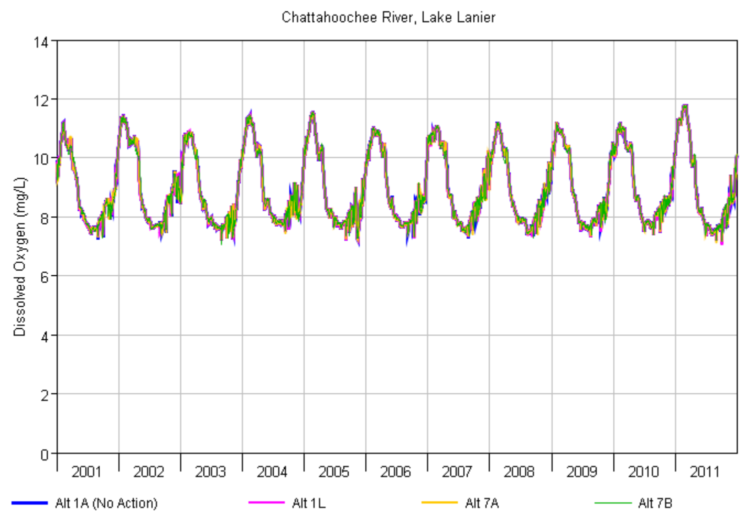


Figure 4.3 Time series of *DO* computed for Chattahoochee River at Lake Lanier, above Buford Dam, during the 2001-2011 modeling period.

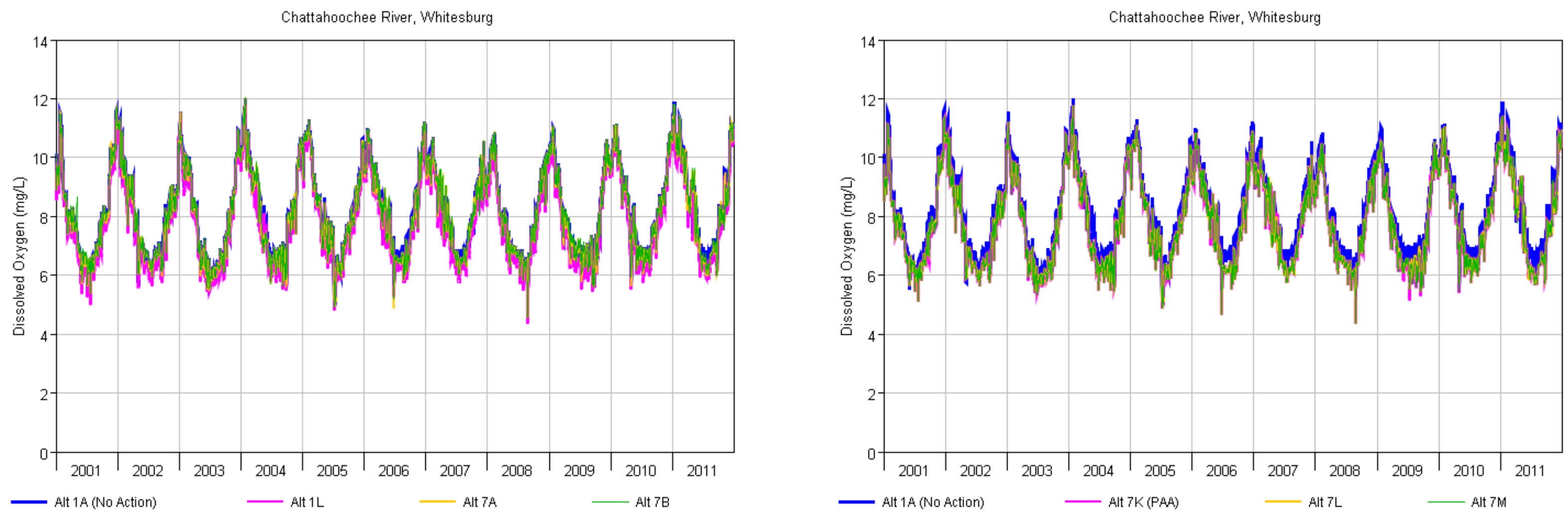


Figure 4.4 Time series of *DO* computed for Chattahoochee River at Whitesburg, above Buford Dam, during the 2001-2011 modeling period.

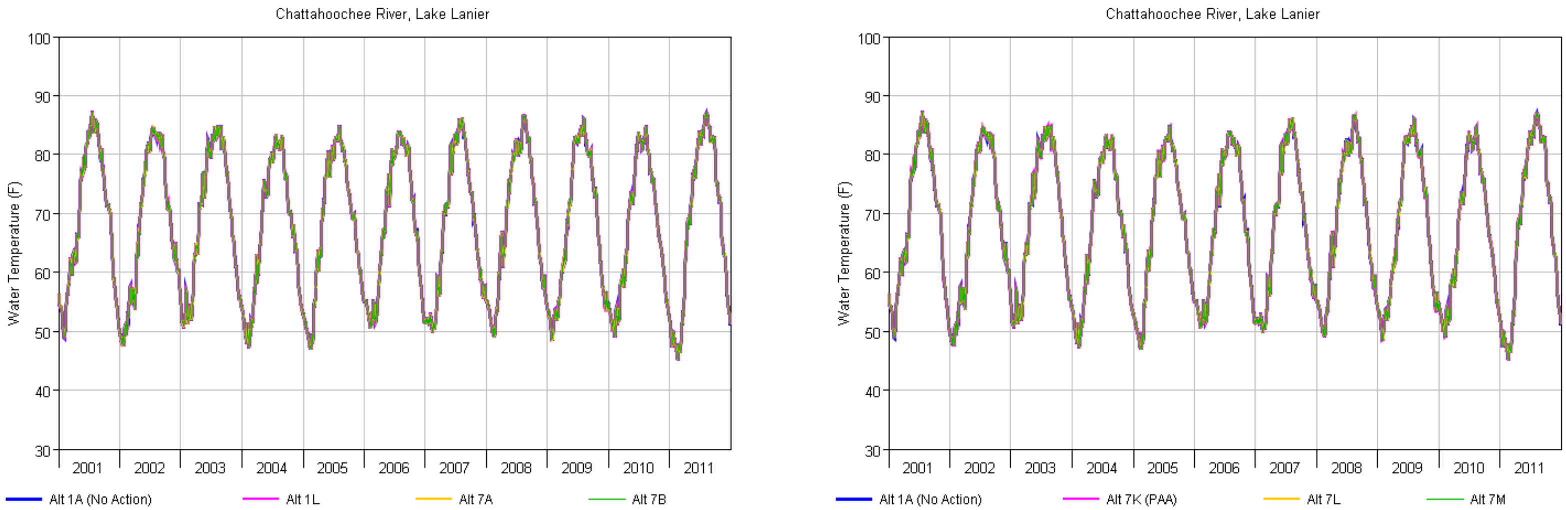


Figure 4.5 Time series of *water temperature* for the Chattahoochee River at Lake Lanier, above Buford Dam, during the 2001-2011 model period.

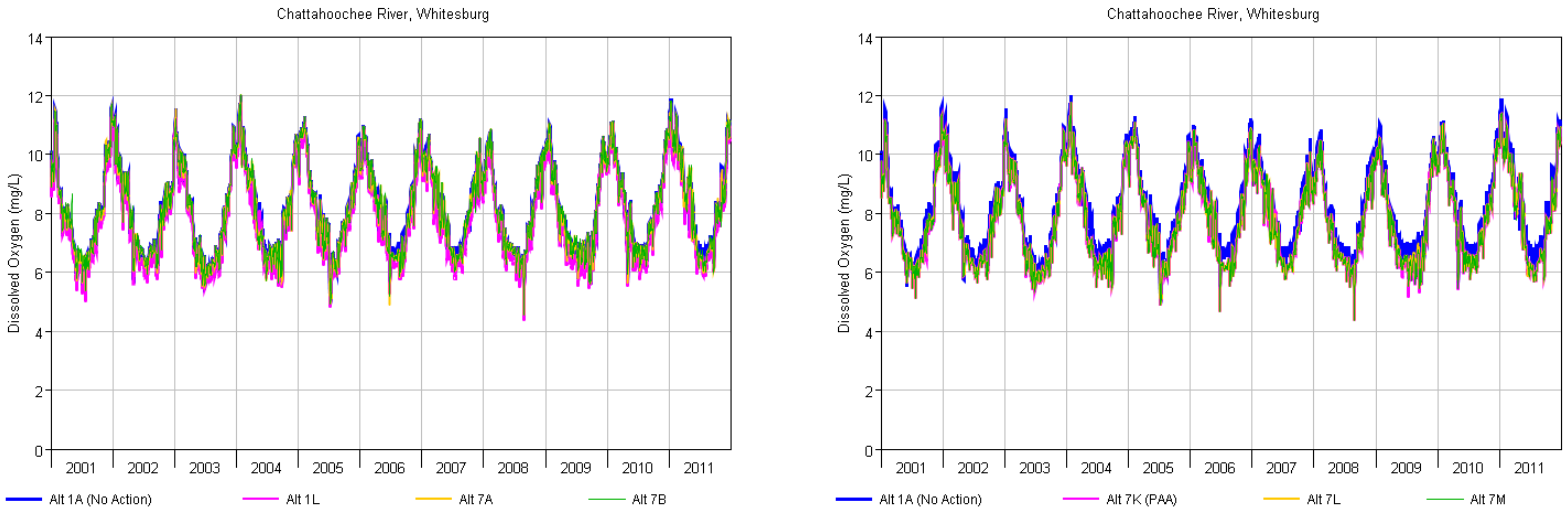


Figure 4.6 Time series of *water temperature* for the Chattahoochee River at Whitesburg, during the 2001-2011 model period.

4.2 Cumulative Occurrence

The cumulative percentage of occurrence of each water quality parameter shown in Table 4.2 was computed for the 2001–2011 modeling period using the computed daily HEC-5Q time series from each location shown in Table 4.1 along the Chattahoochee, Flint, and Apalachicola Rivers. The cumulative occurrence plots show the percentage of time each parameter was lower than a certain concentration level. For example, if a DO plot shows a 5% occurrence level at 6 mg/L, then 5% of the observations were *lower* than this level. An occurrence level of 95% 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 theoretical minimum and maximum values, respectively, of a parameter. These proxies for the minimum and maximum values eliminated reporting of water quality spikes, due to "negative" inflows and other factors. 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 DO plots indicate the DO standard specified by the USFWS. The USFWS DO standard for fish habitat in pristine water bodies is 6 mg/L, while the USFWS standard for the rest of the ACF 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. Only Lake Lanier (Buford) is labeled with a 6 mg/L DO standard. All locations modeled and plotted in this analysis, except Lake Lanier (Buford), required the 5 mg/L standard. The plots of Buford (Lake Lanier) are labeled with the 6 mg/L DO standard.

Representative cumulative occurrence plots of chlorophyll a, DO, and temperature are shown in Figure 4.7 – Figure 4.12 at two sample locations on the Chattahoochee River. The first is Buford station at Lake Lanier, which is above Buford Dam, and the second is Whitesburg station. To improve the clarity of the plots, four sets were plotted. Each set contains the No Action Alternative (NAA). The first set contains all ten alternatives. The other three sets contain the NAA plus three alternatives each. The alternatives comprising each set are as follows:

Set 1: 1A (NAA), 1L, 7A, 7B, 7H, 7I, 7J, 7K (PAA), 7L, 7M

Set 2: 1A (NAA), 1L, 7A, 7B

Set 3: 1A (NAA), 7H, 7I, 7J

Set 4: 1A (NAA), 7K (PAA), 7L, 7M

Examples of the second and fourth sets are shown in Figure 4.7 – Figure 4.12. All plots were provided to the EIS team for analysis and are available by request.

All of the plots in Figure 4.7 – Figure 4.12 represent the cumulative occurrence over the 2001–2011 modeling period. Figure 4.7 – Figure 4.8 show the cumulative occurrence of chlorophyll *a* at Lake Lanier and Whitesburg, respectively. Figure 4.9 and Figure 4.10 show the cumulative occurrence for DO at Lake Lanier and Whitesburg, respectively. The DO plots at Lanier and Whitesburg indicate that their respective DO standards are not violated for any of the alternatives. Finally, Figure 4.11 and Figure 4.12 show the cumulative occurrence for water temperature over the 2001–2011 modeling period.

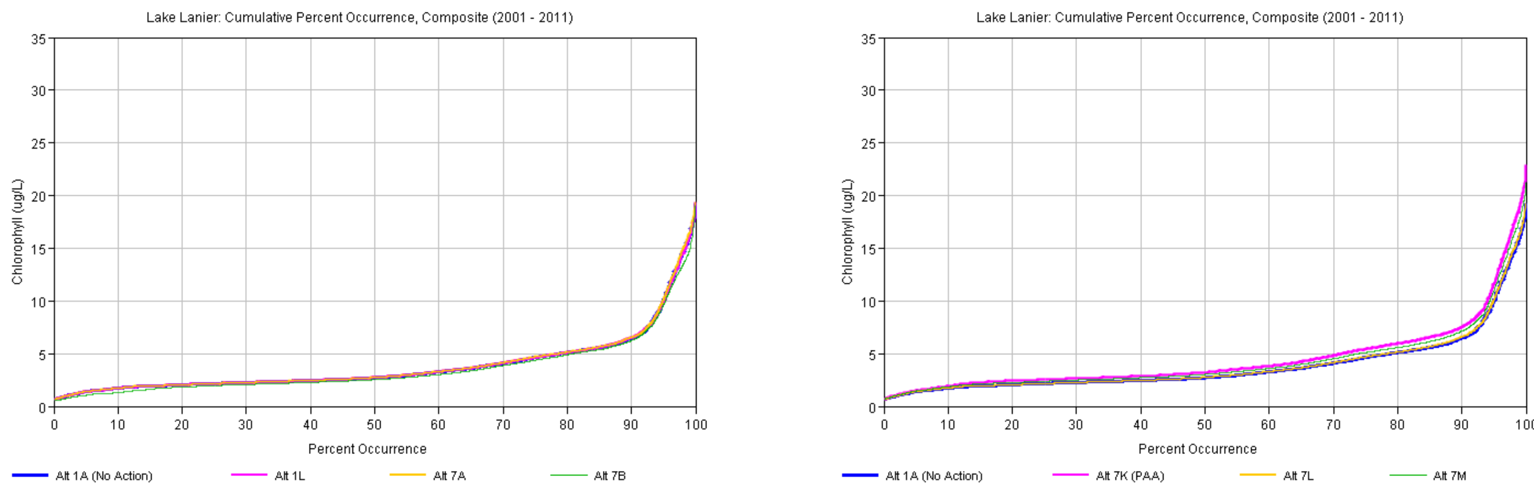


Figure 4.7 Cumulative occurrence of *chlorophyll a* computed for the Chattahoochee River at Lake Lanier, above Buford Dam, for the 2001-2011 modeling period.

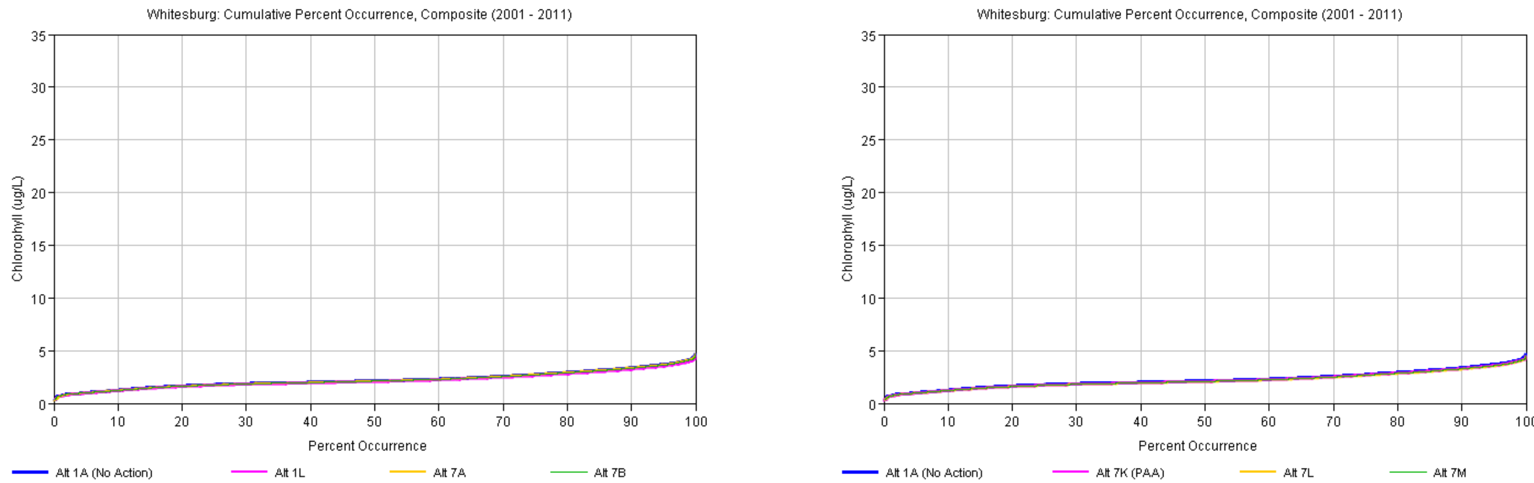


Figure 4.8 Cumulative occurrence of *chlorophyll a* computed for the Chattahoochee River at Whitesburg for the 2001-2011 modeling period.

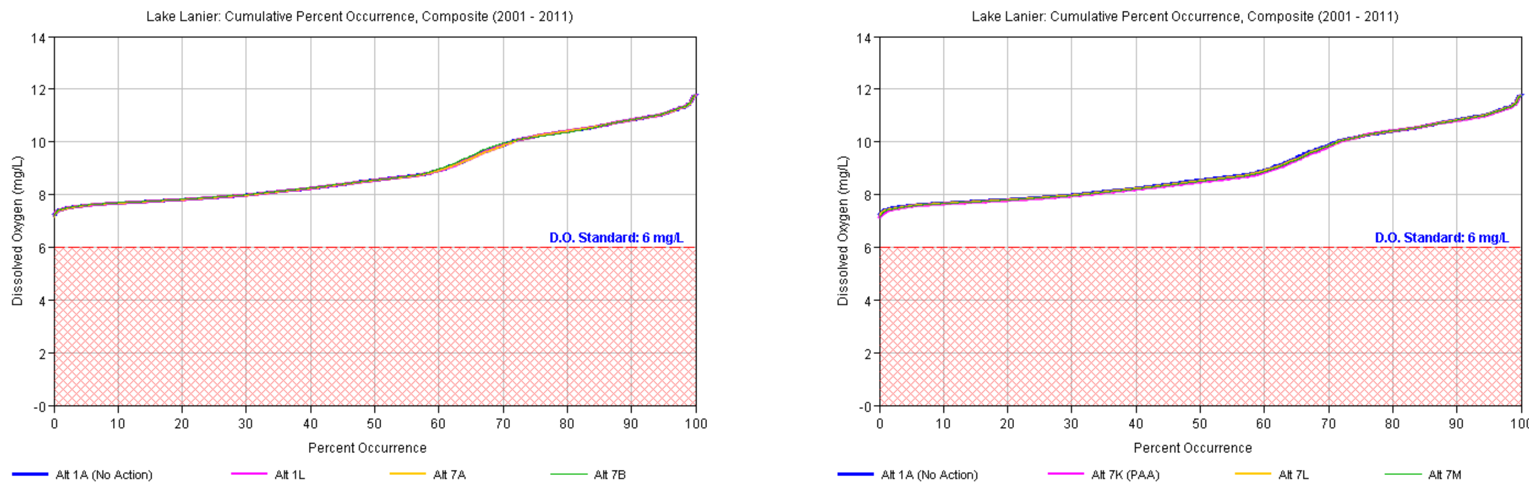


Figure 4.9 Cumulative occurrence of *DO* computed for the Chattahoochee River at Lake Lanier, above Buford Dam, for the 2001-2011 modeling period. The USFWS standard of 6 mg/L (for Lake Lanier) is denoted by the red shaded zone.

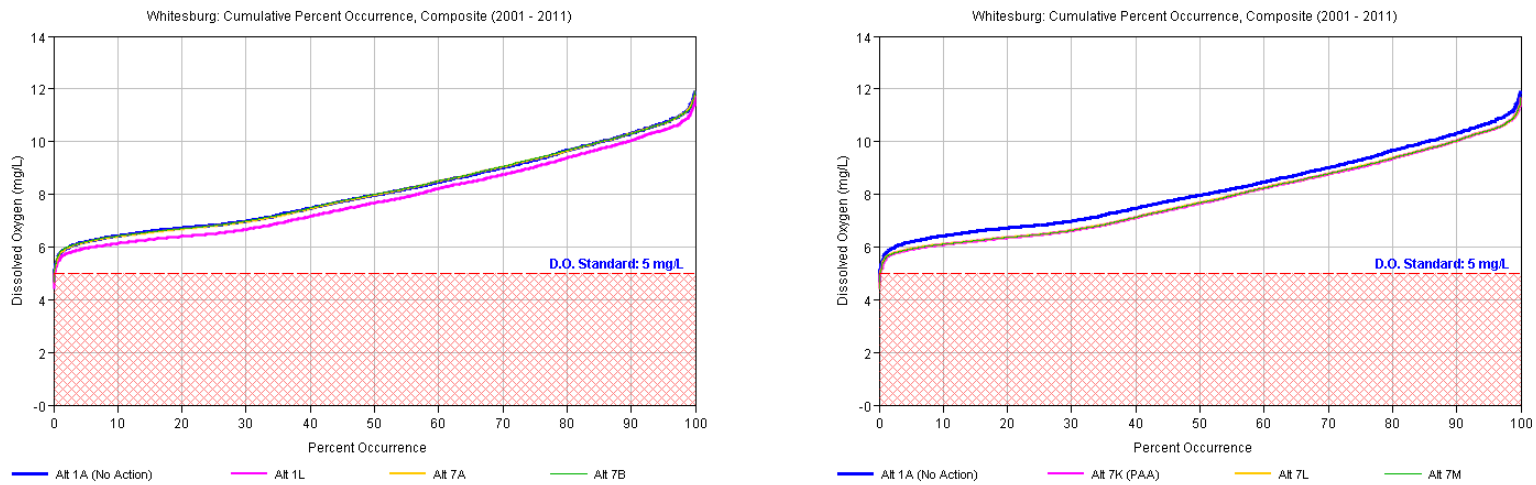


Figure 4.10 Cumulative occurrence of *DO* computed for the Chattahoochee River at Whitesburg for the 2001-2011 modeling period. The USFWS standard of 5 mg/L is denoted by the red shaded zone.

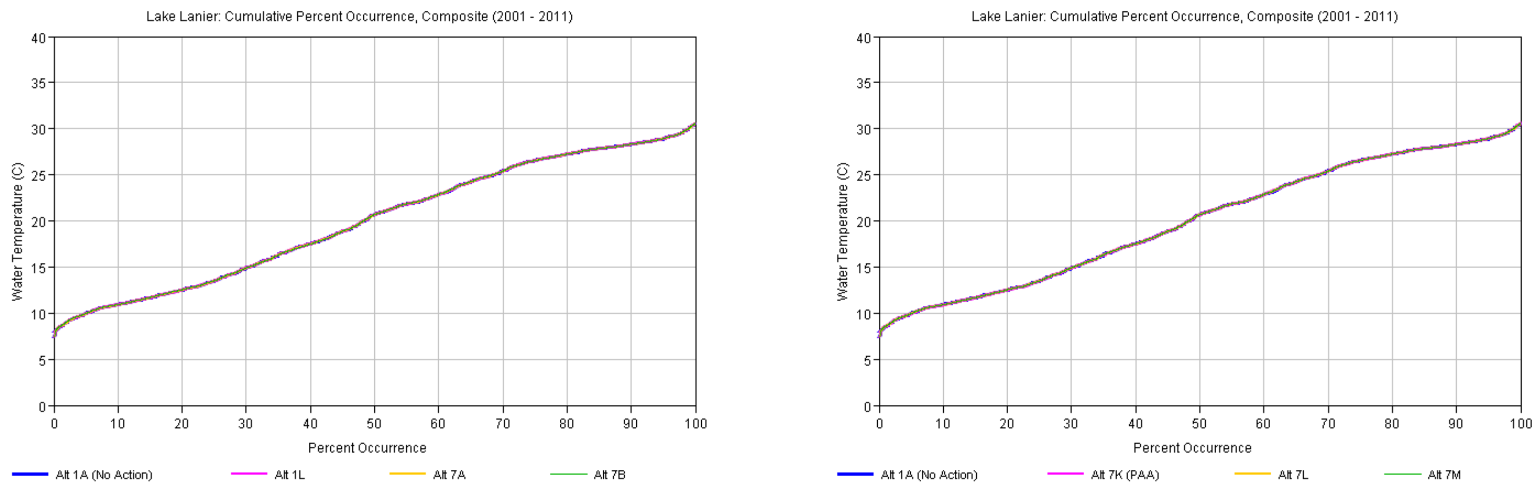


Figure 4.11 Cumulative occurrence of *water temperature* computed for the Chattahoochee River at Lake Lanier, above Buford Dam, for the 2001-2011 modeling period.

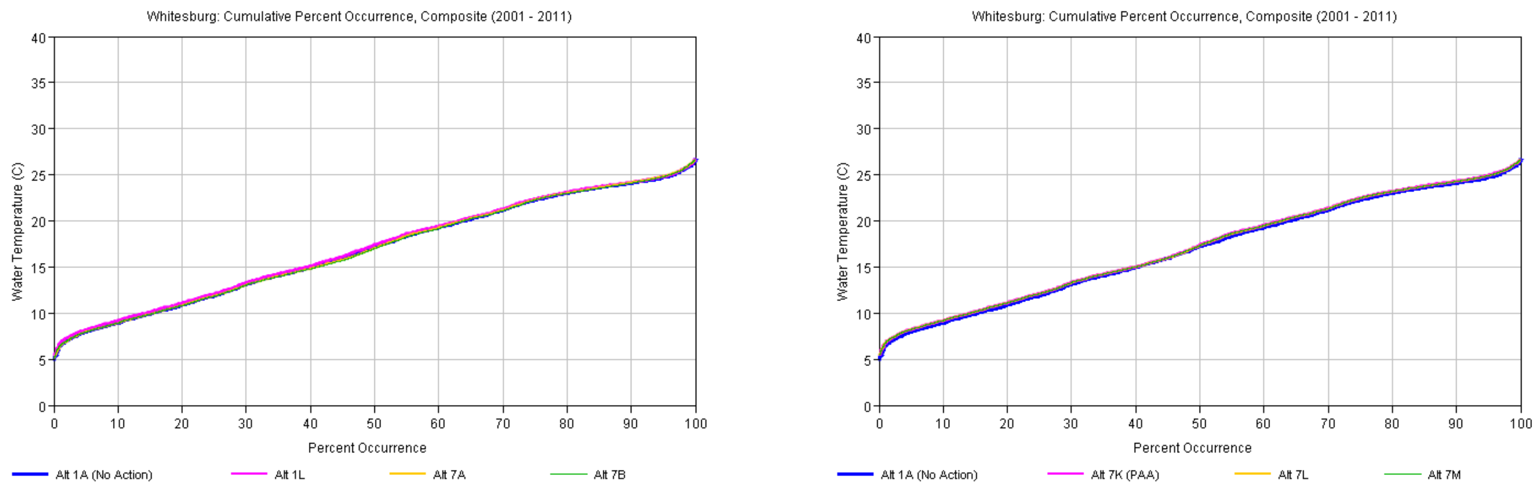


Figure 4.12 Cumulative occurrence of *water temperature* computed for the Chattahoochee River at Whitesburg for the 2001-2011 modeling period.

4.3 River Profiles

4.3.1 Overview

Cumulative occurrence levels of each water quality parameter shown in Table 4.2 were computed from the daily HEC-5Q time series output for each river mile along the Chattahoochee and Flint Rivers for No Action 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 dry year vs. a 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 parameter values in the ACF basin. Therefore, low occurrence levels are analogous to low values of a given parameter, while high occurrence levels are analogous to high values.

4.3.2 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.

4.3.3 Computation Periods

While cumulative occurrence was computed for the entire model period in Section 1.1, several different weekly, seasonal, and annual model periods were computed and shown as longitudinal occurrence profiles.

To show how the ACF system functions during different annual hydrologic conditions, three different years were selected from the 2001–2011 model period to represent normal (2004), wet (2005), and dry (2007) hydrologic conditions. These are plotted along with profiles of the composite of the 2001–2011 modeling period.

In addition to showing the annual percentage of occurrence of each parameter, the functioning of the ACF system is particularly important during the growing season. There are two major definitions of growing season in the ACF basin. Three growing season definitions had to be considered for the ACF basin to address requirements by the States of Georgia and Alabama as well as the USFWS. These definitions are as follows:

1. State of Georgia: April–October
2. State of Alabama: April–October[7]
3. USFWS: May–October

Occurrence profiles were computed for each of these growing seasons. To improve the clarity of the plots, four sets were plotted. Each set contains the No Action Alternative (NAA). The first set contains all ten alternatives. The other three sets contain the NAA plus three alternatives each. The alternatives comprising each set are as follows:

Set 1: 1A (NAA), 1L, 7A, 7B, 7H, 7I, 7J, 7K (PAA), 7L, 7M

Set 2: 1A (NAA), 1L, 7A, 7B

Set 3: 1A (NAA), 7H, 7I, 7J

Set 4: 1A (NAA), 7K (PAA), 7L, 7M

Examples of the second and fourth sets are shown in Figure 4.13 – Figure 4.25. All plots were provided to the EIS team for analysis and are available by request.

[7] Previously, Alabama's growing season was defined as April – November.

These results are available in the HEC-DSS model output files, which are available upon request. Several samples of the weekly intervals are shown below.

Composite Period: Occurrence profiles were computed and plotted for the "composite" 2001 – 2011 model period for eight water quality parameters: dissolved oxygen (DO), chlorophyll *a*, temperature, point-source load percent of flow (Percent Point Load), 5-day uninhibited biochemical oxygen demand (BOD5), ammonia-nitrogen (NH_3-N), nitrate-nitrogen (NO_3-N), and phosphate-phosphorus (PO_4-P). Example plots are shown of DO (Figure 4.13), chlorophyll *a* (Figure 4.14), water temperature (Figure 4.15), Percent Point Load (Figure 4.16), BOD5 (Figure 4.17), NO_3-N (Figure 4.18), and PO_4-P (Figure 4.19).

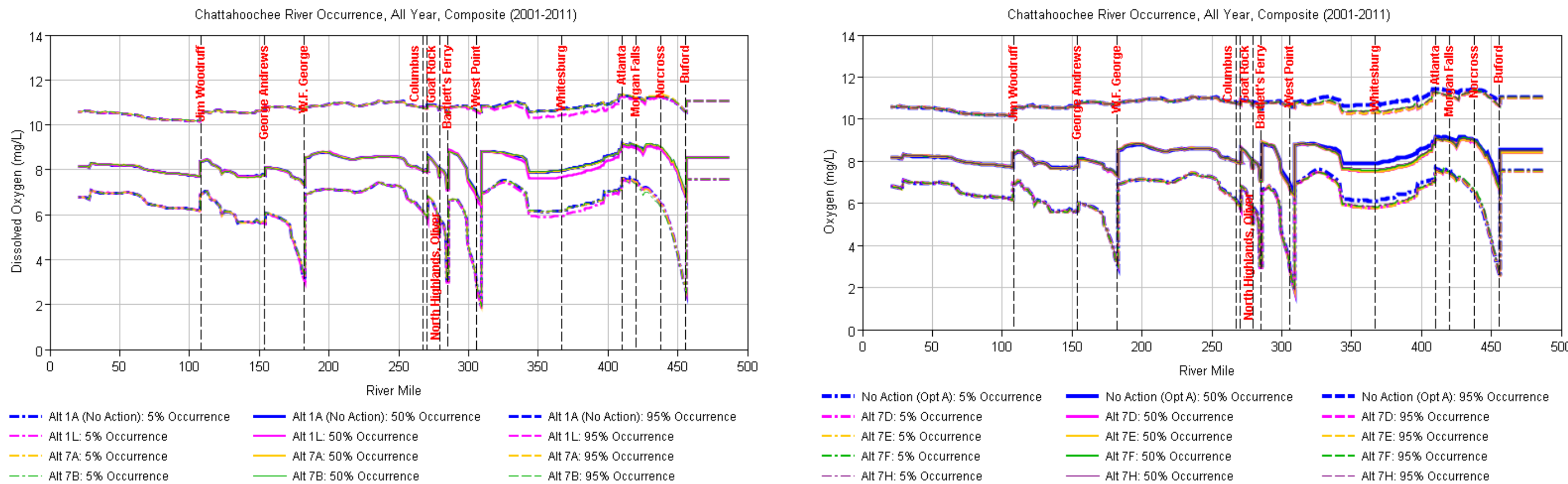


Figure 4.13 Longitudinal occurrence profiles of *DO* were computed along the Chattahoochee Rivers for the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for each alternative.

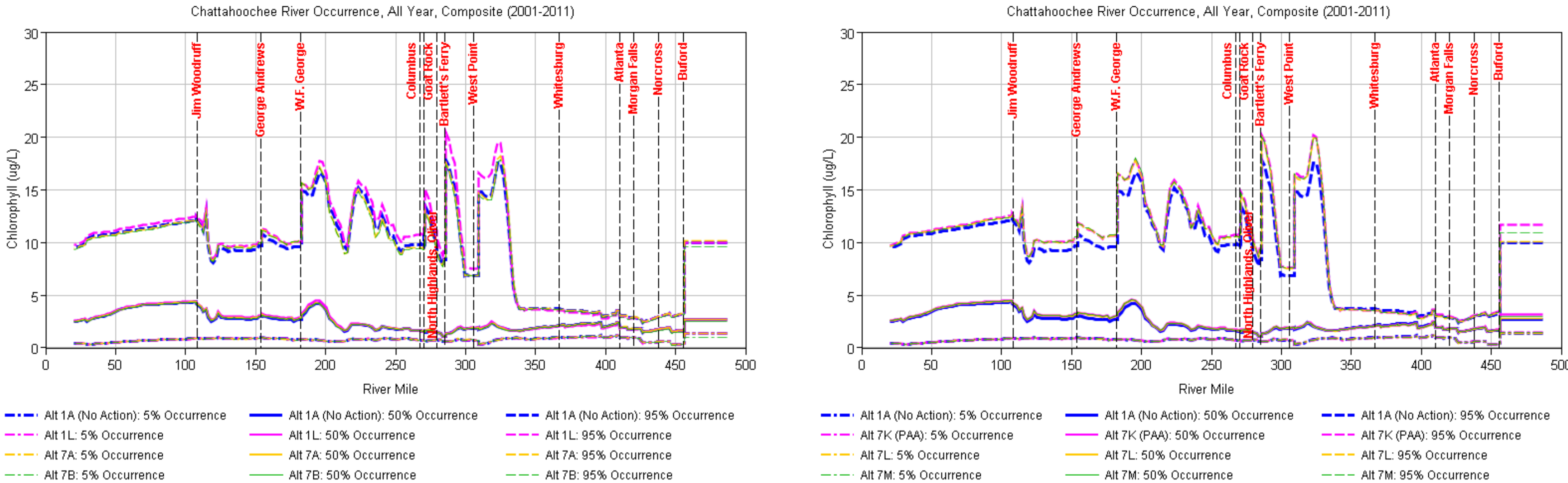


Figure 4.14 Longitudinal occurrence profiles of *chlorophyll a* were computed along the Chattahoochee Rivers for the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for each alternative.

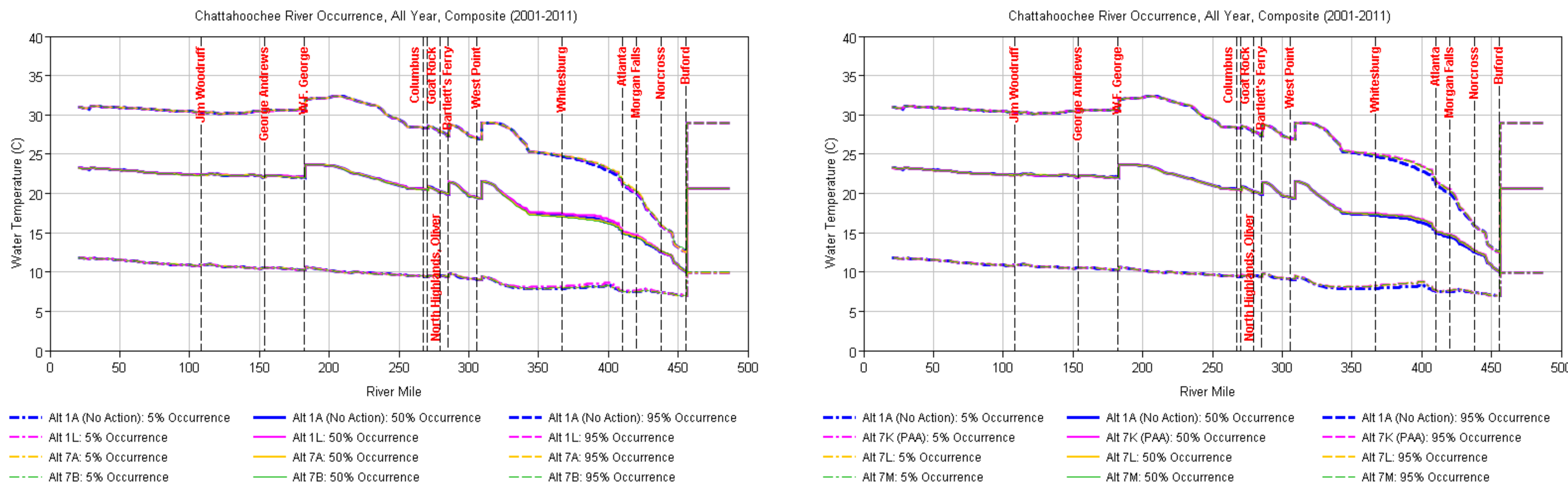


Figure 4.15 Longitudinal occurrence profiles of *water temperature* were computed along the Chattahoochee Rivers for the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for each alternative.

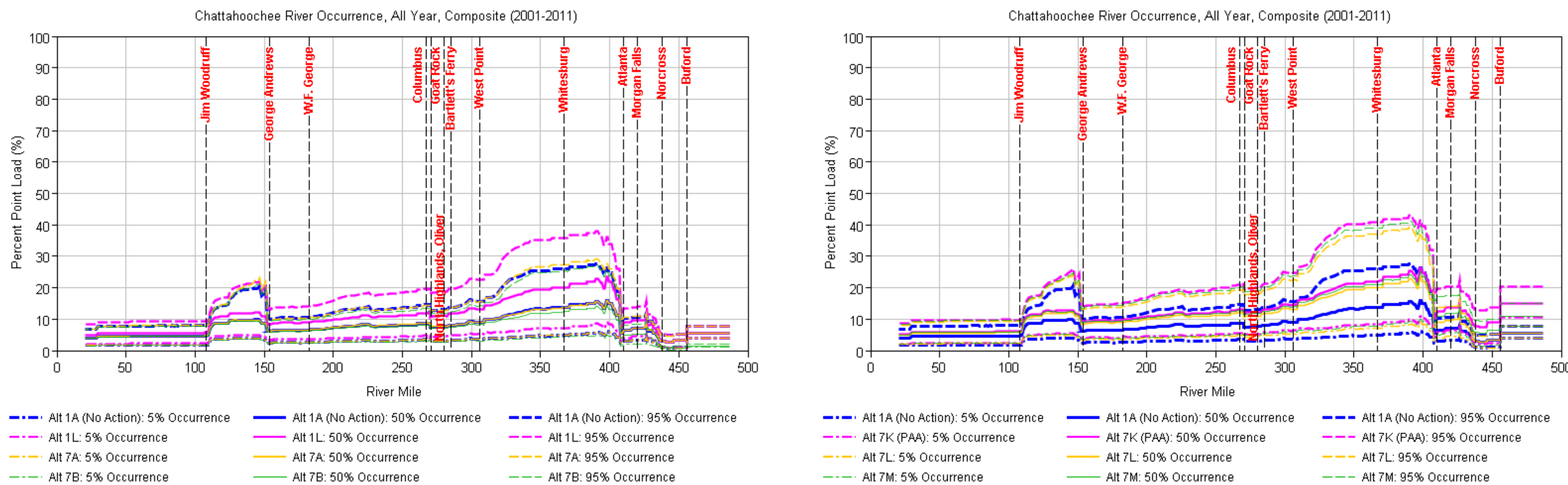


Figure 4.16 Longitudinal occurrence profiles of *wastewater percentage of flow* were computed along the Chattahoochee Rivers for the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for each alternative.

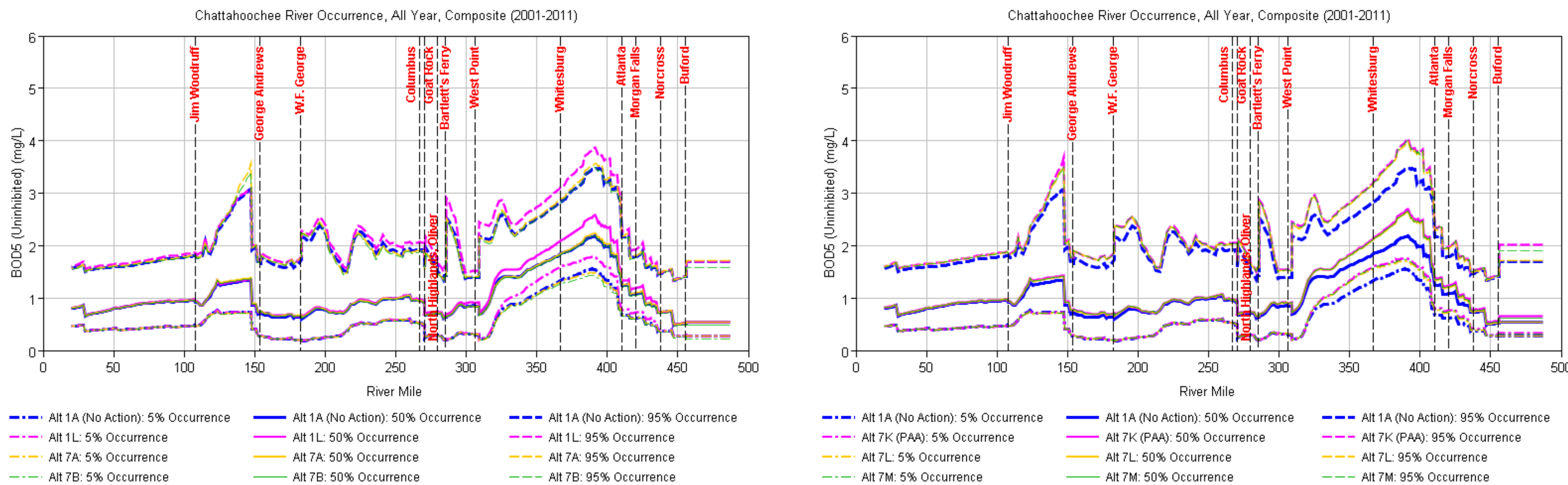


Figure 4.17 Longitudinal occurrence profiles of *5-Day uninhibited biochemical oxygen demand (BOD5U)* were computed along the Chattahoochee Rivers for the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for each alternative.

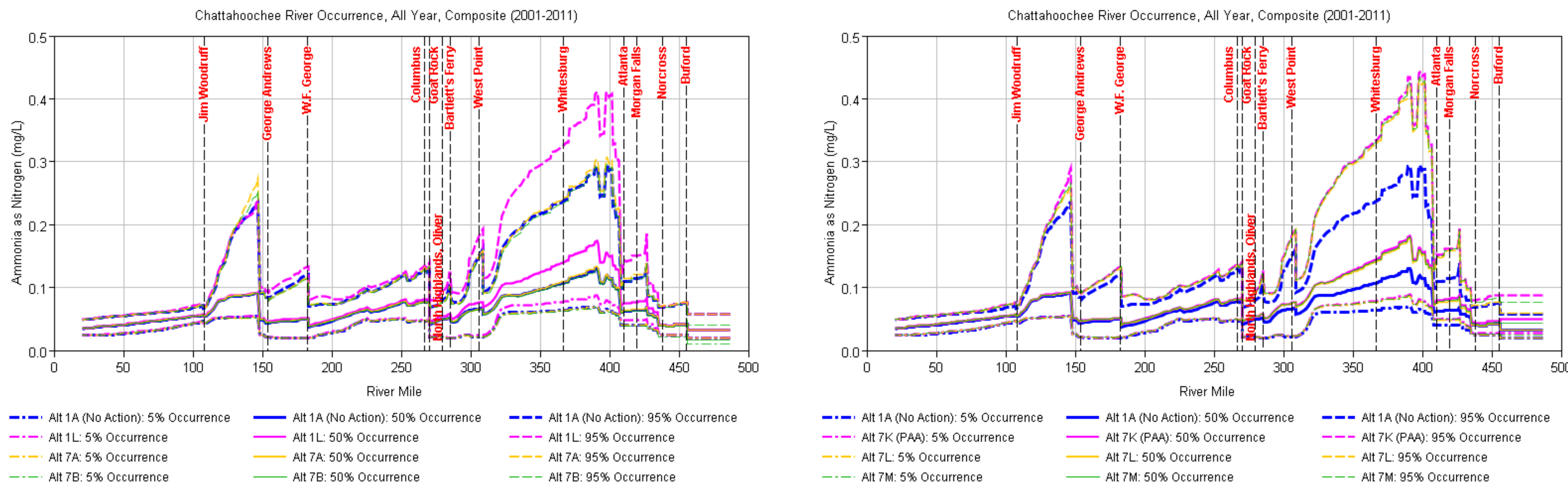


Figure 4.18 Longitudinal occurrence profiles of *ammonia as nitrogen (NH_3-N)* were computed along the Chattahoochee Rivers for the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for each alternative.

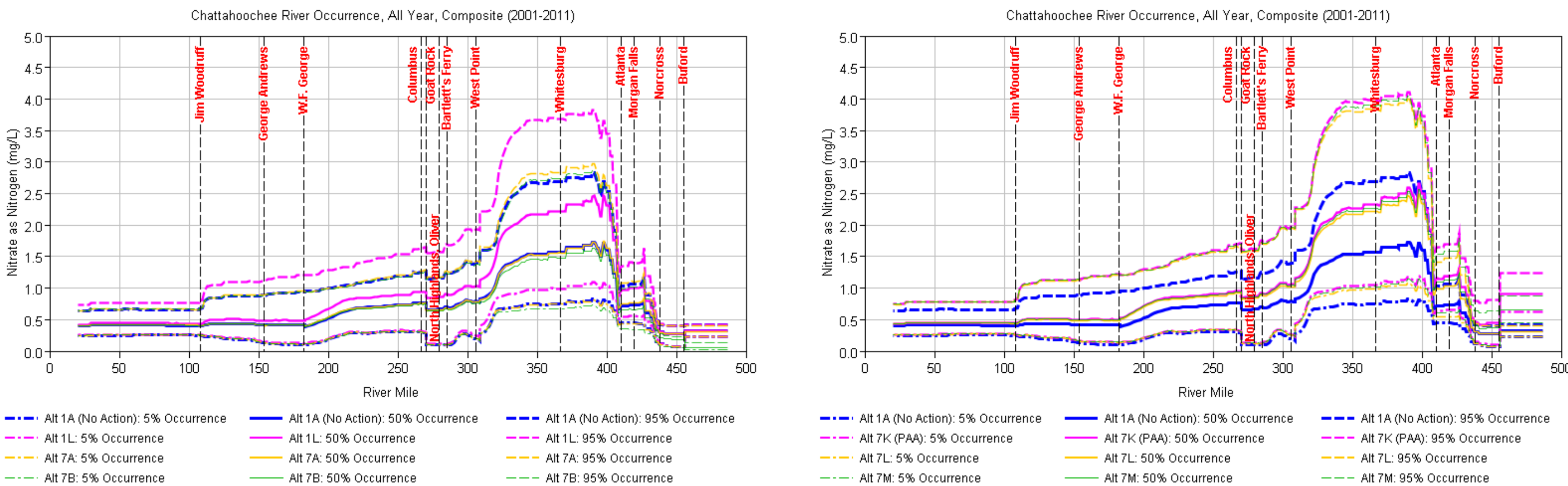


Figure 4.19 Longitudinal occurrence profiles of *nitrate as nitrogen (NO_3-N)* were computed along the Chattahoochee Rivers for the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for each alternative.

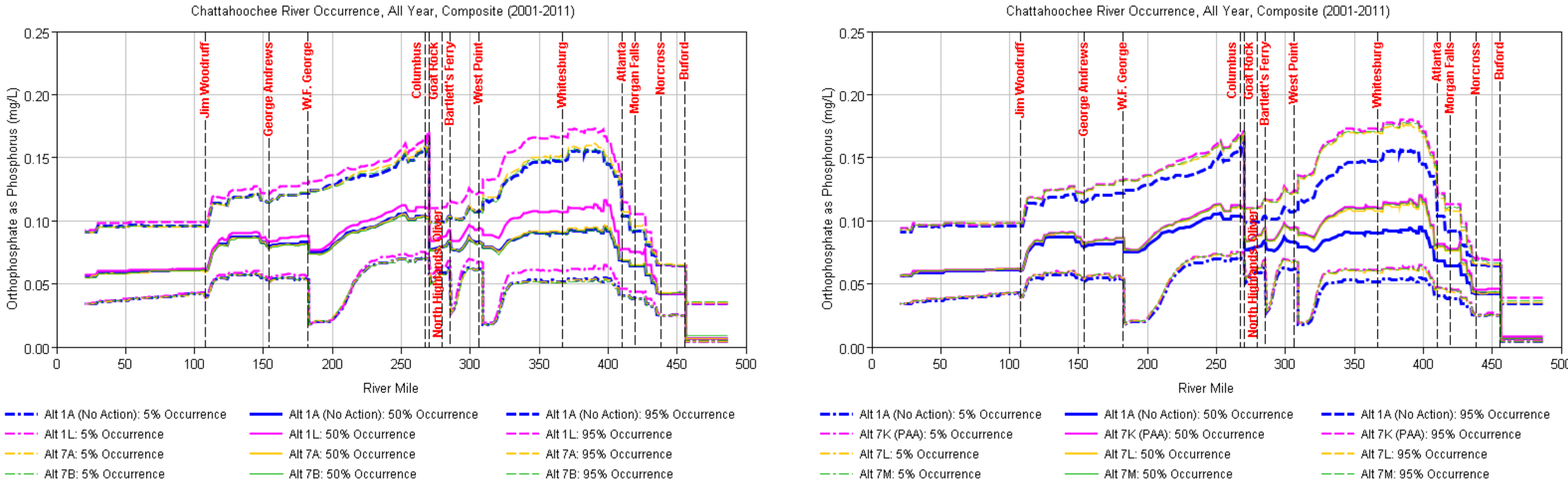
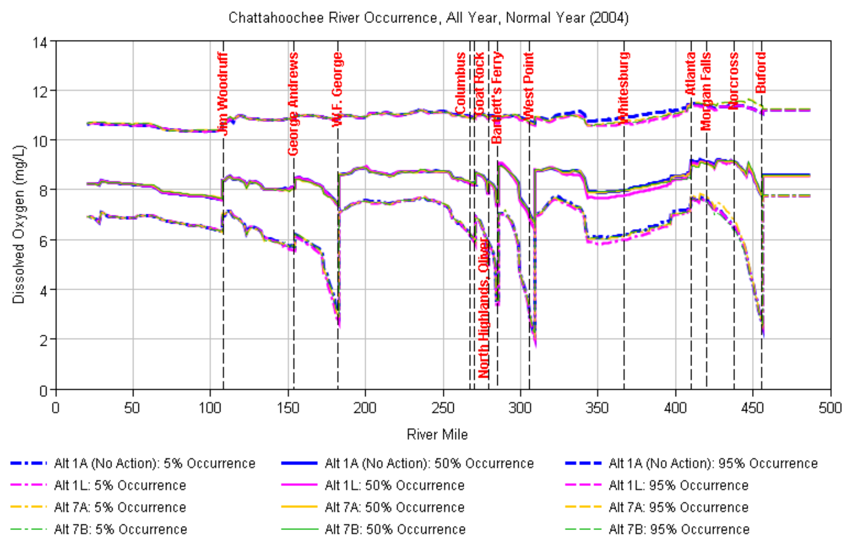


Figure 4.20 Longitudinal occurrence profiles of *orthophosphate as phosphorous (PO_3-P)* were computed along the Chattahoochee Rivers for the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for each alternative.

Annual Hydrologic Periods: Occurrence profiles were computed and plotted for each water quality parameter for representative wet, normal, and dry years during the 2001–2011 modeling period. Figure 4.21, Figure 4.22, and Figure 4.23, show example plots of DO for the years 2004 (Normal), 2005 (Wet), and 2007 (Dry), respectively.



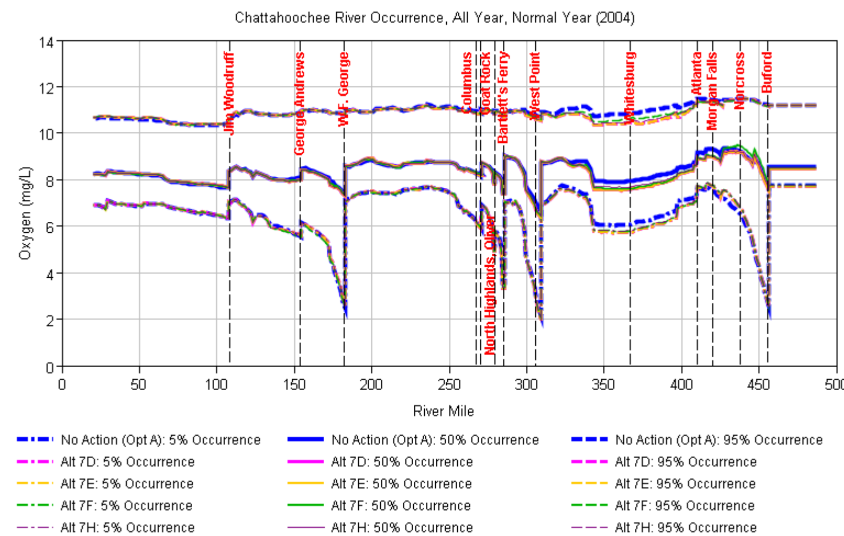
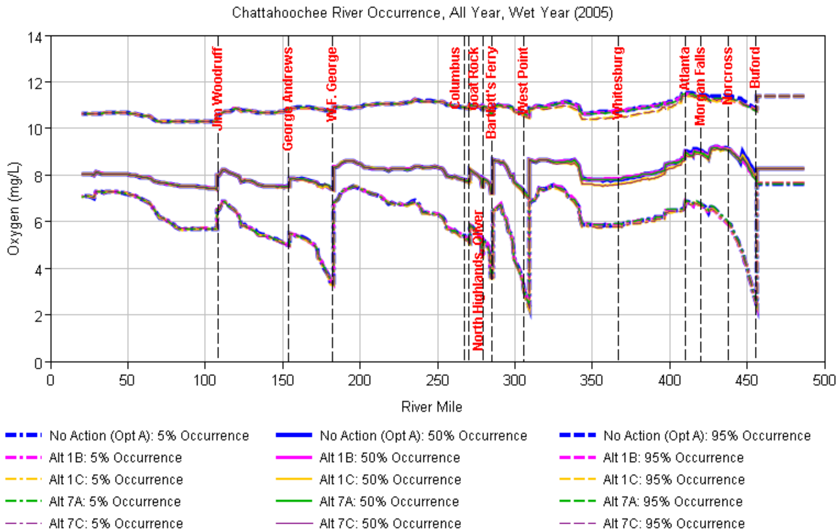


Figure 4.21 Longitudinal occurrence profiles of *DO* were computed along the Chattahoochee River during a "normal" year (2004). The 5, 50, and 95 percent occurrence levels are shown for each alternative.



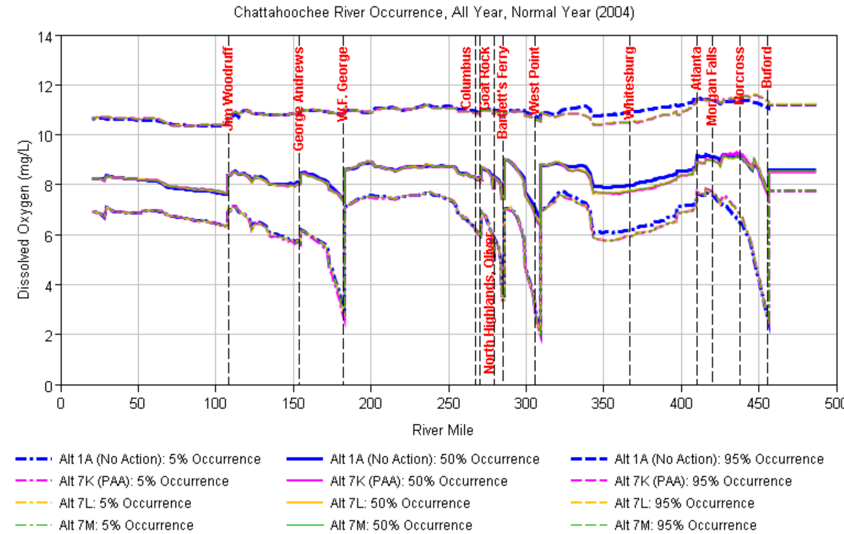


Figure 4.22 Longitudinal occurrence profiles of *DO* were computed along the Chattahoochee River during a “wet” year (2005). The 5, 50, and 95 percent occurrence levels are shown for each alternative.

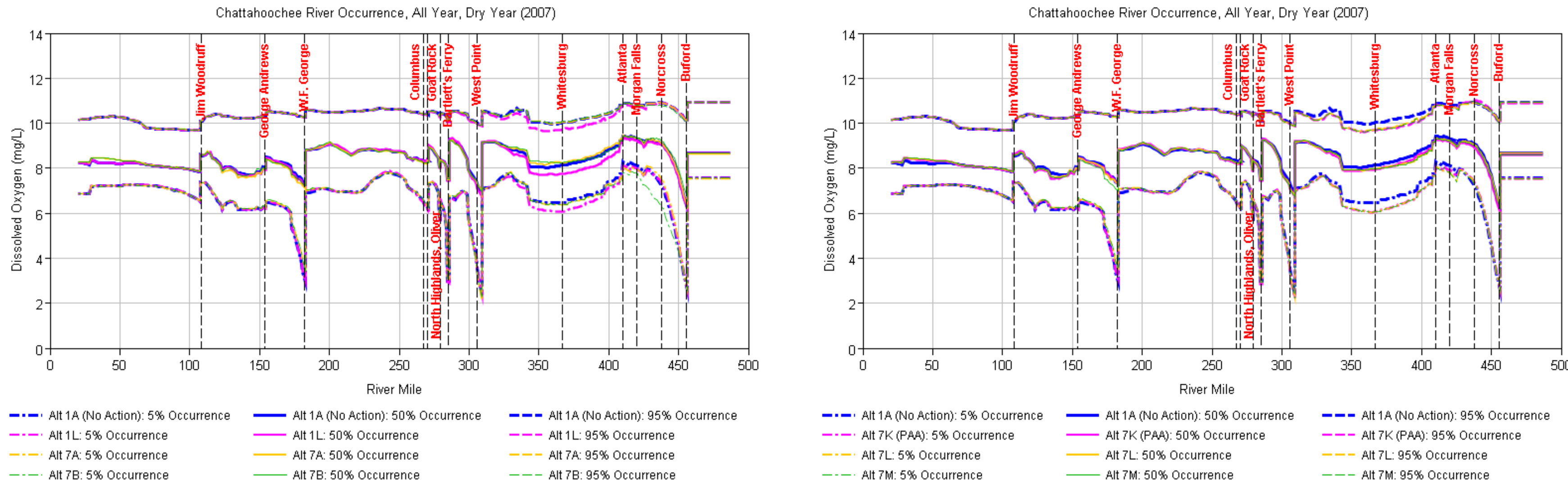


Figure 4.23 Longitudinal occurrence profiles of *DO* were computed along the Chattahoochee River during a "dry" year (2007). The 5, 50, and 95 percent occurrence levels are shown for each alternative.

Growing Seasons: Occurrence profiles were computed and plotted for each water quality parameter and hydrologic period for the "composite" 2001–2001 model period, as well as for two growing seasons, as defined by the U.S. Fish and Wildlife Service (May-Oct) and the State of Georgia (Apr-Oct). Figure 4.24 and Figure 4.25, respectively, show example occurrence profiles of DO computed over the 2001-2011 model period for the May-Oct growing season and Apr-Oct growing season.

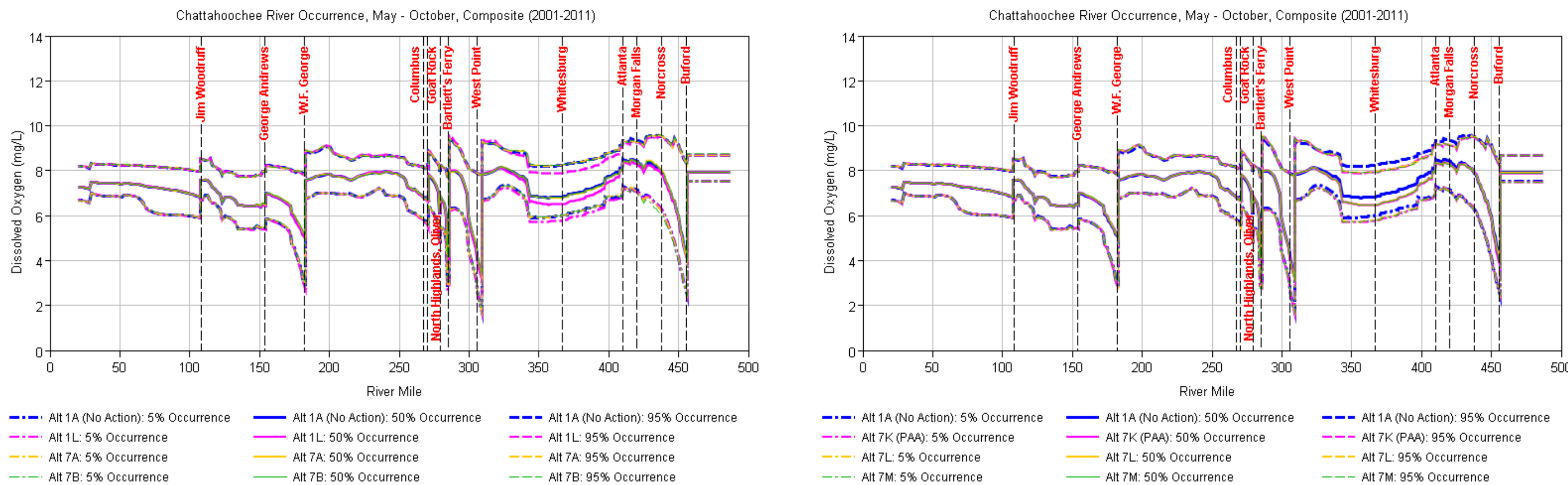


Figure 4.24 To address the standards of the U.S. Fish and Wildlife Service, longitudinal occurrence profiles of *DO* were computed for the months of May-October at the Chattahoochee River during the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for each alternative.

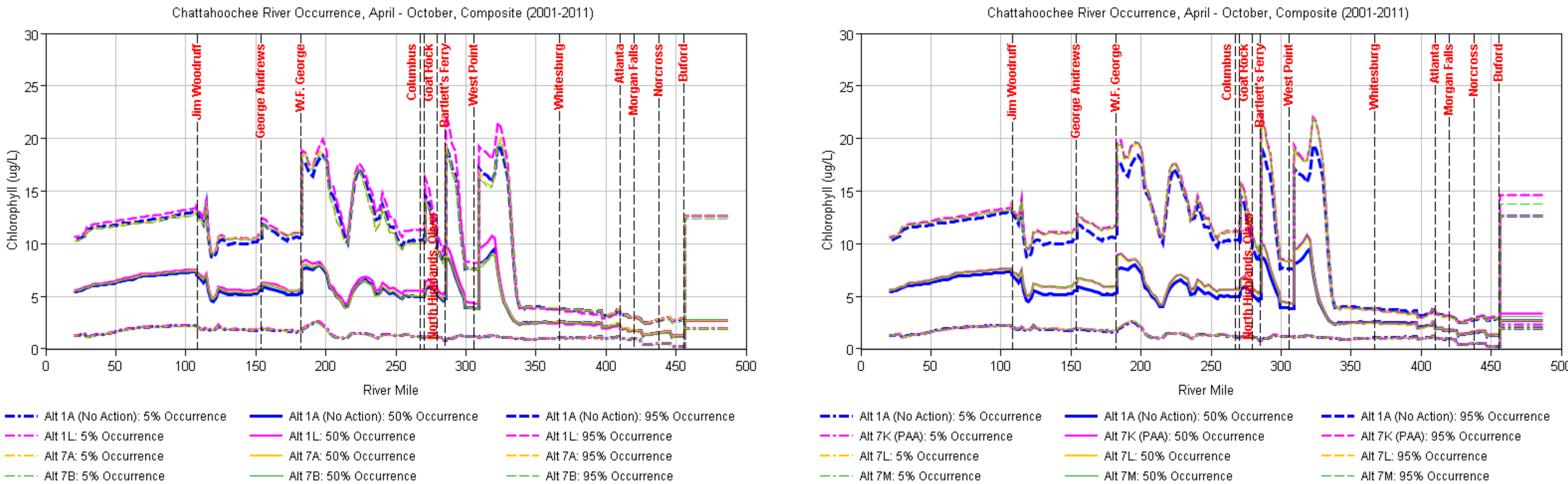


Figure 4.25 To address the standards of the state of Georgia, longitudinal occurrence profiles of *chlorophyll a* were computed for the months of April-October at the Chattahoochee River during the 2001-2011 modeling period. The 5, 50, and 95 percent occurrence levels are shown for each alternative.

5 CLIMATE CHANGE ANALYSIS

The HEC-5Q ACF model was used to simulate water quality for the Proposed Action Alternative using climate-change-projected flows and air temperatures for three sets of hydrologic conditions. Projected incremental local flows were derived by the USACE Institute of Water Resources (IWR, 2014). Climate change impacts were projected for the 2021–2050 period. Delta values were calculated relative to the equivalent 30 year antecedent period 1970-1999 to determine "Dry", "Median", and "Wet" conditions for the 2021–2050 period, denoted in the plots as Q1, Q2, and Q3, respectively. Monthly scaling factors were developed for each month and each quantile of the 2021–2050 period.

The ResSim ACF model was computed using the incremental local flows derived for the three hydrologic conditions (Q1, Q2, and Q3) for this period. These three scenarios are denoted in the plots as Dry (2050-Q1), Avg (2050-Q2), and Wet (2050-Q3). Climate model air temperature projections for the ACF were taken from the corresponding climate model output, and an extrapolation approach was used to derive the equilibrium temperatures. Further details are provided in Section 2.4.1 and IWR (2014).

Water quality was simulated for the Proposed Action Alternative (PAA) under these conditions, and these results were compared to the Proposed Action plan under existing/historical conditions. Longitudinal profiles of occurrence levels were plotted for all water quality parameters, summarizing the results for the full year and the three growing seasons for the 2001–2011 model period and each of the three hydrologic periods (2004, 2005, and 2007) that were used for the analysis of the historical conditions. Representative plots of chlorophyll a, DO, and water temperature are shown in Figure 5.1, Figure 5.2, and Figure 5.3, respectively.

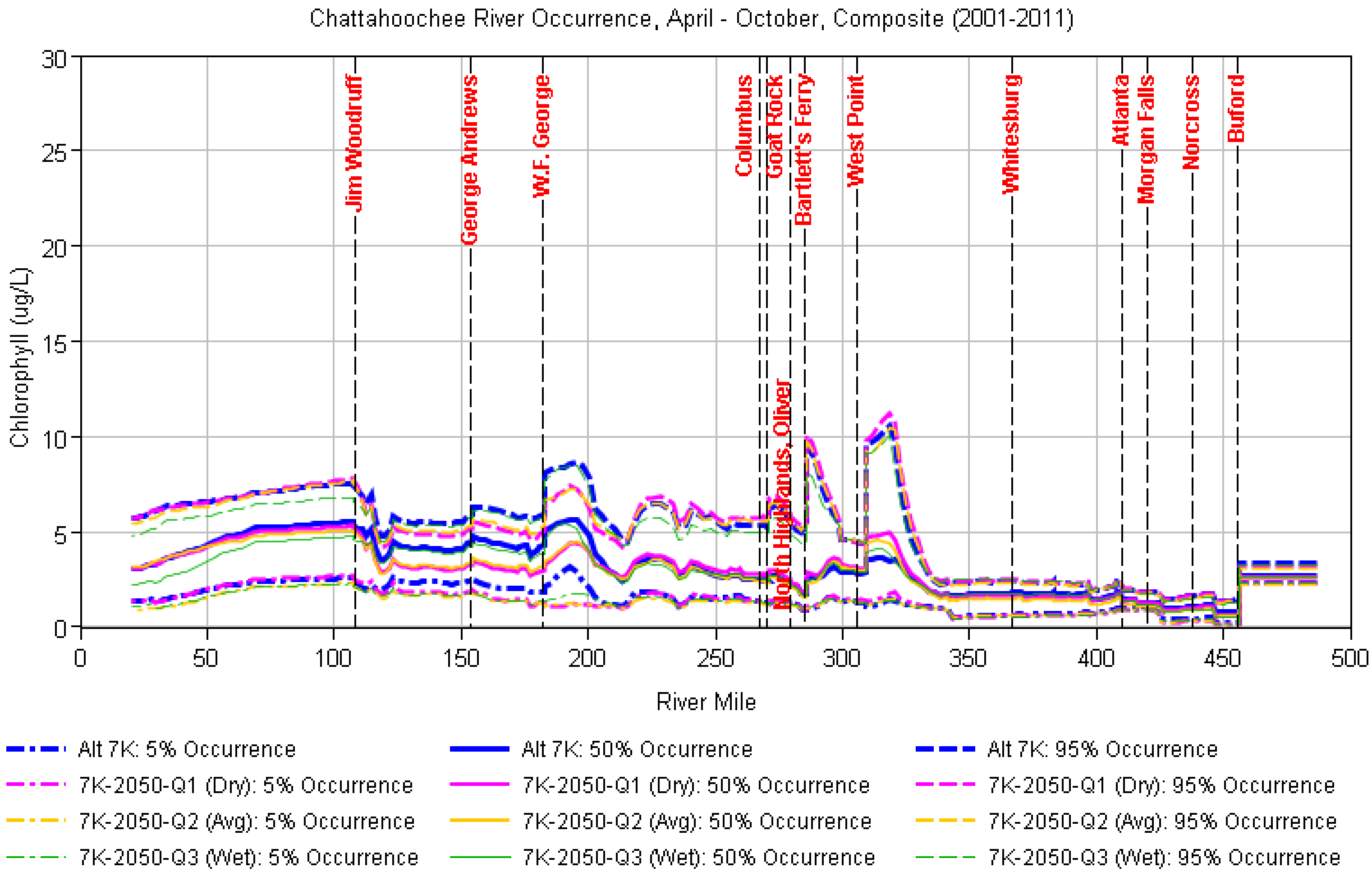


Figure 5.1 Longitudinal occurrence profiles of chlorophyll *a* for the April-October growing season along the Chattahoochee River during the 2001–2011 modeling period.

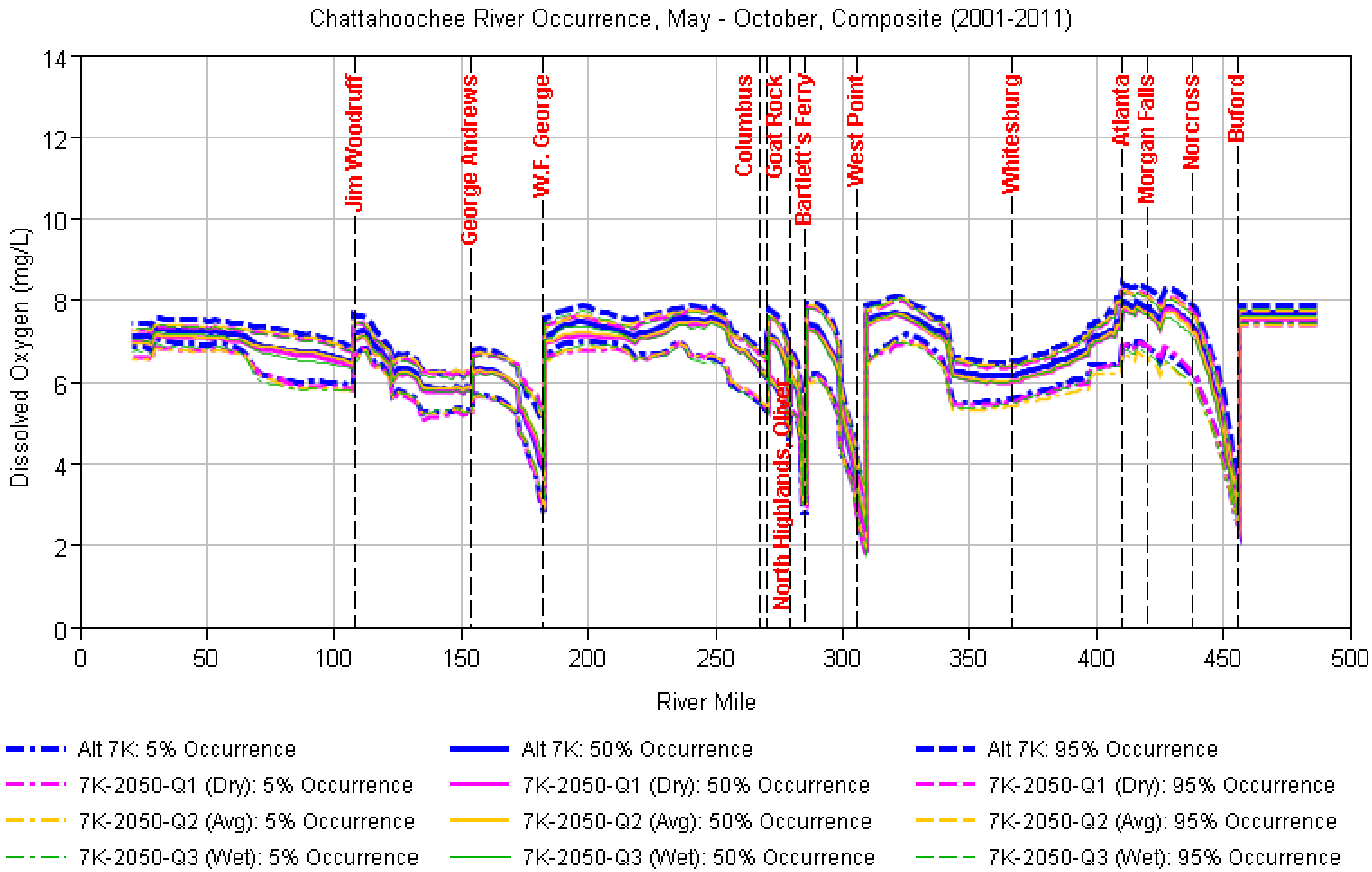


Figure 5.2 Longitudinal occurrence profiles of DO for the May-October growing season along the Chattahoochee River during the 2001–2011 modeling period.

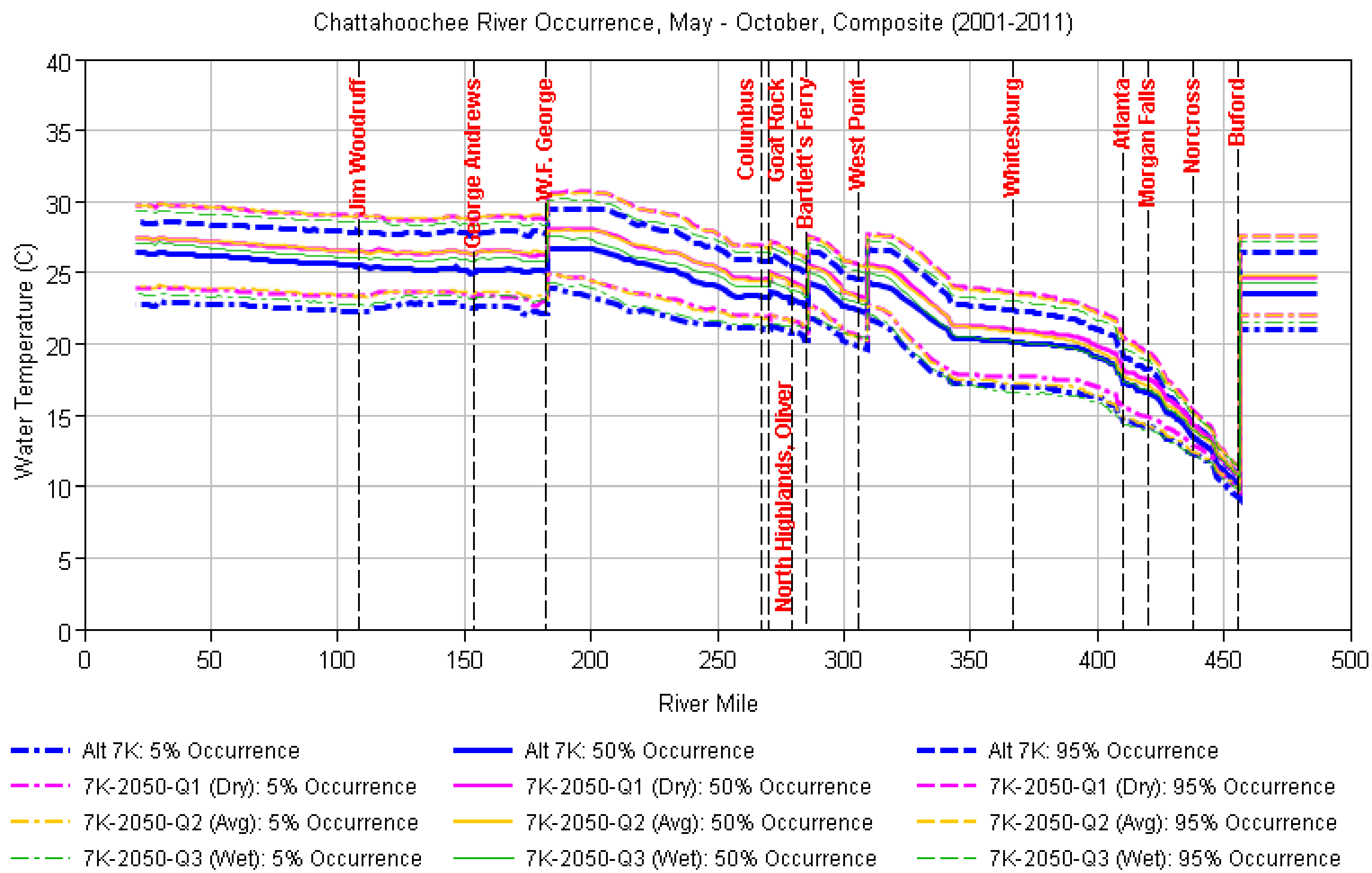


Figure 5.3 Longitudinal occurrence profiles of water temperature for the May-October growing season along the Chattahoochee River during the 2001–2011 modeling period.

6 REFERENCES

Ashby et. al., 1996. "Identification, Complication, and Analysis of Water Quality Data for the Apalachicola-Chattahoochee-Flint/Alabama-Coosa-Tallapoosa (ACF/ACT) Comprehensive Basin Study", U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, MS.

Bohan, J.P. and J.L. Grace, Jr., 1973. "Selective Withdrawal from Man-made Lakes; Hydraulic Laboratory Investigation," Technical Report H-73-4, U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, MS.

Hydrologic Engineering Center, 1986. "HEC-5, Simulation of Flood Control and Conservation Systems, Appendix on Water Quality Analysis", Davis, CA.

Hydrologic Engineering Center (HEC), 1998. "HEC-5, Simulation of Flood Control and Conservation Systems, Appendix on Water Quality Analysis", Davis, CA.

Hydrologic Engineering Center (HEC), 1996, 1999a. "Water Quality Modeling of Reservoir System Operations Using HEC-5, Training Document", Davis, CA.

Hydrologic Engineering Center (HEC), 2014. "Apalachicola-Chattahoochee-Flint (ACF) Watershed – HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Storage Assessment," Davis, CA.

Hydrologic Engineering Center (HEC), 2016. "Addendum: Apalachicola-Chattahoochee-Flint (ACF) Watershed – HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update and Water Storage Assessment," Davis, CA.

Institute of Water Resources (IWR), U.S. Army Corps of Engineers, 2014. "Apalachicola-Chattahoochee-Flint Climate Change Support Analysis." Project Report.

Resource Management Associates, Inc. (RMA), 1999b. "HEC-5Q Simulation of Water Quality in the Alabama-Coosa-Tallapoosa (ACT) and Apalachicola-Chattahoochee-Flint (ACF) River Basins", March 31, 1999.

US Army Corps of Engineers Waterways Experiment Station, 1986. "CE-QUAL-R1: A Numerical One-Dimensional Model of Reservoir and Water Quality – User's Manual", July 1986.

7 APPENDIX A – TRIBUTARY FLOW AND WATER QUALITY INPUTS

Table 7.1 Average, maximum and minimum tributary flow and water quality inputs to the Chattahoochee River.

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM1 (BOD)	DOM2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Lake Lanier (Buford)	456.1												
Chattahoochee River	490	1453	15.5	-	0.17	0.02	1.65	0.04	8.8	-	3.0	1.6	(avg)
			25.8	-	1.14	0.23	10.00	0.22	13.0	-	7.2	11.1	(max)
			4.0	-	0.15	0.01	1.00	0.03	5.8	-	3.0	1.1	(min)
Gainesville - Flat Creek **	460	11.69	20.8	100	10.00	0.28	-	1.50	5.7	10.0	-	3.5	(avg)
			28.0	100	10.00	0.43	-	1.50	7.3	10.0	-	3.5	(max)
			12.0	100	10.00	0.22	-	1.50	4.1	10.0	-	3.5	(min)
Buford Dam to Norcross	456.1												
Swannee Creek	446	185	16.5	-	0.25	0.04	1.65	0.06	8.6	-	3.4	3.2	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Fulton County - Cauley **	440	6.7	23.7	100	10.00	0.09	-	0.20	6.2	7.5	-	3.1	(avg)
			27.2	100	10.00	0.11	-	0.25	7.5	7.5	-	3.1	(max)
			18.6	100	10.00	0.06	-	0.18	4.9	7.5	-	3.1	(min)
Norcross to Morgan Falls_IN	438.5												
Fulton County - Johns Cr **	435	9.3	20.8	100	10.00	0.58	-	1.17	5.4	15.0	-	7.3	(avg)
			28.0	100	10.00	0.70	-	2.29	7.0	15.0	-	7.3	(max)
			12.0	100	10.00	0.51	-	0.40	3.8	15.0	-	7.3	(min)

Reach/ Name (** point load)		River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM1 (BOD)	DOM2 (BOD)	TSS (org)	avg max min
		mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Fulton Co. Big Creek WPCP **		427	33.7	20.8	100	10.00	0.46	-	0.82	5.2	5.0	-	1.4	(avg)
				28.0	100	10.00	0.53	-	1.83	6.3	5.0	-	1.4	(max)
				12.0	100	10.00	0.35	-	0.27	4.1	5.0	-	1.4	(min)
Big Creek		426	200	16.5	-	0.33	0.06	1.65	0.07	8.6	-	3.7	4.2	(avg)
				26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
				4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Morgan Falls to Atlanta_IN		420.4												
Sope Creek		415	141	16.5	-	0.55	0.13	1.65	0.12	8.6	-	5.3	8.1	(avg)
				26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
Lockheed **				4.0	-	0.23	0.01	1.00	0.05	3.0	-	3.0	1.5	(min)
		413	2.6	20.8	100	8.60	0.27	-	0.03	6.9	7.2	-	3.0	(avg)
				28.0	100	8.60	0.38	-	0.03	9.2	10.9	-	3.0	(max)
				12.0	100	8.60	0.18	-	0.03	4.8	5.2	-	3.0	(min)
Atlanta to Whitsburg		410.7												
Nancy and Peachtree Creek		409	311	16.5	-	0.46	0.10	1.65	0.10	8.6	-	4.5	6.3	(avg)
				26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
				4.0	-	0.19	0.01	1.00	0.05	3.0	-	3.0	1.3	(min)
RM Clayton WPCP **		407	121.4	20.8	100	10.00	0.22	-	0.86	6.4	10.0	-	3.8	(avg)
				28.0	100	10.00	0.28	-	1.63	8.0	10.0	-	3.8	(max)
				12.0	100	10.00	0.18	-	0.26	4.9	10.0	-	3.8	(min)
Cobb County - Sutton WPCP **		404	47.8	21.3	100	10.00	0.33	-	0.43	6.2	5.0	-	2.2	(avg)
				25.1	100	10.00	0.45	-	1.10	7.8	5.0	-	2.2	(max)
				16.7	100	10.00	0.25	-	0.18	4.8	5.0	-	2.2	(min)
South Cobb WPCP **		402	36.5	21.3	100	10.00	0.37	-	1.12	7.0	17.5	-	7.0	(avg)
				26.1	100	10.00	0.49	-	2.79	8.5	17.5	-	7.0	(max)
				15.6	100	10.00	0.30	-	0.12	5.2	17.5	-	7.0	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM1 (BOD)	DOM2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Atlanta South River **	399	49.3	20.8	100	10.00	0.29	-	0.58	5.8	7.5	-	2.7	(avg)
			28.0	100	10.00	0.42	-	0.91	7.3	7.5	-	2.7	(max)
			12.0	100	10.00	0.19	-	0.25	4.4	7.5	-	2.7	(min)
Utoy Creek	397	396	16.5	-	0.38	0.08	1.65	0.08	8.6	-	4.1	5.3	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.3	(min)
Atlanta Creek WPCP **	395	43	20.8	100	10.00	0.18	-	0.20	5.8	10.0	-	3.7	(avg)
			28.0	100	10.00	0.26	-	0.39	7.2	10.0	-	3.7	(max)
			12.0	100	10.00	0.13	-	0.09	4.4	10.0	-	3.7	(min)
Camp Creek WPCP **	393.5	22	20.8	100	10.00	0.25	-	2.76	6.3	12.5	-	5.1	(avg)
			28.0	100	10.00	0.34	-	5.07	7.6	12.5	-	5.1	(max)
			12.0	100	10.00	0.21	-	0.93	5.0	12.5	-	5.1	(min)
Douglasville Douglas County **	392	2.3	20.8	100	10.00	0.42	-	1.29	6.4	12.1	-	6.6	(avg)
			28.0	100	10.00	0.50	-	2.20	8.4	16.2	-	6.6	(max)
			12.0	100	10.00	0.36	-	0.84	4.7	8.8	-	6.6	(min)
Camp Creek	390	111	16.5	-	0.31	0.06	1.65	0.07	8.6	-	3.6	4.1	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Bear Creek	383	84	16.5	-	0.23	0.03	1.65	0.05	8.6	-	3.2	2.4	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Snake Creek	370	172	16.5	-	0.26	0.04	1.65	0.06	8.6	-	3.2	2.7	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM1 (BOD)	DOM2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Whitesburg to Franklin	367.6												
Chattahoochee: misc.trib-1	358	90	16.5	-	0.31	0.05	1.65	0.07	8.6	-	3.3	3.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Centralhatchee Creek	344	27	16.5	-	0.32	0.05	1.65	0.07	8.6	-	3.2	2.6	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
West Point Lake	343.2		4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Hillabatchee Creek	342	61	16.5	-	0.23	0.03	1.65	0.05	8.6	-	3.1	1.9	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.0	(min)
New River	335	140	16.5	-	0.26	0.03	1.65	0.05	8.6	-	3.2	2.2	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.1	(min)
Yellowjacket Creek	322	144	16.5	-	0.25	0.03	1.65	0.05	8.6	-	3.2	2.1	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.1	(min)
Wehadkee Creek	312	120	16.5	-	0.25	0.03	1.65	0.05	8.6	-	3.1	1.9	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.0	(min)
West Point Dam to West Point Gauge	309.2												
Oseligee Creek	308.9	345	16.5	-	0.22	0.02	1.65	0.04	8.6	-	3.1	1.8	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.0	(min)
Lanett WWTP **	306.9	3.9	20.8	100	10.00	0.70	-	0.59	6.4	6.8	-	7.7	(avg)
			28.0	100	10.00	0.70	-	1.07	8.9	11.0	-	7.7	(max)
			12.0	100	10.00	0.70	-	0.14	4.4	5.5	-	7.7	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM1 (BOD)	DOM2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
West Point Gauge to Bartletts Ferry	306.7												
Long Cane Creek	304.5	70	16.5	-	0.25	0.04	1.65	0.05	8.6	-	3.3	2.7	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.1	(min)
La Grange WPCP **	302.5	8.8	20.5	100	10.00	0.51	-	0.08	5.8	7.5	-	2.9	(avg)
			30.0	100	10.00	0.72	-	0.22	7.3	7.5	-	2.9	(max)
			8.0	100	10.00	0.32	-	0.03	4.3	7.5	-	2.9	(min)
East Alabama WWTP **	299.5	3.9	20.8	100	5.82	1.73	-	2.09	3.9	9.0	-	16.2	(avg)
			28.0	100	12.87	2.63	-	5.24	5.7	11.8	-	16.2	(max)
			12.0	100	2.94	0.75	-	0.08	2.2	7.0	-	16.2	(min)
Bartletts Ferry	299.0												
Flat Shoal Creek	296	243	16.5	-	0.22	0.02	1.65	0.04	8.6	-	3.2	2.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.0	(min)
Mountain Creek	291	162	16.5	-	0.21	0.02	1.65	0.04	8.6	-	3.1	1.8	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.0	(min)
Halawakee Creek	288	87	16.5	-	0.22	0.02	1.65	0.04	8.6	-	3.2	2.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.1	(min)
Opelika Eastside WWTP **	286	1.1	20.8	100	9.51	9.21	-	2.02	6.9	10.0	-	4.2	(avg)
			28.0	100	12.88	14.43	-	7.94	9.0	10.0	-	4.2	(max)
			12.0	100	5.35	3.48	-	0.94	4.8	10.0	-	4.2	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM1 (BOD)	DOM2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Goat Rock	284.7												
Mulberry Creek	282	312	16.5	-	0.21	0.02	1.65	0.04	8.6	-	3.2	2.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.1	(min)
Oliver	279.0												
Standing Boy Creek	275	31	16.5	-	0.21	0.02	1.65	0.04	8.6	-	3.1	2.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.02	3.0	-	3.0	1.0	(min)
North Highlands	270.7												
Chattahoochee: misc.trib-2	270.5	88	16.5	-	0.30	0.05	1.65	0.07	8.6	-	3.5	3.4	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
North Highlands Dam to Columbus	270.3												
Columbus WWTP **	270	46.7	20.8	100	10.00	2.24	-	2.96	6.3	25.0	-	10.8	(avg)
			28.0	100	10.00	3.11	-	4.93	7.7	25.0	-	10.8	(max)
			12.0	100	10.00	1.47	-	1.61	4.9	25.0	-	10.8	(min)
West Point WWTP **	269.3	1.1	20.8	100	10.00	0.62	-	2.58	5.2	27.3	-	10.8	(avg)
			28.0	100	10.00	1.04	-	4.03	6.4	32.3	-	10.8	(max)
			12.0	100	10.00	0.29	-	1.11	3.9	24.2	-	10.8	(min)
Southern Power Company **	268.7	2.5	23.3	100	4.70	0.10	-	0.60	4.3	12.5	-	5.1	(avg)
			29.3	100	4.70	0.10	-	0.60	5.0	12.5	-	5.1	(max)
			17.8	100	4.70	0.10	-	0.60	3.5	12.5	-	5.1	(min)
Chattahoochee: misc.trib-3	268	68	16.5	-	0.37	0.07	1.65	0.08	8.6	-	4.2	5.1	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
Columbus to W.F. George	267.7		4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.3	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM1 (BOD)	DOM2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Phenix City **	267.5	3.9	22.3	100	5.82	1.73	-	2.09	3.9	9.0	-	16.2	(avg)
			28.0	100	12.87	2.63	-	5.24	5.7	11.8	-	16.2	(max)
			12.3	100	2.94	0.75	-	0.08	2.2	7.0	-	16.2	(min)
Bull Creek	265	62	16.5	-	0.33	0.06	1.65	0.07	8.6	-	3.9	4.3	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Upatoi Creek	260	301	16.5	-	0.28	0.05	1.65	0.06	8.6	-	3.7	3.8	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Walter F George	256												
Columbus - Fort Benning **	256	2.6	22.3	100	1.00	8.12	-	12.63	3.0	53.6	-	20.4	(avg)
			28.0	100	1.00	9.02	-	13.47	4.1	61.3	-	20.4	(max)
			12.3	100	1.00	7.37	-	11.26	2.1	49.7	-	20.4	(min)
Uchee Creek	252	207	16.5	-	0.24	0.03	1.65	0.05	8.6	-	3.2	2.4	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Hichitee Creek	244	75	16.5	-	0.24	0.04	1.65	0.05	8.6	-	3.4	3.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Hannahatchee Creek	234	175	16.5	-	0.22	0.04	1.65	0.05	8.6	-	3.4	2.9	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Mead Coated Board **	225	37.3	22.3	100	0.26	0.12	-	0.91	4.3	12.2	-	11.1	(avg)
			28.0	100	0.26	0.12	-	0.91	5.0	18.5	-	11.1	(max)
			12.3	100	0.26	0.12	-	0.91	3.5	8.1	-	11.1	(min)

Reach/ Name (** point load)		River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM1 (BOD)	DOM2 (BOD)	TSS (org)	avg max min
		mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Grass Creek		224	54	16.5	-	0.30	0.05	1.65	0.07	8.6	-	3.5	3.3	(avg)
				26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
				4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.2	(min)
Eufaula WWTP	**	218	3.9	22.3	100	10.00	0.70	-	0.59	6.4	6.8	-	7.7	(avg)
				28.0	100	10.00	0.70	-	1.07	8.9	11.0	-	7.7	(max)
				12.3	100	10.00	0.70	-	0.14	4.4	5.5	-	7.7	(min)
Cowikee Creek		216	353	16.5	-	0.24	0.04	1.65	0.05	8.6	-	3.4	3.0	(avg)
				26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
				4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Barbour Creek		204	128	16.5	-	0.25	0.04	1.65	0.06	8.6	-	3.4	3.0	(avg)
				26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
				4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Pataula Creek		193	367	16.5	-	0.26	0.05	1.65	0.06	8.6	-	3.5	3.2	(avg)
				26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
				4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Walter F George Dam to Andrews		182.9												
Cemochechobee Creek		182	81	16.5	-	0.21	0.03	1.65	0.05	8.6	-	3.2	2.2	(avg)
				26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
				4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Kolomoki Creek		176	178	16.5	-	0.30	0.04	1.65	0.07	8.6	-	3.2	2.3	(avg)
				26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
				4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.1	(min)
George Andrews		172.9												
Sandy Creek		164	201	16.5	-	0.25	0.03	1.65	0.06	8.6	-	3.2	2.1	(avg)
				26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
				4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM1 (BOD)	DOM2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Omusee Creek	156	260	16.5	-	0.34	0.04	1.65	0.08	8.6	-	3.2	2.2	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.17	0.01	1.00	0.04	3.0	-	3.0	1.1	(min)
Sawhatchee Creek	142	67	16.5	-	0.27	0.05	1.65	0.06	8.6	-	3.4	3.5	(avg)
			26.8	-	0.89	0.32	10.00	0.18	13.0	-	11.6	18.1	(max)
			4.0	-	0.19	0.01	1.00	0.05	3.0	-	3.0	1.5	(min)
George Andrews to Jim Woodruff_IN_CH (Lake Seminole)	154.4												
Farley Nuclear Plant **	151	129.9	20.8	100	0.50	0.15	-	0.20	4.3	10.0	-	4.0	(avg)
			33.4	100	0.50	0.15	-	0.20	5.0	10.0	-	4.0	(max)
			0.8	100	0.50	0.15	-	0.20	3.5	10.0	-	4.0	(min)
Great Southern Paper Co. **	148	73.2	29.4	100	1.00	0.30	-	4.00	4.3	62.3	-	31.0	(avg)
			41.7	100	1.00	0.30	-	4.00	5.0	77.7	-	31.0	(max)
			16.4	100	1.00	0.30	-	4.00	3.5	49.4	-	31.0	(min)
Lake Seminole, Chattahoochee Arm	134.3												
Chattahoochee: misc.trib-4	130	635	16.5	-	0.29	0.02	1.65	0.07	8.6	-	3.1	2.1	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.16	0.01	1.00	0.04	3.0	-	3.0	1.1	(min)

Table 7.2 Average, maximum and minimum flow and water quality inputs to the Flint and Apalachicola Rivers.

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM 1 (BOD)	DOM 2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Griffin to Montezuma	412.2												
Flint R.	405	286	16.5	-	0.31	0.04	1.65	0.07	8.6	-	3.1	2.4	(avg)
			26.8	-	1.00	0.24	10.00	0.20	13.0	-	7.0	10.7	(max)
			4.0	-	0.21	0.01	1.00	0.05	3.0	-	3.0	1.3	(min)
Line Creek	399	157	16.5	-	0.18	0.02	1.65	0.04	8.6	-	3.0	1.6	(avg)
			26.8	-	0.54	0.10	10.00	0.11	13.0	-	3.6	5.3	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
White Oak Creek	391	194	16.5	-	0.18	0.02	1.65	0.04	8.6	-	3.0	1.5	(avg)
			26.8	-	0.57	0.10	10.00	0.12	13.0	-	3.0	4.3	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Red Oak Creek	385	211	16.5	-	0.18	0.02	1.65	0.04	8.6	-	3.0	1.4	(avg)
			26.8	-	0.58	0.09	10.00	0.12	13.0	-	3.0	3.5	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Elkins Creek	378	164	16.5	-	0.17	0.02	1.65	0.04	8.6	-	3.0	1.6	(avg)
			26.8	-	0.52	0.10	10.00	0.11	13.0	-	3.2	4.7	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Pigeon Creek	362	102	16.5	-	0.16	0.02	1.65	0.03	8.6	-	3.0	1.6	(avg)
			26.8	-	0.43	0.08	10.00	0.09	13.0	-	3.3	4.9	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Lazer Creek	359	192	16.5	-	0.19	0.02	1.65	0.04	8.6	-	3.0	1.7	(avg)
			26.8	-	0.59	0.12	10.00	0.12	13.0	-	3.7	5.4	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Griffin WPCP **	358	2.2	20.8	100	10.00	1.77	-	1.85	6.2	15.3	-	7.5	(avg)
			28.0	100	10.00	2.32	-	2.51	8.0	24.3	-	7.5	(max)
			12.0	100	10.00	1.30	-	1.18	4.6	10.3	-	7.5	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM 1 (BOD)	DOM 2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Potato Creek	351	261	16.5	-	0.17	0.02	1.65	0.04	8.6	-	3.0	1.6	(avg)
			26.8	-	0.50	0.10	10.00	0.10	13.0	-	3.4	4.9	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Swift Creek	337	218	6.5	-	0.17	0.02	1.65	0.04	8.6	-	3.0	1.8	(avg)
			26.8	-	0.50	0.12	10.00	0.10	13.0	-	4.4	6.5	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Ulcohatchee Creek	322	171	16.5	-	0.21	0.03	1.65	0.05	8.6	-	3.1	2.2	(avg)
			6.8	-	0.67	0.18	10.00	0.14	13.0	-	5.8	8.8	(max)
			4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.2	(min)
Patsiliga Creek	308	271	16.5	-	0.23	0.02	1.65	0.05	8.6	-	3.1	2.1	(avg)
			6.8	-	0.75	0.16	10.00	0.15	13.0	-	5.5	8.4	(max)
			4.0	-	0.16	0.01	1.00	0.04	3.0	-	3.0	1.2	(min)
Horse and Toteover Creek	295	93	16.5	-	0.17	0.02	1.65	0.04	8.6	-	3.0	1.7	(avg)
			26.8	-	0.51	0.10	10.00	0.11	13.0	-	4.0	5.9	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Whitewater Creek	289	153	16.5	-	0.18	0.02	1.65	0.04	8.6	-	3.0	2.0	(avg)
			26.8	-	0.56	0.13	10.00	0.12	13.0	-	5.0	7.5	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.2	(min)
Montezuma to Albany	288.4												
Montezuma WWTP	287	80	16.5	-	0.32	0.05	1.65	0.07	8.6	-	3.2	2.6	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Buck Creek	275	127	6.5	-	0.31	0.03	1.65	0.07	8.6	-	3.0	2.0	(avg)
			26.8	-	2.00	0.50	10.00	0.45	13.0	-	12.0	20.4	(max)
			4.0	-	0.22	0.01	1.00	0.05	3.0	-	3.0	1.3	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM 1 (BOD)	DOM 2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Camp Creek	262	178	16.5	-	0.34	0.03	1.65	0.07	8.6	-	3.0	2.1	(avg)
			6.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	21.0	(max)
			4.0	-	0.24	0.01	1.00	0.05	3.0	-	3.0	1.3	(min)
Turkey Creek	259	157	16.5	-	0.28	0.02	1.65	0.06	8.6	-	3.0	1.7	(avg)
			26.8	-	2.00	0.48	10.00	0.42	13.0	-	9.5	14.7	(max)
			4.0	-	0.20	0.01	1.00	0.05	3.0	-	3.0	1.2	(min)
Lime Creek	247	39	16.5	-	0.40	0.05	1.65	0.09	8.6	-	3.1	2.2	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	23.5	(max)
			4.0	-	0.29	0.01	1.00	0.06	3.0	-	3.0	1.3	(min)
Gum Creek	241	230	16.5	-	0.40	0.05	1.65	0.08	8.6	-	3.0	2.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	20.5	(max)
			4.0	-	0.28	0.01	1.00	0.06	3.0	-	3.0	1.3	(min)
Swift Creek	233	123	16.5	-	0.38	0.05	1.65	0.08	8.6	-	3.1	2.2	(avg)
			6.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	23.3	(max)
			4.0	-	0.27	0.01	1.00	0.06	3.0	-	3.0	1.3	(min)
Jones Creek	226	105	6.5	-	0.32	0.04	1.65	0.07	8.6	-	3.1	2.6	(avg)
			26.8	-	2.00	0.50	10.00	0.48	13.0	-	12.0	25.0	(max)
			4.0	-	0.23	0.01	1.00	0.05	3.0	-	3.0	1.4	(min)
Abrams Creek	220	94	16.5	-	0.44	0.07	1.65	0.09	8.6	-	3.3	3.2	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.31	0.01	1.00	0.07	3.0	-	3.0	1.5	(min)
Piney Woods Creek	217	178	6.5	-	0.25	0.03	1.65	0.06	8.6	-	3.1	2.2	(avg)
			6.8	-	1.90	0.50	10.00	0.37	13.0	-	12.0	23.8	(max)
			4.0	-	0.17	0.01	1.00	0.04	3.0	-	3.0	1.3	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM 1 (BOD)	DOM 2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Albany to Newton	210.0												
Albany - Joshua St **	209	28	23.2	100	10.00	0.99	-	1.21	5.3	15.4	-	7.6	(avg)
			28.0	100	10.00	3.29	-	1.69	6.7	22.0	-	7.6	(max)
			13.8	100	10.00	0.54	-	0.79	4.2	10.9	-	7.6	(min)
Merc & Co. **	206	2	23.2	100	2.00	5.10	-	0.20	1.7	98.6	-	140.1	(avg)
			8.0	100	2.00	5.10	-	0.20	2.0	99.0	-	140.1	(max)
			13.8	100	2.00	5.10	-	0.20	1.4	94.4	-	40.1	(min)
Miller Breweries **	204.5	2.9	20.8	100	27.70	7.20	-	0.71	6.3	50.4	-	10.5	(avg)
			28.0	100	27.70	7.20	-	0.71	8.0	64.4	-	10.5	(max)
			12.0	100	27.70	7.20	-	0.71	4.8	39.7	-	10.5	(min)
Kinchafoonee Creek	200	676	16.5	-	0.43	0.07	1.65	0.09	8.6	-	3.5	3.8	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.28	0.01	1.00	0.06	3.0	-	3.0	1.2	(min)
Dry Creek	188	190	6.5	-	0.37	0.04	1.65	0.08	8.6	-	3.0	1.9	(avg)
			26.8	-	2.00	0.50	10.00	0.45	13.0	-	9.9	15.4	(max)
			4.0	-	0.25	0.01	1.00	0.06	3.0	-	3.0	1.1	(min)
Racoon Creek	178	178	16.5	-	0.23	0.02	1.65	0.05	8.6	-	3.0	1.6	(avg)
			26.8	-	1.45	0.30	10.00	0.28	13.0	-	6.8	10.4	(max)
			4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.0	(min)
Newton to Bainbridge	177.3												
Cooleewahee Creek	161	101	6.5	-	0.20	0.02	1.65	0.05	8.6	-	3.0	1.7	(avg)
			26.8	-	1.28	0.20	10.00	0.25	13.0	-	7.9	12.2	(max)
			4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.0	(min)
Blakely WPCP **	154	1.9	20.8	100	10.00	0.99	-	0.48	6.1	9.5	-	5.7	(avg)
			28.0	100	10.00	3.30	-	0.82	7.2	12.6	-	5.7	(max)
			12.0	100	10.00	0.28	-	0.28	4.6	6.6	-	5.7	(min)

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM 1 (BOD)	DOM 2 (BOD)	TSS (org)	avg max min
	mile	cfs	C	tracer	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Decatur County Industrial **	152	0.9	0.8	100	6.40	0.46	-	0.31	3.2	9.6	-	4.2	(avg)
			28.0	100	6.40	1.02	-	0.78	3.7	11.8	-	4.2	(max)
			12.0	100	6.40	0.27	-	0.15	2.5	6.6	-	4.2	(min)
Bainbridge WWTP **	150	1.7	20.8	100	10.00	0.97	-	7.65	6.1	26.3	-	10.6	(avg)
			28.0	100	10.00	1.24	-	9.74	7.8	32.0	-	10.6	(max)
			2.0	100	10.00	0.66	-	5.08	4.5	22.9	-	10.6	(min)
Ichawaynochaway Creek	148	1121	6.5	-	0.26	0.02	1.65	0.06	8.6	-	3.0	1.9	(avg)
			26.8	-	1.65	0.26	10.00	0.32	13.0	-	10.1	15.8	(max)
			4.0	-	0.17	0.01	1.00	0.04	3.0	-	3.0	1.1	(min)
Lake Seminole - Flint Arm	139												
Flint: misc.trib-1	136	239	16.5	-	0.26	0.03	1.65	0.06	8.6	-	3.3	2.8	(avg)
			6.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.2	(min)
Big Slough	130	588	16.5	-	0.28	0.02	1.65	0.06	8.6	-	3.1	2.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.1	(min)
Spring Creek	140	834	16.5	-	0.29	0.03	1.65	0.06	8.6	-	3.1	2.2	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.16	0.01	1.00	0.04	3.0	-	3.0	1.1	(min)
Fishpond Drain	120	287	16.5	-	0.25	0.02	1.65	0.06	8.6	-	3.1	1.9	(avg)
			26.8	-	2.00	0.47	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Apalachicola River													
Jim Woodruff Dam to Chattahoochee	107.6												

Reach/ Name (** point load)	River Mile	Flow	Temp	Point inflow	NO3-N	PO4-P	Chl_*a*	NH3-N	DO	DOM 1 (BOD)	DOM 2 (BOD)	TSS (org)	avg max min
	mile	**cfs**	**C**	**tracer**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	
Florida State Hospital **	107.1	0.9	23.9	100	10.00	0.70	-	1.00	4.3	12.5	-	5.0	(avg)
			28.0	100	0.00	0.70	-	1.00	5.0	12.5	-	5.0	(max)
			15.3	100	10.00	0.70	-	1.00	3.5	12.5	-	5.0	(min)
Chattahoochee to Blountstown	107.0												
Apalachicola misc.trib-1	90	167	16.5	-	0.26	0.04	1.65	0.06	8.6	-	3.3	3.0	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.04	3.0	-	3.0	1.2	(min)
Blountstown to Sumatra	78.9												
Apalachicola misc.trib-2	52	334	16.5	-	0.19	0.02	1.65	0.04	8.6	-	3.1	2.3	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Chipola River	28	2035	16.5	-	0.22	0.03	1.65	0.05	8.6	-	3.2	2.4	(avg)
			26.8	-	2.00	0.50	10.00	0.50	13.0	-	12.0	25.0	(max)
			4.0	-	0.15	0.01	1.00	0.03	3.0	-	3.0	1.1	(min)
Sumatra	20.3												

8 APPENDIX B- SENSITIVITY RESULTS

The focus of the sensitivity runs was to quantify the relative impact of various model coefficients and sources on model predictions. The primary emphasis was the impact on phytoplankton (chlorophyll *a*) since phytoplankton dynamics have a major impact on DO and high concentrations are associated with degraded water quality. A total of fourteen sensitivity runs were performed in which the following model parameters or sources were incremented 25%. A fifteenth simulation evaluated the model's sensitivity to the reaeration coefficient by scaling all reaeration coefficients to 75% of the calibrated model. The values within the brackets are the typical baseline ranges.

1. Phytoplankton growth rate, 1/day (1.6 - 2.2)
2. Phytoplankton respiration rate, 1/day (0.25 - 0.3)
3. Phytoplankton settling velocity, m/day (0.15 - 0.5)
4. Benthic oxygen uptake/demand, mg/m^2/day (500 - 1250)
5. Benthic nitrogen source rate, mg/ m^2/day (5 - 12)
6. Benthic phosphorus source rate, mg/ m^2/day (2 - 4)
7. Ammonia decay rate, 1/day (0.1 - 0.2)
8. Dissolved organics decay rate, 1/day (0.06 - 0.2)
9. Non-point/tributary stream dissolved organics, mg/l (variable - BASINS based)
10. Point/municipal and industrial dissolved organics, mg/l (variable - treatment plant specific)
11. Non-point/tributary stream nitrogen (NH_3+NH_4), mg/l (variable - BASINS based)
12. Point/municipal and industrial nitrogen (NH_3+NH_4), mg/l (variable - treatment plant specific)
13. Non-point/tributary stream phosphorus (PO_4), mg/l (variable - BASINS based)
14. Point/municipal and industrial phosphorus (PO_4), mg/l (variable - treatment plant specific)
15. Reaeration rate, m/sec (variable - function of stream flow velocity and lake surface wind speed)

Each sensitivity run impacts multiple parameters throughout the ACF. It is impossible to quantify the impacts at all locations and times, therefore the impacts are demonstrated as a longitudinal profile plot for the Chattahoochee and Apalachicola River system bounded by Lake Lanier (Buford Dam) at river mile 456 and Sumatra at river mile 20. This reach encompasses the entire river system regulated by existing Corps dams. However, the Apalachicola River beginning at Jim Woodruff Dam is impacted by the Flint River. Plots for chlorophyll *a* and the parameter specific to the incremented parameter is presented to show the global impact. Each of these plots is for the phytoplankton growing season of April through October over the 2001 - 2011 simulation period. The average lines are bold for reference clarification.

Additionally, the incremental changes relative to the baseline simulation are listed in an extensive set of tables (available upon request). A decrease (i.e., where the Sensitivity value minus the Base value is negative) indicates a reduction associated with the sensitivity run. The criterion for table listing is an incremental difference between the baseline and sensitivity run greater than |0.5%|. The river segments and each of the time periods and increments for the 5, 25, 50 (median), 75 and 95 percent exceedance levels are included. The table columns are as follows

1) River segment (Chattahoochee or Flint)

2) Parameter

3) Units

4) Year period

5) Monthly time period, baseline label, sensitivity run label & increment label

6-10) Percentage label and length weighted average concentration

11) Average percentage change

Results of the sensitivity runs (SR) are described below.

8.1.1 SENSITIVITY TO PHYTOPLANKTON GROWTH (SR1)

A 25% higher growth rate results in larger phytoplankton concentrations as shown in the chlorophyll *a* profiles in Figure 8.1. The higher growth rate increases phytoplankton concentration at a fairly uniform rate from below Buford Dan to below Whitesburg. The higher growth rate is analogous to longer residence time (lower flow velocity). The percentage increase remains fairly uniform below Whitesburg.

The increase in growth rate decreases the nutrient concentrations (Figure 8.2 and Figure 8.3); however, the percentage impact on phosphorus is greater, indicating that the system is phosphorus limited in the model. Both nutrients are greatly reduced in West Point Lake (mile 343–309) due to phytoplankton uptake. DO (Figure 8.4) generally remains the same or higher throughout the system. The peak oxygen in West Point Lake is moved upstream. Note that these plots reflect the near-surface concentrations. DO is essentially unchanged below the dams.

8.1.2 SENSITIVITY TO PHYTOPLANKTON RESPIRATION (SR2)

A 25% higher respiration rate results in much smaller phytoplankton concentrations (Figure 8.5). The rate of increase in West Point Lake is reduced by approximately half. The effect is fairly uniform below West Point Dam. The increase in respiration rate increases the nutrient concentrations (Figure 8.6 and Figure 8.7) since uptake is less due to the smaller phytoplankton concentrations, and the nutrient byproducts of respiration are greater due to the increased respiration rate. The greatest rate of change is in West Point Lake. The greatest percentage impact is on phosphorus since it is the limiting nutrient in the model. DO concentrations are generally lower (Figure 8.8) since lower phytoplankton concentration results in less photosynthesis production. However, uptake associated with respiration is likely lower since the lower phytoplankton concentration offsets the higher respiration rate. Slight increases are computed below some dams since the smaller phytoplankton concentration at depth offsets the higher respiration rates.

Changes seen in the appendix table show impacts normally not associated with phytoplankton dynamics. BOD5U decreases because there is a smaller respiration component due to the lower phytoplankton concentration.

8.1.3 SENSITIVITY TO PHYTOPLANKTON SETTLING (SR3)

A higher phytoplankton settling rate results in lower phytoplankton concentrations (Figure 8.9). The effect is greatest beginning in West Point Lake. A fairly uniform percentage change is computed below West Point Dam. The response to settling is similar to the response to the respiration rate. The net increase in phosphorus (Figure 8.10) is slightly less than the increase due to the respiration rate since the settled phytoplankton is lost to the bottom sediments. The impact on DO is shown in Figure 8.11.

Small changes in the growth, respiration and settling rates can have a measurable effect on the magnitude and timing of phytoplankton dynamics.

8.1.4 SENSITIVITY TO BENTHIC OXYGEN (SR4)

Benthic oxygen demand reduces DO levels slightly throughout the Chattahoochee River. A larger decrease is computed in the Apalachicola River due to the influence of the Flint River. The profile plots in Figure 8.12 show the near surface concentrations that are impacted the least. At depth in stratified reservoirs, the impacts are slightly greater as indicated by the decrease below dams. This model input is of particular importance during DO calibration of the deeper reservoirs such as Lake Lanier (Buford Dam).

8.1.5 SENSITIVITY TO BENTHIC NITROGEN SOURCE RATE (SR5)

The benthic source rate for nitrogen has very little impact on chlorophyll *a* since phytoplankton growth is phosphorus limited in the model. Ammonia nitrogen (NH4-N), which is the parameter directly impacted by the benthic nitrogen source rate, is increased only slightly as seen in Figure 8.13. The small increase indicates that the benthic source is not the major nitrogen contributor at the rates assumed in the calibrated model. The impact on nitrogen is relatively small since the default NO3-N concentration of 10 mg/L assumed in the model provides the bulk of the nitrogen in the Chattahoochee River.

8.1.6 SENSITIVITY TO BENTHIC PHOSPHORUS SOURCE RATE (SR6)

The benthic source rate for phosphorus increases phosphorus (Figure 8.14) and chlorophyll *a* (Figure 8.15) slightly within and below West Point Lake. Since phosphorus is limiting within the model, an increase in the source rate will result in a direct increase in both chlorophyll *a* and phosphorus. Only very small changes in the other parameters were computed.

8.1.7 SENSITIVITY TO AMMONIA DECAY (SR7)

A higher ammonia decay rate hastens the transformation of ammonia to nitrate resulting in decreases in ammonia nitrogen (Figure 8.16) and corresponding increases in nitrate nitrogen (Figure 8.17). Since the nitrate concentration is approximately ten times that of ammonia, the nitrogen increment is nearly undetectable in Figure 8.17. There is little impact on other parameters, including chlorophyll, since the model is phosphorus limited.

8.1.8 SENSITIVITY TO DISSOLVED ORGANIC MATERIAL DECAY RATE (SR8)

The dissolved organics decay rate has little impact on any parameter. The maximum change of any parameter is less than 4% as seen in the appendix table.

8.1.9 SENSITIVITY TO NON-POINT SOURCE DISSOLVED ORGANIC MATERIAL CONCENTRATION (SR9)

The change in the dissolved organics material (DOM) concentration of the non-point sources (tributary streams) does not have a major impact on any other parameter. With a few exceptions, the maximum change of any parameter is less than 5% as seen in the appendix table. One of the reasons for the insensitivity is the relatively low decay rate assigned to the more refractory DOM of tributary stream origin. Point source DOM is assumed to decay at a higher rate (labile dominated). Note that there are no DOM plots since only the effects on BOD5U are referenced in the report. The largest impact on DO occurs below Atlanta as seen in Figure 8.18.

8.1.10 SENSITIVITY TO POINT SOURCE DISSOLVED ORGANIC MATERIAL CONCENTRATION (SR10)

As with the 25% increase in the non-point source DOM, the change in the dissolved organic material (DOM) concentration of the point sources (treatment plants) does not have a major impact on other parameters. The maximum change of any parameter is less than 5% as seen in the appendix table. Although the point source concentrations are greater than those of the non-point sources, the average non-point flows are considerably less. As with the non-point DOM, the largest impact on DO occurs below Atlanta, as seen in Figure 8.19.

8.1.11 Sensitivity to Non-Point Source Nitrogen (SR11)

A 25% increase in non-point source nitrogen (both NH3 and NO3) concentration results in higher total nitrogen throughout the river system (Figure 8.20). Chlorophyll *a* and DO are impacted only slightly since the limiting nutrient in the model is phosphorus.

8.1.12 Sensitivity to Point Source Nitrogen (SR12)

As with the 25% increase in the non-point source nitrogen, model results for 25% increase in the point source nitrogen (both NH3 and NO3) result in higher total nitrogen throughout the system (Figure 8.22). However, the incremental change due to the point source increment is greater than that for the non-point increment. Chlorophyll *a* and DO are impacted only slightly since the limiting nutrient in the model is phosphorus.

8.1.13 Sensitivity to Non-Point Source Phosphorus (SR13)

A 25% increase in non-point source phosphorus results in higher total phosphorus throughout the system (Figure 8.23). Maximum levels of chlorophyll *a* are increased by up to 10% (Figure 8.24) and near-surface DO (Figure 8.25) is increased slightly.

8.1.14 Sensitivity to Point Source Phosphorus(SR14)

A 25% increase in point source phosphorus results in higher total phosphorus (Figure 8.26). The impact of the point source phosphorus is less than that of the non-point sources due to the high level of treatment and source control in the watershed above Whitesburg. The impacts on chlorophyll *a* (Figure 8.27) and near-surface DO are similar to the non-point phosphorus impacts.

8.1.15 Sensitivity to Lake and Stream Reaeration(SR15)

The lake and stream reaeration coefficients were reduced to 75% of those of the calibrated model. A reduction in DO (Figure 8.28) occurs throughout the system. However there is little impact on the DO below dams since the outflow source is the lake hypolimnion. The location, magnitude and recovery of the oxygen sag above Whitesburg can be affected by scaling the reaeration coefficients.

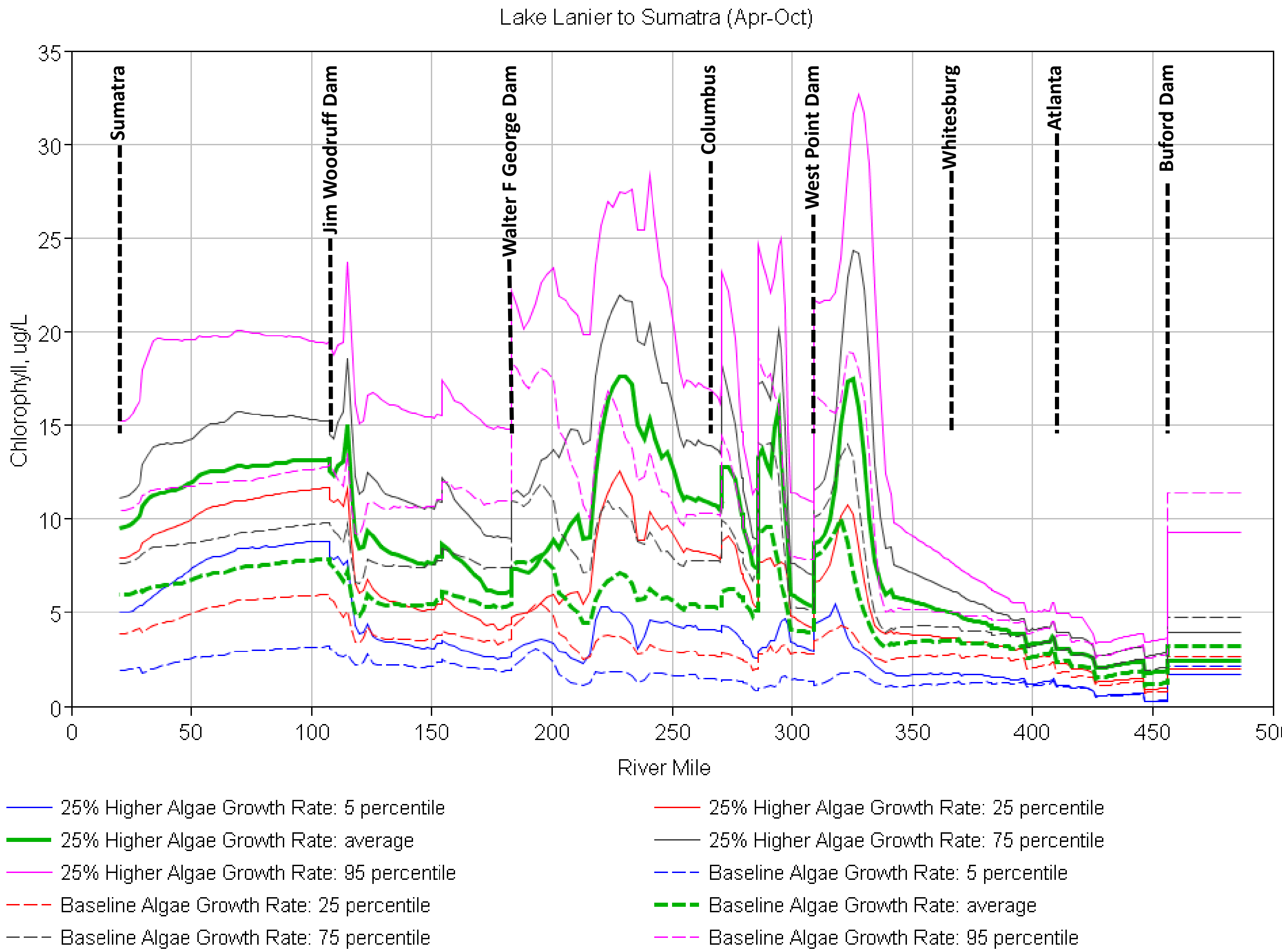


Figure 8.1 Longitudinal profiles of chlorophyll (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton growth rate.

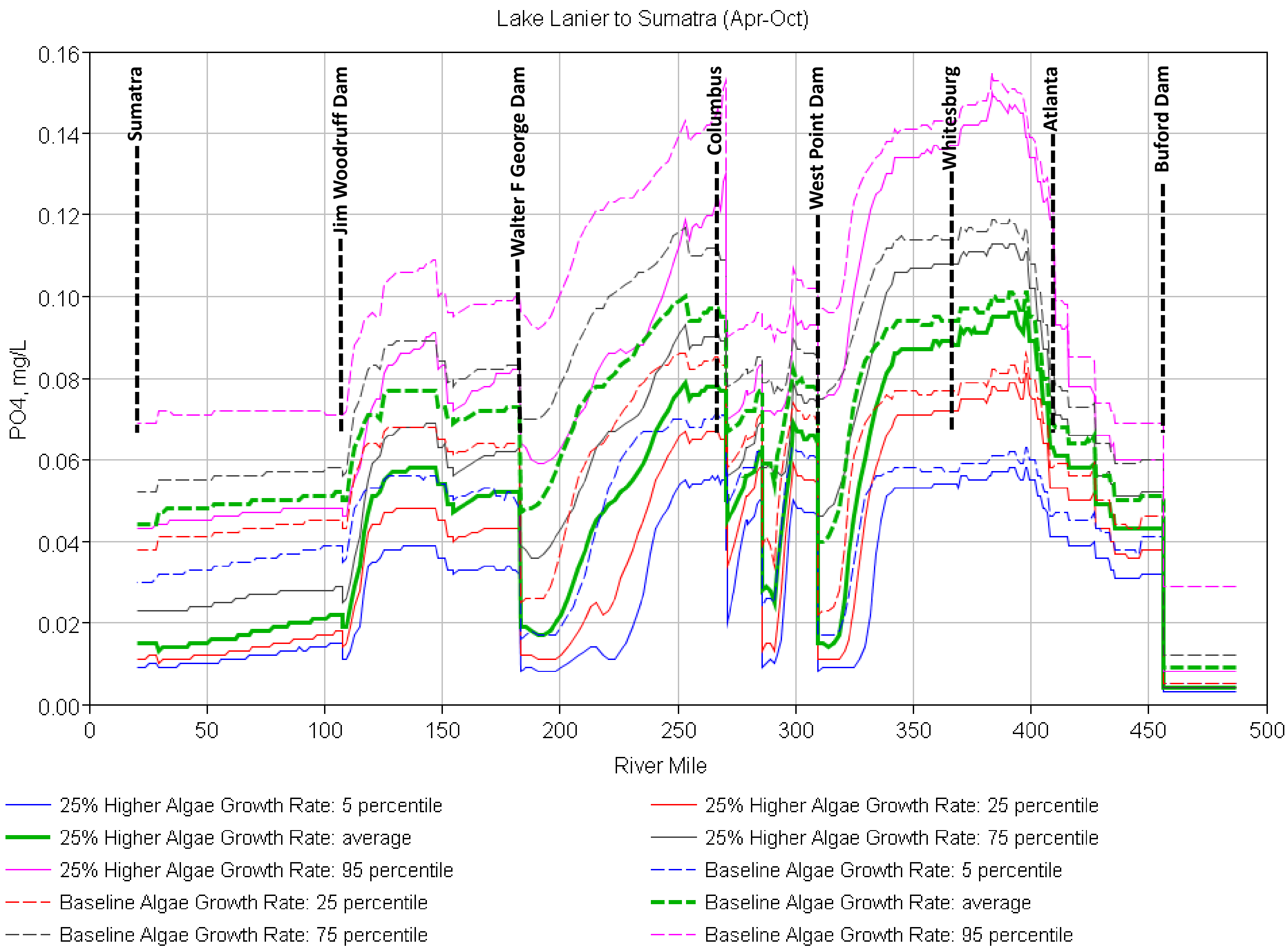


Figure 8.2 Longitudinal profiles of phosphate (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton growth rate.

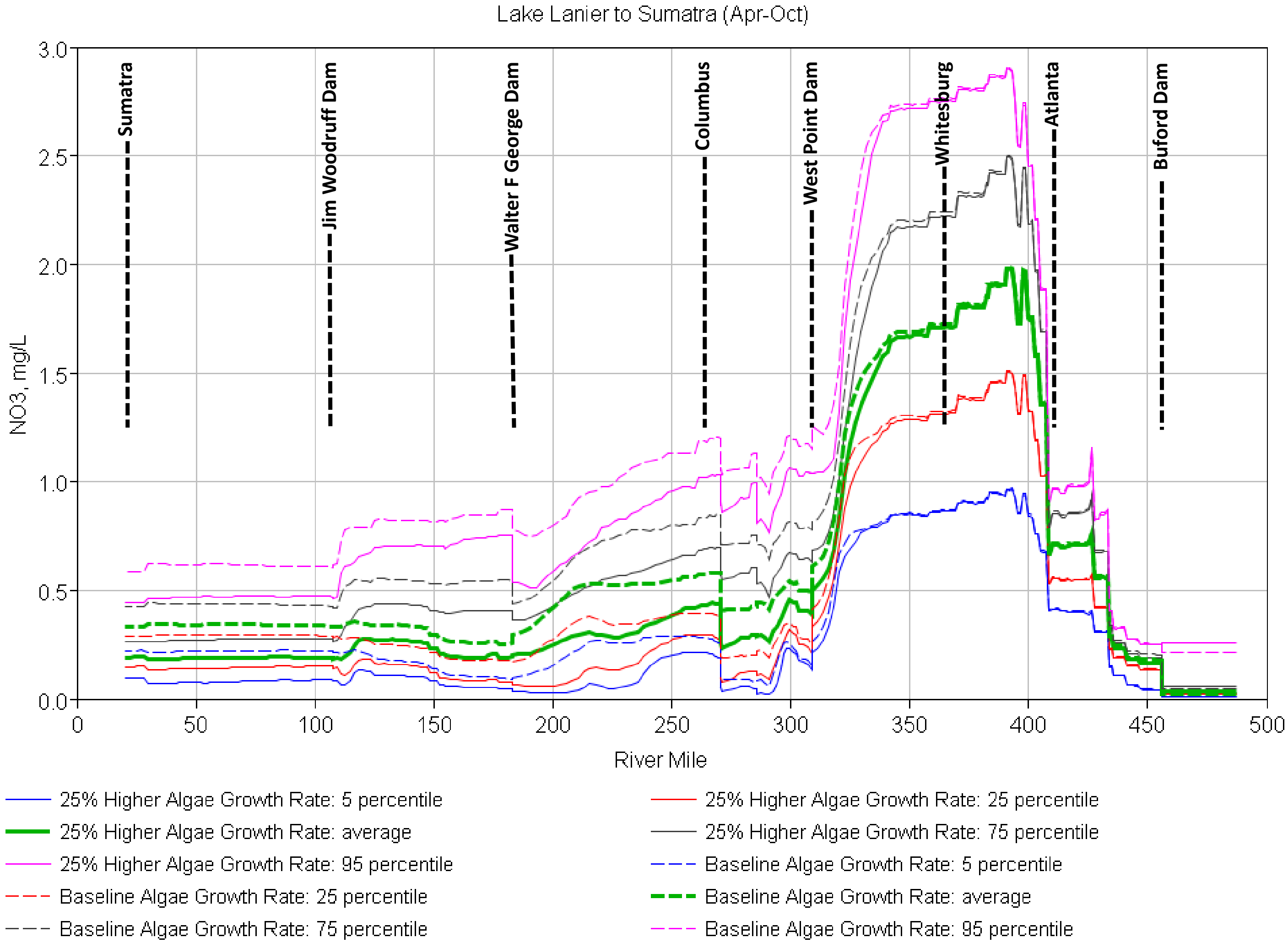


Figure 8.3 Longitudinal profiles of nitrate (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton growth rate.

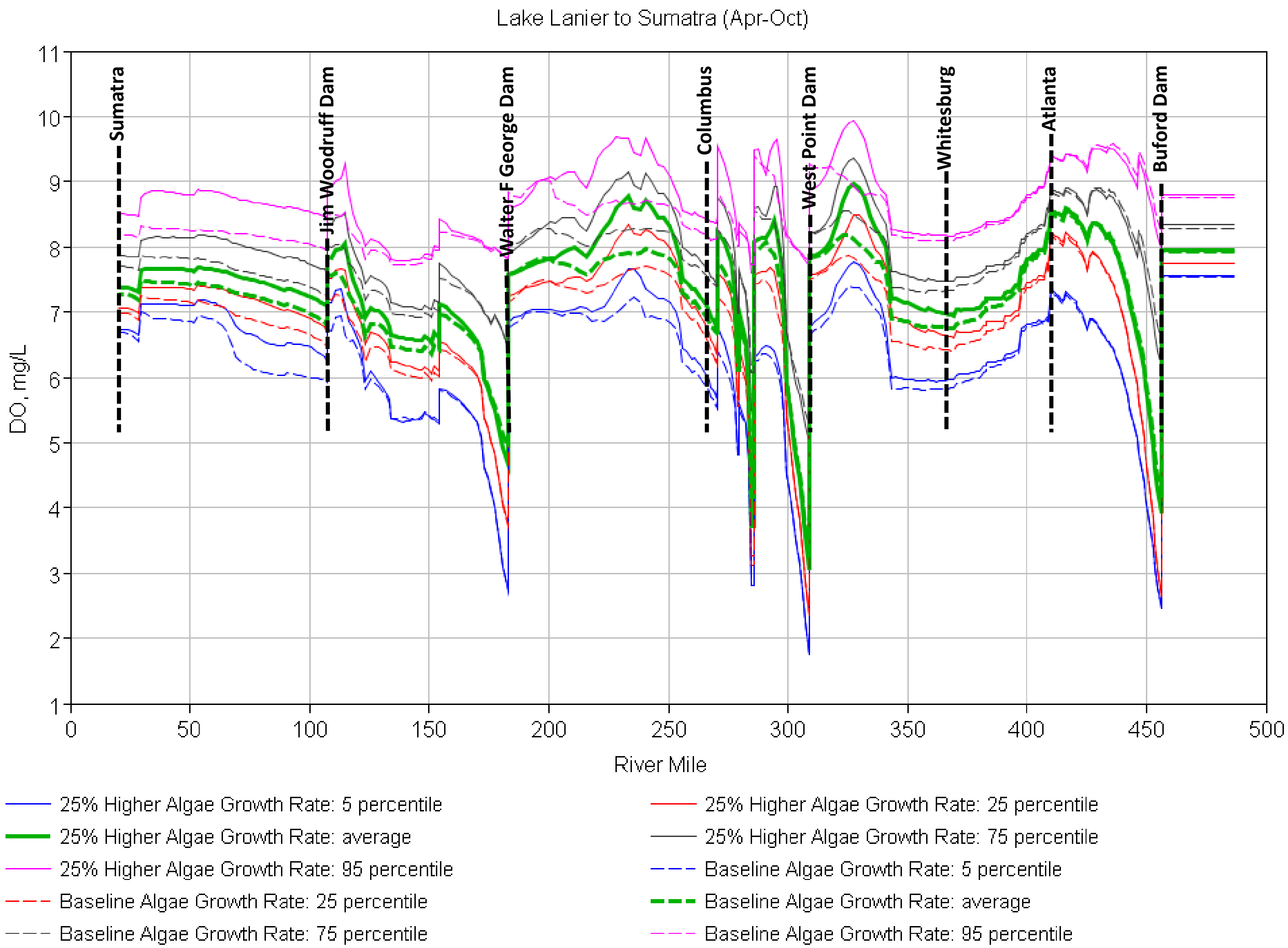


Figure 8.4 Longitudinal profiles of DO (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton growth rate.

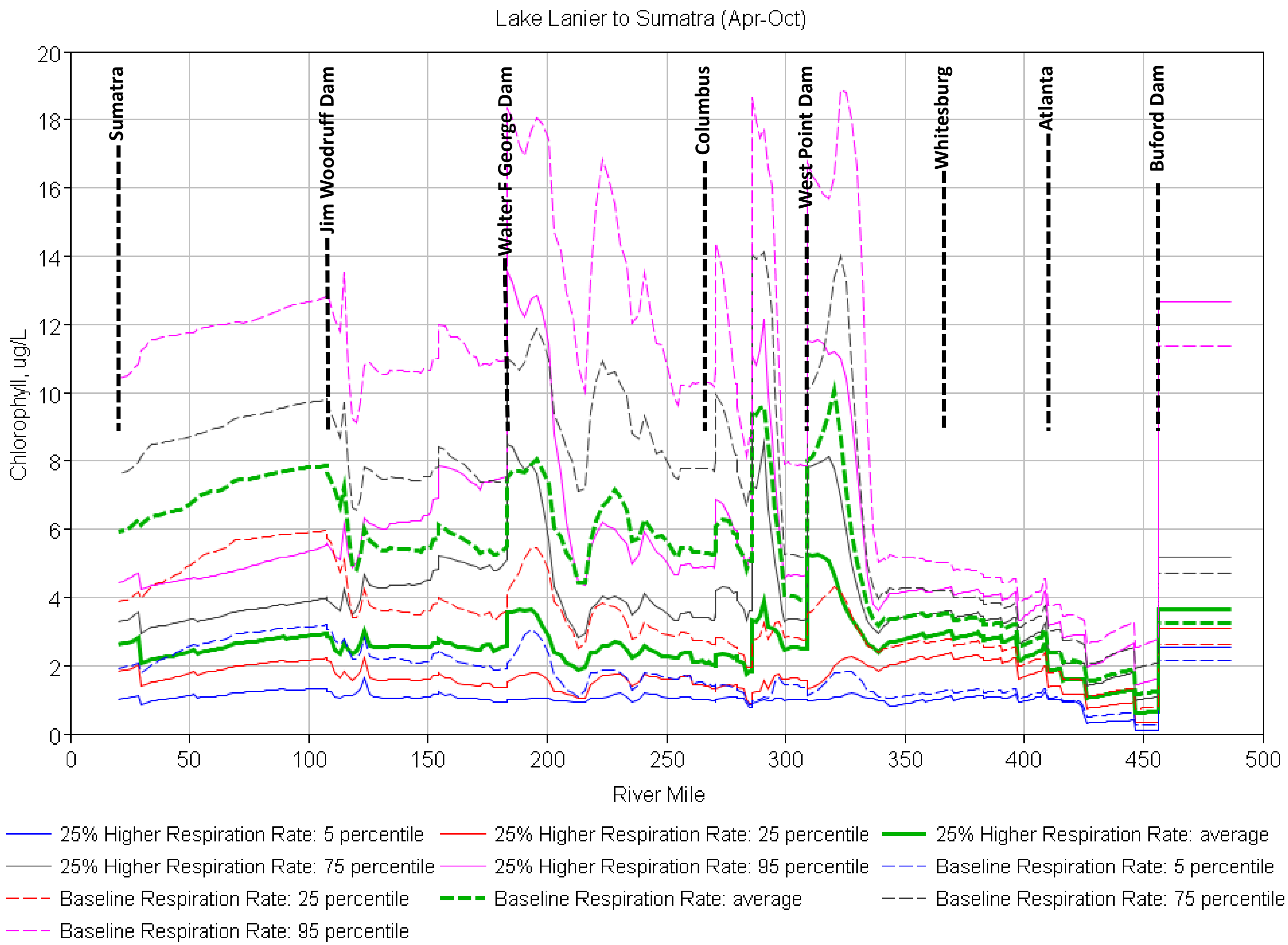


Figure 8.5 Longitudinal profiles of chlorophyll (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton respiration rate.

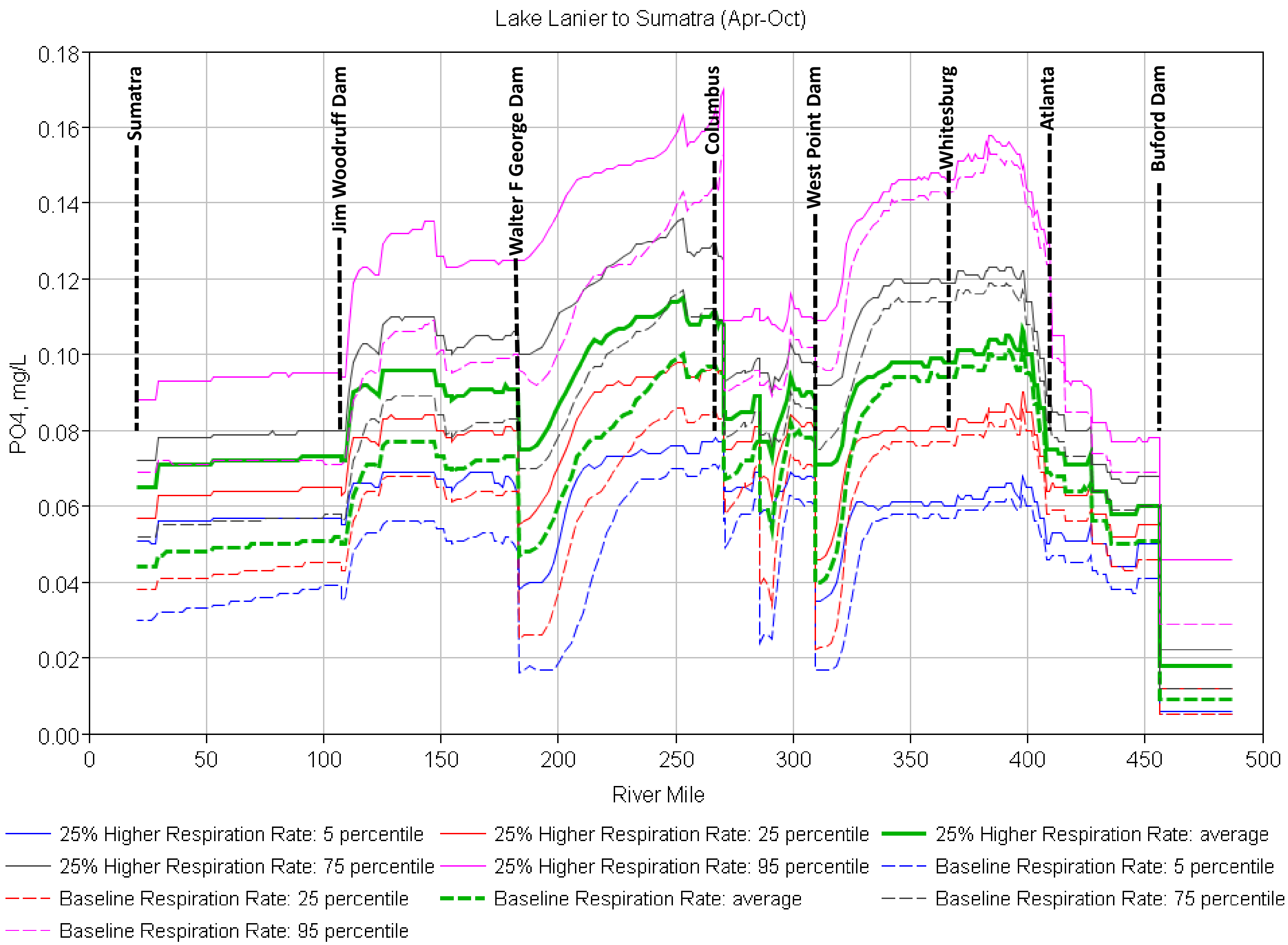


Figure 8.6 Longitudinal profiles of phosphate (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton respiration rate.

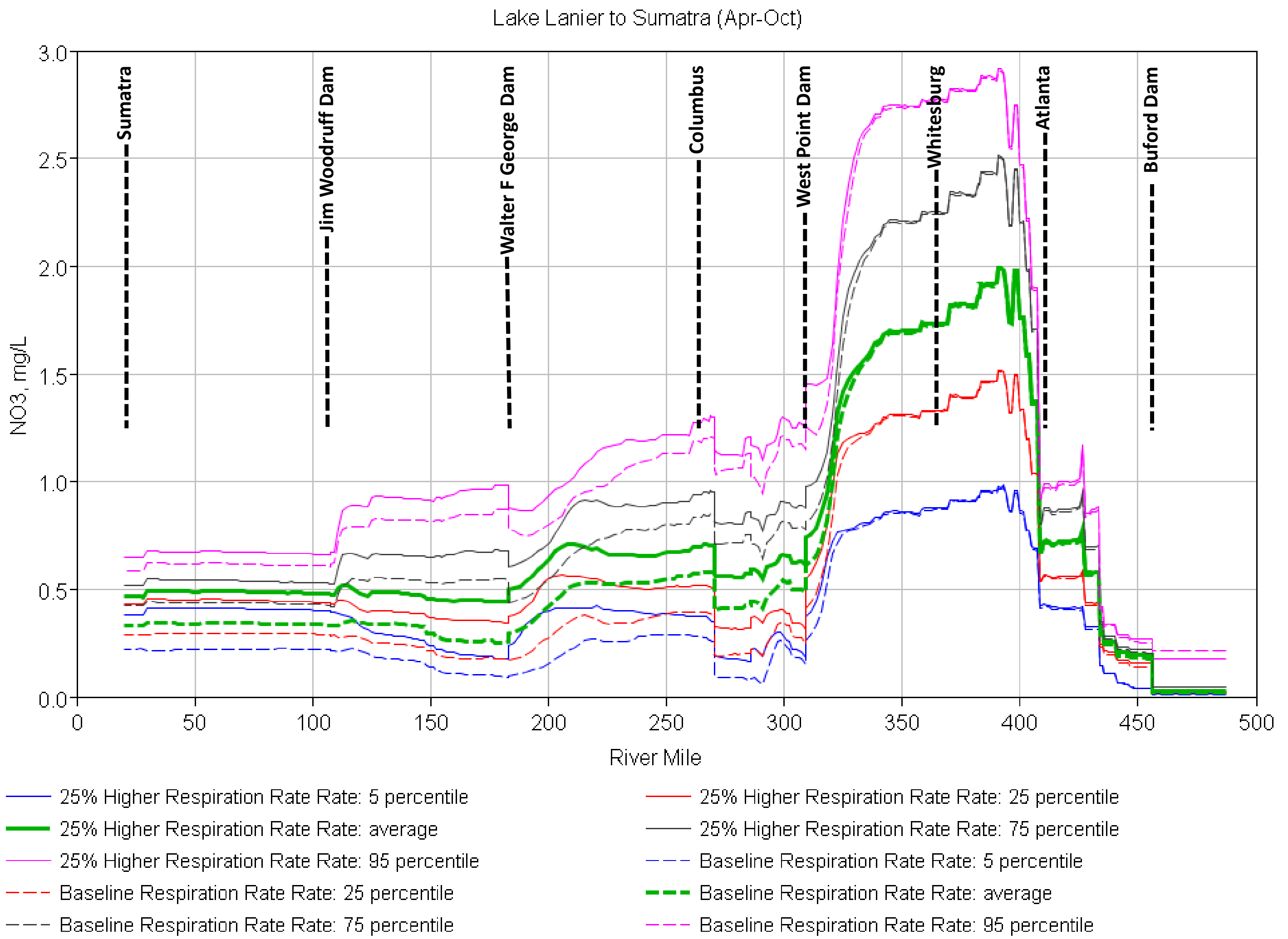


Figure 8.7 Longitudinal profiles of nitrate (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton respiration rate.

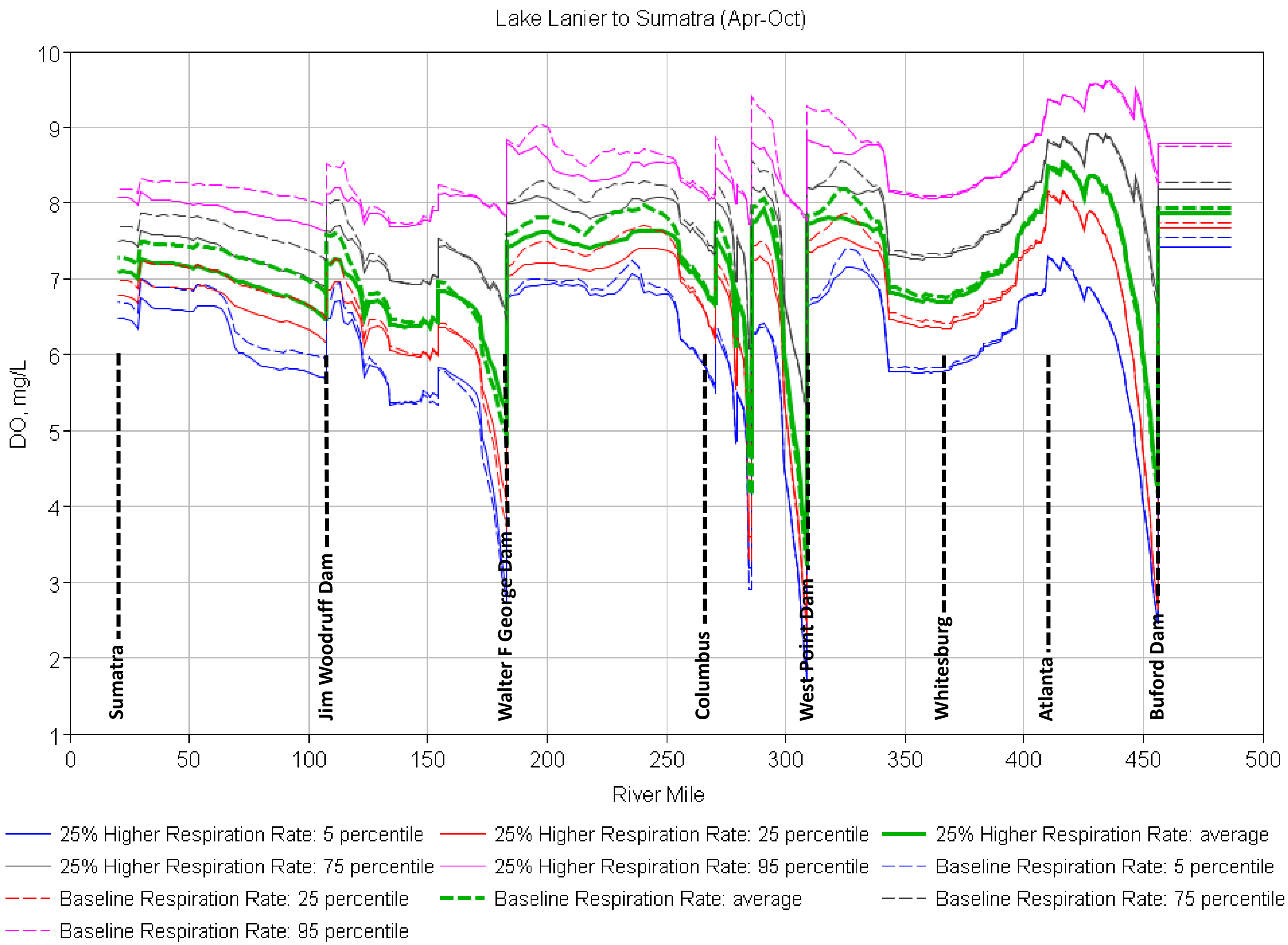


Figure 8.8 Longitudinal profiles of DO (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton respiration rate.

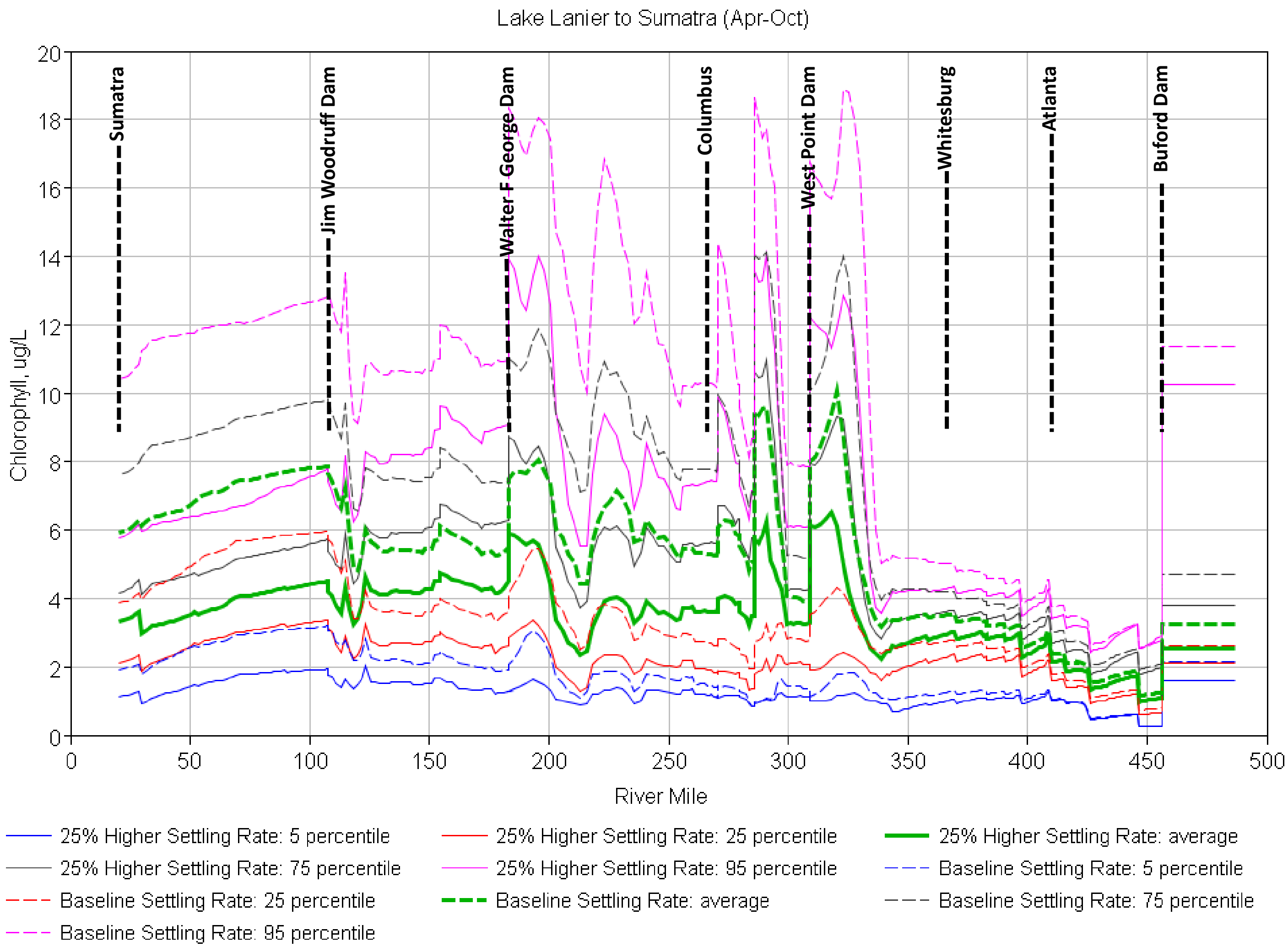


Figure 8.9 Longitudinal profiles of chlorophyll *a* (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton settling rate.

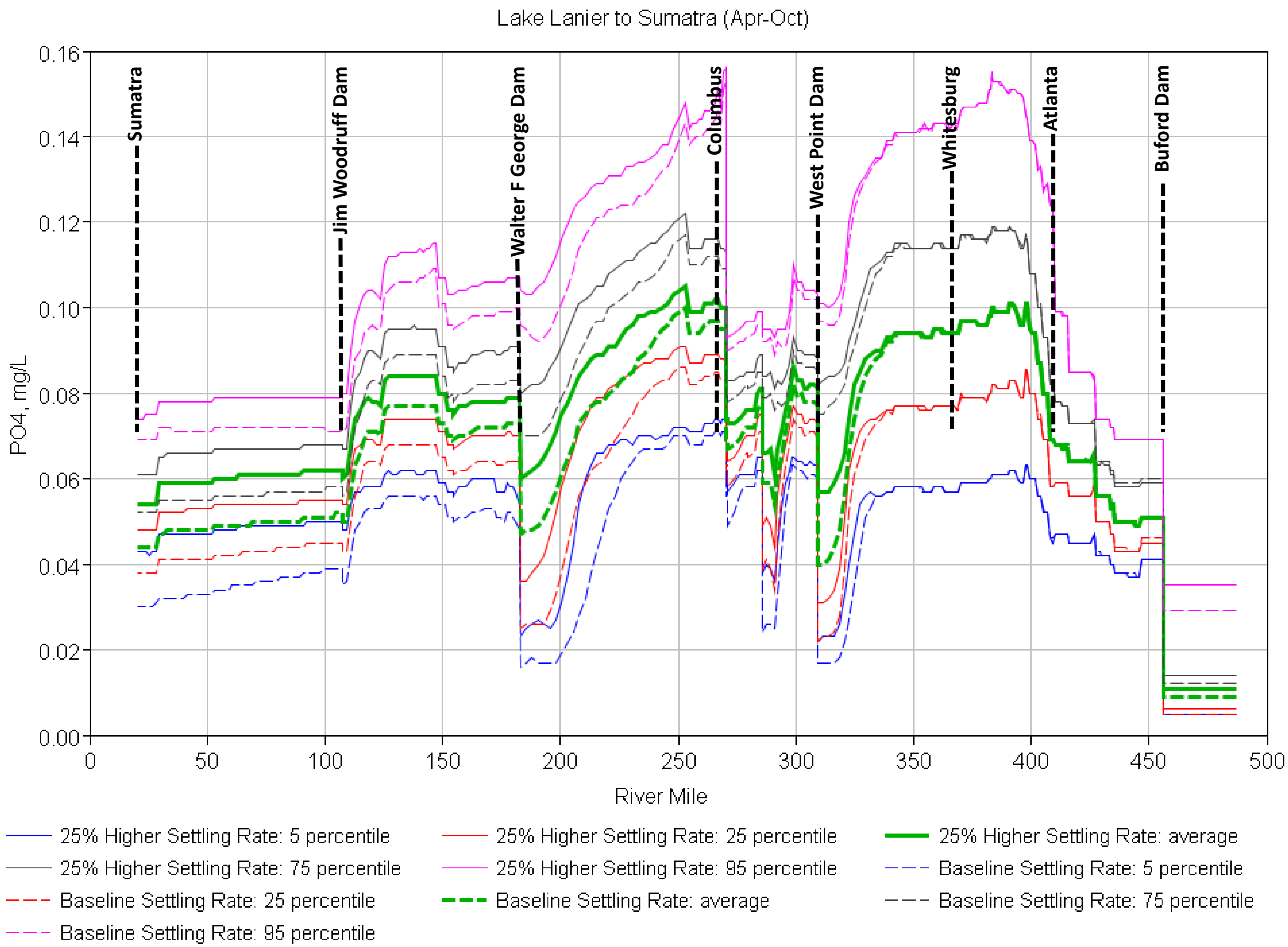


Figure 8.10 Longitudinal profiles of phosphorus (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton settling rate.

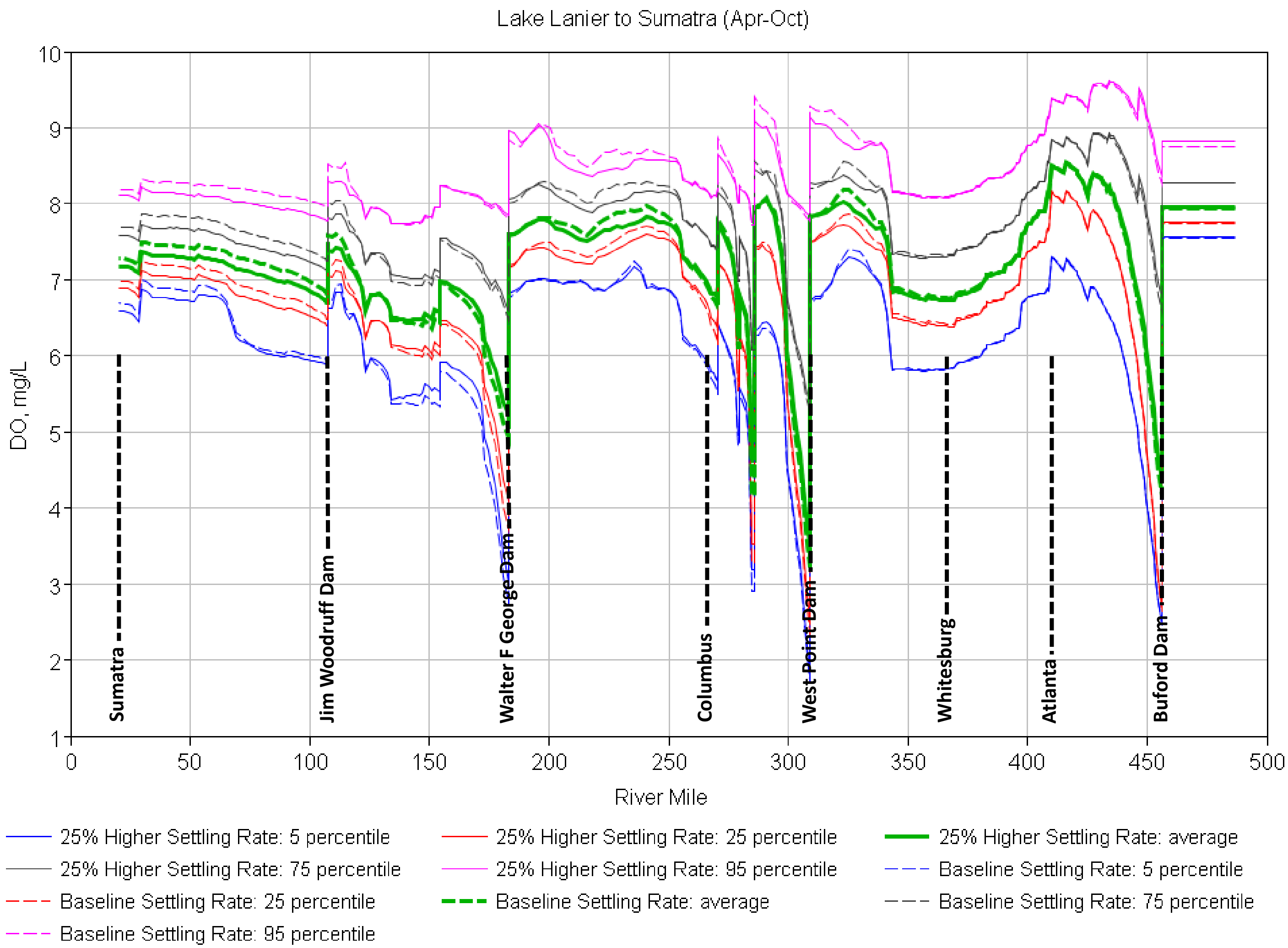


Figure 8.11 Longitudinal profiles of DO (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in phytoplankton settling rate.

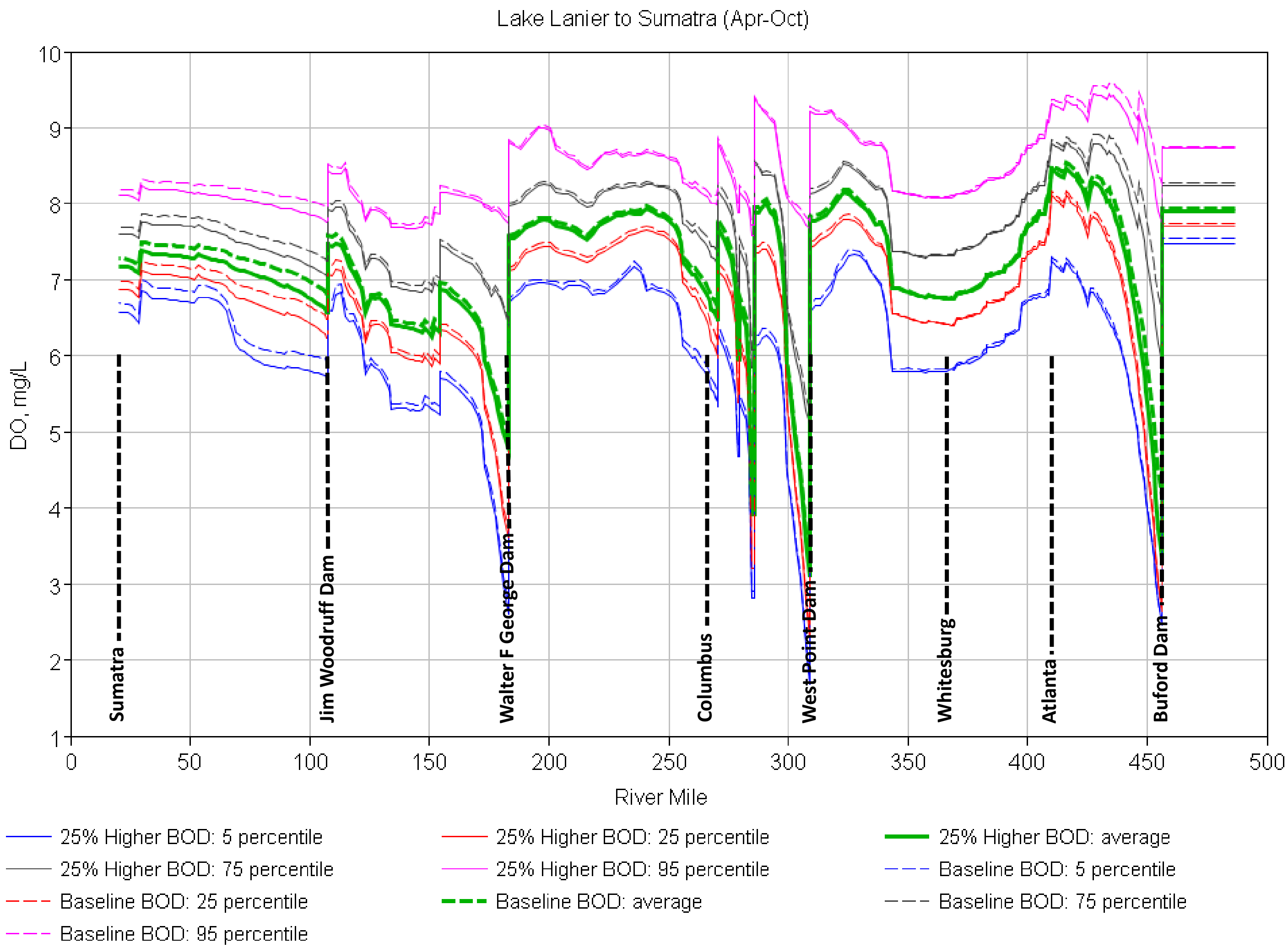


Figure 8.12 Longitudinal profiles of DO (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in bottom sediment BOD.

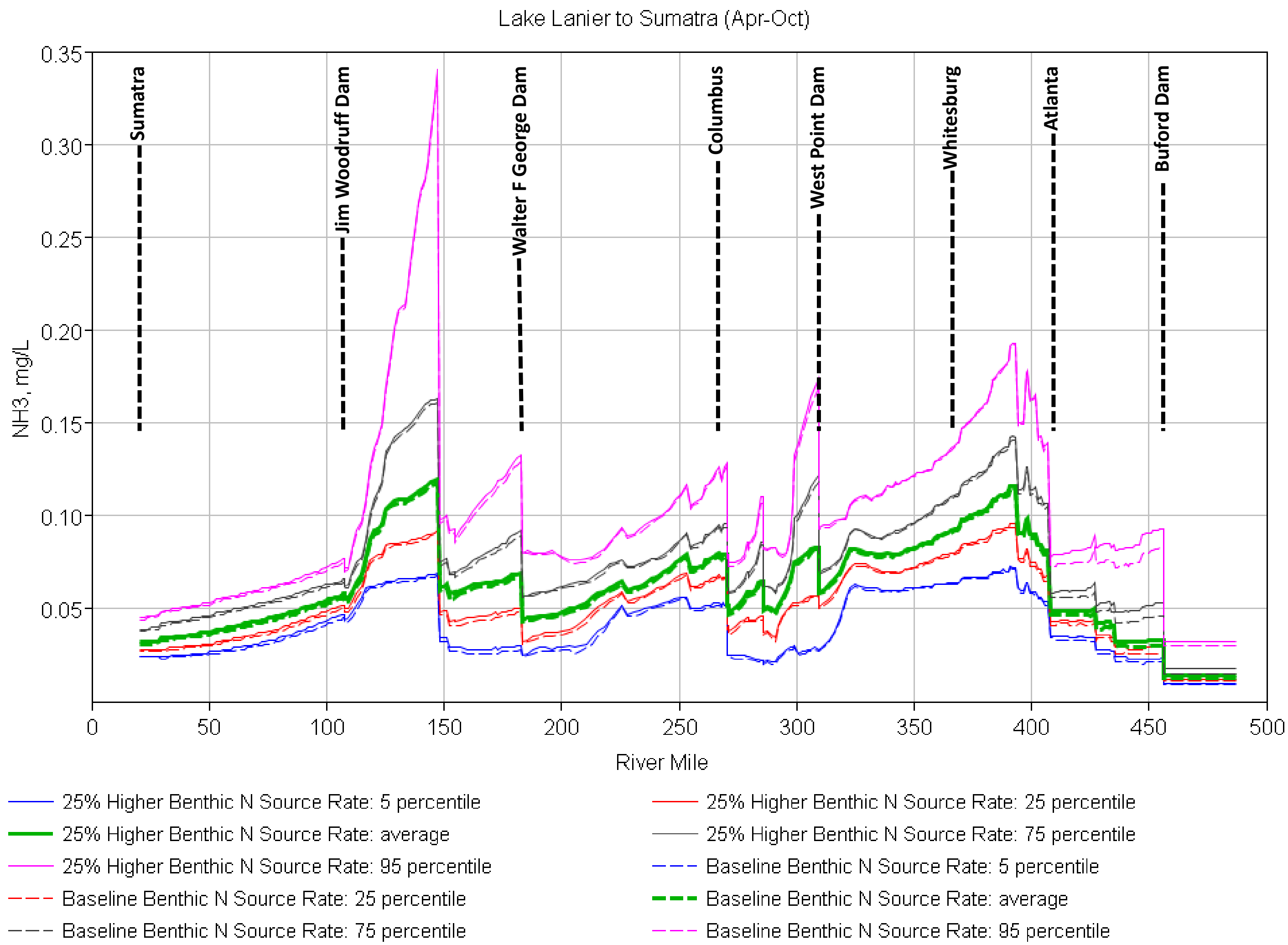


Figure 8.13 Longitudinal profiles of ammonia (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in benthic nitrogen source rate.

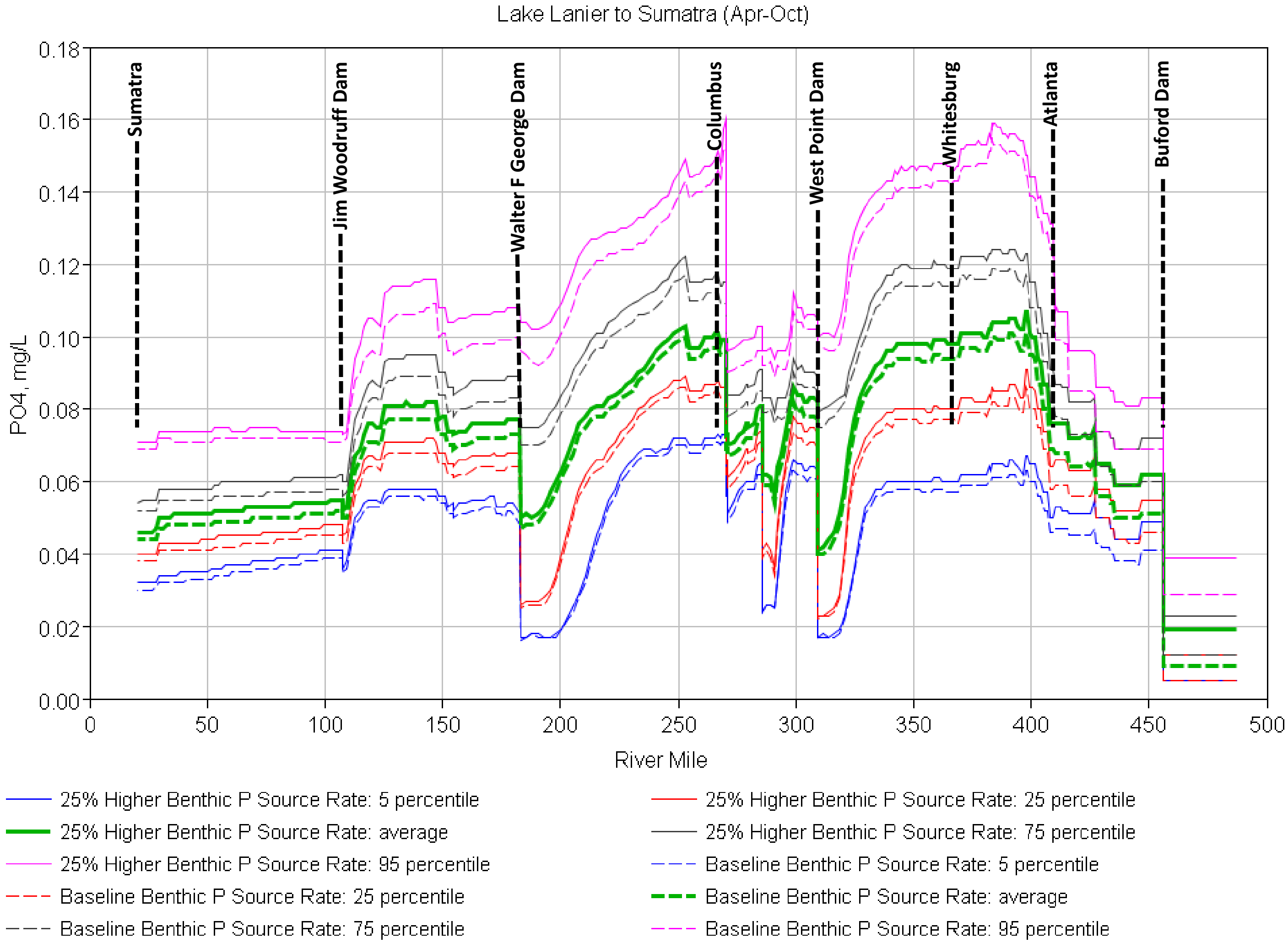


Figure 8.14 Longitudinal profiles of phosphate (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in benthic phosphorus source rate.

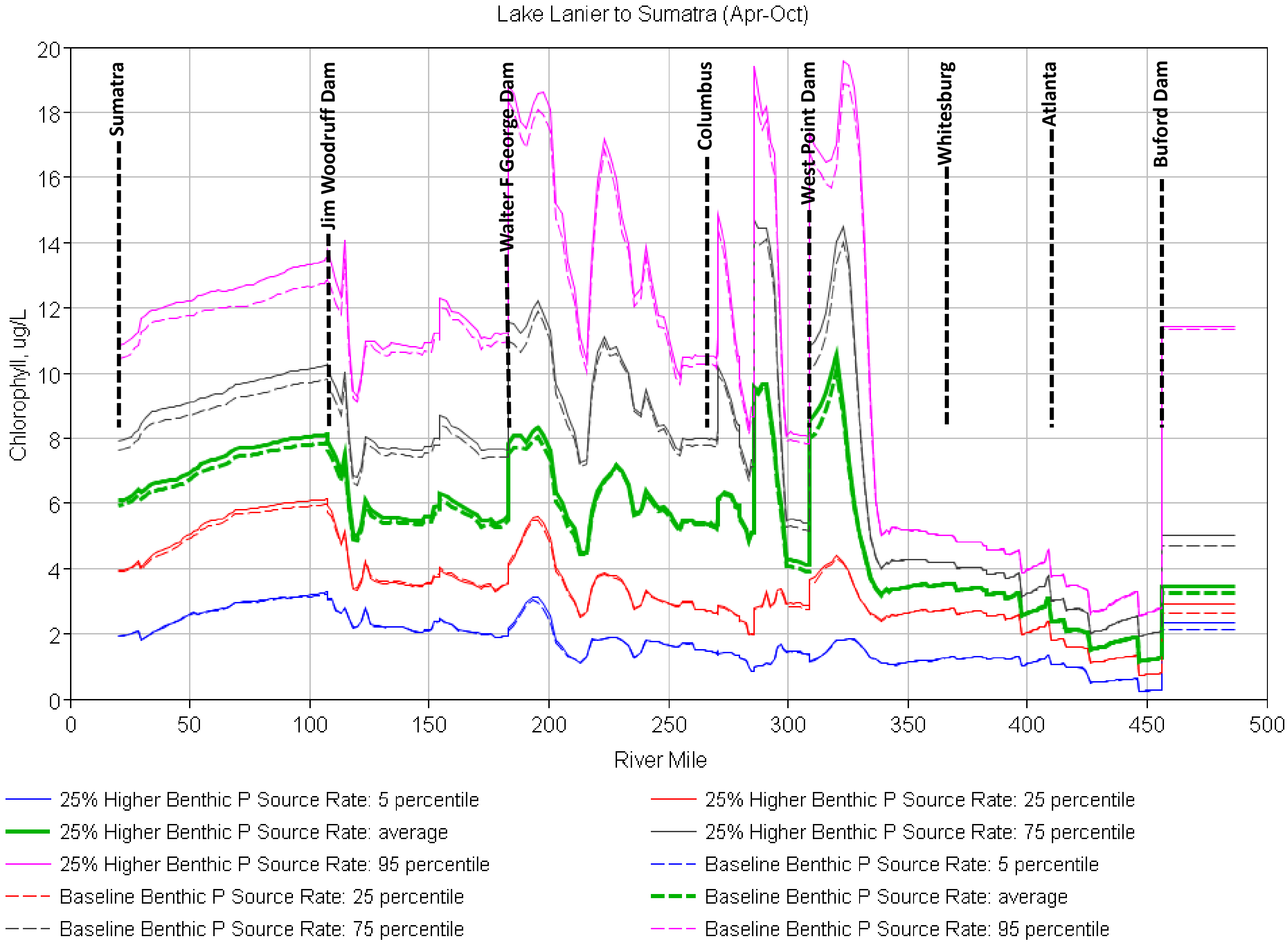


Figure 8.15 Longitudinal profiles of chlorophyll *a* (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in benthic phosphorus source rate.

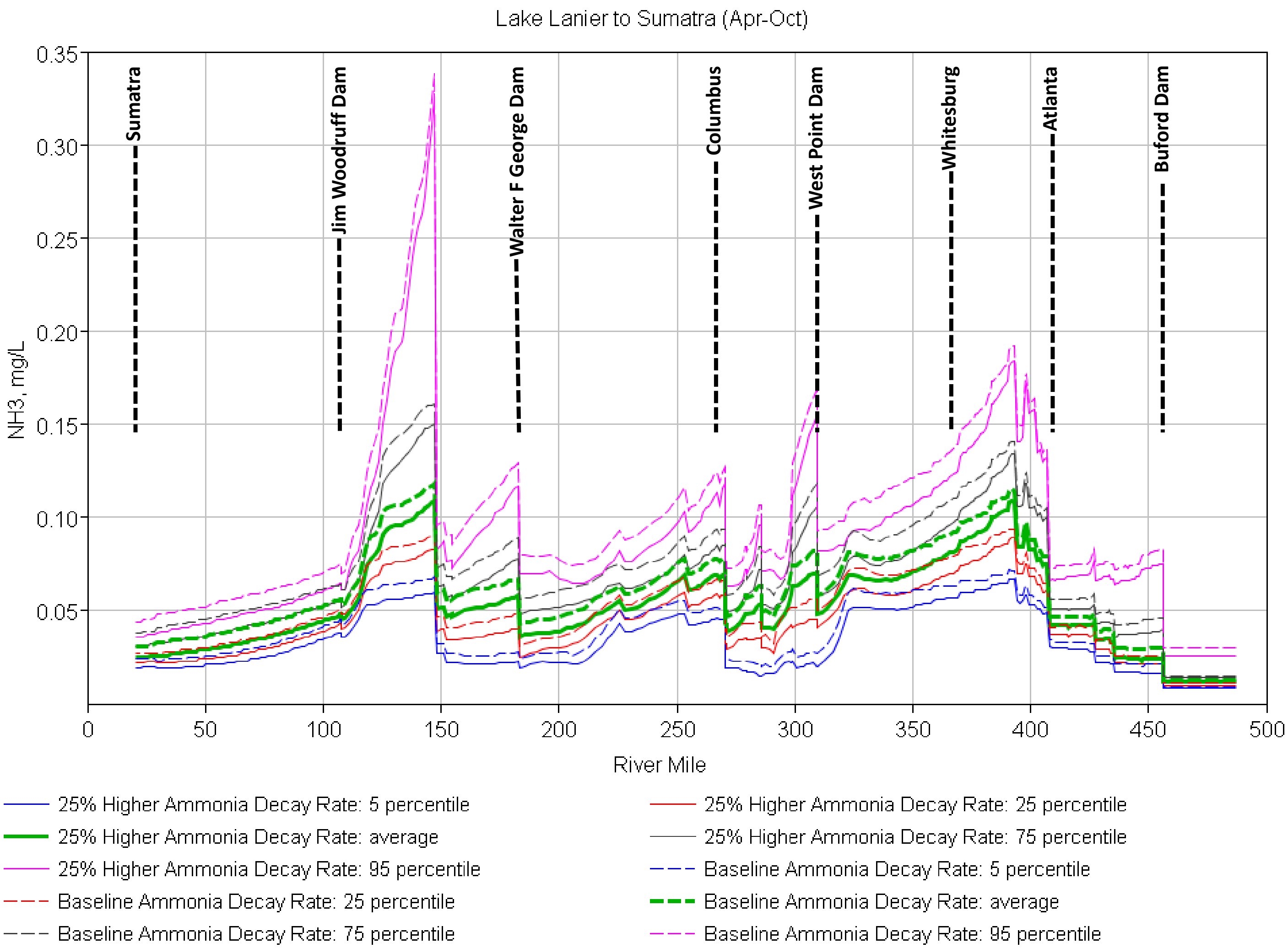


Figure 8.16 Longitudinal profiles of ammonia (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in ammonia decay rate.

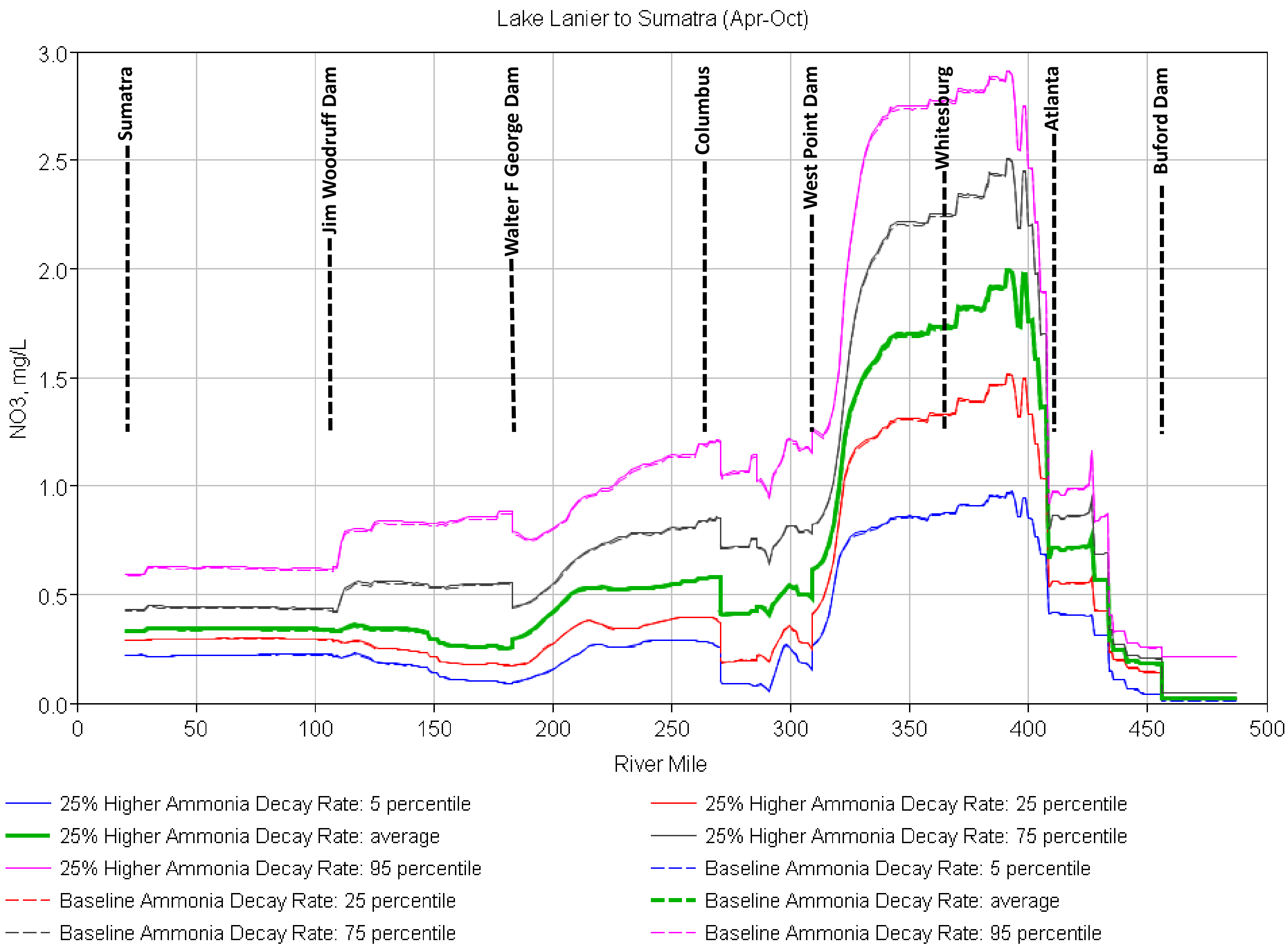


Figure 8.17 Longitudinal profiles of nitrate (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in ammonia decay rate.

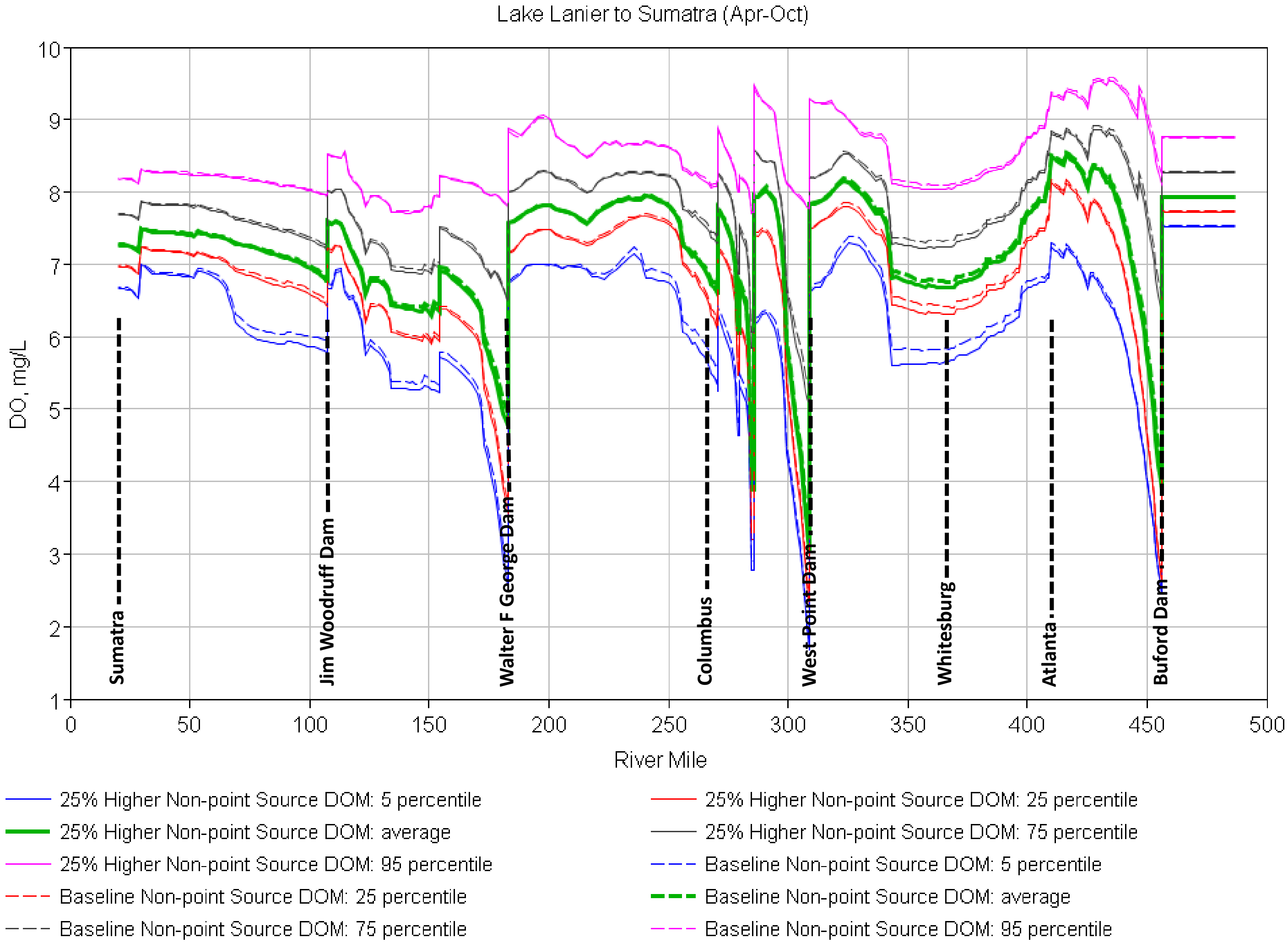


Figure 8.18 Longitudinal profiles of DO (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in non-point source DOM.

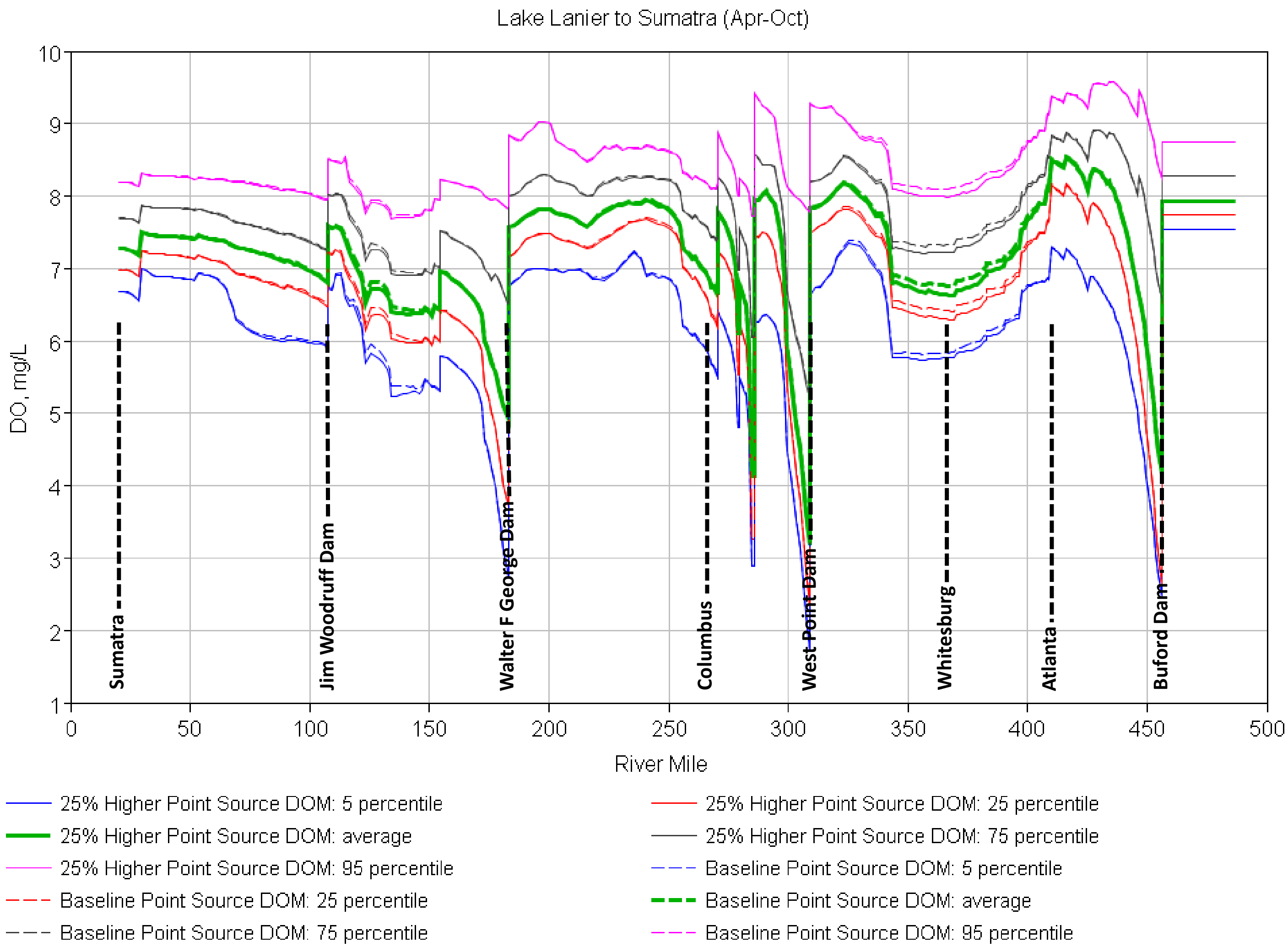


Figure 8.19 Longitudinal profiles of DO (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in point source DOM.

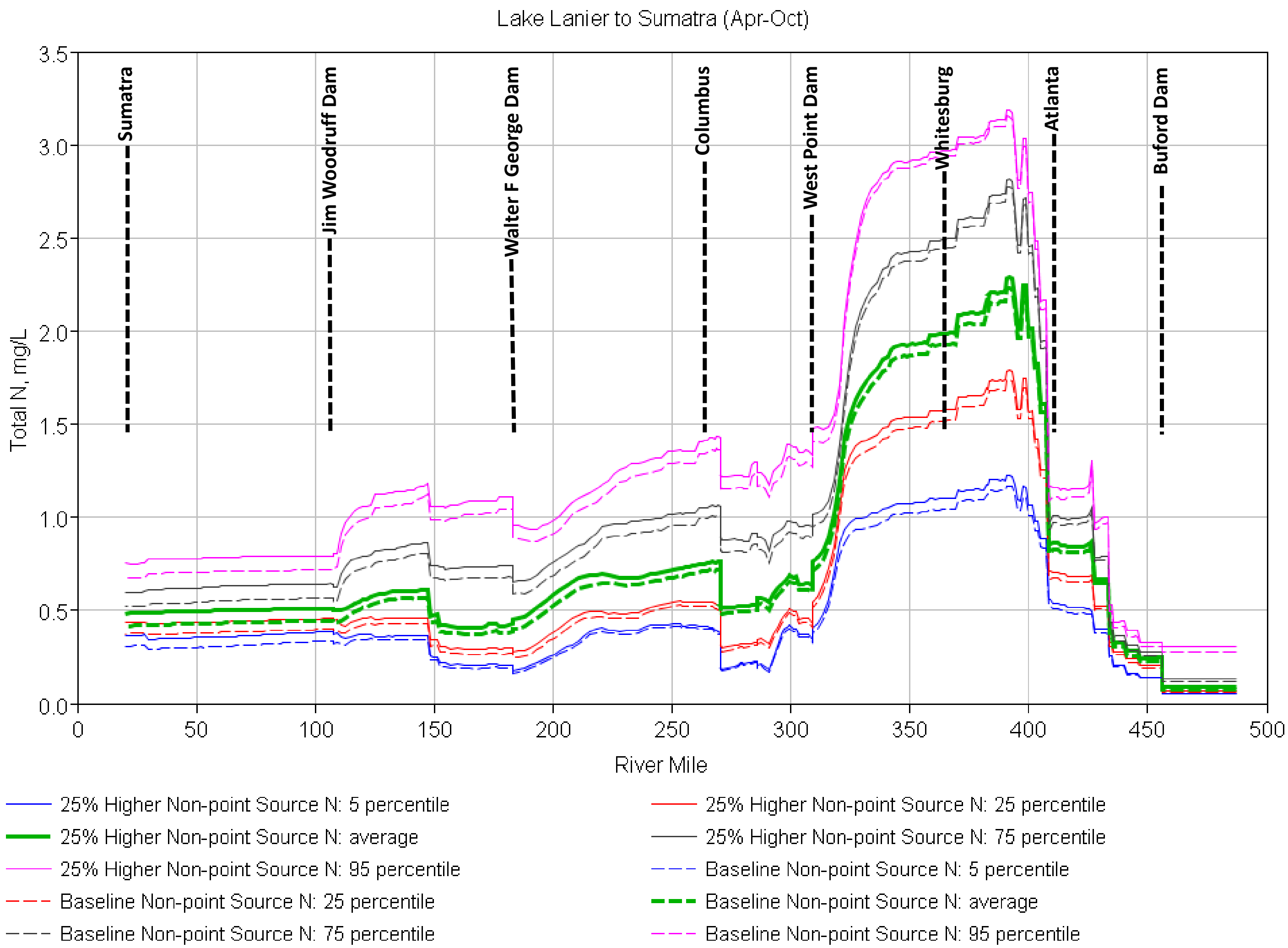


Figure 8.20 Longitudinal profiles of total nitrogen (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in non-point source nitrogen.

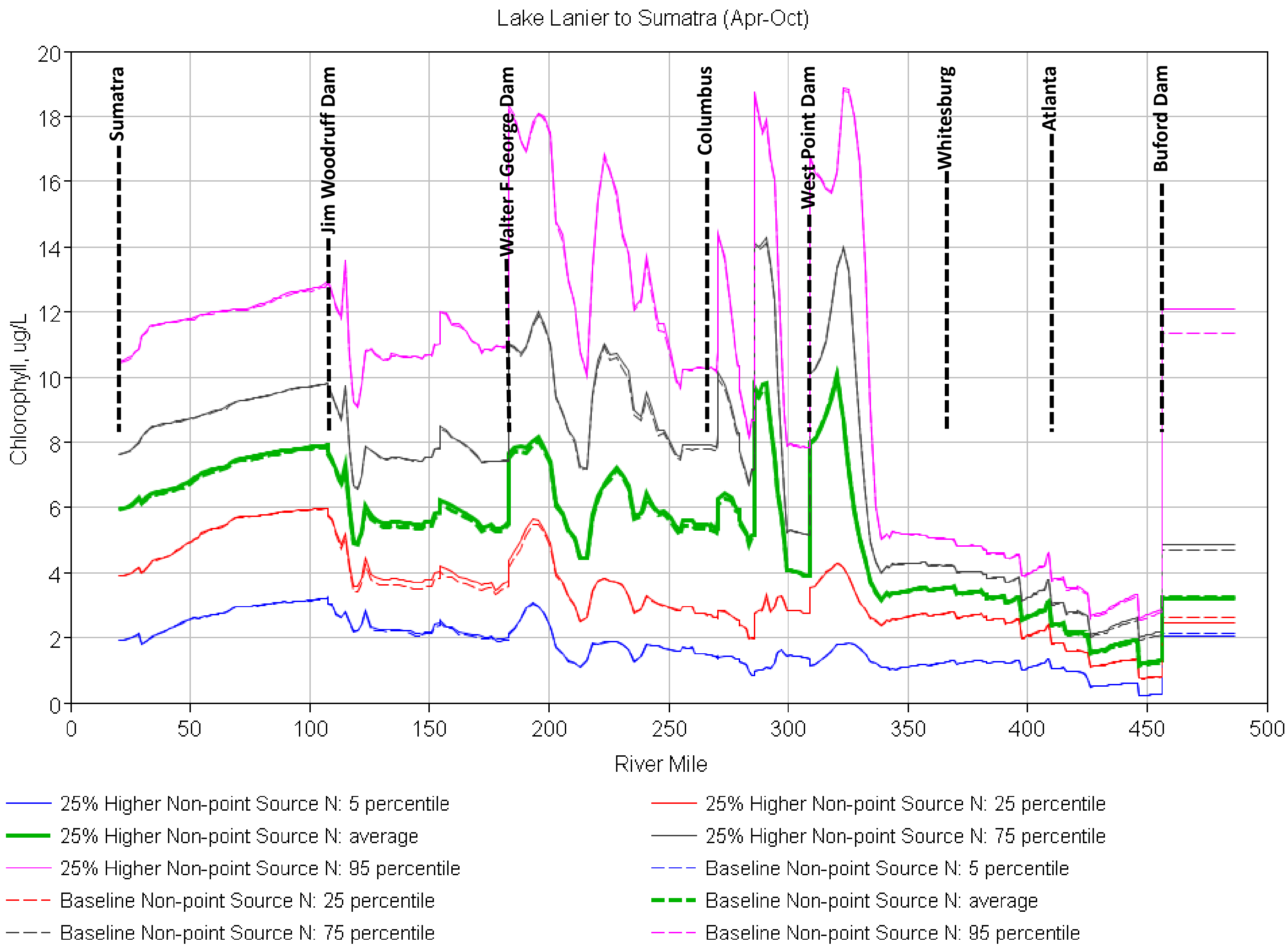


Figure 8.21 Longitudinal profiles of chlorophyll *a* (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in non-point source nitrogen.

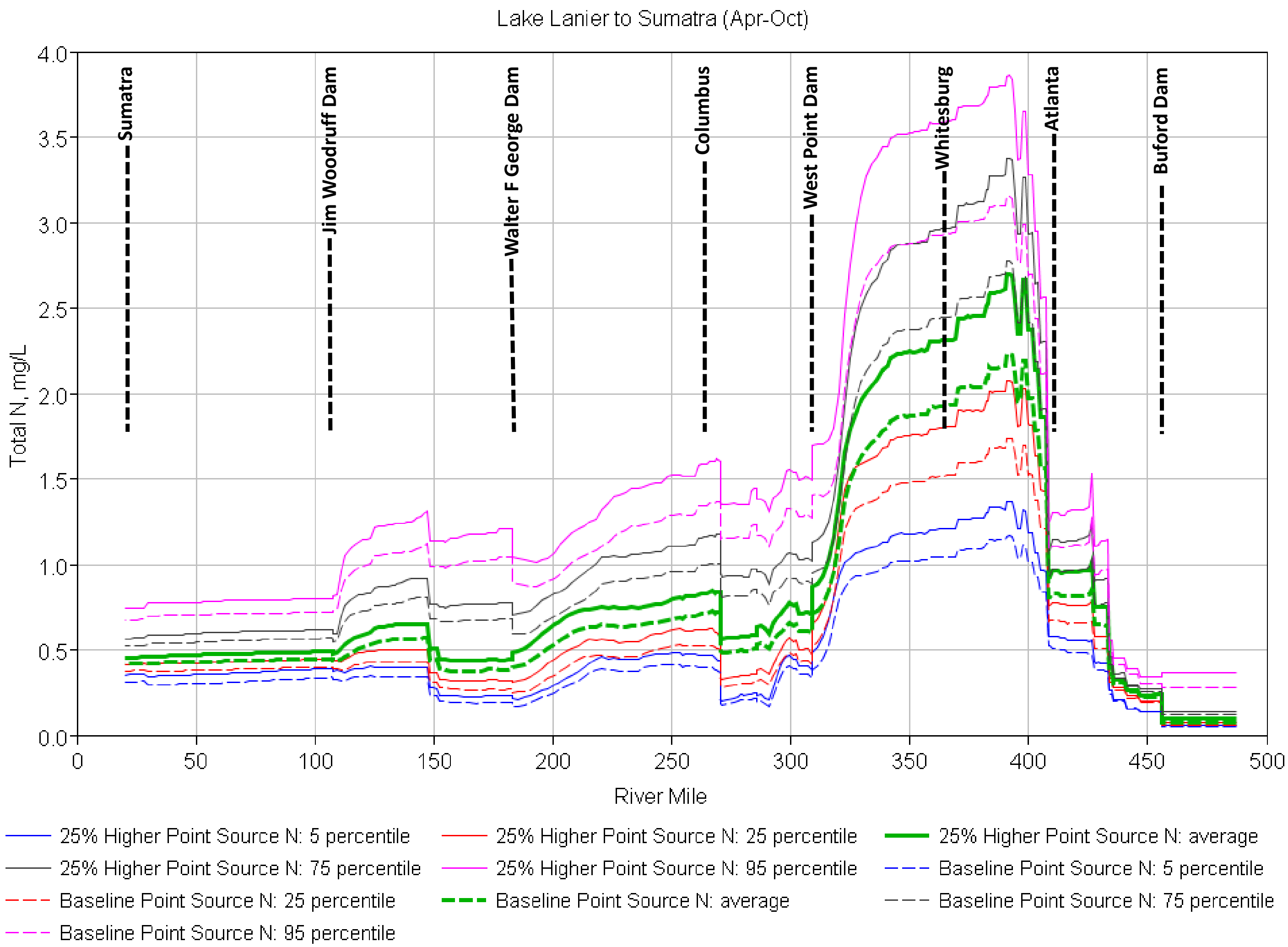


Figure 8.22 Longitudinal profiles of total nitrogen (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in point source nitrogen.

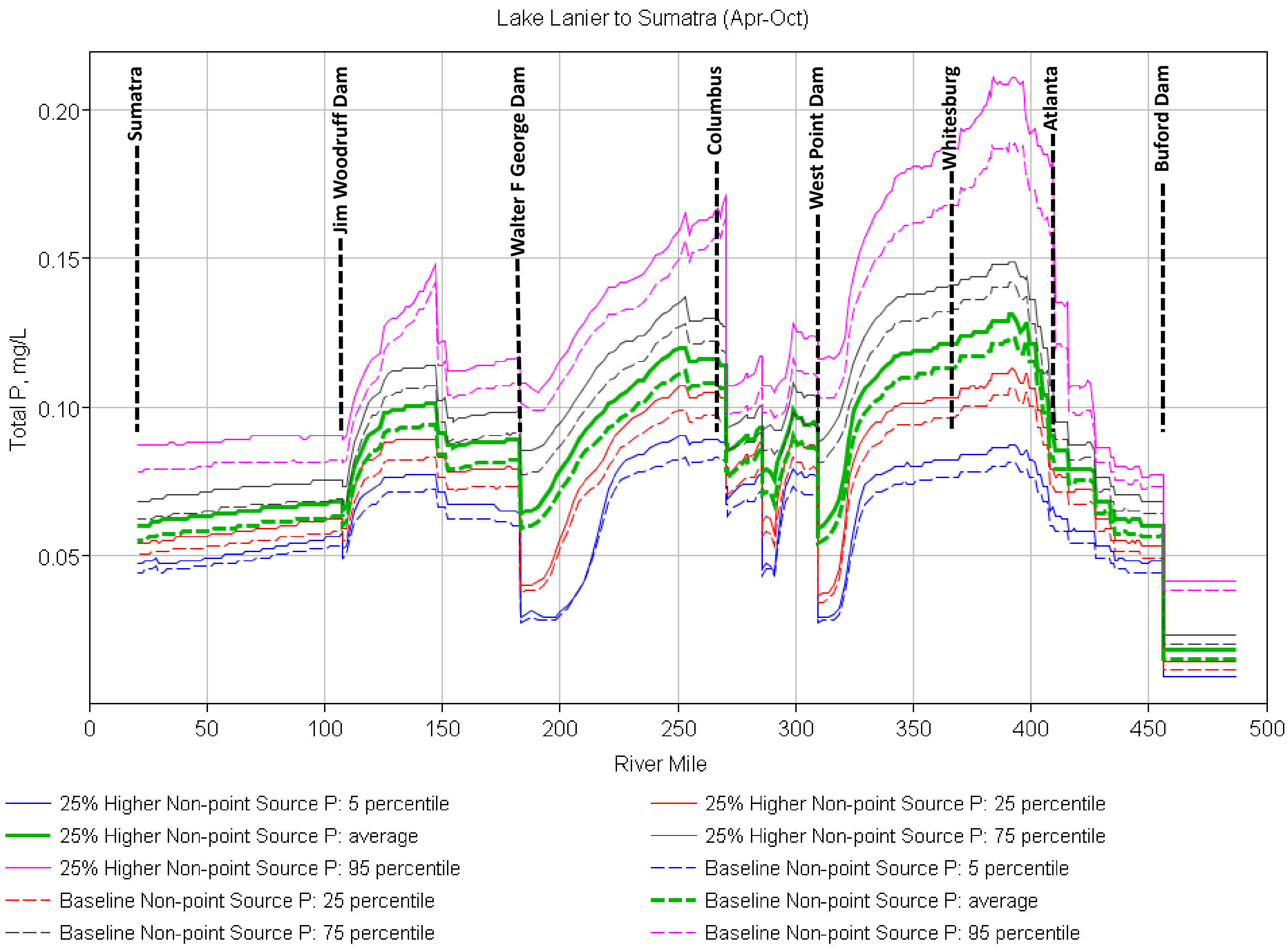


Figure 8.23 Longitudinal profiles of total phosphorus (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in non-point source phosphorus.

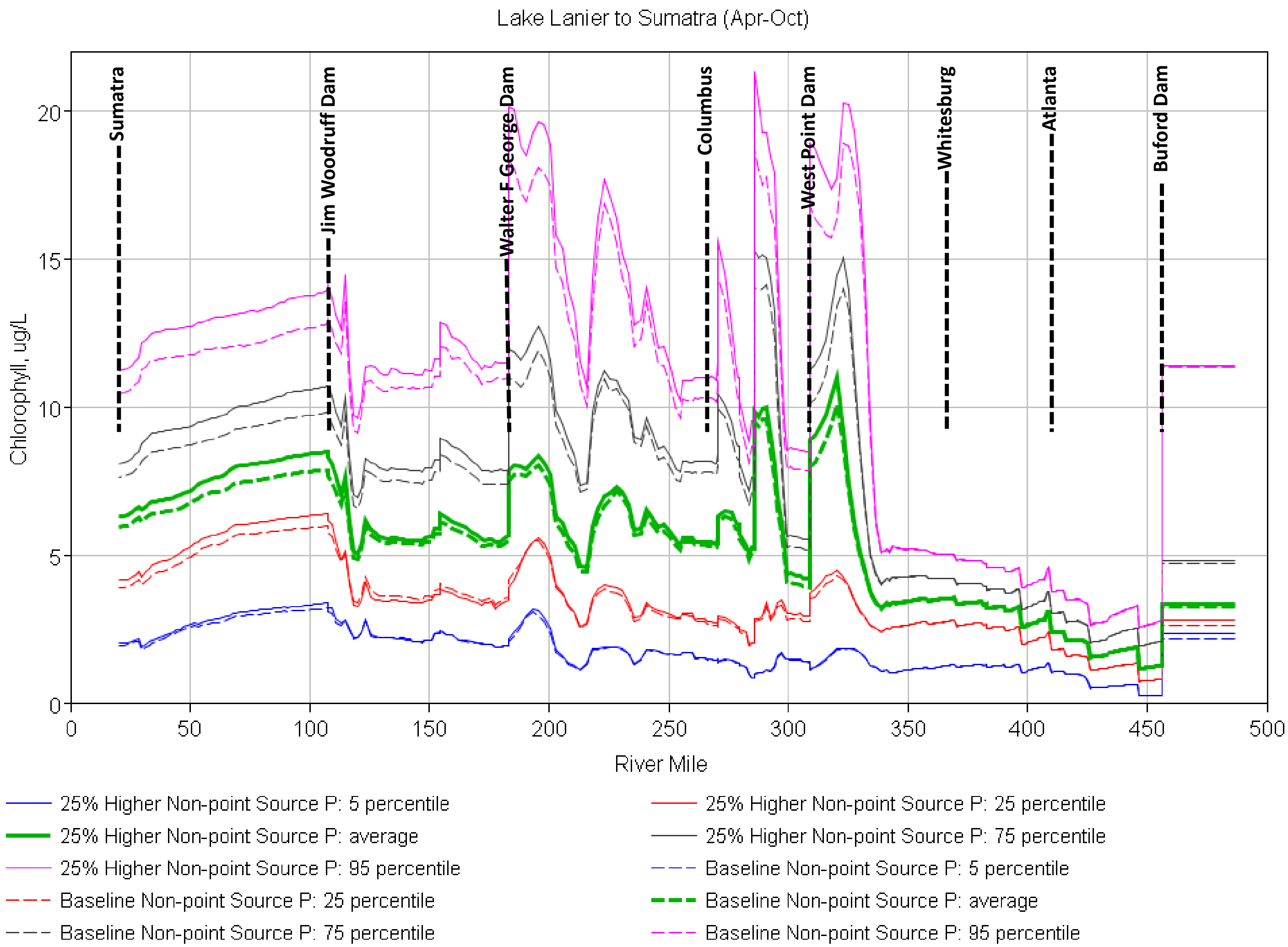


Figure 8.24 Longitudinal profiles of chlorophyll *a* (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in non-point source phosphorus.

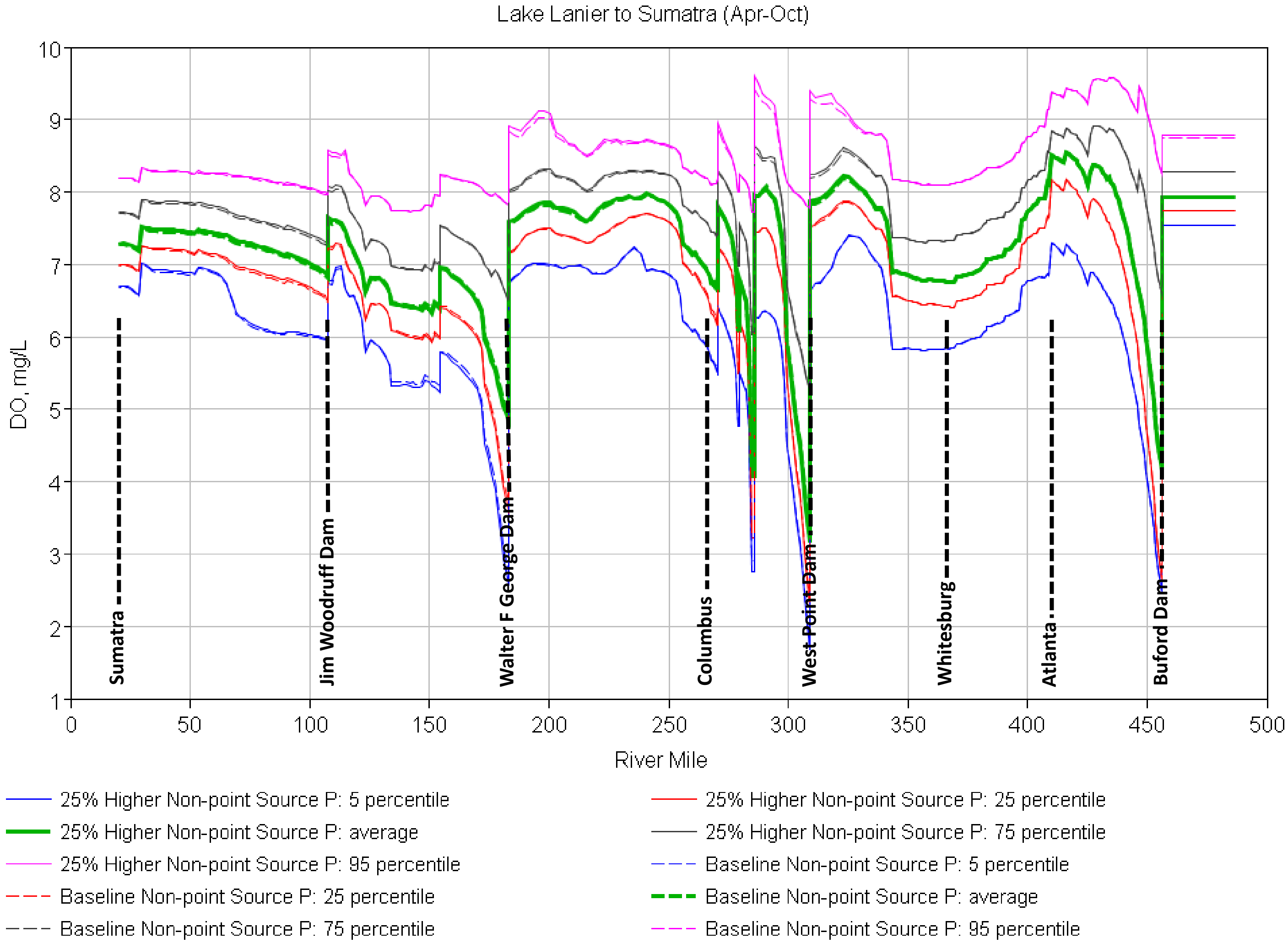


Figure 8.25 Longitudinal profiles of DO (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in non-point source phosphorus.

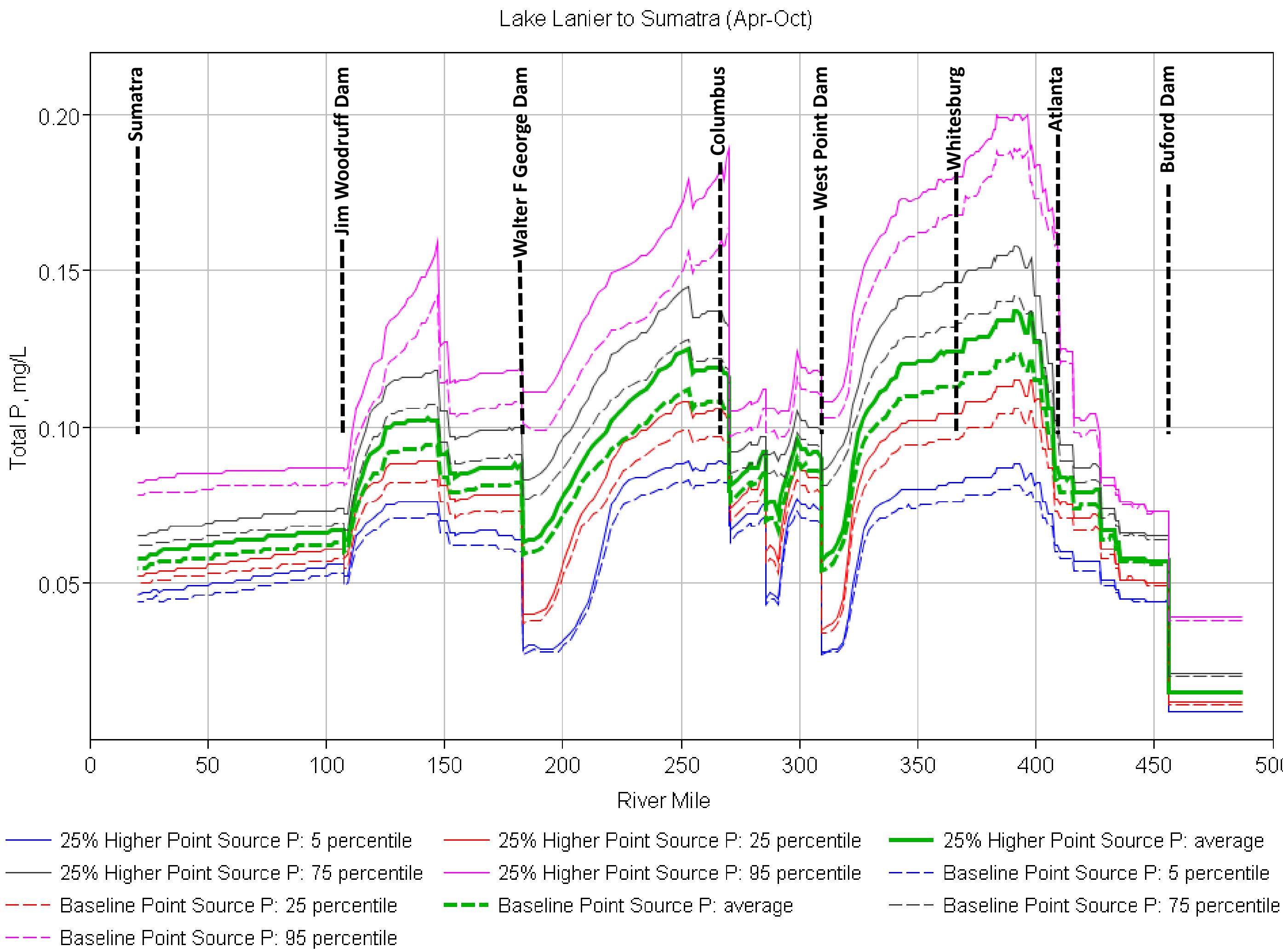


Figure 8.26 Longitudinal profiles of total phosphorus (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in point source phosphorus.

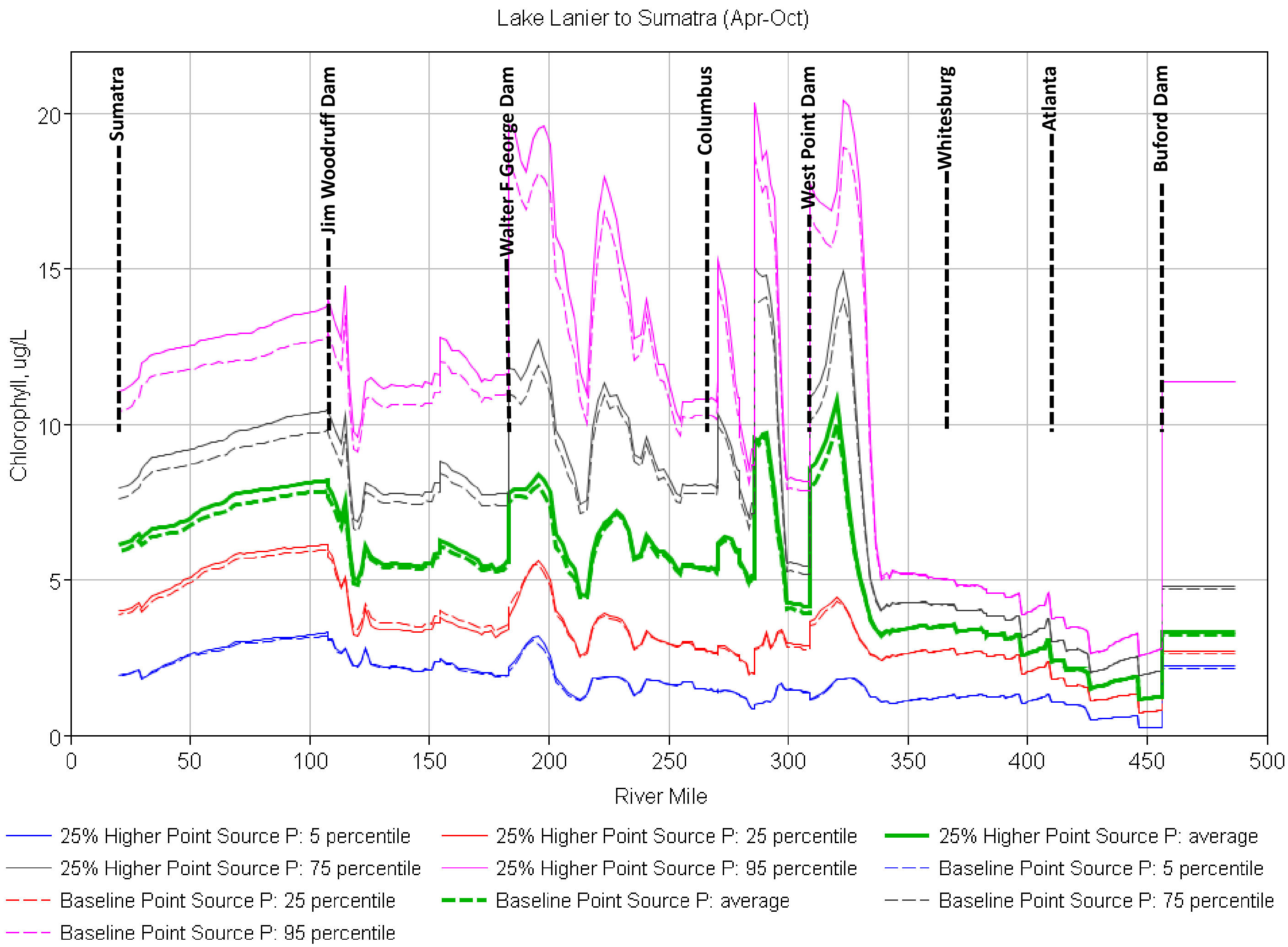


Figure 8.27 Longitudinal profiles of chlorophyll *a* (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating sensitivity to a 25% increase in point source phosphorus.

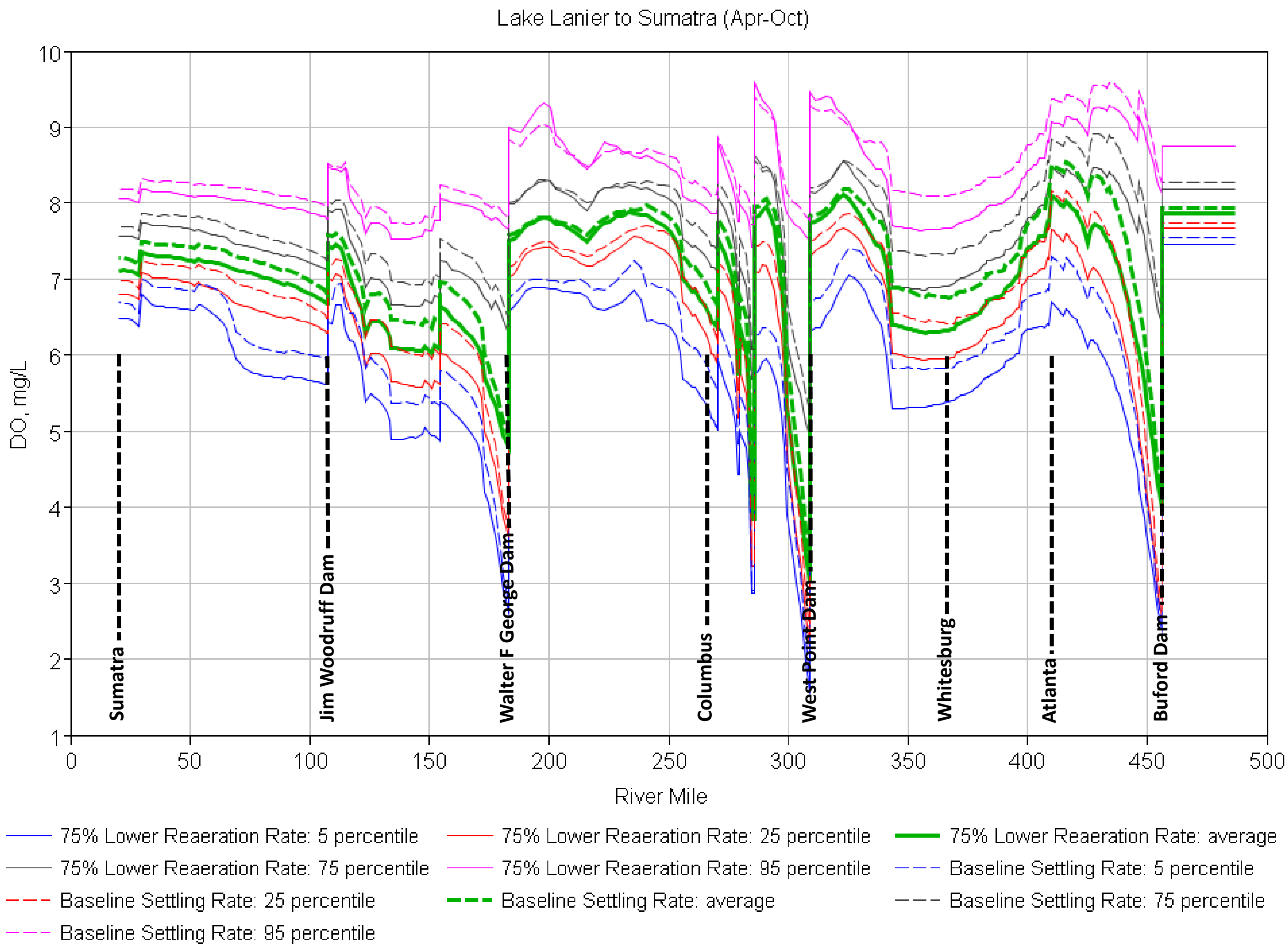


Figure 8.28 Longitudinal profiles of DO (average and 5, 25, 75 and 95 percentile) computed between Lake Lanier and Sumatra during April – October illustrating the relative impact of reducing the stream and lake reaeration rates to 75% of the calibrated model rates

Appendix L

Federal Agency Consistency Determination Under the Coastal Zone Management Act

Florida Coastal Management Program

This page intentionally left blank

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, AL 36628-0001

REPLY TO
ATTENTION OF

September 16, 2016

Inland Environment Team
Planning and Environmental Division

Mr. Jonathan P. Steverson
Secretary
State of Florida Department of
Environmental Protection
Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

Dear Mr. Steverson:

This letter is in reference to your letter dated January 29, 2016, with a determination that the U.S. Army Corps of Engineers proposed update of the Master Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin in Alabama, Florida, and Georgia and Water Supply Storage Assessment was inconsistent with the enforceable policies of the Florida Coastal Management Program (FCMP). A Draft Environmental Impact Statement describing the impacts of the proposed project was released for public comment on October 2, 2015. After review of the Florida Department of Environmental Protection comments, along with all other comments submitted, several modifications have been made to the proposed action and a revised agency determination pursuant to the FCMP has been prepared. Please find enclosed the revised determination and a supplementary document describing the revised action and impacts relevant to the FCMP.

Please provide your concurrence with our determination by October 17, 2016. If you have any questions, concerns or need additional information, please contact Mr. Lewis Sumner at (251) 694-3857 or via email at lewis.c.sumner@usace.army.mil.

Sincerely,

Curtis M. Flakes
Chief, Planning and Environmental
Division

Enclosures

This page intentionally left blank

Federal Agency Consistency Determination Under the Coastal Zone Management Act

Florida Coastal Management Program

For

Apalachicola-Chattahoochee-Flint River Basin,
Master Water Control Manual Update and Water Supply Storage Assessment

This page intentionally left blank

COASTAL ZONE MANAGEMENT ACT (16 U.S.C. §1456)
FEDERAL AGENCY CONSISTENCY DETERMINATION
FLORIDA COASTAL MANAGEMENT PROGRAM

Federal Agency: U.S. Army Corps of Engineers, Mobile District

Project: Apalachicola-Chattahoochee-Flint (ACF) River Basin, Master Water Control Manual Update and Water Supply Storage Assessment

Location: Apalachicola River and Bay, Florida

Introduction

The U.S. Army Corps of Engineers (USACE) proposes to update the ACF Master Water Control Manual (WCM), including a water supply storage assessment (WSSA) to address potential reallocation of reservoir storage in Lake Sidney Lanier, Georgia, for water supply. The purpose and need for this update of the ACF Master WCM are fully described in section 2 of the appended technical support document (Appendix A).

This document provides the state of Florida with the USACE federal agency consistency determination to the maximum extent practicable for the proposed project pursuant to the Coastal Zone Management Act, section 307 (16 U.S.C. § 1456), as amended, and its implementing regulations at 15 CFR Part 230.

Proposed Federal Agency Action

The Proposed Action Alternative (PAA) for the update of the ACF Master WCM is identified as Alternative 7K and described in detail in section 3 of the appended technical support document.

The Florida Coastal Management Program

Florida has developed and implemented a federally approved coastal management program (CMP) describing current coastal legislation and enforceable policies. The Florida CMP is based on a network of state agencies and the five regional water management districts implementing multiple statutes that protect and enhance the state's natural, cultural, and economic coastal resources. The goal of the program is to coordinate local, state, and federal agency activities using existing laws to ensure that Florida's coast is as valuable to future generations as it is to today's generation. Florida's Department of Environmental Protection (FLDEP) is responsible for directing the implementation of the statewide coastal management program.

Federal Consistency Review

Statutes addressed as part of the Florida CMP consistency review and considered in the analysis of the PAA are presented in the following table. USACE has evaluated and determined whether the specific features of the PAA are either not applicable, consistent, or consistent to the maximum extent practicable relative to each state statute/enforceable policy in the Florida CMP. The table also provides the basis for each determination, including specific references to sections in appendix A to support the USACE finding. Section 4 of the technical support document includes an evaluation of potential effects to the natural and human resources in Florida's coastal zone associated with the PAA and the No Action Alternative (NAA) (as defined in the President's Council on Environmental Quality Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act, 40 CFR 1500-1508) .

Overall, USACE has determined that the PAA is consistent with the enforceable policies of the Florida CMP to the maximum extent practicable.

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update				
Statute	**Part**	**Scope**	**Consistency Determination**	**Technical Support Document Reference**
Chapter 161 *Beach and Shore Preservation*	Part I - Regulation Of Construction, Reconstruction, and Other Physical Activity (ss. 161.011-161.242)	Authorizes the Florida Department of Environmental Protection, Beaches, Inlets & Ports Program, to regulate construction on, or seaward of, the state's beaches.	**Not applicable**—The Proposed Action Alternative (PAA) for the Master WCM update would not involve construction activity on, or seaward of, Florida beaches.	Section 4.1
	Part II - Beach and Shore Preservation Districts (ss. 161.25-161.45)	To carry out the beach and shore preservation program, the board of county commissioners of any county are designated the beach and shore preservation authority for their county.	**Not applicable**—The PAA for the Master WCM update would not involve construction activity on, or seaward of, Florida beaches.	Section 4.1
	Part III - Coastal Zone Protection (Ss. 161.52-161.58)	Defines the intent of the Legislature that the most sensitive portion of the coastal area shall be managed through the imposition of strict construction standards in order to minimize damage to the natural environment, private property, and life.	**Not applicable**—The PAA for the Master WCM update would not involve construction activity on, or seaward of, Florida beaches.	Section 4.1
	Part IV - Oceans and Coastal Resources Act (ss. 161.70-161.76)	Defines the intent of the Legislature to create the Oceans and Coastal Council to assist the state in identifying new management strategies to achieve the goal of maximizing the protection and conservation of ocean and coastal resources while recognizing their economic benefits.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None
Chapter 163, Intergovernmental Programs: *Growth Policy; County and Municipal Planning; Land Development Regulation*	Part I - Miscellaneous Programs (ss. 163.01-163.09)	The purpose of this section is enable local governmental units to cooperate with other localities on a basis of mutual advantage and thereby to provide services and facilities in a manner that will accord best with geographic, economic, population, and other factors influencing the needs and development of local communities.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update				
Statute	**Part**	**Scope**	**Consistency Determination**	**Technical Support Document Reference**
	Part II - Growth Policy; County and Municipal Planning; Land Development Regulation (ss. 163.2511-163.3253)	Requires local governments to prepare, adopt, and implement comprehensive plans that encourage the most appropriate use of land and natural resources in a manner consistent with the public interest.	**Consistent to the Maximum Extent Practicable**—The PAA would have a negligible incremental effect on flow conditions in the Apalachicola River compared to the No Action Alternative (NAA). Thus, the PAA would not conflict with any county and municipal plans in Florida affecting land use and natural resource use.	Section 4.2
	Part III - Community Redevelopment (ss. 163.330-163.463)	Any county or municipality may formulate a program for utilizing appropriate private and public resources to eliminate and prevent the development or spread of urban blight, and to encourage needed community rehabilitation as defined as a local priority.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None
	Part IV - Neighborhood Improvement Districts (ss. 163.501-163.526)	Defines the intent of the Legislature to assist local governments in implementing plans that employ crime prevention through a variety of techniques to establish safe neighborhoods.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None
	Part V - Regional Transportation Authorities (ss. 163.565-163.58)	The authority to create, purchase, own, and operate transportation facilities, contract for transit services and exercise defined government actions to implement and operate a regional transportation authority.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None
	Part VI - Collaborative Client Information Systems (ss. 163.61-163.65)	An agency that receives funding from a federal, state, or local entity is encouraged to establish a collaborative client information system.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update				
Statute	**Part**	**Scope**	**Consistency Determination**	**Technical Support Document Reference**
Chapter 186 *State and Regional Planning*		Details state-level planning requirements and requires development of special statewide plans governing water use, land development, and transportation. Intergovernmental coordination should be exercised to define goals for state, regional, and local governments and agencies in the development and implementation of their respective plans, programs, and services.	**Consistent to the Maximum Extent Practicable**—The USACE operates to balance all authorized purposes throughout the ACF Basin. Water conservation in both urban and rural areas is the responsibility of state and local governments and outside the scope of the Water Master Control Manual (WCM) update. However, state and local water management and conservation programs were acknowledged and considered in the modeling. The PAA would have no appreciable incremental effect on flow conditions in the Apalachicola River compared to the NAA. The USACE has taken appropriate steps in evaluating the alternative to develop a plan that is consistent to the maximum extent practicable with relevant state plans governing water use, land development, and transportation.	Section 4.3
Chapter 252 *Emergency Management*	Part I - General Provisions (ss. 252.31-252.63)	Intended to reduce the vulnerability of the people and property of this state; to prepare for efficient evacuation and shelter of threatened or affected persons; to provide for the rapid and orderly provision of relief to persons and for the restoration of services and property; and to provide for the coordination of activities relating to emergency preparedness, response, recovery, and mitigation among and between agencies and officials of Florida, and other entities outside the state in order to promote the state's emergency preparedness, response, recovery, and mitigation capabilities through enhanced coordination, long-term planning, and adequate funding.	**Consistent to the Maximum Extent Practicable**—The PAA would have no influence over whether natural, technological, or manmade emergencies or hostile military or paramilitary actions are experienced by the State of Florida. Therefore, the PAA is consistent with any pertinent emergency response, recovery, and/or mitigation plans.	Section 4.4

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update				
Statute	**Part**	**Scope**	**Consistency Determination**	**Technical Support Document Reference**
	Part II - Florida Emergency Planning and Community Right-To-Know Act (ss. 252.81-252.905)	Implements the Federal Emergency Planning and Community Right-to-Know Act of 1986, Title III of the Superfund Amendments and Reauthorization Act of 1986, ss. 300-329, 42 U.S.C. ss. 11001 et seq.; and federal regulations	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	Section 4.5
	Part III - Emergency Management Assistance Compact (ss. 252.921-252.9335)	Establishes an agreement between member states and governmental entities to provide for mutual assistance in managing any emergency or disaster that is duly declared by the governor of the affected state(s), whether arising from natural disaster, technological hazard, manmade disaster, civil emergency aspects of resource shortages, community disorders, insurgency, or enemy attack.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None
	Part IV Accidental Release Prevention and Risk Management Planning (ss. 252.934-252.946)	The purpose is to establish adequate state authorities to implement, fund, and enforce the requirements of the Accidental Release Prevention Program of s. 112(r)(7) of the federal Clean Air Act and federal implementing regulations for specified sources.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update				
Statute	**Part**	**Scope**	**Consistency Determination**	**Technical Support Document Reference**
Chapter 253 *State Lands*		Addresses the state's administration of public lands and state property and provides guidance and direction regarding the acquisition, disposal, and management of all state lands.	**Consistent to the Maximum Extent Practicable**—The USACE operates to balance all authorized purposes throughout the ACF Basin. Water conservation in both urban and rural areas is the responsibility of state and local governments and outside the scope of the Water Master Control Manual (WCM) update. The PAA would have no appreciable incremental effect on flow conditions in the Apalachicola River compared to the NAA. The USACE has taken appropriate steps in evaluating the alternative to develop a plan that is consistent to the maximum extent practicable with relevant state plans governing the administration and management of state lands in the Apalachicola River corridor.	Section 4.6
Chapter 258 *State Parks and Preserves*	Part I - Parks (ss. 258.001-258.158)	Addresses administration and management of state parks by the FDEP Division of Recreation and Parks.	**Consistent to the Maximum Extent Practicable**—The PAA would not have an adverse effect on administration and management of state parks and preserves in the Apalachicola River corridor.	Section 4.7
	Part II - Aquatic Preserves (ss. 258.35-258.46)	Defines the intent of the Aquatic Preserve Program to protect and preserve those state-owned submerged lands in areas which have exceptional biological, aesthetic, and scientific value and sets them aside as sanctuaries for the benefit of future generations.	**Consistent to the Maximum Extent Practicable**—The USACE operates to balance all authorized purposes throughout the ACF Basin. Water conservation in both urban and rural areas is the responsibility of state and local governments and outside the scope of the Water Master Control Manual (WCM) update. The PAA would have no appreciable incremental effect on flow conditions in the Apalachicola River compared to the NAA. The USACE has taken appropriate steps in evaluating the alternative to develop a plan that is consistent to the maximum extent practicable with relevant state plans governing the administration and management of state lands in the Apalachicola Bay Aquatic Preserve.	Section 4.7
	Part III - Wild And Scenic Rivers (s. 258.501)	Defines the area encompassed by, administration, and management of the Myakka River Wild and Scenic River.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	Section 4.8

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update				
Statute	**Part**	**Scope**	**Consistency Determination**	**Technical Support Document Reference**
	Part IV - Miscellaneous Provisions (s. 258.601)	Defines the enforcement responsibilities within State Parks and Preserves	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None
Chapter 259 *Land Acquisition for Conservation and Recreation*		Authorizes acquisition of environmentally endangered lands and outdoor recreation lands.	**Consistent to the Maximum Extent Practicable**—The PAA would not be in conflict with any planned acquisition of environmentally endangered lands or outdoor recreation lands in the Apalachicola River corridor.	Section 4.9
Chapter 260 *Florida Greenways and Trails Act*		Authorizes acquisition of lands to create a recreational trails system and to facilitate management of the system.	**Consistent to the Maximum Extent Practicable**—The PAA would not have an adverse effect on acquisition and management of recreational trails within the Apalachicola River corridor.	Section 4.10
Chapter 267 *Historical Resources*		Addresses management and preservation of the state's archaeological and historical resources.	**Consistent to the Maximum Extent Practicable**—The PAA is not expected to have an adverse effect on archaeological and historic resources along the Apalachicola River compared to the NAA.	Section 4.11
Chapter 288 *Commercial Development and Capital Improvements*	Part I - General Provisions (ss. 288.0001-288.1258)	Provides the framework for promoting and developing the general business, trade, and tourism components of the state's economy.	**Consistent to the Maximum Extent Practicable**—The PAA would generally have a negligible effect on business and trade in the Florida portion of the ACF Basin. The incremental effects of the PAA on ecotourism and commercial fisheries in the Apalachicola River and Bay would be negligible compared to the NAA. The PAA would provide slightly increased releases from January through May when sufficient water is available in the system that would increase channel reliability for commercial navigation use.	Section 4.12
	Part II - Division Of Bond Finance (ss. 288.13-288.33)	Authorizes the Division of Bond Finance and Board of Trustees of Internal Improvement Trust Fund to finance, construct, acquire, own, and manage lands, easements, rights-of-way, buildings and facilities to support the operation of the State of Florida.	**Consistent to the Maximum Extent Practicable**—The PAA will not have an effect on the management objectives of the Division of the Board of Finance activities related to the operation of property in the Florida portion of the ACF Basin.	None

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update				
Statute	**Part**	**Scope**	**Consistency Determination**	**Technical Support Document Reference**
	Part III - Foreign Trade Zones (ss. 288.35-288.38)	Provides for the establishment, operation, and maintenance of foreign trade zones in ports of entry to encourage foreign commerce within the framework of the federal Foreign Trade Zones Act of 1934, 19 U.S.C. ss. 81a-81u.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None
	Part IV - Small and Minority Business (ss. 288.7015-288.714)	Establishes a program to encourage and manage small and minority business opportunities in the State of Florida	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None
	Part V - Export Finance (ss. 288.770-288.778)	Establishes the Florida Export Finance Corporation to expand employment and income opportunities for residents by providing business with information and technical assistance on export opportunities, exporting techniques, and financial assistance.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None
	Part VI - Gulf Coast Economic Corridor (ss. 288.80-288.8018)	Provide a long-term source of funding for efforts of economic recovery and enhancement in the Gulf Coast region for areas affected by the Deepwater Horizon incident.	**Consistent to the Maximum Extent Practicable**—The USACE operates to balance all authorized purposes throughout the ACF Basin. The PAA would have no appreciable incremental effect on flow conditions in the Apalachicola River compared to the NAA. The USACE has taken appropriate steps in evaluating the alternative to develop a plan that is consistent to the maximum extent practicable with relevant state plans related to economic recovery and enhancement for areas affected by the Deepwater Horizon incident.	Section 4.13
	Part VII - International Affairs (ss. 288.809-288.855)	To assist in the strengthening of international sanctions against Fidel Castro and the Republic of Cuba.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update				
Statute	**Part**	**Scope**	**Consistency Determination**	**Technical Support Document Reference**
	Part VIII - Enterprise Florida, Inc. (ss. 288.901-288.923)	Establishes Enterprise Florida, Inc., to act as the economic development organization for the state, utilizing private sector and public sector expertise to advance opportunities and markets for Florida businesses.	**Consistent to the Maximum Extent Practicable**—The PAA will not have an effect on the management objectives of the Enterprise Florida activities within the Florida portion of the ACF Basin.	None
	Part IX - Technology Development (ss. 288.95155-288.955)	Establishes the framework and management of the Florida Small Business Technology Program within Enterprise Florida.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None
	Part X - Capital Development (ss. 288.9602-288.9614)	Establishes a special development finance authority to attract and encourage activities that promote a more balanced and stable economy in Florida.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None
	Part XI - Capital Formation (ss. 288.9621-288.9627)	Establishes the Institute for the Commercialization of Public Research and creates the Florida Technology Seed Capital to foster private-sector investment funding, to attract advantageous business opportunities.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None
	Part XII - Defense Conversion and Transition (ss. 288.972-288.987)	Provides a mechanism to coordinate with the federal government when military bases, lands, or installations are proposed for closure and supports the locally affected communities.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None
	Part XIII - New Markets Development Program Act (ss. 288.991-288.9922)	Establishes the New Markets Development Program to encourage capital investment in rural and urban low-income communities.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None
	Part XIV - Microfinance Programs (ss. 288.993-288.9937)	Expands job opportunities for Florida’s workforce by increasing access to credit to entrepreneurs and small businesses.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update				
Statute	**Part**	**Scope**	**Consistency Determination**	**Technical Support Document Reference**
Chapter 334 *Transportation Administration*		Addresses the state' policy concerning transportation administration.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	Section 4.14
Chapter 339 *Transportation Finance and Planning*		Addresses the financial and planning needs of the state's transportation systems.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	Section 4.14
Chapter 373 *Water Resources*	Part I - State Water Resource Plan (ss. 373.012-373.200)	Addresses the state's policy concerning water resources.	**Consistent to the Maximum Extent Practicable**—Implementation of the PAA would be expected to have no appreciable incremental effect on flow conditions (quantity or timing) in the Apalachicola River compared to the NAA. Therefore, the PAA would not be expected to have an incremental effect on salinity and hydrodynamic conditions in the Apalachicola Bay estuary compared to the NAA. No appreciable change in water quality in the Apalachicola River is expected as a result of the PAA, and thus no changes would be expected in the Apalachicola Bay estuary.	Section 4.15
	Part II - Permitting of Consumptive Uses Of Water (ss. 373.203-373.250)	Authorizes Water Management Districts within the State of Florida to implement a program for review and approval of requests for consumptive use of water within their respective jurisdictions.	**Not applicable**—This statute is not applicable to the ACF Master WCM update/WSSA.	Section 4.16
	Part III - Regulation of Wells (ss. 373.302-373.342)	Regulate the construction, repair, and abandonment of wells, and the persons and businesses that perform those services.	**Not applicable**—This statute is not applicable to the ACF Master WCM update/WSSA.	None

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update				
Statute	**Part**	**Scope**	**Consistency Determination**	**Technical Support Document Reference**
	Part IV - Management and Storage of Surface Waters (ss. 373.403-373.468)	Provides extensive authority over the management of surface waters in Florida and mandates a permitting, review and approval process for activities to assure that those activities are not contrary to the public interest. Section 373.428 (Federal Consistency - http://www.flsenate.gov/Laws/Statutes/2016/373.428) mandates that activities regulated herein are subject to federal consistency review under Section 380.23, (*Land and Water Management*) the final agency action shall constitute the state's determination as to whether the activity is consistent with the federally approved Florida Coastal Management Program.	**Consistent to the Maximum Extent Practicable**—The USACE operates to balance all authorized purposes throughout the ACF Basin. The PAA would have no appreciable incremental effect on flow conditions in the Apalachicola River compared to the NAA. The USACE has taken appropriate steps in evaluating the alternative to develop a plan that is consistent to the maximum extent practicable with relevant state plans related to the management and storage of surface waters.	Section 4.17
	Part V - Finance and Taxation (ss. 373.470-373.591)	This section is referred to as the "Everglades Restoration Investment Act" and defines the management and funding of activities directly related to restoration of the Everglades.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None
	Part VI - Miscellaneous Provisions (ss. 373.603-373.69)	Provides several miscellaneous provisions related to enforcement, employee relations, penalties, and preference of project award to small businesses and the State University System. Section 373.69 (http://www.flsenate.gov/Laws/Statutes/2016/373.69) specifically defines the Apalachicola-Chattahoochee-Flint River Basin Compact between the states of Alabama, Florida and Georgia and the United States of America.	**Not applicable**—These provisions are not applicable to the ACF Master WCM update. The ACF Basin Compact was allowed to expire in 2003.	None

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update				
Statute	**Part**	**Scope**	**Consistency Determination**	**Technical Support Document Reference**
	Part VII - Water Supply Policy, Planning, Production, and Funding (ss. 373.701-373.715)	To promote the availability of sufficient water for all existing and future reasonable-beneficial uses and natural systems.	**Consistent to the Maximum Extent Practicable**—The USACE operates to balance all authorized purposes throughout the ACF Basin. The PAA would have no appreciable incremental effect on flow conditions in the Apalachicola River compared to the NAA. The USACE has taken appropriate steps in evaluating the alternative to develop a plan that is consistent to the maximum extent practicable with relevant state plans related to the management of Florida's water supply.	Section 4.18
	Part VIII - Florida Springs and Aquifer Protection Act (ss. 373.801-373.813)	Provides for the management and protection of water quality in Outstanding Florida Springs	**Consistent to the Maximum Extent Practicable**—The PAA will not have an effect on the management activities associated with Outstanding Florida Springs.	None
Chapter 375 *Outdoor Recreation and Conservation Lands*		Provides for comprehensive outdoor recreation planning to document recreational supply and demand, describe current recreational opportunities, estimate need for additional recreational opportunities, and propose means to meet the identified needs.	**Consistent to the Maximum Extent Practicable**—The USACE operates to balance all authorized purposes throughout the ACF Basin. The PAA would have no appreciable incremental effect on flow conditions in the Apalachicola River compared to the NAA.	Section 4.19
Chapter 376 *Pollutant Discharge Prevention and Removal*		Regulates transfer, storage, and transportation of pollutants and cleanup of pollutant discharges.	**Consistent to the Maximum Extent Practicable**—Implementation of the PAA would not be expected to directly involve the transfer, storage, and transportation of hazardous and toxic pollutants. Operations at Jim Woodruff Lock and Dam might involve handling small amounts of hazardous and toxic materials. Appropriate material handling, storage and use protocols, and contingency plans are in place to properly handle those materials and to manage any unexpected releases.	Section 4.20
Chapter 377 *Energy Resources*	Part I - Regulation of Oil and Gas Resources (ss. 377.01-377.43)	Addresses regulation, planning, and development of energy resources of the state.	**Consistent to the Maximum Extent Practicable**—The PAA would not affect regulation, planning, and development of energy resources of the state.	None

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update				
Statute	**Part**	**Scope**	**Consistency Determination**	**Technical Support Document Reference**
	Part II - Planning and Development (ss. 377.601-377.712)	Promotes investment and the implementation of strategies to assure that Florida's energy infrastructure is reliable, and the State takes steps to enhance energy independence and diversification, stabilize energy costs, and reduce greenhouse gas emissions.	**Consistent to the Maximum Extent Practicable**—The PAA would not affect regulation, planning, and development of energy resources of the state. Hydropower generation in the ACF projects would slightly decrease under the PAA.	Section 4.21
	Part III - Renewable Energy and Green Government Programs (ss. 377.801-377.816)	Provides incentives to diversify the state's energy supplies, reduce dependence on foreign oil, and mitigate the effects of climate change by providing funding for activities designed to achieve these goals.	**Consistent to the Maximum Extent Practicable**—The PAA would not affect regulation, planning, and development of energy resources of the state.	None
Chapter 379 Fish and Wildlife Conservation.	Part I - General Provisions (ss. 379.101-379.237)	Establishes and empowers the Fish and Wildlife Conservation Commission to manage, regulate, and enforce fish and wildlife conservation measures in Florida in cooperation with adjoining States and the Federal Government. .	**Consistent to the Maximum Extent Practicable**—The USACE operates to balance all authorized purposes throughout the ACF Basin. The PAA would have no appreciable incremental effect on flow conditions and is not likely to have an adverse effect on resources within the Apalachicola River and adjacent Gulf of Mexico area compared to the NAA. The PAA would not be expected to have an incremental effect on salinity and hydrodynamic conditions in the Apalachicola Bay estuary compared to the NAA. Listed species (federal and state) were reviewed for potential effects. Federally-listed species in Florida (many of which are also state-listed) have been subjected to Section 7 consultation under the Endangered Species Act. State-listed species that are not federally-listed were also identified and considered as part of this consistency review and determination. No state-listed species are expected to be jeopardized by the PAA. A comprehensive list of the state-listed species is appended to this consistency determination (appendix B).	Section 4.22

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update				
Statute	**Part**	**Scope**	**Consistency Determination**	**Technical Support Document Reference**
	Part II - Marine Life (ss. 379.2401-379.26)	Policy of the state to manage and preserve it's renewable marine fishery resources, based upon the best available information, emphasizing protection and enhancement of the marine and estuarine environment in such a manner as to provide for optimum sustained benefits	**Consistent to the Maximum Extent Practicable**—The USACE operates to balance all authorized purposes throughout the ACF Basin. The PAA would have no appreciable incremental effect on flow conditions and is not likely to adverse the effect on resources within the Apalachicola River and adjacent Gulf of Mexico area compared to the NAA. The PAA would not be expected to have an incremental effect on salinity and hydrodynamic conditions in the Apalachicola Bay estuary compared to the NAA.	Section 4.22
	Part III - Freshwater Aquatic Life (ss. 379.28-379.295)	Prohibition on the release of non-native species, pollutants, explosives, or other substances into fresh waters of the state.	**Consistent to the Maximum Extent Practicable**—The PAA will not introduce prohibited materials or species into the fresh waters of Florida.	Section 4.23
	Part IV - Wild Animal Life (ss. 379.3001-379.305)	Preservation of hunting lands in Florida and regulates hunting activities.	**Consistent to the Maximum Extent Practicable**—The PAA will not adversely affect wildlife management areas or the species regulated in this Part.	None
	Part V - Law Enforcement (ss. 379.33-379.343)	Establishes law enforcement procedures and penalties to uphold the fish and wildlife conservation policies of the State.	**Consistent to the Maximum Extent Practicable**—The PAA will not adversely affect law enforcement strategies and programs in Florida.	None
	Part VI - Licenses For Recreational Activities (ss. 379.35-379.359)	Establishes a program to manage and administer recreational hunting and fishing licensing and educational programs.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None
	Part VII - Nonrecreational Licenses (ss. 379.361-379.377)	Establishes a program to manage and administer nonrecreational hunting and fishing licensing and includes provides on the possession of regulated species.	**Not applicable**—This statute is not applicable to the ACF Master WCM update.	None
	Part VIII – Penalties (ss. 379.401-379.504)	Defines the civil and criminal penalties associated with violation of the fish and wildlife conservation measures of Florida.	**Consistent to the Maximum Extent Practicable**—The PAA will not adversely affect law enforcement strategies and programs in Florida.	None

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update				
Statute	**Part**	**Scope**	**Consistency Determination**	**Technical Support Document Reference**
Chapter 380 *Land and Water Management*	Part I - Environmental Land and Water Management (ss. 380.012-380.12)	Establishes land and water management policies to guide and coordinate local decisions relating to growth and development.	**Consistent to the Maximum Extent Practicable**—The PAA would not be expected to affect local decisions relating to growth and development in the Apalachicola River corridor. The PAA would provide slightly increased releases from January through May when sufficient water is available in the system that would increase channel reliability for commercial navigation use.	Section 4.24
	Part II - Coastal Planning and Management (ss. 380.20-380.285)	Authorization to maintain and update a program based on existing statutes and existing rules and submit applications to the appropriate federal agency as a basis for receiving funds under the Coastal Zone Management Act.	**Consistent to the Maximum Extent Practicable**—The USACE operates to balance all authorized purposes throughout the ACF Basin. The PAA would have no appreciable incremental effect on flow conditions and is not likely to adverse the effect on resources within the Apalachicola River and adjacent Gulf of Mexico area compared to the NAA.	Section 4.24
	Part III - Florida Communities Trust (ss. 380.501-380.515)	Establishes the Florida Community Trust to administer, coordinate, or fund activities and projects that assist local governmental agencies in bringing comprehensive plans into compliance and help implement the goals, objectives, and policies of the conservation, recreation and open space, and coastal elements of local comprehensive plans, or which will otherwise serve to conserve natural resources.	**Consistent to the Maximum Extent Practicable**—The USACE operates to balance all authorized purposes throughout the ACF Basin. The PAA would have no appreciable incremental effect on flow conditions and is not likely to adverse the effect on resources within the Apalachicola River and Gulf of Mexico compared to the NAA.	Section 4.24
Chapter 381 *Public Health, General Provisions*		Establishes public policy concerning the state's public health system to promote, protect, and improve the health of all people in the state.	**Not applicable**—This statute does not apply to the ACF Master WCM update.	None
Chapter 388 *Mosquito Control*		Addresses mosquito control efforts in the state to protect human health and safety, promote economic development of the state, and facilitate the enjoyment of the state's natural attractions.	**Consistent to the Maximum Extent Practicable**—The PAA would not affect any ongoing mosquito control efforts in the ACF Basin.	None

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update				
Statute	**Part**	**Scope**	**Consistency Determination**	**Technical Support Document Reference**
Chapter 403 *Environmental Control*	Part I - Pollution Control (ss. 403.011-403.42)	Establishes public policy concerning environmental control in the state to conserve state waters, protect and improve water quality, and maintain air quality.	**Consistent to the Maximum Extent Practicable**—The PAA would not have an incremental effect on air quality. Water quality in the Apalachicola River and Bay would not be incrementally affected under the PAA compared to the NAA.	Section 4.25
	Part II - Electrical Power Plant and Transmission Line Siting (ss. 403.501-403.539)	Sets up a program to evaluate and appropriately site, power generation and transmission infrastructure in Florida in a manner that addresses service needs with minimal effects on human health and the environment.	**Consistent to the Maximum Extent Practicable**—The PAA would not affect any ongoing electrical power plant and transmission line siting efforts in the ACF Basin.	None
	Part III - Interstate Environmental Control Compact (s. 403.60)	Establishes the Interstate Environmental Control Compact to assist and participate in the national environment protection programs; to promote intergovernmental cooperation for multistate action relating to environmental protection through interstate agreements; and to encourage cooperative and coordinated environmental protection across state boundaries.	**Consistent to the Maximum Extent Practicable**—The USACE operates to balance all authorized purposes throughout the ACF Basin. The PAA would have a negligible incremental effect on flow conditions and is not likely to adverse the effect on resources within the Apalachicola River and adjacent Gulf of Mexico area compared to the NAA.	Section 4.26
	Part IV - Resource Recovery and Management (ss. 403.702-403.7721)	Addresses solid waste management, recycling programs, and resource recovery within the state.	**Consistent to the Maximum Extent Practicable**—The PAA would not affect any ongoing or future solid waste management strategies or programs in the ACF Basin.	Section 4.27
	Part V - Environmental Regulation (ss. 403.801-403.8163)	To promote more efficient, effective, and economical operation of certain environmental agencies by transferring decision-making authority to environmental district centers and delegating to the water management districts permitting functions related to water quality. To promote proper administration of Florida’s landmark environmental laws.	**Consistent to the Maximum Extent Practicable**—The PAA would not affect any ongoing or future regulatory programs, or their administration, in the ACF Basin.	None

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update				
Statute	**Part**	**Scope**	**Consistency Determination**	**Technical Support Document Reference**
	Part VI - Water Supply; Water Treatment Plants (ss. 403.850-403.891)	Provisions for safe public water supply and treatment systems.	**Consistent to the Maximum Extent Practicable**—The PAA would not affect any ongoing or future public water system operations or programs in the ACF Basin.	None
	Part VII - Miscellaneous Provisions (ss. 403.90-403.9338)	Protection of riparian rights, preservation of mangroves, and coral reef protection in SE Florida,	**Consistent to the Maximum Extent Practicable**—The USACE operates to balance all authorized purposes throughout the ACF Basin. The PAA would have a negligible incremental effect on flow conditions and is not likely to adverse the effect on resources within the Apalachicola River and adjacent Gulf of Mexico area compared to the NAA.	Section 4.28
	Part VIII - Natural Gas Transmission Pipeline Siting (ss. 403.9401-403.9425)	To establish a coordinated permitting process for the location, installation, and maintenance of natural gas transmission pipelines to balance the need for natural gas supplies and the impact on the public and environment.	**Consistent to the Maximum Extent Practicable**—The PAA would not affect any ongoing or future regulatory programs, or their administration, in the ACF Basin.	None
	Part IX - Expedited Permitting (s. 403.973)	Intent is to provide for an expedited permitting and comprehensive plan amendment process for economic development projects that take into consideration the protection of the state's environment	**Consistent to the Maximum Extent Practicable**—The PAA would not affect any ongoing or future regulatory programs, or their administration, in the ACF Basin.	None
Chapter 553 *Building and Construction Standards*	Part I - Manufactured Buildings (ss. 553.35-553.42)	Establishes minimum requirements for manufactured buildings	**Not applicable**—This statute does not apply to the ACF Master WCM update.	None
	Part II - Accessibility By Handicapped Persons (ss. 553.501-553.514)	Incorporates accessibility requirements of the Americans with Disabilities Act of 1990, as amended, 42 U.S.C. ss. 12101 et seq., and adopts federal standards.	**Not applicable**—This statute does not apply to the ACF Master WCM update.	None
	Part III - Trench Safety Act (ss. 553.60-553.64)	Purpose is to provide for increased worker safety by requiring compliance with sufficient standards for trench safety.	**Not applicable**—This statute does not apply to the ACF Master WCM update.	None

Florida Coastal Management Program Consistency Review Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual (WCM) Update				
Statute	**Part**	**Scope**	**Consistency Determination**	**Technical Support Document Reference**
	Part IV - Florida Building Code (ss. 553.70-553.898)	Addresses building construction standards and provides for a unified Florida Building Code.	**Not applicable**—This statute does not apply to the ACF Master WCM update.	None
	Part V - Thermal Efficiency Standards (ss. 553.900-553.912)	Mandates the preparation of a statewide uniform standard for energy efficiency in the thermal design and operation of all buildings.	**Not applicable**—This statute does not apply to the ACF Master WCM update.	None
	Part VI - Energy Conservation Standards (ss. 553.951-553.975)	Provides statewide minimum standards for energy efficiency in certain products such as appliances, lighting, and water fixtures	**Not applicable**—This statute does not apply to the ACF Master WCM update.	None
	Part VII - Standards For Radon-Resistant Buildings (s. 553.98)	Development of building codes for radon-resistant buildings; funding; rules for radon-resistant passive construction standards; ordinances.	**Not applicable**—This statute does not apply to the ACF Master WCM update/WSSA.	None
	Part VIII - Building Energy-Efficiency Rating System (ss. 553.990-553.998)	The purpose of this part is to identify systems for rating the energy efficiency of buildings.	**Not applicable**—This statute does not apply to the ACF Master WCM update/WSSA.	None
Chapter 582 *Soil and Water Conservation*		To promote the appropriate and efficient use of soil and water resources, protect water quality, prevent floodwater and sediment damage, preserve wildlife, protect public lands, and protect and promote the health, safety, and general welfare of the people of this state.	**Consistent to the Maximum Extent Practicable**—The USACE operates to balance all authorized purposes throughout the ACF Basin. The PAA would have a negligible incremental effect on soil and water resources in the Apalachicola River compared to the NAA.	Section 4.29
Chapter 597 *Aquaculture*		Establishes public policy concerning the cultivation of aquatic organisms in the state to enhance the growth of aquaculture, while protecting the state's environment.	**Consistent to the Maximum Extent Practicable**—The USACE operates to balance all authorized purposes throughout the ACF Basin. Implementation of the PAA would not affect any ongoing aquaculture activities in the ACF Basin.	Section 4.30

Technical Support Information for
Coastal Zone Management Act, Federal Agency Consistency Determination

Update of the Water Control Manual for the Apalachicola-Chattahoochee-Flint River Basin in Alabama, Florida, and Georgia and a Water Supply Storage Assessment

1 INTRODUCTION

On 2 October 2015, the U.S. Army Corps of Engineers, Mobile District (USACE) released a Draft Environmental Impact Statement (DEIS) (USACE, 2015) for an Update of the Water Control Manual (WCM) for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in Georgia, Alabama and Florida. The DEIS has been provided to Federal and State agencies, including the Florida Department of Environmental Protection, and the public.

This document is provided to supplement the USACE determination of compliance with the Florida Coastal Management Program. This is a description of the Proposed Action Alternative (PAA) and a summary of the impacts that would be relevant to the Coastal Zone Management Consistency Determination. At a future date USACE will release a Final Environmental Impact Statement (FEIS) which will fully evaluate the impacts of the proposed action.

After consideration of all comments submitted in response to release of the DEIS and a revised Water Supply Storage request by the State of Georgia, several modifications were made to the proposed action to be evaluated in the FEIS. Although they will be discussed in more detail in the next section, the modifications are as follows:

1. The FEIS proposed action alternative analysis does not assume that Bear Creek Reservoir and Glades Creek Reservoir are constructed. The DEIS assumed they were constructed. Both of these permit applications have been withdrawn or suspended.

2. The FEIS proposed action alternative assumes a gross withdrawal of 242 MGD from Lake Lanier directly and 379 MGD downstream. The DEIS proposed action alternative assumes a gross withdrawal of 185 MGD from Lake Lanier directly and 408 MGD downstream.

3. The FEIS proposed action alternative analysis utilized the latest version of HEC-ResSim (the DEIS proposed action alternative used the previous HEC-ResSim version).

4. The FEIS proposed action alternative analysis used an updated Area Capacity Curve for Lake Lanier.

5. The FEIS analysis includes updates to the HEC-5Q based on comments received on the DEIS proposed action alternative.

2 PURPOSE AND NEED

The proposed action is to update the water control plans and manuals for the ACF Basin as directed by Secretary of the Army Pete Geren on January 30, 2008. Specifically, the purpose and need for the federal action is to determine how the USACE projects in the ACF Basin should be operated for their authorized purposes, in light of current conditions and applicable law, and to implement those operations through updated water control plans and manuals. Conditions in the basin (e.g., population, socioeconomic, land use, infrastructure, and demand for water resources) have changed substantially since USACE reservoirs were authorized and constructed, and a variety of applicable federal and state environmental laws have been passed and implemented. Operation of USACE reservoir projects in the basin both affect, and are affected by, current conditions in the basin and must comply with current laws and regulations. This action will result in an updated Master Manual, including updated water control plans and manuals for the ACF system and each USACE project within that system, that reflect operations under existing congressional authorizations, taking into account changes in basin hydrology and demands from years of growth and development, new/rehabilitated structural features, legal developments, and environmental issues.

The updated Master Manual will also include a comprehensive basinwide drought operations plan in accordance with the pertinent USACE regulations. Both the Master WCM and the drought operations plan are needed to accomplish specific congressionally authorized and general statutory authorized project purposes in the basin.

Updates to the WCMs are also needed to:

- Capture project and system operations that have been refined over the years because of changes in basin hydrology and withdrawals/consumption that resulted from years of growth and development.
- Reflect drought operations requirements to account for new data and operational changes.
- Update data reflecting basin conditions.
- Account for new or rehabilitated project structural features.
- Address environmental objectives for water quality, federally listed threatened and endangered species, and fish management.
- Capture and use real-time data provided by additional gages and monitoring devices installed since the last Master Manual updates.
- Use the latest computer models and techniques to evaluate and establish guidelines for project operations.
- Improve and streamline methods for data exchange between USACE and other agencies.

On May 16, 2000, the Governor of the State of Georgia submitted a formal request to the Assistant Secretary of the Army for Civil Works to adjust the operation of Lake Lanier and to enter into agreements with the state or water supply providers to accommodate increases in water supply withdrawals from Lake Lanier and downstream at Atlanta over the next 30 years, culminating in total gross withdrawals of 705 million gallons per day (mgd)—297 mgd from

Lake Lanier and 408 mgd downstream—by the year 2030. The Assistant Secretary of the Army for Civil Works in 2002 denied Georgia's request, concluding that a reallocation of conservation storage in Lake Lanier sufficient to accommodate the requested withdrawals would exceed the Secretary's authority. The 2011 decision of the 11th Circuit Court of Appeals, set aside the Army's 2002 decision to deny Georgia's request and ordered USACE to reconsider whether it has the legal authority to operate the Buford project to accommodate Georgia's request. USACE provided a legal opinion on remand, concluding that it has sufficient authority under applicable law to accommodate that request, but noting that any decision to take action on Georgia's request would require a separate analysis.

On January 11, 2013, the Governor of the State of Georgia provided the Assistant Secretary of the Army for Civil Works with updated demographic and water demand data to confirm the continued need for 705 mgd to meet Georgia's water needs from Lake Lanier and the Chattahoochee River to approximately the year 2040 rather than 2030 as specified in the 2000 request. The 2013 request was considered in the draft EIS published in October 2015. On December 4, 2015, the Georgia Environmental Protection Division (GAEPD), on behalf of the State of Georgia, provided additional updated demographic and water demand data that reduced the state's needs from a total of 705 mgd to a total of 597–621 mgd—242 mgd from Lake Lanier (instead of 297 mgd) and 355–379 mgd downstream (instead of 408 mgd)—through the year 2050 rather than 2040 as specified in the 2013 request. Because of the Circuit Court ruling of June 2011 and the USACE legal opinion, updating the water control plans and manuals will include making a decision on Georgia's water supply request.

3 DESCRIPTION OF PROPOSED ACTION

Under the PAA, the USACE would continue to operate projects in the ACF Basin in a balanced manner to achieve all authorized project purposes, while continuously monitoring the total system water availability to ensure that project purposes can at least be minimally satisfied during critical drought periods. The intent would be to maintain a balanced use of conservation storage rather than to maintain the pools at or above certain predetermined elevations; however, in times of high-flow conditions, flood risk management regulation would supersede all other project functions. At all times, USACE would seek to conserve the water resources entrusted to its regulation authority. The PAA does not include construction of any new facilities or infrastructure. The following sections describe the PAA.

3.1 Guide Curves and Action Zones

In conjunction with meeting authorized project purposes, an important function of the reservoirs in the ACF Basin is to store water when there is an abundance of rain and to release water when there is less rain in an effort to ensure that all water needs can be met throughout the year. Water management in this context is a complex process that requires consideration of many competing demands for water in the basin, consideration of past and anticipated future hydrologic conditions, collaboration with agencies and stakeholders, and determination of the most appropriate operating conditions for all the reservoirs in the basin to meet both human and natural system needs. Water is managed in the reservoir projects in the ACF Basin for a variety of purposes, including flood risk management, hydroelectric power generation, navigation, fish and wildlife conservation, recreation, water supply, and water quality. Water demands can be consumptive or nonconsumptive. Consumptive demands involve withdrawal of water from the basin for some purpose and not returning it or any portion thereof, directly back to the basin. Municipal, industrial, and thermal power water supply consumes a portion of the withdrawn water and returns a portion of the water back to the basin as treated wastewater. For purposes of this analysis, agricultural water supply withdrawals are assumed to provide no return flows to the surface water streams. In contrast, hydroelectric power generation demand is a nonconsumptive use of water. It uses the flow in the river to drive hydroelectric power turbines to generate electricity, but no water is withdrawn or lost from the system. In considering basin water management, it is critical to account for the various withdrawals (losses) from and returns (gains) to the system. Water is lost to the system through evapotranspiration (the total of evaporation and plant transpiration), Municipal and Industrial (M&I) water withdrawals, thermal cooling water withdrawals, agricultural water withdrawals, groundwater transfers, and interbasin transfers. Water is returned, or added, to the basin through precipitation, treated M&I wastewater discharges, thermal power plant discharges, groundwater baseflow contribution, and interbasin transfers.

USACE releases water from its reservoirs primarily through hydropower generation and releases through the spillway gates. Hydropower generation is the preferred method and is generally used except in flood operations or in situations that prohibit the use of turbines, such as maintenance operations. In order to allow the most efficient use of its reservoirs for all project purposes, USACE has established guide curves that serve as target water levels during the year. The guide curves allow for lower reservoir levels during greater risk of flood conditions, typically the rainy winter and spring season, and higher reservoir level during drier periods. This allows storage of water during flood events and release of water during dry weather. Action Zones within the conservation pool (area under the guide curve) allow the decision maker to best balance the authorized purposes as the reservoir is drawn down through increasingly critical levels.

Under the PAA, the USACE would not modify any guide curves of the ACF projects but would modify the action zones for Lake Lanier, West Point Lake, and Walter F. George Lake. The zones are used to manage the lakes at the highest level possible while balancing the needs of all the authorized purposes. Zone 1, the highest in each lake, defines a reservoir condition where all authorized project purposes can be met. As lake levels decline, Zones 2 through 4 define increasingly critical system status where purposes can no longer fully be met. The action zones also provide guidance on meeting minimum hydroelectric power needs at each project.

The revised action zones were derived considering numerous factors, including the ability of the reservoirs to refill (considering hydrology, watershed size, and physical constraints of each reservoir), recreation effects and hazard levels, and the proportionality of zone drawdown between projects. Other factors or activities might cause the lakes to operate differently than the action zones are described, including exceptional flood risk management measures, fish spawn operations, approved deviations, maintenance and repair of turbines, emergency situations (such as a drowning and chemical spills), draw-downs because of shoreline maintenance, releases made to free grounded barges, and other special circumstances.

The storage projects (Lanier, West Point, and Walter F. George) would be operated to maintain their respective lake level in the same action zones concurrently. Because of the hydrologic and physical characteristics of the river system and factors mentioned above, however, there might be periods when one lake would be in a higher or lower zone than another. When that occurs, the USACE would conduct operations to bring the lakes into balance with each other as soon as conditions allow. By doing so, effects within the river basin would be shared equitably among the projects. The action zones for the PAA are shown in Figures 1-3.

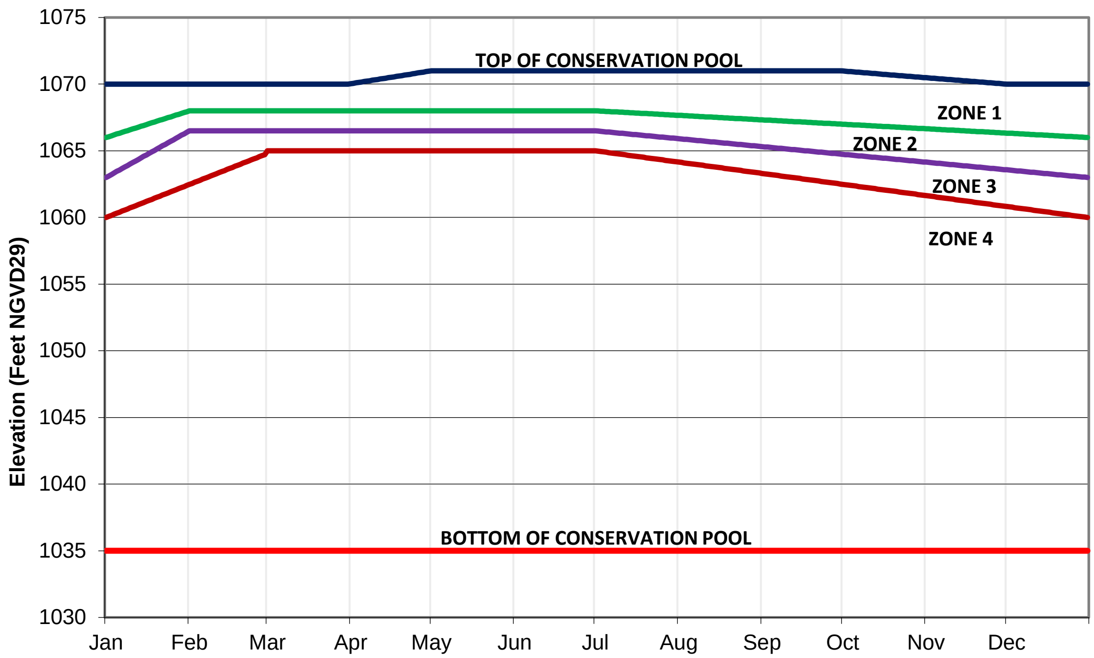


Figure 1. Lake Lanier Water Control Action Zones for the Proposed Action Alternative

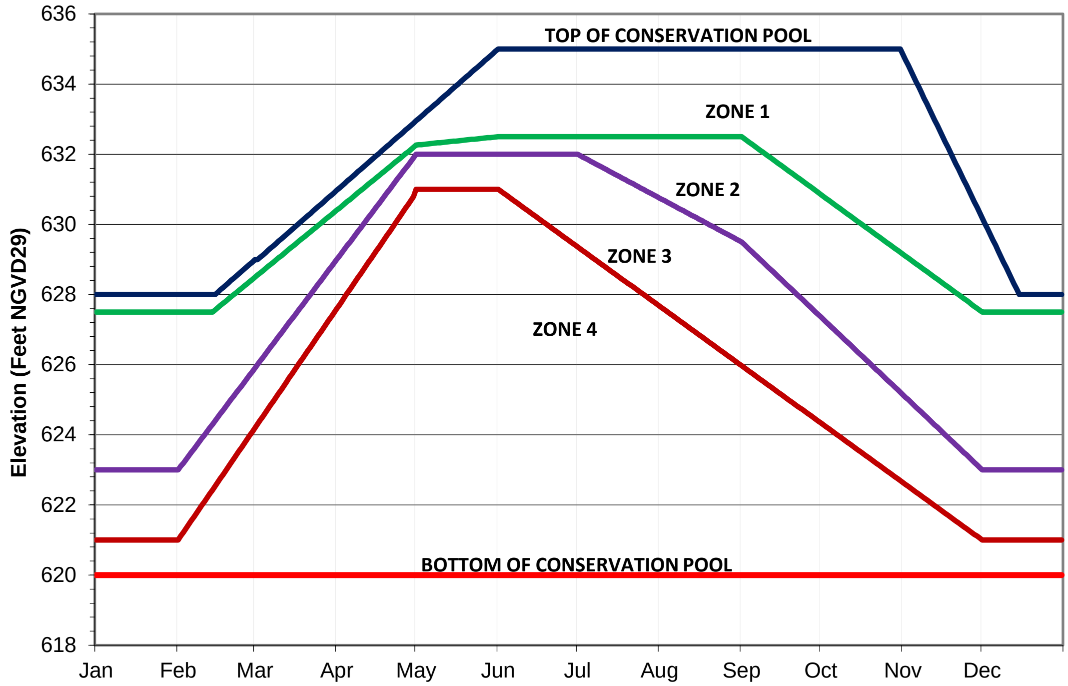


Figure 2. West Point Lake Water Control Action Zones for the Proposed Action Alternative

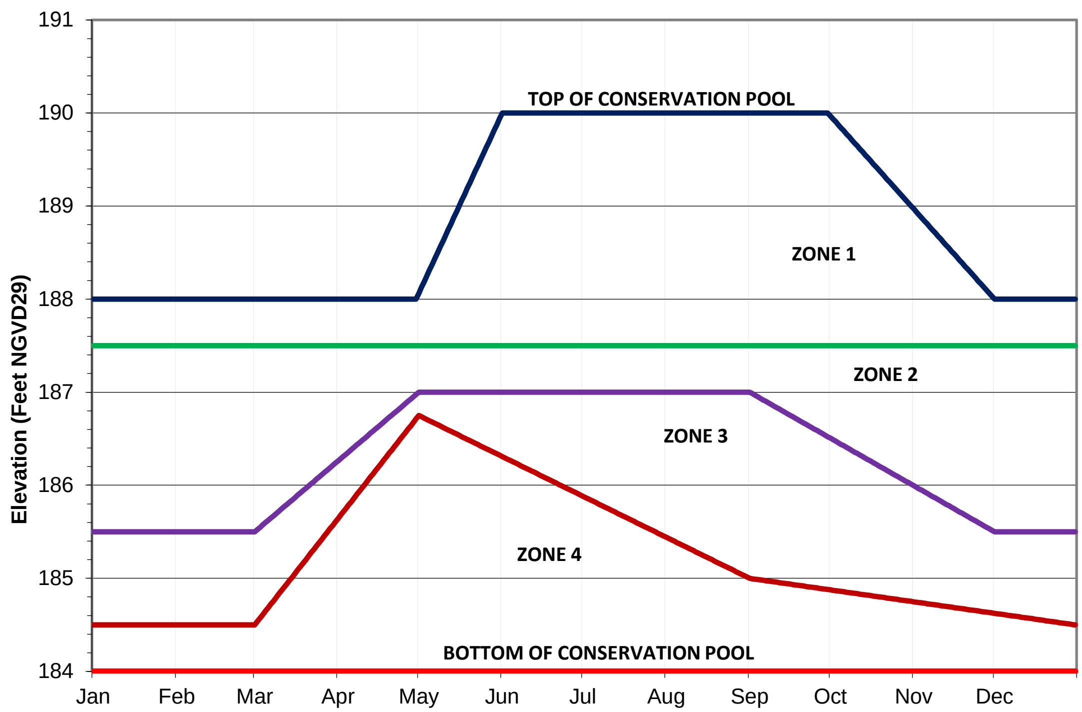


Figure 3. Walter F. George Lake Water Control Action Zones for the Proposed Action Alternative

3.2 Fish and Wildlife Conservation

There is no single operation for fish and wildlife conservation, rather there are several related operations that are implemented in the PAA. West Point Dam is the only federal project in the ACF Basin with fish and wildlife conservation specifically included in its original congressional authorization. Nonetheless, the ACF Basin USACE reservoirs (i.e., Lanier, West Point, Walter F. George, Andrews, and Seminole lakes) operate to support fish and wildlife conservation pursuant to the authority in either the Fish and Wildlife Coordination Act or the Endangered Species Act. Generally, reservoir operations for fish and wildlife conservation consist of either maintaining pool elevations during fish spawns or making special releases to minimize the possibility of fish kills. Special drawdowns for specific environmental purposes may be specified from time to time, but only after coordination with state and federal resource agencies and others, as appropriate. Although the possibility of requiring water control actions may extend throughout a season, the actual actions are usually of short duration. In addition to fishery management, operations include aquatic plant control, waterfowl, and other terrestrial habitat management. The various projects in the basin have specific operations for fish and wildlife, which are described in the individual project WCMs. Specific fish and wildlife conservation activities on USACE ACF Basin projects are addressed in more detail in the following paragraphs.

Federally-Listed Species—Under the PAA, the USACE would continue to make releases for federally-listed, threatened, and endangered species below Jim Woodruff Dam on the basis of seasonal requirements (spawning, non-spawning, and winter), composite conservation storage, and basin inflows.

Release requirements dictated by composite conservation storage would be in accordance with the revised action zones discussed above in the Guide Curves and Action Zones section.

The USACE would manage releases from Jim Woodruff Dam to support the federally-protected Gulf sturgeon and mussel species (fat threeridge, purple bankclimber, and Chipola slabshell) in the Apalachicola River. Daily releases to provide support for fish and wildlife conservation from Jim Woodruff Dam are dictated by two parameters: a minimum discharge (measured in cfs) and a maximum fall rate [measured in feet per day (ft/day)].

Minimum discharges from Jim Woodruff Dam would vary according to composite conservation storage, basin inflow per the 7-day moving average, and by month. Table 2 shows these minimum releases, which are measured as a daily average flow in cfs at the USGS gage at Chattahoochee, Florida. During normal and above normal hydrological conditions within the basin, releases greater than the minimum release provisions could occur consistent with the maximum fall rate schedule described below, or as needed to achieve other project purposes, such as hydroelectric power generation or flood risk management.

During the spawning period (March to May), two sets of four basin inflow thresholds and corresponding releases would exist according to composite conservation storage in Zones 1 and 2 or composite conservation storage in Zone 3. When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the drought contingency operations would be triggered. However, since the decision to implement drought contingency operations occurs monthly, a minimum flow provision while in composite conservation Zone 3 is also included. The USACE

Table 2. Jim Woodruff Lock and Dam, Apalachicola River Minimum Discharge for Federally-Listed Species by Month and by Basin Inflow (BI) Rates

Months	Composite conservation storage zone	Basin inflow (BI)[a] (cfs)	Min. Releases from Jim Woodruff Lock and Dam[b] (cfs)	BI available for storage[a]
March–May	Zones 1 and 2	≥ 34,000	= 25,000	Up to 100% BI>25,000
		≥ 16,000 and < 34,000	= 16,000+50% BI > 16,000	Up to 50% BI>16,000
		≥ 5,000 and < 16,000	= BI	
		< 5,000	= 5,000	
	Zone 3	≥ 39,000	= 25,000	Up to 100% BI>25,000
		≥ 11,000 and < 39,000	= 11,000+50% BI > 11,000	Up to 50% BI>11,000
		≥ 5,000 and < 11,000	= BI	
		< 5,000	= 5,000	
June–November	Zones 1, 2, and 3	≥ 22,000	= 16,000	Up to 100% BI>16,000
		≥ 10,000 and < 22,000	= 10,000+50% BI > 10,000	Up to 50% BI>10,000
		≥ 5,000 and < 10,000	= BI	
		< 5,000	= 5,000	
December–February	Zones 1, 2, and 3	≥ 5,000	= 5,000	Up to 100% BI > 5,000
		< 5,000	= 5,000	
If Drought Triggered	Zone 3	NA	= 5,000[d]	Up to 100% BI > 5,000
At all times	Zone 4	NA	= 5,000	Up to 100% BI > 5,000
At all times	Drought Zone	NA	= 4,500[e]	Up to 100% BI > 4,500

Notes:

a. Basin inflow for composite conservation storage in Zones 1, 2, and 3 is calculated using the 7-day moving average basin inflow. Basin inflow for composite conservation storage in Drought Operations, Zones 3 and 4 or lower (Drought Zone) is calculated using the one-day basin inflow.

b. Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

c. Drought plan is triggered when the composite conservation storage falls into Zone 3, the first day of each month represents a decision point.

d. Once drought operation triggered, reduce minimum flow to 5,000 cfs following the maximum ramp rate schedule.

e. Once composite storage falls below the top of the Drought Zone ramp down to a minimum release of 4,500 cfs at rate of 0.25 ft/day based on the USGS gage at Chattahoochee, Florida (02358000).

would also operate Jim Woodruff Dam to avoid potential Gulf sturgeon take. Potential Gulf sturgeon take is defined as an 8-foot or greater drop in Apalachicola River stage over the last 14-day period (i.e., considering if today's stage is greater than 8 feet lower than the stage of any of the previous 14 days) when flows are less than 40,000 cfs.

During the non-spawning period (June to November), one set of four basin inflow thresholds and corresponding releases would exist according to composite conservation storage in Zones 1 - 3. When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the drought contingency operations would be triggered. However, since the decision to implement drought contingency operations occurs monthly, a minimum flow provision while in composite conservation Zone 3 is also included.

During the winter season (December to February), only one basin inflow threshold and corresponding minimum release (5,000 cfs) would exist while in composite conservation storage Zones 1–4. That would provide the greatest opportunity to refill the storage reservoirs. No basin inflow storage restrictions are in effect as long as this minimum flow is met under such conditions.

When composite conservation storage falls below the bottom of Zone 2 into Zone 3, the drought contingency operations are triggered. Within Zone 4, the minimum flow is the same as in Zone 3. When the composite conservation storage drops further into the Drought Zone, the minimum flow from Jim Woodruff Dam is reduced to 4,500 cfs. A detailed description of the drought operations is provided in the Drought Operations section below.

The federally-listed species operations of the PAA include a fall rate, also called down-ramping rate, defined as the vertical drop in river stage (water surface elevation) that occurs over a given period of time. The fall rates are expressed in units of ft/day measured at the USGS Chattahoochee, Florida, gage as the difference between the daily average river stage on consecutive calendar days. Rise rates (e.g., today's average river stage is higher than yesterday's) are not addressed. The maximum fall rate schedule is provided in Table 3. When composite conservation storage falls into Zone 3, the drought operations plan would be implemented. A detailed discussion of fall rate management when the drought operations plan is implemented is provided in the Drought Operations section below. Down-ramping rates are suspended during periods of prolonged low flow (flows less than 7,000 cfs for a period of more than 30 consecutive days). A prolonged low flow period would be considered over and down-ramping rates would be reinstated when flows are greater than 10,000 cfs for 30 consecutive days. When the maximum fall rate schedule is suspended due to prolonged low flow, down-ramping operations would be managed to match the one-day fall rate of the basin inflow. This prolonged low flow provision could occur under both normal and drought operations. Figure 4 provides an example of this scenario from the ResSim simulation of the PAA. In this example the simulated flows were less than 7,000 cfs for approximately 45 days before a storm system required an increase in releases. Once the storm event was complete the fall rates were managed to match the one day BI fall rate.

Table 3. Maximum Down-Ramping (Fall) Rate

Approximate release range (cfs)	Maximum fall rate (ft/day)	Maximum fall rate (cfs/day)
> 30,000 [a]	No ramping restriction [b]	
> 20,000 and ≤ 30,000 [a]	1.0 to 2.0	2,300 - 5,000
Exceeds Powerhouse Capacity (~ 16,000) and ≤ 20,000 [a]	0.5 to 1.0	1,060 – 2,300
Within Powerhouse Capacity and > 10,000 [a]	0.25 to 0.5	500 – 1,060
Within Powerhouse Capacity and ≤ 10,000 [a]	0.25 or less	220 - 500

Notes:

[a.] Consistent with safety requirements, flood risk management purposes, and equipment capabilities.

[b.] For flows greater than 30,000 cfs, it is not reasonable or prudent to attempt to control the down-ramping rate, and no ramping rate is required.

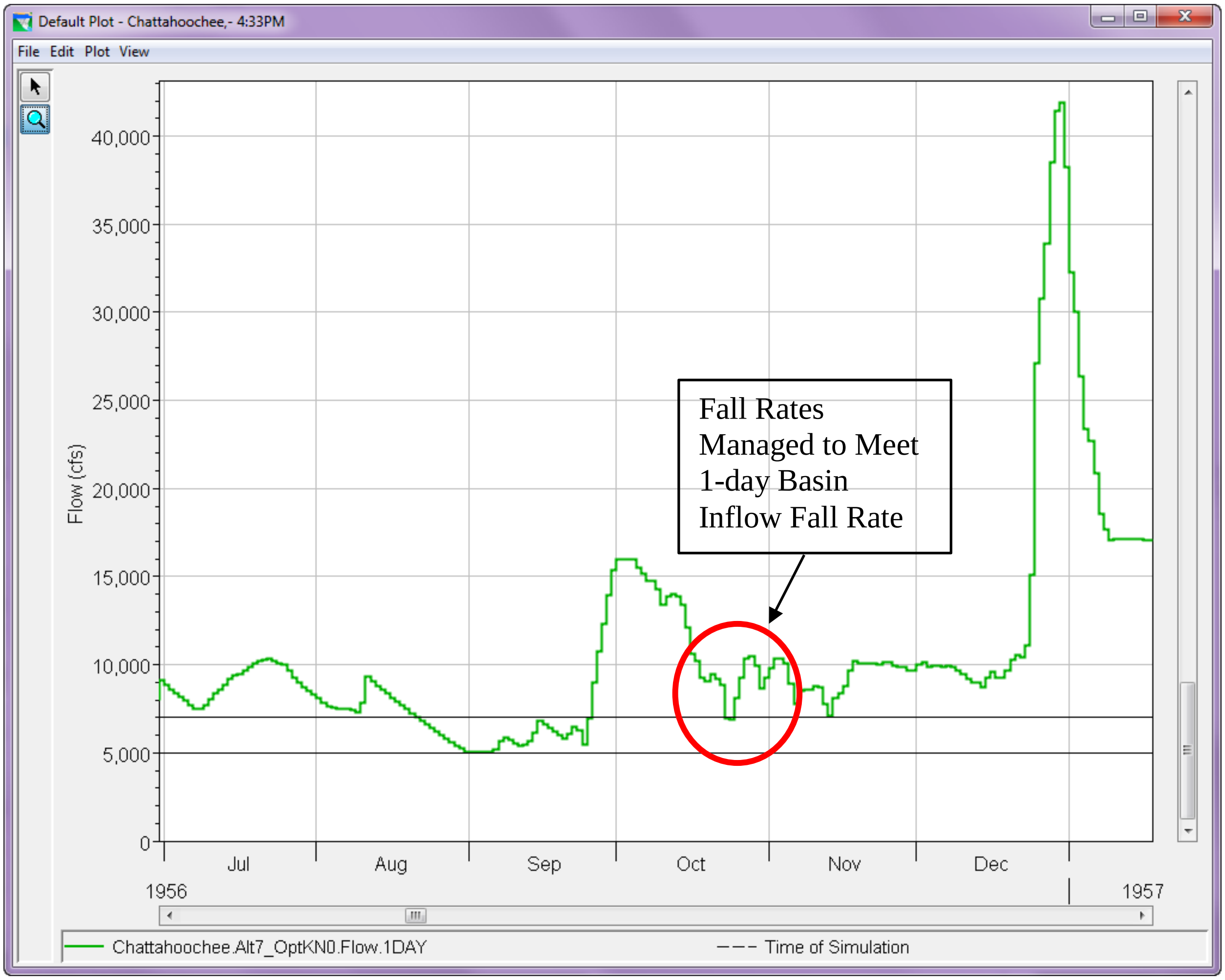


Figure 4. Example of Fall Rate Operations After Prolonged Low Flow

Reservoir Fish Spawning—USACE South Atlantic DR 1130-2-16 (March 30, 2001) and Mobile District Draft SOP 41 1130-2-9 (February 2005) were developed to address reservoir regulation and coordination for fish management purposes. South Atlantic DR 1130-2-16 has been updated and renumbered as South Atlantic DR PDS-O-1 (May 31, 2010), Project Operations, Lake Regulation and Coordination for Fish Management Purposes. It specifically applies to operations at Lake Lanier, West Point Lake, Walter F. George Lake, and Lake Seminole in the ACF Basin as well as other reservoirs in USACE South Atlantic Division. The draft Mobile District SOP (1) identifies designated periods of time within which operations to support fish spawning will be conducted at specific projects and on the Apalachicola River, (2) establishes protocols for coordination between the USFWS, state fisheries personnel, and USACE, and (3) provides for development of an annual plan for special water management operations by USACE (in coordination with USFWS and state fisheries agencies) that would balance impacts and benefits to both reservoir and riverine fisheries during the spring spawning period. A major goal of the SOP is not to lower lake levels more than 6 inches in elevation during the principle fish spawning period to prevent stranding or exposing fish eggs. The protocols in these documents are consistent with the requirements for other project purposes and recognize that reservoir fish spawning operational goals may not be achieved during flood management operations or periods of extended drought.

***Tailrace Dissolved Oxygen Levels*—**Reservoir stratification develops seasonally when surface water becomes warmer and less dense than deeper water, generally summer to late fall in the Southeast. This results in temperature-dependent density differences that prevent mixing and form isolated layers of water, each with their own distinct chemistry. Among the more common concerns is the depletion of oxygen in the deeper layers of lakes when stratified. Below the thermocline, dissolved oxygen is insufficient to support most aquatic life. When water is released from the lower regions of the reservoirs through hydroelectric power generation units and/or sluice gates during periods of reservoir stratification, low dissolved oxygen conditions may be experienced for a short distance downstream of dams, potentially causing stress in the tailrace fishery and occasional fish kills. While dissolved oxygen levels downstream of Buford Dam and West Point Dam are depressed at times as a result of hydroelectric power generation when the lakes are stratified, there have been no recurring instances of fish distress or mortality in the dam tailrace areas as a result of low dissolved oxygen conditions. The Walter F. George Lock and Dam project has experienced recurring instances of stress in the tailrace fishery and occasional fish kills due to low dissolved oxygen. Accordingly, USACE has implemented a SOP, established in 1988 and updated in 1993, to address conditions at the Walter F. George project when low dissolved oxygen values are observed in the tailrace. The SOP calls for spillway gates to be opened in accordance with a specific protocol until dissolved oxygen readings return to an acceptable level. Spillage siphons have also been constructed on the dam that can be used in lieu of spillway gate discharges.

***Fish Passage*—**In most years since the spring of 2005, USACE has operated the lock at Jim Woodruff Lock and Dam between March and May to facilitate downstream-to-upstream passage of Alabama shad (*Alosa alabamae*) and other anadromous fishes (those that return from the sea to the rivers where they were born to breed) in cooperation with pertinent state and federal agencies. In general, two fish locking cycles are performed each day between 0800–1600 hours, one in the morning and one in the afternoon. Studies are ongoing to determine the most appropriate technique and timing for the locks, but the number of lock cycles per day will not change.

***Management of Project Lands*—**The 11,184-acre Eufaula National Wildlife Refuge is operated by the U.S. Fish and Wildlife Service (USFWS) in cooperation with USACE in the upper reaches of Walter F. George Lake within Barbour and Russell counties, Alabama, and Stewart and Quitman counties, Georgia. The refuge has an extensive system of pumps, dikes, and water control structures for water-level management in off-reservoir wetland areas. The refuge provides important habitat for migratory waterfowl and other birds, habitat for federally listed threatened and endangered species, and recreation and environmental education for the public. USACE manages much of the project land around its ACF reservoirs for the benefit of fish and wildlife resources, consistent with other project purposes. In some cases, project lands can be managed by state agencies (i.e., wildlife management areas or state parks) or local interests through leases. Additionally, GADNR operates a fish hatchery on the Chattahoochee River immediately below Buford Dam. USACE coordinates project operations with the fish hatchery staff.

3.3 Drought Operations

The drought plan included in the PAA would be triggered when the composite conservation storage falls below the bottom of Zone 2 into Zone 3 (Figure 5). The purpose for this modification is to facilitate a more proactive approach to drought management in order to better assure that storage is available to meet all project purposes throughout a prolonged drought period worse than has been realized to date. The drought plan specifies a minimum release from Jim Woodruff Dam and would temporarily suspend the normal minimum release and maximum fall rate provisions of the listed species operation (Table 2 and Table 3), until composite conservation storage in the basin could be replenished to a level that could support them (Zone 1).

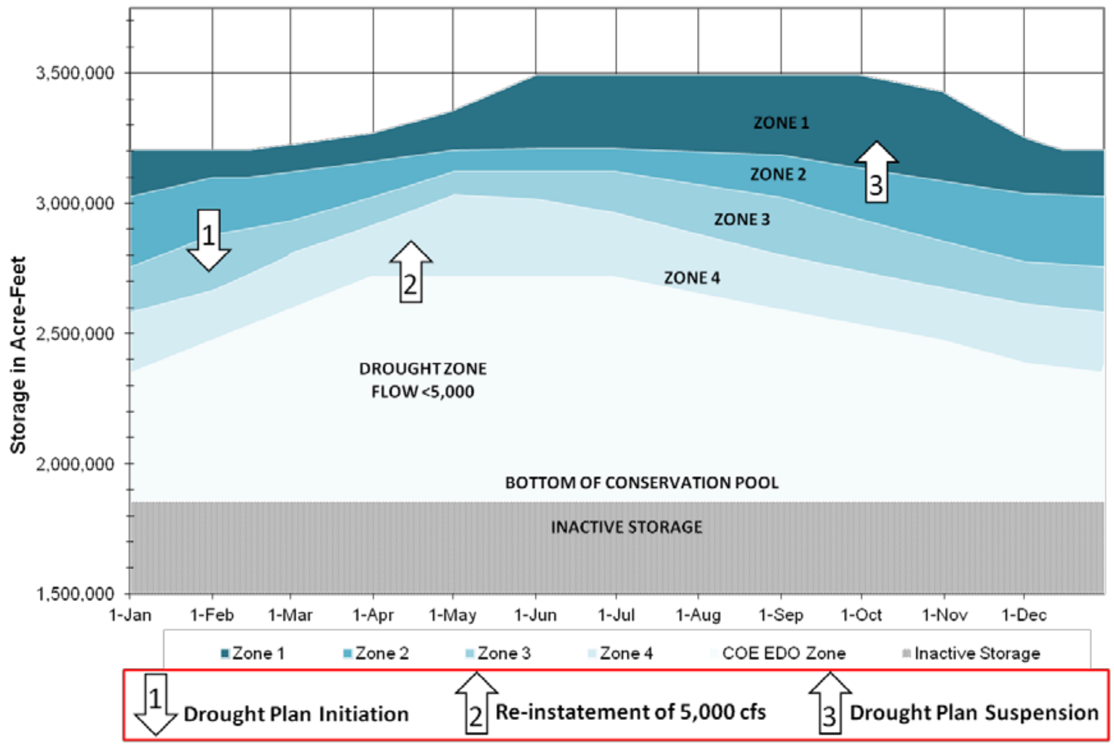


Figure 5. Composite Conservation Storage Zones and Drought Plan Triggers

Under the drought plan the minimum required release from Jim Woodruff Dam would be 5,000 cfs when the composite conservation storage is in Zones 3 and 4. Under the drought plan, the maximum fall rate schedule is suspended. However, the suspension of the maximum fall rate schedule is delayed if releases from Jim Woodruff Dam have not yet reached the 5,000 cfs minimum flow when the drought plan is implemented. The purpose of maintaining the maximum fall rate schedule under these conditions is to facilitate the movement of listed mussels and other aquatic species to lower stages as the river flow drops to stages that have not been recently dewatered. Figure 6 provides an example of this scenario from the ResSim simulation of the PAA. In this example the drought operation is triggered on June 1, 2006 and the discharge from Jim Woodruff Dam is slowly reduced from 10,125 cfs to 5,050 cfs, over a 22 day period, according to the maximum fall rate schedule. In this example the 0.25 ft/day maximum fall rate provision is implemented when drought operations are triggered as the releases are less than 10,000 cfs.

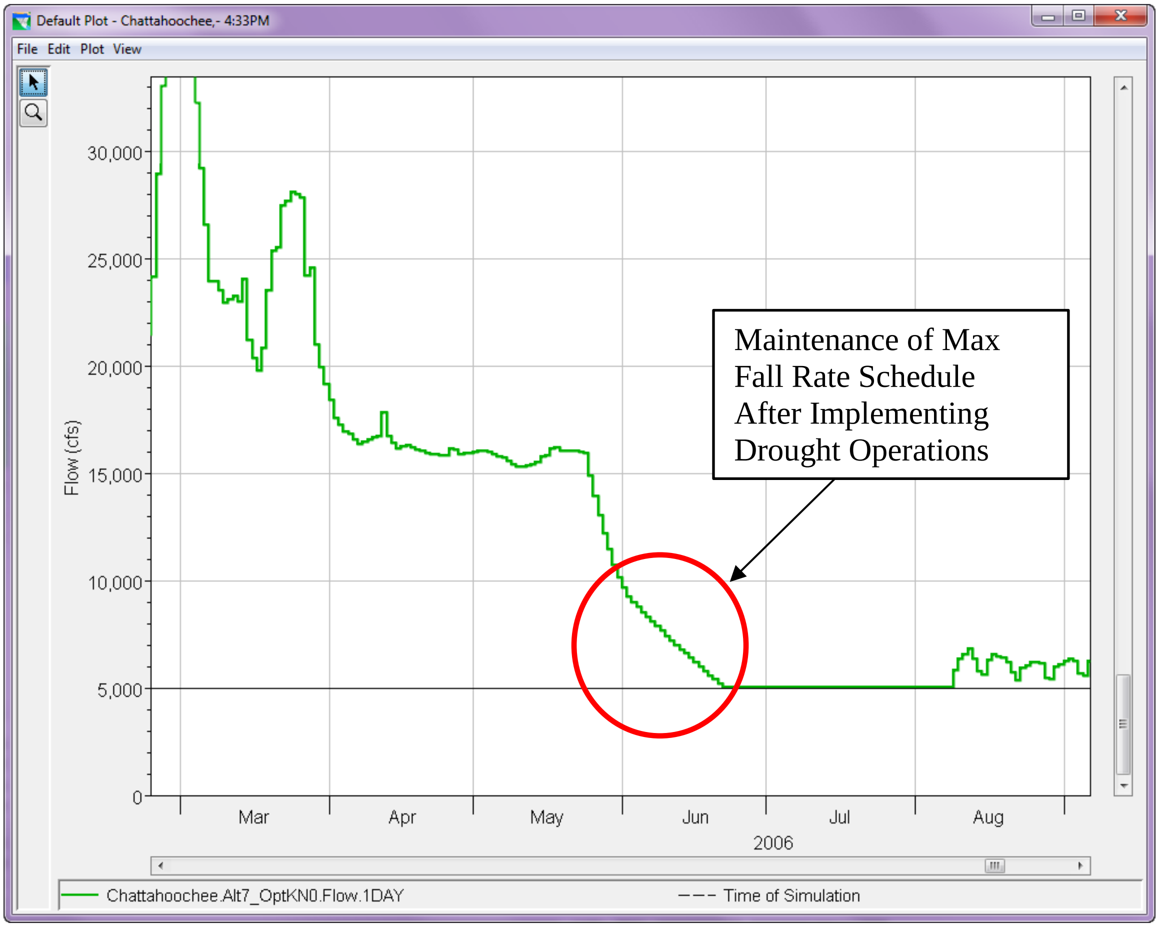


Figure 6. Example Down Ramping after Drought Operation Triggered

Occasionally uncontrolled high flow from the Flint River (resulting from a rainfall event) or hydropower releases from Walter F. George could cause a temporary increase in Jim Woodruff Dam discharge as down ramping to 5,000 cfs occurs during the drought operation. In this case the Jim Woodruff release ramps down using two ramping rates. The peak discharge would ramp down according to the one day basin inflow fall rate until the discharge prior to the temporary increase occurs. At that time, the releases would again be managed according to the maximum fall rate schedule until the minimum flow of 5,000 cfs occurs.

Figure 7 provides an example of this scenario from the ResSim simulation of the PAA. In this example the drought operation is triggered on March 1, 2016 and releases from Jim Woodruff Dam are reduced according to the maximum fall rate schedule from 12,100 cfs to 8,490 cfs over an eight day period. At this time, conditions in the basin result in an increased release from Jim Woodruff Dam until a peak value of 21,750 cfs is reached on March 26, 2016. As releases are decreased following the peak, fall rates are managed according to the one day basin inflow fall rate until the release reaches 8,490 cfs. Because releases less than 8,490 cfs had not occurred prior to the temporary increase in river flow, on May 13, 2016 the maximum fall rate schedule resumes. In this example another temporary discharge increase occurs on May 16, 2016 and the maximum fall rate schedule resumes on May 21, 2016. Implementing the two phase down ramping allows USACE to conserve storage when reducing releases following a temporary increase in river flow and still facilitate the movement of listed mussels and other aquatic species to lower stages as the river flow drops to stages that had not previously occurred. The temporary increases in river flow during the down ramping period are not of sufficient duration to allow mussels to recolonize habitats that were recently dewatered.

Figure 7. Example of Two Phase Down Ramping After Drought Operation Triggered

The drought plan would also include the option for a temporary waiver from the water control plan to allow temporary storage above the winter pool guide curve at the Walter F. George and West Point projects to provide additional conservation storage for future needs, if conditions in the basin dictate the need for such action.

The drought plan of the PAA prescribes two minimum releases on the basis of composite conservation storage. One minimum release while in Zones 3 and 4 and an additional minimum release while in the Drought Zone. The Drought Zone delineates a volume of water roughly equivalent to the inactive storage in Lake Sidney Lanier, West Point Lake, and Walter F. George Lake, plus Zone 4 storage in Lake Sidney Lanier. The Drought Zone line was adjusted to include a smaller volume of water at the beginning and end of the calendar year. When the composite conservation storage is within Zones 3 and 4, but above the Drought Zone, the minimum release from Jim Woodruff Dam would be 5,000 cubic feet per second (cfs) and all basin inflow above 5,000 cfs that is capable of being stored may be stored. Once the composite conservation storage falls below the Drought Zone, the minimum release from Jim Woodruff Dam would be 4,500 cfs and all basin inflow above 4,500 cfs that is capable of being stored may be stored. When transitioning for the first time from a minimum release of 5,000 to 4,500 cfs, fall rates would be limited to a maximum of 0.25 ft/day drop. Should conditions result in releases greater than 4,500 cfs while the composite conservation storage is still in the Drought Zone, fall rates will be determined by a computation based on the one-day basin inflow fall rate. The 4,500 cfs minimum release would be maintained until composite conservation storage returns to a level above the top of the Drought Zone, at which time the 5,000 cfs minimum release would be immediately reinstated. The drought plan provisions would remain in place until conditions improve such that the composite conservation storage reaches Zone 1. At that time, the temporary drought plan provisions would be suspended and all the other provisions of the basin water control plan would be reinstated. During the drought contingency operations a monthly monitoring plan that tracks composite conservation storage in order to determine water management operations (the first day of each month will represent a decision point) would be implemented to determine which operational triggers are applied. It was determined monthly decision points would be the minimum interval to effectively manage drought operations. A more frequent decision point would not allow assurance that a weather-based hydrologic trend was establishing and could result in short isolated periods of rain causing premature exit of drought operations during a prolonged drought.

In the event the composite conservation storage has not recovered to Zone 1 by 1 February, drought operations would be extended to the end of March, unless all the federal reservoirs are full. This provision is intended to ensure full recovery prior to implementing the higher minimum flow provisions in place during normal operations in the sturgeon spawning season. Because of high rainfall amounts, the month of March is typically characterized by higher flow and is critical to reservoir refill. Figure 8 is an example from the ResSim modeling of the PAA of continuing the drought operation through the month of March. In this example, the composite conservation storage enters Zone 1 on February 5, 1982, but drought operation is not suspended until April 1, 1982.

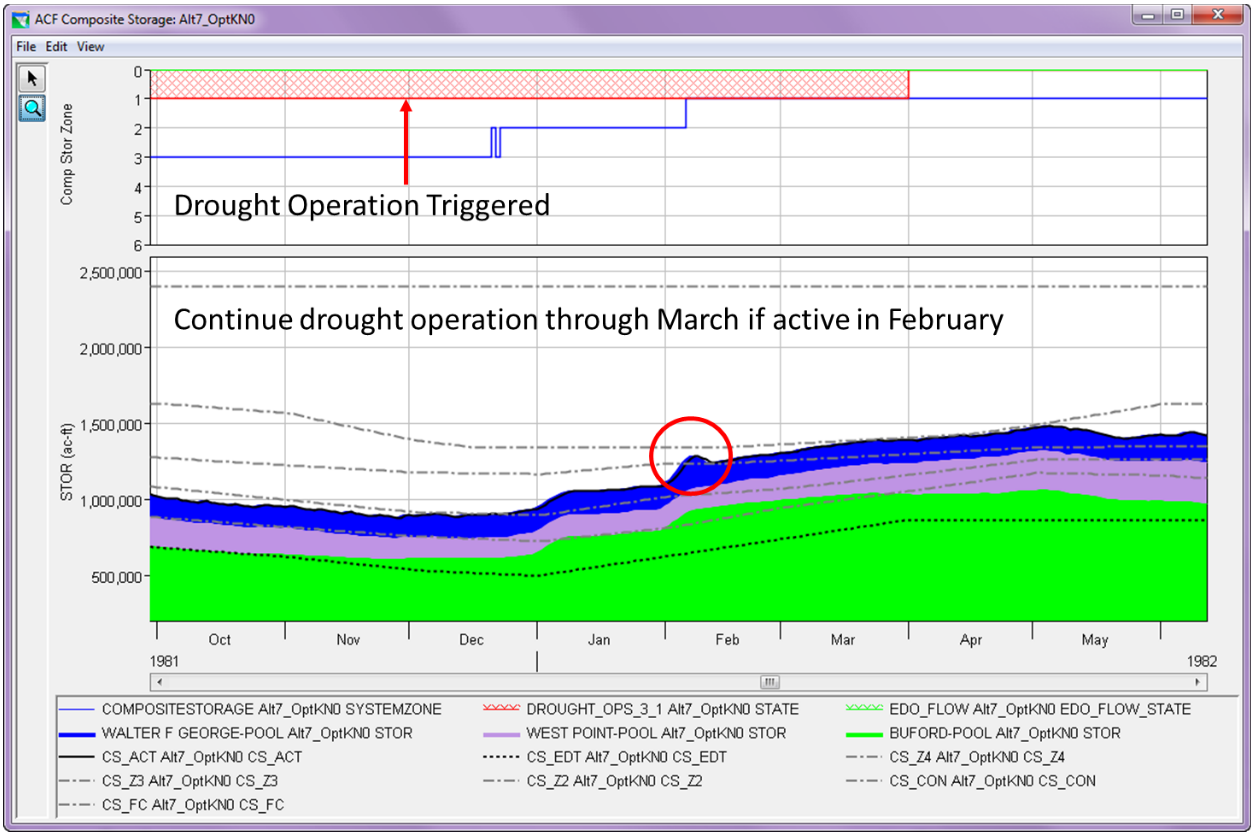


Figure 8. Drought Operation Continued Through Month of March

3.4 Extreme Drought Operations

When the remaining composite conservation storage is about 10 percent of the total capacity, additional emergency actions might be necessary. When conditions have worsened to that extent, use of the inactive storage must be considered. For example, such an occurrence could be contemplated in the second or third year of a drought. Inactive storage zones have been designated for the three Federal projects with significant storage (Figure 9). Table 4 shows the inactive storage capacity within each inactive storage zone for each project. The use of inactive storage during extreme drought conditions would be based on the following actions:

(1) Inactive storage availability would be identified to meet specific critical water use needs within existing project authorizations.
(2) Emergency uses would be identified in accordance with emergency authorizations and through stakeholder coordination including emergency consultation under Section 7 of the ESA. Typical critical water use needs within the basin are associated with public health and safety.
(3) Weekly projections of the inactive storage water availability to meet the critical water uses from Buford Dam downstream to the Apalachicola River would be used when making water control decisions regarding withdrawals and water releases from the USACE reservoirs.

(4) The inactive storage action zones would be instituted as triggers to meet the identified priority water uses (releases will be restricted as storage decreases). Figure 5 lists the typical critical water uses for each inactive storage zone.
(5) Dam safety considerations would always remain the highest priority. The structural integrity of the dams due to static head limitations (Jim Woodruff, 38.5 feet; George W. Andrews, 26 feet; Walter F. George, 88 feet) would be maintained.

- **Zone 1A**
    - Water Supply
    - Water Quality
    - Endangered Species
- **Zone 2A**
    - Water Supply
    - Water Quality
- **Zone 3A**
    - Water Supply

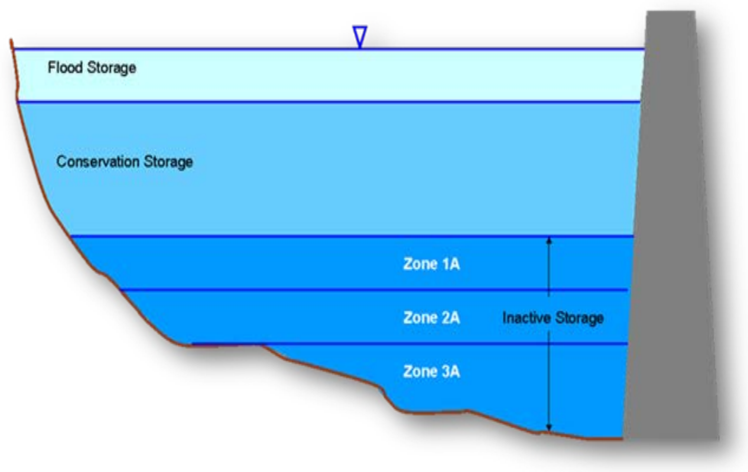


Figure 9. Inactive Storage Zones and Typical Water Use Needs

Table 4. Reservoir Inactive Storage Zone Capacities (ac-ft)

Project	Zone 1A	Zone 2A	Zone 3A	Unusable Inactive
Buford Dam	532,078	234,699	100,823	0
West Point Dam	53,620	138,331	33,344	73,101
Walter F. George Dam	314,799	178,501	0	196,700
Total	901,589	554,345	134,869	266,062

3.5 Flood Risk Management

When developing the PAA, flood risk management capabilities and capacities of reservoirs were not reduced. The objective of flood risk management operations (formerly referred to as flood control) is to impound excess flows, thereby reducing downstream river levels below flood stage. Whenever flood conditions occur, operation for flood risk management takes precedence over all other project functions. Only Buford and West Point dams have storage allocated for flood risk management operations. During the principal flood season, December through April, the regulation plan at Walter F. George Lake provides for lower lake levels to ensure lower peak stages throughout the reservoir during major floods. George W. Andrews and Jim Woodruff lock and dams operate to pass inflows. The timing of flood peaks in the ACF Basin is of considerable importance in determining the effectiveness of reservoir operations for flood risk management and the degree to which such operations can be coordinated. During a flood event, excess water above the guide curve is evacuated (released) consistent with other project needs as soon as downstream waters have receded enough that releases from the reservoirs will not increase the natural maximum flood heights downstream. This timely evacuation is necessary so that consecutive flood events will not cause floodwaters to exceed allocated storage capacities and endanger the integrity of the dam. Both turbines and spillways are used, as necessary, to evacuate floodwaters. Because flooding usually occurs in the winter and spring when rainfall and runoff are more plentiful and hydroelectric power generation demands are lower, the guide curve operation generally reflects this situation by specifying a lower elevation during this time period. Transitions between the seasonal levels are gradual to moderate increases or decreases in outflow. By drawing down the pool in late fall, either specifically for flood risk management as at West Point or coincidentally for other purposes, additional storage is gained for containing floodwaters. For flood risk management purposes, releases are reduced or terminated at Buford Dam, except for the small hydropower unit, as soon as it appears that downstream river stages will exceed flood stage. Key gaging stations in the vicinity are closely monitored to determine when floodwaters have begun to recede so that flood storage in the reservoir can be expeditiously evacuated in a manner consistent with other project functions without exacerbating downstream flooding. Projects on the middle and lower portion of the basin pass flood waters once the pool has reached the top of the conservation pool. West Point and Walter F. George dams operate according to specified flood risk management plans, as outlined in their WCMs. Spillway gates are opened if necessary to assist the turbines in passing these flows. Even though the traditional flood season spans several months, discrete incidences of flooding should have insignificant long-duration effects if pool elevations are maintained close to guide curve elevations. No pool is allowed to remain above its guide curve for any appreciable length of time without prior approval of a temporary deviation or variance by USACE, South Atlantic Division.

3.6 Hydroelectric Power Generation

The PAA includes the current hydroelectric power generation operations at West Point Dam, Walter F. George Dam, and Jim Woodruff Dam which call for a more flexible generation schedule in all action zones under non-drought conditions and a more constrained generation schedule under drier conditions. The Buford, West Point, and Walter F. George Projects are operated as peaking plants, and provide electricity during the peak demand periods of each day and week. Hydroelectric power peaking involves increasing the discharge for a few hours each day to near the full capacity of one or more of the turbines. Typically, the Buford, West Point, and Walter F. George Projects provide generation five days a week at plant capacity throughout the year, as long as their respective lake levels are above Zone 4 and drought operations have not been triggered. For example, demand for peak hydroelectric power at Buford Dam typically occurs on weekdays from 5:00 a.m. to 9:00 a.m. Central time and from 3:00 p.m. to 10:00 p.m. between 1 October and 31 March, and on weekdays from 1:00 p.m. to 7:00 p.m. between 1 April and 30 September. The typical hours represent releases that normally meet water system demands and provide the capacity specified in power marketing arrangements. During dry periods, generation could be eliminated or limited to conjunctive releases. Typical, but not required, hours of operation by action zone are depicted in Table 5.

Table 5. Typical hours of peaking hydroelectric power generation by federal project

Action zone	Buford Dam (hours of operation) normal ops/drought ops	West Point Dam (hours of operation)	Walter F. George Dam (hours of operation)
Zone 1	3/2	4	4
Zone 2	2/1	2	2
Zone 3	2/1	2	2
Zone 4*	0	0	0

*While hydropower would still be generated in Zone 4, it could not be generated on a regular peaking schedule under severe drought conditions

3.7 Navigation

When supported by ACF Basin hydrologic conditions, the PAA would provide a reliable navigation season. The water management objective for navigation is to ensure a predictable minimum navigable channel in the Apalachicola River for a continuous period that is sufficient for navigation use.

Assuming basin hydrologic conditions allow, a typical navigation season would begin in January of each year and continue for 4 to 5 consecutive months (January through April or May). Figure 10 graphically represents the navigation season and its relationship to composite conservation storage. During the navigation season, the flows at the USGS gage at Blountstown, Florida, should be adequate to provide a minimum channel depth of 7 feet. The most recent channel survey and discharge-stage rating were used to determine the flow required to sustain a minimum navigation depth during the navigation season. Flows of 16,200 cfs provide a channel depth of 7 feet. Flows of 20,600 cfs provide a channel depth of 9 feet. USACE's capacity to support a navigation season would be dependent on actual and projected system-wide conditions in the ACF Basin before and during January, February, March, April, and May. Those conditions include the following:

- A navigation season can be supported only when ACF Basin composite conservation storage is in Zone 1 or Zone 2.
- A navigation season will not be supported when the ACF Basin composite conservation storage is in Zone 3 and below. Navigation support will resume when basin composite conservation storage level recovers to Zone 1.
- A navigation season will not be supported when drought operations are in effect. Navigation will not be supported until the ACF Basin composite conservation storage recovers to Zone 1.
- The determination to extend the navigation season beyond April will depend on ACF Basin inflows, recent climatic and hydrologic conditions, meteorological forecasts, and basin-wide model forecasts. On the basis of an analysis of those factors, USACE will determine if the navigation season will continue through part or all of May.
- Down-ramping of flow releases will adhere to the Jim Woodruff Dam fall rate schedule (see Table 4) for federally listed threatened and endangered species during the navigation season.
- Releases that augment the flows to provide a minimum 7-foot navigation depth will also be dependent on navigation channel conditions that ensure safe navigation.

When it becomes apparent that, because of diminishing inflows, downstream flows and depths must be reduced, notices would be issued to project users to give barge owners and other waterway users sufficient time to make arrangements to light load or remove their vessels before action is taken at Jim Woodruff Lock and Dam to reduce releases.

Although special releases would not be standard practice, they could occur for a short duration to assist navigation during the navigation season. For instance, releases can be requested to achieve up to a 9-foot channel. Special releases could also occur outside of the navigation season. However, USACE would evaluate such request on a case-by-case basis, subject to applicable laws and regulations and the conditions above.

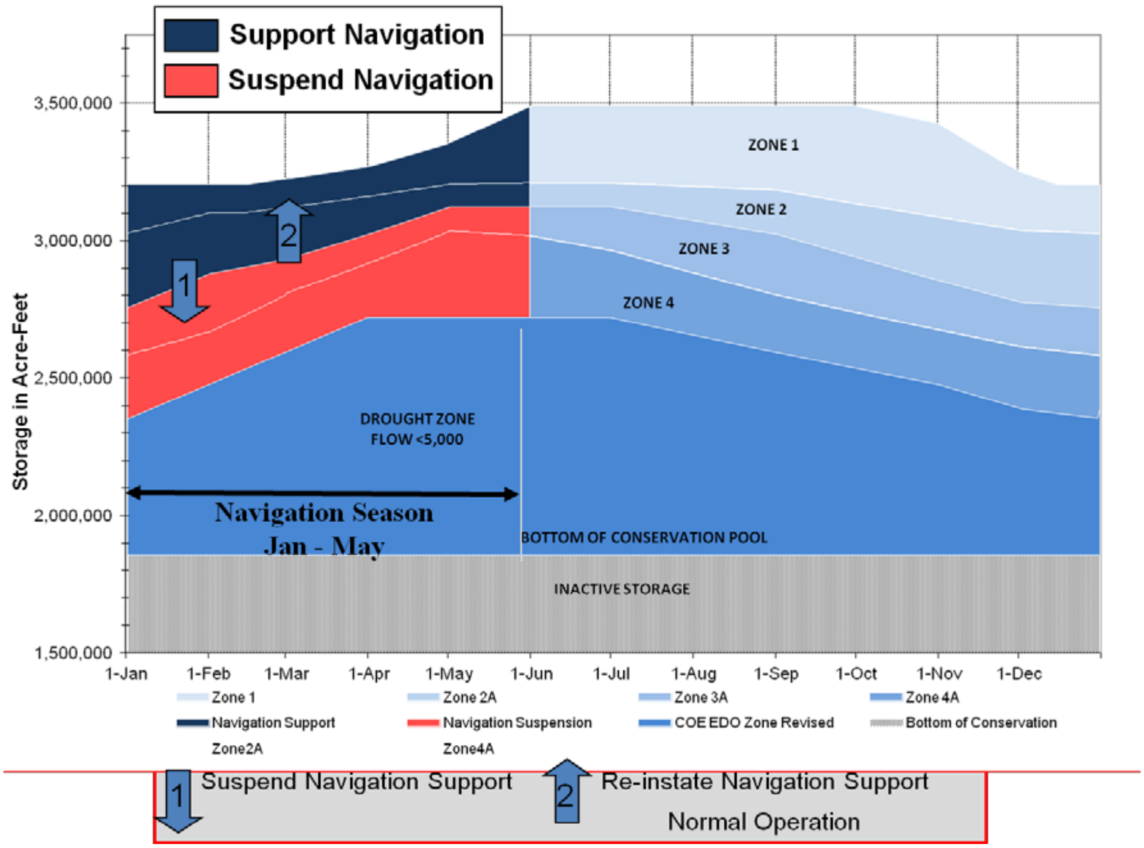


Figure 10. Composite Conservation Storage for Navigation

3.8 Recreation

Under the PAA, operations for recreation would remain the same as current operations. Recreation benefits would be maximized at the lakes to the extent possible consistent with meeting other project purposes by maintaining full or nearly full pools during the primary recreation season which are the warm summer months. In response to meeting other authorized project purposes, lake levels could decline during the primary recreation period, particularly during drier than normal years. Recreation impact levels have been identified for various lake elevations at each of the reservoir projects (Table 6). Recreational impact levels are not applicable to the George W. Andrews project due to the lack of conservation storage and the run-of-river operation at the project.

When pool levels must be lowered, the rates at which the draw-downs occur are as steady as possible. The action zones at Lake Sidney Lanier and West Point Lake are drawn down to correlate the line between Zone 2 and Zone 3 near the IIL at the beginning of the recreation season (May through early September). This is an attempt to maximize the time these projects are above the IIL during the recreation season.

Table 6. Recreation Impact Levels for Federal Projects in the ACF Basin

Project	IIL[a]	RIL[b]	WAL[c]
Lake Lanier	1,066 ft	1,063 ft	1,060 ft
West Point Lake	632.5 ft	629 ft	627 ft
Walter F. George	187 ft	185 ft	184 ft

Notes:
[a.] Initial Impact Level
[b.] Recreation Impact Level
[c.] Water Access Limited Level

3.9 Water Quality

Under the PAA, Buford, West Point, and Jim Woodruff dams would provide continuous minimum flow releases that would benefit the water quality immediately downstream of the dams. There would be no minimum flow provisions downstream of Walter F. George Dam. However, when low dissolved oxygen values are observed below the dam, spillway gates would be opened until the dissolved oxygen readings return to an acceptable level. Occasional special releases would also be made at Buford Dam to ensure adequate dissolved oxygen and water temperature at the Buford Fish Hatchery downstream of the dam.

At Buford Dam, the small turbine generator would run continuously to provide a minimum flow from the dam, which would range from approximately 500 to 700 cfs, depending on head conditions. This minimum flow from Buford Dam would help meet the seasonal minimum flow requirements of 650 cfs and 750 cfs at Atlanta, Georgia, in the Chattahoochee River just upstream of the confluence with Peachtree Creek. At West Point Dam, the minimum flow requirement is 670 cfs and a similar small generating unit would provide a continuous release of approximately 675 cfs. A varying minimum flow from 4,500 to 25,000 cfs, dependent upon basin conditions, would be maintained as a release from the Jim Woodruff Dam to the Apalachicola River, which would assure an adequate water supply for downstream industrial use and water quality. Walter F. George Dam has two siphons on each spillway gate. The siphon discharge could range from about 15 cfs up to 200 cfs when all 12 are in use. Typically, the siphon tubes would be opened continuously from May through the end of September and all would be used at full capacity. The siphons would provide a gravity-fed, typically continuous, minimum flow that would benefit dissolved oxygen levels below the dam.

3.10 Water Supply

Under the PAA, the cities of Gainesville and Buford would continue to withdraw water directly from Lake Sidney Lanier under relocation agreements at rates not exceeding 8 mgd (net) and 2 mgd, respectively. Additionally, pursuant to the Water Supply Act of 1958, the PAA would reallocate 252,950 acre-feet in Lake Sidney Lanier for water supply. The amount of storage is estimated to yield 222 mgd during the critical drought (i.e., during the worst drought on record at the time the agreement was executed). The severity and frequency of droughts change over time, therefore, the yield of this storage may change over time. For the purpose of managing water supply storage, USACE would employ a storage accounting methodology that applies a proportion of inflows and losses, as well as direct withdrawals by specific users, to each account. The amount of water that may actually be withdrawn is ultimately dependent on the amount of water available in the storage account, which will naturally change over time.

Under the PAA releases from Buford Dam would be made to accommodate downstream water demands. Peaking hydroelectric power generation generally accommodates most water supply needs of communities currently withdrawing from the Chattahoochee River; however, under the 1946 Rivers and Harbors Act, generation can occur at non-peaking times to meet the downstream water supply needs, not to exceed 379 mgd. Figure 10 illustrates the current lake and river withdrawals occurring in the metro-Atlanta area.

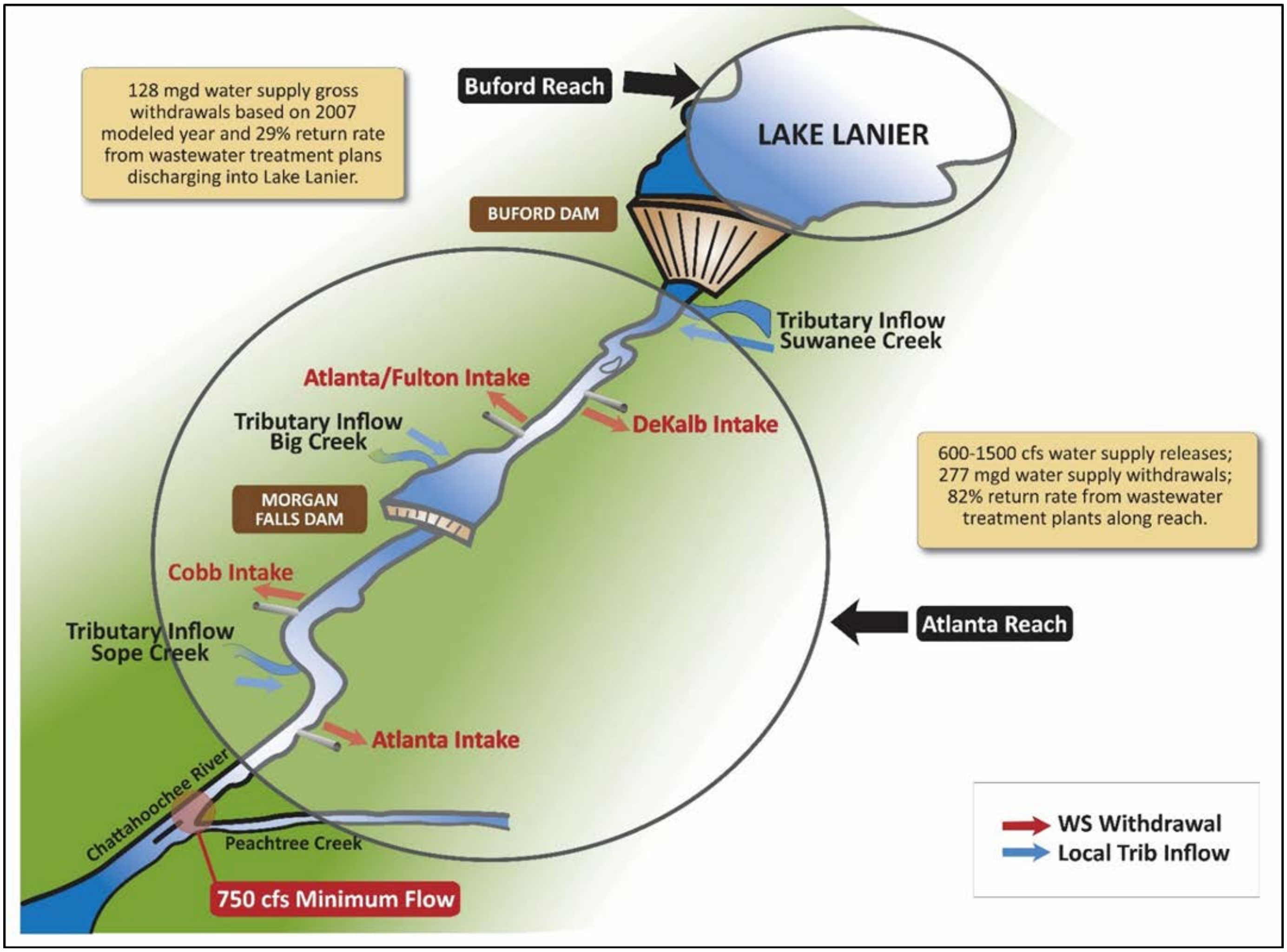


Figure 11. Illustration of Metro-Atlanta Water Supply Withdrawals

4 POTENTIAL IMPACTS TO THE FLORIDA COASTAL ZONE

This section describes potential environmental and socioeconomic effects of the PAA to the Florida Coastal Zone as they relate to the laws describing implementation and Florida Coastal Management Program consistency reviews.

One important tool used by USACE in its evaluation was a hydrologic computer simulation model that compares relative differences of various river flow parameters between the PAA and the existing condition. For the DEIS, USACE used HEC-ResSim Version 3.2, Build 3.2.1.19. The USACE Hydrologic Engineering Center (HEC) developed that decision support tool to meet the needs of modelers performing reservoir project studies as well as of reservoir regulators during real-time events. HEC-ResSim is now the standard for USACE reservoir operations modeling. HEC-ResSim Version 3.3, Build 3.3.1.42 became available in 2015 and is used for analysis of alternatives in this final EIS. Although this newer version of ResSim has not yet been officially released, it offers important advantages over ResSim 3.2, including new features, enhancements, bug fixes, and improved algorithms. The figures presented in the remainder of this document are based on this latest ResSim version.

In addition to the HEC-ResSim model, the water quality effects, including water temperature, associated with the water management alternatives and water supply storage options in the ACF Basin were analyzed with the HEC-5Q model developed by the USACE Hydrologic Engineering Center. For the simulation of water quality conditions under the various alternatives, HEC-5Q inputs included in-stream flows, tributary flows and water quality data, withdrawals, reservoir operations, and other point and nonpoint source flows and quality loads to the system. The HEC-5Q model was linked with the HEC-ResSim model through an input of flows by reach. In addition to the BASINS model loadings developed in previous modeling efforts, observed data was used to represent the nonpoint inputs to the HEC-5Q model for the period of record from 2001 through 2011. The HEC-5Q model also included nontributary inflows, wastewater treatment dischargers, and cooling water returns. Inputs for wastewater treatment discharges were based on discharge monitoring reports (DMRs). When DMRs were not available, permitted limits, concentrations representative of the type of discharge, or an average of DMRs was used. The point source inputs considered only dischargers that contributed more than 1 mgd. Because of limited observed water temperature data, we could not compare simulated data to the baseline (observed) condition. Therefore, the NAA (simulated) was compared to the PAA.

4.1 Chapter 161, Beach and Shore Preservation, Parts I-IV

This part of the statute authorizes regulation of construction on, and seaward of Florida beaches, the Florida beach and shore preservation program, and addresses the intent of the Florida Legislature to manage sensitive coastal areas through strict construction standards.

The PAA would not result in construction.

The scope of the federal action is to update the water control plans and manuals to reflect operations as they have evolved because of changing conditions in the basin and to fully comply with agency regulations, federal laws, and applicable law. The scope also includes a Water

Supply Storage Assessment that considers both current and increased levels of water supply withdrawals from Lake Lanier and downstream at Atlanta. USACE will identify, document and evaluate environmental effects of the PAA that could reasonably be expected to result within the geographic area affected. Because potential impacts of the PAA are limited to those resulting from USACE altering water releases at its reservoirs and the resulting river flows influenced by those releases, there is no potential to impact Florida beaches, construction on beaches or Gulf of Mexico resources.

4.2 Chapter 163, Intergovernmental Programs: Growth Policy; County and Municipal Planning; Land Development Regulation, Part II

This part of the statute addresses the preparation of local governmental plans to encourage community rehabilitation and eliminate the spread of urban blight.

No change in land use would be expected. Effects of the PAA would be the same as under the existing condition, as Jim Woodruff Lock and Dam and Lake Seminole is a run-of-river project normally operating at 77 ft (with minor variations) with no conservation storage. No change would be expected to land use along the project shoreline or downstream along the river shoreline.

Downstream of Jim Woodruff Lock and Dam along the banks of the Apalachicola River, current land use would not be affected. Flow conditions in the Apalachicola River would not change appreciably for the alternatives compared to current conditions (Figures 1-2). Thus, no change in land-use patterns would be expected.

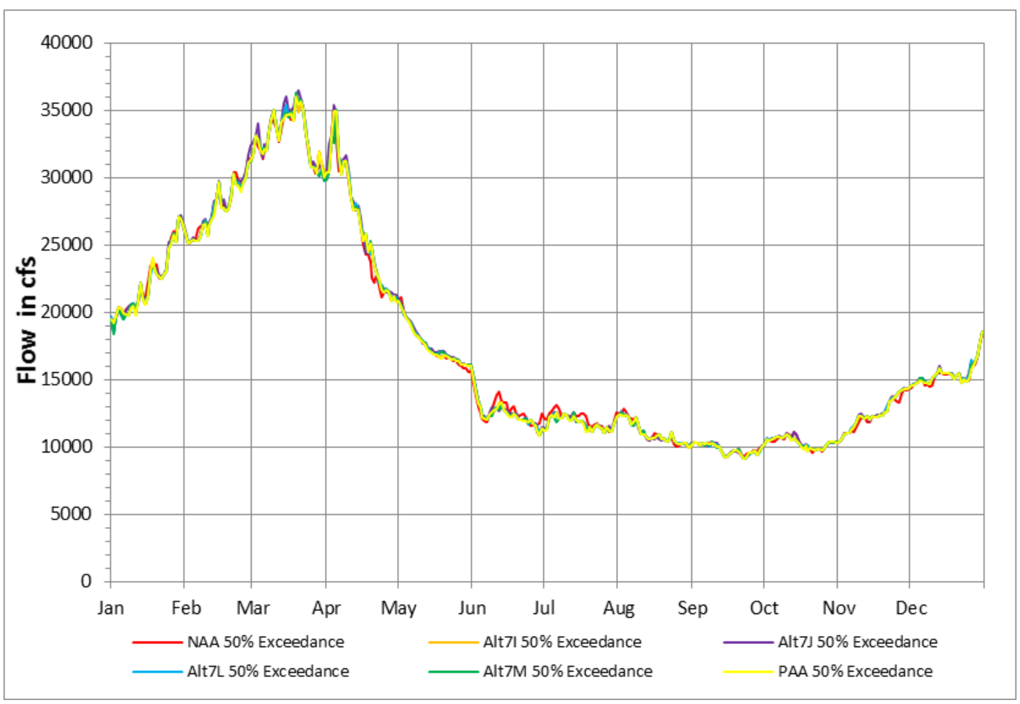


Figure 1. Apalachicola River Median Daily Flows at Chattahoochee, FL, for the NAA and Alt7I, Alt7J, Alt7L, Alt7M, and the PAA.

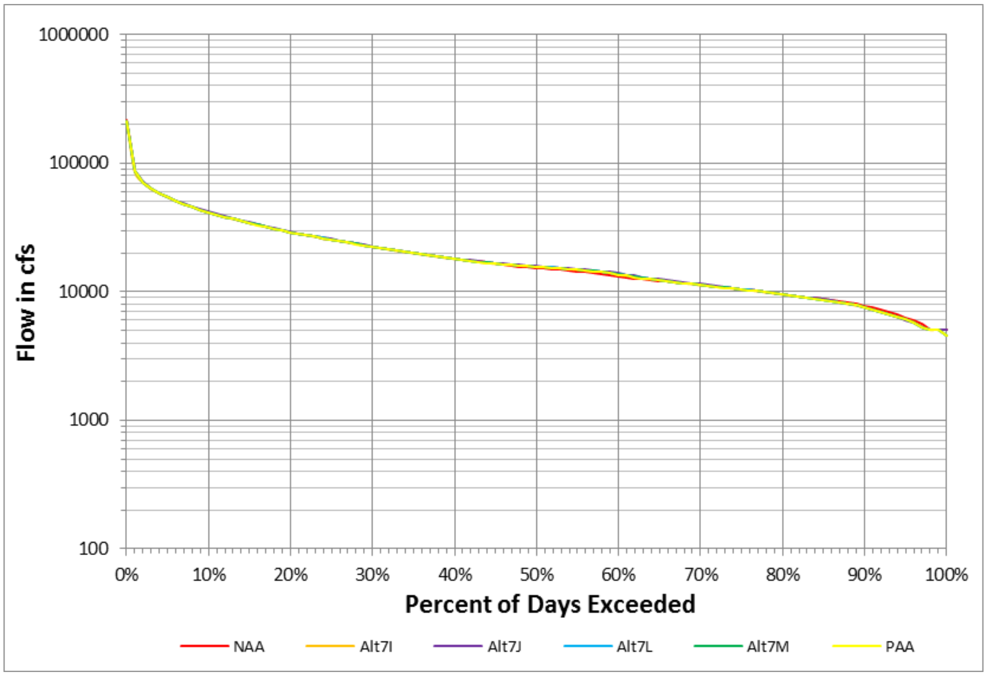


Figure 2. Apalachicola River Flows below Jim Woodruff Lock and Dam at Chattahoochee, FL, Percent of Days Exceeded for the NAA and Alt7I, Alt7J, Alt7L, Alt7M, and the PAA.

4.3 Chapter 186, State and Regional Planning

This part of the statute addresses development of statewide plans for water use, land development and transportation.

USACE projects in the ACF Basin were constructed and are operated to meet federally authorized project purposes. Water control objectives and operational guidelines to meet the authorized project purposes at USACE reservoirs in the ACF Basin are recorded in Water Control Manuals (WCM). An individual project-specific WCM has been prepared for each of the reservoir projects at some point after it was constructed and placed into operation which includes specific water control plans for the project. The original Master WCM for the basin as a whole was completed in 1958. The WCMs were developed in thorough consideration of all project purposes and cover a full array of all foreseeable hydrologic conditions, from flood to drought.

Proposed revisions to water management operations at Buford Dam—including various water supply options for Lake Lanier and downstream of Buford Dam (all of which would occur in the uppermost 10 percent of the Chattahoochee River Basin)—would generally have an inconsequential effect on flow conditions into Lake Seminole and downstream of Jim Woodruff Lock and Dam. The absence of appreciable differences in simulated flow conditions downstream of George W. Andrews Lock and Dam among the alternatives with different water supply options supports this conclusion (Figures 1-2). Based on HEC-ResSim outputs over the modeled period of record, flow in the Apalachicola River and into the bay would be more influenced by hydrologic conditions in the 90 percent of the ACF Basin downstream of Metro Atlanta, except during severe drought conditions when flows would be supported by conservation storage in Lake Lanier and the other USACE reservoirs.

4.4 Chapter 252, Emergency Management, Part I

This part of the statute addresses the State of Florida's emergency preparedness, response, recovery and mitigation.

Effects are limited to those resulting from water releases at Jim Woodruff Lock and Dam and water levels within Lake Seminole. Effects of the PAA would be the same as under the existing condition, as Jim Woodruff Lock and Dam and Lake Seminole is a run-of-river project normally operating at 77 ft (with minor variations) with no conservation storage. No change would be expected along the project shoreline or downstream along the river shoreline that would alter the ability of the state to respond to emergencies. Flow conditions in the Apalachicola River would not change appreciably for the alternatives compared to current conditions (Figures 1-2).

4.5 Chapter 252, Emergency Management, Part II

This part of the statute implements the Federal Emergency Planning and Community Right-to-Know Act of 1986 regarding hazardous and toxic material spills.

Operating and maintaining USACE projects typically requires the use of hazardous and toxic materials. The use of materials such as pesticides, paints, solvents, and petroleum products would be expected during the operation and maintenance of USACE-managed facilities, shoreline, vehicles, and equipment. The use of petroleum products would also be expected from the operation of marinas and from recreational vehicle use. The handling, use, storage, and disposal of these materials must be in accordance with label recommendations; USACE regulations; and local, state, and federal regulatory guidelines. The Proposed Action to manage reservoir operations would not be expected to have an effect on hazardous and toxic materials.

4.6 Chapter 253 State Lands

This part of the statute addresses the state's administration of public lands and state property.

Effects of the PAA are limited to those resulting from water releases at Jim Woodruff Lock and Dam and water levels within Lake Seminole. Effects of the PAA would be the same as under the existing condition, as Jim Woodruff Lock and Dam and Lake Seminole is a run-of-river project normally operating at 77 ft (with minor variations) with no conservation storage. No change would be expected along the project shoreline or downstream along the river shoreline that would alter the ability of the state to respond to emergencies. Flow conditions in the Apalachicola River would not change appreciably for the alternatives compared to current conditions (Figures 1-2). When flow in the river drops below 5,000 cfs during Drought Zone operations under the PAA, vegetation and wildlife along the Apalachicola River would be expected to experience short-term slightly adverse conditions. Drought Zone operations would occur infrequently and would generally be of relatively short duration (i.e., a few weeks or less). The vegetation and wildlife along the Apalachicola River would be able to endure the conditions with no measureable changes to vegetative community composition or wildlife populations.

Thus, implementing the PAA would be expected to have the same effects on terrestrial vegetative communities and wildlife along the Apalachicola River as the NAA.

Floodplain habitat connectivity on the Apalachicola River also is similar across alternatives. The maximum 30-day growing season floodplain habitat connectivity for each alternative was calculated as the maximum amount of floodplain spawning habitat available for at least 30 consecutive days during the months of April–October. This criterion was based on the life history requirements of many riverine fishes, including species specific to the Apalachicola River. This criterion also is an appropriate standard for assessing habitat for the wide range of other aquatic organisms that inhabit the Apalachicola River and its floodplain. USFWS developed the Floodplain Spawning Habitat Performance Measure (FSHPM) to assist in this evaluation (Figure 3).

Estuaries exist at the junction of fresh and salt waters and are integrally linked to freshwater inputs. Principal consequences for the management of freshwater flow to estuaries are related to both the magnitude and timing of flows (Mann and Lazier 1991). Freshwater flows are integral not only to maintaining the delivery of material and energy critical to estuarine productivity but also to providing habitat conditions conducive to maintaining the diversity and abundance of the estuarine community. Three regions in the Apalachicola Bay estuary are of interest with respect to salinity requirements for juvenile Gulf sturgeon, oyster habitat, white shrimp, and several species for which a fishery management plan exists that is consistent with their essential fish habitat (EFH) designation. Changes in salinity and other water quality parameters in Apalachicola Bay and Estuary are negligible, given little to no change in streamflows from the NAA in the Apalachicola River at Chattahoochee, Florida (Figures 1-2, 4). In addition to this analysis, preliminary results of salinity modeling provided by USFWS to the USACE and conducted by Dr. Peter Sheng indicated similar salinity levels in Apalachicola Bay between the NAA and the PAA from the draft EIS (Alt7H) (Paramygin and Sheng 2015). It should be noted that the proposed action evaluated by Dr. Sheng is slightly different than the PAA (Alt7K) presented in this final EIS. However, the difference in the 2015 proposed action and the PAA is limited to water supply assumptions in Metro Atlanta. The PAA provides for less water supply in Metro Atlanta than the 2015 proposed action. It is expected that salinity modeling results for the PAA would be similar to those for the 2015 proposed action.

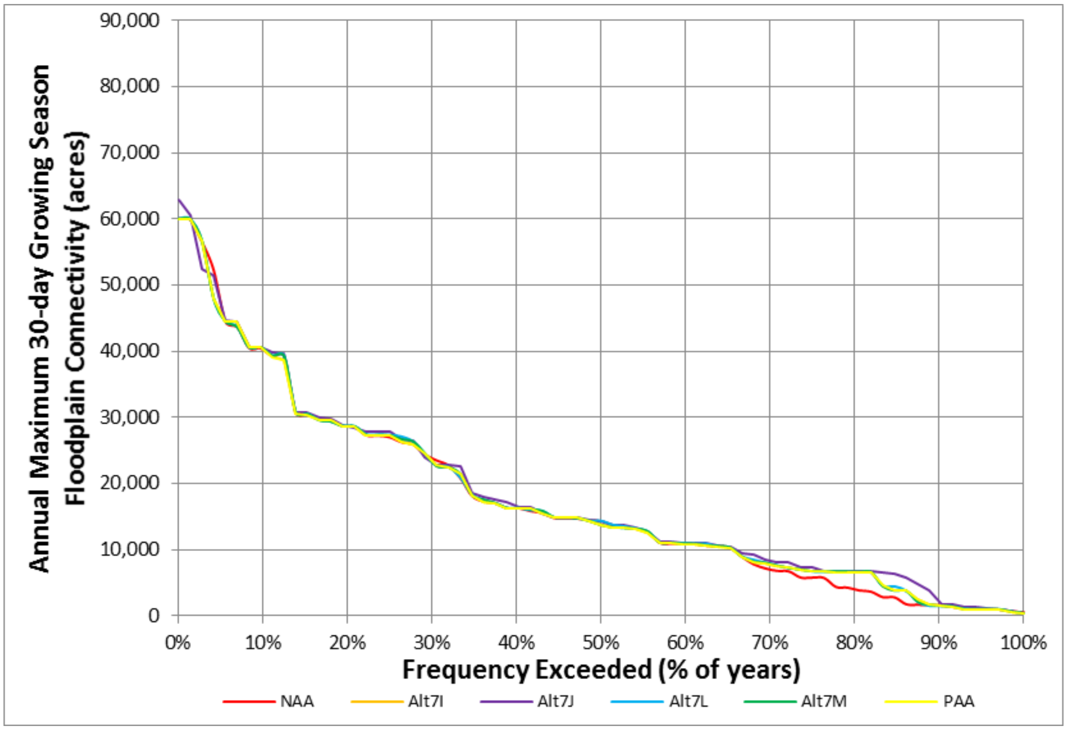


Figure 3. Frequency of Maximum Amount of Floodplain Spawning Habitat Available for at Least 30 Consecutive Days during Apr–Oct over the Modeled Period of Record (1939–2011) for the NAA and Alt7I, Alt7J, Alt7L, Alt7M, and the PAA.

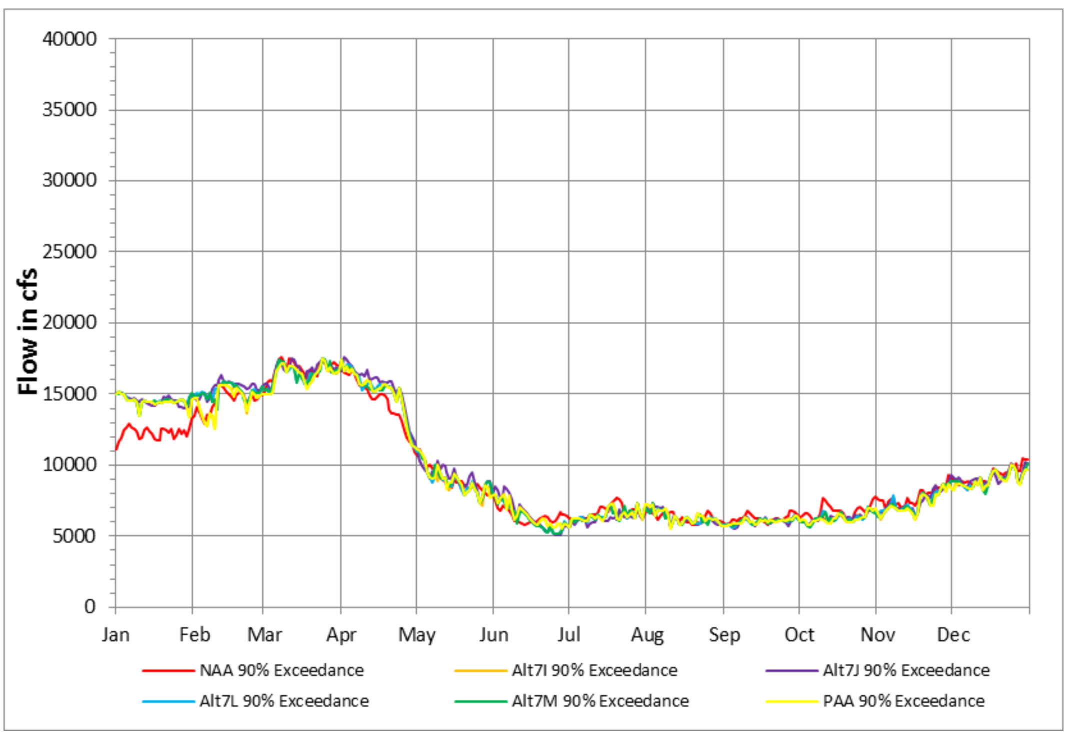


Figure 4. Apalachicola River Daily Flows at the 90-Percent Exceedance Level at Chattahoochee, FL for the NAA and Alt7I, Alt7J, Alt7L, Alt7M, and the PAA.

4.7 Chapter 258 State Parks and Preserves, Parts I-II

This part of the statute addresses state administration of state parks and aquatic preserves and sanctuaries.

Effects are limited to those resulting from water releases at Jim Woodruff Lock and Dam and water levels within Lake Seminole. Effects of the PAA would be the same as under the existing condition, as Jim Woodruff Lock and Dam and Lake Seminole is a run-of-river project normally operating at 77 ft (with minor variations) with no conservation storage. No change would be expected along the project shoreline or downstream along the river shoreline that would alter the ability of the state to respond to emergencies. Flow conditions in the Apalachicola River would not change appreciably for the alternatives compared to current conditions (Figures 1-2). When flow in the river drops below 5,000 cfs during Drought Zone operations under the PAA, vegetation and wildlife along the Apalachicola River would be expected to experience short-term slightly adverse conditions. Drought Zone operations would occur infrequently and would generally be of relatively short duration (i.e., a few weeks or less). The vegetation and wildlife along the Apalachicola River would be able to endure the conditions with no measureable changes to vegetative community composition or wildlife populations. Thus, implementing the PAA would be expected to have the same effects on terrestrial vegetative communities and wildlife along the Apalachicola River as the NAA.

Floodplain habitat connectivity on the Apalachicola River also is similar across alternatives. The maximum 30-day growing season floodplain habitat connectivity for each alternative was calculated as the maximum amount of floodplain spawning habitat available for at least 30 consecutive days during the months of April–October. This criterion was based on the life history requirements of many riverine fishes, including species specific to the Apalachicola River. This criterion also is an appropriate standard for assessing habitat for the wide range of other aquatic organisms that inhabit the Apalachicola River and its floodplain. USFWS developed the Floodplain Spawning Habitat Performance Measure (FSHPM) to assist in this evaluation (Figure 3).

Estuaries exist at the junction of fresh and salt waters and are integrally linked to freshwater inputs. Principal consequences for the management of freshwater flow to estuaries are related to both the magnitude and timing of flows (Mann and Lazier 1991). Freshwater flows are integral not only to maintaining the delivery of material and energy critical to estuarine productivity but also to providing habitat conditions conducive to maintaining the diversity and abundance of the estuarine community. Three regions in the Apalachicola Bay estuary are of interest with respect to salinity requirements for juvenile Gulf sturgeon, oyster habitat, white shrimp, and several species for which a fishery management plan exists that is consistent with their essential fish habitat (EFH) designation. Changes in salinity and other water quality parameters in Apalachicola Bay and Estuary are negligible, given little to no change in streamflows from the NAA in the Apalachicola River at Chattahoochee, Florida (Figures 1-2, 4). In addition to this analysis, preliminary results of salinity modeling provided by USFWS to the USACE and conducted by Dr. Peter Sheng indicated similar salinity levels in Apalachicola Bay between the NAA and the PAA from the draft EIS (Alt7H) (Paramygin and Sheng 2015). It should be noted that the proposed action evaluated by Dr. Sheng is slightly different than the PAA (Alt7K) presented in this final EIS. However, the difference in the 2015 proposed action and the PAA is limited to water supply assumptions in Metro Atlanta. The PAA provides for less water supply in Metro Atlanta than the 2015 proposed action. It is expected that salinity modeling results for the PAA would be similar to those for the 2015 proposed action.

4.8 Chapter 258 State Parks and Preserves, Part III

This part of the statute addresses management of the Myakka River Wild and Scenic River.

There are no formally designated National Wild and Scenic Rivers within the ACF Basin. The Wild and Scenic Myakka River designated in the Florida Statute is not part of the ACF Basin.

4.9 Chapter 259, Land Acquisition for Conservation and Recreation

This part of the statute authorizes the acquisition of environmentally endangered lands and outdoor recreation lands.

As stated in consideration of impacts to land use in Section 4.2, there would be no change expected or impacts that would affect plans for land acquisition. Effects of the PAA would be the same as under the existing condition, as Jim Woodruff Lock and Dam and Lake Seminole is a run-of-river project normally operating at 77 ft (with minor variations) with no conservation storage. No change would be expected to land use or acquisition plans along the project shoreline or downstream along the river shoreline.

Downstream of Jim Woodruff Lock and Dam along the banks of the Apalachicola River, current land use would not be affected. Flow conditions in the Apalachicola River would not change appreciably for the alternatives compared to current conditions (Figures 1-2). Thus, no change in land-use patterns would be expected.

4.10 Chapter 260, Florida Greenways and Trails Act

This part of the statute authorizes the acquisition and management of land for recreation trails.

As stated in consideration of impacts to land use in Section 4.2, there would be no change expected or impacts that would affect plans for land acquisition. Effects of the PAA would be the same as under the existing condition, as Jim Woodruff Lock and Dam and Lake Seminole is a run-of-river project normally operating at 77 ft (with minor variations) with no conservation storage. No change would be expected to land use or acquisition plans along the project shoreline or downstream along the river shoreline.

Downstream of Jim Woodruff Lock and Dam along the banks of the Apalachicola River, current land use would not be affected. Flow conditions in the Apalachicola River would not change appreciably for the alternatives compared to current conditions (Figures 1-2). Thus, no change in land-use patterns would be expected.

4.11 Chapter 267, Historical Resources

This part of the statute addresses the preservation of archeological and historical resources.

Under the PAA, the rate of erosion at cultural resources sites in the ACF basin would be expected to remain generally the same, based on the baseline No Action Study (Fedoroff 2014). It is unlikely that the PAA would reduce the percentage of ACF sites (93 percent of the sites known and unknown) undergoing erosion from the NAA as the baseline inundation rates for the No Action Study largely remained constant despite changes in current USACE water management activities (Fedoroff 2014). Additionally under the PAA, an estimated 33 percent of sites undergoing the effects of deposition also would remain relatively the same. Although the PAA does not approach the issue of flow rate as it specifically affects cultural resource sites, it can be assumed to some degree that the sites within the ACF Basin that would experience high flow action scenarios would experience negative impacts on cultural resources. Areas such as riverbeds located below dam spill gates and in shoals, outside river bends, and steep riverbank slopes with erodible soils would be impacted; however, the actual rate and extent of effects would need to be quantified based on observable data linked to the specific cultural site information. The only such area in Florida is located below Jim Woodruff Dam which is a low gradient river with a stable river bed. Areas subject to negative flow impacts are typically found in high-flow scenarios, thus the effects also could be constant relative to the NAA.

Finally, there are not enough significant differences between the PAA and the NAA in scale to evaluate specific differences in effects to cultural resources in the existing data. However, the 2014 baseline study has illustrated that, with proper monitoring and management using the existing GIS tools available to USACE, mitigations can be recommended as effects are observed over time (Fedoroff 2014). Although the percentage of sites that undergo the effects of erosion and deposition is expected to remain relatively consistent across all the alternatives, some of the effects might be positive for the preservation of cultural resources site, while others will be negative. As with both the NAA and the PAA, either protection or excavation mitigation measures would be pursued when the site is at risk for observable adverse impact.

4.12 Chapter 288, Commercial Development and Capital Improvements, Part I

This part of the statute provides a framework for promoting and developing business, trade and tourism as components of the state's economy.

Navigation is an authorized purpose of the ACF Basin system. Channel availability was modeled for both 7-ft and 9-ft channels, which was measured by evaluating the modeled flow at the Blountstown, Florida, gage. A 7-ft channel would be considered "available" with a flow greater than 16,200 cfs. A 9-ft channel would be considered "available" with a flow greater than 20,600 cfs.

Increasing the reliability of navigation in the ACF system by including operational measures to provide sufficient flows to support a defined, albeit limited, navigation season was intended to provide the opportunity for commercial navigation to occur, not to ensure that some sustainable level of commercial navigation would necessarily return to the system. While the conditions conducive to the use of the navigation channel would likely improve under several alternatives, individual shippers would be responsible for making the decision to use the increased channel availability. Use of the waterway under these alternatives would likely be shipment-specific and opportunistic, and not subject to traditional navigation benefit estimation techniques.

Under the PAA, a 9-ft channel would be available 2.7 percent of the time during the period of record between January and May (the same as under the NAA). A 7-ft channel would be available 42.5 percent of the time during that period, which represents a 22-percent difference over the NAA. The PAA could have a beneficial effect on commercial navigation in the system.

Three regions in the Apalachicola Bay estuary are of interest with respect to salinity requirements for juvenile Gulf sturgeon, oyster habitat, white shrimp, and several species for which a fishery management plan exists that is consistent with their essential fish habitat (EFH) designation. Changes in salinity and other water quality parameters in Apalachicola Bay and Estuary are negligible, given little to no change in streamflows from the NAA in the Apalachicola River at Chattahoochee, Florida (Figures 1-2, 4). In addition to this analysis, preliminary results of salinity modeling provided by USFWS to the USACE and conducted by Dr. Peter Sheng indicated similar salinity levels in Apalachicola Bay between the NAA and the PAA from the draft EIS (Alt7H) (Paramygin and Sheng 2015). It should be noted that the proposed action evaluated by Dr. Sheng is slightly different than the PAA (Alt7K) presented in this final EIS. However, the difference in the 2015 proposed action and the PAA is limited to water supply assumptions in Metro Atlanta. The PAA provides for less water supply in Metro Atlanta than the 2015 proposed action. It is expected that salinity modeling results for the PAA would be similar to those for the 2015 proposed action.

4.13 Chapter 288, Commercial Development and Capital Improvements, Part VI

This part of the statute relates to long-term sources of funding for economic recovery in areas affected by the Deepwater Horizon oil spill. There would be no impacts of the PAA that would affect funding of economic recovery efforts.

Effects of the PAA are limited to those resulting from water releases at Jim Woodruff Lock and Dam and water levels within Lake Seminole. Effects of the PAA would be the same as under the existing condition, as Jim Woodruff Lock and Dam and Lake Seminole is a run-of-river project normally operating at 77 ft (with minor variations) with no conservation storage. No change would be expected along the project shoreline or downstream along the river shoreline that would alter the ability of the state to fund economic recovery efforts. Flow conditions in the Apalachicola River would not change appreciably for the alternatives compared to current conditions (Figures 1-2). When flow in the river drops below 5,000 cfs during Drought Zone operations under the PAA, vegetation and wildlife along the Apalachicola River would be expected to experience short-term slightly adverse conditions. Drought Zone operations would occur infrequently and would generally be of relatively short duration (i.e., a few weeks or less). The vegetation and wildlife along the Apalachicola River would be able to endure the conditions with no measureable changes to vegetative community composition or wildlife populations. Thus, implementing the PAA would be expected to have the same effects on terrestrial vegetative communities and wildlife along the Apalachicola River as the NAA.

Floodplain habitat connectivity on the Apalachicola River also is similar across alternatives. The maximum 30-day growing season floodplain habitat connectivity for each alternative was calculated as the maximum amount of floodplain spawning habitat available for at least 30 consecutive days during the months of April–October. This criterion was based on the life history requirements of many riverine fishes, including species specific to the Apalachicola River. This criterion also is an appropriate standard for assessing habitat for the wide range of other aquatic organisms that inhabit the Apalachicola River and its floodplain. USFWS developed the Floodplain Spawning Habitat Performance Measure (FSHPM) to assist in this evaluation (Figure 3).

Estuaries exist at the junction of fresh and salt waters and are integrally linked to freshwater inputs. Principal consequences for the management of freshwater flow to estuaries are related to both the magnitude and timing of flows (Mann and Lazier 1991). Freshwater flows are integral not only to maintaining the delivery of material and energy critical to estuarine productivity but also to providing habitat conditions conducive to maintaining the diversity and abundance of the estuarine community. Three regions in the Apalachicola Bay estuary are of interest with respect to salinity requirements for juvenile Gulf sturgeon, oyster habitat, white shrimp, and several species for which a fishery management plan exists that is consistent with their essential fish habitat (EFH) designation. Changes in salinity and other water quality parameters in Apalachicola Bay and Estuary are negligible, given little to no change in streamflows from the NAA in the Apalachicola River at Chattahoochee, Florida (Figures 1-2, 4). In addition to this analysis, preliminary results of salinity modeling provided by USFWS to the USACE and conducted by Dr. Peter Sheng indicated similar salinity levels in Apalachicola Bay between the NAA and the PAA from the draft EIS (Alt7H) (Paramygin and Sheng 2015). It should be noted that the proposed action evaluated by Dr. Sheng is slightly different than the PAA (Alt7K) presented in this final EIS. However, the difference in the 2015 proposed action and the PAA is limited to water supply assumptions in Metro Atlanta. The PAA provides for less water supply in Metro Atlanta than the 2015 proposed action. It is expected that salinity modeling results for the PAA would be similar to those for the 2015 proposed action.

4.14 Chapter 334, Transportation Administration and Chapter 339, Transportation Finance and Planning

Chapter 334 statute addresses the state's policy concerning transportation administration. Chapter 339 addresses financial and planning needs of the state's transportation systems.

Navigation is an authorized purpose of the ACF Basin system. Channel availability was modeled for both 7-ft and 9-ft channels, which was measured by evaluating the modeled flow at the Blountstown, Florida, gage. A 7-ft channel would be considered "available" with a flow greater than 16,200 cfs. A 9-ft channel would be considered "available" with a flow greater than 20,600 cfs.

Increasing the reliability of navigation in the ACF system by including operational measures to provide sufficient flows to support a defined, albeit limited, navigation season was intended to provide the opportunity for commercial navigation to occur, not to ensure that some sustainable level of commercial navigation would necessarily return to the system. While the conditions conducive to the use of the navigation channel would likely improve under several alternatives, individual shippers would be responsible for making the decision to use the increased channel availability. Use of the waterway under these alternatives would likely be shipment-specific and opportunistic, and not subject to traditional navigation benefit estimation techniques.

Under the PAA, a 9-ft channel would be available 2.7 percent of the time during the period of record between January and May (the same as under the NAA). A 7-ft channel would be available 42.5 percent of the time during that period, which represents a 22-percent difference over the NAA. The PAA could have a beneficial effect on commercial navigation in the system.

The connection (i.e., relationship) between water management activities on the ACF Basin in general, and nonnavigation and nonrecreation transportation resources is limited. The Proposed Action to manage pool levels and flow requirements would not affect the transportation resources immediately adjacent to the dams and lakes, such as limited development for shoreline and lake access, recreation (marinas, parks, and picnic areas), protected areas, and prohibited access areas.

The PAA not expected to result in any appreciable changes in nonnavigation and nonrecreation traffic. No additional traffic would be directly introduced from the proposed updates. Small changes in traffic in and around the projects might take place due to incremental changes in shipping modes. However, nonnavigation and nonrecreation traffic is not expected to change appreciably due to the proposed updates. As a result, it is assumed than any changes in nonnavigation and nonrecreation traffic would have occurred under the NAA.

4.15 Chapter 373, Water Resources, Part I

The statute addresses the state's policy concerning water resources.

Effects of the PAA are limited to those resulting from water releases at Jim Woodruff Lock and Dam and water levels within Lake Seminole. Effects of the PAA would be the same as under the existing condition, as Jim Woodruff Lock and Dam and Lake Seminole is a run-of-river project normally operating at 77 ft (with minor variations) with no conservation storage. No change would be expected along the project shoreline or downstream along the river shoreline that would alter the ability of the state to fund economic recovery efforts. Flow conditions in the Apalachicola River would not change appreciably for the alternatives compared to current conditions (Figures 1-2). When flow in the river drops below 5,000 cfs during Drought Zone operations under the PAA, vegetation and wildlife along the Apalachicola River would be expected to experience short-term slightly adverse conditions. Drought Zone operations would occur infrequently and would generally be of relatively short duration (i.e., a few weeks or less). The vegetation and wildlife along the Apalachicola River would be able to endure the conditions with no measureable changes to vegetative community composition or wildlife populations. Thus, implementing the PAA would be expected to have the same effects on terrestrial vegetative communities and wildlife along the Apalachicola River as the NAA.

Floodplain habitat connectivity on the Apalachicola River also is similar across alternatives. The maximum 30-day growing season floodplain habitat connectivity for each alternative was calculated as the maximum amount of floodplain spawning habitat available for at least 30 consecutive days during the months of April–October. This criterion was based on the life history requirements of many riverine fishes, including species specific to the Apalachicola River. This criterion also is an appropriate standard for assessing habitat for the wide range of other aquatic organisms that inhabit the Apalachicola River and its floodplain. USFWS developed the Floodplain Spawning Habitat Performance Measure (FSHPM) to assist in this evaluation (Figure 3).

Estuaries exist at the junction of fresh and salt waters and are integrally linked to freshwater inputs. Principal consequences for the management of freshwater flow to estuaries are related to both the magnitude and timing of flows (Mann and Lazier 1991). Freshwater flows are integral not only to maintaining the delivery of material and energy critical to estuarine productivity but also to providing habitat conditions conducive to maintaining the diversity and abundance of the estuarine community. Three regions in the Apalachicola Bay estuary are of interest with respect to salinity requirements for juvenile Gulf sturgeon, oyster habitat, white shrimp, and several species for which a fishery management plan exists that is consistent with their essential fish habitat (EFH) designation. Changes in salinity and other water quality parameters in Apalachicola Bay and Estuary are negligible, given little to no change in streamflows from the NAA in the Apalachicola River at Chattahoochee, Florida (Figures 1-2, 4). In addition to this analysis, preliminary results of salinity modeling provided by USFWS to the USACE and conducted by Dr. Peter Sheng indicated similar salinity levels in Apalachicola Bay between the NAA and the PAA from the draft EIS (Alt7H) (Paramygin and Sheng 2015). It should be noted that the proposed action evaluated by Dr. Sheng is slightly different than the PAA (Alt7K) presented in this final EIS. However, the difference in the 2015 proposed action and the PAA is limited to water supply assumptions in Metro Atlanta. The PAA provides for less water supply in Metro Atlanta than the 2015 proposed action. It is expected that salinity modeling results for the PAA would be similar to those for the 2015 proposed action.

4.16 Chapter 373, Water Resources, Part II

This part of the statute addresses the state's Water Management Districts within the State of Florida to manage requests for consumptive uses of water.

The *Florida Water Plan* is the Florida Department of Environmental Protection's (DEP) principal planning tool for long-term protection of the state's water resources Florida has a system of five regional water management districts under the general supervision of the Florida DEP. Together, Florida DEP and the water management districts share a broad range of responsibilities related to water supply, flood protection and floodplain management, water quality, and protection of natural systems.

The PAA would have no effect on the Florida DEP's authority to manage consumptive uses of water.

4.17 Chapter 373, Water Resources, Part IV

This part of the statute addresses the management of surface waters.

Effects of the PAA are limited to those resulting from water releases at Jim Woodruff Lock and Dam and water levels within Lake Seminole. Effects of the PAA would be the same as under the existing condition, as Jim Woodruff Lock and Dam and Lake Seminole is a run-of-river project normally operating at 77 ft (with minor variations) with no conservation storage. No change would be expected along the project shoreline or downstream along the river shoreline that would alter the ability of the state to fund economic recovery efforts. Flow conditions in the Apalachicola River would not change appreciably for the alternatives compared to current conditions (Figures 1-2). When flow in the river drops below 5,000 cfs during Drought Zone operations under the PAA, vegetation and wildlife along the Apalachicola River would be expected to experience short-term slightly adverse conditions. Drought Zone operations would occur infrequently and would generally be of relatively short duration (i.e., a few weeks or less). The vegetation and wildlife along the Apalachicola River would be able to endure the conditions with no measureable changes to vegetative community composition or wildlife populations. Thus, implementing the PAA would be expected to have the same effects on terrestrial vegetative communities and wildlife along the Apalachicola River as the NAA.

Floodplain habitat connectivity on the Apalachicola River also is similar across alternatives. The maximum 30-day growing season floodplain habitat connectivity for each alternative was calculated as the maximum amount of floodplain spawning habitat available for at least 30 consecutive days during the months of April–October. This criterion was based on the life history requirements of many riverine fishes, including species specific to the Apalachicola River. This criterion also is an appropriate standard for assessing habitat for the wide range of other aquatic organisms that inhabit the Apalachicola River and its floodplain. USFWS developed the Floodplain Spawning Habitat Performance Measure (FSHPM) to assist in this evaluation (Figure 3).

Estuaries exist at the junction of fresh and salt waters and are integrally linked to freshwater inputs. Principal consequences for the management of freshwater flow to estuaries are related to both the magnitude and timing of flows (Mann and Lazier 1991). Freshwater flows are integral not only to maintaining the delivery of material and energy critical to estuarine productivity but also to providing habitat conditions conducive to maintaining the diversity and abundance of the estuarine community. Three regions in the Apalachicola Bay estuary are of interest with respect to salinity requirements for juvenile Gulf sturgeon, oyster habitat, white shrimp, and several species for which a fishery management plan exists that is consistent with their essential fish habitat (EFH) designation. Changes in salinity and other water quality parameters in Apalachicola Bay and Estuary are negligible, given little to no change in streamflows from the NAA in the Apalachicola River at Chattahoochee, Florida (Figures 1-2, 4). In addition to this analysis, preliminary results of salinity modeling provided by USFWS to the USACE and conducted by Dr. Peter Sheng indicated similar salinity levels in Apalachicola Bay between the NAA and the PAA from the draft EIS (Alt7H) (Paramygin and Sheng 2015). It should be noted that the proposed action evaluated by Dr. Sheng is slightly different than the PAA (Alt7K) presented in this final EIS. However, the difference in the 2015 proposed action and the PAA is limited to water supply assumptions in Metro Atlanta. The PAA provides for less water supply in Metro Atlanta than the 2015 proposed action. It is expected that salinity modeling results for the PAA would be similar to those for the 2015 proposed action.

4.18 Chapter 373, Water Resources, Part VII

USACE projects in the ACF Basin were constructed and are operated to meet federally authorized project purposes. Water control objectives and operational guidelines to meet the authorized project purposes at USACE reservoirs in the ACF Basin are recorded in Water

Control Manuals (WCM). An individual project-specific WCM has been prepared for each of the reservoir projects at some point after it was constructed and placed into operation which includes specific water control plans for the project. The original Master WCM for the basin as a whole was completed in 1958. The WCMs were developed in thorough consideration of all project purposes and cover a full array of all foreseeable hydrologic conditions, from flood to drought.

Proposed revisions to water management operations at Buford Dam—including various water supply options for Lake Lanier and downstream of Buford Dam (all of which would occur in the uppermost 10 percent of the Chattahoochee River Basin)—would generally have an inconsequential effect on flow conditions into Lake Seminole and downstream of Jim Woodruff Lock and Dam. The absence of appreciable differences in simulated flow conditions downstream of George W. Andrews Lock and Dam among the alternatives with different water supply options supports this conclusion (Figures 1-2). Based on HEC-ResSim outputs over the modeled period of record, flow in the Apalachicola River and into the bay would be more influenced by hydrologic conditions in the 90 percent of the ACF Basin downstream of Metro Atlanta, except during severe drought conditions when flows would be supported by conservation storage in Lake Lanier and the other USACE reservoirs.

Effects of the PAA are limited to those resulting from water releases at Jim Woodruff Lock and Dam and water levels within Lake Seminole. Effects of the PAA would be the same as under the existing condition, as Jim Woodruff Lock and Dam and Lake Seminole is a run-of-river project normally operating at 77 ft (with minor variations) with no conservation storage. No change would be expected along the project shoreline or downstream along the river shoreline that would alter the ability of the state to fund economic recovery efforts. Flow conditions in the Apalachicola River would not change appreciably for the alternatives compared to current conditions (Figures 1-2). When flow in the river drops below 5,000 cfs during Drought Zone operations under the PAA, vegetation and wildlife along the Apalachicola River would be expected to experience short-term slightly adverse conditions. Drought Zone operations would occur infrequently and would generally be of relatively short duration (i.e., a few weeks or less). The vegetation and wildlife along the Apalachicola River would be able to endure the conditions with no measureable changes to vegetative community composition or wildlife populations. Thus, implementing the PAA would be expected to have the same effects on terrestrial vegetative communities and wildlife along the Apalachicola River as the NAA.

Floodplain habitat connectivity on the Apalachicola River also is similar across alternatives. The maximum 30-day growing season floodplain habitat connectivity for each alternative was calculated as the maximum amount of floodplain spawning habitat available for at least 30 consecutive days during the months of April–October. This criterion was based on the life history requirements of many riverine fishes, including species specific to the Apalachicola River. This criterion also is an appropriate standard for assessing habitat for the wide range of other aquatic organisms that inhabit the Apalachicola River and its floodplain. USFWS developed the Floodplain Spawning Habitat Performance Measure (FSHPM) to assist in this evaluation (Figure 3).

Estuaries exist at the junction of fresh and salt waters and are integrally linked to freshwater inputs. Principal consequences for the management of freshwater flow to estuaries are related to both the magnitude and timing of flows (Mann and Lazier 1991). Freshwater flows are integral not only to maintaining the delivery of material and energy critical to estuarine productivity but also to providing habitat conditions conducive to maintaining the diversity and abundance of the estuarine community. Three regions in the Apalachicola Bay estuary are of interest with respect to salinity requirements for juvenile Gulf sturgeon, oyster habitat, white shrimp, and several species for which a fishery management plan exists that is consistent with their essential fish habitat (EFH) designation. Changes in salinity and other water quality parameters in Apalachicola Bay and Estuary are negligible, given little to no change in streamflows from the NAA in the Apalachicola River at Chattahoochee, Florida (Figures 1-2, 4). In addition to this analysis, preliminary results of salinity modeling provided by USFWS to the USACE and conducted by Dr. Peter Sheng indicated similar salinity levels in Apalachicola Bay between the NAA and the PAA from the draft EIS (Alt7H) (Paramygin and Sheng 2015). It should be noted that the proposed action evaluated by Dr. Sheng is slightly different than the PAA (Alt7K) presented in this final EIS. However, the difference in the 2015 proposed action and the PAA is limited to water supply assumptions in Metro Atlanta. The PAA provides for less water supply in Metro Atlanta than the 2015 proposed action. It is expected that salinity modeling results for the PAA would be similar to those for the 2015 proposed action.

4.19 Chapter 375, Outdoor Recreation and Conservation Lands

The statute addresses planning for outdoor recreation and the need for additional recreation opportunities.

No change in land use would be expected. Effects of the PAA would be the same as under the existing condition, as Jim Woodruff Lock and Dam and Lake Seminole is a run-of-river project normally operating at 77 ft (with minor variations) with no conservation storage. No change would be expected to land use along the project shoreline or downstream along the river shoreline.

Downstream of Jim Woodruff Lock and Dam along the banks of the Apalachicola River, current land use would not be affected. Flow conditions in the Apalachicola River would not change appreciably for the alternatives compared to current conditions (Figures 1-2). Thus, no change in land-use patterns or outdoor recreation planning would be expected.

4.20 Chapter 376, Pollutant Discharge Prevention and Removal

The statute regulates transfer, storage, and transportation of pollutants and cleanup of pollutant discharges.

The PAA involves no direct discharge of pollutants to any ACF waterbody. Operating and maintaining USACE reservoir projects typically requires the use of hazardous and toxic materials. The use of materials such as pesticides, paints, solvents, and petroleum products would be expected during the operation and maintenance of USACE-managed facilities, shoreline, vehicles, and equipment. The use of petroleum products would also be expected from the operation of marinas and from recreational vehicle use. The handling, use, storage, and disposal of these materials must be in accordance with label recommendations; USACE regulations; and local, state, and federal regulatory guidelines. The PAA reservoir operations would not be expected to have an effect on hazardous and toxic materials.

4.21 Chapter 377, Energy Resources, Part II

The statute promotes reliable energy infrastructure, energy independence and reduces greenhouse gas emissions.

Under the PAA, for the ACF basin, the total energy and capacity benefit decrease would result in less than a 1-percent decrease compared to the NAA. There would be no impacts to energy infrastructure.

Minor emissions associated with vehicle and equipment use to conduct routine operation and maintenance activities around the reservoir projects would continue for all these alternatives at about the same level as for the NAA. The amount of hydropower likely to be produced under each of these alternatives would vary compared to the NAA, some higher and some lower. The following paragraphs discuss the extent of the change in GHG emissions resulting from increases or decreases in hydropower production among the alternatives compared to the NAA, including the relative significance of those changes in terms of GHG emissions in the region and their potential to affect climate conditions.

A reduction in hydropower generation may result in an equivalent increase in electrical generation from other sources. The use of fossil fuels to produce that electricity could cause an increase in greenhouse gases. It is estimated that the 1-percent decrease in energy generation described above for the PAA would result in an additional 80 million pounds of carbon dioxide compared to the NAA.

The average vehicle (including cars, minivans, pick-ups, vans, and SUVs) running an average of 12,000 miles per year at an average of 25.5 miles per gallon produces 8,320 pounds of carbon dioxide per year (American Forests 2016). The PAA, the alternative that would result in the largest reduction in hydropower (and, in turn, the largest increase in GHG emission of the alternatives considered), would equate to running an additional 9,593 cars on the road. In a 2011 report, the Atlanta Regional Commission estimated that there were approximately 3.6 million vehicles on the road in the Metro Atlanta area (ARC 2011). Adding the equivalent of about 9,593 cars to the road in the Metro Atlanta area would represent an increase of about 0.27 percent. Both of these alternatives, representing the highest and lowest deviation from the NAA, would result in a negligible change in GHG emissions.

4.22 Chapter 379, Fish and Wildlife Conservation, Part I, II

This part of the statute addresses the authority of the state Fish and Wildlife Conservation Commission to manage, regulate, and enforce fish and wildlife conservation measures in Florida in cooperation with adjoining States and the Federal Government and to manage and preserve renewable marine fishery resources.

USACE projects in the ACF Basin were constructed and are operated to meet federally authorized project purposes. Water control objectives and operational guidelines to meet the authorized project purposes at USACE reservoirs in the ACF Basin are recorded in Water Control Manuals (WCM). An individual project-specific WCM has been prepared for each of the reservoir projects at some point after it was constructed and placed into operation which includes specific water control plans for the project. The original Master WCM for the basin as a whole was completed in 1958. The WCMs were developed in thorough consideration of all project purposes and cover a full array of all foreseeable hydrologic conditions, from flood to drought.

Proposed revisions to water management operations at Buford Dam—including various water supply options for Lake Lanier and downstream of Buford Dam (all of which would occur in the uppermost 10 percent of the Chattahoochee River Basin)—would generally have an inconsequential effect on flow conditions into Lake Seminole and downstream of Jim Woodruff Lock and Dam. The absence of appreciable differences in simulated flow conditions downstream of George W. Andrews Lock and Dam among the alternatives with different water supply options supports this conclusion (Figures 1-2). Based on HEC-ResSim outputs over the modeled period of record, flow in the Apalachicola River and into the bay would be more influenced by hydrologic conditions in the 90 percent of the ACF Basin downstream of Metro Atlanta, except during severe drought conditions when flows would be supported by conservation storage in Lake Lanier and the other USACE reservoirs.

Effects of the PAA are limited to those resulting from water releases at Jim Woodruff Lock and Dam and water levels within Lake Seminole. Effects of the PAA would be the same as under the existing condition, as Jim Woodruff Lock and Dam and Lake Seminole is a run-of-river project normally operating at 77 ft (with minor variations) with no conservation storage. No change would be expected along the project shoreline or downstream along the river shoreline that would alter the ability of the state to fund economic recovery efforts. Flow conditions in the Apalachicola River would not change appreciably for the alternatives compared to current conditions (Figures 1-2). When flow in the river drops below 5,000 cfs during Drought Zone operations under the PAA, vegetation and wildlife along the Apalachicola River would be expected to experience short-term slightly adverse conditions. Drought Zone operations would occur infrequently and would generally be of relatively short duration (i.e., a few weeks or less). The vegetation and wildlife along the Apalachicola River would be able to endure the conditions with no measureable changes to vegetative community composition or wildlife populations. Thus, implementing the PAA would be expected to have the same effects on terrestrial vegetative communities and wildlife along the Apalachicola River as the NAA.

Floodplain habitat connectivity on the Apalachicola River also is similar across alternatives. The maximum 30-day growing season floodplain habitat connectivity for each alternative was calculated as the maximum amount of floodplain spawning habitat available for at least 30 consecutive days during the months of April–October. This criterion was based on the life history requirements of many riverine fishes, including species specific to the Apalachicola River. This criterion also is an appropriate standard for assessing habitat for the wide range of other aquatic organisms that inhabit the Apalachicola River and its floodplain. USFWS developed the Floodplain Spawning Habitat Performance Measure (FSHPM) to assist in this evaluation (Figure 3).

Estuaries exist at the junction of fresh and salt waters and are integrally linked to freshwater inputs. Principal consequences for the management of freshwater flow to estuaries are related to both the magnitude and timing of flows (Mann and Lazier 1991). Freshwater flows are integral not only to maintaining the delivery of material and energy critical to estuarine productivity but also to providing habitat conditions conducive to maintaining the diversity and abundance of the estuarine community. Three regions in the Apalachicola Bay estuary are of interest with respect to salinity requirements for juvenile Gulf sturgeon, oyster habitat, white shrimp, and several species for which a fishery management plan exists that is consistent with their essential fish habitat (EFH) designation. Changes in salinity and other water quality parameters in Apalachicola Bay and Estuary are negligible, given little to no change in streamflows from the NAA in the Apalachicola River at Chattahoochee, Florida (Figures 1-2, 4). In addition to this analysis, preliminary results of salinity modeling provided by USFWS to the USACE and conducted by Dr. Peter Sheng indicated similar salinity levels in Apalachicola Bay between the NAA and the PAA from the draft EIS (Alt7H) (Paramygin and Sheng 2015). It should be noted that the proposed action evaluated by Dr. Sheng is slightly different than the PAA (Alt7K) presented in this final EIS. However, the difference in the 2015 proposed action and the PAA is limited to water supply assumptions in Metro Atlanta. The PAA provides for less water supply in Metro Atlanta than the 2015 proposed action. It is expected that salinity modeling results for the PAA would be similar to those for the 2015 proposed action.

USACE has coordinated its activities closely with U.S. Fish and Wildlife Service in accordance with the Fish and Wildlife Coordination Act and Endangered Species Act (ESA). USACE has engaged USFWS since 2006 to seek input on the potential effects of proposed operational modifications to USACE ACF Basin projects on fish and wildlife resources in the basin, including federally listed threatened and endangered species. Endangered species consultation for conservation of protected species in the Apalachicola River below Jim Woodruff Lock and Dam, in accordance with section 7 of the ESA is being conducted prior to implementation of the PAA.

4.23 Chapter 379, Fish and Wildlife Conservation, Part III

This part of the statute prohibits the release of non-native species, pollutants, explosives, or other substances into fresh waters of the state.

The PAA would neither directly nor indirectly result in introduction of any substance into Florida State waters. In addition, HEC-5Q water quality modeling indicates that there would be negligible changes in water quality parameters in the Apalachicola River including water temperature, dissolved oxygen, phosphorus, nitrogen and chlorophyll *a*.

4.24 Chapter 380 Land and Water Management, Parts I, II and III

The statute addresses local policies to manage growth and development, managing funds under the Coastal Zone Management Act, and assisting local governmental agencies in conserving natural resources.

No change in land use would be expected, as described in Section 4.2. Effects of the PAA would be the same as under the existing condition, as Jim Woodruff Lock and Dam and Lake Seminole is a run-of-river project normally operating at 77 ft (with minor variations) with no conservation storage. No change would be expected to land use along the project shoreline or downstream along the river shoreline.

Downstream of Jim Woodruff Lock and Dam along the banks of the Apalachicola River, current land use would not be affected. Flow conditions in the Apalachicola River would not change appreciably for the alternatives compared to current conditions (Figures 1-2). Thus, no change in land-use patterns would be expected. No impacts to Land and Water Management programs would occur as a result of the PAA.

4.25 Chapter 403 Environmental Control, Part I

This part of the statute establishes policy in Florida to conserve state waters, water quality, and air quality.

The PAA would neither directly nor indirectly result in introduction of any substance into Florida State waters. In addition, HEC-5Q water quality modeling indicates that there would be negligible changes in water quality parameters in the Apalachicola River including water temperature, dissolved oxygen, phosphorus, nitrogen and chlorophyll *a*.

Minor emissions associated with vehicle and equipment use to conduct routine operation and maintenance activities around the reservoir projects would continue for all these alternatives at about the same level as for the NAA. The amount of hydropower likely to be produced under each of these alternatives would vary compared to the NAA, some higher and some lower. The following paragraphs discuss the extent of the change in GHG emissions resulting from increases or decreases in hydropower production among the alternatives compared to the NAA, including the relative significance of those changes in terms of GHG emissions in the region and their potential to affect climate conditions.

A reduction in hydropower generation may result in an equivalent increase in electrical generation from other sources. The use of fossil fuels to produce that electricity could cause an increase in greenhouse gases. It is estimated that the 1-percent decrease in energy generation described above for the PAA would result in an additional 80 million pounds of carbon dioxide compared to the NAA.

The average vehicle (including cars, minivans, pick-ups, vans, and SUVs) running an average of 12,000 miles per year at an average of 25.5 miles per gallon produces 8,320 pounds of carbon dioxide per year (American Forests 2016). The PAA, the alternative that would result in the largest reduction in hydropower (and, in turn, the largest increase in GHG emission of the alternatives considered), would equate to running an additional 9,593 cars on the road. In a 2011 report, the Atlanta Regional Commission estimated that there were approximately 3.6 million vehicles on the road in the Metro Atlanta area (ARC 2011). Adding the equivalent of about 9,593 cars to the road in the Metro Atlanta area would represent an increase of about 0.27 percent. Both of these alternatives, representing the highest and lowest deviation from the NAA, would result in a negligible change in GHG emissions.

4.26 Chapter 403 Environmental Control, Part III

This part of the statute establishes participation in national environmental protection programs and to encourage cooperative environmental protection across state boundaries.

Effects of the PAA are limited to those resulting from water releases at Jim Woodruff Lock and Dam and water levels within Lake Seminole. Effects of the PAA would be the same as under the existing condition, as Jim Woodruff Lock and Dam and Lake Seminole is a run-of-river project normally operating at 77 ft (with minor variations) with no conservation storage. No change would be expected along the project shoreline or downstream along the river shoreline that would alter the ability of the state to fund economic recovery efforts. Flow conditions in the Apalachicola River would not change appreciably for the alternatives compared to current conditions (Figures 1-2). When flow in the river drops below 5,000 cfs during Drought Zone operations under the PAA, vegetation and wildlife along the Apalachicola River would be expected to experience short-term slightly adverse conditions. Drought Zone operations would occur infrequently and would generally be of relatively short duration (i.e., a few weeks or less). The vegetation and wildlife along the Apalachicola River would be able to endure the conditions with no measureable changes to vegetative community composition or wildlife populations. Thus, implementing the PAA would be expected to have the same effects on terrestrial vegetative communities and wildlife along the Apalachicola River as the NAA. No impacts to participation in national environmental protection programs or interstate agreements are anticpated.

4.27 Chapter 403 Environmental Control, Part IV

This part of the statute addresses solid waste management, recycling and resource recovery.

The PAA involves no direct discharge of pollutants to any ACF waterbody. Operating and maintaining USACE reservoir projects typically requires the use of hazardous and toxic materials. The use of materials such as pesticides, paints, solvents, and petroleum products would be expected during the operation and maintenance of USACE-managed facilities, shoreline, vehicles, and equipment. The use of petroleum products would also be expected from the operation of marinas and from recreational vehicle use. The handling, use, storage, and disposal of these materials must be in accordance with label recommendations; USACE regulations; and local, state, and federal regulatory guidelines. The PAA reservoir operations would not be expected to have an effect on hazardous and toxic materials. In addition, there would be direct or indirect impacts associated with solid waste, recycling or resource recovery.

4.28 Chapter 403 Environmental Control, Part VII

This part of the stature addresses protection of riparian rights as well as mangrove and coral reef habitat in southeast Florida

No mangroves or coral reefs occur in the project area, which is outside southeast Florida. Effects of the PAA are limited to those resulting from water releases at Jim Woodruff Lock and Dam and water levels within Lake Seminole. Effects of the PAA would be the same as under the existing condition, as Jim Woodruff Lock and Dam and Lake Seminole is a run-of-river project normally operating at 77 ft (with minor variations) with no conservation storage. No change would be expected along the project shoreline or downstream along the river shoreline that would alter the ability of the state to fund economic recovery efforts. Flow conditions in the Apalachicola River would not change appreciably for the alternatives compared to current conditions (Figures 1-2). No riparian rights would be affected.

4.29 Chapter 582, Soil and Water Conservation

This part of the statute addresses soil and water conservation, protection of water quality, prevention of flood damage, protection of public lands and promoting the general welfare of the people of Florida.

The PAA would see the continuation of the current water control operations at Lake Seminole that entail little variation in lake levels. No change in erosion and sedimentation patterns in Lake Seminole would be expected. Downstream of Jim Woodruff Lock and Dam, erosion and sedimentation patterns in the Apalachicola River for all of the alternatives likely would not differ from patterns that would continue under current conditions. No appreciable differences in discharges from Jim Woodruff Lock and Dam and flow conditions in the Apalachicola River would occur over the modeled period of record for any of the nine other alternatives when compared to conditions under the NAA.

USACE projects in the ACF Basin were constructed and are operated to meet federally authorized project purposes. Water control objectives and operational guidelines to meet the authorized project purposes at USACE reservoirs in the ACF Basin are recorded in Water Control Manuals (WCM). An individual project-specific WCM has been prepared for each of the reservoir projects at some point after it was constructed and placed into operation which includes specific water control plans for the project. The original Master WCM for the basin as a whole was completed in 1958. The WCMs were developed in thorough consideration of all project purposes and cover a full array of all foreseeable hydrologic conditions, from flood to drought.

Proposed revisions to water management operations at Buford Dam—including various water supply options for Lake Lanier and downstream of Buford Dam (all of which would occur in the uppermost 10 percent of the Chattahoochee River Basin)—would generally have an inconsequential effect on flow conditions into Lake Seminole and downstream of Jim Woodruff Lock and Dam. The absence of appreciable differences in simulated flow conditions downstream of George W. Andrews Lock and Dam among the alternatives with different water supply options supports this conclusion (Figures 1-2). Based on HEC-ResSim outputs over the modeled period of record, flow in the Apalachicola River and into the bay would be more influenced by hydrologic conditions in the 90 percent of the ACF Basin downstream of Metro Atlanta, except during severe drought conditions when flows would be supported by conservation storage in Lake Lanier and the other USACE reservoirs.

Effects of the PAA are limited to those resulting from water releases at Jim Woodruff Lock and Dam and water levels within Lake Seminole. Effects of the PAA would be the same as under the existing condition, as Jim Woodruff Lock and Dam and Lake Seminole is a run-of-river project normally operating at 77 ft (with minor variations) with no conservation storage. No change would be expected along the project shoreline or downstream along the river shoreline that would alter the ability of the state to fund economic recovery efforts. Flow conditions in the Apalachicola River would not change appreciably for the alternatives compared to current conditions (Figures 1-2). When flow in the river drops below 5,000 cfs during Drought Zone operations under the PAA, vegetation and wildlife along the Apalachicola River would be expected to experience short-term slightly adverse conditions. Drought Zone operations would occur infrequently and would generally be of relatively short duration (i.e., a few weeks or less). The vegetation and wildlife along the Apalachicola River would be able to endure the conditions with no measureable changes to vegetative community composition or wildlife populations. Thus, implementing the PAA would be expected to have the same effects on terrestrial vegetative communities and wildlife along the Apalachicola River as the NAA.

4.30 Chapter 597 Aquaculture

This part of the statute establishes policy concerning the enhancement of aquaculture, while protecting the state's environment.

Proposed revisions to water management operations at Buford Dam—including various water supply options for Lake Lanier and downstream of Buford Dam (all of which would occur in the uppermost 10 percent of the Chattahoochee River Basin)—would generally have an inconsequential effect on flow conditions into Lake Seminole and downstream of Jim Woodruff Lock and Dam. The absence of appreciable differences in simulated flow conditions downstream of George W. Andrews Lock and Dam among the alternatives with different water supply options supports this conclusion (Figures 1-2). Based on HEC-ResSim outputs over the modeled period of record, flow in the Apalachicola River and into the bay would be more influenced by hydrologic conditions in the 90 percent of the ACF Basin downstream of Metro Atlanta, except during severe drought conditions when flows would be supported by conservation storage in Lake Lanier and the other USACE reservoirs.

Effects of the PAA are limited to those resulting from water releases at Jim Woodruff Lock and Dam and water levels within Lake Seminole. Effects of the PAA would be the same as under the existing condition, as Jim Woodruff Lock and Dam and Lake Seminole is a run-of-river project normally operating at 77 ft (with minor variations) with no conservation storage. No change would be expected along the project shoreline or downstream along the river shoreline that would alter the ability of the state to fund economic recovery efforts. Flow conditions in the Apalachicola River would not change appreciably for the alternatives compared to current conditions (Figures 1-2). When flow in the river drops below 5,000 cfs during Drought Zone operations under the PAA, vegetation and wildlife along the Apalachicola River would be expected to experience short-term slightly adverse conditions. Drought Zone operations would occur infrequently and would generally be of relatively short duration (i.e., a few weeks or less). The vegetation and wildlife along the Apalachicola River would be able to endure the conditions with no measureable changes to vegetative community composition or wildlife populations. Thus, implementing the PAA would be expected to have the same effects on terrestrial vegetative communities and wildlife along the Apalachicola River as the NAA.

Floodplain habitat connectivity on the Apalachicola River also is similar across alternatives. The maximum 30-day growing season floodplain habitat connectivity for each alternative was calculated as the maximum amount of floodplain spawning habitat available for at least 30 consecutive days during the months of April–October. This criterion was based on the life history requirements of many riverine fishes, including species specific to the Apalachicola River. This criterion also is an appropriate standard for assessing habitat for the wide range of other aquatic organisms that inhabit the Apalachicola River and its floodplain. USFWS developed the Floodplain Spawning Habitat Performance Measure (FSHPM) to assist in this evaluation (Figure 3).

Estuaries exist at the junction of fresh and salt waters and are integrally linked to freshwater inputs. Principal consequences for the management of freshwater flow to estuaries are related to both the magnitude and timing of flows (Mann and Lazier 1991). Freshwater flows are integral not only to maintaining the delivery of material and energy critical to estuarine productivity but also to providing habitat conditions conducive to maintaining the diversity and abundance of the estuarine community. Three regions in the Apalachicola Bay estuary are of interest with respect to salinity requirements for juvenile Gulf sturgeon, oyster habitat, white shrimp, and several species for which a fishery management plan exists that is consistent with their essential fish habitat (EFH) designation. Changes in salinity and other water quality parameters in Apalachicola Bay and Estuary are negligible, given little to no change in streamflows from the NAA in the Apalachicola River at Chattahoochee, Florida (Figures 1-2, 4). In addition to this analysis, preliminary results of salinity modeling provided by USFWS to the USACE and conducted by Dr. Peter Sheng indicated similar salinity levels in Apalachicola Bay between the NAA and the PAA from the draft EIS (Alt7H) (Paramygin and Sheng 2015). It should be noted that the proposed action evaluated by Dr. Sheng is slightly different than the PAA (Alt7K) presented in this final EIS. However, the difference in the 2015 proposed action and the PAA is limited to water supply assumptions in Metro Atlanta. The PAA provides for less water supply in Metro Atlanta than the 2015 proposed action. It is expected that salinity modeling results for the PAA would be similar to those for the 2015 proposed action. The change in flows in the Apalachicola River can be used as a metric for potential effects to the oyster populations in Apalachicola Bay. Consequently, differences between the PAA and the current condition would not be expected and would have no effect on oyster populations or the oyster industry.

CITATIONS

American Forests. 2016. A Carbon Conundrum. Accessed July 2016. http://www.americanforests.org/a-carbon-conundrum/.

ARC (Atlanta Regional Commission). 2011. 2011 Transportation Fact 1 Book, July 2011. Accessed July 2016. http://documents.atlantaregional.com/transportation/TPD2011factbook_v04.pdf.

Fedoroff, M. 2014. ACF Cultural Technical Study. Unpublished study. U.S. Army Corps of Engineers, Mobile District, Mobile, AL.

Mann, K.H., and J.R.N. Lazier. 1991. Dynamics of Marine Ecosystems: Biological-Physical Interactions in the Oceans. Blackwell Scientific Publications, Cambridge, MA.

Paramygin, V.A. and Sheng, Y.P. 2015. A Preliminary Report: Simulating the response of estuarine salinity in Apalachicola Bay. Prepared for U.S. Fish and Wildlife Service. Prepared by Engineering School of Sustainable Infrastructure and Environment, University of Florida.

United States Army Corps of Engineers (USACE). 2015. Draft Environmental Impact Statement, Update of the Water Control Manual for the Apalachicola-Chattahoochee –Flint River Basin in Alabama, Florida, Georgia and a Water Supply Storage Assessment.

Appendix M

Recreation Benefit Analysis

This page intentionally left blank

Apalachicola-Chattahoochee-Flint River Basin Environmental Impact Statement for Water Control Manual Update

Recreation Analysis Summary Memorandum

October 2016

Apalachicola-Chattahoochee-Flint River Basin
Environmental Impact Statement
for Water Control Manual Update

Recreation Analysis Summary Memorandum

October 2016

Page intentionally blank

TABLE OF CONTENTS

TABLES

FIGURES

Page intentionally blank

1. Introduction

1.1. Purpose, Scope, and Objectives

The purpose of this memorandum is to summarize the objectives, methods, and results of the recreation analysis performed for the Environmental Impact Statement (EIS) of the update to the Water Control Manual for the Apalachicola-Chattahoochee-Flint (ACF) River Basin.

Both federal and non-federal recreation facilities and use at three federal multipurpose projects in the ACF basin were included in the evaluation. The most recent available recreation use data was provided by the resource managers at each federal project. The federal project resource managers also participated in scoring of the quality of recreation resources per the Unit Day Value analysis framework (discussed further in Section 2). This analysis provides decision makers a quantitative characterization of the effects of recreation that is consistent across the three projects.

1.2. Study Area

For this analysis, the study area includes the ACF River Basin located in Georgia, Florida and Alabama. More specifically, it includes the federal and non-federal recreation facilities at Lake Sidney Lanier, West Point Lake, and Walter F. George Lake. Figure 1 provides a map showing the location of the three projects within the basin.

2. Unit Day Value Analysis

2.1. General Methodology

The value of recreation can be estimated through approximation of visitors' willingness to pay for the recreation resource. Willingness-to-pay is assumed to represent the economic value, in dollars, that a visitor places on a recreation resource. Estimating the economic value of the recreation resource under current water control operations and comparing it to the value of alternative scenarios, allows the calculation of net effects on recreation benefits resulting from a scenario.

The appropriate valuation methodology was selected based on the guidelines in Appendix E, Engineer Regulation (ER) 1105-2-100 Planning Guidance Notebook, dated 22 April 2000, paragraph E-50b(4). For this study, there is no regional model available for recreation; the project is not creating specialized recreation activities as defined in the ER; and there is no increase in Federal costs for recreation, since the water management alternatives do not include recreation features. As such, the Unit Day Value (UDV) methodology was selected as the appropriate valuation method.

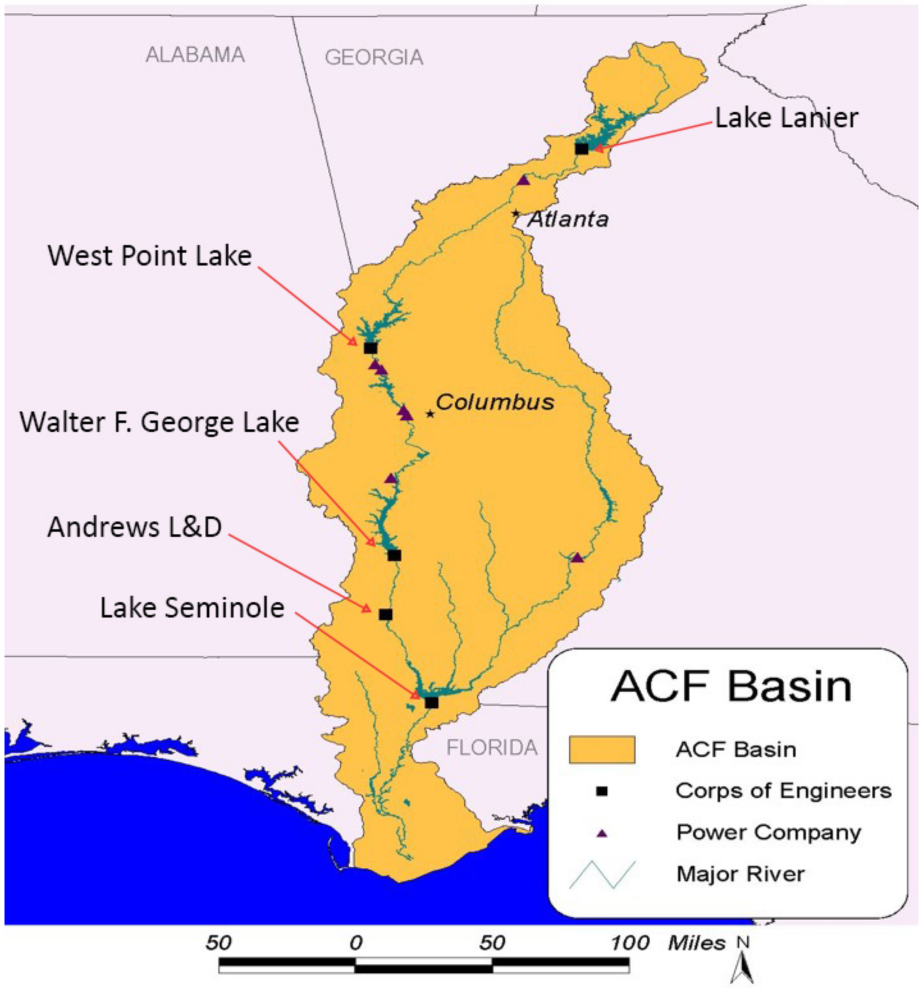


Figure 1. Study Area

When applying the UDV methodology, two categories of outdoor recreation visits, general and specialized, may be differentiated for evaluation purposes. “General” refers to a recreation visit involving primarily those activities that are attractive to the majority of outdoor users and that generally require the development and maintenance of convenient access and adequate facilities. “Specialized” refers to a recreation visit involving those activities for which opportunities in general are limited, intensity of use is low, and a high degree of skill, knowledge, and appreciation of the activity by the user may often be involved (USACE, Economic Guidance Memorandum (EGM) 17-03, Unit Day Values for Recreation, Fiscal Year 2017). All of the activities at the ACF reservoirs, with and No Action Alternative, were determined to fall into the general recreation category.

The UDV method for estimating recreation benefits relies on expert or informed opinion and judgment to approximate the average willingness to pay of users of Federal or Federally assisted recreation resources. By applying a unit day value per visitor, an approximation of project recreation benefits is obtained.

The UDV process includes scoring of the project site using five guidance-defined criteria to yield a point score for the groups of recreation activities at the site. The point score is converted to dollars per visit using tables provided in the UDV guidance (updated annually). The final dollars-per-visit value is the

UDV. The UDV is then multiplied by the number of annual visitors to generate an estimate of the annual recreation value at the site. This annual value is then projected over the 50 year period of analysis based on visitation projections for the study area.

This method of estimating annual recreation value is completed twice. First, a valuation is completed for the No Action Alternative. Second, a valuation is completed for the "with" project alternatives. The difference between the two estimates is the net recreation value attributable to the alternative being evaluated.

2.2. APPLICATION FOR THIS ANALYSIS

In this analysis, a separate UDV evaluation is presented for each of the three reservoirs (Lake Sidney Lanier, West Point Lake, and Walter F. George Lake). This approach required site-specific visitation data as well as separate UDV scorings for each of the three reservoirs.

No recreation features are proposed for construction as part of the alternatives. The water management alternatives affect recreation by altering reservoir pool levels during the recreation season. The extent to which recreation is affected was accounted for as a function of the amount of time the pool is held at or below four pool levels as defined by ResSim modeling. For the No Action Alternative and for each alternative, ResSim modeled the amount of time the pool level of each reservoir would remain at or below these four levels. See Section 2.3 for a detailed summary by alternative.

- Full Pool (Above Initial Impact Level) (No Effect)
- Initial Impact Level
- Recreation Impact Level
- Water Access Limited Level

Next, UDV scores were elicited from the project resource managers from each reservoir. A UDV score was developed for each pool level at each reservoir (12 scores in total). In doing so, the effect on recreation for each alternative could be measured as a function of effect on pool level. This approach reflects that pool levels which are less than optimal for recreation would result in reduced value of the recreation resource (i.e., visitors have a lower willingness to pay for recreation at these reservoirs as pool levels drop below optimal levels).

These scores were converted to a dollar value per recreation visit (see Section 2.6) and then applied to estimates of annual visitation obtained from the project resource managers. This method resulted in an estimate of recreation value at each reservoir for the time spent at each pool level. Adding up the value for each pool level based upon the amount of time at each level resulted in an estimate of recreation value across the 50-year period of analysis. This value was annualized using the Fiscal Year (FY) 2017 Federal discount rate of 2.875 percent to yield an estimate of the average annual recreation value for each alternative. These average annual values can be compared to the No Action Alternative average annual value to assess the incidental effect of each alternative on recreation value.

2.3. WATER MANAGEMENT ALTERNATIVES SUMMARY

This recreation analysis estimated the effects of the following alternatives on recreation resources at Lake Sidney Lanier, West Point Lake, and Walter F. George Lake. As described in Section 5.2 of the EIS, the alternatives combine either Water Management Alternative 1 described in section 4.2.1 or Water Management Alternative 7 (i.e., the Proposed Water Management Alternative described in section 4.3) with one of the water supply options A, B, or H through M shown in Table 5.1-3 of the EIS. The alternatives are identified by the number of the water management plan followed by the letter designating the water supply option included in the alternative. Following the bulleted list below, Table 1 summarizes these alternatives according to their modeled effects on pool level in terms of the percent of time spent in each zone during the recreation season.

- No Action Alternative - Water Management Alternative 1 (Current Operations) w/Water Supply Option A
- Alt 1L - Water Management Alternative 1 (Current Operations) w/Water Supply Option L
- Alt 7A - Water Management Alternative 7 w/Water Supply Option A
- Alt 7B - Water Management Alternative 7 w/Water Supply Option B
- Alt 7H - Water Management Alternative 7 w/Water Supply Option H
- Alt 7I - Water Management Alternative 7 w/Water Supply Option I
- Alt 7J - Water Management Alternative 7 w/Water Supply Option J
- Alt 7K - Water Management Alternative 7 w/Water Supply Option K
- Alt 7L - Water Management Alternative 7 w/Water Supply Option L
- Alt 7M - Water Management Alternative 7 w/Water Supply Option M

Table 1. Alternatives Summary

Alter-native	Description	Impact Level*											
		Lake Sidney Lanier				West Point Lake				Walter F George Lake			
		F.P.	I.I.L.	R.I.L.	W.A.L.	F.P.	I.I.L.	R.I.L.	W.A.L.	F.P.	I.I.L.	R.I.L.	W.A.L.
No Action A	Current Operations w/Water Supply Option A	67 percent	23 percent	8 percent	3 percent	74 percent	22 percent	3 percent	1 percent	97 percent	3 percent	0 percent	0 percent
ALT 1 - Opt L	Current Operations w/Water Supply Option L	63 percent	25 percent	9 percent	3 percent	76 percent	21 percent	2 percent	1 percent	97 percent	3 percent	0 percent	0 percent
ALT 7 - Opt A	Water Management Alternative 7 w/Water Supply Option A	67 percent	24 percent	7 percent	2 percent	72 percent	23 percent	4 percent	1 percent	94 percent	5 percent	0 percent	0 percent
ALT 7 - Opt B	Water Management Alternative 7 w/Water Supply Option B	75 percent	19 percent	5 percent	0 percent	73 percent	23 percent	3 percent	1 percent	94 percent	6 percent	0 percent	0 percent
ALT 7 - Opt H	Water Management Alternative 7 w/Water Supply Option H	60 percent	27 percent	9 percent	3 percent	76 percent	22 percent	2 percent	0 percent	95 percent	5 percent	0 percent	0 percent
ALT 7 - Opt I	Water Management Alternative 7 w/Water Supply Option I	61 percent	27 percent	9 percent	3 percent	75 percent	22 percent	2 percent	1 percent	97 percent	3 percent	0 percent	0 percent
ALT 7 - Opt J	Water Management Alternative 7 w/Water Supply Option J	74 percent	19 percent	6 percent	1 percent	76 percent	22 percent	2 percent	1 percent	95 percent	5 percent	0 percent	0 percent
ALT 7 - Opt K	Water Management Alternative 7 w/Water Supply Option K	60 percent	27 percent	9 percent	3 percent	75 percent	22 percent	2 percent	0 percent	95 percent	5 percent	0 percent	0 percent
ALT 7 - Opt L	Water Management Alternative 7 w/Water Supply Option L	67 percent	23 percent	7 percent	3 percent	76 percent	21 percent	2 percent	0 percent	96 percent	4 percent	0 percent	0 percent
ALT 7 - Opt M	Water Management Alternative 7 w/Water Supply Option M	64 percent	25 percent	8 percent	3 percent	75 percent	22 percent	2 percent	0 percent	95 percent	4 percent	0 percent	0 percent

**NOTE: F.P. = Full Pool (Above Initial Impact Level) (No Effect); I.I.L. = Initial Impact Level; R.I.L. = Recreation Impact Level; W.A.L = Water Access Limited Level*

2.4. VISITATION ESTIMATE

Visitation estimates were provided by the project resource managers for Lake Sidney Lanier, West Point Lake, and Walter F. George Lake. These estimates included visitation at both federal and non-federal facilities over approximately the last decade. The data over the period of record was averaged to generate a typical baseline annual visitation for each reservoir. Expected annual growth in visitation over time was estimated to be 2 percent, based upon the mean annual population growth rate of the 27 counties within a 10-mile radius of the three lakes. To reflect consideration of facility carrying capacity at the reservoirs, available capacity data was reviewed and discussed with project resource managers, resulting in the assumption that visitation growth be capped after ten years and remain constant for the rest of the period of analysis. Table 2 summarizes the estimated annual visitation projections for each of the projects.

Table 2. Visitation Over the Period of Analysis

Years	Lake Sidney Lanier Visits	West Point Lake Visits	Walter F. George Lake Visits
1	5,891,000	1,880,000	2,500,000
2	6,009,000	1,918,000	2,550,000
3	6,129,000	1,956,000	2,601,000
4	6,252,000	1,995,000	2,653,000
5	6,377,000	2,035,000	2,706,000
6	6,504,000	2,076,000	2,760,000
7	6,634,000	2,117,000	2,815,000
8	6,767,000	2,160,000	2,872,000
9	6,902,000	2,203,000	2,929,000
10	7,040,000	2,247,000	2,988,000
11-50	7,181,000	2,292,000	3,047,000

2.5. UDV SCORING / POINT ASSIGNMENT

UDV scoring was developed through expert elicitation from the project resource managers. For each project, scores were developed for each pool level at each reservoir (12 scores in total). In doing so, the effect on recreation for each alternative could be measured as a function of effect on pool. The five UDV criteria for which points are assigned were:

- Recreation Experience: score increases in proportion to the number of available activities at the site
- Availability of Opportunity: score is based on availability of substitute sites; the fewer the sites in the region that offer comparable recreation experience, the higher the score
- Carrying Capacity: score rates level of facilities at the site to support the activities
- Accessibility: score rates ease of access to the site
- Environmental: rates the aesthetic/environmental quality of the recreation site/activities

Scoring was based on the consideration of general recreation activities that would be affected at each project. Table 3 provides a copy of the USACE guidance which contains the scoring rubric. Table 4 shows the scores developed by the team. In the sections following the table, the rationale is provided for the point assignments according to the five UDV criteria. In Section 2.6, these scores are converted to dollar value equivalents.

Table 3. UDV Scoring Rubric

Criteria	Judgment Factors				
Recreation Experience (1) Points Possible: 30	Two general activities (2) 0-4	Several general activities 5-10	Several general activities: one high quality value activity (3) 11-16	Several general activities: more than one high quality value activity 17-23	Numerous high quality value activities; some general activities 24-30
Availability of Opportunity (4) Points Possible: 18	Several within 1 hr travel time; a few within 30 min travel time 0-3	Several within 1 hr travel time; none within 30 min travel time 4-6	One or two within 1 hr travel time; none within 45 min travel time 7-10	None within 1 hr travel time 11-14	None within 2 hr travel time 15-18
Carrying Capacity (5) Points Possible: 14	Minimum facility for development for public health and safety 0-2	Basic facility to conduct activity(ies) 3-5	Adequate facilities to conduct without deterioration of the resource or activity experience 6-8	Optimum facilities to conduct activity at site potential 9-11	Ultimate facilities to achieve intent of selected alternative 12-14
Accessibility Points Possible: 18	Limited access by any means to site or within site 0-3	Fair access, poor quality roads to site; limited access within site 4-6	Fair access, fair road to site; fair access, good roads within site 7-10	Good access, good roads to site; fair access, good roads within site 11-14	Good access, high standard road to site; good access within site 15-18
Environmental Quality Points Possible: 20	Low aesthetic factors (6) that significantly lower quality (7) 0-2	Average aesthetic quality; factors exist that lower quality to a minor degree 3-6	Above average aesthetic quality; any limiting factors can be reasonably rectified 7-10	High aesthetic quality; no factors exist that lower quality 11-15	Outstanding aesthetic quality; no factors exist that lower quality 16-20

Guidance Notes:
(1) Value for water-oriented activities should be adjusted if significant seasonal water level
(2) General activities include those that are common to the region and that are usually of normal quality. This includes picnicking, camping, hiking, riding, cycling, and fishing and hunting of normal quality.
(3) High quality value activities include those that are not common to the region and/or Nation, and that are usually of high quality.
(4) Likelihood of success at fishing and hunting.
(5) Value should be adjusted for overuse.
(6) Major esthetic qualities to be considered include geology and topography, water, and vegetation.
(7) Factors to be considered to lowering quality include air and water pollution, pests, poor climate, and unsightly adjacent areas.

Table 4. UDV Score Summary

	Criteria					
	Recreation Experience	Availability of Opportunity	Carrying Capacity	Accessibility	Environ-mental	Total
Lake Sidney Lanier						
Full Pool[a]	30	14	14	18	19	**95**
Initial Impact	28	14	14	18	17	**91**
Recreation Impact	25	14	12	18	15	**84**
Water Access Limited	17	12	9	18	9	**65**
West Point Lake						
Full Pool[a]	27	4	11	15	15	**72**
Initial Impact	24	4	10	15	13	**66**
Recreation Impact	20	4	8	15	11	**58**
Water Access Limited	20	4	6	15	9	**54**
Walter F George Lake						
Full Pool[a]	30	14	12	17	17	**90**
Initial Impact	30	14	10	17	14	**85**
Recreation Impact	30	14	6	17	10	**77**
Water Access Limited	16	14	3	17	6	**56**

Note: [a] Above Initial Impact Level

2.5.1. Recreation Experience

2.5.1.1. Lake Sidney Lanier

Full Pool (Above Initial Impact Level)

This criteria was scored 30 out of 30 points. All high quality and general activities would be available at the lake, including all of the 10,000 private boat docks. Lake Sidney Lanier offers the largest quantity of recreation development of the tree projects.

Initial Impact

This criteria scored 28 out of 30 points. Most facilities remain available, but beaches are beginning to experience an impact. Beach surface areas are increased while swim areas (water) are decreased and the effects on visitation are offset. Boating access is not significantly affected due to extended boat ramps and marinas which have been designed to accommodate a fluctuating pool level. Private boat docks are minimally affected at this lake level (approximately 10 percent of total docks on the lake).

Recreation Impact

This criteria scored 25 out of 30 points to reflect some additional effect compared to the Initial Impact level, but not enough to drop the score into the 17-23 point range.

Water Access Limited

This criteria scored 17 out of 30 points. At this pool level, land based activities are still minimally affected but numerous water based activates are significantly affected.

2.5.1.2. West Point Lake

Full Pool (Above Initial Impact Level)

This criteria was scored 27 out of 30 points. This score reflects that at full pool all recreation facilities are operational at the project and are in in a usable and safe condition.

INITIAL IMPACT

This criteria was scored 24 out of 30 points. At this level, recreation begin to be noticeable. Swimming areas become marginally usable, commercial marinas prepare to shift docks/boat slips outward, approximately one third of private docks become marginally usable, and boat launching ramps begin for to accumulate silt which hinders boat launching into the lake. Safety becomes a factor as some unmarked, potential hazards to navigation begin to appear.

RECREATION IMPACT

This criteria was scored 20 out of 30 points. At this impact level significant impacts to recreation are noticeable and all swimming beaches become unusable, necessitating the drop in point score. Commercial marinas have to shift docks/boat slips outward to prevent them from becoming unusable, approximately 50 percent of private docks become only marginally usable, and 25 percent of courtesy docks at public boat ramps become unusable. The remaining 75 percent of them are only marginally usable. Boat launching ramps have silt build-up that requires frequent removal. Access to upper reaches of the reservoir, beyond Ringer Park, is limited by silt accumulation and a braided river channel. Unmarked navigation hazards continue to emerge. Shallow tributaries become unsafe for skiing.

WATER ACCESS LIMITED

This criteria was scored 20 out of 30 points. At this impact level, there may be some additional effects but the number of activities is unlikely to change, so the point score is maintained. Business at Marinas drops significantly, approximately 70 percent of private docks are unusable, over 60 percent of courtesy docks at boat ramps are unusable. Shallow tributaries are not accessible by boat.

2.5.1.1. WALTER F. GEORGE LAKE

FULL POOL (ABOVE INITIAL IMPACT LEVEL)

This criteria was scored 30 out of 30 points. At full pool all recreation facilities are operational, including the high quality bass fishery, nicknamed the "Bass Capital of the World." Also regionally unique are the two navigation locks providing access to the Gulf of Mexico, both of which operate normally at full pool.

INITIAL IMPACT

This criteria was scored 30 out of 30 points. It was judged that the score would remain the same at this pool level, as all activities would remain viable somewhere on the lake, and the score it based on the number of activities available. However, impacts to recreation may begin to become noticeable, including safety issues related to barely-submerged obstacles, minor reduction in the size of swim beaches, the beginning effects on boat ramps and the potential for 30 percent of private docks to become unusable.

RECREATION IMPACT

This criteria was scored 30 out of 30 points. At this level significant impacts to recreation are noticeable. However, activities remain available at certain points on the lake and gulf access may still be available, still meeting the criteria for recreation experience score based on the number of activities available. Effects include: swimming beaches become undesirable or unusable, approximately 35 percent of private docks become marginally usable, 10 percent of courtesy docks at boat ramps become unusable, and 90 percent of them marginally usable. All boat launching ramps have frequent silt build-up and several become unusable. Prime fishing sites become inaccessible. Marina operations become affected with some inaccessible boat slips. Unmarked navigation hazards continue to emerge, with vast areas of the project having less than three feet of water. Conditions may allow invasive aquatics to establish a strong hold in normally deeper areas of the lake. Gulf access may be impacted by reduced releases downstream.

Water Access Limited

This criteria was scored 16 out of 30 points. The substantial drop in score reflects that activities may no longer be viable anywhere on the lake. At this level major impacts to recreation are noticeable. All swimming beaches will be unusable, commercial marinas will have impacts causing them to become unusable and business at Marinas would likely dip significantly. Approximately 85-90 percent of private docks would be unusable, and over 75 percent of courtesy docks at boat ramps become unusable. Boat launching ramps would be significantly impacted. A significant number of unmarked navigation hazards would continue to emerge. Shallow tributaries and large areas of the main lake become unsafe for skiing and boat traffic, moving skiers to main river channels. Access to the Gulf may be lost at this impact level.

2.5.2. Availability of Opportunity

2.5.2.1. Lake Sidney Lanier

Full Pool (Above Initial Impact Level)

This criteria was scored 14 out of 18 points. This score reflects that other high quality value activities and general activities are available in the Metro-Atlanta area just within a one hour travel time.

Initial Impact

This criteria was scored 14 out of 18 points. This impact level would have minimal additional effect on land-based activities and navigation would be minimally affected by a reduction in surface acreage available for recreational boating traffic. Under water boating hazards are not a concern until lower lake levels. At this impact level, there would still not be more than one suitable substitute with an hour travel time, thus the score is maintained.

Recreation Impact

This criteria was scored 14 out of 18 points as well. While effects would be increased, the team judged that there would still not be more than one suitable substitute with an hour travel time, thus score is maintained rather than reduced to the next category on the rubric. The score reflects that Corps-operated boat ramps are marginally affected at pool elevation 1063. At this lake level, 17 boat ramps have lanes that are unusable. Private boat docks would be marginally affected at this lake level (approximately 20 percent of total docks on the lake). Marinas/Clubs with boat slips in shallow areas are minimally affected. Approximately 2 percent or 142 slips are unusable. Most Corps-operated swim areas are unusable for swimming except where swim lines have been safely relocated to allow for at least 2 feet of water at the line. Navigation hazards would become more numerous and vessels would need to be operated with increased caution.

Water Access Limited

This criteria was scored 12 out of 14 points. This small reduction from the Recreation Impact level reflects that Corps operated boat ramps are significantly affected at pool elevation 1060. At this lake level, 39 boat ramps would have lanes that are unusable. Navigation hazards would become more numerous and vessels would need to be operated with increased caution. Private boat docks would be significantly affected at this lake level (approximately 50 percent of total docks on the lake).

2.5.2.2. West Point Lake

All Impact Levels

This criteria was scored 4 out of 18 points. This score reflects that there are several locations within one hour drive time that provide similar recreational opportunities to the public. This score was held constant across all impact levels.

2.5.2.1. Walter F. George Lake

All Impact Levels

This criteria was scored 14 out of 18 points. The team judged that there are no locations within one hour drive time that provide the unique recreational opportunities listed above to the public. This score was held constant across all impact levels.

2.5.3. Carrying Capacity

2.5.3.1. Lake Sidney Lanier

Full Pool (Above Initial Impact Level)

This criteria was scored 14 out of 14 points, reflecting that Sidney Lake Lanier is one of the most developed lake recreation projects in the region.

Initial Impact

This criteria was scored 14 out of 14 points, reflecting that the Initial Impact pool level would not substantially affect land-based or water activities.

Recreation Impact

This criteria was scored 12 out of 14 points. This reduced score reflects that at this pool level, the project would may see reduced visitation due lack of accessible boat ramp facilities and other lake access for water-based recreation. Land based facilities would still not be affected significantly.

Water Access Limited

This criteria was scored 9 out of 14 points. Further reduction in the score reflects that the number of accessible boat ramps and other water access points would be further reduced at this pool level.

2.5.3.2. West Point Lake

Full Pool (Above Initial Impact Level)

This criteria was scored 11 out of 14 points. The score reflects that the project consists of favorable and commonly requested facilities/amenities as evidenced by public demand and use. Because of relatively intensive maintenance, most areas accommodate frequent public use without severe deterioration facilities and resources.

Initial Impact

This criteria was scored 10 out of 14 points. This score reflects that there would be only minor decrease in carrying capacity due to reduced lake levels.

Recreation Impact

This criteria was scored 8 out of 14 points. This score reflects that at this lower reservoir level, recreational opportunities would be reduced by limiting the number of usable facilities available. Potential visitors may perceive that boating conditions are unsafe and stay away from the project. Some major tributaries may be too shallow for boat operation, shifting boat traffic to deeper water and making navigation channels more congested.

WATER ACCESS LIMITED

This criteria was scored 6 out of 14 points. At this lowest level many of the project's courtesy docks are unusable. Visitors may shift to other parks with usable courtesy docks, creating more impact to those recreation areas. Both marinas’ boat ramps are unusable, again shifting visitors to other Corps parks for water access. Business at marinas is negatively impacted. The majority of boat traffic is focused on the main river channel, making navigation channels more congested. Many potential lake users perceive that the lake is inaccessible at this level.

2.5.3.1. WALTER F. GEORGE LAKE

FULL POOL (ABOVE INITIAL IMPACT LEVEL)

This criteria was scored 12 out of 14 points. The project consists of favorable and the most commonly requested facilities/amenities as evidenced by public demand and use. Most areas can easily accommodate high use with no deterioration to the resource due to overuse.

INITIAL IMPACT

This criteria was scored 10 out of 14 points. The drop in score reflects loss of access to some boat ramps and reduced swimming areas which would impacts visitation and enjoyment of the resource.

RECREATION IMPACT

This criteria was scored 6 out of 14 points. Further reduction in score reflects that at this level, 50 percent of the courtesy docks become unusable which could potentially shift lake access users to other parks with usable courtesy docks, therefore creating more impact to those recreation areas. Additionally, tributaries will be too shallow for boat operation, shifting boat traffic to deeper water and making navigation channels more congested. Risk of erosion due to wave action on exposed shoreline may increase.

WATER ACCESS LIMITED

This criteria was scored 3 out of 14 points. An even lower score reflect lower water levels, which result in exposed shoreline and increased soil erosion risk. At this level, most critical fish habitat structure would be compromised and esthetic quality would decrease as well. Floating debris and trash may begin to be deposited on the exposed shoreline.

2.5.4. ACCESSIBILITY

2.5.4.1. LAKE SIDNEY LANIER

ALL IMPACT LEVELS

This criteria was scored 18 out of 18 points. This score reflects that all access roads to parks and interior roads within parks have been improved and paved to provide year round safe access to all facilities. This score was held constant across all impact levels.

2.5.4.2. WEST POINT LAKE

ALL IMPACT LEVELS

This criteria was scored 15 out of 18 points. The score reflects that recreation areas and facilities at the project are easily accessible via suitable public roadways, and roads within parks are maintained in reasonably good condition. Signage on most roads directs users to parks around the project. This score was held constant across all impact levels.

2.5.4.1. Walter F. George Lake

All Impact Levels

This criteria was scored 17 out of 18 points. The score reflects that many roads provide access to the project's parks and campgrounds. Roads are paved, adequate width to accommodate types of vehicles entering/exiting, and all areas and are maintained in good condition. Signage directs users to park areas around the project. This score was held constant across all impact levels.

2.5.5. Environmental

2.5.5.1. Lake Sidney Lanier

Full Pool (Above Initial Impact Level)

This criteria was scored 19 out of 20 points. The score reflects that the project offers clear water, unique topography (foothills of the Appalachian Mountains), four distinct seasons effecting vegetation, and high water quality despite some industrial and municipal water treatment feeding tributaries.

Initial Impact

This criteria was scored 17 out of 20 points. While the team judged that environmental quality would not be substantially affected by this pool level, there was concern related to the migration of existing silt beds to deeper water.

Recreation Impact

This criteria was scored 15 out of 20 points. At this pool level, additional concerns were raised related to reduced aesthetic quality of the exposed banks.

Water Access Limited

This criteria was scored 9 out of 20 points, reflecting still further reduction of aesthetic quality due to the exposed banks.

2.5.5.2. West Point Lake

Full Pool (Above Initial Impact Level)

This criteria was scored 15 out of 20 points. At this level, the project provides many areas of high aesthetic quality with few factors that lower the environmental quality. There are minimal impacts from noise and water quality. Numerous positive environmental factors are present such excellent wildlife habitat, suitable water clarity, lush vegetation, etc. Positive outdoor recreation experiences are available.

Initial Impact

This criteria was scored 13 out of 20 points. At this level, the project continues to provide areas of high aesthetic quality. Visitors may begin to express concern about the lower reservoir level during the recreation season, negatively impacting their recreational experience. Positive outdoor recreation experiences remain available.

Recreation Impact

This criteria was scored 11 out of 20 points. At this level, lower water levels result in exposed shoreline which increases the opportunity for soil erosion. Some critical fish habitat structure would be compromised, and esthetic quality would decrease as well. Floating debris and trash begins to be deposited on the exposed shoreline.

Water Access Limited

This criteria was scored 9 out of 20 points. At this level, the appearance of the reservoir is negatively affected, with a large expanse of exposed, bare soil surrounding the water's edge. Critical fish habitat structure is compromised and esthetic quality decrease as the water level continues to decline.

2.5.5.1. Walter F. George Lake

Full Pool (Above Initial Impact Level)

This criteria was scored 17 out of 20 points. At this level, the project provides many areas of high aesthetic quality with few factors that lower the environmental quality. There are minimal impacts from noise and water quality and numerous positive environmental factors are present such as wildlife viewing, water clarity, solitude, and high quality natural value (such as scenic rivers with zero development).

Initial Impact

This criteria was scored 14 out of 20 points. The reduction in score at this impact level reflects that exposed mudflats would detract from the natural beauty.

Recreation Impact

This criteria was scored 10 out of 20 points. Further score reduction reflects that lower water levels would result in significant exposed shoreline and increased risk of soil erosion. Some critical fish habitat structure would be compromised and esthetic quality would decrease as well. Exposed mudflats continue to detract from the natural beauty at this impact level. Floating debris and trash begins to be deposited on the exposed shoreline, and sedimentation begins to accrue in normal deep water areas.

Water Access Limited

This criteria was scored 6 out of 20 points. Additional score reduction reflects that soil erosion impacts begin to expand exponentially at this water level, critical fish habitat structure is compromised, and aesthetic quality decreases as the water level continues to decline. Shoreline and access to water is limited by mud at this impact level, and floating debris and trash continues to be deposited on the exposed shoreline.

2.6. Unit Day Value Conversion

The points described above were converted to a dollar value based on the FY2017 UDV conversion table in EGM 17-03 (USACE 2016). The scores were interpolated linearly as necessary. Table 5 shows the point conversion table from the guidance, and Table 6 summarizes the converted values.

Table 5. FY17 UDV Conversion

General Recreation	
Point Values	**Values ($)**
0	$3.96
10	$4.70
20	$5.20
30	$5.94
40	$7.43
50	$8.42
60	$9.16
70	$9.66
80	$10.65
90	$11.39
100	$11.89
USACE CECW-CP EGM 17-03 for FY2017	

Table 6. Assigned Scores Converted

	Total Points	Value per Visit ($)
Lake Sidney Lanier		
Full Pool	95	$11.64
Initial Impact	91	$11.44
Recreation Impact	84	$10.95
Water Access Limited	65	$9.41
West Point Lake		
Full Pool	72	$9.86
Initial Impact	66	$9.46
Recreation Impact	58	$9.01
Water Access Limited	54	$8.72
Walter F George Lake		
Full Pool	90	$11.39
Initial Impact	85	$11.02
Recreation Impact	77	$10.35
Water Access Limited	56	$8.86

3. Recreation Value Calculations

Having completed estimates of visitation for each of the three projects and the UDV scoring, the two are combined to estimate recreation value. Recreation value was estimated for each alternative, including the No Action Alternative, and for each of the three projects.

The following example considers only Lake Sidney Lanier and the No Action Alternative. In order to estimate recreation value, the annual visits in each year of the period of analysis were proportionally applied to the four pool levels (full, initial, recreation, water access limited) according to the data shown in Table 1. Then visits for each pool level are multiplied by the corresponding UDV value in Table 6 to estimate recreation value by pool level. Adding up the four values corresponding to the four pool levels in a single year gives the estimate of total recreation value in that year. The total value for each year is then discounted using the FY 2017 discount rate of 2.875 percent to give the present value of recreation in that year. Then the values for each year in the period of analysis are summed to calculate the total present value of recreation for that scenario . This value is amortized to give average annual recreation value over the period of analysis.

This same calculation was completed for all the alternatives at each of the projects. Tables 7 through 9 summarize the results of the recreation valuation calculations. In the tables, the No Action Alternative is the first row, and the alternatives are sorted according to increasing annual recreation value.

Table 7. Lake Sidney Lanier Recreation Value Summary

	Annualized Recreation Value ($)	Present Value ($)	Annualized Change vs. No Action Alternative	Percent Change
No Action A	$79,579,000	$2,097,058,000	$0	0.00%
ALT 1 - Opt L	$79,406,000	$2,092,500,000	($173,000)	-0.22%
ALT 7 - Opt A	$79,699,000	$2,100,217,000	$119,900	0.15%
ALT 7 - Opt B	$80,131,000	$2,111,585,000	$551,300	0.69%
ALT 7 - Opt H	$79,336,000	$2,090,649,000	($243,200)	-0.31%
ALT 7 - Opt I	$79,384,000	$2,091,919,000	($195,000)	-0.25%
ALT 7 - Opt J	$80,052,000	$2,109,511,000	$472,600	0.59%
ALT 7 - Opt K	$79,363,000	$2,091,365,000	($216,000)	-0.27%
ALT 7 - Opt L	$79,648,000	$2,098,860,000	$68,400	0.09%
ALT 7 - Opt M	$79,516,000	$2,095,378,000	($63,700)	-0.08%

Table 8. West Point Lake Recreation Value Summary

	Annualized Recreation Value ($)	Present Value ($)	Annualized Change vs. No Action Alternative	Percent Change
No Action A	$21,532,000	$567,395,000	$0	0.00%
ALT 1 - Opt L	$21,567,000	$568,341,000	$35,900	0.17%
ALT 7 - Opt A	$21,520,000	$567,091,000	($11,600)	-0.05%
ALT 7 - Opt B	$21,526,000	$567,260,000	($5,100)	-0.02%
ALT 7 - Opt H	$21,573,000	$568,474,000	$40,900	0.19%
ALT 7 - Opt I	$21,558,000	$568,100,000	$26,700	0.12%
ALT 7 - Opt J	$21,565,000	$568,284,000	$33,700	0.16%
ALT 7 - Opt K	$21,566,000	$568,312,000	$34,800	0.16%
ALT 7 - Opt L	$21,575,000	$568,534,000	$43,200	0.20%
ALT 7 - Opt M	$21,568,000	$568,365,000	$36,800	0.17%

Table 9. Walter F. George Lake Recreation Value Summary

	Annualized Recreation Value ($)	Present Value ($)	Annualized Change vs. No Action Alternative	Percent Change
No Action A	$33,485,000	$882,403,000	$0	0.00%
ALT 1 - Opt L	$33,486,000	$882,408,000	$200	0.00%
ALT 7 - Opt A	$33,443,000	$881,290,000	($42,200)	-0.13%
ALT 7 - Opt B	$33,438,000	$881,141,000	($47,900)	-0.14%
ALT 7 - Opt H	$33,459,000	$881,704,000	($26,500)	-0.08%
ALT 7 - Opt I	$33,486,000	$882,418,000	$600	0.00%
ALT 7 - Opt J	$33,459,000	$881,691,000	($27,000)	-0.08%
ALT 7 - Opt K	$33,459,000	$881,714,000	($26,200)	-0.08%
ALT 7 - Opt L	$33,474,000	$882,094,000	($11,700)	-0.03%
ALT 7 - Opt M	$33,460,000	$881,731,000	($25,500)	-0.08%

4. SUMMARY CONCLUSIONS

As shown in Tables 6 through 8, none of the alternatives would be expected to provide positive net recreation effects compared to the No Action Alternative at all three of the projects. The magnitude of effect, positive or negative, estimated for nearly all the alternatives does not exceed 0.5 percent at any project; with the only exceptions being alternatives 7B and 7J at Lake Lanier, which were estimated to result in beneficial recreation effects of 0.69 percent and 0.59 percent compared to the No Action Alternative, respectively.

If the estimated recreation effects for all three projects are combined for each alterative, the results show that alternatives 7A, 7B, 7J, and 7L would provide positive net effects compared to the No Action Alternative, as shown in Table 10. For the remaining alternatives which provide negative net effects, the magnitude of effect is relatively minor, with a percent change of less than two tenths of a percent.

Table 10. Combined Recreation Value Summary (All 3 Lakes)

	Annualized Recreation Value ($)	Present Value ($)	Annualized Change vs. No Action Alternative	Percent Change
No Action A	$134,596,000	$3,546,856,000	$0	0.00%
ALT 1 - Opt L	$134,459,000	$3,543,249,000	($136,900)	-0.10%
ALT 7 - Opt A	$134,662,000	$3,548,598,000	$66,100	0.05%
ALT 7 - Opt B	$135,095,000	$3,559,986,000	$498,300	0.37%
ALT 7 - Opt H	$134,368,000	$3,540,827,000	($228,800)	-0.17%
ALT 7 - Opt I	$134,429,000	$3,542,437,000	($167,700)	-0.12%
ALT 7 - Opt J	$135,076,000	$3,559,487,000	$479,300	0.35%
ALT 7 - Opt K	$134,389,000	$3,541,391,000	($207,400)	-0.15%
ALT 7 - Opt L	$134,696,000	$3,549,488,000	$99,900	0.07%
ALT 7 - Opt M	$134,544,000	$3,545,474,000	($52,500)	-0.04%

5. REFERENCES

(USACE) U.S. Army Corps of Engineers. 25 October 2016. EGM 17-03 Unit Day Values for Recreation for Fiscal Year 2017. CECW-CP Memorandum for Planning Community of Practice. Retrieved online via https://planning.erdc.dren.mil/toolbox/library/EGMs/EGM17-03.pdf.

(USACE) U.S. Army Corps of Engineers. 25 October 2016. EGM 17-01 Federal Interest Rates for Corps of Engineers Project for Fiscal Year 2017. CECW-P Memorandum for Planning Community of Practice. Retrieved online https://planning.erdc.dren.mil/toolbox/library/EGMs/EGM17-01.pdf

.

Appendix N

USACE Institute for Water Resources
ACF Climate Change Support Analysis

This page intentionally left blank

Scientific evidence from the immediately preceding decades demonstrates that the natural climate might be changing (Stocker et al. 2013[1]), and the changes are expected to continue over the course of the 21st century. The anticipated changes might reflect shifts in the average or baseline conditions, regional meteorological phenomena, and the range of variability of those phenomena. The potential changes are raising concerns about the capacity of U.S. Army Corps of Engineers (USACE) projects and operations to accommodate different climatological baselines, greater climatological variation, and a wider range of meteorological conditions.

In response to public interest and USACE guidance, the Apalachicola-Chattahoochee-Flint (ACF) River Basin Master Water Control Manual Update Project Delivery Team engaged the Institute for Water Resources (IWR) to develop a numerical modeling analysis that can be used to evaluate the resilience and limitations of proposed ACF water management scenarios in relation to climate change. The ACF numerical model was written to correlate with the Hydrologic Engineering Center-Reservoir System Simulation (HEC-ResSim) and System Water Quality Modeling (HEC-5Q) of the ACF system. The HEC-ResSim and HEC-5Q software was developed by the USACE Hydrologic Engineering Center (HEC) and is now the standard for USACE reservoir operations modeling. Allowing the model-projected unimpaired flow (UIF) to be run in HEC-ResSim and HEC-5Q would give a sense of the effects of prospective climate change on hydrology and water quality in the ACF Basin. (UIF is also used interchangeably with antecedent data in this summary.) The objective of the IWR effort was a quantitative analysis of potential climate change in ACF Basin hydrology and, by extension, ACF Basin management.

The effort capitalized on existing data and analysis developed by a coalition of agencies and academic institutes as part of the Coupled Model Intercomparison Project phase 5 (CMIP5). In broad terms, an atmospheric general circulation model (GCM) numerically representing the physical processes (e.g., atmospheric, ocean, land surface) was employed to estimate the potential range of climate change due to man-made influences. The GCM outputs were statistically scaled to a finer time and space scale, and bias-corrected to describe anticipated conditions in the ACF Basin. The scaled and bias-corrected GCM outputs were applied to a variable infiltration capacity (VIC) model to predict rainfall-runoff relationships for the basin (Liang et al. 1994[2]). The Liang VIC model is a globally applied, open-source, macroscale hydrologic model that solves full water-energy balances (Liang et al. 1994). VIC model output for future climate model projections has been calculated for the contiguous U.S. and is available

[1] Stocker, T.F., D. Qin, G.-K. Plattner, L.V. Alexander, S.K. Allen, N.L. Bindoff, F.-M. Bréon, J.A. Church, U. Cubasch, S. Emori, P. Forster, P. Friedlingstein, N. Gillett, J.M. Gregory, D.L. Hartmann, E. Jansen, B. Kirtman, R. Knutti, K. Krishna Kumar, P. Lemke, J. Marotzke, V. Masson-Delmotte, G.A. Meehl, I.I. Mokhov, S. Piao, V. Ramaswamy, D. Randall, M. Rhein, M. Rojas, C. Sabine, D. Shindell, L.D. Talley, D.G. Vaughan, and S.-P. Xie, 2013: Technical summary. In Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Doschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley, Eds. Cambridge University Press, 33-115, doi:10.1017/CBO9781107415324.005.

[2] Liang, X., Lettenmaier, D.P., Wood, E.F., Burges, S.J. (1994). *A simple hydrologically based model of land surface water and energy fluxes for general circulation models*. Journal of Geophysical Research, Volume 99, No. D7, Pages 14,415-428.) retrieved from http://www.hydro.washington.edu/Lettenmaier/Models/VIC/index.shtml

at http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/. It should be noted that these models have not been certified in accordance with USACE model certification guidance.

The U.S. Geological Survey (USGS) has classified watershed drainage areas using a hierarchical system in which each contiguous drainage area is assigned a hydrologic unit code (HUC). The first two levels of the hierarchy identify the region (HUC 2) and subregion (HUC 4). The U.S. contains 222 HUC 4s with an average size of 16,800 mi^2. To detail the ACF numerical model, the hydrological features of the HUC 4 for the ACF Basin were employed as the UIF. The VIC model, building from the UIF, generated local and cumulative flow projections of the ACF HUC 4.

The CMIP5 global carbon projects evaluated a number of different representative concentration pathways (RCPs) that describe different trajectories of greenhouse gas emissions (i.e., carbon dioxide, methane, nitrous oxide, and fluorocarbons). For the ACF Basin, the range of hydrologic responses produced from different GCMs is larger than the difference among RCPs; therefore, the decision was made not to select specific RCPs but rather to treat them all as equally plausible for this analysis.

The full set of 100 available ACF Basin HUC 4 hydrologic projections was tabulated for two future time periods: Years 2021–2050 and years 2061–2090. An empirical cumulative distribution function (ECDF) was developed for both sets of hydrologic projections (i.e., 2021–2050 and 2061–2090). The purpose of the ECDF is to support an estimate of the frequency and degree of climate change occurrences throughout the period of analysis.

With regard to ACF Basin analysis, the ECDF approximates potential changes in volume of runoff from in the basin. The approximations are used to develop monthly volumes that can be compared to the ACF Basin UIF antecedent flow set (1970–1999). ECDF change ratios were created by dividing the 30-year hydrologic projections (2021–2050 and 2061–2090) by the antecedent UIF for 1970–1999 to establish a ratio for each HUC 4 data point.

The ECDF-generated ratio values were plotted against three quantiles representing basin hydrologic conditions (10th percentile [wet], 50th percentile [median], and 90th percentile [dry]) (see Figure 1). These values were further subdivided to create plots that represented each quantile by month for both the 2021–2050 and the 2061–2090 hydrologic projections.

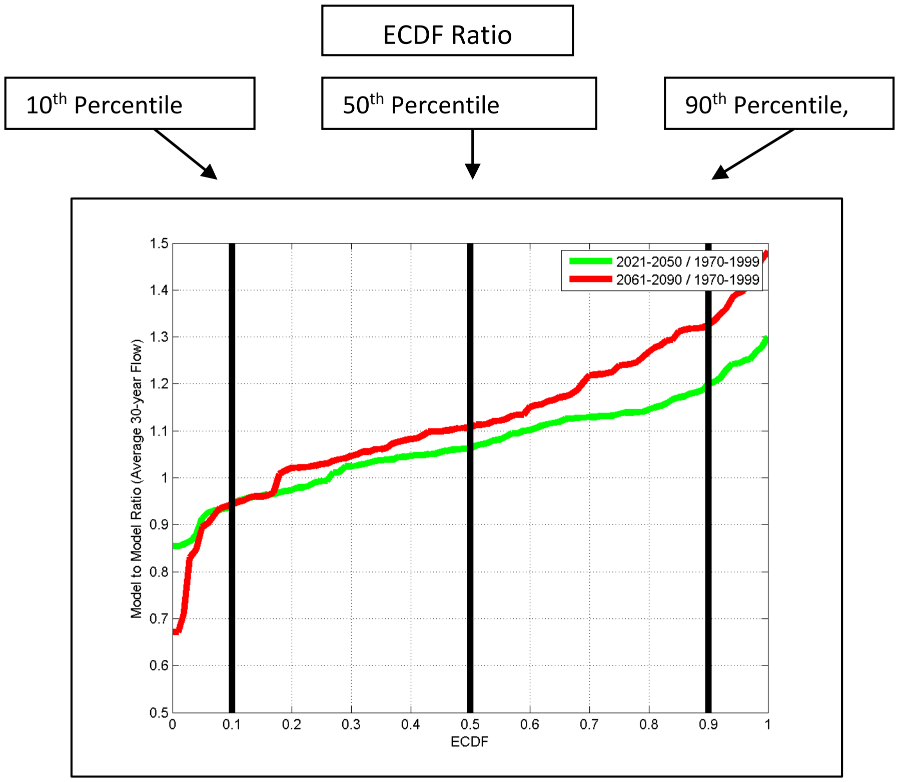


Figure 1. ECDF-generated model to model ratio for two time periods

The UIF antecedent data set was averaged by month, then the monthly average flows were mapped to the appropriate quantile plot. This process yielded a series of plots that represented the future hydrologic ECDF ratios and the antecedent UIF ECDF for each month in each quantile, resulting in a visual representation of the same drainage location in the same month (see Figure 2 for an example of the 10th percentile [Quartile 1] dry projection for 2021–2050 [Time Period 1]). The projected future ECDF HUC 4 data point was divided by the newly positioned antecedent ECDF data point to yield a new ratio. The new ratio was applied to the antecedent UIF to produce a new UIF that reflects climate change conditions.

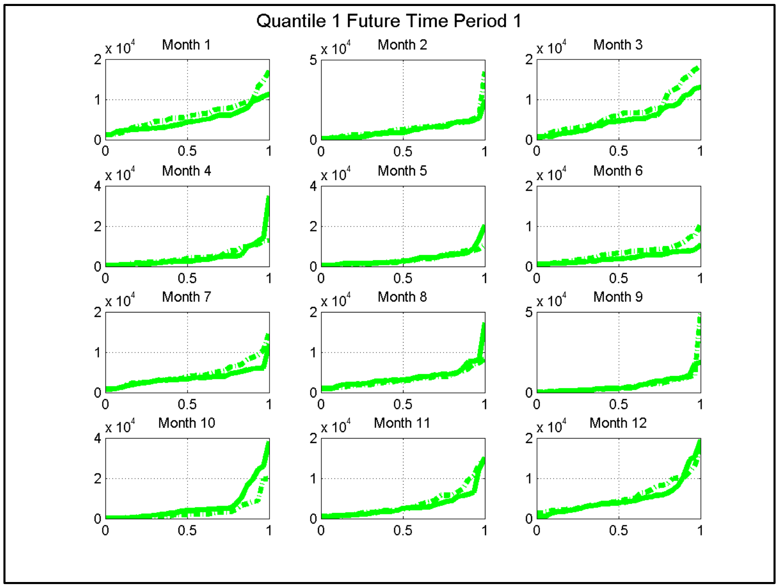


Figure 2. Example of the 10^{th} Percentile (Quartile 1) Dry Projection for 2021–2050 (Time Period 1)

To ensure compatibility with the HEC-ResSim and HEC-5Q models, it was necessary to convert the climate change-affected UIF monthly values produced to a daily time step. A monthly ratio was applied to the UIF daily value for each month. The process output was a climate change-adjusted UIF adapted to a daily time step that can be used in the HEC-ResSim model to speculate how climate change might affect the ACF Basin. This climate change-affected UIF was run in the ACF HEC-ResSim model to generate outputs that approximate the effects of ACF water management scenarios under the climate change-influenced hydrology.

Details of this process are provided in *Apalachicola-Chattahoochee-Flint Climate Change Support Analysis*, performed by USACE Institute for Water Resources, and authored by Dr. David Raff, PhD, P.E., D.WRE, and Dr. Jeff Arnold, PhD.

For the purposes of the ACF Master Water Control Manual Update climate change analysis, only the climate change-affected UIF for 2021–2050 was carried forward. Years 2021–2050 most closely match the anticipated project lifespan used in the National Environmental Policy Act documentation and in the water supply storage assessment analyses. The climate change-affected UIF was used in the ACF HEC-ResSim model to craft a hydrologic range that might occur if climate change trends continue.

This analysis generally assesses the capacity of the operations described as the Proposed Action Alternative (PAA) to meet the congressionally authorized purposes of the ACF system of federal reservoirs under climate change-adjusted conditions. The analysis, using water quality as an analytic proxy, also makes a general appraisal of impacts to biological resources.

The PAA and the No Action Alternative (NAA) were plotted against the climate change-adjusted UIF to ascertain if operational scenarios could be supported by the projected future hydrology. The plots indicated that the climate change-adjusted flows are sufficient to support current water management activities as well as water management activities described in the PAA, illustrating that either operational scenario would be achievable given the ACF system's climate-adjusted flows.

The plotting analysis brought to light no noteworthy deviations between the baseline (i.e., the NAA) and the PAA (see Figure 3 through Figure 16). This finding implies that the effects of operating under the PAA are essentially the same as those resulting from operating under the NAA. Both scenarios are sufficiently resilient to effectively management the federal projects for congressionally authorized purposes under the climate change-affected UIFs.

The climate-adjusted UIF follows the same seasonal trends as the present-day UIF. However, the climate change-adjusted UIF high and low boundaries show greater extremes. Comparing the climate change-adjusted high and low extremes to the period of record identify no conditions that were consistently more severe than those that have been historically experienced in the ACF Basin.

HEC-5Q water quality model outputs were developed to provide a general sense of environmental impacts when the PAA was run under climate change-affected conditions. The dry (90^{th} percentile) scenarios yielded ACF flows similar to actual flows experienced in 2001–2011. This result implies that more water could be in the ACF system under climate change conditions.

Concentrations of water quality constituents in the PAA and those projected to occur in 2050 are similar; median concentrations during wet years are generally less. Figure 17 through Figure 25 illustrate this finding for various water quality parameters. The ranges are reasonable for the parameters considered. The chlorophyll *a* range is also reasonable, but can be expected to be a function of nutrient loads in the ACF system.

The climate change-adjusted water quality scenarios displayed increased water temperature, as compared to the PAA, throughout the length of the ACF Basin. The system-wide consistency of the increased temperatures implies that it is the function of a systemic condition that is outside the influence of the NAA or PAA. For the purposes of modeling and analysis of the model outputs, it was assumed that the increased water temperature was attributable to the increased air temperature projected in the climate change model.

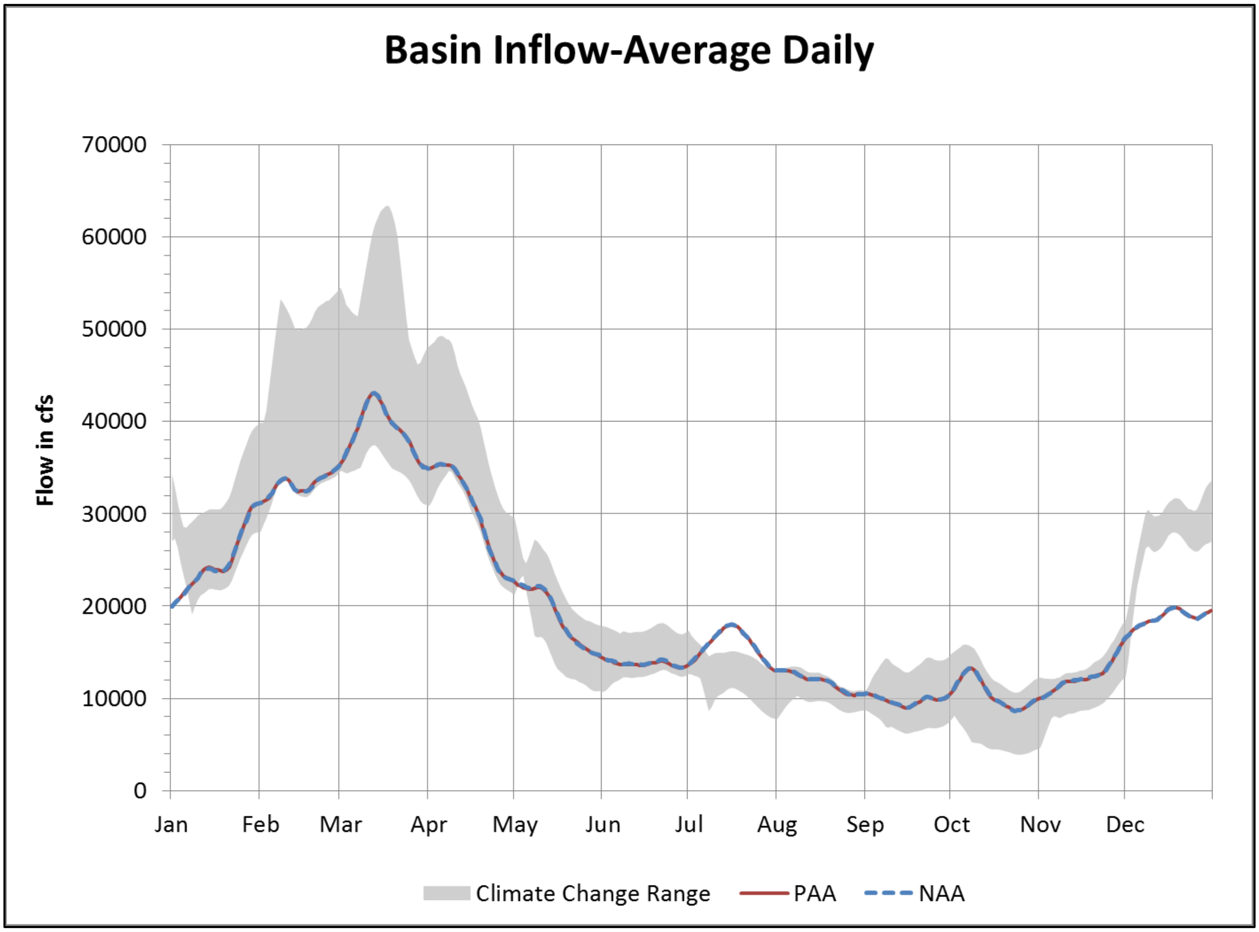


Figure 3. Comparison of Daily Average Basin Inflow between the NAA, PAA and Range of Climate Change

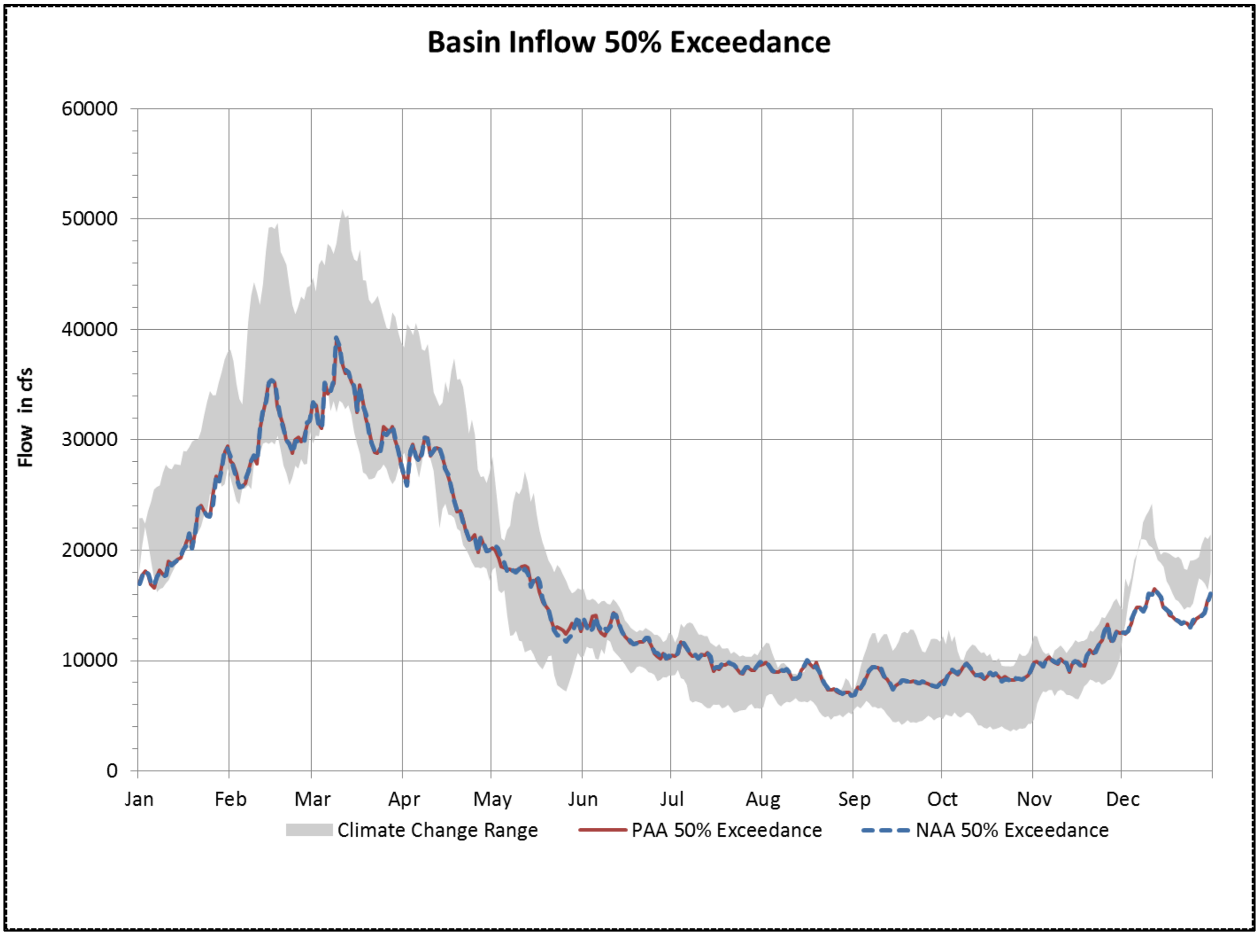


Figure 4. Comparison of Basin Inflow Median Exceedance between the NAA, PAA and Range of Climate Change

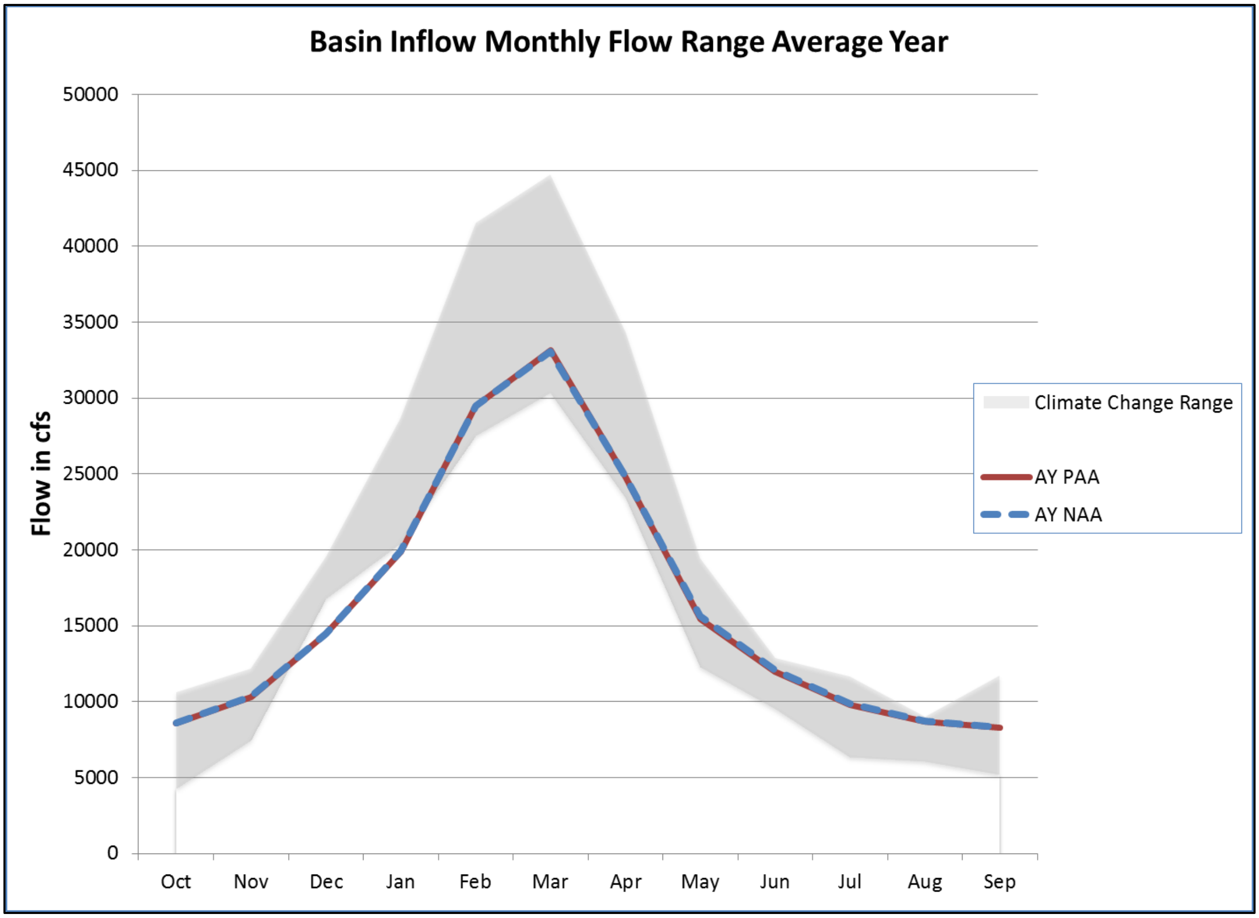


Figure 5. Comparison of Monthly Basin Inflow in an Average Year between the NAA, PAA and Range of Climate Change

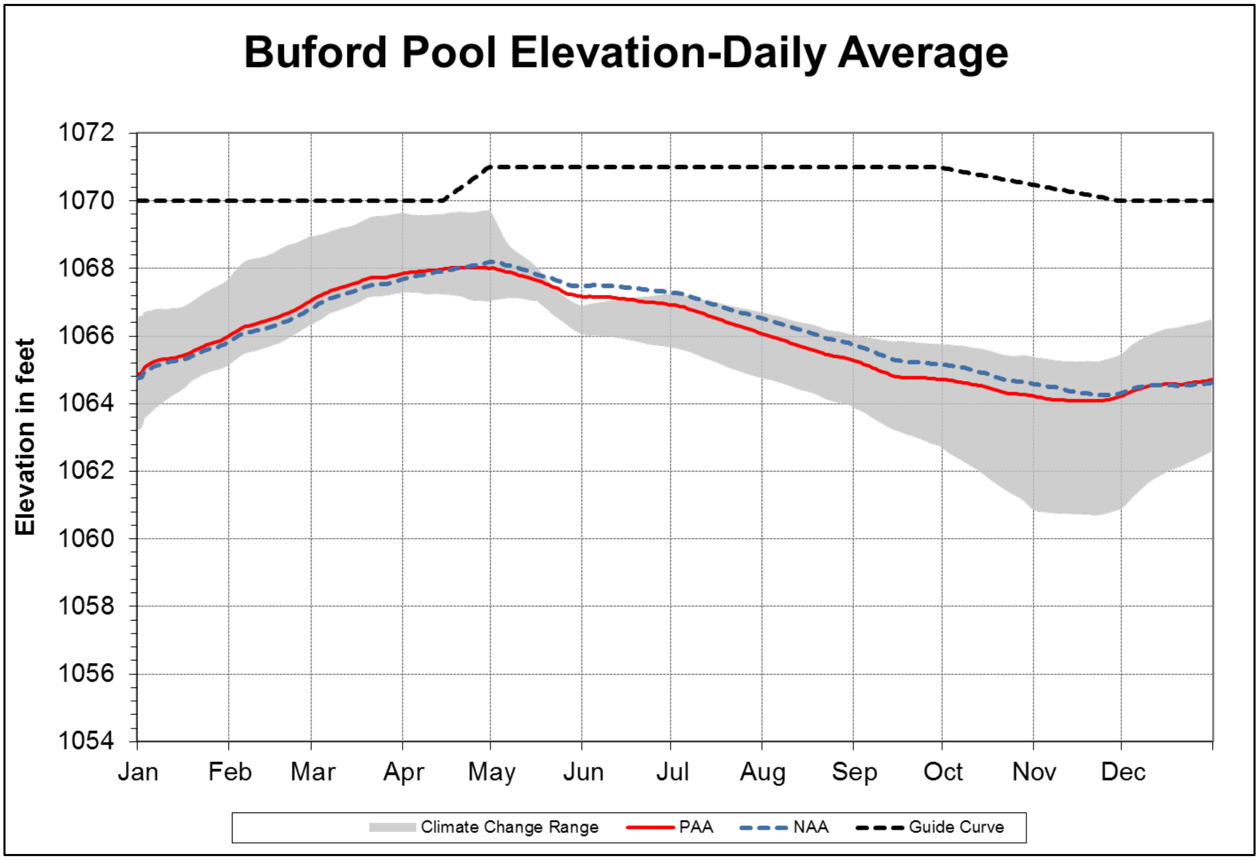


Figure 6. Comparison of Daily Average Buford Pool Elevation between the NAA, PAA and Range of Climate Change

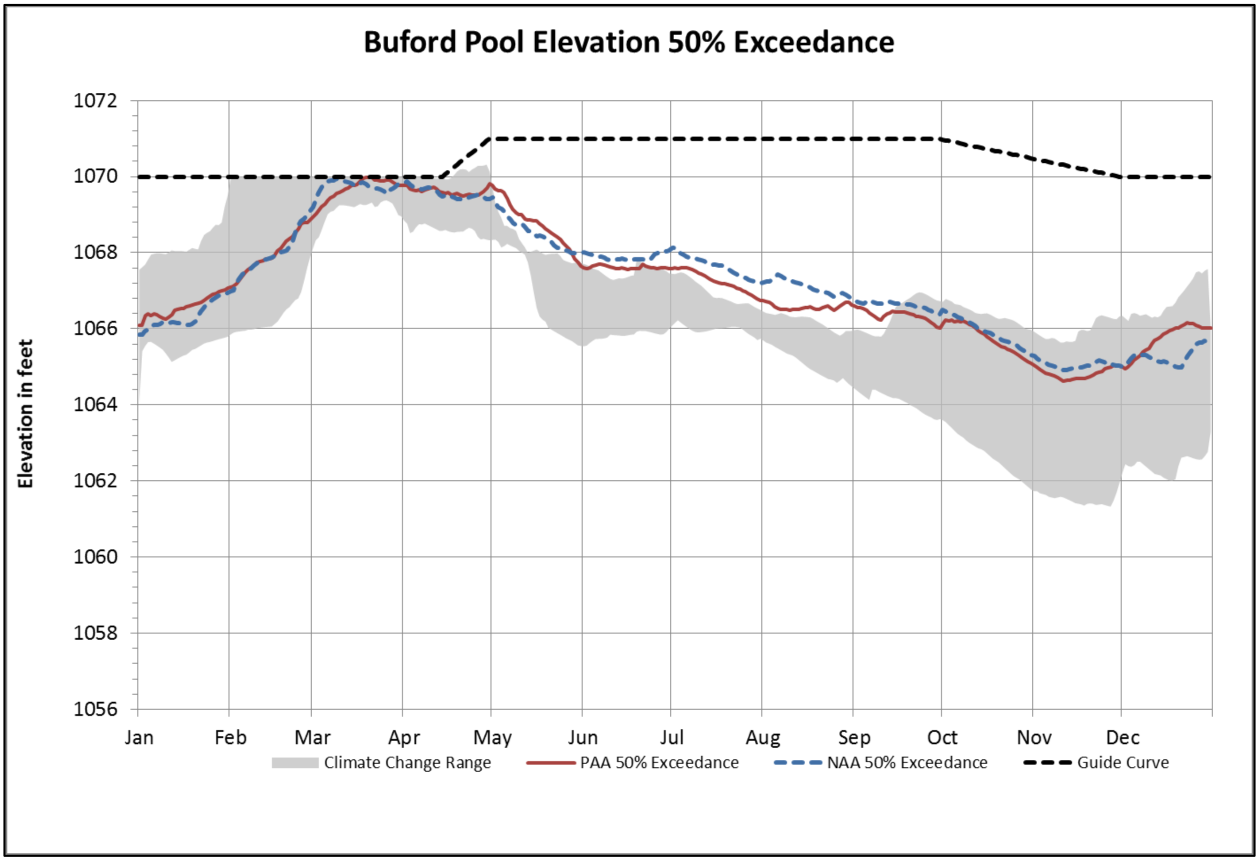


Figure 7. Comparison of Median Exceedance of Buford Pool Elevation between the NAA, PAA and Range of Climate Change

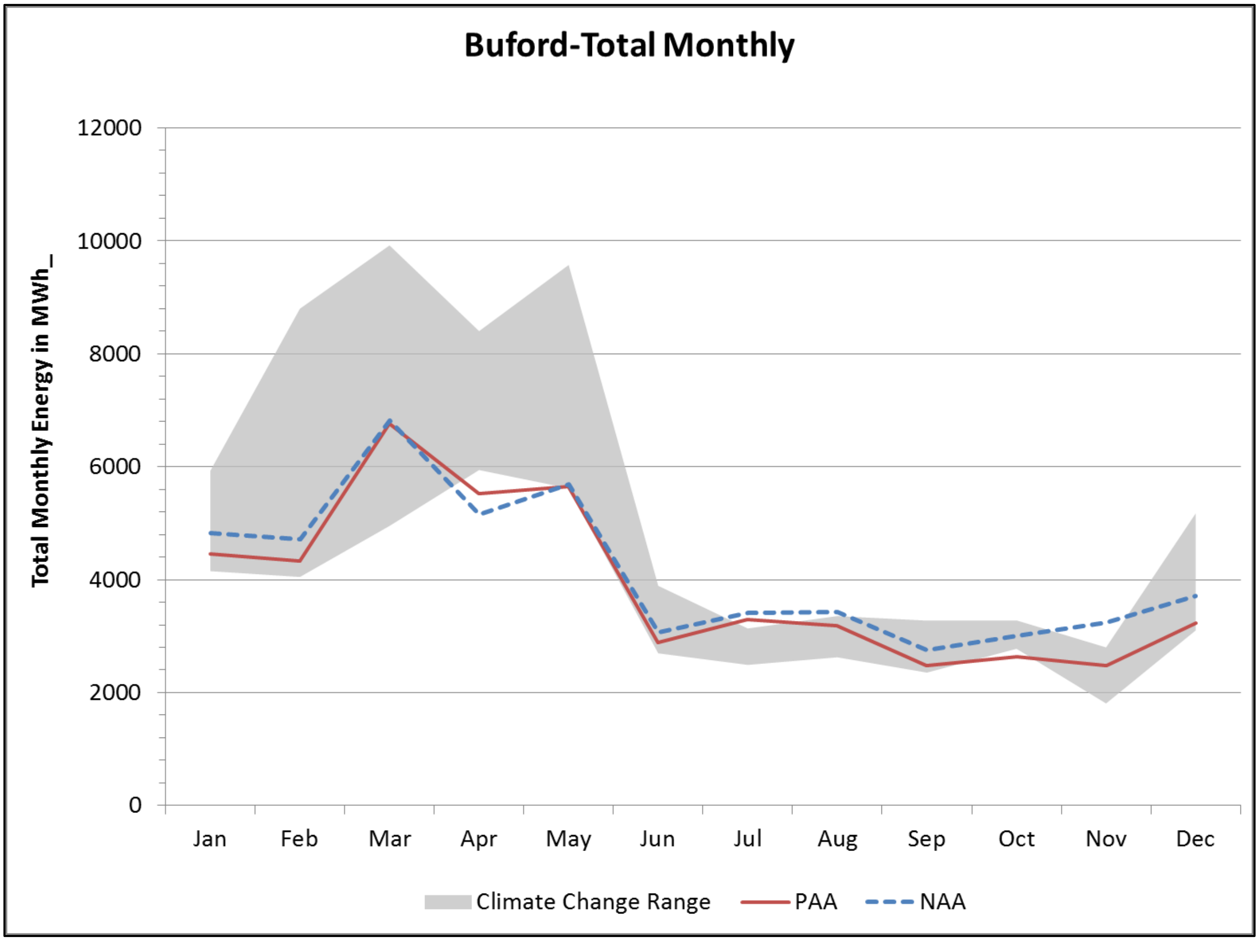


Figure 8. Comparison of Total Monthly Energy Generated in Megawatt Hours from the Buford Pool between the NAA, PAA and Range of Climate Change

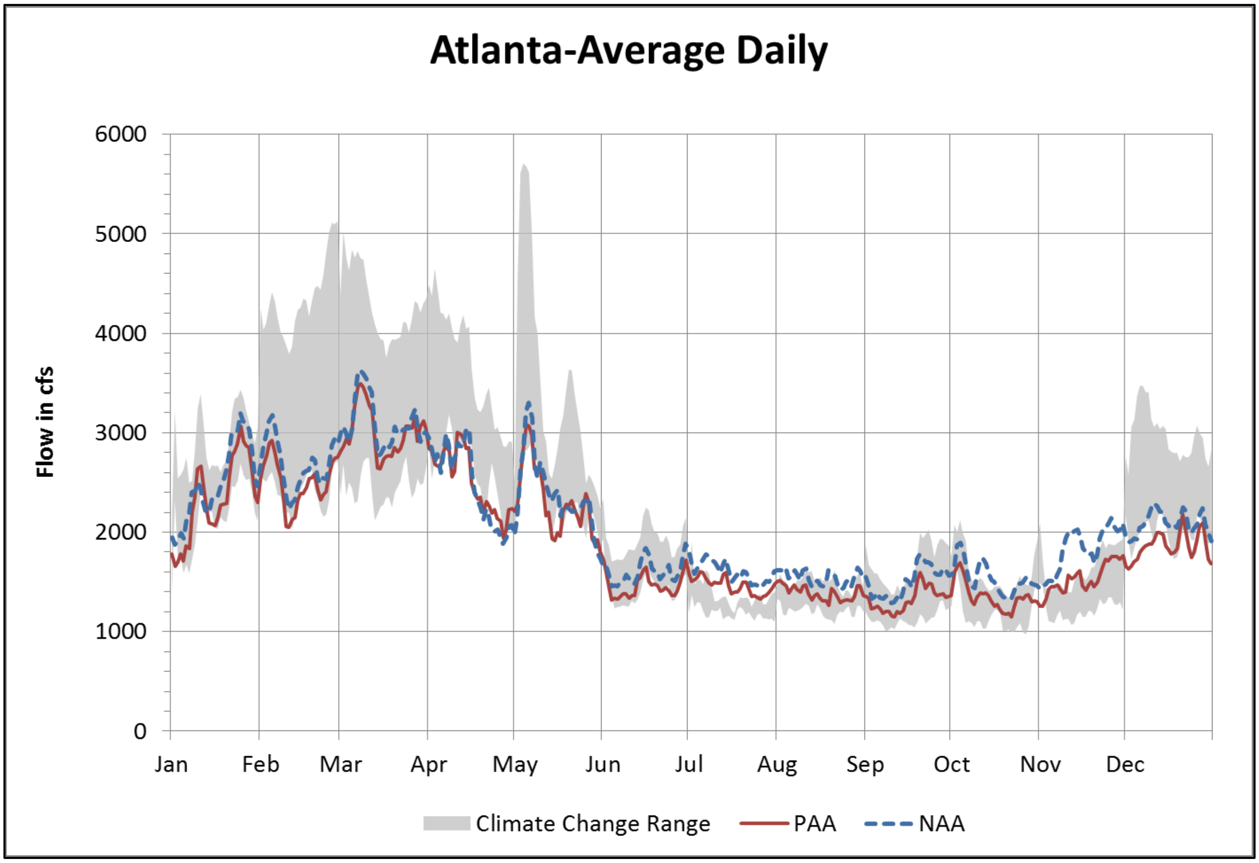


Figure 9. Comparison of Daily Average Flow between the NAA, PAA and Range of Climate Change in Atlanta, Georgia

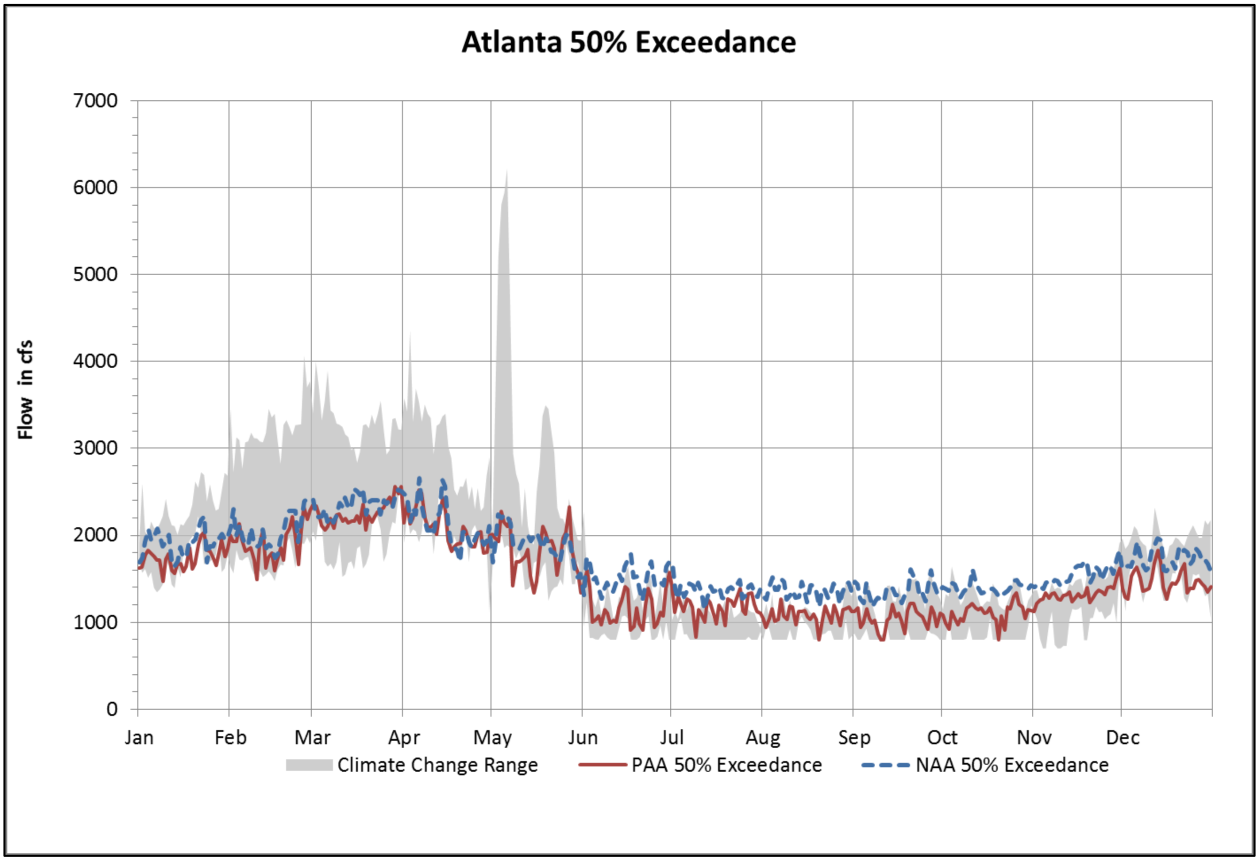


Figure 10. Comparison of the Median Exceedance of Flow between the NAA, PAA and Range of Climate Change in Atlanta, Georgia

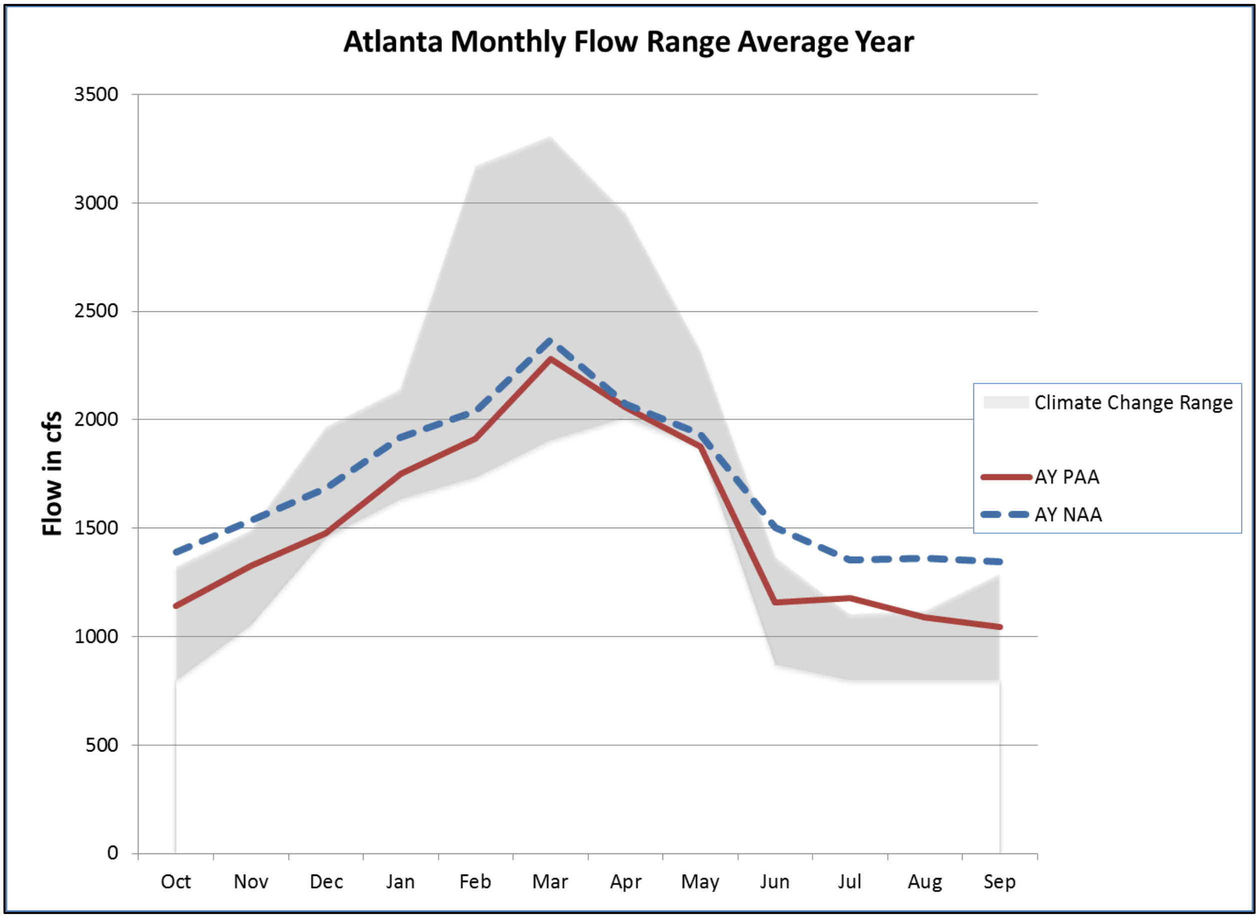


Figure 11. Comparison of Monthly Flow in Atlanta, Georgia in an Average Year between the NAA, PAA and Range of Climate Change

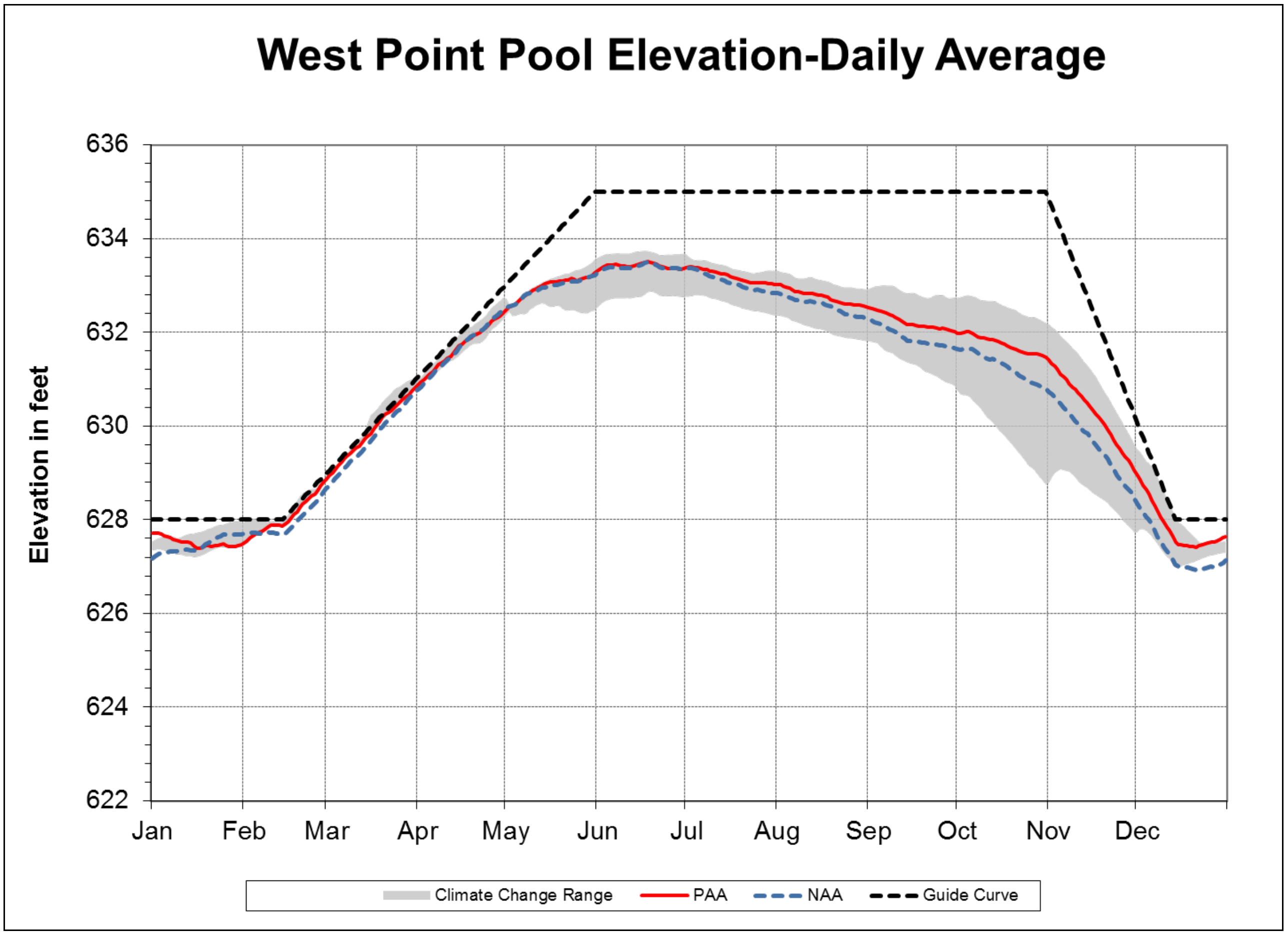


Figure 12. Comparison of Daily Average West Point Pool Elevation between the NAA, PAA and Range of Climate Change

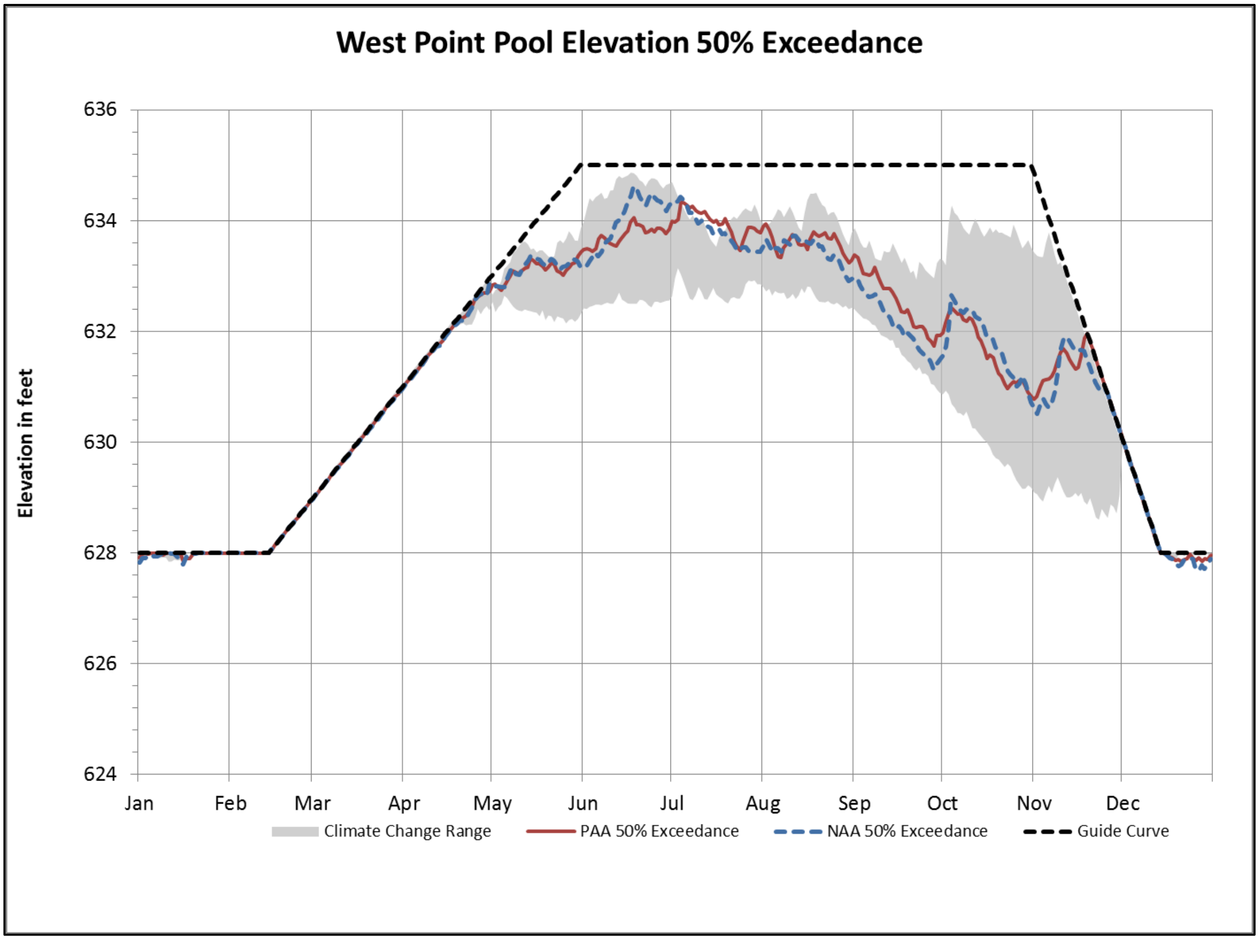


Figure 13. Comparison of Median Exceedance of West Point Pool Elevation between the NAA, PAA and Range of Climate Change

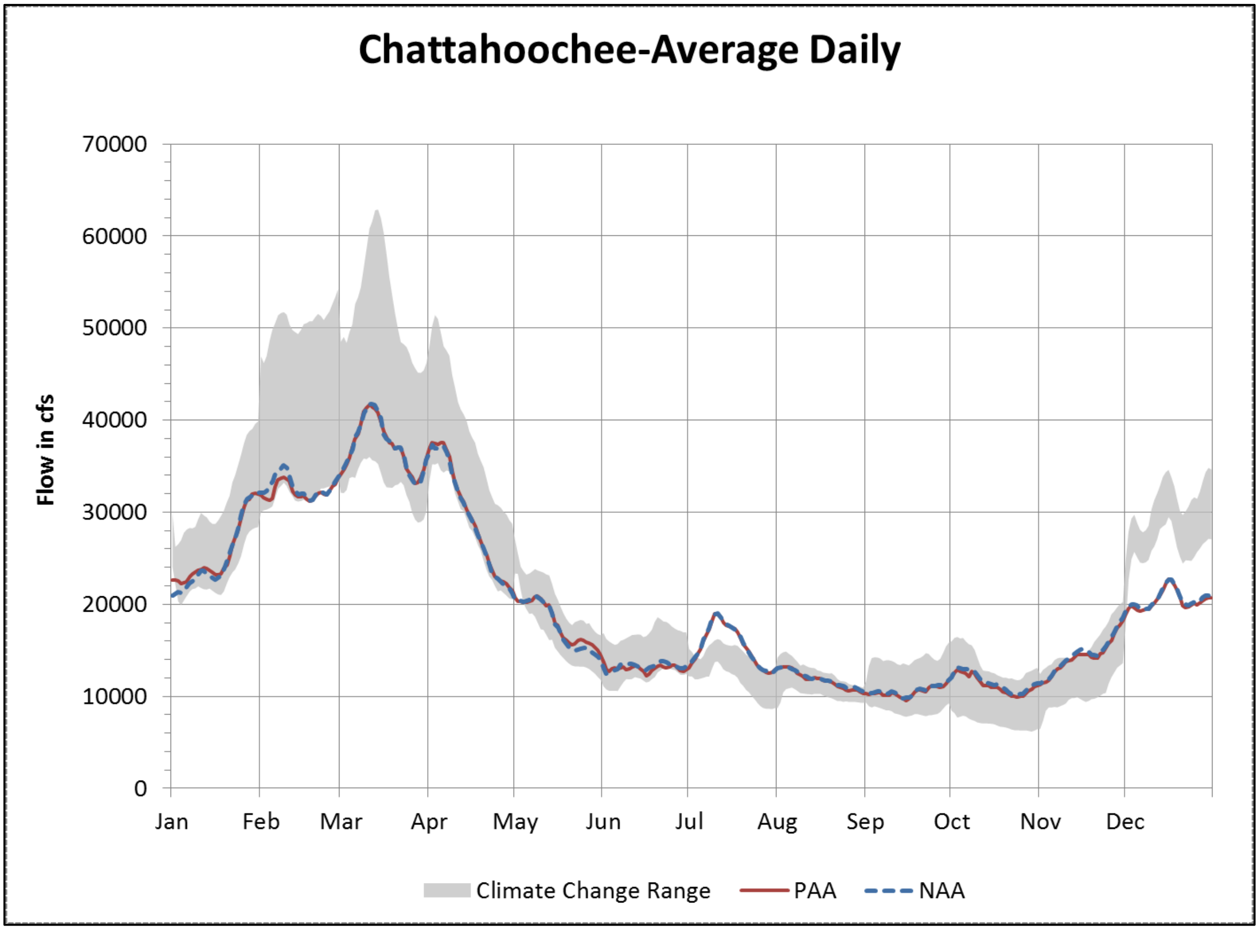


Figure 14. Comparison of Daily Average Flow between the NAA, PAA and Range of Climate Change in Chattahoochee, Florida

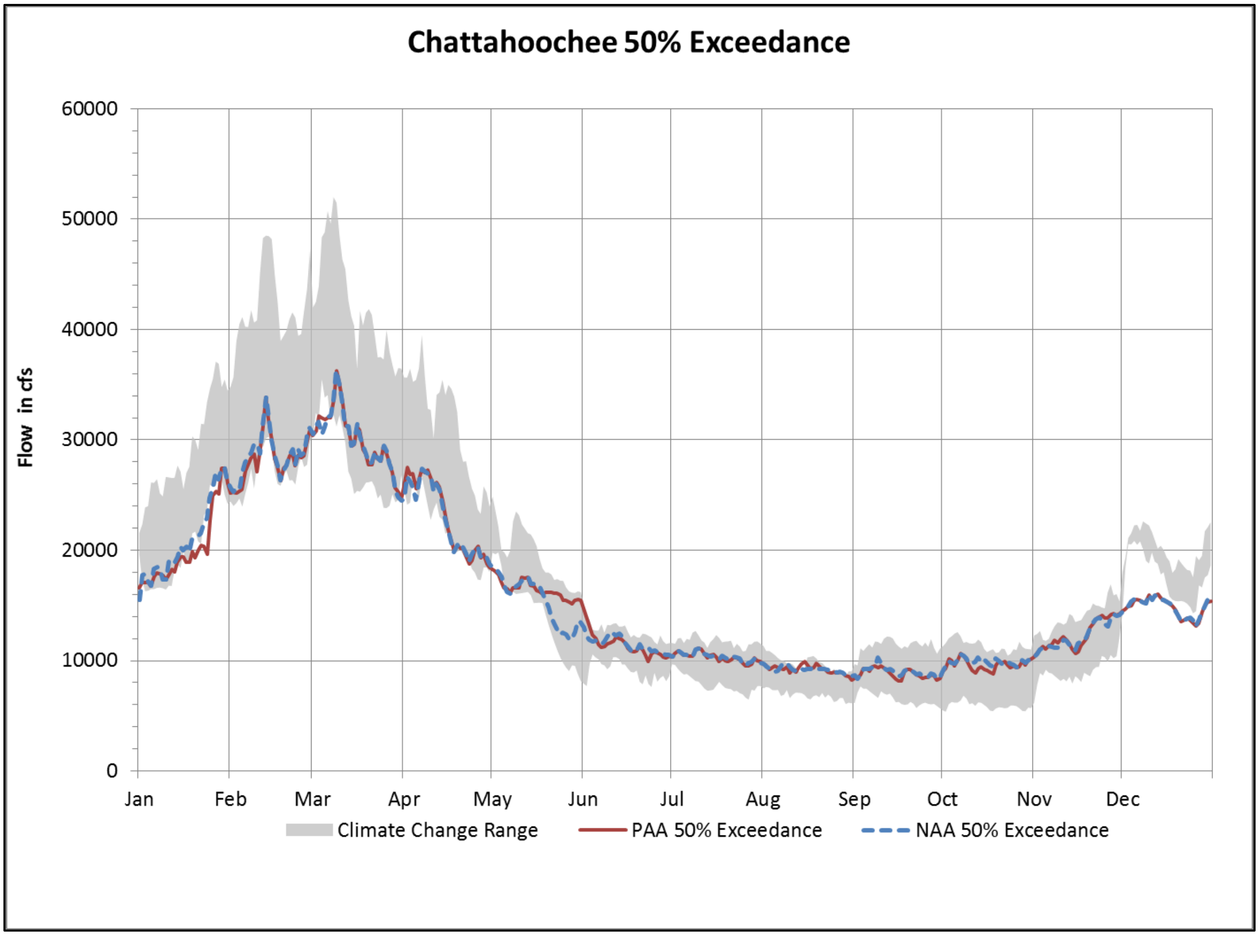


Figure 15. Comparison of the Median Exceedance of Flow between the NAA, PAA and Range of Climate Change in Chattahoochee, Florida

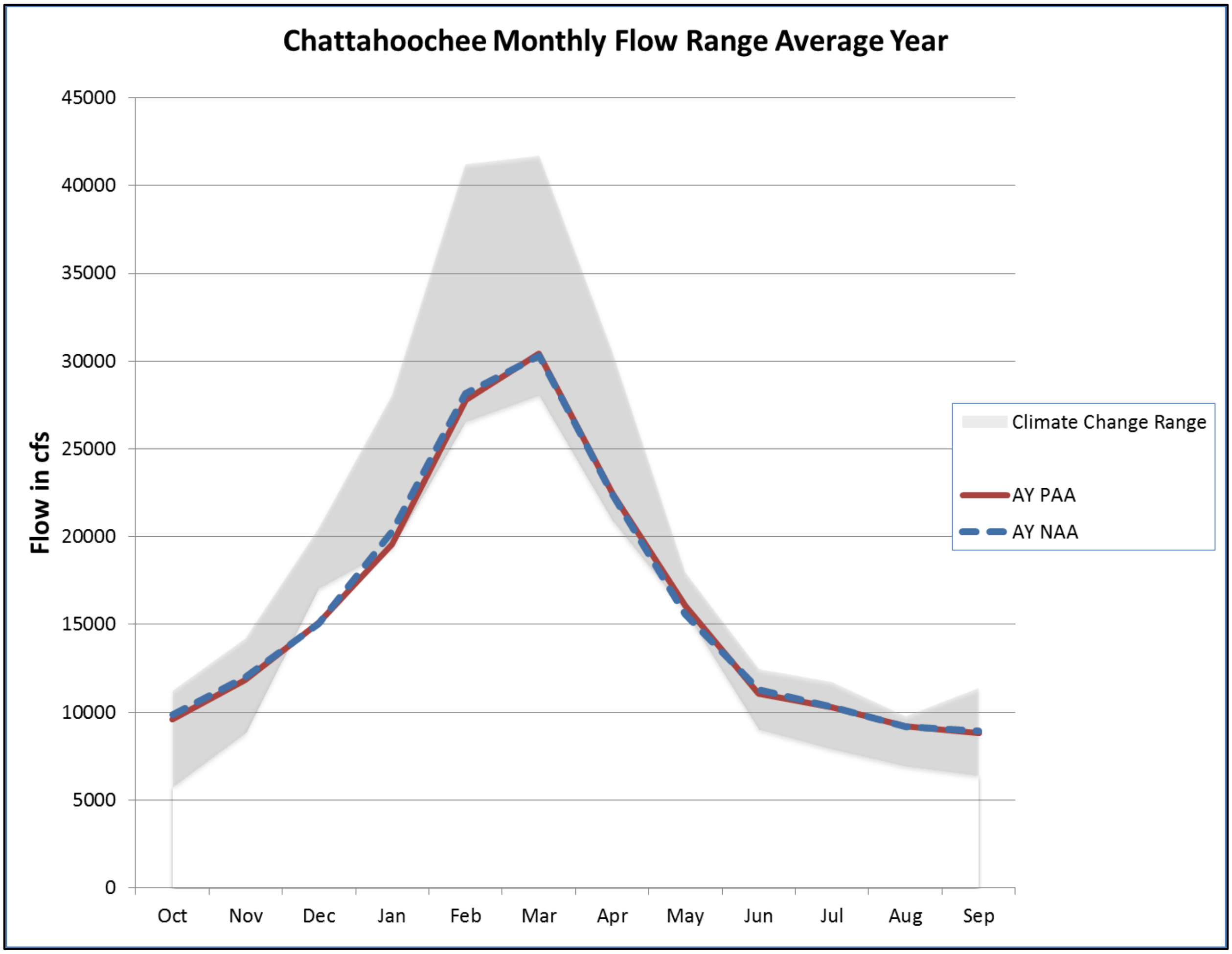


Figure 16. Comparison of Monthly Flow in Chattahoochee, Florida in an Average Year between the NAA, PAA and Range of Climate Change in Chattahoochee, Florida

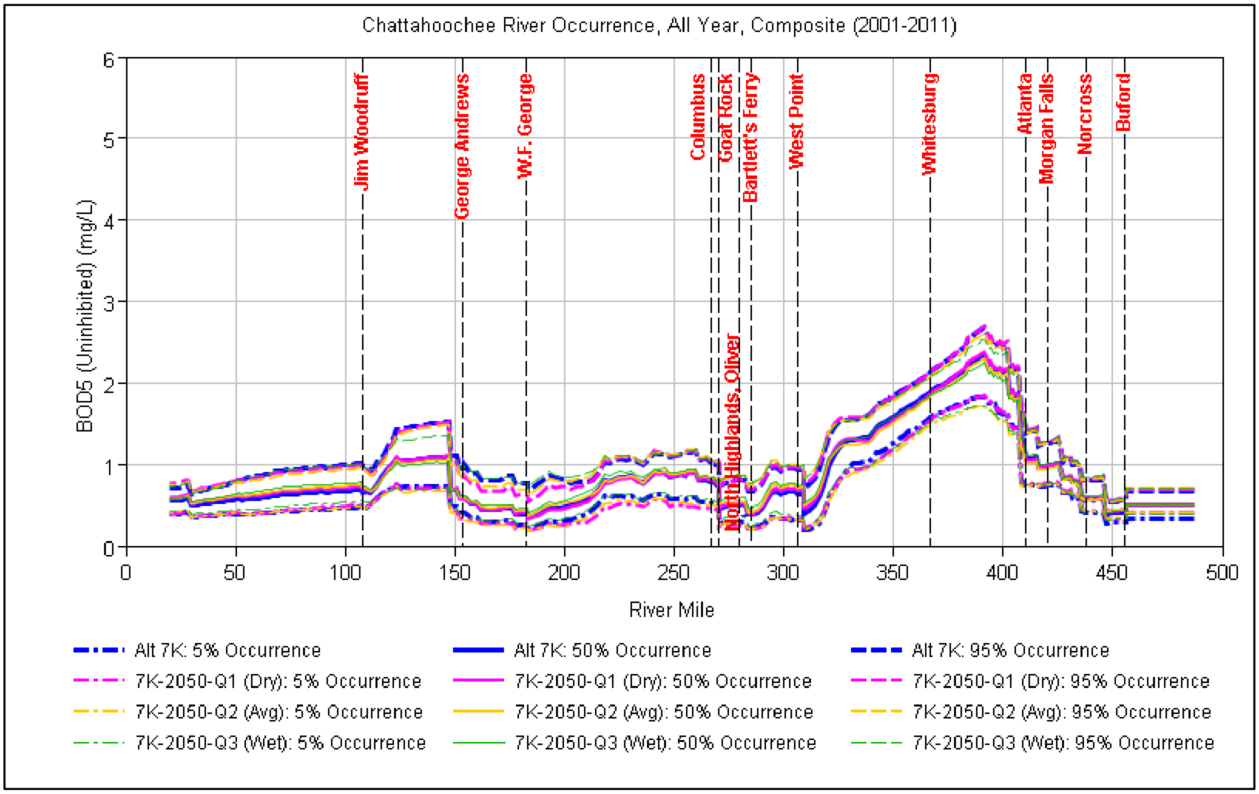


Figure 17. Longitudinal Profile of Modeled BOD5 in the ACF Basin (2001–2011) for the PAA (Alt7K) and three Climate Scenarios

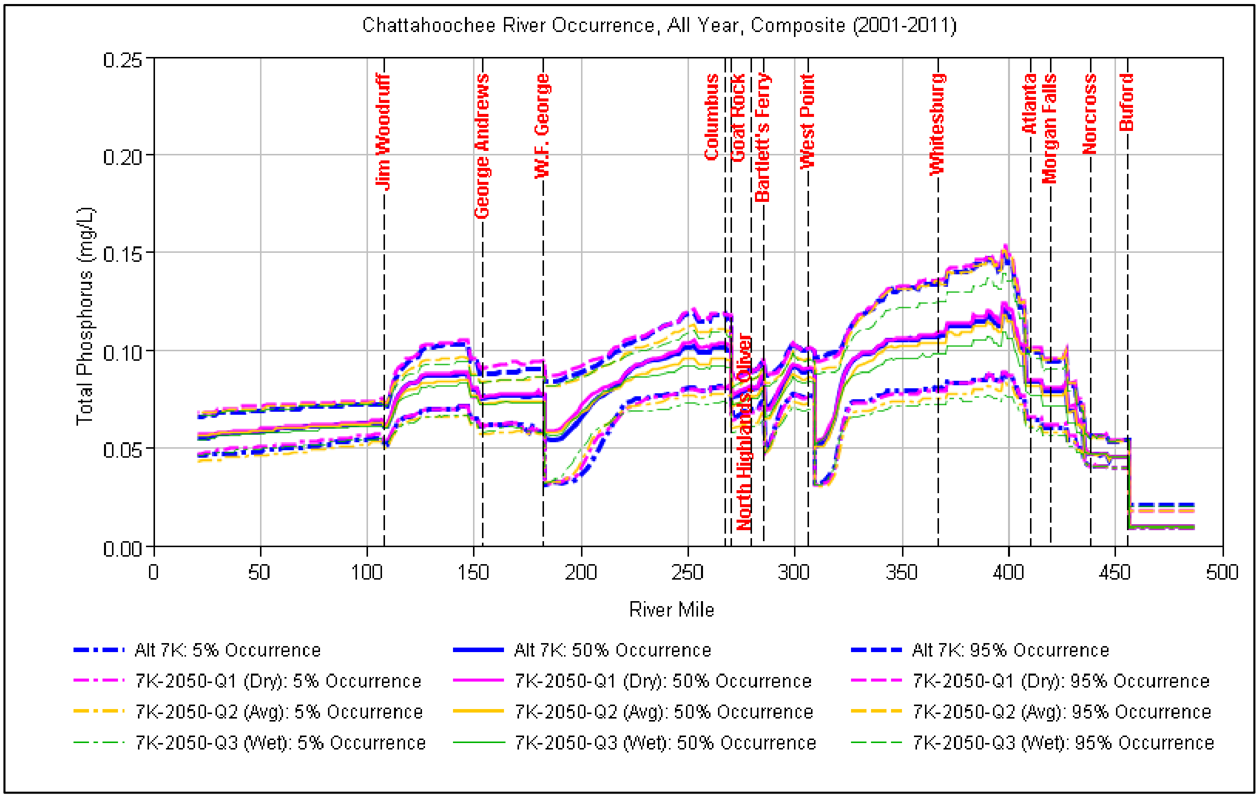


Figure 18. Longitudinal Profile of Modeled Total Phosphorus in the ACF Basin (2001–2011) for the PAA (Alt7K) and three Climate Scenarios

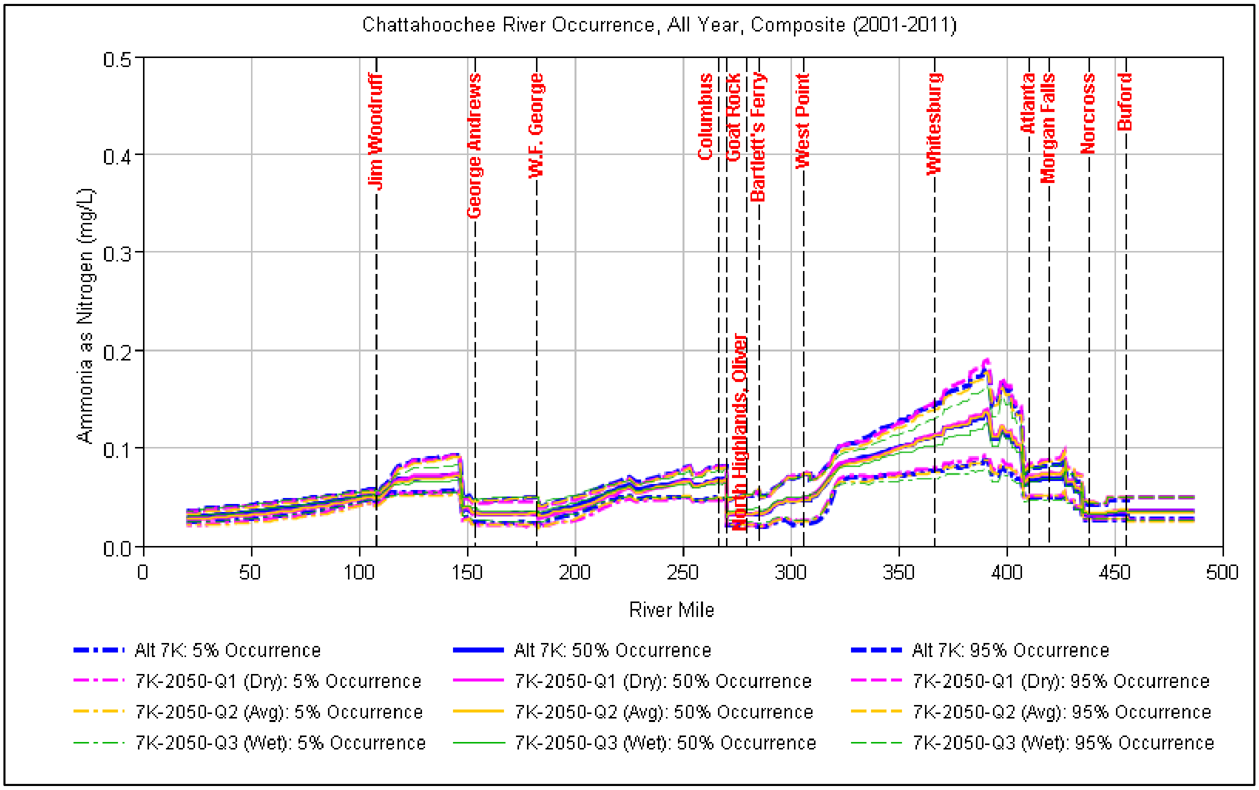


Figure 19. Longitudinal Profile of Modeled Ammonia in the ACF Basin (2001–2011) for the PAA (Alt7K) and three Climate Scenarios

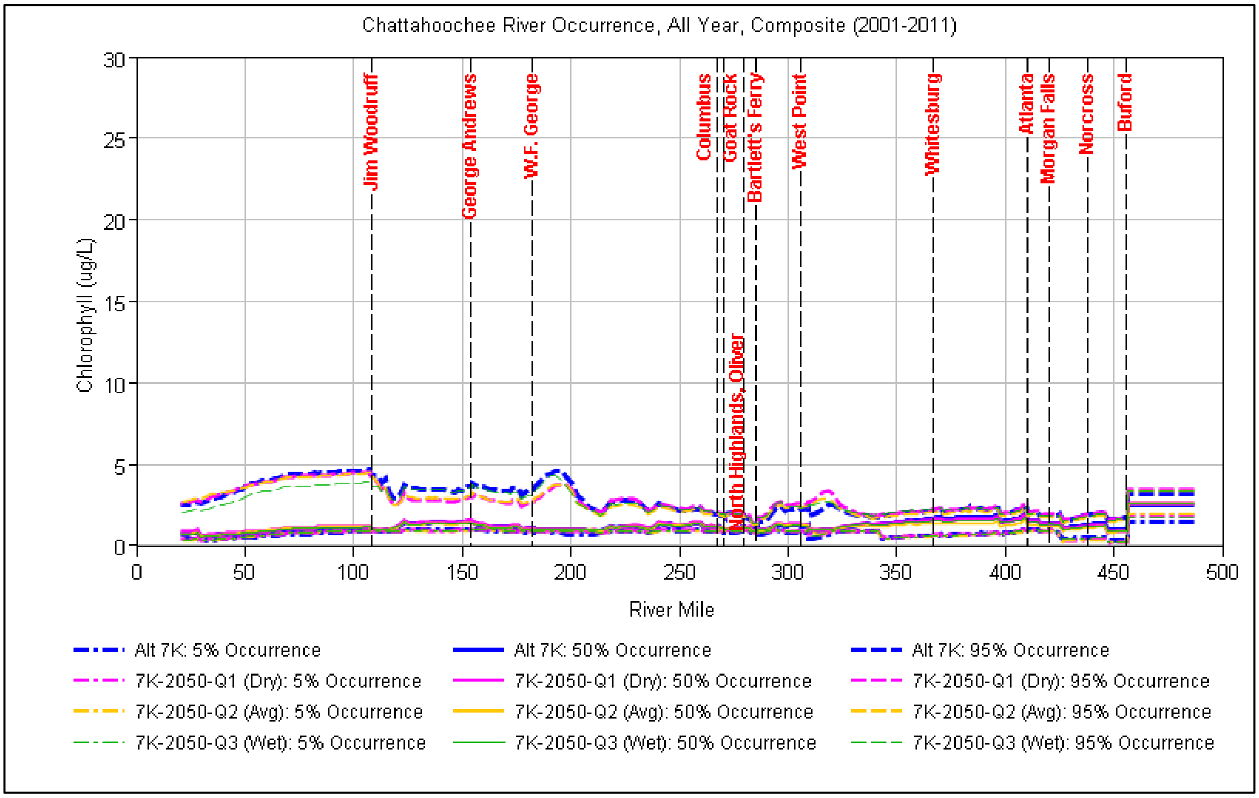


Figure 20. Longitudinal Profile of Modeled Chlorophyll in the ACF Basin (2001–2011) for the PAA (Alt7K) and three Climate Scenarios

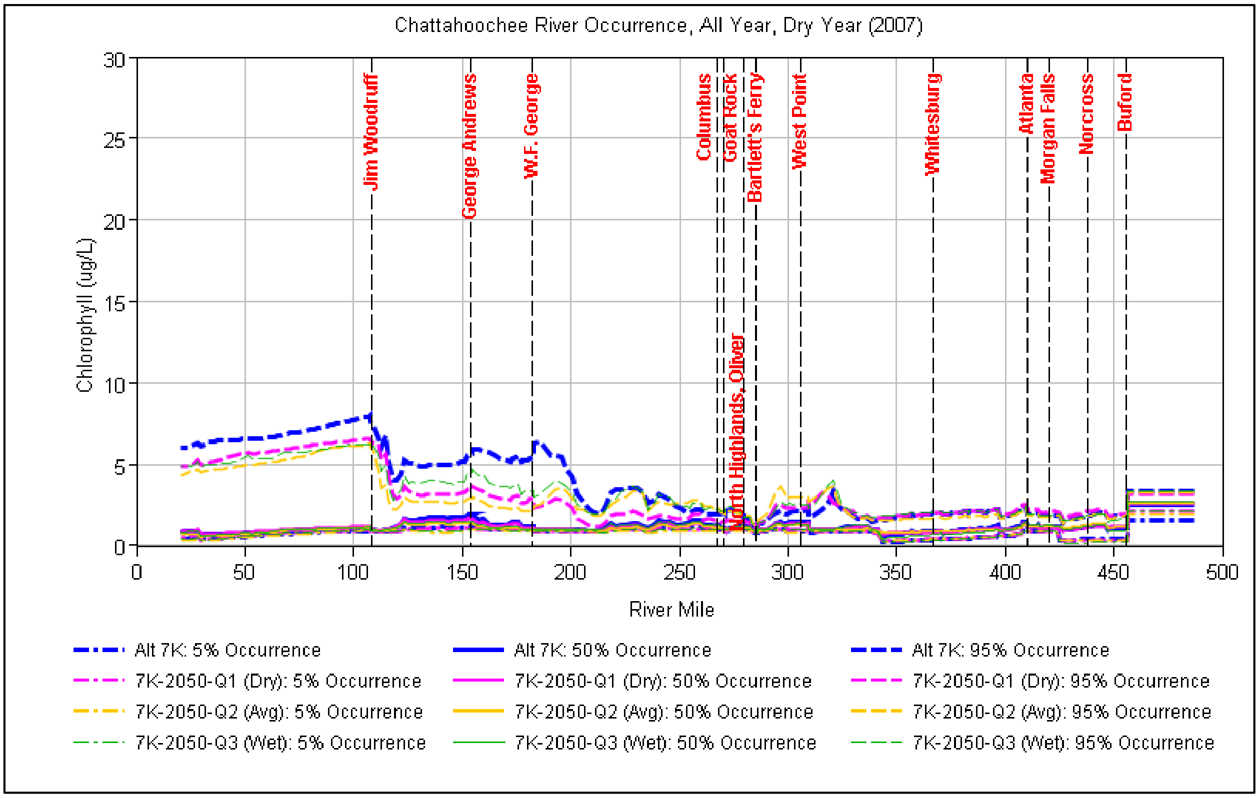


Figure 21. Longitudinal Profile of Modeled Chlorophyll in the ACF Basin for the Representative Dry Period (2007) for the PAA (Alt7K) and three Climate Scenarios

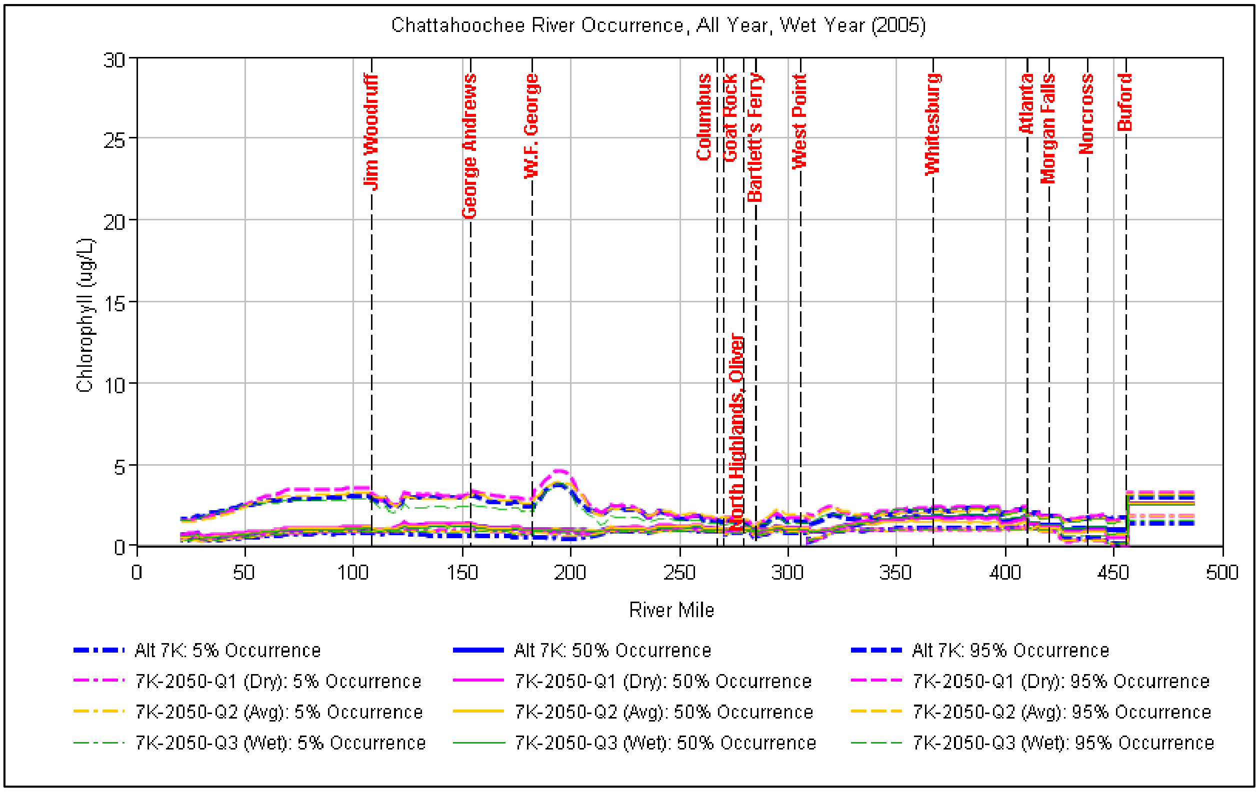


Figure 22. Longitudinal Profile of Modeled Chlorophyll in the ACF Basin for the Representative Wet Period (2005) for the PAA (Alt7K) and three Climate Scenarios

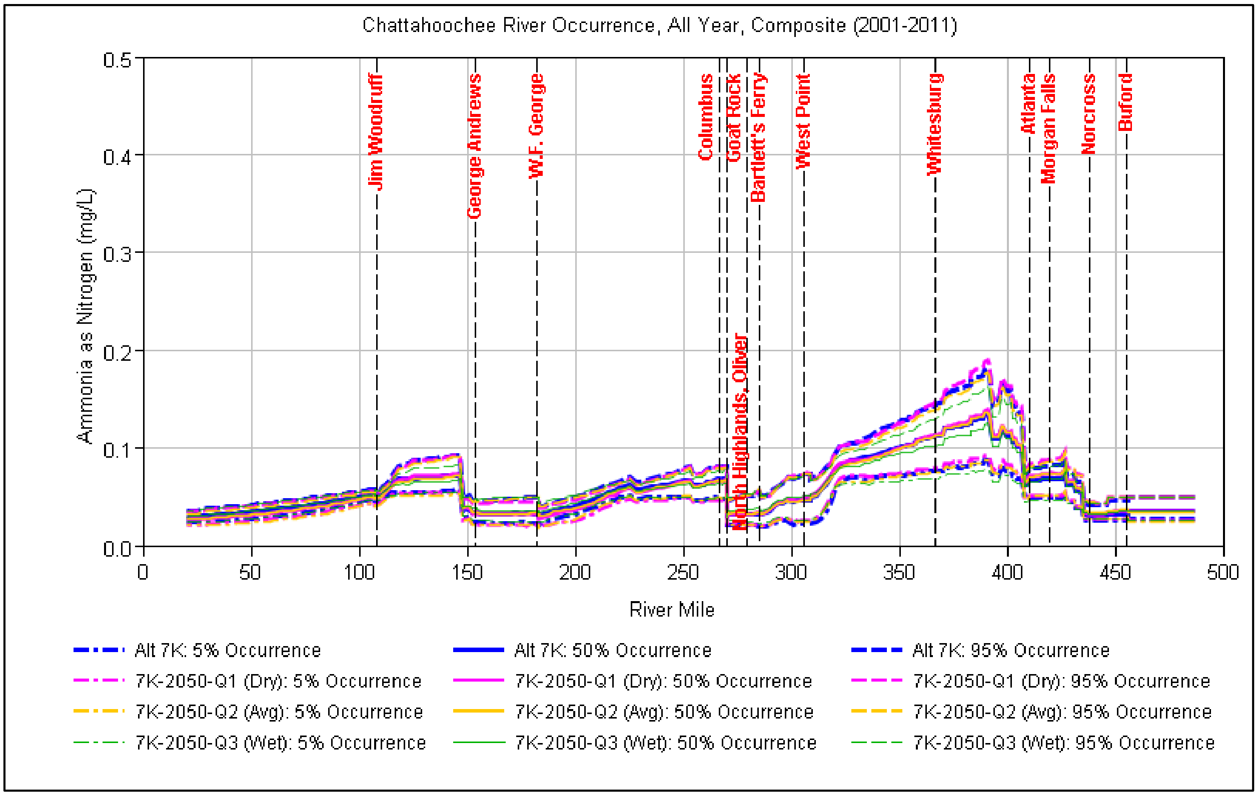


Figure 23. Longitudinal Profile of Modeled Nitrate as Nitrogen in the ACF Basin (2001–2011) for the PAA (Alt7K) and three Climate Scenarios

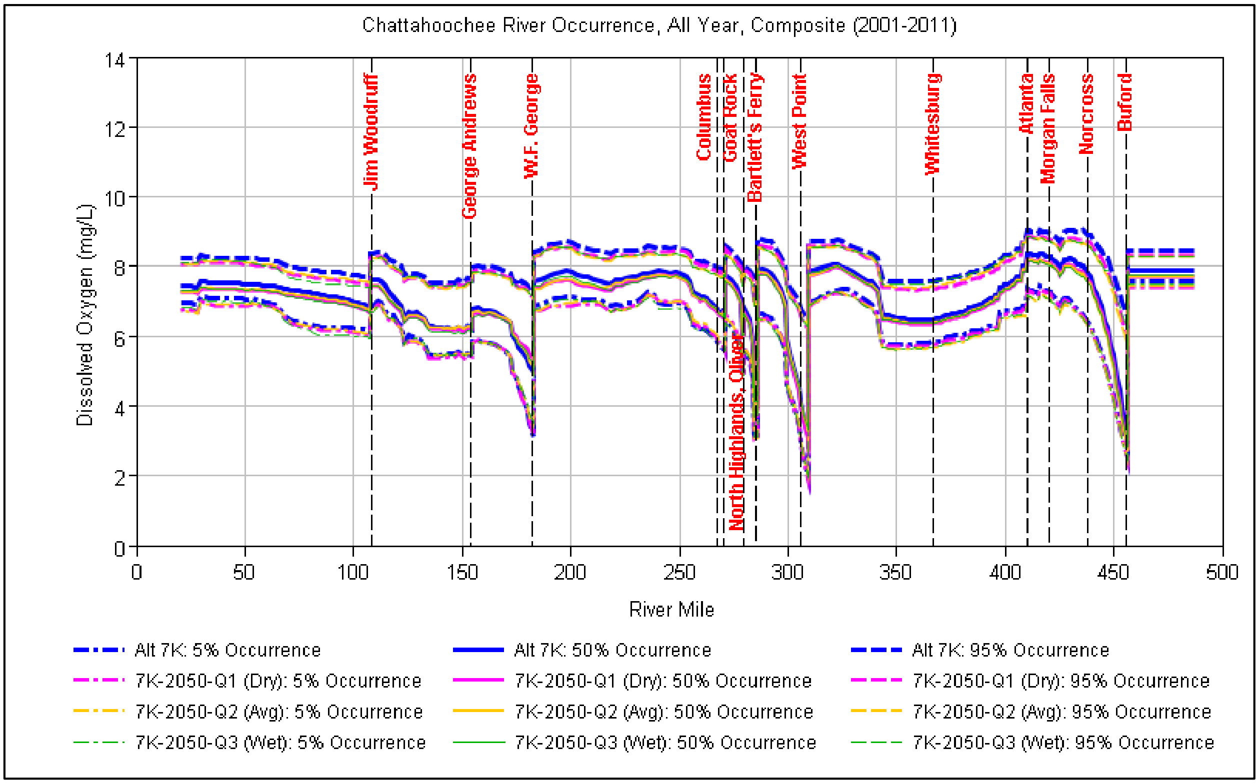


Figure 24. Longitudinal Profile of Modeled Dissolved Oxygen in the ACF Basin (2001–2011) for the PAA (Alt7K) and three Climate Scenarios

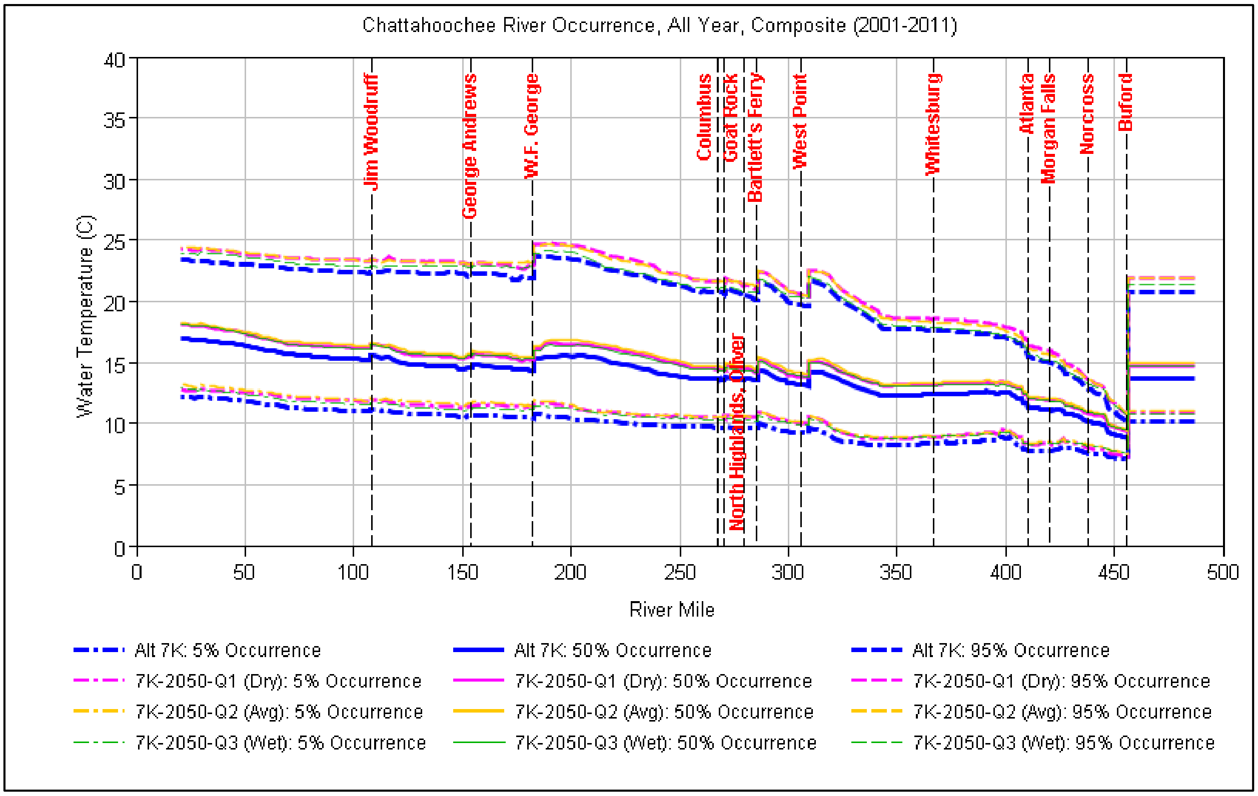


Figure 25. Longitudinal Profile of Modeled Water Temperature in the ACF Basin (2001–2011) for the PAA (Alt7K) and three Climate Scenarios

Apalachicola-Chattahoochee-Flint Climate Change Support Analysis

Performed by USACE Institute for Water Resources
POC: David Raff, PhD, PE, D.WRE (david.raff@usace.army.mil)
Jeff Arnold, PhD (jeffrey.r.arnold@usace.army.mil)

Introduction: USACE SAM is currently in the process of producing an environmental impact statement (EIS) for the Apalachicola-Chattahoochee-Flint (ACF) watershed and is interested in including the potential impacts from climate change within that EIS. There is currently an expectation both within USACE as well as with stakeholders in the watershed that climate change be considered within the development of project alternatives and ultimately decision making processes.

Dr. David Raff (IWR) briefed SAD in October 2013 on upcoming climate change inland hydrology guidance intended to go beyond current expectations for considering climate change but which describes the requirements of inclusion of climate change within USACE inland hydrology projects and studies. After this briefing Beverley Stout (SAM) contacted David to discuss possibilities for supporting the ACF EIS. Dr. Jeff Arnold (IWR) joined a series of ACF working team meetings to discuss various approaches ranging from a strictly qualitative presentation of climate change information to a quantitative analysis of climate change impacts on hydrology and operations within the basin. All types of approaches are consistent with the qualitative approaches to be required by the forthcoming USACE climate change guidance. Following these discussions, SAM would like to proceed with a numerical modeling assessment of firm yield impacts due to climate change that can be included within the EIS. A scope of work – attached here as Appendix A - for USACE IWR support was developed and approved in December 2013 that outlines the climate change analysis steps that can support the firm yield impacts desired by SAM.

The form of this project report follows the order of tasks in that scope of work. The individual tasks represented by the scope have been accomplished and climate change hydrologic projections have been transmitted to SAM.

The analysis includes a set of readily available hydrologic projection data developed by USACE in cooperation with the National Center for Atmospheric Research (NCAR) as well as utilizing and leveraging cooperative analysis performed with the Department of Interior Bureau of Reclamation and US Geological Survey, Lawrence Livermore National Laboratory, Santa Clara University, Climate Central, and Scripps Institution of Oceanography. The hydrologic projections utilize numerical model outputs from the Coupled Model Intercomparison Project, phase 5 (CMIP5) (Taylor et al. 2011) organized by the World Meteorological Organization. Model outputs from CMIP5 are used in very many climate change applications including in support of the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5). This represents the latest generation of General Circulation Models (GCMs) used to create projections of climate change due to anthropogenic forcings. For CMIP5, the experimental design utilized four projections of anthropogenic atmospheric forcings called representative concentration pathways (RCPs) which are identified by their 2100 radiative forcings from 2.6, 4.5, 6.0, and 8.5 W/m^2, respectively (van Vuuren et al. 2011). For this work on the ACF, GCM projections, which consist of an antecedent period from 1950 – 2010 and projections from 2011 – 2099, were bias corrected and spatially downscaled (BCSD) in conjunction with an ongoing archive of projections for use within water management agencies (Reclamation 2013). The BCSD projections were used as external forcings with the Variable Infiltration Capacity (VIC) (Liang, X. et al. 1994) model to generate Hydrologic Unit Code level 4 (HUC4) hydrologic projections.

The hydrologic projections consist of total runoff for each HUC4 within the continental United States (as well as transboundary basins for much of the NLDAS domain) and were computed for each HUC4 basin (local) and for cumulative totals relevant for the SAM application to the ACF (cumulative). The change in HUC4 hydrologic projections against the modeled historical flows were computed for two future time periods:

- Time Period 1: 2021 - 2050
- Time Period 2: 2061 - 2090

Delta values were calculated relative to the equivalent 30 year antecedent period 1970 – 1999; that comparison of projections to modeled antecedent conditions is the basis for making assertions about potential future climate changed altered hydrology for the ACF.

Outline Step 1. Information provided by SAM on December 12, 2013, via email from Ryan Crane. That information set included two sets of flow data for the ACF. Both sets were for 22 sites within the basin and were cumulative values at those sites, including all upstream flows. One site included naturalized flows that allowed negative numbers, assumed for mass balance purposes, the second data set was "smoothed" and eliminated any negative values.

Following a presentation of interim status held on Tuesday, January 14th, 2014, Mr. James Hathorn (SAM), Chief, Water Management Section, requested that the analysis be performed on local flows in addition to a single set of cumulative flows. This required an additional data transfer which took place on Wednesday January 15th, 2014. The hydrologic outputs that used the localized flows and the single set of cumulative flows described here and which accompany this project report supersede any previous analysis and presentation of interim results.

Outline Step 2. In order to access the appropriate HUC 4 hydrologic projections produced by USACE with NCAR, the sites provided by SAM were placed within a GIS layer of HUC4 boundaries. All sites provided by SAM are located within a single HUC 4 (0313 - Apalachicola).

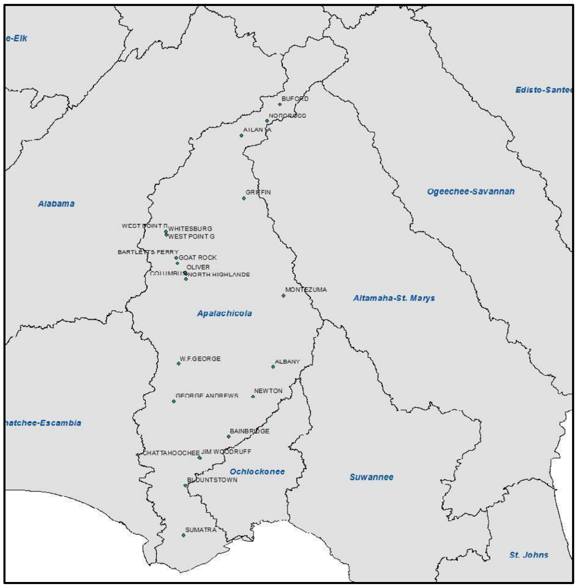


Figure 1: Map of input nodes provided by USACE SAM to be evaluated as part of the ACF Climate Change project. All nodes exist within HUC4 – 0313 – Apalachicola.

Outline Step 3.

The HUC4 - 0313 data is accessed from the hydrologic projection total data set. Before making a selection about which projections to consider (Outline Step 4) an intermediate step was deemed prudent given the substantially wide range of radiative forcings considered within the CMIP5 experiment. The HUC4 hydrologic responses were evaluated to determine the degree and type of differences as a function of RCPs to determine whether all or only selected RCPs needed to be used. The two figures below show this analysis. The first indicates the range of all hydrologic projections (yellow band) and the RCP medians at each month for the entire antecedent and future time periods considered wtihin the USACE-NCAR project. The second figure is a box and whiskers plot for each RCP as well as the dataset as a whole. Based upon visual inspection of these figures it was determined that for this location, the hydrologic projection responses computed using these methods are not obviously dependent on RCP. Therefore, there is no reason to sub-select from the RCPs but rather to treat them all as equally plausible for this analysis.

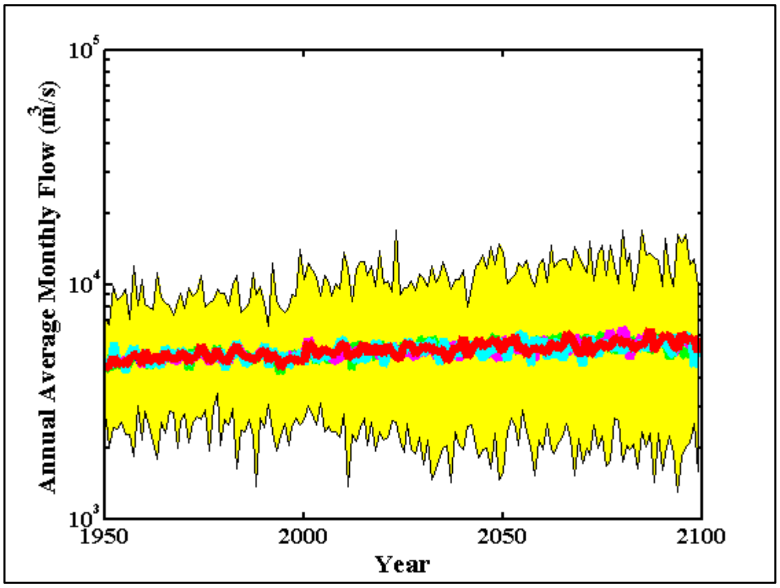


Figure 2: Full spread (yellow shading) of the 100 monthly hydrologic simulations that were developed as part of the VIC CMIP5 project at the HUC 4 level. The mean values at each month for each RCP are shown as the four solid (overlapping) lines. Visual evaluation indicates that the mean trends are indistinguishable across the various RCPs used in the analysis.

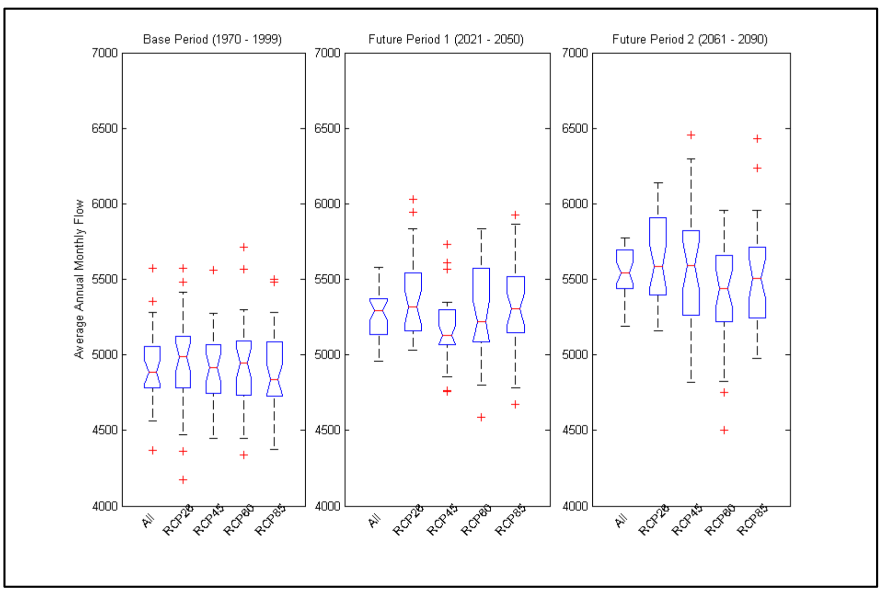


Figure 3: For each of the two time periods (2021 – 2050, 2061-2090) being explored for this climate change analysis GCM-projected spread for each RCP is presented. Visual analysis indicates no clear trend in the different W/m^2 at 2100 radiative forcings for this HUC 4 hydrologic analysis.

Outline Step 4.

Based upon the determination to consider all 100 projections equally plausible, empirical cumulative distribution functions (ECDFs) were developed for a climate change metric for the two future time periods (2021-2050, 2061-2090). The ECDFs represent the mean of all months for each of the 100 hydrologic projections within the 30-year time period ratioed against the mean of all months from the same model for the antecedent time period. Selection of the particular hydrologic projections to be utilized further was made by determining a "Dry", "Median", and "Wet Condition" for the two future time periods which are the 10th, 50th, and 90th quantiles, respectively (shown in Figure 4 by the black vertical lines).

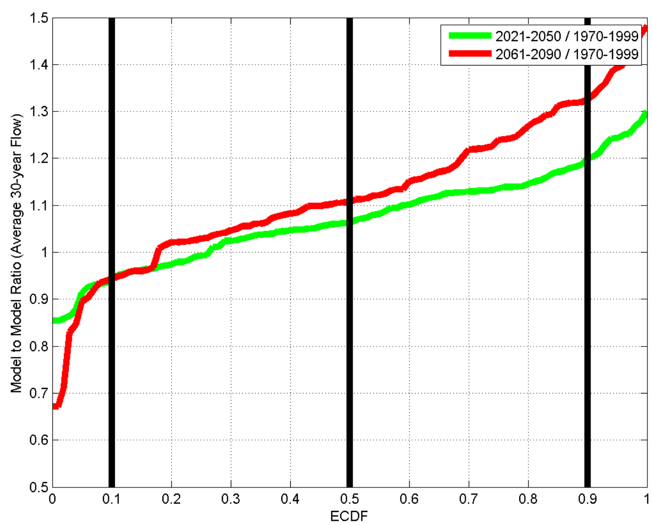


Figure 4: Empirical Distribution Functions for the 100 available HUC4 hydrologic projections for the Apalachicola. The ratios represent model to model of future period to antecedent period 30 year average monthly values.

Table 1: Selected hydrologic projections for further analysis.

	10% Quantile (DRY)	50% Quantile (AVERAGE)	90% Quantile (WET)
Time Period			
2021 - 2050	HadGEM2-ES.rcp60.monthly.runoff.1950-2099.HUC4.SUM.nc	HadGEM2-CC.rcp85.monthly.runoff.1950-2099.HUC4.SUM.nc	CCSM4.rcp60.monthly.runoff.1950-2099.HUC4.SUM.nc
2061 - 2090	HadGEM2-AO.rcp60.monthly.runoff.1950-2099.HUC4.SUM.nc	ACCESS1-0.rcp85.monthly.runoff.1950-2099.HUC4.SUM.nc	CCSM4.rcp60.monthly.runoff.1950-2099.HUC4.SUM.nc

We acknowledge the World Climate Research Programme's Working Group on Coupled Modeling, which is responsible for CMIP, and we thank the climate modeling groups listed in Table 2 of this documentation for producing and making available their model output. For CMIP, the U.S. Department of Energy's Program for Climate Model Diagnostics and Intercomparison provides coordinating support and led development of software infrastructure in partnership with the Global Organization for Earth System Science Portals.

Table 2: Recognition of climate modeling groups within the World Climate Research Programme's Working Group on Coupled Modeling being utilized within final analyses.

WCRP CMIP5 Climate Modeling Group[1]	WCRP CMIP5 Climate Model ID	RCP 2.6 Runs	RCP 4.5 Runs	RCP 6.0 Runs	RCP 8.5 Runs
Met Office Hadley Centre (additional HadGEM2-ES realizations contributed by Instituto Nacional de Pesquisas Espaciais)	HadGEM2-AO	0	0	1	0
	HadGEM2-CC	0	0	0	1
	HadGEM2-ES	0	0	1	0
Commonwealth Scientific and Industrial Research Organization and Bureau of Meteorology, Australia	ACCESS1-0	0	0	0	1
National Center for Atmospheric Research	CCSM4	0	0	1	0

[1] http://cmip-pcmdi.llnl.gov/cmip5/docs/CMIP5_modeling_groups.pdf

Outline Step 5.

For each of the three selected hydrologic projections for each time period ECDF maps are created for the full 30 year projection period against the full 30 year selected retrospective material for each month separately. An example of those maps is provided as Figure 5. The "map" that will be utilized to scale the ACF naturalized flows is created by taking each future ECDF point and dividing by the equivalent plotting position from the antecedent ECDF point. The remaining maps are provided within Monthly_VIC_Figs.zip.

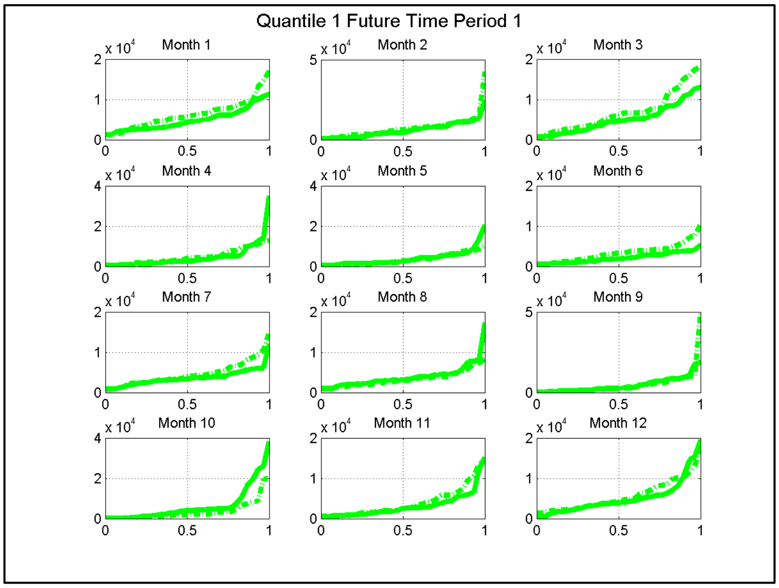


Figure 5. Example ECDF map for Quantile 1 (Dry 10% Projection) for Future Time Period 1 (2021 – 2050). Dashed line within each month figure represents the antecedent ECDF and the solid line represents the future ECDF.

Outline Step 6.

Utilizing the maps created in Outline Step 5 each of the 22 ACF sites is scaled by the appropriate monthly map. To accomplish this, each of the 22 ACF sites is subdivided into months utilizing the monthly average flow from the naturalized data set provided by SAM. An example for Jim Woodruff for future time period 1 (2021 – 2050) for quantile 1 (Dry 10%) is provided as Figure 6 for local flows and an example for Chattahoochee for future time period 1 for quantile 1 is provided as Figure 7. The remaining scaled flows for site 1 are provided as Monthly _ACF_Figs.zip.

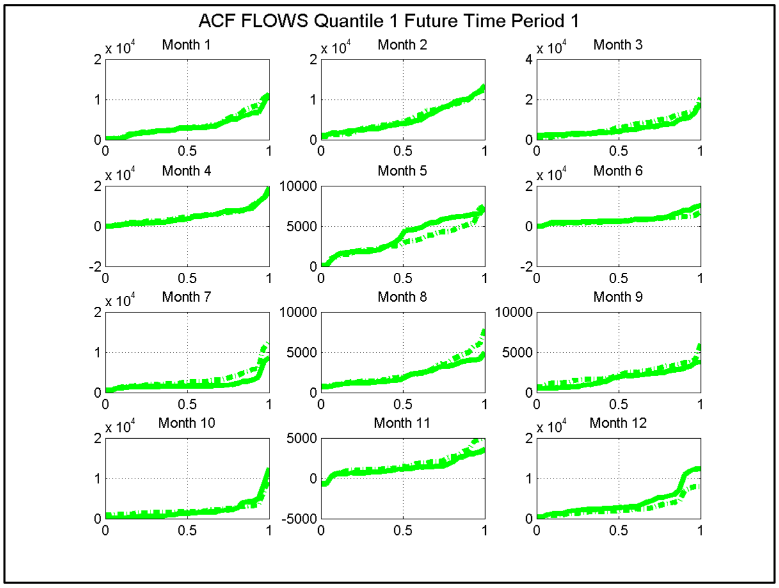


Figure 6. Example scaling of monthly flows for the local naturalized flows at Jim Woodruff. The dashed line indicates the naturalized ECDF flows for Jim Woodruff for each month and the solid line represents the climate changed ECDF flows.

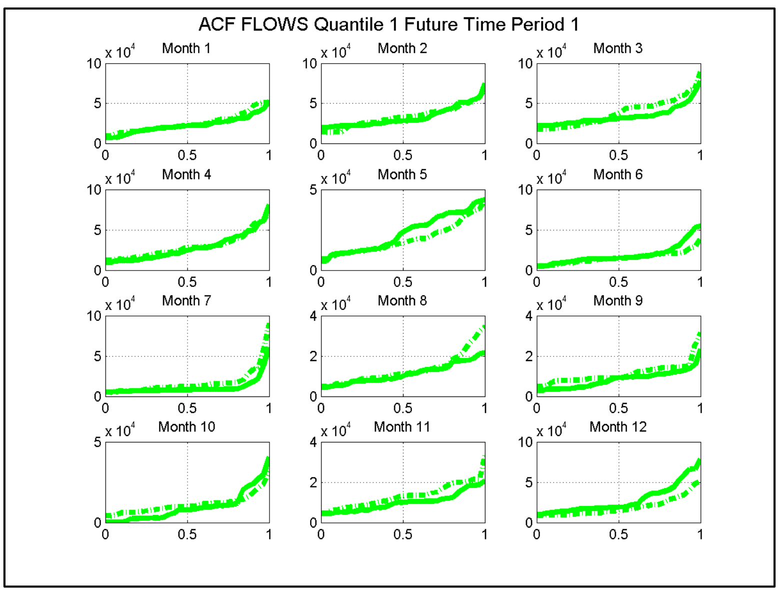


Figure 7. Example scaling of monthly flows for the cumulative naturalized flows at Chattahoochee. The dashed line indicates the naturalized ECDF flows for Chattahoochee for each month and the solid line represents the climate changed ECDF flows.

Outline Step 7.

Reconstituting the climate changed flows by ACF node site requires reassigning the appropriate month from the ECDF into chronological order. At this point that has been accomplished to the monthly basis. An example time series for Chattahoochee utilizing the cumulative flows is shown within Figure 8.

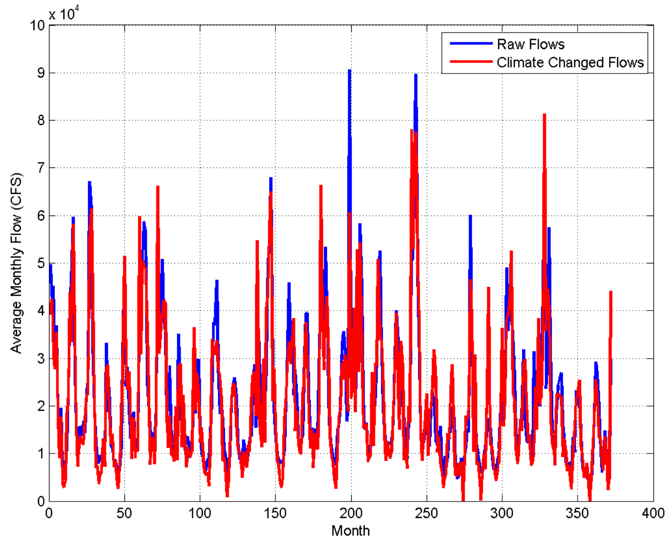


Figure 8. Example Monthly time series reconstituted from climate changed ECDF for the cumulative flows for Chattahoochee. The blue line represents the raw naturalized flows received from SAM averaged for the month. The red line represents the average monthly values reconstituted from the climate changed flows.

As a measure of quality control and assurance, as well as for communication purposes, the climate-altered monthly flows for each site were compared to the original projection selection represented within Figure 4. For each site the ratio of average monthly values for the future period was taken with respect to the antecedent period. The comparisons are shown within Figure 9 and Figure 10 for the local and cumulative naturalized flows, respectively. Sites, individually and collectively, may not match exactly the model-to-model ratio that was initially utilized to select quantiles for analysis. Upon further investigation it was determined that this is due, in some part, to the skew of the VIC flows relative to the skew of the naturalized raw flows. When the skews do not match and the quantile map is applied flows get "pulled" either wetter or drier depending on whether the skew of the VIC is greater than the skew of the raw naturalized flows, or vice versa.

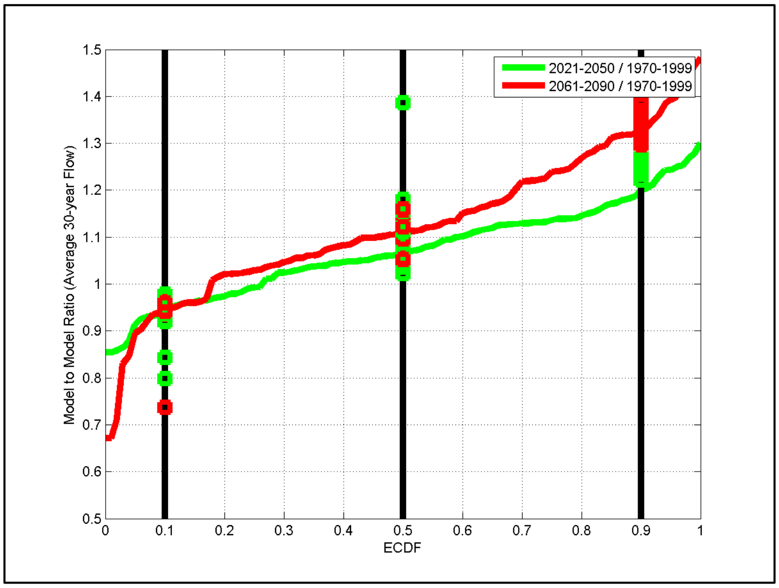


Figure 9. Figure shows the average monthly values of future to antecedent ratios for each of the sites for the ACF analysis for the climate change local naturalized flows. The green open circle values are for time period 1 (2021 – 2050) and the red open circle values are for time period 2 (2061 – 2090). The distribution of site ratios is indicative of differences amongst "skew" of the flow data with respect to the skew of the VIC quantile maps as described just above.

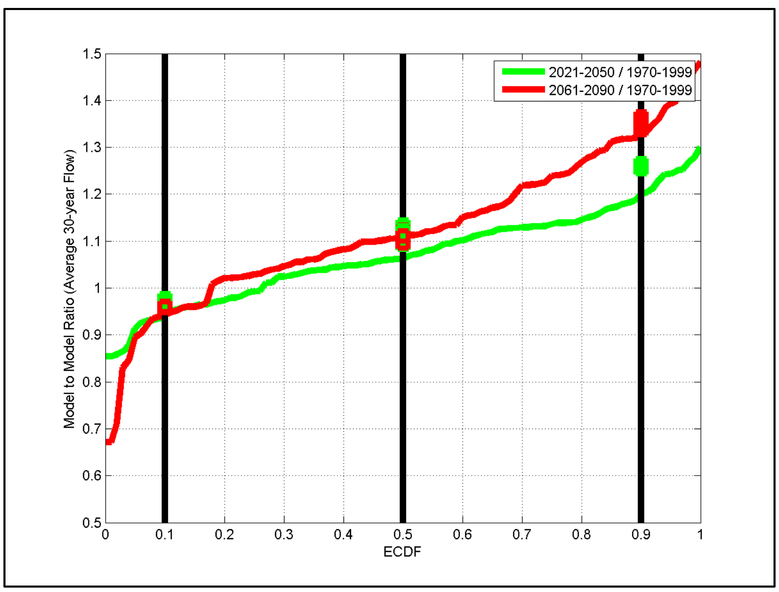


Figure 10. As for Figure 9 but here for cumulative naturalized flows.

Outline Step 8.

In order to utilize the climate-changed hydrology within the operational models of the ACF, which is the goal of the project on sensitivity analysis, it is required to reconstitute daily values from the monthly values created within Outline Step 7. Daily values for each site for each month were calculated by assigning the same daily percentage of monthly flows that were represented within the original naturalized flow files for both the local and cumulative values. In this manner the same day for the same month represents the same percentage of monthly flows within the climate-changed analysis. An example of the daily scaling is provided within Figure 11 for the cumulative flows at Chattahoochee for time period 1 and quantile 1. The figure represents the first January scaled to the climate-changed values. The daily values were then exported to an excel file in the same order of sites as was the original data. There is one excel file for each quantile for each of two time periods. Therefore, there are 6 total files of daily values for the climate change local naturalized flows and 6 total files of daily values for the climate change cumulative naturalized flows.

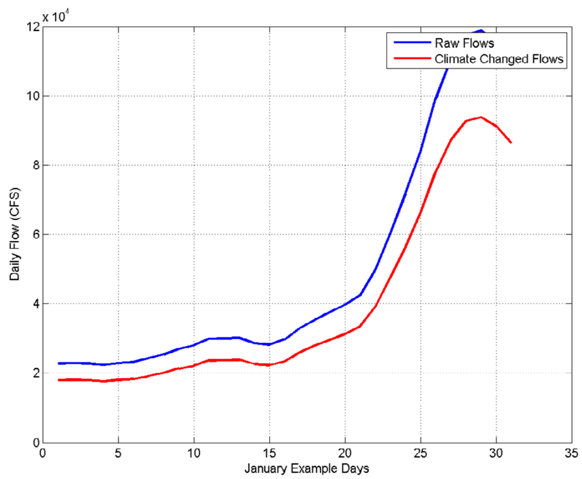


Figure 11: Example reconstitution of daily values for the first January in the time series for the cumulative flows at Chattahoochee for time period 1 and quantile 1. The blue line represents the raw daily values and the red line represents the climate changed values.

As a measure of quality control and assurance, the final daily values were compared to the original projection selection represented within Figure 4 as well as to the expectation of monthly flows represented within Figures 9 and 10. The ratio of the average daily values for the 30 year period of future to antecedent was taken for each site and these values are shown within Figure 12 and Figure 13 for the local and cumulative naturalized flows, respectively.

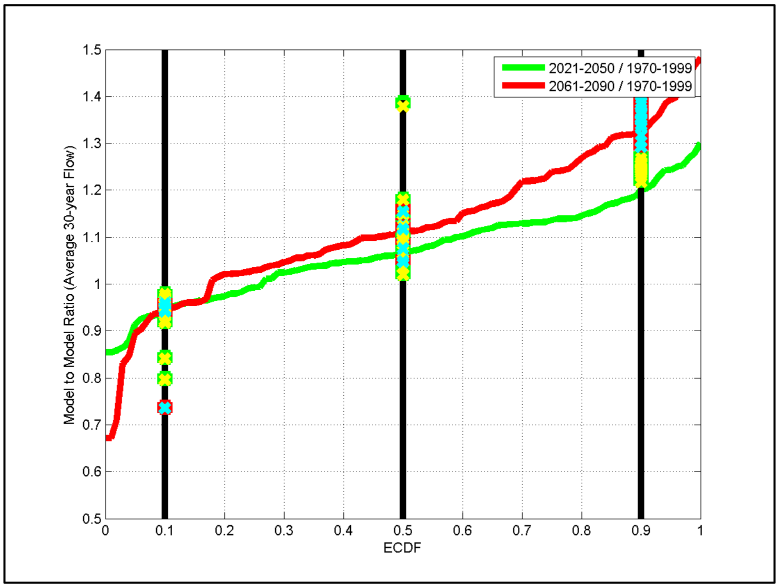


Figure 12. Figure shows the average daily values of future to antecedent ratios for each of the sites for the ACF analysis for the climate change local naturalized flows. The yellow "X" values are for time period 1 (2021 – 2050) and the blue "X" values are for time period 2 (2061 – 2090). The agreement between the "X" values and the "O" values (monthly ratios) is indicative of the daily disaggregation achieving the desired outcome.

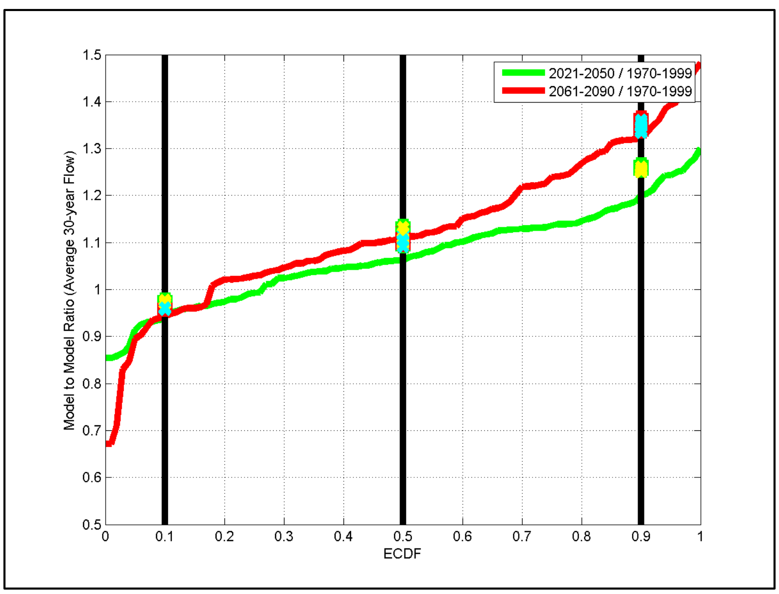


Figure 13. Figure shows the average daily values of future to antecedent ratios for each of the sites for the ACF analysis for the climate change cumulative naturalized flows. The yellow "X" values are for time period 1 (2021 – 2050) and the blue "X" values are for time period 2 (2061 – 2090). The agreement between the "X" values and the "O" values (monthly ratios) is indicative of the daily disaggregation achieving desired outcome.

References:

Liang, X., D.P. Lettenmaier, E.F. Wood, and S.J. Burges, 1994. A Simple Based Model of Land Surface Water and Energy Fluxes for GSMs, J. Geophys. Res., 99(D7), 14, 415-14,428.

Reclamation, 2013. Downscaled CMIP3 and CMIP5 Climate Projections: Release of Downscaled CMIP5 Climate Projections, Comparison with Preceding Information, and Summary of User Needs. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado, 116 p. available at: http://gdo-dcp.ucllnnl.org/downscaled_cmip_projections/techmemo/downscaled_climate.pdf.

Taylor, K.E., R.J. Stouffer, and G.A. Meehl, 2011. A Summary of the CMIP5 Experiment Design. january 22, 2011, 33 p., available at: http://cmip-pcmdi.llnl.gov/cmip5/docs/Taylor_CMIP5_design.pdf.

van Vuuren, D.P., J. Edmonds, M. Kainuma, K. Riahi, A. Thomson, K. Hibbard, G.C. Hurtt, T. Kram, V. Krey, J-F Lamarque, T. Masui, M. Meinshausen, N. Nakicenovic, S.J. Smith, and S.K. Rose, 2011. "The Representative Concentration Pathways: An Overview," Climatic Change, 109:5-31.

Appendix A: Scope of Work for IWR support of climate change analysis for ACF EIS 2014.

Climate Change Analysis Support Apalachicola-Chattahoochee-Flint (ACF) Study
Scope of Work – Prepared by Dr. David Raff (IWR)
11/19/2013

Background: Dr. David Raff (IWR) briefed SAD on upcoming climate change inland hydrology guidance in October 2013. Following that presentation Beverley Stout (SAM) contacted David to discuss possibilities for including a climate change analysis within an ongoing EIS for the ACF. Dr. Jeff Arnold (IWR) joined a series of ACF working team meetings to discuss various approaches including a strictly qualitative presentation of climate change information through a quantitative analysis of climate change impacts on hydrology and operations within the basin. All types of approaches are consistent with the qualitative approaches to be required by the forthcoming climate change guidance. Following these discussions SAM would like to proceed with a numerical modeling assessment of firm yield impacts due to climate change that can be included within the EIS.

Outline Numerical Modeling Assessment.

1. Identify input nodes to HEC ResSim used within SAM ACF planning model.
2. Map input notes to HUC 4s.
3. Access BCSD – VIC HUC 4 hydrological simulations for the HUC 4s identified in 2. Simulations are those created as part of Responses to Climate Change and Actions for Change work with National Center for Atmospheric Research developed in 2013. No additional activity assumed to be necessary to develop hydrologic simulations.
4. For each future time periods 2020 – 2050 and 2060 – 2090 identify 3 VIC simulations that represent dry, median, and wet conditions for those time periods based on average annual flows across all HUC 4s. ** Want to use the same model for all subbasins in each run. Option is to identify key subbasins and use those for identifying a series of dry, median, and wet conditions -> could lead to more than 3 total. **
5. For those models selected on a monthly basis identify the future to base cumulative distribution function (CDF) shift for each of the models identified in 4.
6. Rank (create empirical distribution function) a 30 year sequence of unimpaired flows currently used by SAM for current modeling efforts.
7. Using the CDF shifts of 5 alter the unimpaired flows of 6 on a monthly basis such that the new CDFs match the projected shifts from 5.
8. Take the altered unimpaired flows from 7 and run through HEC ResSim model to identify range of firm yield impacts.
9. QA / QC of all work completed
10. Documentation for work performed.

IWR Scope of Work.

Outline Step	Responsibility	Product	Cost 1,000$ (IWR)	Proposed Completion
1	SAM	SAM will provide IWR with lat / long of nodes. SAM will provide IWR with a chosen 30 year sequence of unimpaired flows at all nodes	N/A	December 15, 2013
2	IWR	Matrix of HUC 4s for nodes	2	December 21, 2013
3	IWR	100 hydrology simulations for each HUC 4	2	January 5, 2013
4	IWR / SAM	3 hydrology simulations for all HUC 4s	2	January 10, 2013
5	IWR	CDF Maps	7	January 31, 2013
6	IWR	EDF for unimpaired flows	2	February 7, 2013
7	IWR	Altered unimpaired flows in same format as those provided by SAM to IWR in step 1. Passed to SAM.	4	February 19, 2013
8	SAM / HEC*			March 7, 2013
9	SAM / IWR		5	March 14, 2013
10	SAM / IWR		7	March 21, 2013
Total			31	

*HEC – Assumed this is HEC support of firm yield modeling.

This page intentionally left blank

Appendix O

Extended Unimpaired Flow Report
January 1939 – December 2012
for the
Apalachicola-Chattahoochee-Flint (ACF) River Basin

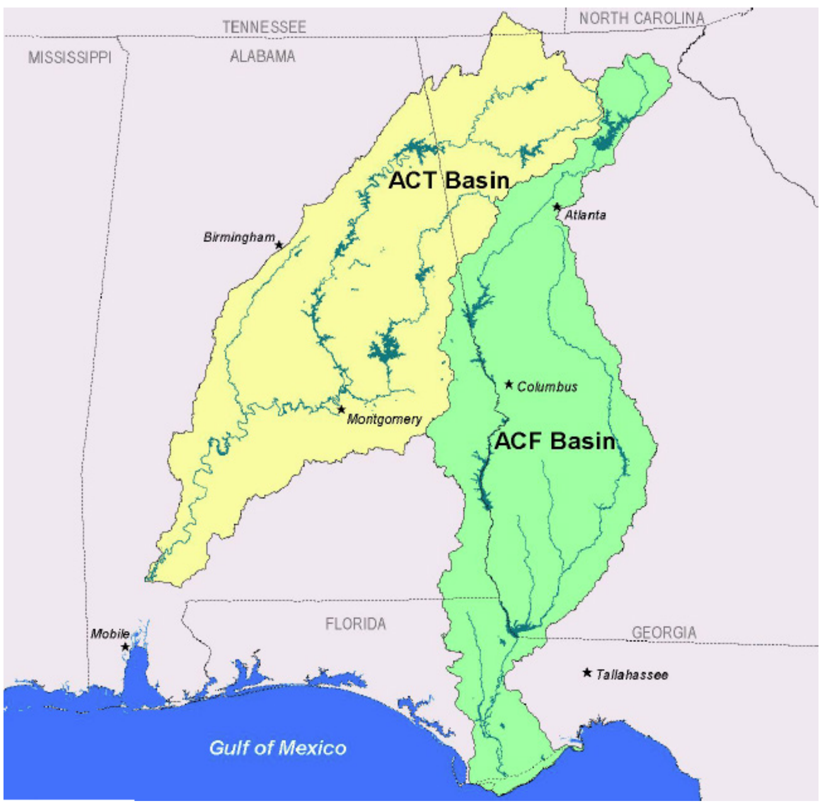
This page intentionally left blank

Extended Unimpaired Flow Report

January 1939 – December 2012

for the

Apalachicola-Chattahoochee-Flint (ACF) River Basin



US Army Corps
of Engineers
Mobile District

September 2016

Contents

Tables

Figures

Executive summary

Situation

Unimpaired flows are defined as historically observed flows adjusted for human influence by accounting for the effect of reservoirs, and municipal, industrial, thermal power, and agricultural withdrawals and returns. The Corps of Engineers Mobile District (Mobile District) requires the computation of unimpaired flows as part of the *Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint (ACT/ACF) river basins comprehensive continuing water resources studies*. The Mobile District computed flows at over 50 locations for the 1939 to 1993 period of record, which is documented in the report titled *ACT/ACF comprehensive water resources study, Surface water availability, Volume I: Unimpaired flow, July 8, 1997* (*Unimpaired flow report*). A 2004 update report titled *Extended unimpaired flow report January 1994–December 2001 for the Alabama-Coosa-Tallapoosa and Apalachicola Chattahoochee Flint (ACT/ACF) river basins* (*Extended unimpaired flow report*) documents the steps that were taken to extend the ACT/ACF unimpaired flow dataset to include the 1994–2001 calendar years. In 2009, the Mobile District extended the unimpaired flow calculations through the year 2008. This work is not documented.

The period of record unimpaired flow dataset is used as input into the HEC-ResSim system model to allow for evaluation of surface water resources in the ACF basin to determine water availability of a full range of alternatives.

Tasks

We extended the unimpaired flow dataset for the ACF basin through 2012 using the same procedures outlined in the *Unimpaired flow report,* the *Extended unimpaired flow report,* and the 2008 extension.

To do this we collected streamflow, reservoir, evaporation, and precipitation, as well as municipal and industrial (M&I) and agricultural withdrawals and returns. We then reviewed the data and adjusted or filled in missing data where necessary. All computations except for Modified Puls routing were done in Excel workbooks.

Actions

To extend the unimpaired flows in the ACF basin, we reviewed the unimpaired flow calculations used in the 2 previous studies, and prepared a work flow diagram to recommend a consistent approach for each type of calculation.

We used the methodology described in the *Unimpaired flow report* (pp. 42-53) to compute unimpaired incremental local flows. In the previous studies computations were completed using HEC-DSS. In this study, we used Excel as the primary tool to complete the computations, and then wrote the time series data to HEC-DSS for use in the HEC-ResSim modeling.

The work flow to compute the unimpaired flows and steps completed in each workbook are shown in Figure 1. Workbook names and a description of computations completed in each are shown in Table 1. To compute unimpaired flows we:

- Collected the streamflow, water use, and reservoir data.

- Filled in missing streamflow values and reservoir data.
- Computed the net evaporation at the 4 of 5 Corps reservoirs, and adjusted reservoir inflows for net evaporation.
- Aggregated the M&I and agricultural water use data by reach.
- Routed the gaged flows.
- Computed incremental local flows for each location.
- Added net withdrawals to incremental local flows.
- Smoothed incremental local flows to reduce the number of negative cumulative flows.
- Computed cumulative unimpaired flows.
- Routed cumulative unimpaired flows.
- Computed cumulative unimpaired flows at each downstream location by adding incremental local flows in the reach to the cumulative flows at each upstream location.
- Stored resulting flows in HEC-DSS.

Results

Resulting unimpaired flows are computed and stored in the 10 workbooks shown in Figure 1 and listed in Table 1.

Recommendations

For future updates, we may consider using a database or tool designed to store and analyze large volumes of time series data. Examples of other databases are HEC-DSS, SQL, and Microsoft Access. We recommend this because:

- All required time series data could be stored in a consistent manner that meets the needs of Mobile District and individual stakeholders as needed.
- Custom scripts and database queries could be developed and used to import data from various sources. (For example importing water use data from state agencies.) In addition, such scripts could be easily modified when the format of the provided data changes for a given source.
- All intermediate computation values could be stored if desired.
- Custom scripts and database queries could be developed and used to export and report data and information given the specific needs of the Mobile District and individual stakeholders.
- All time series could be stored for each update to allow for easy comparison as data are revised between unimpairment updates.
- Microsoft Excel is not appropriate to store and analyze large volumes of time series data due to limitations. Limitations encountered were: an 8,000 character limit for formulas, potential breaks when referencing other workbooks, and referencing errors for certain Excel functions when referencing other workbooks.

If Excel is used for future updates, we recommend using a single workbook to prevent potential breaks in referencing, and duplication of time series values.

We also recommend that unimpaired flow updates computed using Excel be completed in 10 year blocks with small periods of overlaps, not for period of record to minimize file size. This allows each 10 year update to be provided to stakeholders for review, and the period of record flows to be imported into and stored in HEC-DSS.

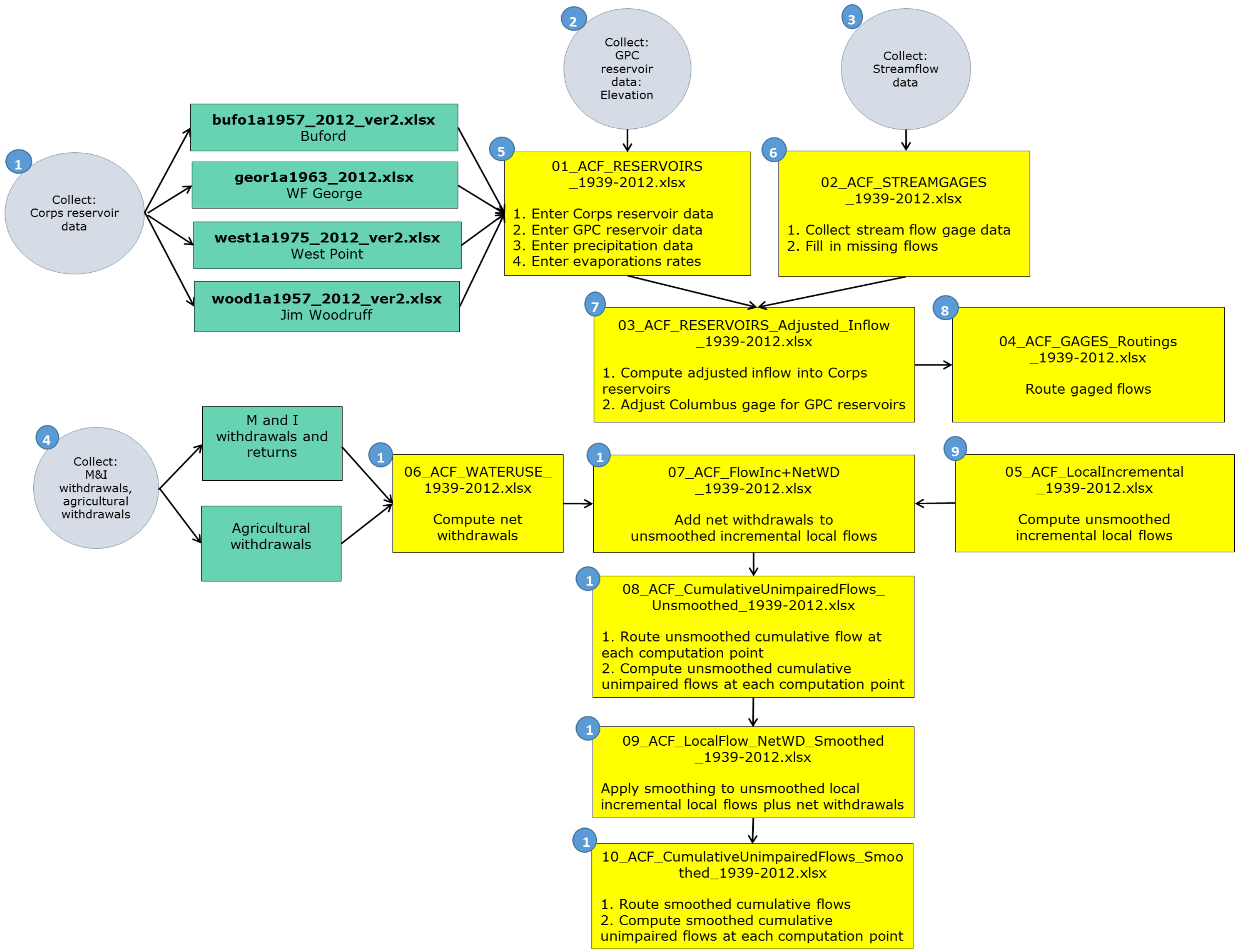


Figure 1. Work flow of computations of unimpaired flows, by workbook name

Table 1. Workbooks and sheets used to compute unimpaired flows

Workbook (1)	Computations (2)	Worksheet (3)
01_ACF_RESERVOIRS_1939-2012.xlsx	• Enter monthly precipitation data, rating curves, evaporation rates. • Compute monthly net precipitation. • Adjust reservoir inflows for net precipitation.	OBS_ADJ Input_Precip RatingCurves Evaporation MonthlyPrecip-Evap ResEvapAdjust
02_ACF_STREAMGAGES_1939-2012.xlsx	• Enter streamgage data. • Fill in missing values.	USGS_StreamgageData StreamgageDataAdjust
03_ACF_RESERVOIRS_Adjusted_Inflow_ 1939-2012.xlsx	Compute reservoir inflows.	Adj_Inflow
04_ACF_GAGES_Routings_1939-2012.xlsx	Route gaged flows.	RoutedFlows
05_ACF_LocalIncremental_1939-2012.xlsx	Compute routed incremental local flows.	LocalFlow
06_ACF_ WATERUSE _1939-2012.xlsx	• Import_TOTAL-WATER-USE • Import NetM&I • Export_ACFHEC_10_AG • Export_from_ACFM&I.DSS	Total net withdrawal, summing the net M&I and agricultural 1939-2012 Total net M&I withdrawal 1939-2012 Net AG withdrawal 1939-1993 Net M&I withdrawal 1939-1993
07_ACF_FlowInc_NetWD_1939-2012.xlsx	Add net withdrawals to unsmoothed incremental local flows	TotalDemand LocalFlow+NetWD_Unsmoothed
08_ACF_CumulativeUnimpairedFlows_ Unsmoothed_1939-2012.xlsx	• Route unsmoothed cumulative flow at each computation point • Compute unsmoothed cumulative unimpaired flow at each computation point	CumulativeRouting_Unsmoothed CumulativeUnimpaired_Unsmoothed
09_ACF_LocalFlow_NetWD_Smoothed_193 9-2012.xlsx	Apply smoothing to incremental local flows.	Smoothing LocalFlow_NetWD_Smoothed
10_ACF_CumulativeUnimpairedFlows_Smo othed_1939-2012.xlsx	• Route smoothed cumulative flows. • Compute smoothed cumulative unimpaired flows at each computation point.	CumulativeRouting CumulativeUnimpairedFlows

Introduction

The presence of man-made reservoirs in the ACF basin has affected the volume of surface water through increased evaporation and increased rainfall-runoff. In addition, water is withdrawn in the system for municipal and industrial and agricultural purposes.

An unimpaired flow dataset was originally required for the Surface Water Availability study element of the *ACT-ACF comprehensive water resources study*. Unimpaired flows are defined as historically observed flows adjusted for human influence by accounting for the presence of surface water reservoirs and for withdrawals and returns to serve municipal, industrial, and agricultural water uses.

This update documents the steps required to extend the ACF unimpaired flow dataset to include the 2002-2012 calendar years, for a comprehensive 1939-2012 dataset. The resulting extended unimpaired flow dataset is intended for use as input to reservoir system models. The Mobile District modeling team is the group responsible for developing the dataset. The states of Alabama, Florida, and Georgia provide water use data and are given the opportunity to review the unimpaired flow dataset before finalizing. The ACT and ACF basins and the Mobile District boundary are shown in Figure 2. A schematic of the ACF basin is shown in Figure 3. It should be noted that Alabama provided partial water use data for calendar year 2012. Therefore the 2012 calendar year Unimpaired Flow remains provisional until the Alabama complete water use data set is include in the computation.

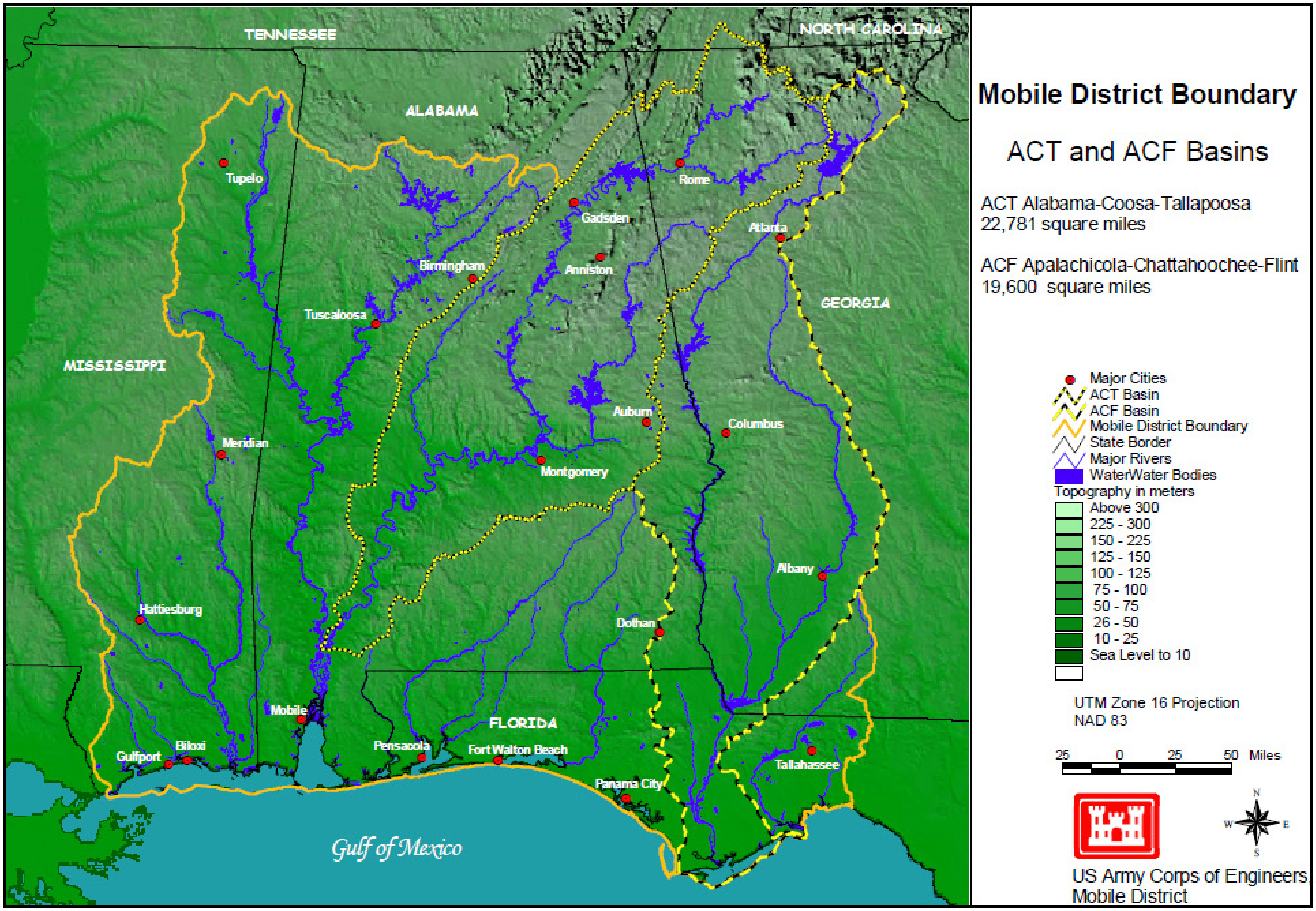


Figure 2. Location of the ACT and ACF basins

Figure 3. ACF basin schematic showing reservoirs and model computation points

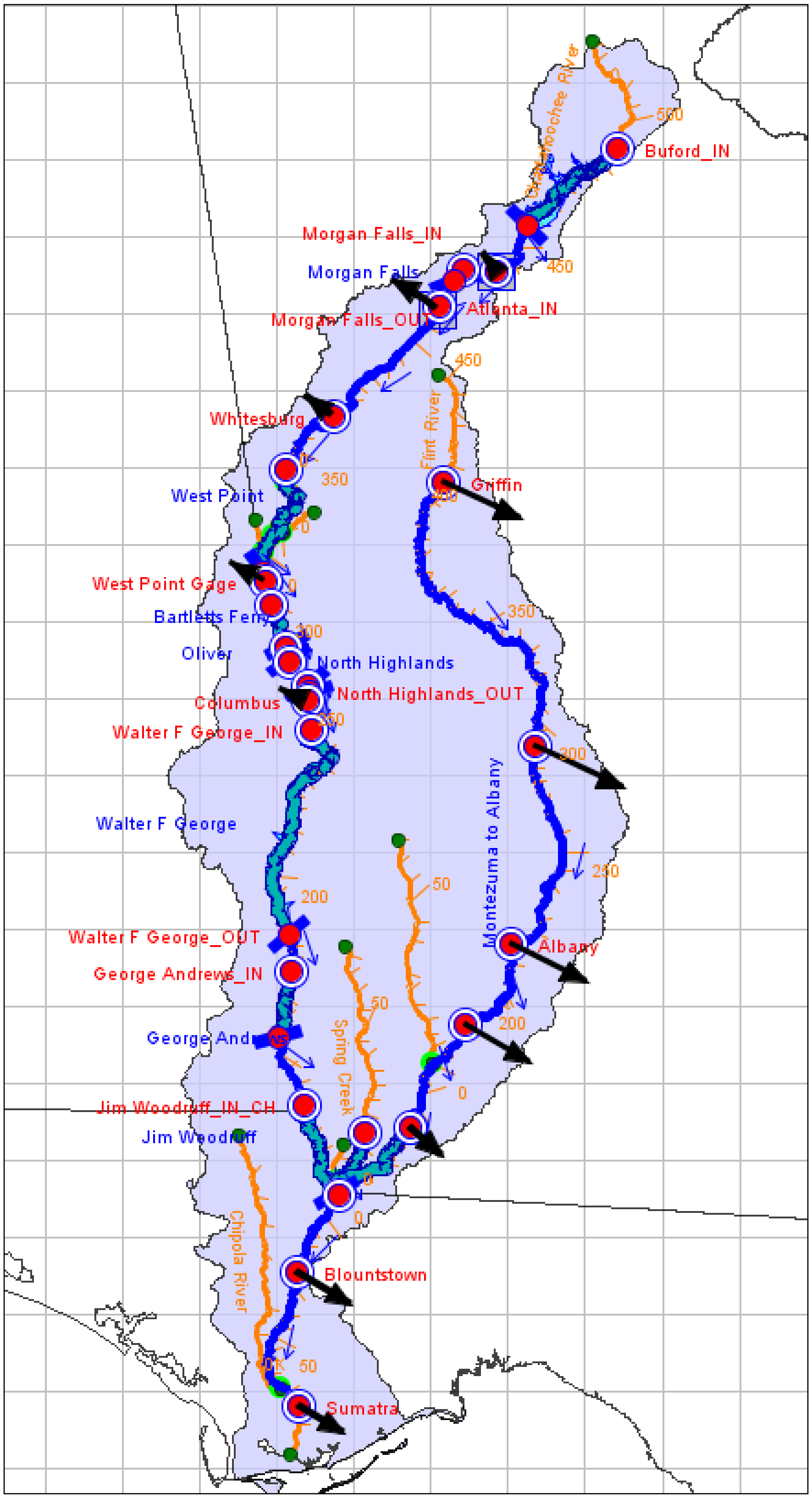


Figure 4. ACF HEC-ResSim system schematic showing reservoirs and model computation points

Data collection

Hydrologic data for the ACF basin is collected by government and state agencies and private companies. Table 2 lists the data types, source of data, and the method of transfer.

Table 2. Data types, sources, and methods of transfer

Data type (1)	**Source (2)**	**Method of transfer (3)**
Streamflow	USGS	Internet
USACE reservoir inflow, elevation, flow, storage	Mobile District Mobile District	Internet (CESAM website) ftp
Georgia Power Company reservoir elevation	Mobile District	ftp transfer
Precipitation	National Climate Data Center (NCDC) Mobile District	Internet ftp transfer from Mobile District
Evaporation	NOAA	Internet

Streamflow data

We gathered daily streamflow data for January 2002 through December 2012 from the USGS website for the 14 gages listed in Table 3. The data are entered in workbook 02_ACF_STREAMGAGES_1939-2012.xlsx.

We cataloged the missing streamflow data and listed the dates, number of missing values, and the method we used to estimate the missing values in Table 3. The estimated values are highlighted in yellow in workbook 02_ACF_STREAMGAGES_1939-2012.xlsx. A description of the fill-in method used, and correlation equation, is listed in the comments in row 1 of workbook 02_ACF_STREAMGAGES_1939-2012.xlsx.

Table 3. Streamflow gages, missing data, and fill-in method

Station No. (1)	Station name (2)	No. missing values (3)	Dates (4)	Fill-in method (5)
02335000	Chattahoochee R nr Norcross, GA	3653	01OCT46 - 30SEP56	Power Equation Equal to, Y=Buford gage Q ^0.980902 *1.21261
02336000	Chattahoochee R at Atlanta, GA	0	None	N/A
02338000	Chattahoochee R nr Whitesburg, GA	3838	(01JUL54 - 31DEC64, 01OCT90)	Power Equation, Equal to, Y=West Point gage Q^0.918633*1.42358 West Point Q shifted back 1 day
02339500	Chattahoochee R at West Point, GA	0	None	N/A
02341500	Chattahoochee R at Columbus, GA	6	04Oct2012-09Oct2012	Estimated Linear interpolation
02343801	Chattahoochee R at Andrews L&D Nr Columbia, AL	89	01Jan1939 – 31Dec2012	Flow at Andrews L&D is estimated as (Computed inflow to W. F. George)/0.93
02343801	Chattahoochee R at Andrews L&D Nr Columbia, AL	2	03Nov2012, 18Nov2012	Linear interpolation
02344500	Flint R at Griffin, GA	1	13Sep2010	Linear interpolation
02349500	Flint R at Montezuma, GA	0	None	N/A
02352500	Flint R at Albany, GA	0	None	N/A
02353000	Flint R at Newton, GA	3015	01OCT45 - 30SEP46 01OCT47 - 31DEC48 01OCT50 - 30SEP56	Power Equation Equal to, Y=Albany Q^0.866358 *3.56746 Albany Q shifted forward 1 day
023556000	Flint R at Bainbridge, GA	10878	01Oct1971-13Jul2001	Cyclical MOVE.2, Linear equation for each month
02358000	Apalachicola R at Chattahoochee FL	0	None	N/A

Station No. (1)	Station name (2)	No. missing values (3)	Dates (4)	Fill-in method (5)
02358700	Apalachicola R nr Blountstown, FL	82	01Oct2011-29Oct2012, 05Nov2012-07Nov2012, 12Nov2012-31Dec2012	Equal to (Flow at Sumatra 2 days later)/3.26937]^(1/0.898313)
02358700	Apalachicola R nr Blountstown, FL	10	30Oct2012-04Nov2012, 08Nov2012-11Nov2012	Linear interpolation
02359170	Apalachicola R nr Sumatra, FL	10	01Nov2012-06Nov2012, 10Nov2012-13Nov2012	Equal to 3.26937 x (flow at Blountstown 2 days prior)^0.898313

Reservoir data

In addition to the streamflow and precipitation data, a large volume of reservoir data have been collected for Federal reservoirs and the Georgia Power Company (GPC) reservoirs. The GPC provided hourly pool elevation for the limited period January 1, 2001, to December 31, 2007, and daily pool elevations through 2012.

While commonly referred to as observed data, reservoir inflows are actually calculated from pool elevations and reservoir outflows. Reservoir inflows are computed using the continuity equation given the elevation-storage relationship, change in storage, and reservoir outflow.

Table 4 lists the reservoirs in the ACF basin, their owners, and the types of data needed for the unimpaired flow computations. Table 5 shows the inflow adjustments for the GPC reservoirs. Table 6 list the reservoirs and data sources representing flow at the reservoir site prior to filling the reservoir. Dates for special cases are also included in the table.

Table 4. Reservoirs in the ACF basin, their owners, and data collected

Reservoir (1)	**Owner (2)**	**Data collected (3)**
Bartlett's Ferry	Georgia Power Company	Midnight pool elevations
Oliver	Georgia Power Company	Midnight pool elevations
North Highlands	Georgia Power Company	Midnight pool elevations
Goat Rock	Georgia Power Company	Midnight pool elevations
Buford	Corps of Engineers	Pool elevation, inflow, outflow, rainfall
West Point	Corps of Engineers	Pool elevation, inflow, outflow, rainfall
Walter F. George	Corps of Engineers	Pool elevation inflow, outflow, rainfall
Jim Woodruff	Corps of Engineers	Pool elevation inflow, outflow, rainfall

Table 5. GPC reservoir inflow adjustments

GPC reservoir (1)	**Inflow adjustment (drainage area ratio x *Columbus Q[1]) (2)**
Bartletts Ferry	0.908xAdj Columbus Q
Goat Rock	0.968xAdj Columbus Q
Oliver	0.974xAdj Columbus Q
North Highlands	0.991xAdj Columbus Q

[1]Columbus flows adjusted for regulation by GPC fall-line projects

Table 6. Reservoir data prior to filling

Reservoir Data. (1)	Inflow/Outflow (2)	No. missing values (3)	Dates (4)	Fill-in method (5)
Buford	Inflow and Outflow		01Jan39-26Jan42	Y=Norcross Q 0.993918 *.996261
	Inflow		27Jan42-07Feb56	Y=Buford gage Q
	Discharge		27Jan42-06Feb56	Y=Buford gage Q
West Point	Inflow and Discharge		01Jan1939-15Oct74	Y=West Point gage Q
	Inflow		16Oct74-08May75	Y=Atlanta gage Q x 2.48 shifted forward 2 days
	Discharge		16Oct74-09May75	Y=West Point gage Q
	Inflow		08Oct93-01Nov93	Y=Atlanta routed flow adjusted for volume
W.F. George	Inflow and Discharge		01Jan1939-30Sep1960	Y=0.93 Columbia Q
	Inflow and Discharge		01OCT60 - 10MAY62	Y=Ft. Gaines Q
	Inflow		11May62-12Mar63	Y=1.387 Columbus routed Q
	Inflow		(20-30Sep70, 02-04Oct81, 06-07Oct81, 11-12Oct93)	Special Cases
	Discharge		11May62 - 30Sep62	Y=Ft. Gaines Q
	Discharge		01OCT62 - 12MAR63	Y=0.87 Alga Q
Jim Woodruff	Inflow and Discharge		01Jan39 - 03Feb57	Y=Chattahoochee Q

Leakage

We did not make flow adjustments due to leakage at the reservoirs. This is consistent with the 1997 analysis as stated on p. 69 of the *Unimpaired flow report.*

Evaporation and precipitation data

The presence of man-made reservoirs in the ACF basin has affected the volume of surface water through increased evaporation and increased rainfall-runoff.

Developing unimpaired flows requires removal of existing reservoir effects. Appendix B of the *Unimpaired flow report* contains a detailed description of the methodology used for evaporation and precipitation adjustments. Net evaporation includes both positive and negative values, which may either increase or decrease inflows at a reservoir. A map of the precipitation and evaporation gages used to compute the adjustments is shown in Figure 5.

Net evaporation adjustments were limited to large storage reservoirs. No adjustments were applied to the fall-line run-of-river projects and George Andrews. The inflows to these projects were estimated based on nearby gages.

To compute net evaporation we:

- Collected the average annual evaporation values from NOAA.
- Distributed the annual values monthly using pan monthly evaporation stations.
- Computed the surface runoff from rainfall values from 1939-2012.
- Computed the net evaporation in inches at each reservoir.
- Converted the net evaporation to cfs using the daily pool areas and the rating curve at each of the reservoirs.

Net evaporation computations are completed in workbook 03_ACF_RESERVOIRS_Adjusted_Inflow_1939-2012.xlsx.

The monthly precipitation data is listed in Table 7, and the monthly evaporation data listed in Table 8. Figure 5 is a map of rainfall and evaporation stations.

Table 7.Precipitation stations used for each reservoir and status of data

Reservoir (1)	**Rainfall station (2)**	**ID (3)**	**Data status (4)**
Buford	Cummings 2NNE, GA	USC00092408	No monthly data in NCDC. We used available daily data averaged monthly. Missing 123 daily values. 8/1948-12/2008 Missing 36 months
Buford	Gainesville, GA	USC00093621	1/1939-12/2012 Missing 4 months.
West Point	Lafayette, AL	USC00014502	11/1948-12/2012 Missing 47 month, August 2005.
West Point	La Grange, GA	USC00094949	No monthly data in NCDC. We used available daily data averaged monthly Missing 2,861 daily values. 1/1994-2/2002 Missing 5 months
West Point	West Point, GA	USC00099291	1/1939-12/1993 Missing 12 months
WF George	Abbeville 1 NNW, AL	USC00010008	Not found in NCDC. We collected data for “ABBEVILLE, AL”. 1/1953-3/1956, 2/1959-12/2012 Missing 35 months
WF George	Eufaula WR, AL	USC00012730	3/1967-12/2012 Missing 18 months
WF George	Eufaula, AL	USC00012727	1/1939-6/1966 Missing 24 months.
WF George	Fort Gaines, GA	USC00093516	7/1948-8/1984 Missing 12 months
Jim Woodruff	COLQUITT 2 W, GA	USC00092153	1/1994-12/2012 Missing 6 months.
Jim Woodruff	Quincy 3 SSW, FL	USC00087429	1/1960-10/1978, 1/1987-12/2012 Missing 35 months.
Jim Woodruff	Bainbridge, GA	USC00092736	1939-1976 Missing 21 months
Jim Woodruff	Bainbridge International Paper, GA	USC00090586	1977-2012 Missing 55 months.

Reservoir (1)	Rainfall station (2)	ID (3)	Data status (4)
Jim Woodruff	Donalsonville 1 S, GA	USC00092736	1948-1986 Missing 3 months

Table 8. Annual evaporation stations

Reservoir (1)	Annual evaporation from NWS 33, Map3 (inches) (2)	Pan stations used to distribute annual to monthly (3)
Buford	36.7	Rome WSO AP, GA
West Point	40.2	Columbus WB AP, GA
WF George	42.0	Jim Woodruff Dam
Jim Woodruff	43.2	Jim Woodruff Dam

Table 9. Monthly distribution of the annual evaporation values.

Month (1)	Buford evaporation rate (in) (2)	West Point evaporation rate (in) (3)	W. F. George evaporation rate (in) (4)	Jim Woodruff evaporation rate (in) (5)
January	1.24	1.51	1.69	1.73
February	1.94	1.95	2.01	2.07
March	2.7	3.06	3.37	3.47
April	3.71	4.05	4.26	4.38
May	4.47	4.97	4.84	4.98
June	4.7	4.97	4.94	5.09
July	4.81	4.48	4.71	4.84
August	4.23	4.53	4.55	4.68
September	3.55	3.91	4.26	4.38
October	2.64	3.2	3.52	3.62
November	1.63	2.04	2.21	2.27
December	1.08	1.54	1.65	1.69
Total	36.7	40.2	42.0	43.2

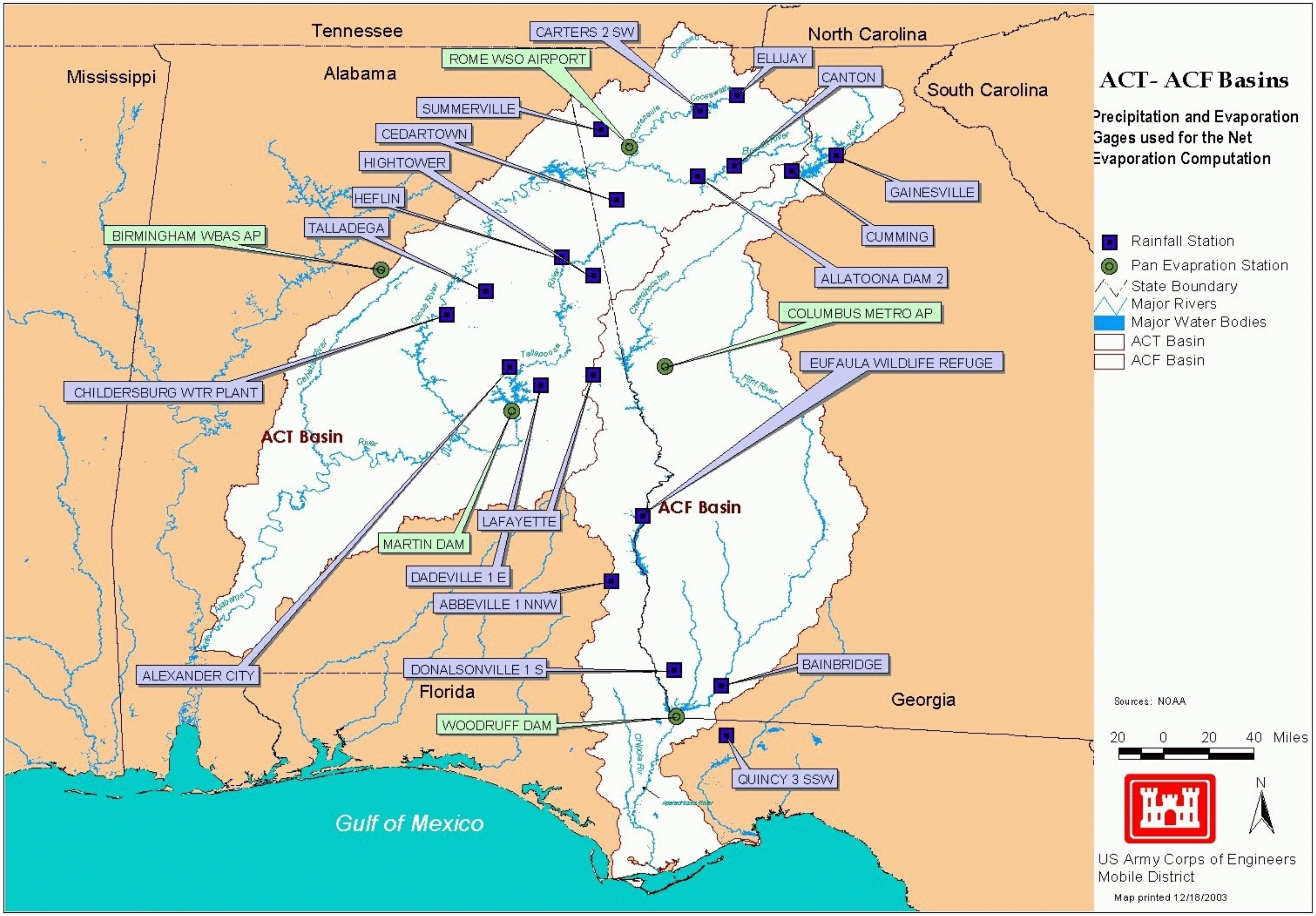


Figure 5. Gages used to compute net evaporation in the ACF basin

(not all rainfall stations are shown)

Assessment of data quality

Within the "remarks" portion of the USGS gage description is a statement about the accuracy of the records:

"The accuracy of streamflow records depends primarily on: (1) The stability of the stage-outflow relationship or, if the control is unstable, the frequency of outflow measurements; and (2) the accuracy of measurements of stage, measurement of outflow, and interpretation of records. The accuracy is excellent, good, fair, or poor. 'Excellent' means that about 95 percent of the daily outflow are within 5 percent of the true; 'good' within 10 percent' and 'fair', within 15 percent. Records that do not meet the criteria mentioned are rated 'poor.' Different accuracy levels may be attributed to different parts of a given record."

Mobile District uses the same USGS principles to determine the accuracy of streamflow records. Consequently, the data contain known levels of accuracy for all USGS and Mobile District streamflow records.

There are no statements about the accuracy of data for rainfall and reservoir records. There is either a recorded value or missing value on any day. Modelers discovered inconsistencies in the reservoir inflow, outflow, and change in storage for many of the reservoirs. Since pool elevations and outflows are observed values, they are more reliable than computed inflow values. Change in storage is a direct measurement of daily changes in pool elevation. Reservoir inflows were recomputed for every reservoir using the outflow and change in storage.

Reservoir inflow computations

We recomputed reservoir inflows using the reconstructed elevations and outflows after the data quality check. We used the reservoir continuity equation to maintain flow volume:

Inflow = Outflow + Change in storage

Reservoir outflow is the total outflow from turbines, spillway gates, low flow outlets, and navigation locks, and is defined in the reservoir storage outflow rating table.

To compute the change in daily storage we used the elevation-storage rating tables to look up the storage using the adjusted midnight pool elevation on day 2 and subtracted from the storage for the adjusted midnight pool elevation on day 1. We computed reservoir inflows in workbook 03_ACF_RESERVOIRS_Adjusted_Inflow_1939-2012.

To compute the inflows at Columbus, we:

1. Entered the observed elevations for each of the GPC reservoirs.
2. Computed the daily change in storage for each of the GPC reservoirs.
3. Summed the change in storage for the 4 GPC reservoirs.
4. Converted the storage to cfs per day.
5. Adjusted the flow at Columbus to account for storage at the 4 GPC reservoirs (added the total flow to the observed Columbus gage flow).
6. Adjusted the inflow for each of the 4 GPC reservoirs by applying a drainage area ratio to the adjusted Columbus flow. Drainage area ratios for each GPC reservoir are shown in Table 5.

Table 6 includes the reservoir data prior to filling.

To compute the flows at George Andrews, we used the following equation: George Andrews's inflow/outflow = 1.10 x W F George outflow.

Morgan Falls is not included in the incremental local flow computations. However, for the purpose of HEC-ResSim modeling, we multiplied the Atlanta local flow by 0.71 to compute the incremental local flow at Morgan Falls.

Routing

To route flows between locations, we used the same routing parameters that were used in the 2002 update, listed in Table 23 on p. 29 of the *Extended unimpaired flow report.* All reaches use Muskingum or coefficient routing methods, except for Blountstown to Sumatra, where Modified Puls routing is used. Details of routing methods used are in Appendix I*.*

Modified Puls routing parameters for Blountstown to Sumatra were obtained from DSS macro MATHMAC10,ACF and ACFCUM_10.DSS and are listed in Table 10.

Muskingum and coefficient routing reaches and routing parameters are listed in Table 11.

Routed flows are computed in workbook 04_ACF_GAGES_Routings_1939-2012.xlsx, with the exception for the Modified Puls routing from Blountstown to Sumatra, which is computed using HEC-DSSVue because Excel computations were not reproducing the HEC-DSS results.

Table 10. Modified puls routing parameters for Blountstown (192) to Sumatra (185)

Storage, ac-ft (1)	**Flow, cfs (2)**
0	0
99174	25000
2082654	275000

Table 11. Routing parameters for all reaches except Blountstown to Sumatra (Table 23 Extended unimpaired flow report)

River (1)	Reach description (2)	Length, mi. (3)	Travel time, hr. (4)	Musk. K (5)	No. of sub-reaches (6)	Musk. X (7)	Coefficient routing parameters (8)
Flint	Griffin (360) to Montezuma (350)	124	120	120	5	0	-
Flint	Montezuma (350) to Albany (340)	77	48	48	2	0	-
Flint	Albany (340) to Newton (330)	34	24	24	1	0	-
Flint	Newton (330) to Bainbridge (320)	40	24	24	1	0	-
Flint	Bainbridge (320) to Jim Woodruff (196)	29	Null	-	-	-	-
Chattahoochee	Buford (225) to Norcross (222)	18	12	12	1	.3	-
Chattahoochee	Norcross (222) to Morgan Falls (221)	18	6	-	-	-	.75,.25
Chattahoochee	Atlanta (220) to Whitesburg (217)	43	24	24	1	.1	-
Chattahoochee	Whitesburg (217) to West Point Res (215)	61	24	24	1	.1	-
Chattahoochee	West Point Res (215) to West Point Gage (214)	2	Null	-	-	-	-
Chattahoochee	West Point Gage (214) to Bartletts Ferry (211)	21	6	-	-	-	.75,.25
Chattahoochee	Bartletts Ferry (211) to Goat Rock (210)	5	Null	-	-	-	-
Chattahoochee	Goat Rock (210) to Oliver (209)	9	Null	-	-	-	-
Chattahoochee	Oliver (209) to North Highlands (208)	1	Null	-	-	-	-
Chattahoochee	North Highlands (208) to Columbus (205)	3	Null	-	-	-	-
Chattahoochee	Columbus (205) to WF George (200)	85	12	-	-	-	.58,.38,.04
Chattahoochee	WF George(200) to George Andrews (199)	29	Null	-	-	-	-
Chattahoochee	George Andrews (199) to Jim Woodruff (196)	47	12	-	-	-	.58,.38,.04
Apalachicola	Jim Woodruff (196) to Chattahoochee (194)	1	Null	-	-	-	-
Apalachicola	Chattahoochee (194) to Blountstown (192)	29	18	18	1	0	-

Incremental local flow computations

To compute incremental local flows, we routed the upstream flows at each location to the next downstream location and subtracted the routed flow from the downstream observed flow. A hypothetical example of a local flow computation is show graphically in Figure 6. Incremental local flows are computed on worksheet LocalFlow of workbook 05_ACF_LocalIncremental_1939-2012.xlsx.

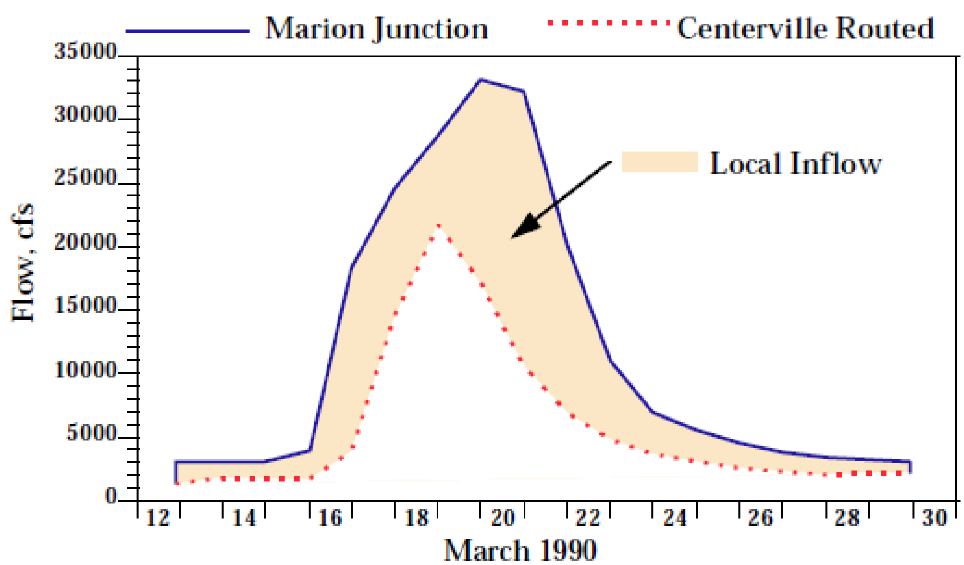


Figure 6. Hypothetical graphic of incremental local flow computation; incremental local flow is the difference between the downstream and routed upstream hydrographs, source: Unimpaired flow report, p. 44

Municipal and industrial withdrawals and returns

Inherent in the measured or observed flow records are the impacts of man-made changes within the river basins. An identifiable and quantifiable component of these man-made changes is the municipal and industrial water withdrawals and returns. A complete inventory of all municipal, industrial, and power withdrawals and returns greater than 0.1 million gallons per day (mgd) was a required part of the ACT/ACF River Basins Comprehensive Water Resources Study. The Municipal, Industrial, Power and Agriculture Water Use Inventory, commonly known as "PIPES", contains data for the period January 1, 1980 through December 31, 1993.

Mobile District contacted the state agencies involved in the Comprehensive Study to provide all available water use data. The states had provided data to support previous unimpaired flow extensions in years 2004 and 2009. Information on M&I withdrawals and returns are shown in Table 12. These data were provided in workbooks by Alabama's Office of Water Resources and Georgia's Environmental Protection Division. The Florida data were provided by the Northwest Florida Water Management District (NWFWMD). Daily average values within each month is equivalent to the monthly average. Since the states provided the water use data as monthly average, there was no attempt to distribute the net water use as a varying daily pattern.

Table 12. M&I withdrawal data

State (1)	Workbooks provided (2)	Dates (3)
FL	• ACF_Surface_Water_1994-2012.xls	1994-2012
	• ACF_FL_Total_use_by_reach-2013-07-12.xlsx	2008-2012
	• FL-Apalachicola_1994-2008.xls	1980-2008
GA	• ACF_Surface_Water_1994-2012.xls	1994-2012
	• 201403190-ACT-ACF-GA Withdrawal Returns 1990-2012-updated-June2013.xlsx	1994-2012
	• GA-ACF-water-use-agr-1970_2012.xlsx	1970-2012
AL	• ACF_Surface_Water_1994-2012.xls	1994-2012
	• 20130920 - ACF Unimpaired_2009_2012_Final.xlsx	2008-2012
	• ALreformatACF_COE.xls	1994-2001
	• AL_CHATT_2002-2008.xls	2002-2008
	• AL_CHATT_1994-2001.xls	1994-2001

Alabama and Georgia grouped the municipal and industrial data by reaches according to reaches defined in the HEC-5 model. Florida provided surface water use for 2 reaches (above Blountstown and above Sumatra).

The definition of a reach is the area between an upstream control point and a downstream control point. Table 13 shows the river, the upstream control point, the downstream control point, and the reach number for each reach. (The HEC-5 downstream control point, as defined in the HEC-5 model, designates each reach). The basin model schematic labeled with HEC-5 control point numbers is shown in Figure 3.

There are a total of 105 M&I withdrawal sites (10 in Alabama, 91 in Georgia, and 4 in Florida).

Table 14 lists the withdrawal sites located in Alabama, Table 15 lists the withdrawal sites in Georgia, and Table 16 lists the withdrawal sites in Florida by Individual Water Use Permit (IWUP).

Table 13. Model reaches for water withdrawals

River (1)	Upstream control point (2)	Downstream control point (3)	HEC-5 reach no. (4)
Flint	None	Griffin	360
Flint	Griffin	Montezuma	350
Flint	Montezuma	Albany (Flint R Dam Gage)	340
Flint	Albany (Flint R Dam Gage)	Newton	330
Flint	Newton	Bainbridge	320
Chattahoochee	None	Buford	225
Chattahoochee	Buford	Norcross	222
Chattahoochee	Norcross	Morgan Falls	221
Chattahoochee	Morgan Falls	Atlanta	220
Chattahoochee	Atlanta	Whitesburg	217
Chattahoochee	Whitesburg	West Point Dam	215
Chattahoochee	West Point Dam	West Point Gage	214
Chattahoochee	West Point Gage	Columbus	205
Chattahoochee	Columbus	Walter F George	200
Chattahoochee	Walter F George	George Andrews	199
Flint	Bainbridge	Jim Woodruff	196F
Chattahoochee	George Andrews	Jim Woodruff	196C
Apalachicola	Jim Woodruff	Chattahoochee	194
Apalachicola	Chattahoochee	Blountstown	192
Apalachicola	Blountstown	Sumatra	185

Table 14. M&I withdrawal sites in Alabama

County (1)	Facility name (2)	Certificate no. (3)	HEC-5 reach no.(4)	Category
CHAMBERS	Westpoint Stevens Inc. - Fairfax Finishing Plant Water Intake	293	205	NonPublic
CHAMBERS	Chattahoochee Valley Water	229	205	Public

County (1)	Facility name (2)	Certificate no. (3)	HEC-5 reach no.(4)	Category
	Supply District Lanett Filter Plant - 072-1291-04			
CHAMBERS	Langdale Mill - Non-contact Cooling	231	205	NonPublic
LEE	Opelika Water Works Board R.A. Betts - Halawalkee Creek Intake	236	205	Public
LEE	Smiths Water Authority - Intake No. 1	215	205	Public
RUSSELL	MeadWestvaco Corporation Mahrt Mill - River Intake	1	200	NonPublic
RUSSELL	Continential Carbon Company Phenix City Plant - Back-up River Pump	129	200	NonPublic
RUSSELL	Continential Carbon Company Phenix City Plant - Main River Pump	129	200	NonPublic
RUSSELL	Phenix City Water Works	185	200	Public
HOUSTON	J.M. Farley Nuclear Plant-Units 1 & 2 Intake	63	196C	NonPublic

Table 15. M&I withdrawal sites in Georgia

County (1)	Facility (2)	Permit no. (3)	HEC-5 reach no. (4)
Clayton	Clayton County Water Auth - Shoal (1)	031-1101-01	360
Clayton	Clayton County Water Auth - Shoal (2)	031-1101-01 (a)	360
Clayton	Clayton County Water Auth - Shoal (3)	031-1101-01 (b)	360
Coweta	Newnan Water Supply & Light Comm	038-1102-11	350
Coweta	Newnan Water Supply & Light Comm	038-1103-02	350
Coweta	Senoia, City Of	038-1102-05	350
Fayette	Board Of Commissioners Of Fayette Co.	056-1102-06	350
Fayette	Board Of Commissioners Of Fayette Co.	056-1102-09	350
Fayette	Board Of Commissioners Of Fayette Co.	056-1102-10	350
Fayette	Fayette County Water System	056-1102-03	350
Fayette	Fayette County Water System (1)	056-1102-12 (04)	350
Fayette	Fayette County Water System (2)	056-1102-12	350
Fayette	Fayetteville, City Of	056-1102-14	350
Meriwether	Roosevelt Warm Springs Rehab	099-1106-04	360
Meriwether	Woodbury, City Of	099-1106-02	350
Spalding	Griffin, City Of	126-1190-01	360
Spalding	Griffin, City Of	114-1104-03	350

County (1)	Facility (2)	Permit no. (3)	HEC-5 reach no. (4)
Talbot	Manchester, City of	130-1106-05	350
Talbot	Manchester, City of	130-1106-06	350
Taylor	Unimin Georgia Company, L.P.	133-1109-01	360
Taylor	Unimin Georgia Company, L.P.	133-1109-02	360
Upson	Southern Mills, Inc.	145-1104-02	350
Upson	Thomaston, City Of	145-1105-01	350
Upson	Thomaston, City Of	145-1105-02	350
Upson	Thomaston, City Of	145-1105-03	350
Macon	Weyerhaeuser Company	094-1191-01	340
Dawson	McRae and Stolz, Inc.	042-1202-01	225
Forsyth	Cumming, City Of	058-1290-07	225
Forsyth	Forsyth County Board Of Commissioners	058-1207-06	225
Forsyth	Lanier Golf Club	058-1207-05	225
Habersham	Baldwin, City Of	068-1201-04	225
Habersham	Clarkesville, City Of	068-1201-03	225
Habersham	Cornelia, City Of	068-1201-01	225
Hall	Buford, City Of	069-1290-04	225
Hall	Gainesville, City Of	069-1290-05	225
Hall	Gwinnett County Water & Sewerage Auth	069-1290-06	225
Hall	LLI Management Company, LLC	069-1205-01	225
Hall	LLI Management Company, LLC	069-1205-02	225
Hall	Milliken & Co. - New Holland Plant	069-0301-02	225
Lumpkin	Birchriver Golf, L.P.	093-1202-03	225
Lumpkin	Dahlonega, City Of - New Plant	093-1204-01	225
White	White County Water & Sewer Authority	154-1202-02	225
Forsyth	Olde Atlanta Golf Club, LP	058-1207-03	222
Forsyth	Southeast Investments, L.L.C. (1)	058-1207-08	222
Forsyth	Southeast Investments, L.L.C. (2)	058-1207-08	222
Forsyth	Southeast Investments, L.L.C. (3)	058-1207-08	222
Forsyth	Westbrook Windermere, LLC	058-1207-09	222
Fulton	Atlanta Athletic Club	060-1209-02	222
Cobb	Cobb Co - Marietta Water Auth	033-1290-01	220
Dekalb	Dekalb Co Public Works - Water & Sewer	044-1290-03	221
Fulton	Atlanta-Fulton Co. Water Res. Commission	060-1207-02	221
Fulton	Cherokee Town & Country Club	060-1290-09	221
Fulton	GCG Members' Purchasing Committee, Inc.	060-1209-04	221

County (1)	Facility (2)	Permit no. (3)	HEC-5 reach no. (4)
Fulton	Riverfarm Enterprises, Inc.(RiverPines Golf)	060-1207-04	221
Fulton	Roswell, City Of - Big Creek	060-1209-01	221
Fulton	Standard Golf Club	060-1209-03	221
Fulton	Tattersall Club Corp	060-1290-08	221
Fulton	Atlanta, City of	060-1291-01	217
Carroll	Carroll County Water Authority	022-1217-01	217
Cobb	Caraustar Mill Group, Inc. - Mill 2	033-1214-02	217
Cobb	Caraustar Mill Group, Inc. - Sweetwater	033-1214-01	217
Cobb	Georgia Power Co - Plant McDonough	033-1291-03	217
Coweta	Coweta County Water & Sewerage Authority	038-1218-02	217
Douglas	Douglasville - Douglas County W & S A	048-1216-03	217
Douglas	Douglasville - Douglas County W & S A	048-1217-03	217
Douglas	East Point, City Of	048-1214-03	217
Fulton	Palmetto, City Of	060-1218-01	217
Coweta	Georgia Power Co - Plant Yates	038-1291-02	215
Coweta	Newnan Water Supply & Light Comm	038-1221-01	215
Coweta	Newnan Water Supply & Light Comm	038-1221-02	215
Heard	Georgia Power Co - Plant Wansley	074-1291-07	215
Heard	Heard County Water Authority	074-1220-02	215
Heard	Heard County Water Authority	074-1220-03	215
Troup	Hogansville, City Of	141-1222-01	215
Troup	Lagrange, City Of	141-1292-01	215
Troup	West Point, City Of	141-1292-02	214
Harris	Chat Valley Water Supply District	072-1291-04	205
Harris	Harris County Water Dept	072-1224-01	205
Harris	West Point Stevens, Inc. - Fairfax Mill	072-1293-03	205
Lee	Georgia Power Co - Plant Franklin	106-1225-08	205
Muscogee	Columbus, City Of	106-1293-05	205
Muscogee	Smiths Water Authority	106-1225-05	205
Chattahoochee	Fort Benning	026-1225-01	200
Marion	Unimin Georgia Company, L.P.	096-1225-09	200
Muscogee	Continental Carbon	106-1225-07	200
Early	Great Southern Paper Co. (Ga. Pacific Corp.)	049-1295-01	196C

Table 16. M&I withdrawal sites in Florida

IWUP (1)	Use (2)	HEC-5 reach no. (3)
19850072	Gulf Power (Sholz Electric)	192
	St Joe Paper Co (FL Coast Paper)	185
19830039	City of Port St. Joe	185
	St. Joe Timberland (Prudential Ins)	185

There are a total of 234 M&I return sites (22 in Alabama and 212 in Georgia) as shown in Table 17 and Table 18, respectively. No return information is available for the Florida withdrawals in the Blountstown and Sumatra reaches.

We entered the M&I withdrawals and returns provided by Alabama, Florida, and Georgia in workbook 06_ACF_WATERUSE_1939-2012.xlsx. We aggregated the water use by reach and computed the total M&I net surface water use for each reach. The totals for 1994-2012 are shown in Table 19. A map of withdrawal sites in the ACT and ACF basins is shown in Figure 7.

Table 17. M&I return sites in Alabama

County (1)	**Facility (2)**	**Certificate no. (3)**	**HEC-5 reach no. (4)**	Certificate Category
Chambers	Fairfax Finishing Plant	293	205	NonPublic
Chambers	Fairfax Plant	293	205	NonPublic
Chambers	Lanett Filter Plant	229	205	Public
Chambers	Lanett Waste Water Treatment Plant	1103	205	Public
Chambers	Langdale Mill	231	205	NonPublic
Chambers	Lower Valley WWTP	208	205	Public
Lee	Grifftex Chemical	230	205	NonPublic
Lee	Opelika Filter Plant	230	205	NonPublic
Lee	Opelika Finishing NPDES NO. AL0002968	230	205	NonPublic
Lee	Opelika Finishing SID No. IU 34-41-00011	230	205	NonPublic
Barbour	Eufaula WWTF	255	200	Public
Barbour	Treatment Plant	962	200	Public
Russell	Hurtsboro HRC Lagoon	757	200	Public
Russell	Mead Coated Board	1	200	NonPublic
Russell	Phenix City WWTP	129	200	Public
Henry	Abbeville Waterworks and Sewer Board - AL0059358	199	199	Public
Henry	Farm Discharge No. 1	209	199	NonPublic
Henry	Jimmy Carr Wastewater Treatment Plan	51	199	Public
Houston	Columbia Wastewater Lagoon	658	199	Public
Houston	Omussee Creek Waste Water Treatment Plant	27	199	Public
Houston	Cypress Creek Waste Water Treatment Plant	27	196C	Public
Houston	J.M. Farley Nuclear Plant	63	196C	NonPublic

Table 18. M&I return sites in Georgia

County (1)	Facility (2)	Permit no. (3)	HEC-5 reach no. (4)
Clayton	Lafarge Aggregates SE Inc.	GA0046108	350
Coweta	Autumn's Gate MHP	GA0034606	350
Coweta	Coweta County-Shenandoah WPCP	GA0034614	350
Coweta	Peachtree City-Line Creek WPCP	GA0035777	360
Crawford	Atlanta Sand And Supply	GA0001384	350
Crawford	Roberta WPCP	GA0020834	350
Fayette	Fayetteville-Whitewater Creek WPCP	GA0035807	360
Fayette	Fernwood Park	GA0023078	350
Fayette	Florida Rock Industries-Tyrone Qry	GA0031844	350
Fayette	Four Seasons MHP	GA0023388	350
Fayette	Hanson Aggregates-Fayette	GA0046060	360
Fayette	Marnelle Mobile Home Estates	GA0030198	350
Fayette	North Fayette Elementary School	GA0035670	350
Fayette	Peachtree City-Flat Creek	GA0020371	350
Fayette	Peachtree City-Rockaway WPCP	GA0046655	350
Fulton	Vulcan Materials Company-Red Oak Qry	GA0000752	360
Henry	Atlanta Motor Speedway	GA0031160	350
Henry	Clayton County-Shoal Creek WPCP	GA0038369	360
Henry	Hampton WPCP	GA0020320	360
Lamar	Griffin-Potato Creek WPCP	GA0030791	350
Macon	Ideal WPCP	GA0048011	350
Macon	Marshallville WPCP	GA0047431	350
Macon	Oaks Nursing Home	GA0031691	350
Macon	Oglethorpe Pond	GA0036919	350
Marion	Buena Vista WPCP	GA0023710	350
Meriwether	Greenville-Kennel Cr. WPCP	GA0047813	350
Meriwether	Warm Springs WPCP	GA0001601	350
Pike	Concord North #2	GA0025461	350
Pike	Concord South #1	GA0025470	350
Pike	Georgia Baptist Children's Home-Pine Mountain Campus	GA0022314	350
Pike	Molena Nursing Home	GA0024031	350
Spalding	Beaverbrook Elementary School	GA0034380	350
Spalding	Timber Creek MHP	GA0023531	350
Talbot	Talbotton WPCP	GA0047805	350
Taylor	Reynolds Pond	GA0020729	350
Upson	Thomaston-Bell Creek WPCP	GA0020079	350

County (1)	Facility (2)	Permit no. (3)	HEC-5 reach no. (4)
Upson	Thomaston-Town Branch WPCP	GA0030121	350
Upson	Thomaston Mills Inc.	GA0000213	350
Crisp	Cordele WPCP	GA0024503	340
Crisp	Marvair Division of Airxcel Inc.	GA0037184	340
Crisp	Super 8 Motel (Cordele Inn)	GA0048933	340
Dooly	Byromville Pond	GA0025623	340
Dougherty	Miller Breweries East Inc.	GA0049093	340
Lee	Lee County-Kinchafoonee Creek	GA0026603	340
Lee	Leesburg Pond	GA0026638	340
Lee	Martin Marietta Aggregates	GA0048968	340
Lee	Smithville Pond	GA0047422	340
Macon	C-E Minerals-Plant 5	GA0023728	340
Macon	Montezuma WPCP #1	GA0021288	340
Macon	Montezuma WPCP #2	GA0020486	340
Macon	Weyerhaeuser Company-Flint River Operations	GA0049336	340
Marion	Tyson Foods Inc.	GA0000817	340
Schley	Ellaville Pond	GA0050105	340
Stewart	Richland Pond	GA0021539	340
Sumter	Americus-Mill Creek WPCP	GA0047767	340
Sumter	Andersonville WPCP	GA0033669	340
Sumter	Plains WPCP	GA0020931	340
Worth	Worthy Manor Subdivision	GA0026891	340
Dougherty	Albany-Joshua Street WPCP	GA0037222	330
Dougherty	Merck Manufacturing Division-Flint River Plant	GA0001619	330
Dougherty	Proctor & Gamble Paper Products	GA0049981	330
Mitchell	Baconton WPCP	GA0037737	330
Calhoun	Arlington-Pond #2 Cherry Rd WPCP	GA0050075	320
Calhoun	Edison WPCP	GA0037427	320
Calhoun	Leary WPCP	GA0026212	320
Decatur	Decatur County Industrial Airpark WPCP	GA0033511	320
Decatur	Palmer's Motel-Bainbridge	GA0034746	320
Grady	Grady Aggregate Corporation	GA0036731	320
Randolph	Cuthbert WPCP	GA0037249	330
Randolph	Shellman WPCP	GA0032361	330
Terrell	Dawson WPCP	GA0021326	320
Forsyth	Buckhorn Ventures LLC	GA0037290	225
Forsyth	Cumming-Lanier Beach South	GA0031674	225

County (1)	Facility (2)	Permit no. (3)	HEC-5 reach no. (4)
Forsyth	Habersham On Lanier	GA0030261	225
Habersham	Baldwin WPCP	GA0033243	225
Habersham	Clarkesville WPCP	GA0032514	225
Habersham	Cornelia WPCP	GA0021504	225
Habersham	Demorest WPCP	GA0032506	225
Habersham	Habersham Central High School	GA0033952	225
Habersham	Hanson Aggregates SE	GA0046086	225
Habersham	Scovill Fasteners Inc.	GA0001112	225
Hall	Flowery Branch WPCP	GA0031933	225
Hall	Gainesville-Flat Creek WPCP	GA0021156	225
Hall	Gainesville-Linwood WPCP	GA0020168	225
Hall	LLI Management Company-Lake Lanier Islands WPCP	GA0049115	225
Hall	Lula Pond WPCP	GA0024767	225
Lumpkin	Dahlonega WPCP	GA0026077	225
Lumpkin	Oak Grove MHP	GA0034207	225
Lumpkin	Vulcan Construction Materials-Dahlonega II	GA0037508	225
Lumpkin	Vulcan Materials Company	GA0037958	225
White	Camp Barney Medintz	GA0034983	225
White	Camp Coleman	GA0035467	225
White	Cleveland WPCP	GA0036820	225
White	Long Mountain Quarry	GA0046302	225
White	Mountain Lakes Resort	GA0046400	225
	Gwinnett County-Crooked Creek/North WPCP	GA0038130	225
Forsyth	Martin Marietta Aggregates-Forsyth Qry	GA0047562	222
Fulton	Fulton County-Cauley Creek WRF	GA0038440	222
Gwinnett	Buford-Southside WPCP	GA0023167	222
Gwinnett	Buford-Westside WPCP	GA0023175	222
Gwinnett	Chattahoochee MHP	GA0050041	222
Gwinnett	Lafarge Building Materials	GA0047601	222
Forsyth	Cumming-Bethelview Rd WPCP	GA0046019	221
Fulton	Fulton County-Big Creek WPCP	GA0024333	221
Fulton	Fulton County-Johns Creek WRF	GA0030686	221
Fulton	Gwinnett County-Crooked Creek/North WPCP	GA0026433	221
Fulton	Lafarge Building Materials	GA0048640	220
Cobb	Ajay Chemicals Inc.	GA0048283	217

County (1)	Facility (2)	Permit no. (3)	HEC-5 reach no. (4)
Cobb	Caraustar Mill Group Inc.	GA0001911	217
Cobb	Cobb County-R.L. Sutton WPCP	GA0026140	217
Cobb	Cobb County-South WPCP	GA0026158	217
Cobb	Colonial Pipeline Outfall No. 1	GA0048429	217
Cobb	Colonial Pipeline Outfall No. 2	GA0048429	217
Cobb	Colonial Pipeline Outfall No. 3	GA0048429	217
Cobb	Lafarge Building Materials	GA0001627	217
Cobb	USAF Lockheed (Plant No. 6)	GA0001198	217
Douglas	Arbor Village MHP	GA0031526	217
Douglas	Bill Arp Elementary School	GA0034622	217
Douglas	Douglas County-Beaver Estates WPCP	GA0031402	217
Douglas	Douglas County-Rebel Trails WPCP	GA0049786	217
Douglas	Douglasville-North WPCP	GA0030350	217
Douglas	Douglasville-Southside WPCP	GA0030341	217
Douglas	Douglasville Douglas County-Sweetwater WPCP	GA0047201	217
Douglas	Pine Lake MHP	GA0035271	217
Douglas	Villa Rica-Sweetwater WPCP	GA0027171	217
Fulton	Atlanta-R.M. Clayton WPCP	GA0021482	217
Fulton	Atlanta-R.M. Clayton WPCP	GA0039012	217
Fulton	Atlanta-South River WPCP	GA0024040	217
Fulton	Atlanta-South River WPCP	GA0039012	217
Fulton	Atlanta-Utoy Creek WPCP	GA0021458	217
Fulton	Atlanta-Utoy Creek WPCP	GA0039012	217
Fulton	E.C. West Elementary School	GA0035378	217
Fulton	Fulton County-Camp Creek WPCP	GA0025381	217
Fulton	Fulton County-Little Bear Creek	GA0047104	217
Fulton	Lafarge Building Materials	GA0001643	217
Fulton	Lafarge Concrete Paul Ave.	GA0001643	217
Fulton	Vulcan Materials Company-Bellwood Qry	GA0048356	217
Gwinnett	Lafarge Building Materials	GA0046906	217
Carroll	Cedar Village MHP	GA0038512	215
Coweta	Coweta County-Arnall WPCP	GA0000299	215
Coweta	Coweta County-Arnco WPCP	GA0000311	215
Coweta	Days Inn	GA0022632	215
Coweta	Grantville Pond #2	GA0033201	215
Coweta	Grantville Pond #3	GA0033219	215
Coweta	Grantville Pond #4	GA0033227	215
Coweta	Grantville Pond #1	GA0033197	215

County (1)	Facility (2)	Permit no. (3)	HEC-5 reach no. (4)
Coweta	Newnan-Mineral Springs WPCP	GA0021423	215
Coweta	Newnan-Wahoo Creek WPCP	GA0031721	215
Douglas	Newnan Water Supply & Light Comm	038-1102-11	215
Douglas	Newnan Water Supply & Light Comm	038-1103-02	215
Heard	Franklin WPCP	GA0021148	215
Heard	Vulcan Construction Materials-Heard County Qry	GA0046612	215
Harris	Acres of Shade MHP	GA0035912	205
Harris	Callaway Gardens	GA0022527	205
Harris	DNR-Franklin Delanore Roosevelt State Park	GA0049204	205
Harris	Hamilton WPCP	GA0033618	205
Harris	LaGrange-Long Cane Creek WPCP	GA0036951	205
Harris	Oakview Home	GA0031208	205
Harris	Pine Mountain WPCP	GA0025691	205
Harris	West Point WPCP	GA0020052	205
Troup	Interstate Wastewater Svcs	GA0032565	205
Troup	Vulcan Construction Materials-LaGrange	GA0024422	205
Chattahoochee	Columbus-Fort Benning (WPCP 1)	GA0000973	200
Chattahoochee	Columbus-Fort Benning (WPCP 2)	GA0000973	200
Muscogee	Columbus-South WPCP	GA0020516	200
Stewart	DNR-Florence Marina State Park	GA0030147	200
Stewart	Lumpkin WPCP	GA0021032	200
Clay	Fort Gaines WPCP	GA0026191	199
Randolph	Randolph-Clay Mid High School	GA0035874	199
Decatur	Bainbridge WPCP	GA0024678	196C
Seminole	Donalsonville WPCP	GA0026123	196C
Early	Arlington-Pond #1 Wood Valley Road WPCP	GA0026204	196F
Early	Blakely-Pond A	GA0031968	196F
Early	Blakely-Pond B	GA0031976	196F
Early	Blakely WPCP	GA0025585	196F
Early	Georgia Pacific-Great Southern Paper	GA0001201	196C
Miller	Colquitt WPCP	GA0047252	196F

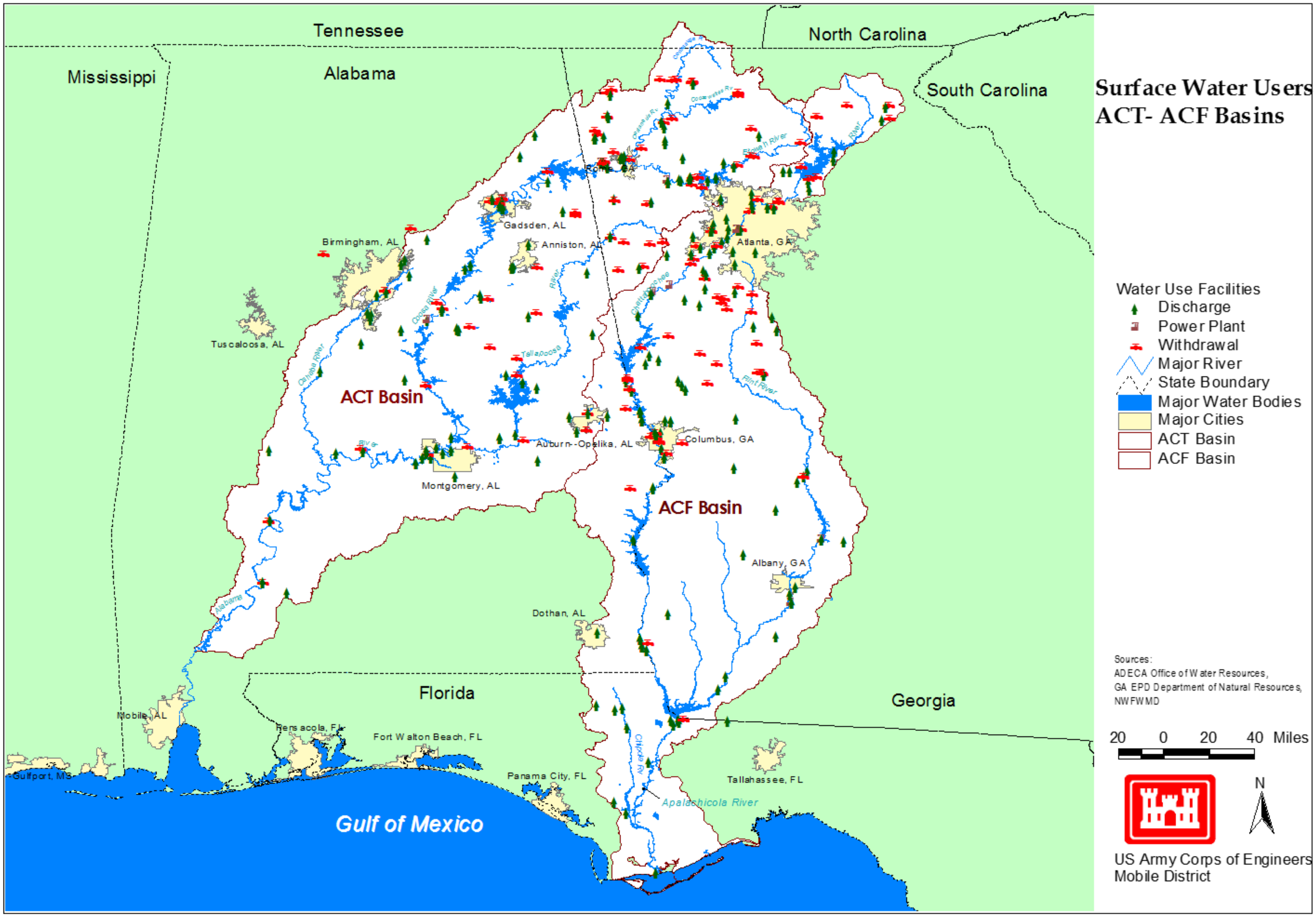


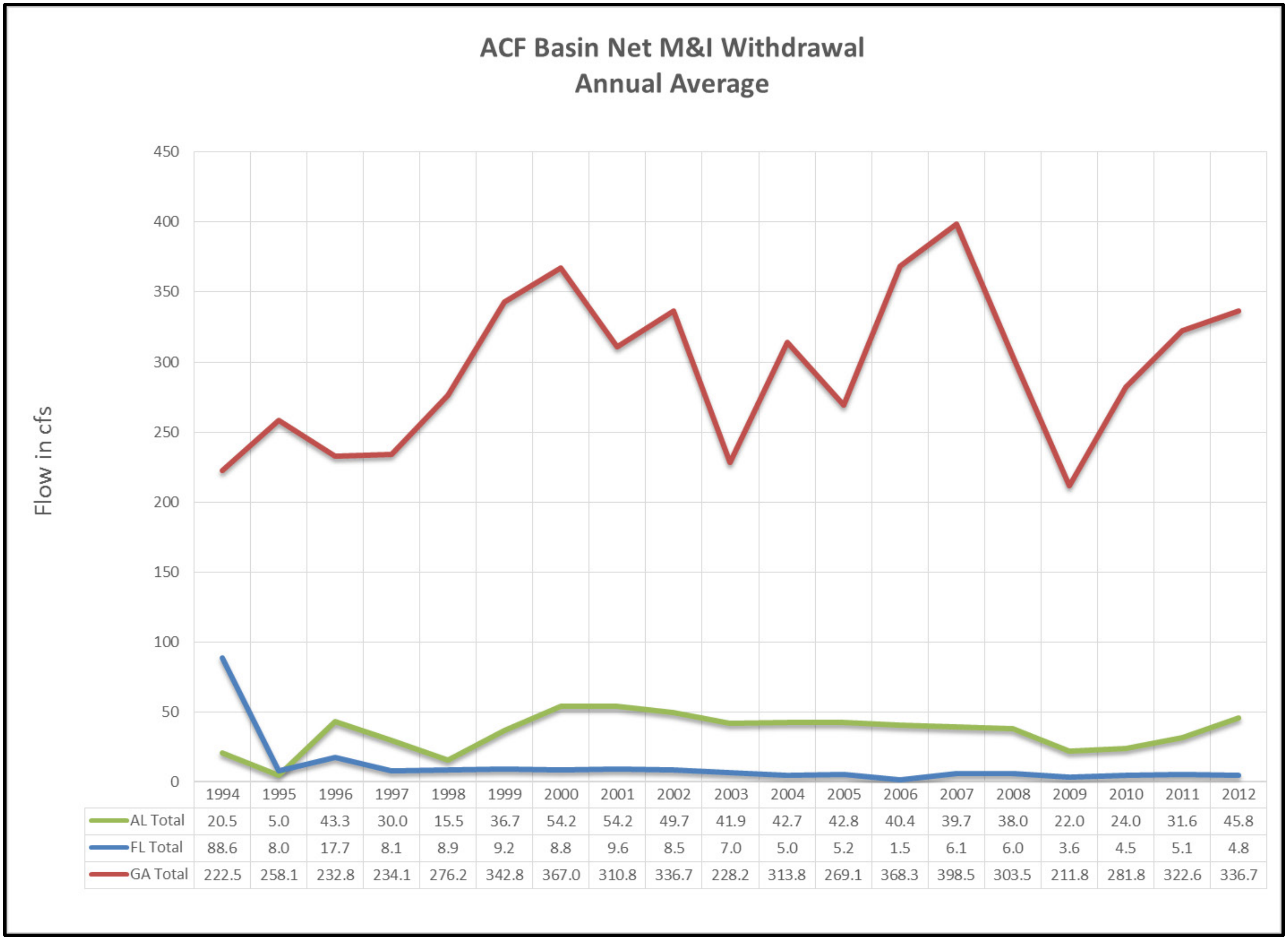
Figure 7. Location of surface water users in the ACT and ACF basins

*Note: Map does not include all water users

Table 19. Net M&I water use by reach, 1994-2012

Reach No (1)	River (2)	Years, cfs																		
		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
360	Flint	12.9	24.3	28.3	28.4	26.6	27.7	30.1	30.3	28.4	29.3	27.3	23.8	25.7	23.1	17.6	11.5	12.6	23.0	24.2
350	Flint	2.7	1.3	1.8	0.4	0.1	0.8	2.3	-1.3	23.1	20.3	16.4	11.4	18.5	25.8	24.5	21.8	23.8	24.2	26.1
340	Flint	-17.4	-10.6	-8.4	-4.7	0.6	-9.5	-9.1	-8.7	-10.1	-11.8	-11.8	-13.9	-10.2	-7.9	1.4	2.8	1.8	2.4	2.8
330	Flint	-2.0	-2.2	-2.4	-9.6	-31.7	-30.5	-31.2	-28.3	-29.0	-31.7	-30.8	-32.2	-30.1	-26.3	-29.6	-27.0	-26.7	-23.2	-22.1
320	Flint	-3.5	-3.1	-2.9	-3.3	-4.4	-2.7	-2.5	-2.7	-2.3	-3.2	-2.8	-3.3	-2.6	-2.5	-3.3	-3.2	-2.7	-2.0	-1.7
196F	Flint	-2.5	-1.7	-2.0	-2.1	-2.2	-1.1	-1.0	-1.3	-1.8	-2.6	-1.9	-3.2	-2.5	-1.9	-2.5	-3.1	-2.5	-1.9	-1.9
225	Chattahoochee	112.5	129.4	133.7	133.4	164.7	177.2	175.0	176.4	174.6	159.7	176.1	174.8	194.1	190.0	157.2	155.2	135.7	127.0	122.9
222	Chattahoochee	-1.4	-1.2	-1.6	-1.6	-1.6	-1.5	-1.3	-1.5	-2.2	-2.1	-2.7	-4.8	-5.3	-5.2	-4.7	-5.3	-4.9	-5.2	-4.6
221	Chattahoochee	127.0	135.1	128.4	128.3	138.7	154.1	150.3	130.7	124.9	104.3	106.9	105.6	110.7	106.7	82.3	67.8	108.1	126.9	135.2
220	Chattahoochee	61.6	55.7	48.4	59.2	66.6	67.5	72.8	66.4	67.2	64.5	72.5	72.6	78.9	80.7	67.6	67.4	66.9	69.8	75.3
217	Chattahoochee	-157.0	-165.8	-176.9	-179.0	-161.2	-124.3	-104.4	-127.8	-125.6	-163.4	-136.6	-151.2	-120.2	-89.8	-80.6	-126.3	-119.5	-104.0	-87.1
215	Chattahoochee	61.2	60.7	60.7	60.6	60.4	55.0	54.7	55.8	60.0	56.3	78.4	83.5	86.5	83.6	75.0	61.7	73.0	61.8	47.7
214	Chattahoochee	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.3	1.1	1.0	1.0	1.1	1.1	1.2	1.1	1.5	1.7	1.7
*205	Chattahoochee	73.8	77.9	76.3	78.1	72.8	83.5	88.7	82.1	67.3	55.4	62.8	63.5	67.8	83.1	67.4	56.2	76.3	81.5	79.7
*200	Chattahoochee	-31.5	-28.9	-35.9	-39.8	-29.3	-27.3	-32.0	-35.3	-29.2	-33.4	-24.3	-37.3	-34.4	-28.8	-37.1	-49.1	-39.6	-33.1	-23.8
*199	Chattahoochee	-7.3	-6.6	-7.1	-7.5	-8.5	-7.2	-6.5	-6.5	-6.6	-7.6	-7.1	-8.8	-6.7	-7.7	-7.3	-8.0	-6.9	-4.5	-5.1
*196C	Chattahoochee	12.8	-2.4	34.3	21.9	-1.1	16.6	34.0	35.3	46.4	34.8	33.0	30.3	37.4	14.1	12.6	10.4	9.1	9.7	13.2
192	Apalachicola	41.8	-38.9	6.3	5.5	6.3	5.5	5.3	6.3	5.5	6.3	5.5	6.3	5.5	7.7	5.9	2.0	2.5	3.3	2.7
185	Apalachicola	46.8	46.9	11.3	2.6	2.6	3.7	3.5	3.2	3.0	0.7	-0.5	-1.1	-4.0	-1.6	0.1	1.5	2.0	1.9	2.1
	ACF Basin Total	331.7	271.1	293.8	272.1	300.6	388.7	429.9	374.6	394.9	277.1	361.5	317.1	410.3	**444.3**	347.5	237.4	310.3	359.3	387.3

*2012 Year is not complete



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
AL Total	20.5	5.0	43.3	30.0	15.5	36.7	54.2	54.2	49.7	41.9	42.7	42.8	40.4	39.7	38.0	22.0	24.0	31.6	45.8
FL Total	88.6	8.0	17.7	8.1	8.9	9.2	8.8	9.6	8.5	7.0	5.0	5.2	1.5	6.1	6.0	3.6	4.5	5.1	4.8
GA Total	222.5	258.1	232.8	234.1	276.2	342.8	367.0	310.8	336.7	228.2	313.8	269.1	368.3	398.5	303.5	211.8	281.8	322.6	336.7

Figure 8. Net M&I water use by state, 1994-2012

*2012 Year is not complete

Agricultural withdrawals

There are a total of 44 agricultural withdrawal sites, 29 in Alabama, 9 in Georgia, and 6 in Florida, as shown in Table 20, Table 21, and Table 22, respectively. There are no agricultural returns.

We computed the total agricultural net surface water use by reach in workbook 06_ACF_WATERUSE_1939-2012.xlsx. The totals for 1994-2012 are shown in Table 23.

Previously as part of the ACT/ACF River Basins Comprehensive Water Resources Study, the task of incorporating the Agriculture/Groundwater data into unimpaired flow involved a detailed process. The process integrated surface water and groundwater irrigation usage impacts by reach and considered the streamflow reduction caused by groundwater usage in Subarea 4 of the ACF basin for which information was available.

Georgia EPD provided the Agricultural water use data for use in developing the Unimpaired Flow. The Georgia ACF Agricultural file contains the amount of surface water withdrawal and the effect of groundwater pumping for agricultural irrigation purpose. When Georgia did the State Water Plan work, mapped irrigated acreage (by sources) data and recorded/estimated application depth were used to estimate the amount of water used for irrigation. The stream flow reduction resulting from groundwater pumping was computed using USGS Torak/Jones groundwater model (USGS MODFE, Jones et al, 2006; Torak et al, 1996). This reduction is then added on top of the amount withdrawn directly from surface water streams for the total stream flow reduction. Starting 2008, Georgia used metered data from the systems where meters are installed. These data provide an annual reading of how much water has been used for the year. These data were then disaggregated to monthly patterns from prior Jim Hook studies (Reference Ag Pumping Report, Flint River Plan, and Jim Hook 2009 Study). Starting 2012, Georgia also has a subset of the metered systems (about 90 of them) with monthly readings. Georgia extrapolated the sub-annual readings and use their intra-annual patterns for all systems and all irrigated acreage. Georgia provided Agricultural water use data for years 1970 – 2012.

Alabama Office of Water Resources provided the Agricultural water use for the Alabama within the ACF Basin. The ACF Agricultural file contains the amount of surface water withdrawal for agricultural irrigation purpose. Since there is not a known surface water groundwater interaction in this portion of the basin. Alabama did not compile groundwater use. Georgia provide Agricultural water use data for years 2002 – 2012.

The NWFWMD provided the Agricultural water use for Florida within the ACF Basin. Each file provides the surface water withdrawal for agricultural irrigation purpose. Florida provided Agricultural water use data for years 2009 – 2012.

Table 20. Agriculture withdrawal sites in Alabama

County (1)	Facility (2)	Certificate no. (3)	HEC-5 reach no. (4)
Chambers	J. T. Cattle Co. - Robert Hamilton	744	205

County (1)	Facility (2)	Certificate no. (3)	HEC-5 reach no. (4)
Barbour	Beasley - Dempsey Boyd Farm	574	200
Barbour	Heritage Turf, Inc. Buck Lake Electric - Cowikee Turf	796	200
Barbour	Heritage Turf, Inc. Cat Pump - Cowikee Turf	796	200
Barbour	Lakepoint Resort State Park - Intake No. 1	854	200
Barbour	Red Eagle Golf Course - Transfer Pump	539	200
Barbour	Heritage Turf, Inc. Transfer - Electric	796	200
Russell	Frog Pond Turf - William Baker	610	200
Russell	Valley Nursery Sod Farm # 830 - Intake No. 1	830	200
Barbour	Riversid-Barbour - Intake No. 1	1008	199
Henry	Gulledge Farms - Sandy Creek #1	641	199
Henry	Circle W Farms Hasty Pond	571	199
Henry	Circle W Farms House Pond	571	199
Henry	Marshall - Rushing Farms Intake #1 - ASCA #2076	716	199
Henry	Marshall - Rushing Farms Intake #2 - ASCS #2964	716	199
Henry	Circle W Farms Jump & Run	571	199
Henry	Lester Killebrew Farm - Pond No. 1	693	199
Henry	Circle W Farms Little Pond	571	199
Henry	Circle W Farms Pipeline No. 2	571	199
Henry	Circle W Farms Pipeline No. 3	571	199
Henry	W. O. Gulledge and Sons - Sandy Creek 2	641	199
Henry	Auburn University/Wiregrass Substation - No. 1	629	199
Henry	Circle W Farms Wood's Place River	571	199
Henry	Circle W Farms Wood's Pond	571	199
Henry	Circle W Farms McGriff Pond No. 1	571	196C
Houston	McCallister Farms - River Intake	777	196C
Houston	Auburn University/Money 1	762	196C
Houston	Riverbend Plantation River Pump - Intake No. 1	807	196C

County (1)	Facility (2)	Certificate no. (3)	HEC-5 reach no. (4)
Houston	Robert L. Robinson - Farm No. 2072	832	196C

Table 21. Agriculture withdrawal sites in Georgia[1]

Reference location (1)	HEC-5 reach no. (2)
WOODRF_R	196C
WESTPT_R	215
WFG_R	200
WHITSBRG	217
BUFORD_R	225
ALBANY	340
BAINBRDG	320
MONTEZMA	350
NEWTON	330

[1]Georgia provided data summed by model reach and individual users were not included in spreadsheet.

Table 22. Agriculture withdrawal sites in Florida

Individual water use permit (IWUP) no. (1)	HEC-5 reach no. (2)
19910096	192
19960127	192
19960129	192
20000064	192
19910069	185
20120007	185

Table 23. Net agricultural water use by reach, 1994-2012

Reach No (1)	River (2)	Year, cfs 1994 (3)	1995 (4)	1996 (6)	1997 (7)	1998 (8)	1999 (9)	2000 (10)	2001 (11)	2002 (12)	2003 (13)	2004 (14)	2005 (15)	2006 (16)	2007 (17)	2008 (18)	2009 (19)	2010 (20)	2011 (21)	2012 (22)
350	Flint	5.0	5.1	5.3	5.5	5.6	10.1	10.3	10.5	10.6	5.9	5.9	8.6	15.3	15.3	17.3	14.6	18.4	22.6	19.8
340	Flint	54.4	55.7	57.6	59.5	61.5	109.7	111.9	113.1	114.0	64.7	64.7	54.4	95.9	95.9	104.9	88.0	110.6	137.7	117.9
330	Flint	37.5	37.9	38.6	39.3	39.9	61.1	62.0	62.4	62.7	41.3	41.3	45.2	60.6	60.6	43.3	33.9	41.2	52.1	39.8
320	Flint	81.5	83.4	86.2	89.0	91.8	183.4	187.1	189.0	190.0	96.6	96.6	103.8	179.8	179.8	167.1	138.1	172.0	220.8	176.2
196F	Flint	53.9	55.2	57.2	59.1	61.0	110.1	112.4	113.5	114.1	64.4	64.4	62.2	105.6	105.6	87.9	72.6	89.9	116.5	88.0
225	Chattahoochee	0.2	0.2	0.3	0.3	0.3	0.5	0.5	0.5	0.5	0.3	0.3	0.3	0.5	0.5	0.7	0.6	0.7	0.9	0.8
217	Chattahoochee	0.3	0.3	0.3	0.3	0.3	0.5	0.5	0.5	0.5	0.3	0.3	0.3	0.5	0.5	0.4	0.4	0.4	0.5	0.5
215	Chattahoochee	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1
*205	Chattahoochee	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
*200	Chattahoochee	3.3	3.4	3.5	3.6	3.7	6.8	6.9	7.0	9.4	7.2	7.0	6.3	8.7	12.4	22.2	17.9	24.2	22.3	18.5
*199	Chattahoochee	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	1.3	2.4	1.0	3.1	4.7	1.7	1.4	2.6	3.1	0.0
*196C	Chattahoochee	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.0	0.2	2.0	1.6	2.5	0.2	0.1	1.5	0.5	0.0
192	Apalachicola	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	0.0	0.1	0.1	0.0
185	Apalachicola	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	0.0	0.0	0.0	0.0
	ACF Basin Total	258.8	263.9	271.5	279.2	286.8	504.8	514.3	519.1	528.6	306.1	306.3	307.1	494.4	500.4	468.4	367.6	461.6	**577.2**	461.6

*2012 Year is not complete

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Alabama	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	5.6	5.8	6.0	8.1	14.1	8.0	5.7	11.1	4.8	0.0
Florida	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	0.0	0.1	0.1	0.0
Georgia	236.2	241.3	248.9	256.6	264.2	482.2	491.7	496.5	499.6	277.9	277.9	278.5	463.7	463.7	437.8	361.9	450.4	572.4	461.6

Figure 9. Agricultural withdrawal by state, 1994-2012

*Alabama data not complete for Year 2012

Total Net withdrawals and returns

Total monthly net withdrawals are computed by summing the net M&I and agricultural data by reach in workbook 06_ACF_ WATERUSE _1939-2012.xlsx. The M&I withdrawals and returns is a combination of the PIPES 1980-1993 data and 1994-2012 data provided by the state agencies. These total net withdrawals are added to the incremental local flow during the work flow to compute the unimpaired flows. The totals for 1994-2012, average annual by reach and basin total, are shown in Table 25. Year 2007 represents the year of highest net consumption basin wide, see Table 24. Figure 10 illustrates the annual total net wateruse by basin for the 1994-2012 period. The bulk of the net consumption occurs in the Chattahoochee and Flint basins.

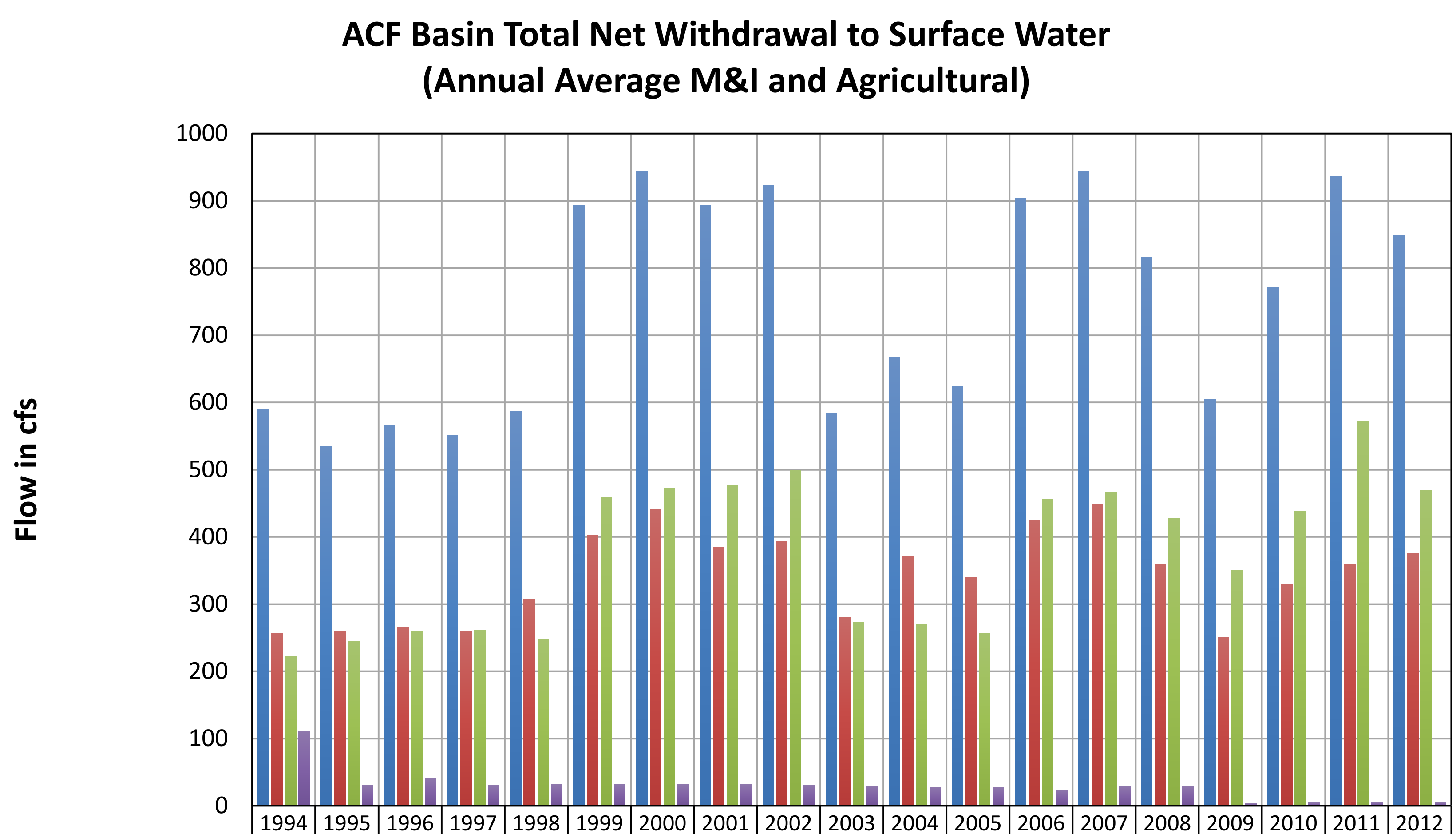
Table 24. Annual average net withdrawal by basin ranked highest to lowest

Year	Total ACF Basin Net Withdrawal (cfs)	Chattahoochee Basin (cfs)	Flint Basin (cfs)	Apalachicola Basin (cfs)
2007	945	449	467	29
2000	944	441	472	31
2011	937	359	572	5
2002	924	393	500	31
2006	905	425	456	24
2001	894	385	477	32
1999	894	403	459	32
2012	849	375	469	5
2008	816	359	428	29
2010	772	329	438	5
2004	668	371	269	28
2005	624	340	257	28
2009	605	251	350	4
1994	590	257	223	111
1998	587	307	249	31
2003	583	280	273	30
1996	565	266	259	40
1997	551	259	261	31
1995	535	259	245	31

Table 25. Total net withdrawal by basin, 1994-2012

		Year, cfs																		
Reach No (1)	**River (2)**	**1994 (3)**	**1995 (4)**	**1996 (6)**	**1997 (7)**	**1998 (8)**	**1999 (9)**	**2000 (10)**	**2001 (11)**	**2002 (12)**	**2003 (13)**	**2004 (14)**	**2005 (15)**	**2006 (16)**	**2007 (17)**	**2008 (18)**	**2009 (19)**	**2010 (20)**	**2011 (21)**	**2012 (22)**
360	Flint	12.9	24.3	28.3	28.4	26.6	27.7	30.1	30.3	28.4	29.3	27.3	23.8	25.7	23.1	17.6	11.5	12.6	23.0	24.2
350	Flint	7.7	6.4	7.1	5.9	5.8	10.9	12.6	9.2	33.7	26.2	22.3	20.1	33.8	41.1	41.8	36.4	42.2	46.9	45.9
340	Flint	37.0	45.1	49.2	54.8	62.1	100.2	102.8	104.4	103.9	52.9	53.0	40.4	85.7	88.0	106.2	90.8	112.3	140.1	120.6
330	Flint	35.5	35.7	36.2	29.7	8.2	30.6	30.7	34.1	33.7	9.7	10.5	13.0	30.5	34.3	13.7	6.9	14.4	28.9	17.7
320	Flint	78.1	80.3	83.3	85.7	87.4	180.7	184.6	186.3	187.7	93.4	93.8	100.5	177.2	177.2	163.8	135.0	169.3	218.9	174.6
196F	Flint	51.5	53.5	55.2	56.9	58.8	109.0	111.4	112.2	112.2	61.8	62.5	58.9	103.1	103.7	85.4	69.5	87.4	114.6	86.2
225	Chattahoochee	112.7	129.6	134.0	133.7	164.9	177.7	175.5	176.9	175.1	160.0	176.4	175.1	194.6	190.5	157.9	155.7	136.4	127.9	123.7
222	Chattahoochee	-1.4	-1.2	-1.6	-1.6	-1.6	-1.5	-1.3	-1.5	-2.2	-2.1	-2.7	-4.8	-5.3	-5.2	-4.7	-5.3	-4.9	-5.2	-4.6
221	Chattahoochee	127.0	135.1	128.4	128.3	138.7	154.1	150.3	130.7	124.9	104.3	106.9	105.6	110.7	106.7	82.3	67.8	108.1	126.9	135.2
220	Chattahoochee	61.6	55.7	48.4	59.2	66.6	67.5	72.8	66.4	67.2	64.5	72.5	72.6	78.9	80.7	67.6	67.4	66.9	69.8	75.3
217	Chattahoochee	-156.8	-165.5	-176.6	-178.7	-160.9	-123.8	-103.8	-127.3	-125.0	-163.0	-136.3	-150.9	-119.7	-89.3	-80.2	-126.0	-119.1	-103.4	-86.6
215	Chattahoochee	61.2	60.7	60.7	60.7	60.4	55.0	54.7	55.8	60.1	56.7	78.7	83.8	86.6	83.7	75.1	61.7	73.1	61.8	47.8
214	Chattahoochee	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.3	1.1	1.0	1.0	1.1	1.1	1.2	1.1	1.5	1.7	1.7
205	Chattahoochee	73.8	77.9	76.3	78.1	72.8	83.5	88.7	82.1	67.4	55.4	63.0	63.6	67.9	83.1	67.4	56.2	76.3	81.5	79.7
200	Chattahoochee	-28.2	-25.5	-32.4	-36.1	-25.6	-20.5	-25.1	-28.3	-19.8	-26.2	-17.3	-31.0	-25.7	-16.4	-15.0	-31.2	-15.4	-10.8	-5.3
199	Chattahoochee	-7.3	-6.6	-7.1	-7.5	-8.5	-7.2	-6.5	-6.5	-3.9	-6.3	-4.8	-7.7	-3.6	-3.0	-5.6	-6.6	-4.4	-1.4	-5.1
196C	Chattahoochee	12.8	-2.4	34.3	21.9	-1.1	16.6	34.0	35.3	47.7	35.8	33.2	32.3	39.0	16.6	12.8	10.5	10.6	10.2	13.2
192	Apalachicola	44.1	-36.6	8.7	7.8	8.7	7.8	7.6	8.7	7.8	8.7	7.8	8.7	7.8	10.0	8.2	2.1	2.6	3.4	2.7
185	Apalachicola	67.1	67.2	31.6	22.8	22.8	23.9	23.8	23.5	23.3	20.9	19.8	19.1	16.2	18.7	20.4	1.5	2.0	1.9	2.1
	ACF Basin Total	590.5	534.9	565.3	551.2	587.4	893.5	944.2	893.6	923.5	583.2	667.8	624.2	904.7	**944.7**	815.9	605.1	771.9	936.6	848.9

*Alabama data not complete for Year 2012



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total	590	535	565	551	587	894	944	894	924	583	668	624	905	945	816	605	772	937	849
Chattahoochee Basin	257	259	266	259	307	403	441	385	393	280	371	340	425	449	359	251	329	359	375
Flint Basin	223	245	259	261	249	459	472	477	500	273	269	257	456	467	428	350	438	572	469
Apalachicola Basin	111	31	40	31	31	32	31	32	31	30	28	28	24	29	29	4	5	5	5

Figure 10. Total net withdrawal by basin, 1994-2012

*Alabama data not complete for Year 2012

Unimpaired flow computations

To compute unimpaired incremental local flows, we added the net M&I and agricultural withdrawals and returns to the incremental local flows. Unimpaired incremental local flows are computed in workbook 07_ACF_LocalFlwo+NetWD_Unsmoothed_1939-2012.xlsx. Cumulative unimpaired flows are computed in workbook 08_ACF_CumulativeUnimpairedFlows_Unsmoothed_1939-2012. Step by step instructions are shown in Figure 18 and Table 33 and Table 34 in Appendix I.

Smoothing

The incremental local flows we computed contained large negative values at some locations. Often the incremental hydrographs were not smooth with little appearance of the expected natural shapes. There are many reasons for erratic data and most relate to short time phenomena. Erratic incremental hydrographs are due mainly to routing errors and inconsistent flow measurements at tandem gage sites.

There are 2 sources of routing errors. First, hourly flows are averaged over a 24hour period. The daily time step obscures hourly flow variations such as power releases. The hourly maximum and minimum weekday release from a hydropower plant differ significantly. For example, typical summer peaking operation at W. F. George calls for a release of 24,000 cfs for a 5-hour period in the afternoon and no releases the rest of the day. The daily average is therefore 5000 cfs. However the reservoir did not release 5000 cfs each hour for the 24-hour period. A 24-hour period is therefore too long to capture fluctuations caused by power releases. Figure 11 shows an example of routing reach W. F. George to Andrews with and without smoothing.

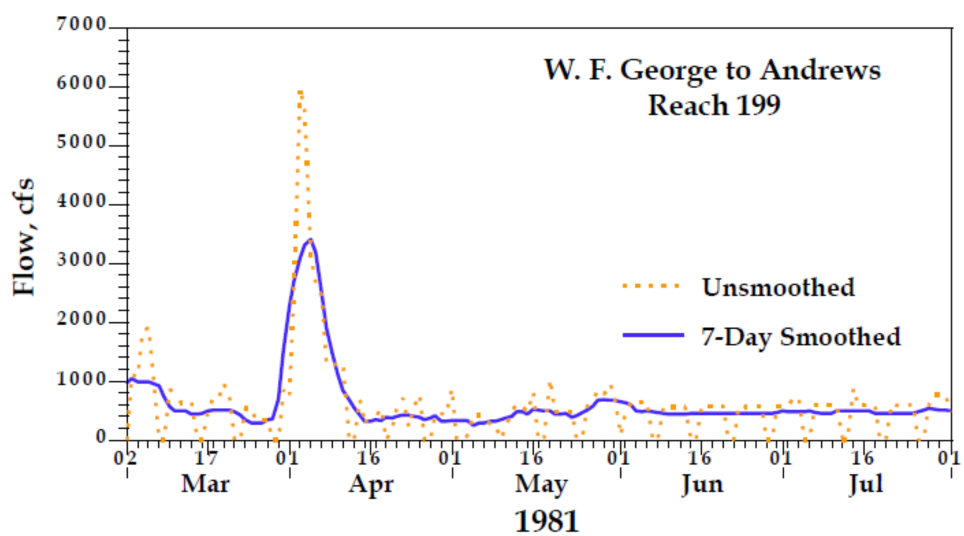


Figure 11. Reaches impacted by hydropower releases generally require a 7-day smoothing interval to achieve naturally shaped local flows

Second, routing travel times are limited to 24 hours in a daily simulation. Actual travel times may not coincide with 24-hour increments as shown in Table 11.

Computation of incremental local flows includes routing upstream daily flows to the next downstream control point and subtracting the routed flow from the downstream observed flows. Routing coefficients are sensitive to both flow rates and operation scheduling. However, a single best estimate of routing coefficients must represent the entire range of events. Often this leads to peak flows routed from upstream not coinciding with peak flows at the downstream point. With non-coincident peaks, negative incremental flows occur after the subtractions. When routing techniques are the only errors, the total volume remains correct over a longer period of time than the time period used for routing. That is, the routings for each day affect computed incremental flows for 1, 2, or 3 days on either side of the day in question.

Inconsistent flow measurements at tandem gage sites can be a chronic source of both erratic and negative incremental flows. A relative abundance of gage sites is the cause for these erratic flows. All gages have an element of error and within this range of errors an upstream gage may show a greater flow rate than the downstream gage. At regular river gaging sites, such as USGS gages, the error range may be fairly constant across the full range of flows experienced. However, at dams flow measurements consist of several factors, such as leakage, lockages, turbine ratings, and gate ratings, which present differing degrees of potential error at various flow rates.

Since much of the erratic hydrograph shape and the largest negatives result from short time routing events, averaging flows over a few days reveals the more naturally shaped hydrograph. Such averaging, or smoothing, may also resolve problems related to inconsistent gage information. To begin this process of smoothing the flow hydrographs, it is necessary to know the magnitude of this problem. First, hydrograph comparisons by observation revealed to the modelers the extent of smoothing required. Next, statistical evaluations provided quantitative details in a numerical format. Trials using various time periods for smoothing, along with the modelers' judgment, determined the required minimum time period, 0, 3, 5, or 7-day averaging to correct problems.

We selected a smoothing interval for each reach that reduces the most negative incremental local flows. The smoothing interval selected for each location is shown in Table 26 (indicated by reach with the location being the downstream end of the reach).

Many reaches in the upper drainage basin required no smoothing, as shown in Figure 12. Smoothing computations are completed in workbook 09_ACF_LocalFlow+NetWD_Smoothed_1939-2012.xlsx.

Some periods in some reaches required special smoothing intervals to reduce negative flows. These special cases are shown highlighted in yellow on Worksheet LocalFlow_NetWD_Smoothed and Table 27.

Table 26. Selected time interval used for smoothing

Reach (1)	Smoothing interval, days (2)
Headwaters to Griffin (360)	0
Griffin (360) to Montezuma (350)	0
Montezuma (350) to Albany (340)	5
Albany (340) to Newton (330)	5
Newton (330) to Bainbridge (320)	5
Bainbridge (320) to Jim Woodruff (196)	7
Headwaters to Buford (225)	7
Buford (225) to Norcross (222)	7
Norcross (221) to Atlanta (220)	7
Atlanta (220) to Whitesburg (217)	7
Whitesburg (217) to West Point Res (215)	7
West Point Res (215) to West Point Gage (214)	7
West Point Gage (214) to Bartletts Ferry (211)	7
Bartletts Ferry (211) to Goat Rock (210)	7
Goat Rock (210) to Oliver (209)	7
Oliver (209) to North Highlands (208)	7
North Highlands (208) to Columbus (205)	7
Columbus (205) to WF George (200)	7
WF George(200) to George Andrews (199)	7
George Andrews (199) to Jim Woodruff (196)	7
Jim Woodruff (196) to Chattahoochee (194)	0
Chattahoochee (194) to Blountstown (192)	7
Blountstown (192) to Sumatra (185)	7

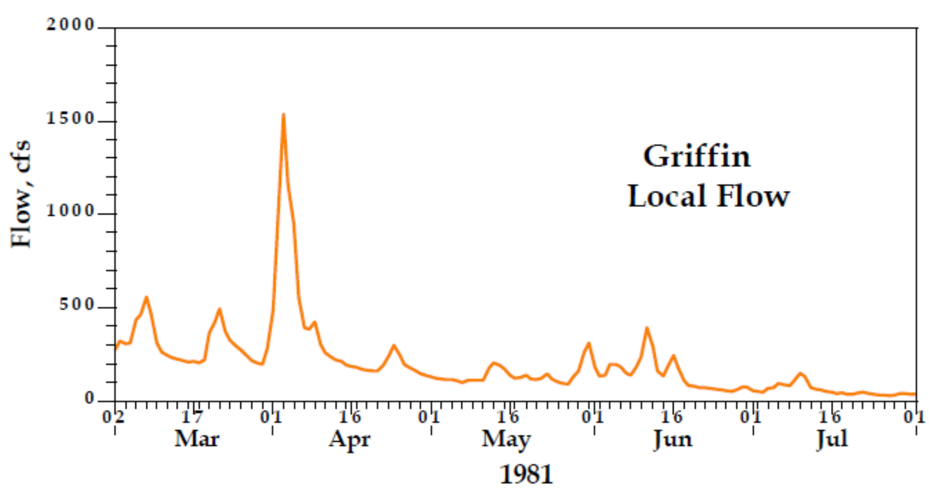


Figure 12. Example of reach in upper basin that did not require smoothing

Table 27. ACF basin flow revisions to eliminate negative cumulative flows

Location:	**Date:**	**Changed from:**	**Changed to:**
Buford	02-17Sep2002	7-day smoothing	11-day smoothing
Norcross	07-23Sep1999	7-day smoothing	9-day smoothing
Norcross	10-19Oct2007	7-day smoothing	9-day smoothing
Norcross	20Jul2008-11Sep2008	7-day smoothing	35-day smoothing
Whitesburg	03-15Aug2002	7-day smoothing	13-day smoothing
Whitesburg	01-15Sep2002	7-day smoothing	13-day smoothing
Whitesburg	07Aug2011-14Sep2011	7-day smoothing	37-day smoothing
West Point Inflow	13Aug1995-21Aug1995	7-day smoothing	9-day smoothing
West Point Inflow	01-15Aug2002	7-day smoothing	11-day smoothing
West Point Inflow	22Aug2002-25Sep2002	7-day smoothing	27-day smoothing
West Point Inflow	05-14Sep2007	7-day smoothing	9-day smoothing
West Point Inflow	01Aug2008-19Aug2008	7-day smoothing	9-day smoothing
West Point Inflow	24Sep2008-09Oct2008	7-day smoothing	11-day smoothing
West Point Inflow	07Aug2011-07Sep2011	7-day smoothing	15-day smoothing
West Point Inflow	28Sep2011-09Oct2011	7-day smoothing	9-day smoothing
Bartletts Ferry	15Jul1978-10Aug1978	7-day smoothing	29-day smoothing
Bartletts Ferry	04Aug1999-31Oct1999	7-day smoothing	89-day smoothing
Bartletts Ferry	05-15Jul2000	7-day smoothing	11-day smoothing
Bartletts Ferry	28Sep2001-06Oct2001	7-day smoothing	9-day smoothing
Bartletts Ferry	01-19Aug2002	7-day smoothing	13-day smoothing
Bartletts Ferry	01-19Sep2007	7-day smoothing	11-day smoothing
Bartletts Ferry	23Sep2007-14Oct2007	7-day smoothing	17-day smoothing
Bartletts Ferry	25Sep2008-14Oct2008	7-day smoothing	11-day smoothing
Bartletts Ferry	18Aug2011-03Sep2011	7-day smoothing	17-day smoothing
WF George	18Oct2001-09Dec2001	7-day smoothing	53-day smoothing
WF George	01Aug2002-19Sep2002	7-day smoothing	23-day smoothing
WF George	01Sep2007-24Nov2007	7-day smoothing	21-day smoothing
WF George	29Jul2008-15Sug2008	7-day smoothing	17-day smoothing
WF George	20Sep2008-09Oct2008	7-day smoothing	13 day smoothing
WF George	29Aug2011-13Oct2011	7-day smoothing	22-day smoothing

Computation of cumulative unimpaired flows

We computed unimpaired smoothed cumulative local flows at each model location by routing the smoothed unimpaired cumulative flows at the upstream end of the reach and adding the smoothed unimpaired incremental local flows for each reach listed in Table 26. The final unimpaired smoothed cumulative flows are in workbook 10_ACF_CumulativeUnimpairmentFlows_Smoothed_1939-2012.xlsx.

For each model location, we compared the computed unimpaired flows with the unimpaired flows computed during the 2002 update for a 1 month overlap period.

After all computations were completed in the workbooks, we entered the flows into HEC-DSS. We list the HEC-DSS pathnames in Table 28.

Table 28. HEC-DSS pathnames in HEC-DSS file ACFHEC_11_30May2014.dss

ACF-ULFT Workbook (1)	Spreadsheet (2)	Contents (3)	F-part (4)	C-part (5)	A-part description (6)	B-part description (7)	Time Step (8)
01_ACF_RESERVOIRS _1939-2012.xlsx	OBS_ADJ	USACE reservoirs: Adjusted observed reservoir flows and elevations			River name	Project name or gage name	
		Reservoir discharge with adjustments	COE_ADJ	DISCHARGE			daily
		Reservoir elevations with adjustments	OBS_ADJ	ELEV			daily
		Reservoir inflow with corrections, without evaporation adjustments	COE_CORR	INFLOW			daily
		GPC reservoirs: Observed elevations	OBSERVED	ELEV			daily
02_ACF_STREAMGAGES _1939-2012.xlsx	Streamgage DataAdjust	USGS streamgage recorded and adjusted flows			River name	Gage Name	
		Observed flow	USGS	FLOW			daily
		Adjusted (and filled-in) flow	OBS_ADJ	FLOW			daily
03_ACF_RESERVOIRS _Adjusted_Inflow _1939-2012.xlsx	Adj_Inflow	USACE reservoirs: Evaporation adjusted reservoir inflows	COE_ADJ	INFLOW	River name	Project name	daily
		GPC reservoirs					
		Observed elevations	OBSERVED	ELEV			daily
		USACE adjusted elevations	OBS_ADJ	ELEV			daily
		Storage	COMPUTED	STORAGE			daily
		GPC reservoir Bartlett's Ferry					
		Change in storage	COMPUTED	CHG_STOR			daily

ACF-ULFT Workbook (1)	Spreadsheet (2)	Contents (3)	F-part (4)	C-part (5)	A-part description (6)	B-part description (7)	Time Step (8)
		from previous day					
		Drainage area ratio computed inflow	OBS_ADJ	INFLOW			daily
		Drainage area ratio computed discharge	OBS_ADJ	DISCHARGE			daily
		GPC reservoirs Goat Rock, Oliver, and North Highlands					
		Drainage area ratio computed flow	OBS_ADJ	FLOW			daily
		Change in storage from previous day	COMPUTED	DSTORAGE			daily
		Columbus Gage adjusted for storage in Fall Line Projects					
		Fall Line Projects total change in storage from previous day	COMPUTED	DSTORAGE		FALL-LINE	daily
		Columbus gage observed flows	OBS_ADJ	FLOW		COLUMBUS	daily
		Columbus gage adjusted flows (to account for Fall Line storage)	COE_ADJ	FLOW		COLUMBUS	daily
04_ACF_GAGES_Routings _1939-2012.xlsx	RoutedFlows	Routed adjusted reservoir discharges	ROUTED	DISCHARGE	River name	Project name	daily
		Routed adjusted observed gage flow	ROUTED	FLOW		Project name or gage name	daily
		Sum of routed flows from George Andrews and Bainbridge	ROUTED_SUM	FLOW		JIM WOODRUFF	daily
05_ACF_LocalIncremental _1939-2012.xlsx	LocalFlow	Unregulated local flows	COM	FLOW_INC	River name	Project name or	daily

ACF-ULFT Workbook (1)	Spreadsheet (2)	Contents (3)	F-part (4)	C-part (5)	A-part description (6)	B-part description (7)	Time Step (8)
						gage name	
06_ACF_WATERUSE_1939-2012.xlsx	Import_TOTAL _WATER_USE	Sum of net monthly M&I and Ag demands	TOTAL _DEMAND	FLOW	River name	REACH_xxx	monthly
	Import_NetM& I	Net monthly M&I demand	NET_WITHDR AWAL_CFS	FLOW		REACH_xxx	monthly
07_ACF_LocalFlow+NetWD _Unsmoothed _1939-2012.xlsx	LocalFlow +NetWD _Unsmoothed	Unimpaired local flow without smoothing	UNIMPAIRED	FLOW_INC	River name	Project name or gage name	daily
08_ACF_Cumulative UnimpairedFlows _Unsmoothed _1939-2012.xlsx	Cumulative Routing _Unsmoothed	Routed unimpaired cumulative flow without smoothing	ROUTED_CUM	FLOW_CUM	River name	Project name or gage name	daily
	Cumulative Unimpaired _Unsmoothed	Unimpaired cumulative flow without smoothing	UNIMPAIRED	FLOW_CUM			daily
09_ACF_LocalFlow+NetWD _Smoothed _1939-2012.xlsx	LocalFlow +NetWD _Smoothed	Unimpaired local flow		FLOW_INC	River name	Project name or gage name	
		Unimpaired flow with no smoothing	UNIMP_CMA0				daily
		Unimpaired flow with 5 day smoothing	UNIMP_CMA5				daily
		Unimpaired flow with 7 day smoothing	UNIMP_CMA7				daily
10_ACF_Cumulative UnimpairedFlows _Smoothed _1939-2012.xlsx		Unimpaired cumulative flow		FLOW_CUM	River name	Project name or gage name	
	Cumulative Routing	Routed unimpaired cumulative flow with smoothing	ROUTED _CUM_CMA				daily
	Cumulative Unimpaired	Unimpaired cumulative flow with smoothing	UNIMP_CMA				daily

ACF-ULFT Workbook (1)	Spreadsheet (2)	Contents (3)	F-part (4)	C-part (5)	A-part description (6)	B-part description (7)	Time Step (8)
	Flows						

References

Farnsworth, Richard K., Edwin S. Thompson, and Eugene L. Peck. (June 1982). *Evaporation atlas for the contiguous 48 United States, NOAA technical report NWS 33*, US Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Office of Hydrology, Washington, DC.

Farnsworth, Richard K., and Edwin S. Thompson. (December 1982). *Mean monthly, seasonal, and annual pan evaporation for the United States, NOAA technical report NWS 34*, US Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Office of Hydrology, Washington, DC.

US Army Corps of Engineers (USACE), Mobile District. (1997). *ACT/ACF comprehensive water resources study unimpaired flow*, Mobile, AL.

USACE, Mobile District. (2004). *Extended unimpaired flow report January 1994-December 2001 for the ACT/ACF river basins*, Mobile, AL.

USACE, (1994) *EM 1110-2-1417, Engineering and Design, Flood Runoff Analysis, CECW-EH-Y.*

USACE, Hydrologic Engineering Center (1998). *HEC-5 simulation of flood control and conservation systems user's manual.*

Abbreviations

ACF	Apalachicola-Chattahoochee-Flint
ACT	Alabama-Coosa-Tallapoosa
ADECA	Alabama Department of Economic and Community Affairs
APC	Alabama Power Company
COE	Corps of Engineers
GA EPD	Georgia Environmental Protection Division
GPC	Georgia Power Company
NCDC	National Climate Data Center
NDMC	National Drought Mitigation Center
NRCS	National Resources Conservation Service
NOAA	National Oceanic and Atmospheric Administration
NWFWMD	Northwest Florida Water Management District
NWS	National Weather Service
OWR	Alabama Office of Water Resources
USGS	United States Geological Survey

Appendix I. Channel Routing

Muskingum method

On the recommendation of the TRP, the modelers adopted the Muskingum routing method for channel routing in the ACT/ACF basins. The routing method considers river-reach storage in 2 parts: prism storage and wedge storage (USACE, 1994). A schematic is shown in Figure 13. Steady flow concepts are the basis for prism storage, with storage equal to the outflow times the travel time through the reach (*K*). Wedge storage is equal to the difference between inflow and outflow times a weighting coefficient, *X*, and the travel time, *K*. Also, the value of *K* represents the change in storage per change in outflow (i.e., the slope of the storage-outflow relation).

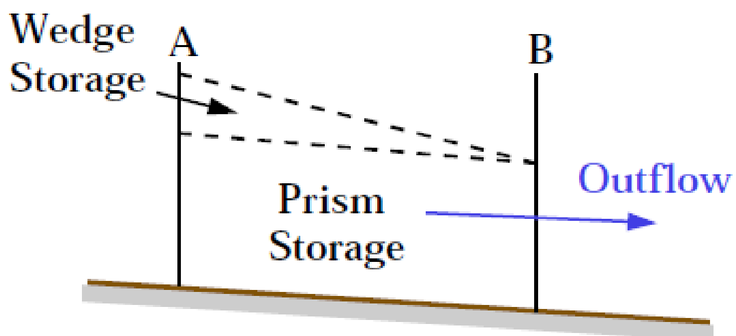


Figure 13.The Muskingum routing method considers wedge and prism storage

The coefficient *K* is in hours and corresponds to the travel time of the flood wave through the reach. The weighting of coefficient *X* is dimensionless, ranging in value from 0.0 to 0.5. With *X* = 0.0, there is no inflow effect on storage and the routed hydrograph will have the maximum attenuation for a fixed value of *K* (similar to reservoir storage routing). With *X* = 0.5, inflow has the maximum effect on storage and the routed hydrograph has no attenuations; it is only delayed in time by *K* hours. For most channels, the value for *X* will usually be between the 2 extremes.

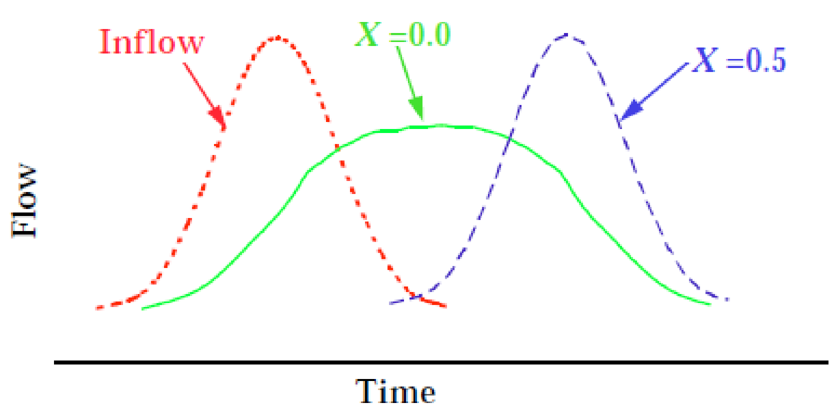


Figure 14.The weighting coefficient X determines hydrograph attenuation using the Muskingum method

A third parameter is the number of steps to use in the routing reach. Because K represents the travel time in the reach, it is generally recommended that longer reaches be subdivided into multiple steps such that, in each step, the travel time approximately equals the simulation time interval. The intended application is 24-hour time steps; therefore reaches with travel times much greater than 24 hours should be subdivided into an integer number of steps. There is no capability to deal with the opposite problem of reach travel times much less than the time interval of simulation. The section on developing the routing criteria describes the procedure used in this study.

Muskingum routing equation

The routing equation is developed from the continuity of mass (Inflow – Outflow = Change in storage). The storage in a river reach is defined by the sum of prism and wedge storage:

$$S = KO + KX(I - O), \text{ or}$$

$$S = K[XI + (1 - X)O]$$

where:

S = total storage in the routing reach (acre-feet)

O = rate of outflow from the routing reach (cfs)

I = rate of inflow in the routing reach (cfs)

K = travel time of the flood wave through the reach (hours)

X = dimensionless weighting factor

By combining the above expression for storage with the standard continuity equation and solving for outflow, the basic routing equation is developed:

$$O_2 = C_1 I_2 + C_2 I_1 + C_3 O_1$$

where:

$$C_1 = \frac{\Delta t - 2KX}{2K(1 - X) + \Delta t}$$

$$C_2 = \frac{\Delta t + 2KX}{2K(1 - X) + \Delta t}$$

$$C_3 = \frac{2K(1 - X) - \Delta t}{2K(1 - X) + \Delta t}$$

Because the outflow at the beginning of a time step (O_1) is the result of the previous time period computation, the coefficients can be developed based on inflow only as described in the HEC-5 User's Manual Exhibit I (USACE 1998).

Also, noting the subtraction of $2KX$ from Δt and Δt from $2K(1 - X)$, there is the possibility of developing negative coefficients (C) which are physically impossible. This problem occurs when the travel time (*K*) becomes much less than the 24-hour computation interval. The "short routing reaches" section that follows describes the approach taken to avoid negative coefficients.

Developing Muskingum K and X

The general procedure for developing Muskingum coefficients *K* and *X* are to start with an estimate of the flood wave travel time through each river reach. Then with an estimated *K*, assume a value of *X* and route observed upstream hydrographs to the downstream gaged location and compare the routed result to the observed hydrograph. The routed hydrograph should be contained within the observed downstream hydrograph and the difference between the 2 is an estimate of the local inflow occurring between the 2 gages, as shown in Figure 15. If there are no losses in the reach, the computed local flow should be positive and reflect the size and shape of local inflow. Therefore, computed local flow can be used to evaluate the routing criteria.

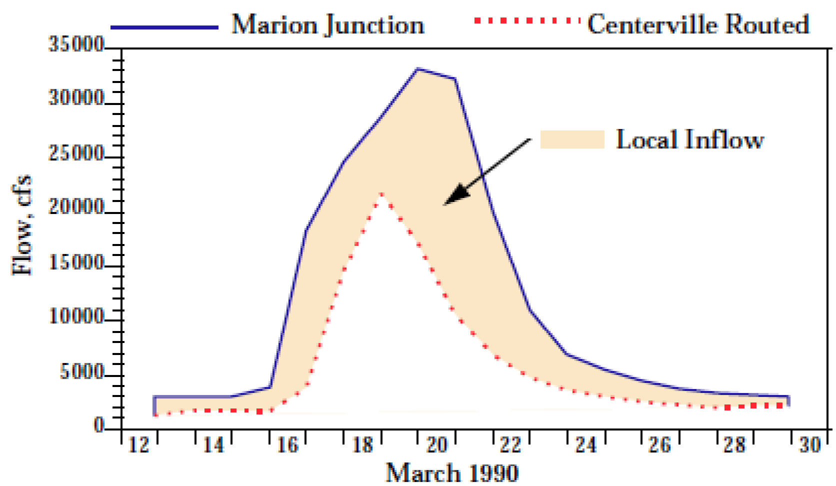


Figure 15. Local, or incremental flow, is the difference between the downstream and routed upstream hydrographs

Several different approaches were used to develop the river reach travel time. The length of the river reach and comparisons with similar reaches provided approximate scales for travel time. Approximate travel times were obtained from staff at Mobile District, the Alabama Power Company, and others with experiences with some of the reaches. The USGS had conducted dye studies on some of the reaches and the average travel times were recorded. Table 30 and Table 33 list the sources of information used in the study.

Table 29. ACF river reach travel times

River (1)	Reach (2)	Travel time, hours (3)	Distance, miles (4)
Chattahoochee	Buford to Atlanta	8-10	46
Chattahoochee	Atlanta to West Point	24	102
Chattahoochee	West Point to W.F. George	24	126
Chattahoochee	W. F. George to Jim Woodruff	24	76
Chattahoochee	Jim Woodruff to Sumatra	24	88
Flint	Montezuma to Jim Woodruff	72	180

Table 30. ACF river reach USGS travel times from dye studies, provided by Georgia Department of Natural Resources

River (1)	Reach (2)	Travel time, hours (3)	Distance, miles (4)	Discharge, cfs (5)
Chattahoochee	Buford to Norcross	20 8	18	710 6300
Chattahoochee	Norcross to Morgan Falls	48 12	18	720-1030 3800-6300
Chattahoochee	Morgan Falls to Atlanta	12 7	10	960-1030 3800-4800
Flint	"Culloden" to "Vienna"	144 (0.6 mph)	84	380-1150
Flint	Albany to Newton	50 (0.7 mph) 34 (1 mph)	34	1280-2400 3000-4000
Flint	Newton to Bainbridge	60 (0.7 mph) 39 (1 mph)	40	1850-2800 3700-5800

However, the primary approach was to utilize the routing optimization option in computer program HEC-1, "Flood Hydrograph Package" to develop Muskingum routing criteria, and then substantiate the results with the information from other sources.

The HEC-1 approach requires observed upstream and downstream hydrographs, plus a hydrograph representing the pattern for intervening flow. Generally, the downstream hydrograph was used for the pattern for intervening flow. The program then determines the Muskingum coefficients that will route the upstream hydrograph to the downstream location with a minimum negative intervening flow. Because the routing model is an approximation, different input hydrographs will produce different results. Experience, dye studies, and comparisons with other reaches were used to assist in selection of the appropriate routing criteria. Water availability is most critical during low flow events, therefore, low to medium flow hydrographs were selected for routing coefficient determination. From this process, an initial set of routing criteria and computed local flows were developed and distributed to Study Partners in December 1995.

Low flow analysis

Following the initial selection of Muskingum *K* and *X* for each routing reach, the computed local flows were evaluated for the 55-year record. For each routing reach, negative local flow values were written to an HEC-DSS record for processing. Statistics on the average value, maximum negative value, and average negative value were developed to isolate reaches with significant problems. Again, numerous or large negative values were considered unrealistic. By identifying locations and times of these negative values, graphical displays were developed to see the nature of the problem. For these reaches, additional adjustments of *K* and/or *X* values were tested in an attempt to minimize the apparent errors. Additionally, 2 basic routing problems were identified: short routing reaches and dual travel times for low flow and high flow. The following sections describe the approach used to solve these problems.

Short routing reaches

Routing reaches with travel times much less than the 24-hour computation time are considered short reaches. As mentioned in the Muskingum routing equation section, when the travel time (*K*) becomes much less than the computational time interval, negative coefficients are derived from the Muskingum method. Depending on the value of Muskingum *X*, negative coefficients will result for short travel times.

Using a spreadsheet, the Muskingum coefficients of inflow were computed for *K* = 24, 18, 12, and 6 hours, and for *X* = 0.0 to 0.5 at increments of 0.1. Table 31 shows the results as coefficients of inflow, *C1* to *C5*, and the residual. The *CC* column is the combining coefficients used to compute the *C2-C5* series. The sum of the coefficients must equal 1.0. The residual value is the difference between 1.0 and the sum of the 5 coefficients. As shown in Table 31, negative coefficients appear t with *K* = 18 hours and *X* = 0.04; *K* = 12 hours and *X* = 0.1; and all cases of *K* = 6 hours.

Generally, values of *X* were 0.3 or smaller; therefore the 18-hour routing reach could be modeled with the Muskingum routing equation. However, several reaches in both basins had travel times less than 18 hours. To provide routing for these shorter reaches, sets of positive coefficients were estimated for *K* = 12 and 6 hours and *X* values of 0.0, 0.1, 0.2, and 0.3. As *X* gets larger, it becomes more difficult to develop positive coefficients that reasonably mimic the Muskingum routing. The objective was to define coefficients for the shorter travel times that would combine to produce a reasonable representation of the coefficients for a 24-hour travel time. These coefficients would be used in place of those computed with the Muskingum equations. No routing was used for travel times less than 6 hours.

Table 31. Muskingum routing coefficients for K less than Delta t

		Delta *t* = 24 hours			***K* = 6 hours**		
X (1)	**C1 (2)**	**C2 (3)**	**C3 (4)**	**C4 (5)**	**C5 (6)**	**Residual (7)**	**CC (8)**
0	0.66667	0.11111	-0.03704	0.01235	-0.00412	0.25103	-0.33333
0.1	0.65517	0.12649	-0.03704	0.01405	-0.00533	0.24666	-0.37931
0.2	0.64286	0.14757	-0.03704	0.01587	-0.00680	0.23754	-0.42857
0.3	0.62963	0.17601	-0.03704	0.07183	-0.00859	0.22215	-0.48148
0.4	0.61538	0.21409	-0.03704	0.01994	-0.01074	0.19835	-0.53846
0.5	0.60000	0.26500	-0.03704	0.02222	-0.01333	0.16315	-0.60000
		Delta *t* = 24 hours			***K* =12 hours**		
X (1)	**C1 (2)**	**C2 (3)**	**C3 (4)**	**C4 (5)**	**C5 (6)**	**Residual (7)**	**CC (8)**
0	0.50000	0.33333	0.00000	0.00000	0.00000	0.16667	0.00000
0.1	0.47368	0.36793	-0.01936	0.00102	-0.00005	0.17679	-0.05263
0.2	0.44444	0.41216	-0.04580	0.00509	-0.00057	0.18457	-0.11111
0.3	0.41176	0.46900	-0.08277	0.01461	-0.00258	0.18997	-0.17647
0.4	0.37500	0.54261	-0.13565	0.03391	-0.00848	0.19260	-0.25000
0.5	0.33333	0.63889	-0.21296	0.07099	-0.02366	0.19342	-0.33333
		Delta *t* = 24 hours			***K* = 18 hours**		
X (1)	**C1 (2)**	**C2 (3)**	**C3 (4)**	**C4 (5)**	**C5 (6)**	**Residual (7)**	**CC (8)**
0	0.40000	0.41333	0.08267	0.01653	0.00331	0.08416	0.20000
0.1	0.36170	0.46458	0.06919	0.01031	0.00153	0.09268	0.148941
0.2	0.31818	0.52893	0.04808	0.00437	0.00040	0.10004	0.09091
0.3	0.26829	0.61071	0.01490	0.00036	0.00001	0.10573	0.02439
0.4	0.21053	0.71619	-0.03769	0.00198	-0.00010	0.10910	-0.05263
0.5	0.14286	0.85459	-0.12208	0.01744	-0.00249	0.10969	-0.14286
		Delta *t* = 24 hours			***K* = 24 hours**		
X (1)	**C1 (2)**	**C2 (3)**	**C3 (4)**	**C4 (5)**	**C5 (6)**	**Residual (7)**	**CC (8)**
0	0.33333	0.44444	0.14815	0.04938	0.01646	0.00823	0.33333
0.1	0.28571	0.51020	0.14577	0.04165	0.01190	0.00476	0.28571
0.2	0.23077	0.59172	0.13655	0.03151	0.00727	0.00218	0.23077
0.3	0.16667	0.69444	0.11574	0.01929	0.00322	0.00064	0.16667
0.4	0.09091	0.82645	0.07513	0.00683	0.00062	0.00006	0.09091
0.5	0.00000	1.00000	0.00000	0.00000	0.00000	0.00000	0.00000

For *X* = 0.0, Table 32 shows the estimated coefficients for 12 hours. *COEFF 12* (estimated) and the combining of 2 12-hour routing reaches *COEF 24* (computed) which is equivalent to a 24-hour travel time. The third column shows the coefficients for 24 hours, *COEF 24* (actual) for comparison. The second set of 3 columns shows the estimated coefficients for 6 hours, *COEF 6* (estimated) and the computation for 2 6-hour reaches, *COEF 12* (computed) compared to the estimated 12 hour coefficients *COEF 12* (estimated). For *X* = 0.0, the results are close. However, as the *X* value increases, the estimation departs from the “true” value. Estimated coefficients were developed for *X* = 0.0 to 0.3. Reasonable estimates could not be developed for *X* greater than 0.3.

Table 32. Estimated routing coefficients and computed product (X = 0.0)

COEF 12, **estimated (1)**	***COEF 24,*** **computed (2)**	***COEF 24,*** **actual (3)**	***COEF 6,*** **estimated (4)**	***COEF 12,*** **computed (5)**	***COEF 12,*** **estimated (6)**
0.58	0.3364	0.33330	0.75	0.5625	0.058
0.38	0.4408	0.44440	0.25	0.3750	0.038
.0.4	0.1908	0.14815	-	0.0625	0.04
-	0.0304	0.04938	-	-	-
-	0.0016	0.02470	-	-	-

Multiple travel times

When developing the Muskingum routing parameters, the emphasis was on channel flows, rather than overbank flood flow conditions. When flow is in the channel, a linear method can be sufficient for modeling the translation of flow through the reach. However, when flows are high and overbank storage is large, a different *K* coefficient may be required to model the translation of the flood flow. Such is the case in the reach between Blountstown and Sumatra.

In the Sumatra reach, there was a significant difference in travel time between in-channel flow and flood flow. By adopting Muskingum *K* for in-channel flow, the routed flood hydrographs precede the observed downstream hydrographs. For the days that the routed hydrograph is higher than the observed hydrograph, the computed local flow will be negative. With the larger discharges associated with flooding conditions, large negative local flows were computed for several days on the rising limb of the hydrograph, and large positive local flows were computed for several days following. While the 2 phases balance out, the resulting local flow hydrograph is unreasonable and could affect reservoir simulations for that period.

Reviewing routing with flows in the channel suggest a *K* = 48 hours, and high flows suggest a *K* = 96 hours. The Muskingum routing method does not support using 2 *K* values, and processing the flow series in separate blocks of time using different *K* values is not practical and cannot be replicated when HEC-5 reservoir modeling is performed.

Muskingum method with the Modified Puls routing method

An alternative, equivalent of the Muskingum routing method is to use Modified Puls with a storage-outflow curve representing the 3 Muskingum *K* values. The only additional information is the outflow value where the *K* value changes from 48 hours to 96 hours. Several outflows were tested and the initial estimate of 25,000 cfs was chosen. The computation of the storage-outflow follows:

1. The starting storage-outflow values are assumed to be zero.

   S(1) = 0.0 acre-feet

   Q(1) = 0.0 ft^3/sec (cfs)

2. K = 48 hours and the slope changes at 25,000 cfs; therefore *ΔOutflow* = 25,000 cfs

   Q(2) = 25,000 cfs

   48 hours = *ΔStor*/25,000 cfs

   ΔStor = (48 hours * 25,000 ft^3/sec*3600 sec/hour)/(43,560 ft^2/acre)

   ΔStor = 99,174 acre-feet

   S(2) = 99,174 acre-feet

3. K = 96 hours from 25,000 cfs to 75,000 cfs, *ΔOutflow* = 50,000 cfs

   Q(3) = 75,000 cfs

   96 hours = *ΔStor*/50,000 cfs

   ΔStor = (96 hours * 50,000 ft^3/sec*3600 sec/hour)/(43,560 ft^2/acre)

   ΔStor = 396,694 acre-feet

   S(3) = 99,174 + 396,694 = 495,868 acre-feet

Figure 16 shows that for the routing reach from Blountstown to Sumatra, flood flows have much longer travel times than lesser flows on the lower Apalachicola River.

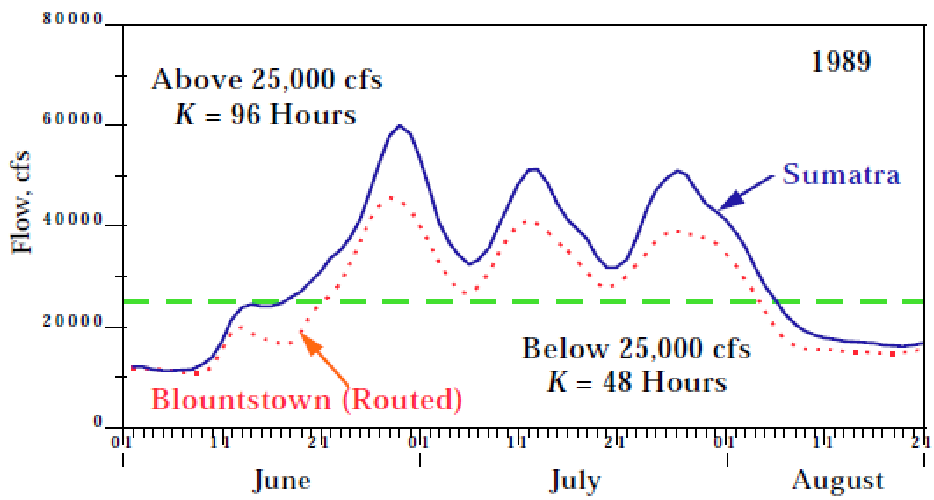


Figure 16. In the Blountstown to Sumatra reach, flood flows have much longer travel times than lesser flows on the lower Apalachicola River

Equivalent to Muskingum routing is the Modified Puls routing method with a storage-outflow curve representing the 2 Muskingum *K* values, as shown in Figure 17.

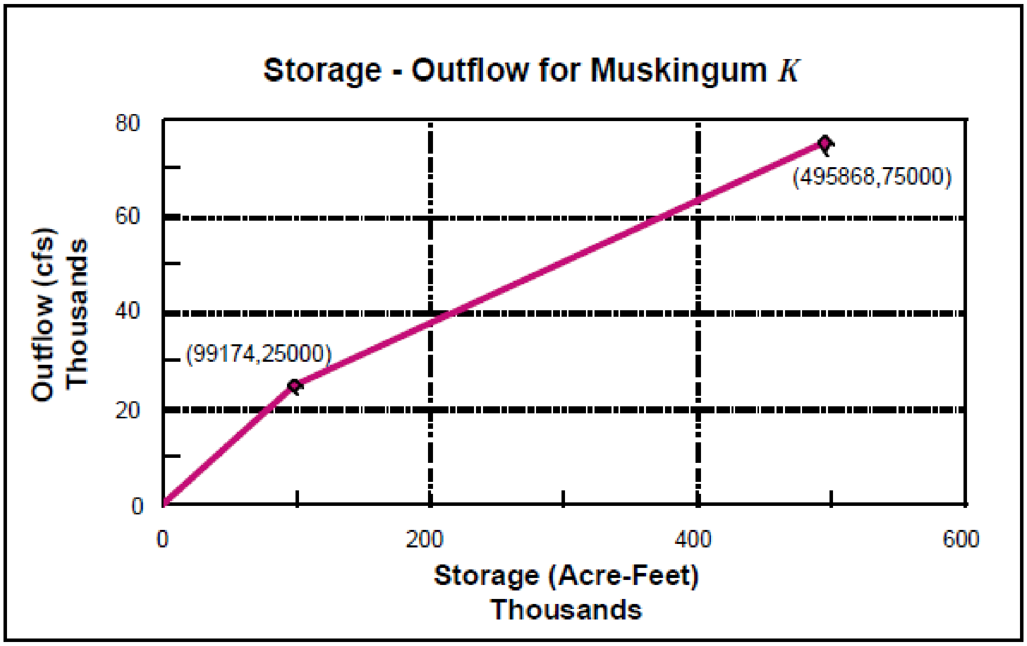


Figure 17. Equivalent to the Muskingum routing is the Modified Puls routing method with a storage-outflow curve representing the 2 Muskingum K values

Adopted routing coefficients

Each member of the TCG designated one representative to serve as Point of contact (POC) for the Surface Water Availability study element of the ACT/ACF Comprehensive Water Resources Study. The POCs and the modelers analyzed the computed local flows to evaluate the routing criteria. The modelers revised the routing coefficients and travel times to minimize the number of negative local flows. The adopted routing coefficients are shown in Table 10 and Table 11 (pp. 23-24) of this report.

Appendix II. Contents of workbooks

Figure 18 shows a schematic of the workflow involved to complete the update. Data collection tasks are shown as blue circles and green rectangles, and the 10 workbooks used to compute unimpaired flows are shown as yellow rectangles.

A description of the data and computations completed in each of the 10 workbooks is shown in Table 33 and Table 34.

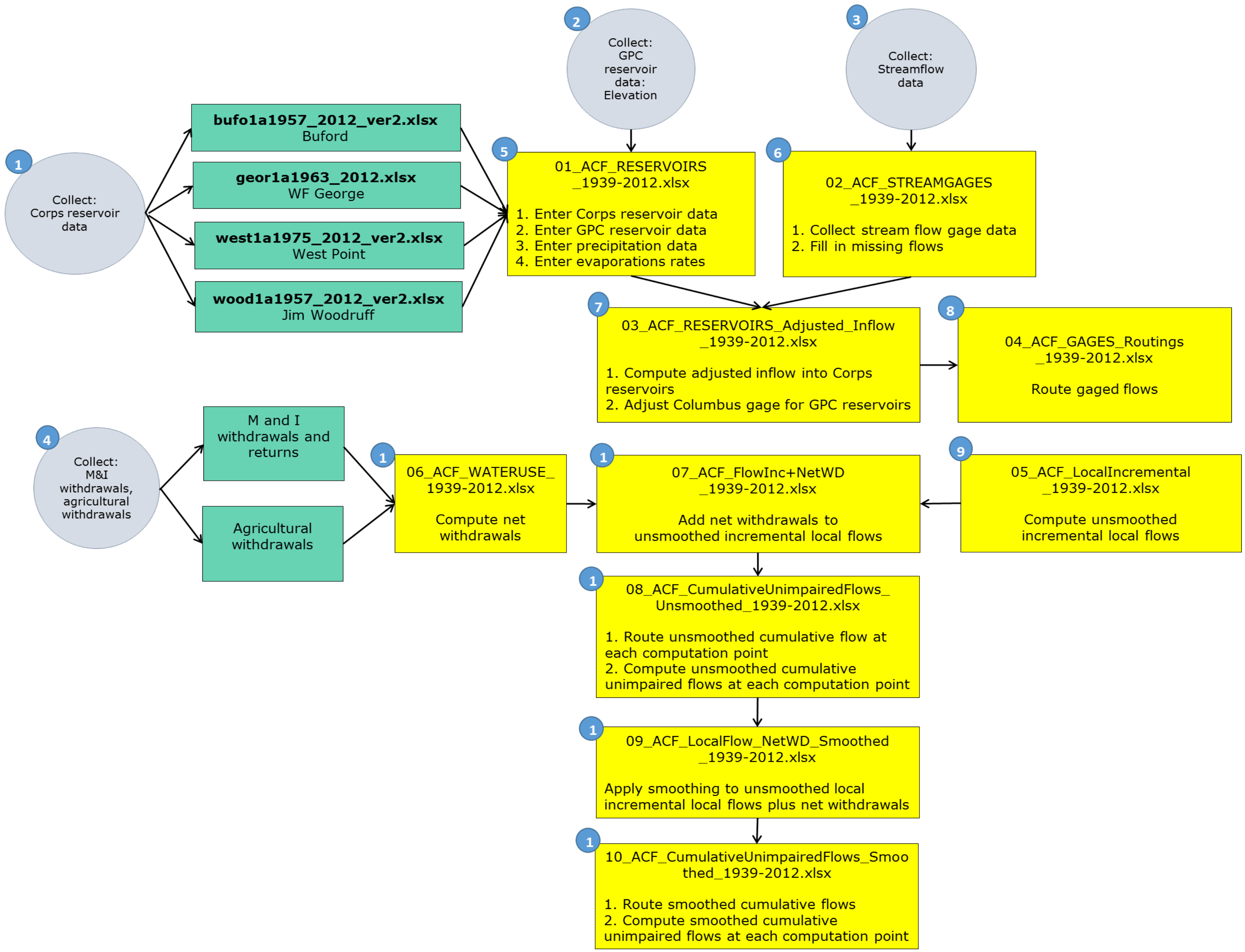


Figure 18. Flow process of steps to compute unimpaired flows

Table 33. Description of computation process overview shown in Figure 18

Step (1)	**Process description (2)**	**Applicable workbook name(s) (3)**	**Data/information/computations (4)**
1	Collect data for 4 Corps reservoirs: • Buford • WF George • West Point • Jim Woodruff	• bufo1a1957_2012_ver2.xlsx • geor1a1963_2012.xlsx • west1a1975_2012_ver2.xlsx • wood1a1957_2012_ver2.xlsx	Each workbook contains the observed midnight pool elevations, average daily outflows, and computed daily inflows for one reservoir. These workbooks were created by the Mobile District.
2	Collect data for 4 GPC reservoirs: • Bartlett's Ferry • Goat Rock • Oliver • North Highlands	Not in workbook	Data were provided in files by GPC in various formats.
3	Collect streamflow data.	Not in workbook	USGS streamgage data were imported into HEC-DSS, then into Excel using import tools available in HEC-DSSVue.
4	Collect municipal and industrial (M&I) and agricultural withdrawals and returns.	ACF_Surface_Water_1994-2012.xls	Contains the net withdrawal data for users in Alabama and Florida for the period of 2002-2008. Georgia data were superseded by data in workbooks indicated in step 4.
		AL_CHATT_2002-2008.xls	Contains the net withdrawal data for users in Alabama for the period 1994-2008
		20130920 - ACF Unimpaired_2009_2012_Final.xlsx	Contains the net withdrawal data for users in Alabama for the period 2009-2012.

Step (1)	Process description (2)	Applicable workbook name(s) (3)	Data/information/computations (4)
		ACF_FL_Total_use_by_reach-2013-07-12.xlsx	Contains the net withdrawal data for users in Florida for the period 2009-2012.
		20140319-ACT-ACF GA Withdrawal Returns 1990-2012.xlsx	Contains the M&I net withdrawal data for users in Georgia for the period 2002-2012.
		GA-ACF-water-use-agr-1970_2012.xlsx	Contains the agricultural net withdrawal data for users in Georgia and was used for the period 2009-2012.
5	Enter reservoir data into workbook and compute evaporation-adjusted reservoir inflows.	01_ACF_RESERVOIRS_1939-2012.xlsx	Contains the data collected for all 8 reservoirs in the ACF basin (Steps 1 and 2). Adjusts the computed reservoir inflows for each of the 4 Corps reservoirs based on precipitation and evaporation values.
6	Collect and adjust streamflow gage data.	02_ACF_STREAMGAGES_1939-2012.xlsx	Contains the data collected (in step 3) for 15 USGS streamgages and adjustments required to fill in missing values.
7	Compute evaporation-adjusted reservoir inflows.	03_ACF_RESERVOIRS_Adjusted_Inflow_1939-2012.xlsx	Contains the evaporation-adjusted inflows for the Corps reservoirs (computed in Step 5). Contains the computations of the GPC reservoir inflows and outflows.
8	Route reservoir releases and gaged flows.	04_ACF_GAGES_Routings_1939-2012.xlsx	Contains the computations that route gaged flows or reservoir releases to next downstream gage or reservoir for each of 22 reaches listed in Table 10 and Table 11.
9	Compute incremental local flows.	05_ACF_LocalIncremental_1939-2012.xlsx	Computes the incremental local flows for each of 22 reaches listed in Table 10 and Table 11.
10	Compute net withdrawals.	06_ACF_WATERUSE_1939-2012.xlsx	Computes the net withdrawals (collected in step 4) for each of 19 computation points.

Ste p (1)	Process description (2)	Applicable workbook name(s) (3)	Data/information/computations (4)
11	Compute unimpaired unsmoothed incremental local flows.	07_ACF_LocalFlow+NetWD_Unsmoothed_1939-2012.xlsx	Add net withdrawals to unsmoothed incremental local flows.
12	Route flows.	08_ACF_CumulativeUnimpariedFlows_Unsmooothed_1939-2012.xlsx	Route unsmoothed cumulative flows and compute unsmoothed cumulative unimpaired flows at each computation point.
13	Apply smoothing.	09_ACF_LocalFlow_NetWD_Smoothed_1939-2012.xlsx	Apply smoothing to incremental local flows
14	Compute cumulative unimpaired flows.	10_ACF_CumulativeUnimpairedFlows_Smoothed_1939-2012.xlsx	Computes the incremental unimpaired flows in the ACF basin by using the computed incremental local flows (Step 9) and the net withdrawals (step 10). Computes the smoothed incremental and cumulative unimpaired flows.

Table 34. Description of worksheets in each workbook

Item (1)	Workbook (2)	Worksheet (3)	Description contents/computations (4)
1	01_ACF_RESERVOIRS_1939-2012.xlsx	OBS_ADJ	References observed midnight pool elevations, average daily outflows, and computed daily inflows data (provided in workbooks created by the Mobile District) for each of the 4 Corps reservoirs.
2		Input_Precip	Contains the monthly precipitation values at each of 13 precipitation gages.
3		RatingCurves	Contains the storage-area-elevation rating curves for each Corps reservoir.
4		Evaporation	Contains monthly evaporation rates for each Corps reservoir. These values are specified by the Mobile District.
5		MonthlyPrecip-Evap	Computes the net monthly evaporation rate equal to the monthly evaporation rate (item 4) less the monthly precipitation values (item 2) for each of the 4 Corps reservoirs.
6		ResEvapAdjust	Computes the daily net evaporation based on reservoir surface area (items 3 and 5) and adjusts the computed reservoir inflows (item 1) with these values for each of the 4 Corps reservoirs.
7	02_ACF_STREAMGAGES_1939-2012.xlsx	USGS_StreamgageData	Contains the USGS streamgage data for 18 streamgages. These data were first imported into HEC-DSS directly using the import tools available in HEC-DSSVue.
8		StreamgageDataAdjust	References the USGS streamgage data (item 7) for 14 streamgages, and then identifies and fills in missing values. The methods for filling in streamgage data are described in Table 3.
9		Bainbridge MOVE2	Bainbridge Correlation, Cyclical MOVE.2, Linear equation for each month 01Oct1971-13Jul2001

Item (1)	Workbook (2)	Worksheet (3)	Description contents/computations (4)
10	03_ACF_RESERVOIRS_Adjusted_Inflow_1939-2012.xlsx	Adj_Inflow	References the evaporation-adjusted inflows for the 4 Corps reservoirs computed in item 6. Computes the GPC reservoir inflows and outflows as follows: 1. Computes the daily changes in storage at each of the 4 GPC reservoirs. 2. Lags these changes in storage 1 day. 3. Adds the lagged changes in storage to the streamflow at the Columbus streamgage. 4. Computes the GPC reservoir inflows and outflows using ratios and the storage-adjusted Columbus streamflow.
11	04_ACF_GAGES_Routings_1939-2012.xlsx	RoutedFlows	Routes flow for each of 22 reaches. Specifically, gaged flows (item 8) or reservoir releases (item 1) are routed to next downstream streamgage or reservoir. The routing parameters are listed in Table 11.
12	05_ACF_LocalIncremental_1939-2012.xlsx	LocalFlow	Computes local flows by subtracting the routed flows computed previously (item 11) from the observed flows (item 8) or computed, evaporation-adjusted reservoir inflows (item 10) as required, for each of 22 reaches.
13	06_ACF_WATERUSE_1939-2012.xlsx	Export_ACFHEC_10_AG	Net AG withdrawals by reach for 1939-1993 from previous version of unimpaired flow data set. (DATA NOT USED)
14		Export_from_ACFM&I.DSS	Net M&I withdrawals by reach for 1939-1993 from previous version of unimpaired flow data set.
15		Import_NetM&I	Combined Net M&I water use values for 1939-2012 period, source Export _from_ACFM&I.DSS (item 14) and ACF_Surface_Water_1994-2012.xlsx
16		Import_TOTAL-WATER-USE	Computes the total monthly net withdrawals by summing the net M&I (item 15) and agricultural (ACF_Surface_Water_1994-2012.xlsx) data by reach.

Item (1)	Workbook (2)	Worksheet (3)	Description contents/computations (4)
17	07_ACF_FlowInc+NetWD_1939-2012.xlsx	TotalDemand	References the total monthly net withdrawals by each reach (item 16).
18		LocalFlow+NetWD_Unsmoothed	References the computed incremental local flows (item 12) and the total net daily withdrawals (item 17) by reach. These values are considered “unsmoothed” because they are the raw computations and contain many negative values.
19	08_ACF_CumulativeUnimpairedFlows_ Unsmoothed_1939-2012.xlsx	CumulativeRouting_Unsmoothed	Routes the unsmoothed, cumulative flow at each computation point by reach.
20		CumulativeUnimpaired_Unsmoothed	Computes the unsmoothed cumulative unimpaired flows at each computation point by adding the unsmoothed incremental local flows to the net water withdrawals (item 18) and routed unsmoothed cumulative unimpaired flows (item 19).
21	09_ACF_LocalFlow_NetWD_Smoothed_1939-2012.xlsx	Smoothing	Applies “smoothing” to the unsmoothed incremental local flows plus the net withdrawals (item 18) to reduce the number of negative values by reach.
22		LocalFlow_NetWD_Smoothed	References the smoothed incremental local flows and the net withdrawals (item 21).
23	10_ACF_CumulativeUnimpairedFlows_ Smoothed_1939-2012.xlsx	CumulativeRouting	Routes the smoothed, cumulative flow at each computation point (item 24) by reach.
24		CumulativeUnimpairedFlows	Computes the smoothed cumulative unimpaired flows at each computation point by adding the smoothed incremental local flows to the net withdrawals (item 22), and routed smoothed cumulative unimpaired flows (item 23).