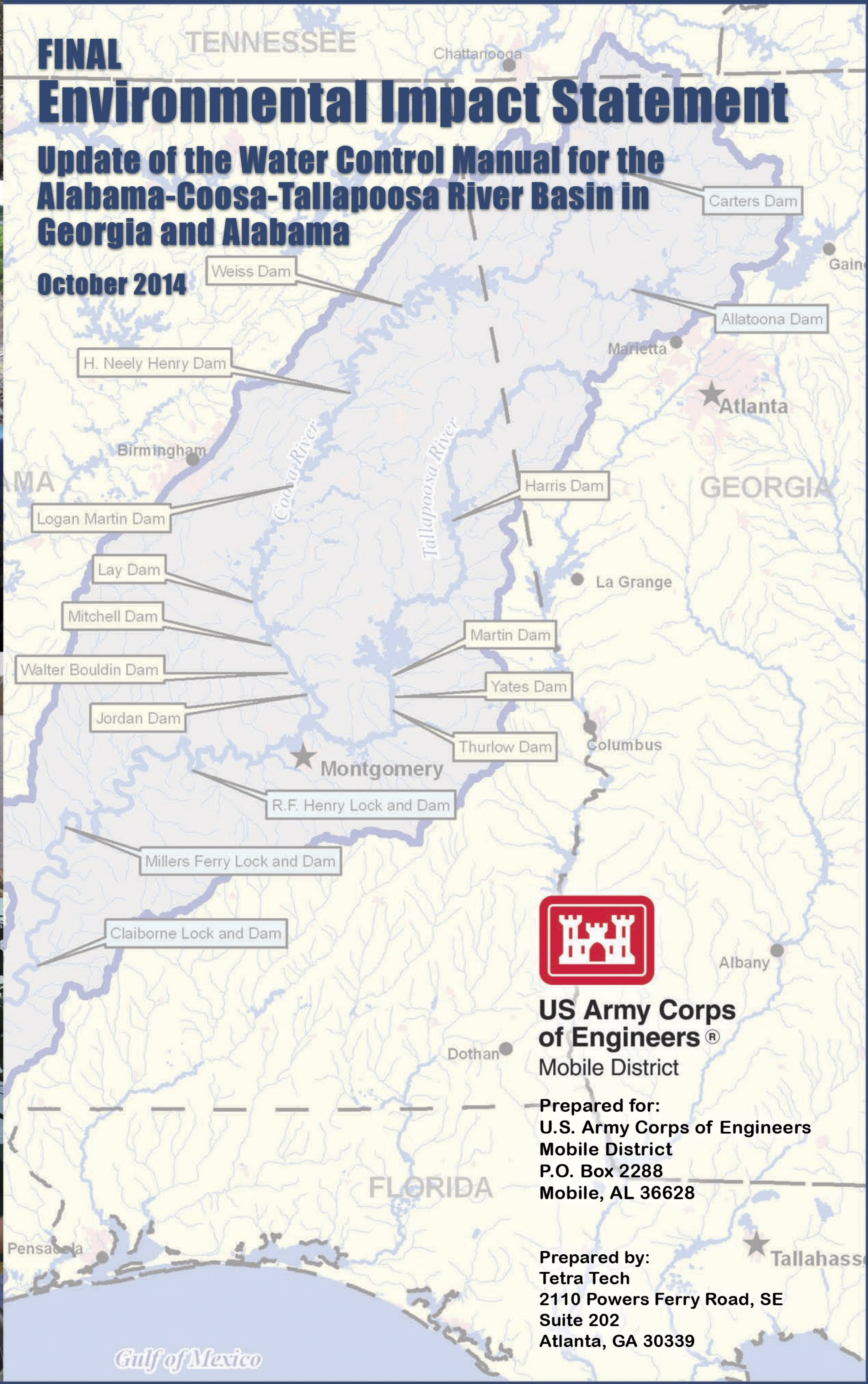
Volume 4: Appendices C – F

FINAL
Environmental Impact Statement

Update of the Water Control Manual for the Alabama-Coosa-Tallapoosa River Basin in Georgia and Alabama

October 2014



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Appendix C

HEC-ResSim Modeling Report

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Alabama-Coosa-Tallapoosa (ACT) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update

[Baseline]

March 2011 (DRAFT)

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I. Introduction

This report describes the reservoir system modeling activities performed in support of the Mobile District Water Control Manual Update for the Alabama-Coosa-Tallapoosa (ACT) River Basin (Figure 1). The reservoir system model performs simulations of project operations for a baseline condition. The primary output of the reservoir system modeling activities consists of 70 years (1939-2008) of continuously simulated, daily time step, lake levels and river flows throughout the ACT basin. Project Delivery team members evaluated these results in terms of economic, environmental, and operational improvements or disadvantages.

Figure 1. Alabama-Coosa-Tallapoosa (ACT) River Basin

The team began work in May 2008 and work continues through the Water Control Manual Update Environmental Impact Statement (EIS) process. Most of the initial effort went toward refinements to the baseline model. In concept, the Water Control Manual Update required only relative differences in the results, but in practice, the plan formulation process depended on results being as realistic as possible, to provide feedback regarding serious and complex questions posed along the way. Additionally, the Mobile District intends to apply models developed under this study for other purposes, including cooperative follow-up activities with stakeholders, and operational use for real-time water control. Consequently, the baseline reservoir system model eventually grew to include the detailed physical characteristics (as available) and almost all the operational rules used at each project in the system.

A. Overview of Reservoir Projects

The following information is excerpted from the Mobile District's web page regarding "Master Water Control Manual Update Environmental Impact Statement for the Alabama-Coosa-Tallapoosa River Basin" (http://www.sam.usace.army.mil/pa/act-wcm/bg1.htm):

> Eighteen dams are in the ACT basin, which form 16 major reservoirs (Jordan and Bouldin share a common reservoir and Carters Dam and Carters Reregulation Dam function as a single system). Six dams are federally owned by the Corps and 12 are privately owned projects. Of the 18 dams, 2 are on the Coosawattee River, 1 on the Etowah River, 7 on the Coosa River, 4 on the Tallapoosa River, 1 on the Cahaba River, and 3 on the Alabama River. *Note -- the dam on the Cahaba River is not included in the ResSim model. Therefore, for the purposes of the ResSim model, there are 17 dams in the ACT watershed.*
>
> Water Control Manuals are required for four of Alabama Power Company's projects that have flood control. On June 28, 1954, the 83rd Congress, second session, enacted Public Law 436, which suspended the authorization under the River and Harbor Act of March 2, 1945, insofar as it concerned federal development of the Coosa River for the development of electric power, to permit development by private interests under a license to be issued by the Federal Power Commission (Federal Energy Regulatory Commission). The law stipulates that the license must require the provision of flood control storage and further states that the projects will be operated for flood control and navigation in accordance with reasonable rules and regulations of the Secretary of the Army. Thus, the water control manual requirement for the four dams Weiss, H. Neely Henry, Logan Martin, and Harris.

(end of excerpt from http://www.sam.usace.army.mil/pa/act-wcm/bg1.htm)

B. Model Selection

This analysis used HEC-ResSim Version 3.1 "Release Candidate 3, Build 42" (USACE, 2010a). The label "Release Candidate" means that the software is undergoing final testing before distribution as an official version. HEC-ResSim is the Next Generation GUI-based reservoir operations simulation software that takes place of its precursor, HEC-5 (USACE, 1998).

Per ECB 2007-6 (USACE, 2007) and EC 1105-2-407 (USACE, 2005b), HEC-ResSim falls under the category of "engineering models used in planning studies," leaving certification to the Science & Engineering Technology (SET) initiative associated with the Corps Technical Excellence Network (TEN). The Corps Hydrologic Engineering Center developed this software which is now the standard for Corps reservoir operations modeling. As of January 2010, the TEN guidance listed HEC-ResSim as "Community of Practice Preferred" for the purpose of reservoir system analysis.

The Water Control Manual Update team selected HEC-ResSim as the tool most capable of faithfully representing District water management practices as the culmination of a three-year model development and verification process. In 2006 Mobile District began working with HEC to create ResSim watershed models based on established HEC-5 models simulating 1977, 1995, and 2008 physical and operational conditions. The three HEC-5 models hold significance as the tools "of record" used for analyses concerning the previous Environmental Impact Statement and the 1990's Comprehensive Study. After ensuring that the corresponding ResSim models could effectively reproduce the HEC-5 results, Mobile District and HEC created another ResSim model that captured the most significant operations as of 2008. This model was presented to stakeholders in October 2008 and generally accepted as a promising improvement to ACT reservoir system modeling.

Other considerations factoring into Mobile District's selection of ResSim include ease of adaptation to other studies or operational use, availability of training, access to software developers for model extensions, opportunity for linkage with water quality models, and ability to share with partners and stakeholders without licensing cost or restriction. Since the Water Control Manual Update was heavily accelerated but subject to unpredictable changes in scope, the long-standing relationship between Mobile District and HEC also afforded an important element of organizational trust that provided flexibility.

For the purpose of showing a general location map of the study area within the ResSim model, the main window of the Watershed Setup module for the ACT ResSim watershed model named "ACT_WCM-March2011" is shown in Figure 2. Details of the watershed model will be presented in subsequent sections and appendices of this report.

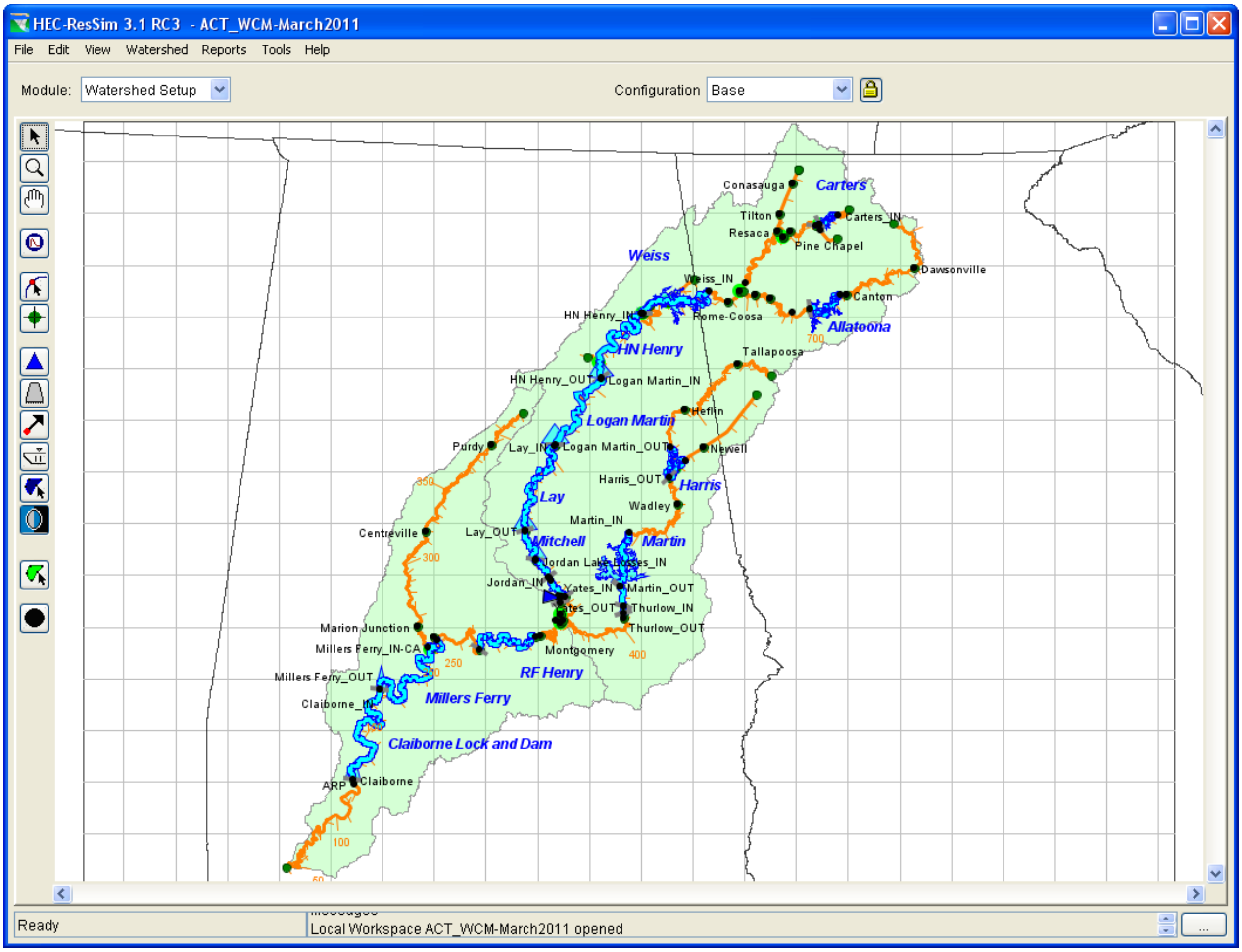


Figure 2. ACT Model – Watershed Setup Module

C. HEC-ResSim Improvements

The prior model verifications and comparisons with HEC-5 identified three ResSim improvements required for the Water Control Manual Update Study. The ACT (and corresponding ACF) Water Control Manual Update Study funded the following improvements to the ResSim source code, which are now available to all users of ResSim 3.1 (and later versions):

- Allow the specification of both positive and negative diversions amounts
- Allow the null routing method to translate negative flow downstream
- Allow the power plant generating capacity to vary as a function of head (or elevation, storage, or release)

The negative values found in the unimpaired inflows and diversion data sets require that ResSim handle negative diversions and translate (not route) negative flows downstream in order to satisfy the continuity equation.

The variable power capacity feature resembles an HEC-5 capability that allows a better estimate of energy produced as a result of Mobile District's water management operations than previously possible with ResSim. The feature allows head vs. energy ratings based on either "best gate" (most efficient flow) or "full gate" (maximum flow) through each unit.

Operations in the ACT system typically reflect the "full gate" situation. Mobile District and HEC worked with the Corps' Hydropower Analysis Center to derive updated ratings for each unit at the Corps reservoirs to conform to the ResSim power plant parameter definitions.

II. Overview of ACT Study Model

This section describes the basic attributes of the ResSim model used to simulate the baseline condition. The appendices contain more detailed information describing the ResSim "Baseline" alternative. Figure 3 shows the location of the reservoirs, junctions, and diversions of the ACT basin in the "2009" network (used for modeling the baseline operations).

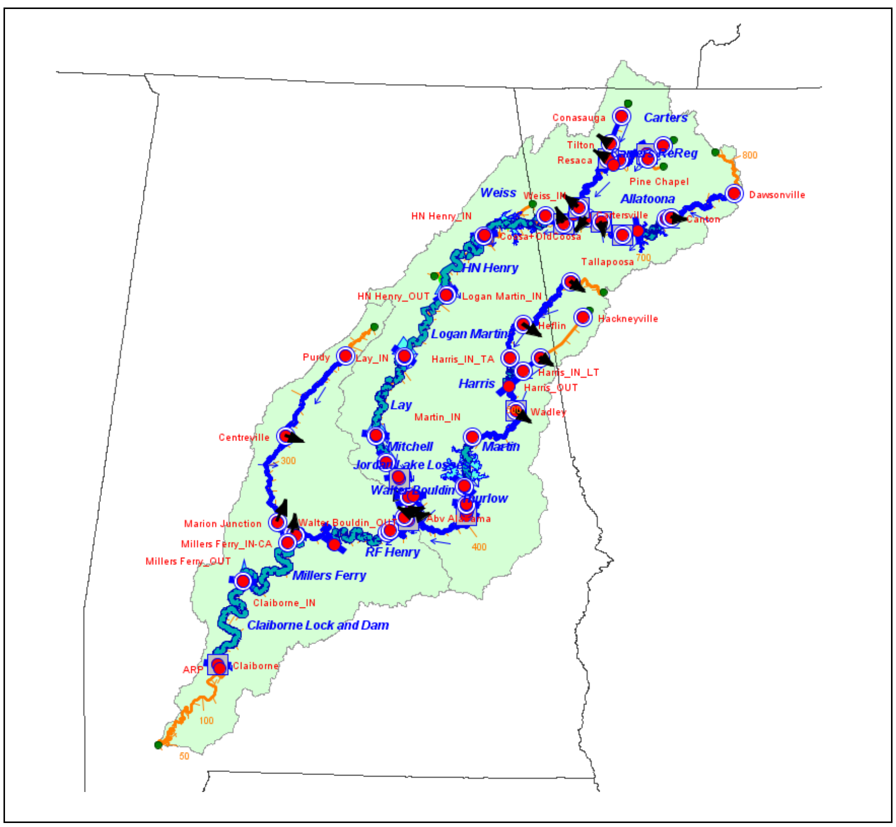


Figure 3. HEC-ResSim Network Module – 2009 Network (for ACT Baseline Modeling)

A. Simulation Time Step

The ACT model uses a daily time step to simulate operations. The selection of a daily time step was made based on previous models, available input data, and compute time considerations. This interval provides consistency with previous HEC-5 modeling activities in the basin and maintains a degree of familiarity for partners and stakeholders. The boundary condition data (i.e., diversion amounts and unimpaired inflows) exist only as daily or monthly values, and offer no advantage from a finer time interval. Study time constraints precluded development and vetting of sub-daily boundary condition data for period-of-record analysis. Finally, for such a complex study (many alternatives, complicated operations, and long simulation period), a daily time step makes it feasible to compute all alternatives in an efficient and timely manner.

The daily time step provides adequate granularity to capture the effects of conservation operations, provided that hydropower generating rules and certain flood control operations are formulated properly according to the interval. A sub-daily interval (used in the flood model) allows refinement of hydropower generating and flood control rules.

B. Routing

Although initial versions of the ACT model did not use channel routing, the final delivered model includes routing at some locations. Prior to the Agency Technical Review (ATR) team meeting, during the ACF model review (in May 2010), the development of the ACF and ACT daily time step models used null routing in all reaches of the model. Null routing implies that an inflow hydrograph at the upstream end of a reach matches the outflow hydrograph at the downstream end of the reach (before adding local inflows), which effectively neglects lag and flow attenuation effects through the routing reaches. In the system operation and storage balance between projects, an HEC-ResSim model using null routing essentially assumes that releases from the most upstream reservoirs in the watershed would influence flows in the lower portion of the watershed on the same day. This approach was consistent with prior studies and models of the basin. However, in advance comments from the ATR team during the ACF model technical review, it was strongly suggested that the modeling team consider adding some form of routing to the ACF model. The modeling team anticipated similar comments during the ACT technical review, and decided to add routing to the ACT model as well.

ResSim routing capabilities include the ability to consider the effects of routing when operating for downstream requirements. ResSim also provides features to allow a system of reservoirs to operate together for a common objective. The typical system operation is for two parallel reservoirs to operate together for a common downstream control point. This operation accounts for routing effects, but it uses a simple linear routing assumption for the total routing from each reservoir to the control point. This assumption can be very good if all reaches use a linear routing method and very poor if one or more reaches use a very non-linear routing method. Other system operations, like tandem balancing and system hydropower operation, lack the sophistication to fully account for flow changes due to routing. This may show up in the results as an oscillation in operation of the reservoirs in the system as they attempt to compensate for one another's releases.

The Muskingum and Coefficient methods were used for routing. The Muskingum routing method (which provides an easy means of representing both lag and attenuation) and the Coefficient routing method (which assumes no attenuation and distributes flow for reach travel times between 6 to 18 hours) were selected for use in the final model because these methods were used in developing the unimpaired inflow data set. Table 1 lists the routing parameters used in each reach. *(Note: in the "Logan Martin to Lay" and "Tallassee to Abv Alabama" reaches, the routing parameters were replaced by **Null routing** to minimize negative impacts on the daily operation for downstream minimum flow requirements at the JBT Goal. This was necessary due to the complex parallel operation of Logan Martin and Martin reservoirs and the ResSim logic having difficulty in accounting for the attenuation effects in the reaches below the reservoirs and above the minimum flow requirement control point. The actual routing methods and parameters are included using a strike-through format in Table 1.)*

Table 1. Routing Parameters Used in the ACT Watershed

River	Reach	Length (mi)	Routing Method	… "Muskingum" …		
				K (hrs)	X	Steps
				or … "Coefficients" …		
Conasauga River	Conasauga to Tilton	31	*Null*			
Conasauga River	**Tilton** to Coosawattee-Conasauga	16 (to Resaca)	**Coefficient**	**0.75**	**0.25**	
Talking Rock Creek	Talking Rock to Carters ReReg_IN	*n/a*	*Null*			
Coosawattee River	Carters_OUT to Carters ReReg_IN	2	*Null*			
Coosawattee River	Carters ReReg_OUT to Pine Chapel	16	**Coefficient**	**0.45**	**0.55**	
Coosawattee River	**Pine Chapel** to Coosawattee-Conasauga	13 (to Resaca)	**Coefficient**	**0.58**	**0.38**	**0.04**
Oostanaula River	Coosawattee-Conasauga **to Resaca**	---	*Null*			
Oostanaula River	**Resaca** to Rome-Oostaunala	50 (to Rome-Coosa)	**Muskingum**	**36**	**0.0**	**1**
Oostanaula River	Rome-Oostaunala to Oostanaula-Etowah-Coosa	---	*Null*			
Etowah River	Dawsonville to Canton	51	**Muskingum**	**24**	**0.5**	**1**
Etowah River	Canton to Allatoona_IN	30	*Null*			
Etowah River	**Allatoona**_OUT to Cartersville	26 (to Kingston)	**Coefficient**	**0.75**	**0.25**	
Etowah River	Cartersville **to Kingston**	---	**Coefficient**	**0.75**	**0.25**	
Etowah River	Kingston to Rome-Etowah	20	**Coefficient**	**0.58**	**0.38**	**0.04**
Etowah River	**Rome-Etowah** to Oostanaula-Coosa	9	*Null*			

… Continued …

Table 1. Routing Parameters Used in the ACT Watershed -- *Continued*

River	Reach	Length (mi)	Routing Method	… "Muskingum" …		
				K (hrs)	X	Steps
				or	… "Coefficients" …	
Coosa River	Oostanaula-Coosa **to Rome-Coosa**	---	*Null*			
Coosa River	Rome-Coosa to Weiss_IN	53	**Coefficient**	**0.58**	**0.38**	**0.04**
Coosa River	**Weiss**_OUT to Coosa+OldCoosa	74	*Null*			
Coosa River	Coosa+OldCoosa **to HN Henry_IN**	---	**Coefficient**	**0.58**	**0.38**	**0.04**
Coosa River	HN Henry_OUT to Logan Martin_IN	52	**Coefficient**	**0.75**	**0.25**	
Coosa River	Logan Martin_OUT to Lay_IN	46	***** NULL ***** ~~Coefficient~~	~~0.75~~	~~0.25~~	
Coosa River	Lay_OUT to Mitchell_IN	15	*Null*			
Coosa River	**Mitchell**_OUT to Jordan Lake Losses_IN	17	*Null*			
Coosa River	Jordan Lake Losses_OUT to J.D.Minimum	---	*Null*			
Coosa River	J.D.Minimum **to Jordan**_IN	---	*Null*			
Coosa River	Jordan_OUT to Coosa	15	*Null*			
Bouldin Canal	Walter Bouldin_OUT to Coosa	---	*Null*			
Coosa River	**Coosa** to **JBT Goal**	31 (to Montgomery)	*Null*			
Little Tallapoosa River	Newell to Harris_IN_LT	45	**Coefficient**	**0.62**	**0.38**	
Tallapoosa River	Tallapoosa to Heflin	74	**Muskingum**	**24**	**0.5**	**1**
Tallapoosa River	Heflin to Harris_IN_TA	48	**Coefficient**	**0.62**	**0.38**	
Tallapoosa River	Harris_OUT to Wadley	14	**Coefficient**	**0.75**	**0.25**	
Tallapoosa River	Wadley to Martin_IN	65	**Coefficient**	**0.58**	**0.38**	**0.04**
Tallapoosa River	Martin_OUT to Yates_IN	8	*Null*			
Tallapoosa River	Yates_OUT to Thurlow_IN	3	*Null*			
Tallapoosa River	Thurlow_OUT to Tallassee	2	*Null*			
Tallapoosa River	**Tallassee** to Abv Alabama	75 (to Montgomery)	***** NULL ***** ~~Muskingum~~	~~36~~	~~0.0~~	~~1~~
Tallapoosa River	Abv Alabama to **JBT Goal**	---	*Null*			
Alabama River	**JBT Goal** to Alabama-Coosa	---	*Null*			
Alabama River	Alabama-Coosa **to Montgomery**	---	**Muskingum**	**18**	**0.0**	**1**
Alabama River	Montgomery to RF Henry_IN	42	*Null*			
Alabama River	RF Henry_OUT to Selma	31	*Null*			
Alabama River	Selma to Millers Ferry_IN-AL	73	**Coefficient**	**0.75**	**0.25**	
Cahaba River	Purdy to Centreville	71	**Muskingum**	**24**	**0.5**	**1**
Cahaba River	Centreville to Marion Junction	60	**Muskingum**	**36**	**0.2**	**1**
Cahaba River	Marion Junction to Millers Ferry_IN-CA	77	**Muskingum**	**24**	**0.2**	**1**
Alabama River	**Millers Ferry**_OUT to Claiborne_IN	66	*Null*			
Alabama River	Claiborne **to ARP**	---	**Coefficient**	**0.75**	**0.25**	

C. Boundary Conditions

The operational ACT model extends from Carters Dam (on the Coosawattee River in the state of Georgia), Allatoona Dam (on the Etowah River in the state of Georgia), and Harris Dam (on the Tallapoosa River in the state of Alabama) to the tailwater of the Claiborne Lock and Dam Project (assumed to be represented by the USGS Claiborne gage 02428401 on the Alabama River in the state of Alabama). The upper extents of the complete ACT watershed model include: the headwaters of the Conasauga River above Tilton, GA; the headwaters of the Coosawattee River above Carters; the headwaters of the Etowah River above Dawsonville, GA; the Tallapoosa and Little Tallapoosa Rivers above Harris Reservoir; and, the headwaters of the Cahaba River above Purdy, AL. This complete model also extends through the confluence of the Oostanaula and Etowah Rivers (to form the Coosa River) and the confluence of the Coosa and Tallapoosa Rivers (to form the Alabama River).

The 70-year period of record that was modeled with ResSim includes calendar years 1939-2008. The unimpaired incremental local flows, evaporation data, and diversion data were obtained from CESAM. Development of these data sets are described in unimpaired flow reports (USACE, 1997) and (USACE, 2004[2009]). Use of unimpaired inflows allows simulation to capture the natural variability of supplies to the system in terms of flow frequency and volume.

D. Reservoir Projects

The ACT Basin consists of the Alabama River and three main tributaries: the Cahaba River, the Coosa River (and its upstream tributaries), and the Tallapoosa River. The Coosa and Tallapoosa Rivers join to form the Alabama River as previously shown in Figure 1. The major stream regulation in the upper basin by Corps of Engineers (COE) federal projects is provided by Carters and Allatoona Reservoirs, located about 60 miles and 30 miles, respectively, northwest of Atlanta, Georgia. These projects provide the total conservation and flood control storage capacity available above Rome, Georgia for flow regulation. Significant amounts of storage in the middle portion of the watershed are provided by eleven Alabama Power Company (APC) projects on the Coosa and Tallapoosa Rivers. Additional federal projects being modeled on the Alabama River include RF Henry, Millers Ferry and Claiborne Reservoirs. The Cahaba River is essentially unregulated.

On the Coosa River, there are seven projects that are owned and operated by Alabama Power Company (APC). From upstream to downstream they are Weiss, H. Neely Henry, Logan Martin, Lay, Mitchell, Jordan, and Walter Bouldin Reservoirs. On the Tallapoosa River, there are four projects that are owned and operated by APC. From upstream to downstream they are Harris, Martin, Thurlow, and Yates Reservoirs. Five of the APC projects (Lay, Mitchell, Walter Bouldin, Thurlow, and Yates) do not have much operational storage and are modeled as pass-through (flow-thru) projects in the daily ResSim model. These projects depend largely upon inflows controlled by upstream reservoirs. The ResSim model included these projects initially as a carryover from the HEC-5 models, and their utility for modeling within the Water Control Manual Update Study consists mainly of providing flow through the project and approximate hydropower generated. The Corps' Claiborne Lock and Dam project is also represented as a flow-through and has little water management impact within the ResSim model, but is required to perform quality calculations linked to the reservoir simulations.

Appendices A through D include screen captures of reservoir representation in ResSim, for each of the four major Corps' projects: (A) Carters and ReReg; (B) Allatoona; (C) RF Henry; and, (D) Millers Ferry. Appendices E through J include screen captures of reservoir representation in ResSim for each of the five major APC projects, plus Jordan: (E) Weiss; (F) HN Henry; (G) Logan Martin; (H) Harris; (I) Martin; (J) Jordan and Bouldin. Included in these appendices are physical data and Baseline operations for the major reservoirs. Appendix K contains information for the four APC projects (Lay, Mitchell, Thurlow, and Yates) and one Corps' project (Claiborne L&D) that are modeled as flow-through reservoirs. The reservoirs are described below, listed in order of position in the basin, from upstream to downstream.

1. Carters Reservoir (and Carters Reregulation Reservoir)

Carters Reservoir and Dam and Carters Reregulation Dam (ReReg) are operated by the Mobile District of the Army Corps of Engineers. They are located on the Coosawattee River 1.5 miles upstream of Carters in northwest Georgia. This location is 60 miles north of Atlanta, Georgia and 50 miles southeast of Chattanooga, Tennessee. The reregulation dam is 1.8 miles downstream from the main dam in Murray County. The pool extends into both Gilmer and Gordon Counties.

Carters Reservoir is designed for flood control and hydroelectric power. It increases protection to farmlands along the Coosawattee and Oostanaula Rivers. This project helps reduce flood stages approximately 72 miles downstream. Carters has a powerhouse with four generators and a modeled variable capacity from 496.93 to 605.27 MW. Two of the generators also function as pumps. Carters Project is 11 miles long and 62 miles in circumference. The dam is a massive rolled rock structure with a height of 445 ft and a length of 2,053 ft. It also contains a gated spillway with five 40 ft wide gates.

Carters Dam is modeled in ResSim to limit the flow going into the ReReg to either 3,200 cfs or 5,000 cfs depending on the time of year. These amounts can be exceeded during an induced surcharge operation or due to power generation requirements. Pump-back operations in the flood pool are a function of the inflow between Carters and Carters ReReg. With increasing inflow, there is increased pumping. In the conservation pool, the pump-back operations are a function of the pool elevation at Carters ReReg. Higher pools elevations lead to greater pumping amounts. Carters ReReg maintains a minimum release of 240 cfs for all zones above the inactive zone. Appendix A provides detailed ResSim modeling information for Carters and Carters ReReg.

2. Allatoona Reservoir

Allatoona Reservoir is operated by the Mobile District of the Corps of Engineers. It is located in Georgia about 32 miles northwest of Atlanta, Georgia along the Etowah River. It is a multiple purpose project with principal purposes of flood control, hydropower, navigation, water quality, water supply, fish and wildlife enhancement and recreation. Its major flood protection area is Rome, Georgia, about 48 river miles downstream. The drainage area above Allatoona Dam is 1,110 square miles. The dam is made of concrete and is 1250 ft long. The top of the dam is at an elevation of 880 ft. The pool lies within Bartow, Cobb, and Cherokee Counties.

The dam has three outlets which are the spillway, the flood control sluice, and the power plant. The spillway consists of 11 gates with nine gates being 40 ft wide by 26 ft high and two gates being 20 ft wide by 26 ft high. The crest of the spillway is at elevation 835 ft. The flood control sluice consists of four sluices that are 5 2/3 ft x10 ft. Allatoona has a power plant with two large generators and a modeled variable capacity from 83.75 to 94.88 MW.

This project is modeled in ResSim with a minimum release of 215 cfs in all zones. Releases can be affected by the downstream conditions at Cartersville, Kingston, and Rome-Coosa. The maximum release from the project is limited to 9,500 cfs unless an induced surcharge operation is activated. This project is also modeled with required power generation as well as drawdown limits during the fish spawn. Appendix B provides detailed ResSim modeling information for Allatoona.

3. Weiss Reservoir

Weiss Reservoir is owned by the Alabama Power Company. It is located on the Coosa River 50 miles upstream of Gadsden, Alabama. The reservoir lies within Cherokee County, Alabama and Floyd County, Georgia. The principal purpose of Weiss Reservoir is for the production of hydropower and to provide flood control benefits. The reservoir is also a source of water supply for domestic, agricultural, municipal and industrial use. It also provides recreational opportunities.

Weiss Dam has a concrete gated spillway section with compacted earth abutment dikes. The spillway has five tainter gates 40 ft wide and 38 ft high and one tainter gate 16 ft wide and 22 ft high. The crest of the portion of spillway with five gates is at elevation 532 ft while the crest of the portion of spillway with one gate is at elevation 550.0 ft. Weiss has a powerhouse with three generators and a modeled capacity of 76.3 MW. The total drainage area above Weiss Dam is 5,270 square miles. The flood control storage is limited at Weiss and may not contribute a large reduction in peak flows during major flood events. The degree of control varies with the time of year.

This project is modeled in ResSim with a maximum release of 40,000 cfs in and above the flood pool when not in induced surcharge. This maximum is reduced to the power plant capacity of 26,021 cfs when in the conservation pool. In addition to having a required power generation, this project is also operated in tandem with the downstream project, HN Henry. Appendix E provides detailed ResSim modeling information for Weiss.

4. H. Neely Henry Reservoir

H. Neely Henry (HN Henry) Reservoir is operated by the Alabama Power Company. The dam is on the Coosa River about 27 miles downstream from the city of Gadsden, Alabama. The reservoir lies within St. Clair, Calhoun, Etowah and Cherokee Counties. The drainage area of HN Henry Dam is 1,330 square miles, between HN Henry and Weiss, and the total drainage area is 6,600 square miles. The dam has a concrete gated spillway section with compacted earth abutment dikes. The crest of the spillway is at elevation 480 ft. The spillway contains six gates which are 40 ft wide and 29 ft high. HN Henry has a powerhouse with three generators and a modeled capacity of 58.9 MW.

The primary purpose of the dam is the production of hydro power for the Alabama Power Company. The reservoir is also a source of water supply for domestic, agricultural, municipal and industrial uses. It also creates a large recreational area.

The project is modeled in ResSim with a 96,000 cfs maximum release in all zones, along with a required power generation rule in the flood control and conservation zones. The project is operated in tandem with the downstream reservoir, Logan Martin. Appendix F provides detailed ResSim modeling information for HN Henry.

5. Logan Martin Reservoir

Logan Martin Reservoir is owned by the Alabama Power Company. The project is located 99 river miles upstream of the confluence of the Coosa and Tallapoosa Rivers. It extends about 48.5 miles upstream on the Coosa River and is situated within Calhoun, St. Clair, and Talladega Counties in Alabama. The total drainage area contributing flow at this location is 7,700 square miles. The lake is primarily used for the production of hydropower and flood control. There is limited flood control storage in Logan Martin Reservoir, but it is used in conjunction with other power generating reservoirs owned by Alabama Power Company to attempt to minimize flooding. Other purposes include navigation flow augmentation, water quality, water supply, and fish and wildlife.

The dam is a concrete gravity structure. It includes a spillway that has six tainter gates which are 40 ft wide and 38 ft high. The crest of the spillway is at elevation 432 ft. Logan Martin has a powerhouse with three generators and a modeled capacity of 134.6 MW.

Logan Martin is modeled in ResSim with minimum release requirements in all zones for both JBT Goal and J.D. Minimum, along with required power generation in the flood control and conservation zones. Appendix G provides detailed ResSim modeling information for Logan Martin.

6. Lay Reservoir

Lay Reservoir is owned by the Alabama Power Company. It is located on the Coosa River and lies within Chilton, Coosa, Shelby, St. Clair and Talladega Counties in Alabama. It is 51 river miles upstream of the confluence of the Coosa River and Tallapoosa River. The total drainage area contributing flow at this location is 9,087 square miles. The main purpose of this project is the production of hydroelectric power. Other purposes include water supply, recreation, and fish and wildlife. There is no flood control storage in Lay Reservoir and the project is operated in a run-of-river mode where the peak inflows are passed directly downstream.

The dam is 2,120 ft long and includes a gated spillway. The spillway contains 26 vertical lift gates that are 30 ft wide and 17 ft high. Lay has a powerhouse with six generators and a modeled capacity of 165.5 MW.

The baseline operation set for Lay Reservoir contains no rules of operation, making it a flow-through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity. Appendix K provides detailed ResSim modeling information for Lay.

7. Mitchell Reservoir

Mitchell Reservoir is owned by the Alabama Power Company. It is located on the Coosa River in Chilton and Coosa Counties, Alabama. It is 37 river miles upstream of the confluence of the Coosa and Tallapoosa Rivers. The reservoir extends approximately 14 miles upstream of Mitchell Dam. The lake is used for hydroelectric generation, industrial and municipal water supply, water quality, recreation, and fish and wildlife. Mitchell is basically a run-of-river project where daily outflow equals daily inflow.

Mitchell Dam has a length of 1,264 ft with a gated concrete spillway. The spillway consists of 23 timber, 30 ft wide and 15 ft high, radial gates and three steel-faced, 30 ft wide and 25 ft high, radial gates. The spillway crest for the timber gates is at elevation 297 ft while the spillway crest for the steel-faced gates is at elevation 287 ft. Mitchell has a powerhouse with four generators (total of seven, but three are retired) and a modeled capacity of 167.5 MW.

The baseline operation set for Mitchell Reservoir contains no rules of operation making it a flow-through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity. Appendix K provides detailed ResSim modeling information for Mitchell.

8. Jordan Reservoir (and Jordan Lake Losses)

Jordan Reservoir is on the Coosa River in central Alabama. It is owned and operated by the Alabama Power Company. The reservoir lies within Chilton, Coosa, and Elmore Counties. It stretches 18 miles upstream of Jordan Dam. The dam is approximately 19 miles above the confluence of the Coosa and Tallapoosa Rivers. There are 10,165 square miles of drainage area contributing flow at this location. The Bouldin project, located on a man-made canal off the Coosa River, also receives flow from Jordan Lake and discharges into the Coosa River. The main purpose of the lake is the production of hydroelectric power. Other purposes include navigation, water quality, water supply, recreation, and fish and wildlife.

Jordan is operated in a run-of-river mode, where daily outflow equals the daily inflow. This is because there is no flood control storage in Jordan Reservoir. The project has a 1,330 ft long gated concrete spillway. The crest elevation for 724 ft of this spillway is at elevation 245 ft. This section has 18 radial gates that are 34 ft wide and 8 ft high. The other 606 ft has a crest elevation of 234 ft. This section has 17 vertical lift gates that are 30 ft wide and 18 ft high. Jordan has a powerhouse with four generators and a modeled capacity of 127.6 MW.

The only rule modeled for Jordan in ResSim is the relationship between the inflow into Jordan and the amount of water diverted to Walter Bouldin Reservoir. A pseudo-reservoir (or “dummy” reservoir) called Jordan Lake Losses was used to represent the local inflows and the evaporation and diversion losses from Jordan Lake. This “dummy” reservoir does not represent a physical structure; its addition to the model was a modeling technique used to represent certain operations. Appendix J provides detailed ResSim modeling information for Jordan and Jordan Lake Losses.

9. Walter Bouldin Reservoir

Walter Bouldin Reservoir is owned by the Alabama Power Company. It is located in Elmore County, Alabama, on a man-made canal off the Coosa River. A three mile long forebay canal connects with Jordan Reservoir, approximately one mile upstream from Jordan Dam. The water retaining structures at Walter Bouldin Dam have a total length of 9,428 ft. This length includes two earth embankments of 2,200 ft and 7,000 ft. The remaining 228 ft is a concrete intake section. There is no spillway structure at this project since the spillway at Jordan Dam serves both projects. Walter Bouldin has a powerhouse with three generators and a modeled capacity of 228.3 MW.

The baseline operation set for Walter Bouldin Reservoir contains no rules of operation making it a flow-through reservoir. This project is supplied by a canal from Jordan Reservoir. The capacity of this canal is limited to the capacity of the power plant at Walter Bouldin. Inflow into Walter Bouldin will only exceed the power plant capacity if the canal flow plus the local inflow into Bouldin exceeds 28,296 cfs. Appendix J provides detailed ResSim modeling information for Walter Bouldin.

10. Harris Reservoir

RL Harris Reservoir is on the Tallapoosa River in Randolph County, Alabama. The reservoir is 24 miles long and extends up both the Tallapoosa and Little Tallapoosa Rivers and lies within Randolph and Clay Counties. Crooked Creek is just downstream of the dam. The dam is located halfway (as the crow flies) between Montgomery, Alabama and Atlanta, Georgia. The total drainage area that contributes flow at this location is 1,453 square miles. The dam is owned and operated by the Alabama Power Company.

The project consists of a concrete gravity dam about 150 ft high and 1,142 ft long. It includes a 310 ft long spillway. The spillway contains six tainter gates, each 40.5 ft wide and 40 ft high. The spillway crest elevation is 753.0 ft. Harris has a powerhouse with two generators and a modeled capacity of 138.9 MW.

This project is modeled in ResSim with both a minimum requirement and a maximum constraint at the downstream gage at Wadley. This maximum limit can be exceeded when Harris is in the flood pool and follows the induced surcharge function. There is also a minimum release requirement based on the flow at the upstream gage of Heflin. The flood control and conservation zones also contain a required power generation rule. The project is operated in tandem for the downstream reservoir, Martin, when the pool is in either the conservation or drought zones. Appendix H provides detailed ResSim modeling information for Harris.

11. Martin Reservoir

Martin Reservoir is owned by the Alabama Power Company. It is located on the Tallapoosa River near the town of Dadeville, Alabama. It is eight miles upstream from Yates Dam and lies within Elmore and Tallapoosa Counties. At the time of construction (in 1926) the 40,000 acre reservoir was the largest artificial body of water in existence. The total area of watershed draining into the reservoir is 3,000 square miles. The dam is a concrete gravity-type 2,000 ft long and 168 ft high. There are twenty spillway gates which are 30 ft by 16 ft each. Martin has a powerhouse with four generators and a modeled capacity of 183.8 MW. The primary purposes of the reservoir are the production of hydro power and flood control storage.

Martin Reservoir is modeled in ResSim with a minimum flow requirement at the downstream location named JBT Goal. Martin also contains rules setting a minimum release based on the time of year. This minimum can be based on flow values at three upstream gages or can be a minimum flow at the downstream gage of Tallassee, depending on time year. The maximum release is dependent on the pool elevation at Martin. With increasing pool elevations, there is an increasing maximum release. This maximum release can be exceeded by the induced surcharge operation. There is also a minimum power generation requirement in both the flood control and conservation zones. Appendix I provides detailed ResSim modeling information for Martin.

12. Yates Reservoir

Yates Reservoir lies on the Tallapoosa River near Tallassee between the reservoirs of Martin and Thurlow. The project is owned by Alabama Power Company. It is a small reservoir, relative to other Alabama Power Company impoundments. Yates has a powerhouse with three generators and a modeled capacity of 45.8 MW. It also has an uncontrolled spillway.

The baseline operation set for Yates contains no rules of operation, making it a flow-through reservoir. The pool elevation will remain at the top of the conservation pool, unless the inflow exceeds the total release capacity. Appendix K provides detailed ResSim modeling information for Yates.

13. Thurlow Reservoir

Thurlow Reservoir is owned by the Alabama Power Company. It is the smallest reservoir in the chain of Alabama Power Company impoundments. The dam is located in east central Alabama, about 30 miles northeast of Montgomery in the City of Tallassee on the Tallapoosa River. The reservoir is 574 acres and its main purpose is the production of hydroelectric power. Other uses include water supply and recreation. Thurlow Reservoir is directly downstream of Yates and Martin Reservoirs. Thurlow has a powerhouse with two generators and a modeled capacity of 78.5 MW. The project also has a gated spillway.

The baseline operation set for Thurlow contains no rules of operation making it a flow-through reservoir. The pool elevation will remain at the top of the conservation pool, unless the inflow exceeds the total release capacity. Appendix K provides detailed ResSim modeling information for Thurlow.

14. RF Henry Lock and Dam

Robert F. Henry (RF Henry) Reservoir includes a lock and dam and is owned by the Mobile District of the Army Corps of Engineers. It is located on the Alabama River 245.4 miles upstream of the mouth. Most of the dam and reservoir lie within Autauga County and the rest lies within Lowndes, Montgomery, and Elmore Counties. The operating purposes of the RF Henry Project are navigation and hydropower. There is no flood control storage in this project. Access and facilities are provided for recreation, but water is not normally controlled for that purpose.

The RF Henry project consists of a gravity-type dam with gated spillway supplemented by earth dikes, a navigation lock and a control station. The spillway has eleven tainter gates, 50 ft wide and 35 ft high. It has a crest elevation of 91 ft. The lock chamber is 84 ft wide and 655 ft long. RF Henry has a powerhouse with four generators and a modeled variable capacity from 5.0 to 20.45 MW.

There is only one rule governing the operations at RF Henry in ResSim. This rule operates RF Henry in tandem with the downstream project, Millers Ferry. Appendix C provides detailed ResSim modeling information for RF Henry.

15. Millers Ferry Lock and Dam

Millers Ferry Reservoir includes a lock and dam and is operated by the Mobile District of the Army Corps of Engineers. It is located in the southwestern part of the state of Alabama about 142 miles upstream of the mouth of the Alabama River. It is located about 10 miles northwest of Camden and 30 miles southwest of Selma. The reservoir lies within Wilcox and Dallas Counties. The total drainage area contributing flow at this location is 20,700 square miles. Millers Ferry serves as a major unit of the navigation system on the Alabama River and for the production of hydroelectric power. Other project purposes include recreation, fish and wildlife conservation, and wildlife mitigation.

Millers Ferry Dam is a concrete gravity-type dam with a gated spillway, supplemented by earth dikes, a navigation lock and a control station. The lock chamber is 84 ft wide and has a usable length of about 600 ft. The spillway consists of 17 tainter gates which are 50 ft wide by 35 ft high. The spillway crest elevation is 46 ft. Millers Ferry has a powerhouse with three generators and a modeled variable capacity from 16.6 to 101.24 MW.

In the ResSim model, there is a downstream control function rule in the flood control and conservation pools that sets a downstream flow requirement for the inflow junction at Claiborne Lock and Dam. The minimum flow at this location is a function of the flow at the upstream location named JBT Goal. In the operating inactive zone, the project minimum release is modeled as a function of the net inflow into the project. Appendix D provides detailed ResSim modeling information for Millers Ferry.

16. Claiborne Lock and Dam

Claiborne Reservoir (or Claiborne Lock and Dam) includes a lock and dam and is operated by the Mobile District of the Army Corps of Engineers. The dam is located in the southwestern part of the state of Alabama, approximately 82 miles above the mouth of the Alabama River. The drainage area from Millers Ferry to Claiborne is 820 square miles, with a total drainage area of 21,473 square miles contributing flow at this location. The Claiborne Dam is primarily a navigation structure. It also reregulates the peaking power releases from the upstream Millers Ferry project, providing navigable depths in the channel below Claiborne. The project is also used for water quality, public recreation, and fish and wildlife conservation.

Claiborne consists of a concrete gravity-type dam with both a gated spillway section and a free overflow section, supplemented by earth dikes. It also contains a navigation lock and control station. The spillway has two sections. One section is a controlled broad crested weir with a crest elevation of 15 ft. This section is controlled by six tainter gates that are each 60 ft wide and 21 ft high. The other spillway section is an ogee-type, free overflow that has a length of 500 ft and a crest elevation of 33 ft.

The baseline operation set for Claiborne Reservoir contains no rules of operation, making it a flow-through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity. Appendix K provides detailed ResSim modeling information for Claiborne Lock and Dam.

E. System Operations

The reservoirs in the ACT watershed are represented as several systems in which each reservoir has its role to play. Many interests and conditions must be continually considered and balanced when making water control decisions for the basin. Many factors must be evaluated in determining project or system operation, including project requirements, time-of-year, weather conditions and trends, downstream needs, and the amount of water remaining in storage. In the daily model, two state variables were created for the purpose of operating Carters and Carters ReReg (described in detail in Appendix L).

Both parallel and tandem systems are included in the ResSim model. The daily model operation for the JBT Goal creates a parallel operation between APC projects Logan Martin and Martin and relies on upstream tandem rules in APC reservoirs for balancing conservation storages between upstream and downstream projects. The ResSim model includes an explicit storage balance definition designed to preserve balance across similar zones of the five APC storage projects. Figure 4 shows the Reservoir System editor where the "APC for JBT" Reservoir System is reflected for the System Storage Balance named "Even-by-Zone_Baseline" (which is used by the Baseline alternative).

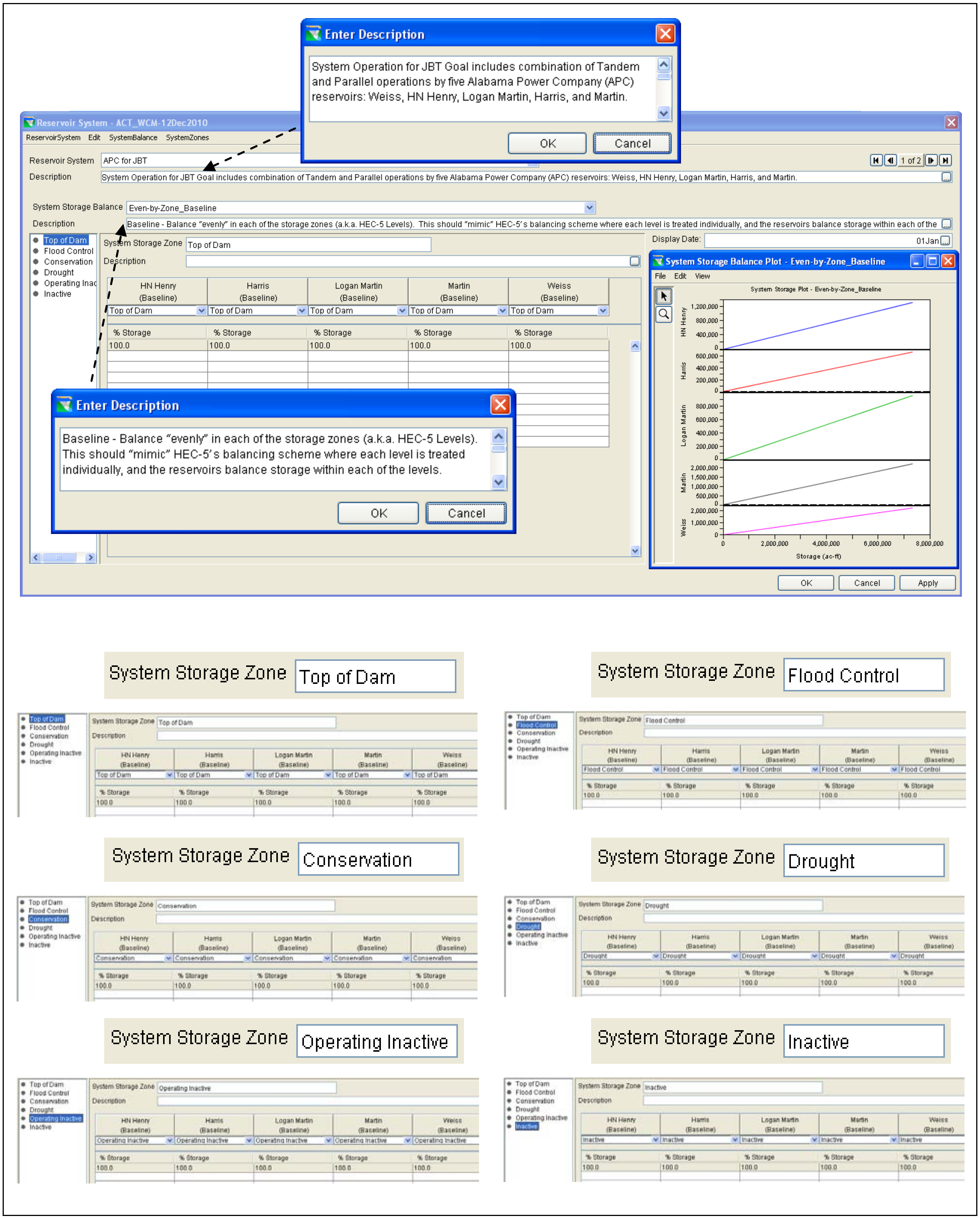


Figure 4. Reservoir System Balancing for Baseline Operations:
Reservoir System = "APC for JBT"
System Storage Balance = "Even-by-Zone_Baseline"

F. Diversions

Flow withdrawals occur in the ACT basin for various purposes. Water is diverted from the federal and APC projects as well as from the rivers. Flow withdrawals from the reservoirs and from the rivers are modeled differently using the following methods:

1. Withdrawals from a reservoir are modeled at the reservoir inflow junction as a negative local inflow specified as an external time-series, so that a diversion from a reservoir can never be "shorted."

2. Withdrawals from a river are modeled more flexibly as diversion elements (black arrows) from junctions. These withdrawals might be constant, specified as an external time-series, or represented as a function of a model variable.

For both method 1 (negative local inflow) and method 2 (diversion element), the amount of flow diverted is included in the net inflow calculation. In other words, the net inflow to a reservoir accounts for the flow withdrawal, and is calculated before release decisions from the pool are made. The difference between these two methods is that there is no control on the flow withdrawal for method 1, even if there's insufficient inflow from upstream. If the withdrawal (represented as a negative inflow) is greater than the (positive) inflow in a time step, the withdrawal will be subtracted from the pool. Even if the pool is at the bottom of a conservation zone, withdrawal will still take place until the pool is dry (regardless of any outlet elevations). This scenario represents the actual withdrawal conditions occurring in all the COE and APC projects. For method 2, if the amount withdrawn is greater than the inflow, withdrawals will be shorted. This scenario reflects the actual withdrawals from the river reaches. Figure 5 shows examples of both methods being used in the modeling of reservoir and non-reservoir diversions.

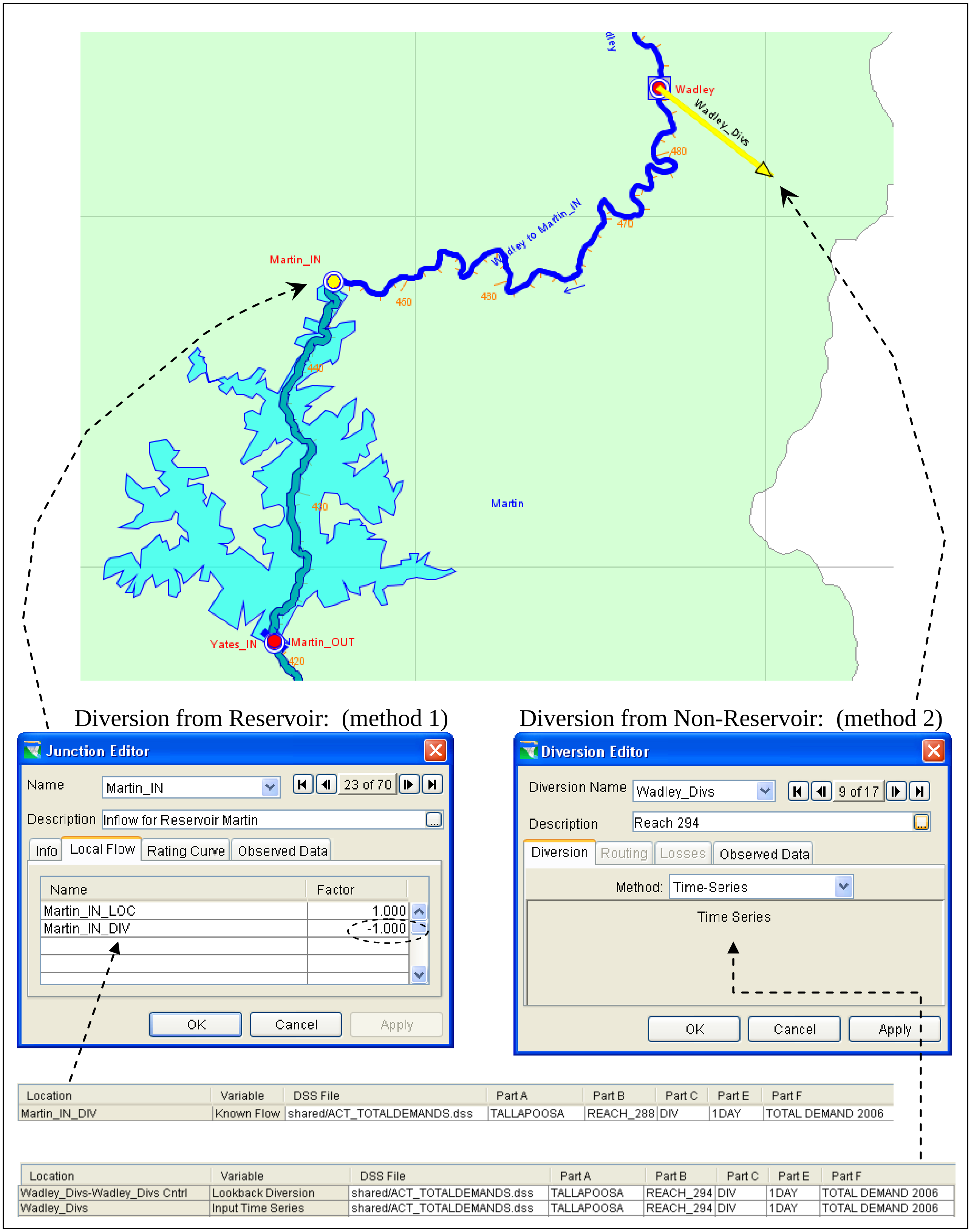


Figure 5. Two Methods Used in Modeling Diversions (for Reservoirs and Non-Reservoirs)

III. Description of Baseline Operations

The ACT Water Control Manual Update follows the National Environmental Policy Act (NEPA), (EPA, 1969[2000]) process toward the ultimate goal of adopting a new set of water management guidelines for the Corps projects in the ACT system. This requires comparison of anticipated effects due to a proposed new plan against those of the baseline conditions.

In October 2007, the Secretary of the Army directed the Corps to develop updated Water Control Plans and Manuals for the projects of the Alabama-Coosa-Tallapoosa (ACT) River Basin. (The Water Control Manuals for the individual projects are collectively referred to as the ACT Basin Master Water Control Manual or Master Manual.) In response to this directive, the Mobile District began the initial Environmental Impact Statement scoping process. The Corps current ACT Basin Master Manual is dated 1951. The update of the manual requires inclusion of additional projects constructed after 1951 and operational refinements to meet authorized project purposes.

A. Current Operations

The modeling process began with formulating a model of "Baseline" conditions, which reflects current operations. The Baseline condition (current operations) and each measure are described in the following section. On the basis of the nature of the proposed action, the Baseline Alternative represents no change from the current management direction or level of management intensity. This condition represents continuation of the current water control operations at each of the federal projects in the ACT Basin. The Corps' operations have changed incrementally since completion of the 1951 ACT Master Manual. Except in very general terms, it is not possible to describe a single set of reservoir operations that apply to the entire period since completion of the 1951 ACT Master Manual.

Current operations include the following:

- Operations consistent with the Master Manual of 1951 and project-specific water control manuals. For the Corps, those manuals and their dates are: Allatoona Dam (1993), Carters Dam and Reregulation Dam (1975), Robert F. Henry Lock and Dam (1999), Millers Ferry Lock and Dam (1990), and Claiborne Lock and Dam (1993). For APC projects, the applicable manuals and their dates are Weiss Dam (1965), H. Neely Henry Dam (1979), Logan Martin Dam (1968), and Harris Dam (2003).
- The Corps continues to recognize that APC generates power under a FERC (Federal Energy Regulatory Committee) license, which requires specific operational actions. The FERC license could be amended in light of APC's request to modify winter pool levels at the Weiss Dam and Logan Martin Dam projects; however, the current operations do not include these modifications.

- The H. Neely Henry Dam, which operates under a revised guide curve, would return to operation under its original guide curve. The baseline condition (505' winter level) represents the rules and guidelines in the most recent water control manuals. HN Henry currently uses a temporary guide curve (507'winter level) approved by the Corps of Engineers (agreed to in 2003). It is anticipated that the interim guide curve (507') will become permanent at the conclusion of the ACT Basin manual update, by including as an alternative operation. Using the original guide curve (505') allows the PDT to perform an effects analysis. The NEPA documentation supporting the basin manual update provides the effects analysis required to remove the interim label.

- Specified flow requirements apply to several projects. Allatoona Dam and Carters Dam must provide for a 240 cfs minimum flow. The Corps must also ensure a minimum flow rate of 6,600 cfs from Claiborne Lake during normal conditions. The APC must ensure a 4,640 cfs release, measured at Montgomery, Alabama, for navigation during normal conditions.

- The Corps reserves a total of 19,511 AF of storage in Lake Allatoona for water supply. Of this, 6,371 AF is allocated to the city of Cartersville, Georgia, which is expected to provide (yield) 16.8 million gallons per day (mgd); and 13,140 AF is reserved for the Cobb County-Marietta Water Authority (CCMWA), which is expected to yield 34.5 mgd.

- The Corps reserves 818 AF in Carters Lake for water supply for the city of Chatsworth, Georgia, which is expected to yield 2 mgd.

- The Corps continues to manage fish spawning operations at Lake Allatoona, as outlined in the South Atlantic Division Regulation (DR) 1130-2-16, Project Operations, Lake Regulation and Coordination for Fish Management Purposes (USACE, 2001) and draft Standing Operational Procedure (SOP) Reservoir Regulation and Coordination for Fish Management Purposes (USACE, 2005a). During the largemouth bass spawning period, from March 15 to May 15, the Corps seeks to maintain generally stable or rising reservoir levels at Lake Allatoona. Generally stable or rising levels are defined as not lowering the reservoir levels by more than 6 inches, with the base elevation generally adjusted upward as levels rise from increased inflows or refilling of the reservoir.

B. Water Supply/Diversions

In developing its updated Water Control Manuals, the Corps considered the historic 2006 net water withdrawals through the ACT Basin and the existing water storage contracts for Allatoona and Carters (listed in Table 2).

Table 2. Net 2006 ACT Basin Withdrawals

Location	Storage Volume	Anticipated Yield
Allatoona		
CCMWA	13,140 AF	34.5 MGD
City of Cartersville	6371 AF	16.76 MGD
Carters		
City of Chattsworth	818 AF	2.0 MGD

Year 2006 represented the greatest annual amount through the 1939-2008 simulation period. The 2006 net water withdrawals are modeled as diversions, as described in Section II-F. Starting with average monthly values, average daily values were calculated for each month, resulting in a year of daily values. The values were repeated and applied to each calendar year in the simulation. In other words, the diversions for 1939 are the same as 2008 and every year in between.

Each state provided the historical water use data for the 1980 to 2008 through the appropriate state agency. The Corps combined the data and prepared for inclusion into the ResSim model and development of the unimpaired flow. Annual total ACT net withdrawals for years 1994 to 2008 are presented in Figure 6 and year 2006 is the largest value.

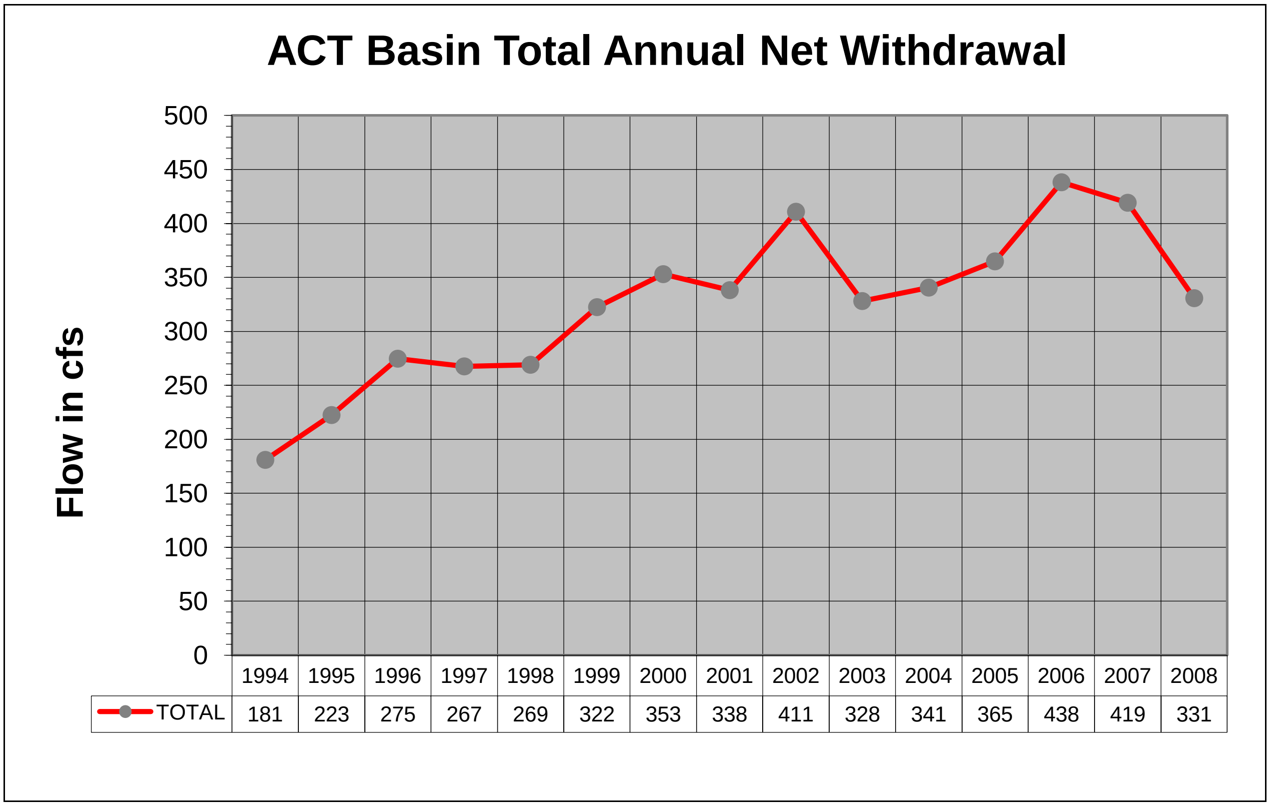


Figure 6. Annual ACT Net Withdrawals for Years 1994 to 2008

Monthly water withdrawals and returns of individual entities (users) are summed by model reaches to produce the net withdrawal. Modeled diversions from reservoirs (Section II-F, Method 1) and reaches (Section II-F, Method 2) are listed in Table 3. Figure 7 plots the monthly distribution of the 2006 withdrawal for the entire ACT Basin. Figure 8 plots the monthly diversion for the Weiss Dam reach.

Table 3. List of Diversions Modeled in ResSim

Diversion	Description
Reservoir Diversions (Method 1)	
Allatoona_IN_DIV	Allatoona diversion from inflow node
Carters_IN_DIV	Carters diversion from inflow node
Claiborne_IN_DIV	Claiborne diversion from inflow node
Harris_IN_DIV	Harris diversion from inflow node
HN Henry_IN_DIV	HN Henry diversion from inflow node
Jordan_IN_DIV	Jordan diversion from inflow node
Lay_IN_DIV	Lay diversion from inflow node
Logan Martin_IN_DIV	Logan Martin diversion from inflow node
Martin_IN_DIV	Martin diversion from inflow node
Millers Ferry_IN_DIV	Millers Ferry diversion from inflow node
Mitchell_IN_DIV	Mitchell diversion from inflow node
RF Henry_IN_DIV	RF Henry diversion from inflow node
Thurlow_IN_DIV	Thurlow diversion from inflow node
Weiss_IN_DIV	Weiss diversion from inflow node
Yates_IN_DIV	Yates diversion from inflow node
Reach Diversions (Method 2)	
Abv Alabama_Div	Reach 130T
Canton_Divs	Reach 164
Centreville_Divs	Reach 480
Coosa_Divs-1	Reach 130C
Coosa_Divs-2	Reach 131 (Wetumpka Water Works and Sewer Board waste water discharge)
Heflin_Divs	Reach 326
Kingston_Divs	Reach 158
Marion Junction_Divs	Reach 470
Newell_Divs	Reach 310
Resaca_Divs	Reach 170
Rome-Coosa_Divs	Reach 154E
Rome-Etowah_Divs	Reach 156
Rome-Oostanaula_Divs	Reach 154O ("Oh")
Selma_Divs	Reach 126
Tallapoosa_Divs	Reach 329
Tilton_Divs	Reach 386
Wadley_Divs	Reach 294

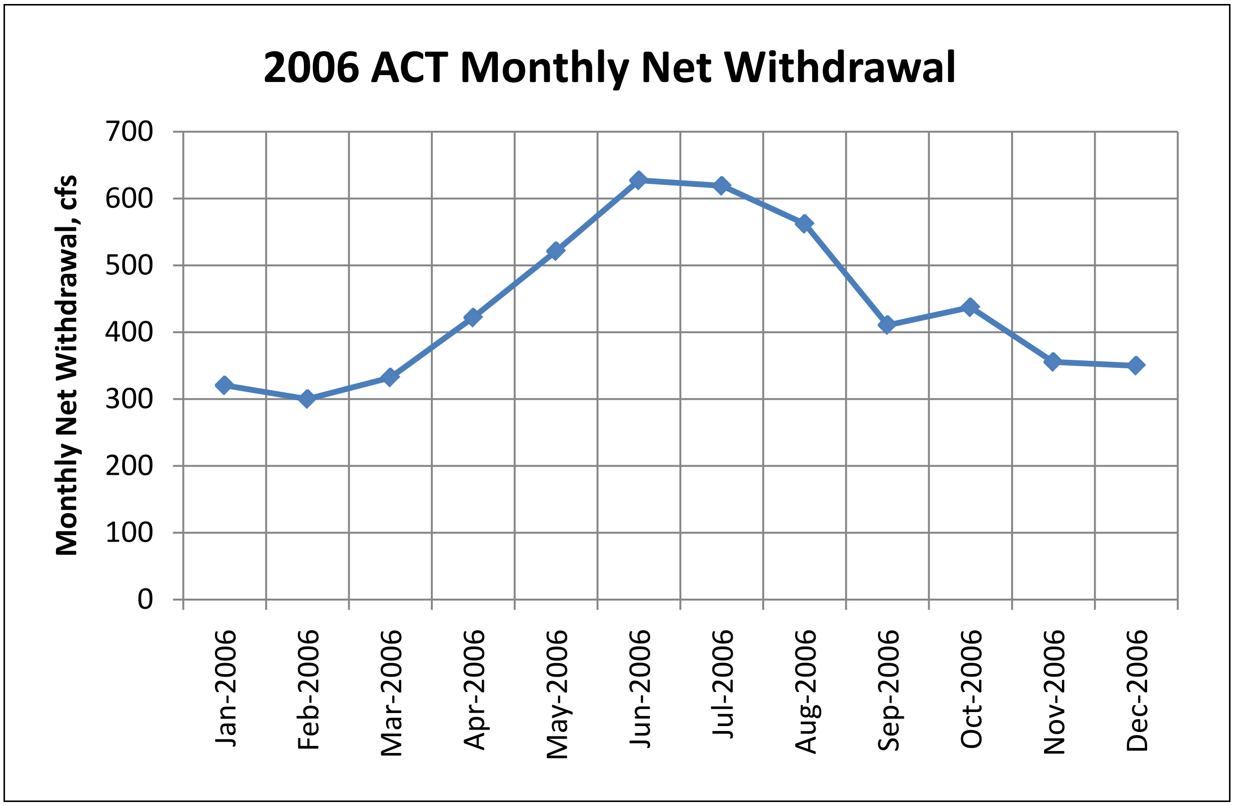


Figure 7. 2006 ACT Monthly Net Withdrawal

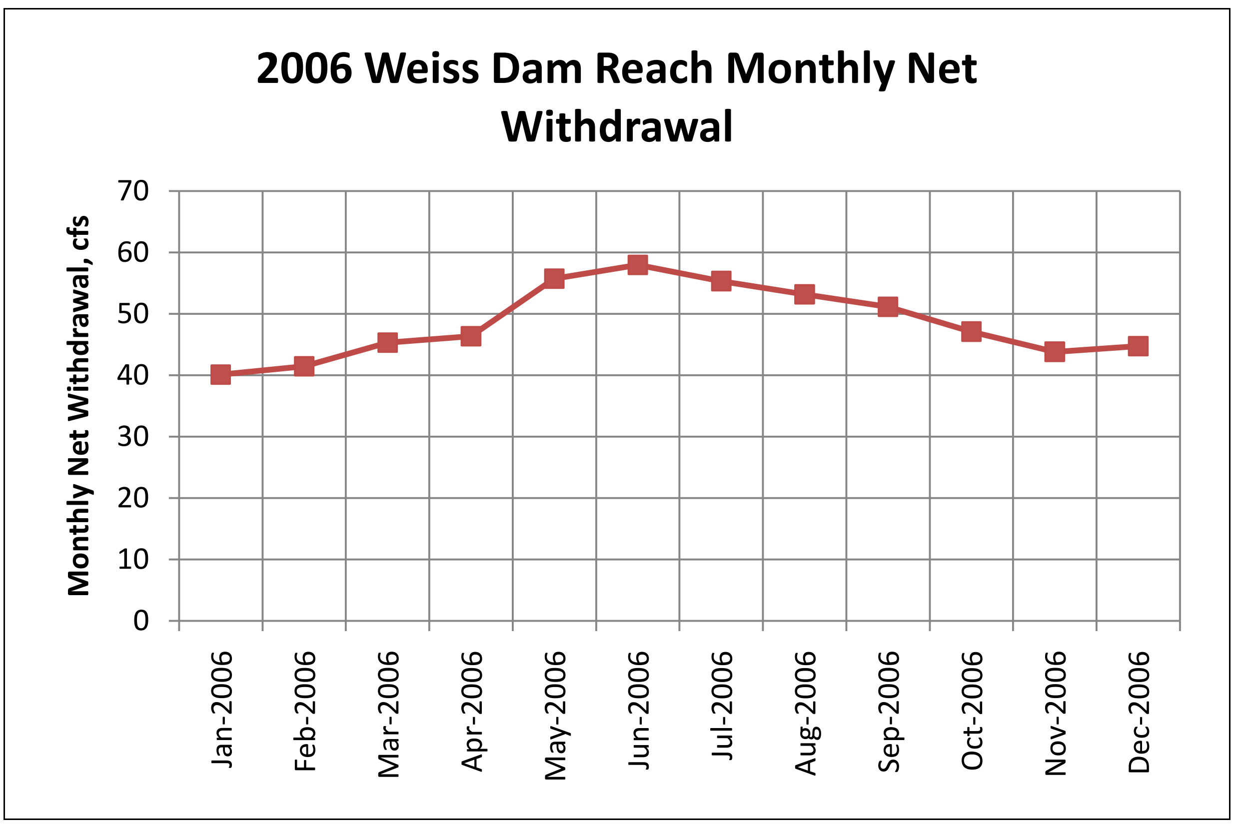


Figure 8. 2006 Weiss Dam Reach Monthly Net Withdrawal

C. Fish Spawning

The Baseline operations reflect fish spawning operations at Lake Allatoona, as outlined in the South Atlantic Division Regulation (DR) 1130-2-16, Project Operations, Lake Regulation and Coordination for Fish Management Purposes and draft standing operational procedure (SOP) Reservoir Regulation and Coordination for Fish Management Purposes (Mobile District SOP 1130-2-9, draft, February 2005). During the largemouth bass spawning period, from March 15 to May 15, the Corps seeks to maintain generally stable or rising reservoir levels at Lake Allatoona. Generally stable or rising levels are defined as not lowering the reservoir levels by more than 6 inches, with the base elevation generally adjusted upward as levels rise from increased inflows or refilling of the reservoir.

D. Historic Storage Usage

Figure 9 depicts historic storage usage by project on a monthly basis from 1982 to 2008.

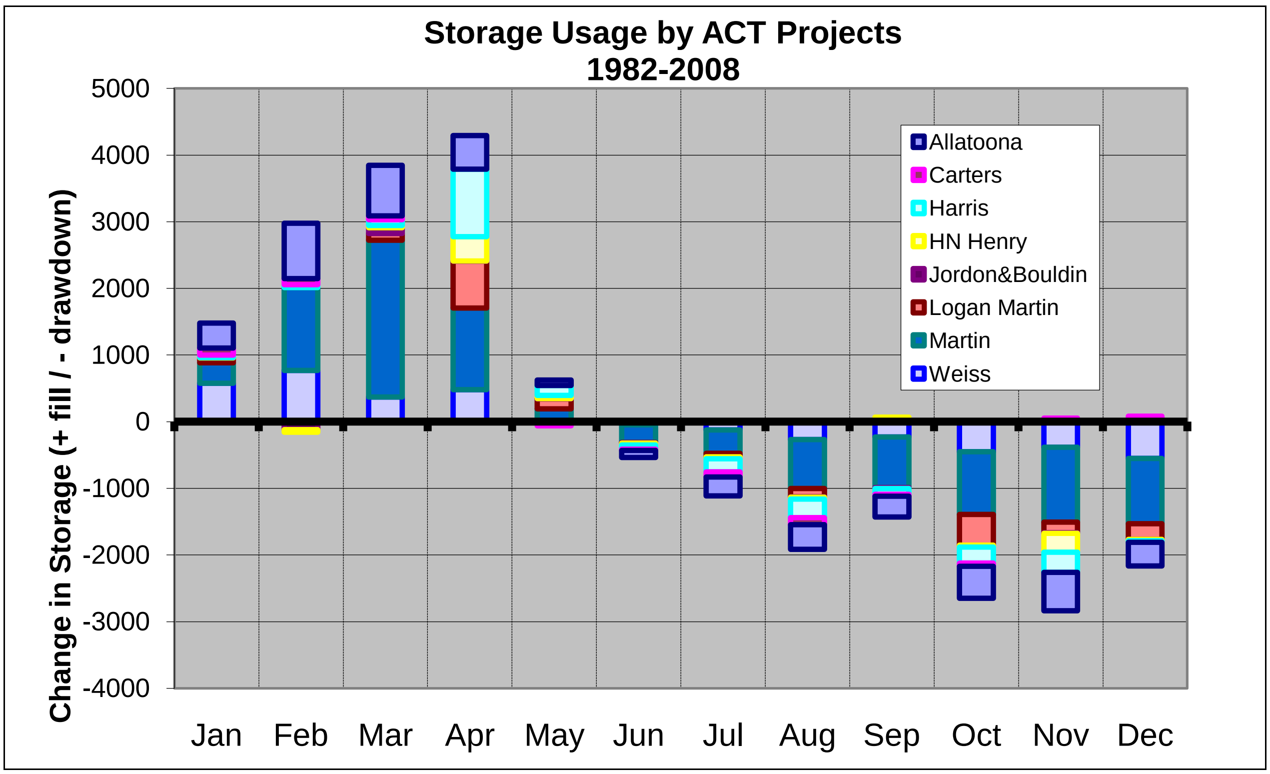
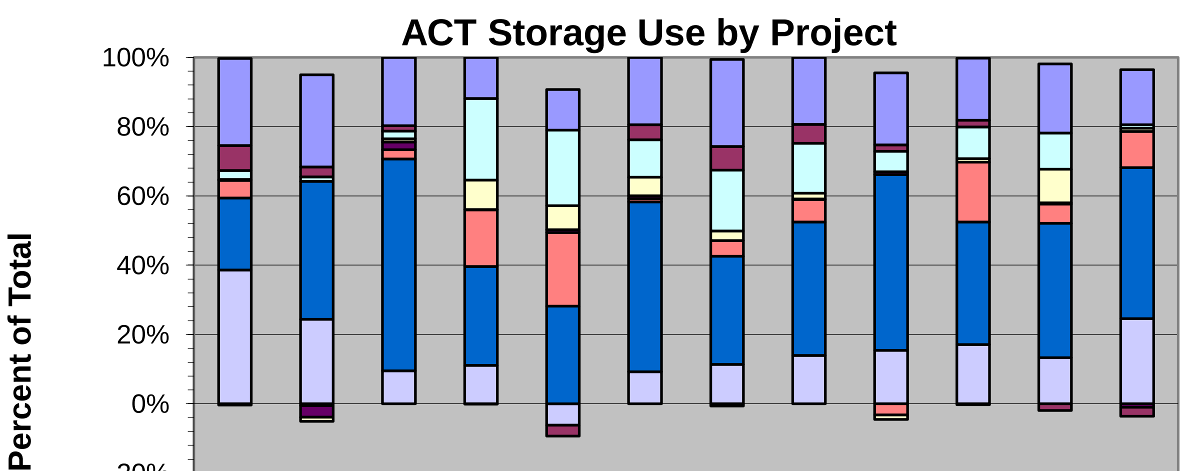


Figure 9. Average Monthly Storage Usage by ACT Projects, 1982-2008

Currently, there is no required contribution of storage usage by project within the basin to meet navigation. Each project operates to meet its project purposes. Since 1972, APC projects on the Coosa and Tallapoosa Rivers have included operations to meet a minimum 7-day average flow of 4,640 cfs from the two basins. At the time of the 1972 agreement between the Corps and APC, the 4,640 cfs was designated to provide for full navigation on the Alabama River. The 7-day average flow of 4,640 cfs is based on the 7Q10 flow of the USGS gage below Claiborne Lock and Dam (6500 cfs), prorated on the basis of the portion of the total drainage area controlled above the APC projects. APC has the discretion to use storage from any of its projects to meet the 4,640 cfs flow requirement when inflow into system is less than 4,640 cfs. Allatoona and Carters are not regulated specifically for navigation. However, all water released from Allatoona and Carters contributes to inflow into Weiss Dam, the most upstream project on the Coosa system, and therefore, indirectly contributes to meeting the downstream navigation target. The Corps lock and dam projects on the Alabama River (RF Henry, Millers Ferry, and Claiborne) are authorized for navigation, but these are run-of-river projects with inadequate storage to support navigation.

Figure 10 depicts historic storage usage by project on a monthly basis from 1982 to 2008 as percentages. The largest Corps project, Allatoona, ranges from 12% to 30% storage usage during filling and 17% to 25% during drawdown periods. Martin, the largest APC project, ranges from 21% to 61% storage usage during filling and 32% to 56% during drawdown period. Figure 11 depicts the ACT individual project contribution to the system total conservation storage. The Corps total contribution is 19 percent and the remaining 81 percent is from Alabama Power Company projects.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Allatoona	25%	30%	20%	12%	14%	19%	25%	19%	23%	18%	21%	17%
Carters	7%	3%	2%	0%	-4%	4%	7%	5%	2%	2%	-2%	-3%
Harris	3%	1%	2%	24%	27%	11%	18%	14%	7%	9%	11%	1%
HN Henry	0%	-1%	1%	8%	9%	5%	3%	2%	-1%	1%	10%	1%
Jordon&Bouldin	0%	-4%	2%	0%	1%	1%	-1%	0%	1%	0%	0%	-1%
Logan Martin	5%	-1%	3%	16%	26%	1%	5%	6%	-4%	17%	6%	11%
Martin	21%	44%	61%	29%	35%	49%	32%	39%	56%	36%	40%	47%
Weiss	39%	27%	10%	11%	-8%	9%	11%	14%	17%	17%	14%	26%

Figure 10. ACT Storage Use by Project as Percent of Total

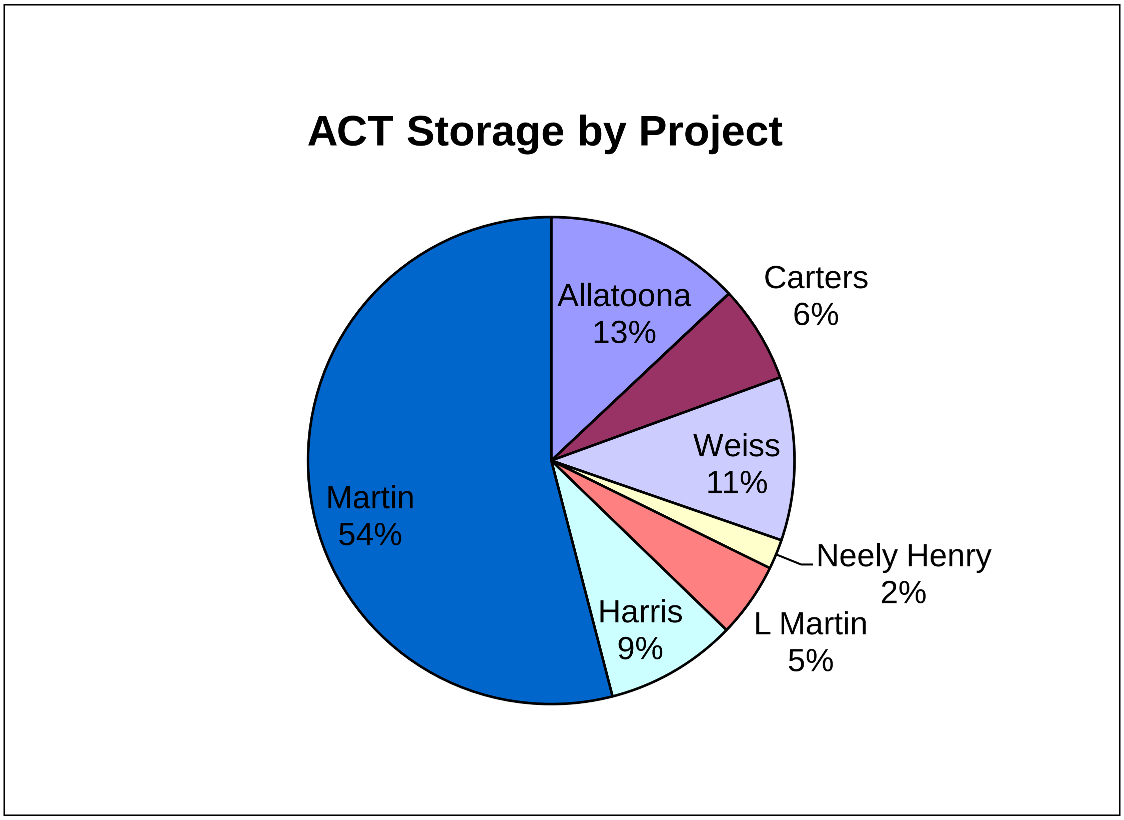


Figure 11. ACT Conservation Storage by Project as a Percent of Total Conservation Storage

Table 4 lists project annual storage usage from 1982 to 2008 and individual project storage contribution to total system storage as percentages. As previously stated, there is no required contribution of storage usage by projects within the basin. Values in Table 4 indicate the annual average project storage usage from 1982 to 2008 is similar to contribution of total storage.

Table 4. Comparison of Project Contribution to System Storage and Storage Usage by Project

Project	ACT Storage Usage by Project (1982-2008)	Contribution to Total System Conservation Storage
Allatoona	20%	13%
Carters	2%	6%
HN Henry	3%	2%
Harris	11%	9%
Logan Martin	8%	5%
Martin	41%	54%
Weiss	16%	11%

Figure 12 depicts historic storage usage by APC projects on a monthly basis from 1982 to 2008.

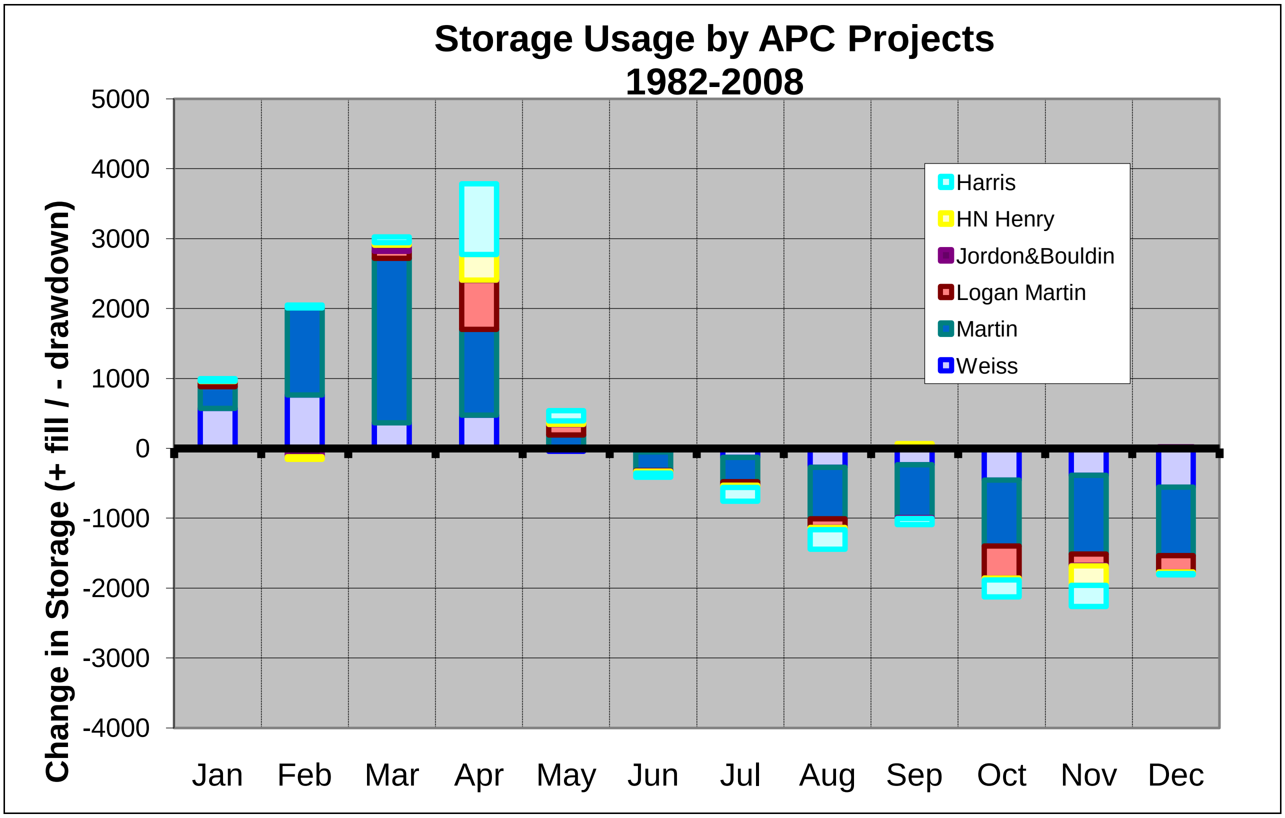


Figure 12. Average Monthly Storage Usage by Alabama Power Projects, 1982-2008

IV. Results of Modeling

Each simulated alternative produces daily results including reservoir release (distributed by outlet) and storage, and streamflow at all locations throughout the model. To assist with the analysis of so many results, scripted plot templates and report generation templates were created to provide on-demand illustrations of the state of various reservoir systems operations. Figure 13 shows the list of custom "Baseline" scripts used for plotting and building reports. Appendix L includes the contents of these utility scripts for analyzing results.

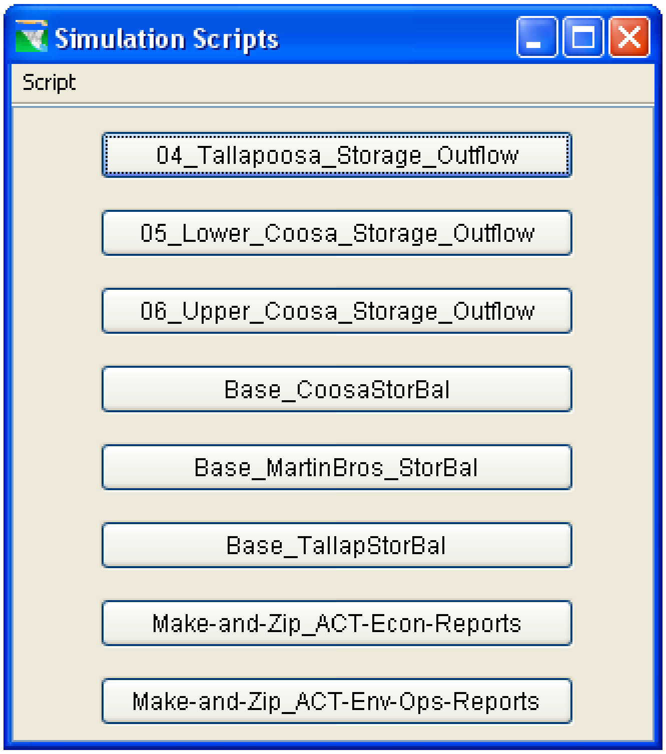


Figure 13. Simulation Scripts for Generating "Baseline" Plots and Reports

Three main custom plot types were designed for viewing system balances. The Coosa Storage Balance script plots the storage as a percentage of zone in Weiss, HN Henry, and Logan Martin, as well as reservoir releases and flow at J.D.Minimum and JBT Goal (Figure 14). Reservoirs on the Coosa River operate to meet a minimum flow at J.D.Minimum and Logan Martin operates to meet a minimum at JBT Goal. The objective flows for J.D.Minimum and JBT Goal are also plotted, as are the computed values of the minimum flow rules (Min@JBT_Goal_4640 and Min@J.D.Minimum). The other two storage balance plot types are similar. The Martin Brothers Storage Balance script plots the storage in Martin and Logan Martin, along with reservoir releases and flow at JBT Goal, for which Martin and Logan Martin operate together (Figure 15). The Tallapoosa Storage Balance script plots storage in Harris and Martin, as well as reservoir releases and flows at Tallassee and JBT Goal (Figure 16). Reservoirs on the Tallapoosa operate to meet a minimum at Tallassee. The pool of each reservoir is shown at 200% of zone when the Conservation Pool is full. The Drought Pool is full at 100% and the Flood Pool is full at 300%.

In addition to the plotting scripts are report scripts, "Make-and-Zip_ACT-Econ-Reports" and "Make-and-Zip_ACT-Env-Ops-Reports." These scripts build excel data files of results that are useful to the economic, environmental, and operational analysis and assembles them in zip files.

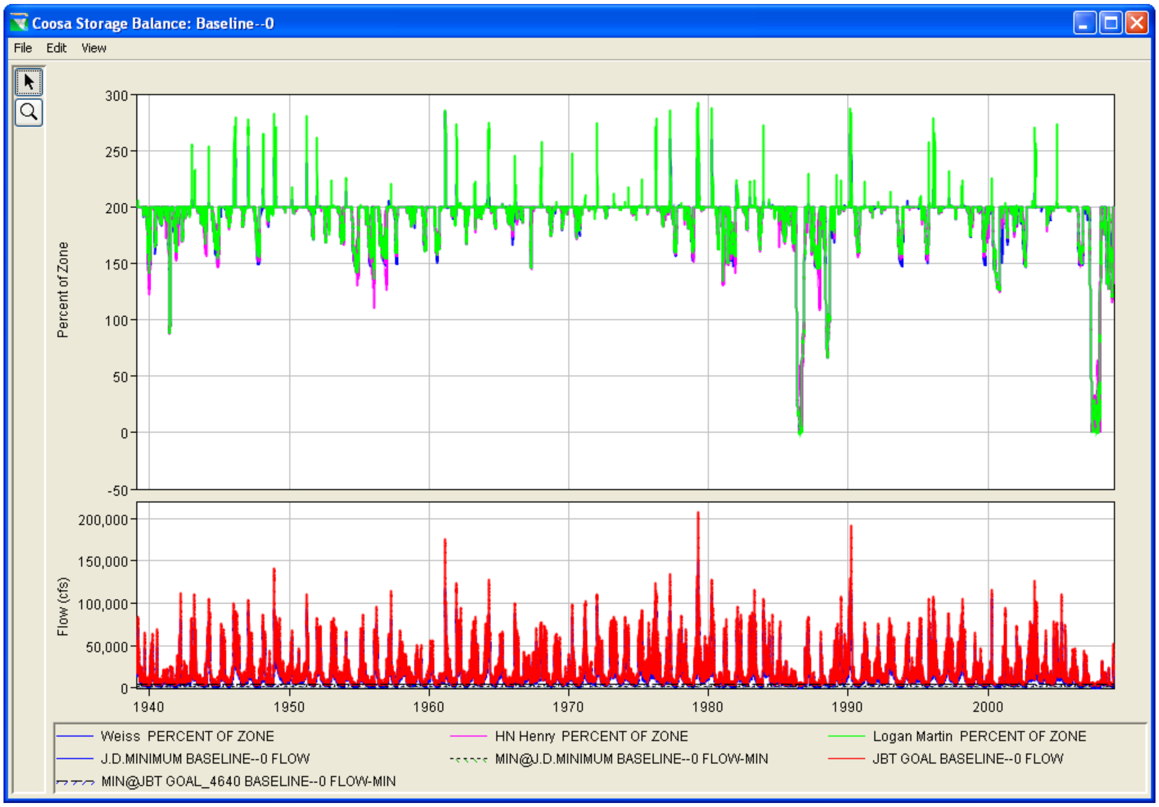


Figure 14. Coosa Storage Balance for Baseline Alternative

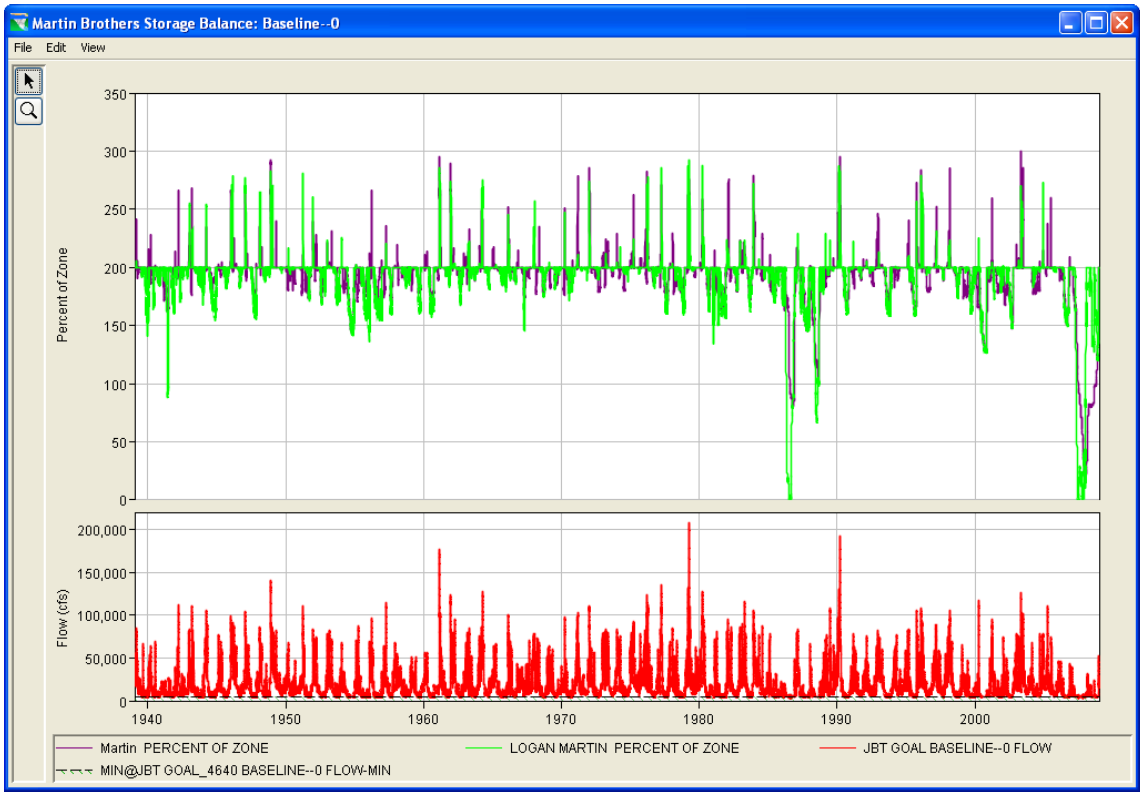


Figure 15. Martin Brothers Storage Balance for Baseline Alternative

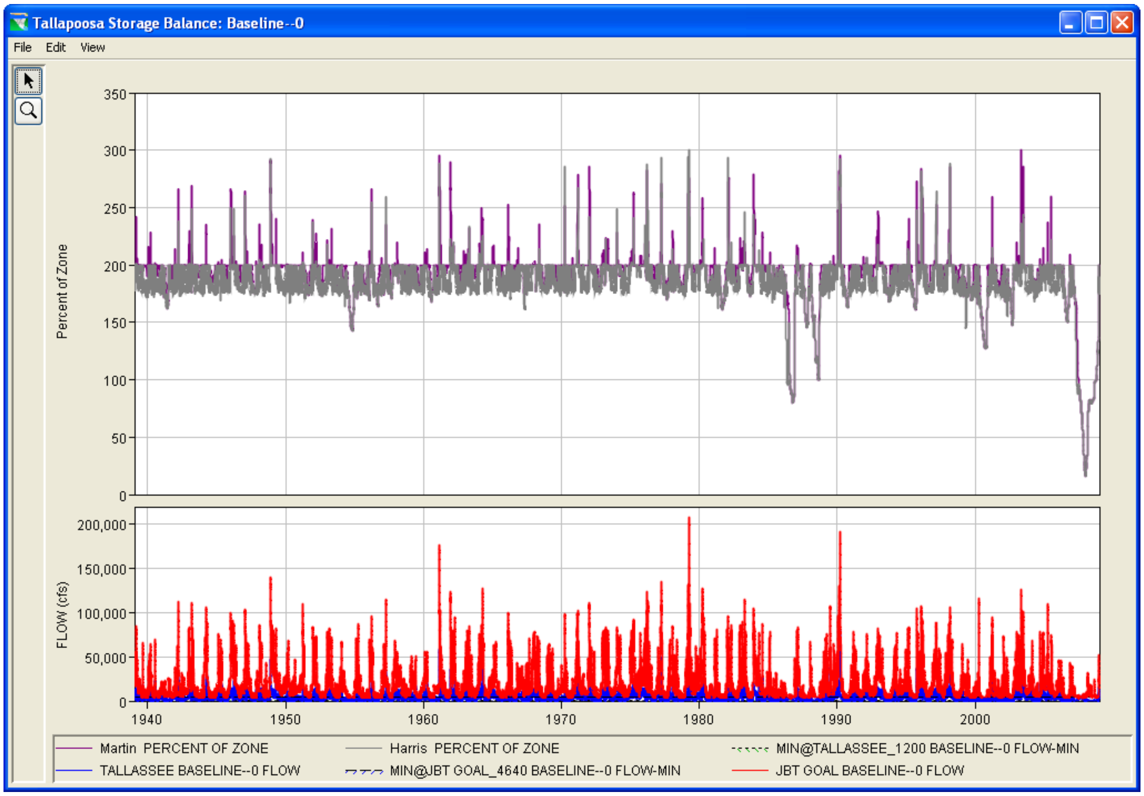


Figure 16. Tallapoosa Storage Balance for Baseline Alternative

V. References

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Alabama-Coosa-Tallapoosa (ACT) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update

List of Appendices *[Baseline]*

March 2011 (DRAFT)

Prepared for:
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Alabama-Coosa-Tallapoosa (ACT) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update

[Baseline]

Appendix A – Carters and Carters Reregulation Reservoirs

March 2011 (DRAFT)

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Appendix A – Carters and ReReg [Baseline] (DRAFT)

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List of Figures:

Carters Reservoir and Carters Reregulation Reservoir

I. Overview

Carters Reservoir and Dam and Carters Reregulation Reservoir and Dam are operated by the Mobile District of the Corps of Engineers. They are located on the Coosawattee River 1.5 miles upstream of Carters in northwest Georgia. This location is 60 miles north of Atlanta, GA and 50 miles southeast of Chattanooga, Tennessee. The reregulation dam is 1.8 miles downstream from the main dam in Murray County. The pool extends into both Gilmer and Gordon Counties.

Carters Reservoir is designed for flood control and hydroelectric power. It increases protection to farmlands along the Coosawattee and Oostanaula Rivers. This project helps reduce flood stages approximately 72 miles downstream. Downstream areas are assured 240 cfs in the river as long as sufficient water is available. This is due to the hydroelectric plant. Carters Project is 11 miles long and 62 miles in circumference. The dam is a massive rolled rock structure with a height of 445 ft and a length of 2,753 ft (including saddle dikes). It also contains a gated spillway with five 40 ft wide gates.

Figure A.01 shows the location of Carters Reservoir and Dam as well as Carters Reregulation Reservoir and Dam as they are represented in the HEC-ResSim model.

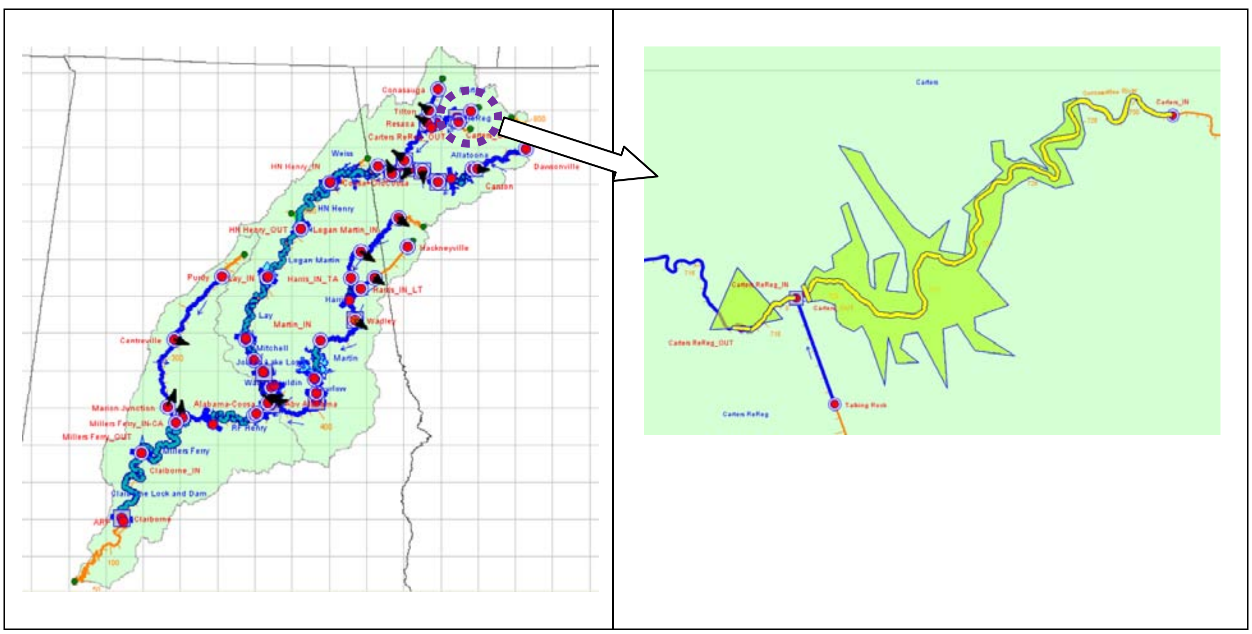


Figure A.01 HEC-ResSim Map Display Showing Location of Carters Reservoir and Carters ReReg

Figure A.02 shows a photo of Carters Reservoir Main Dam, and Figure A.03 shows a photo of Carters Reregulation Reservoir and Dam.

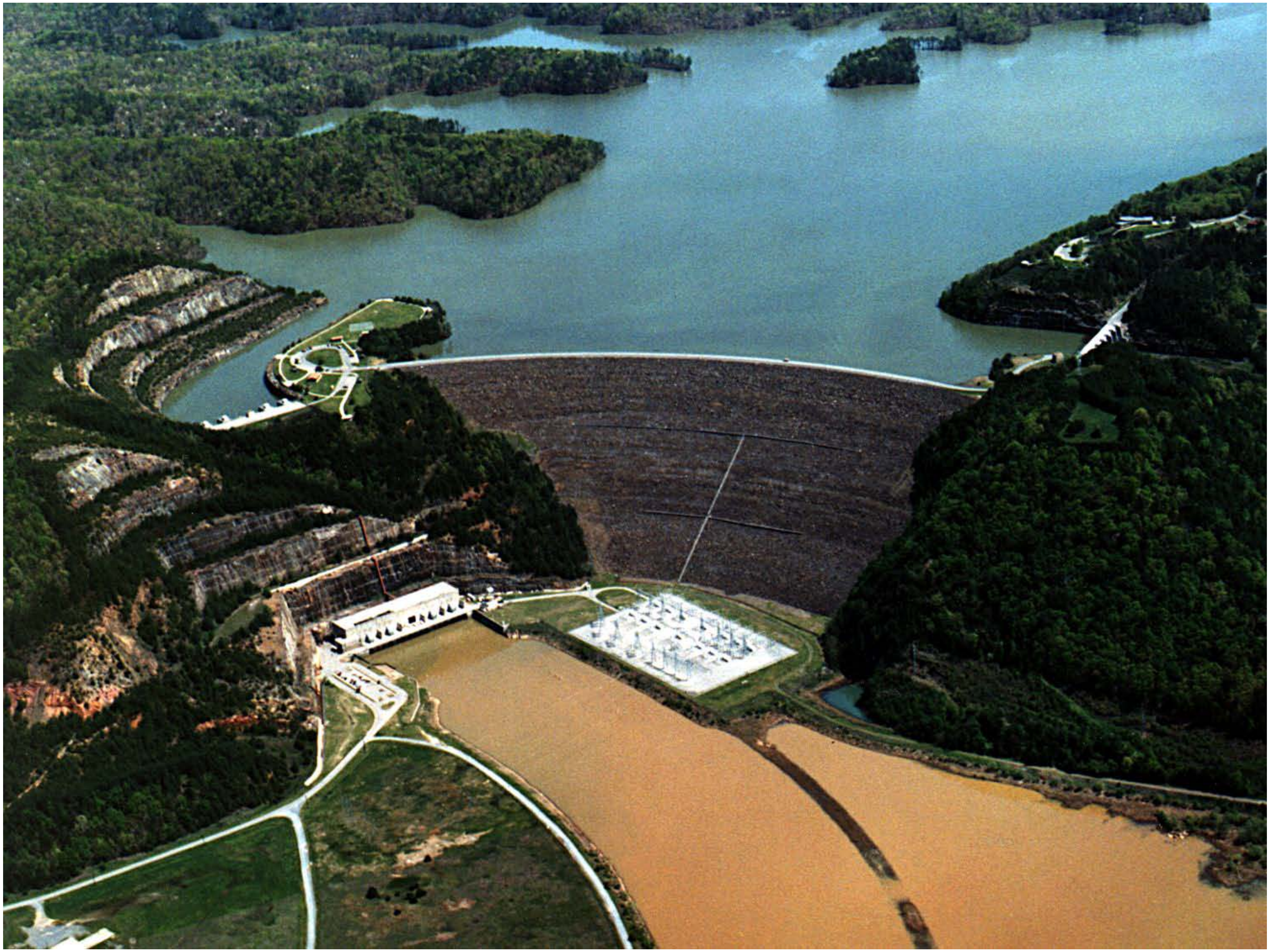
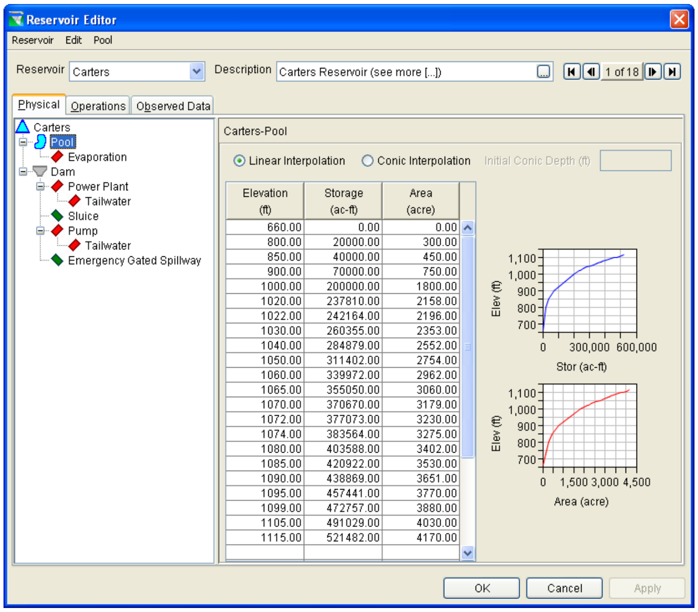


Figure A.02 Photo of Carters Main Dam

Figure A.03 Photo of Carters Reregulation Dam

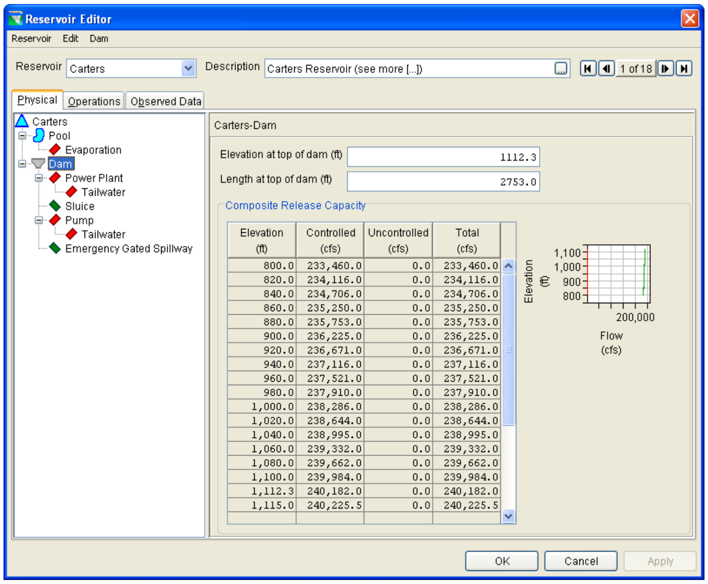
II. Physical Characteristics

The physical characteristics of each reservoir are separated between the "Pool" and the "Dam" in the ResSim model. The "elevation-storage-area" defines the pool as shown for Carters Reservoir in Figure A.04. Carters Dam consists of three types of outlets: (1) an emergency gated spillway; (2) a sluice; and, (3) a power plant. Each of these outlets is defined in the model, and the Dam reflects the composite release capacity of all of the outlets as shown in Figure A.05. Carter's Pump unit (as reflected in Figure A.04) is shown in detail in Figure A.06 and Figure A.07



Elevation (ft)	Storage (ac-ft)	Area (acre)
660.00	0.00	0.00
800.00	20000.00	300.00
850.00	40000.00	450.00
900.00	70000.00	750.00
1000.00	200000.00	1800.00
1020.00	237810.00	2158.00
1022.00	242164.00	2196.00
1030.00	260355.00	2353.00
1040.00	284879.00	2552.00
1050.00	311402.00	2754.00
1060.00	339972.00	2962.00
1065.00	355050.00	3060.00
1070.00	370670.00	3179.00
1072.00	377073.00	3230.00
1074.00	383564.00	3275.00
1080.00	403588.00	3402.00
1085.00	420922.00	3530.00
1090.00	438869.00	3651.00
1095.00	457441.00	3770.00
1099.00	472757.00	3880.00
1105.00	491029.00	4030.00
1115.00	521482.00	4170.00

Figure A.04 2009 Network… Carters Reservoir Editor: Physical Tab – Pool



Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
800.0	233,460.0	0.0	233,460.0
820.0	234,116.0	0.0	234,116.0
840.0	234,706.0	0.0	234,706.0
860.0	235,250.0	0.0	235,250.0
880.0	235,753.0	0.0	235,753.0
900.0	236,225.0	0.0	236,225.0
920.0	236,671.0	0.0	236,671.0
940.0	237,116.0	0.0	237,116.0
960.0	237,521.0	0.0	237,521.0
980.0	237,910.0	0.0	237,910.0
1,000.0	238,286.0	0.0	238,286.0
1,020.0	238,644.0	0.0	238,644.0
1,040.0	238,995.0	0.0	238,995.0
1,060.0	239,332.0	0.0	239,332.0
1,080.0	239,662.0	0.0	239,662.0
1,100.0	239,984.0	0.0	239,984.0
1,112.3	240,182.0	0.0	240,182.0
1,115.0	240,225.5	0.0	240,225.5

Figure A.05 2009 Network… Carters Reservoir Editor: Physical Tab – Dam

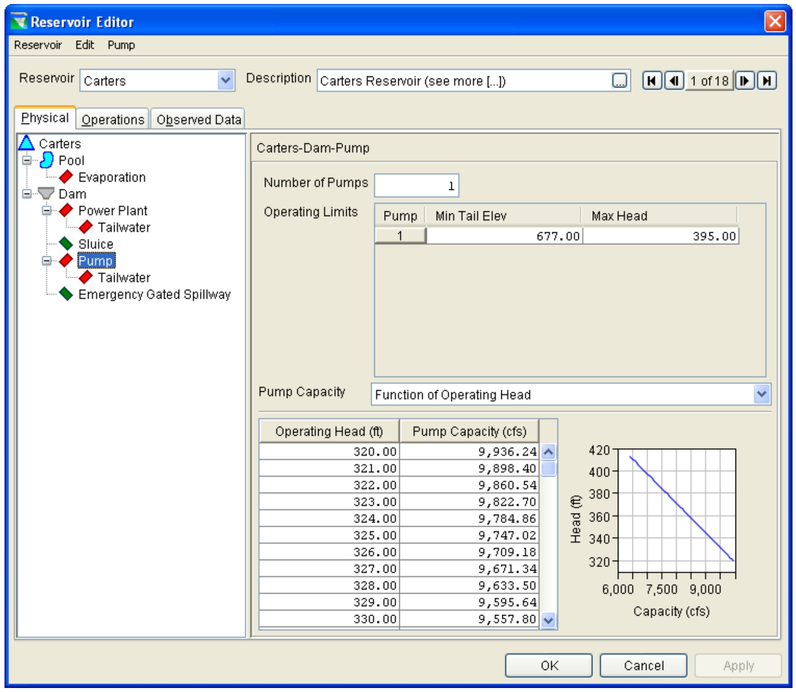


Figure A.06 2009 Network… Carters Reservoir Editor: Physical Tab – Pump

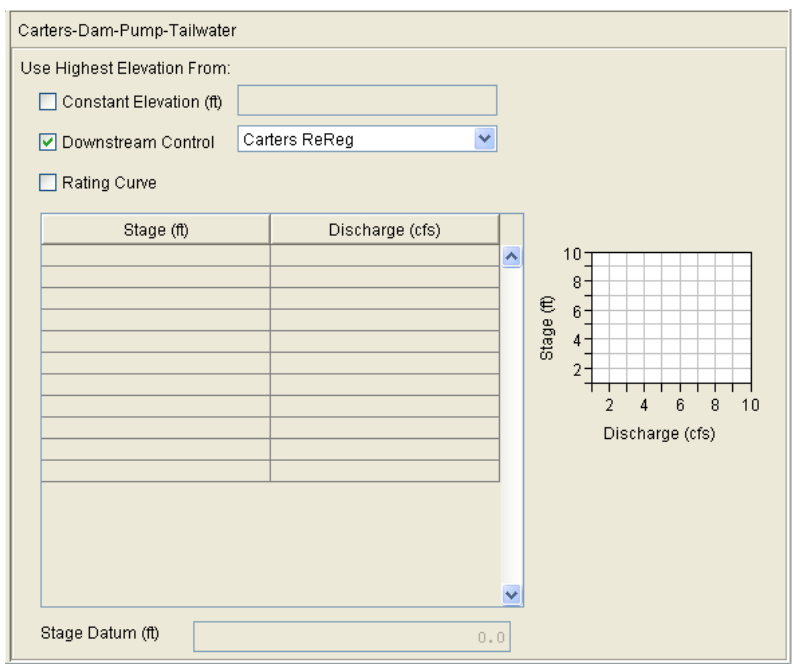
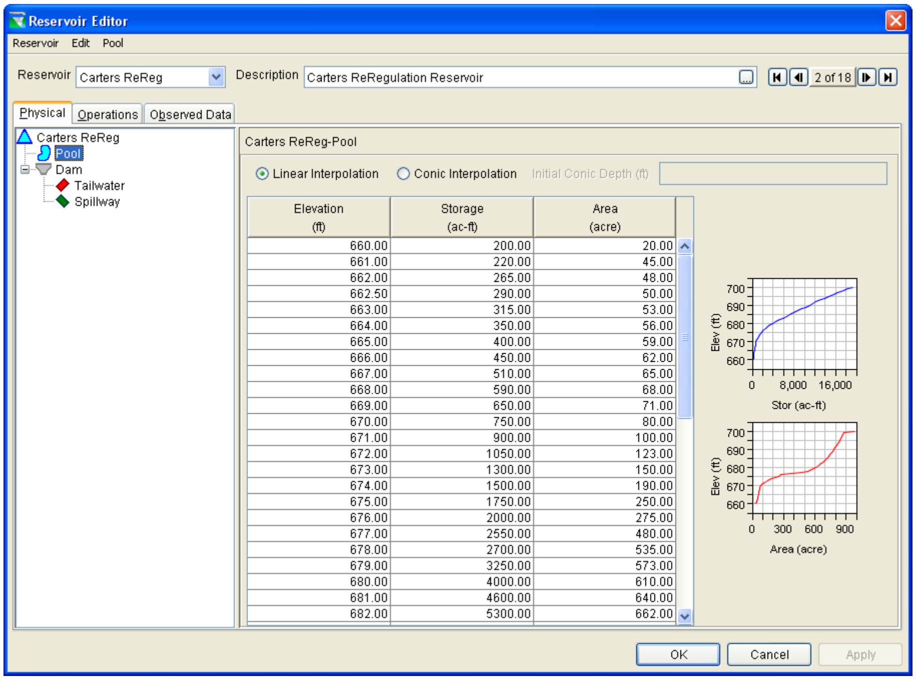


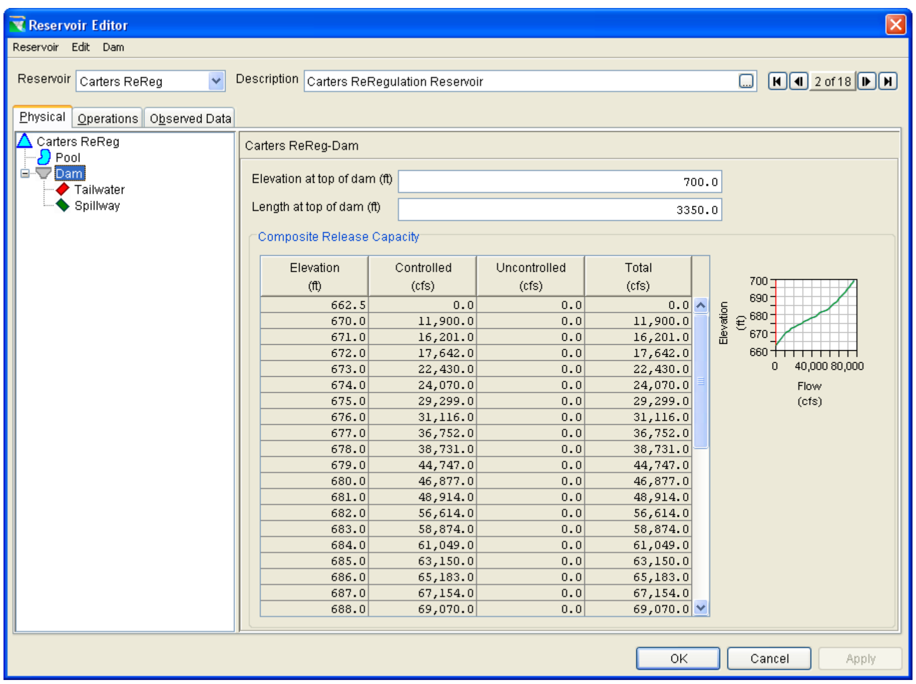
Figure A.07 2009 Network… Carters Reservoir Editor: Physical Tab – Pump Tailwater

The "elevation-storage-area" defining Carters ReReg pool is shown in Figure A.08. Carters ReReg consists of a single controlled outlet named "Spillway". Since the Dam reflects the composite release capacity of all of the outlets (one in this case), Figure A.09 shows the release capacity of the ReReg's spillway outlet.



Elevation (ft)	Storage (ac-ft)	Area (acre)
660.00	200.00	20.00
661.00	220.00	45.00
662.00	265.00	48.00
662.50	290.00	50.00
663.00	315.00	53.00
664.00	350.00	56.00
665.00	400.00	59.00
666.00	450.00	62.00
667.00	510.00	65.00
668.00	590.00	68.00
669.00	650.00	71.00
670.00	750.00	80.00
671.00	900.00	100.00
672.00	1050.00	123.00
673.00	1300.00	150.00
674.00	1500.00	190.00
675.00	1750.00	250.00
676.00	2000.00	275.00
677.00	2550.00	480.00
678.00	2700.00	535.00
679.00	3250.00	573.00
680.00	4000.00	610.00
681.00	4600.00	640.00
682.00	5300.00	662.00

Figure A.08 2009 Network… Carters ReReg Reservoir Editor: Physical Tab – Pool



Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
662.5	0.0	0.0	0.0
670.0	11,900.0	0.0	11,900.0
671.0	16,201.0	0.0	16,201.0
672.0	17,642.0	0.0	17,642.0
673.0	22,430.0	0.0	22,430.0
674.0	24,070.0	0.0	24,070.0
675.0	29,299.0	0.0	29,299.0
676.0	31,116.0	0.0	31,116.0
677.0	36,752.0	0.0	36,752.0
678.0	38,731.0	0.0	38,731.0
679.0	44,747.0	0.0	44,747.0
680.0	46,877.0	0.0	46,877.0
681.0	48,914.0	0.0	48,914.0
682.0	56,614.0	0.0	56,614.0
683.0	58,874.0	0.0	58,874.0
684.0	61,049.0	0.0	61,049.0
685.0	63,150.0	0.0	63,150.0
686.0	65,183.0	0.0	65,183.0
687.0	67,154.0	0.0	67,154.0
688.0	69,070.0	0.0	69,070.0

Figure A.09 2009 Network… Carters ReReg Reservoir Editor: Physical Tab –Dam

III. Baseline Operations

A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table A.01 shows the definition of "Baseline" operational zones for Carters Reservoir, which consist of zones of flood control and conservation. The flood control pool is divided into several operational zones.

Table A.01 Carters Zone Elevations for "Baseline" Operation Set

Carters	Baseline Top of Zone Elevation Values (feet)				
Seasons =	**1-Jan**	**1-Apr**	**1-May**	**1-Nov**	**1-Dec**
Zones:					
Top of Dam	1112.3	*1112.3*	*1112.3*	*1112.3*	*1112.3*
Top of Surcharge	1107	*1107*	*1107*	*1107*	*1107*
Flood Control	1099	*1099*	*1099*	*1099*	*1099*
GC Buffer	1073	1073	1075	1075	1073
Conservation	1072	1072	1074	1074	1072
Inactive	1022	*1022*	*1022*	*1022*	*1022*

Table A.02 shows the definition of "Baseline" operational zones for Carters ReReg, which consist of zones of flood control and conservation. The conservation pool is divided into a couple of operational zones.

Table A.02 Carters ReReg Zone Elevations for "Baseline" Operation Set

Carters ReReg	Baseline Top of Zone Elevation Values (feet)
Seasons =	**1Jan - 31Dec**
Zones:	
Top of Dam	700
Flood Control	698
Conservation	695
Buffer	677
Inactive	663

At Carters Reservoir, the top of the Conservation zone varies seasonally and has been set to be the operational Guide Curve for Baseline operations (as shown in Figure A.10).

Guide Curve definition (top of **Conservation** zone)

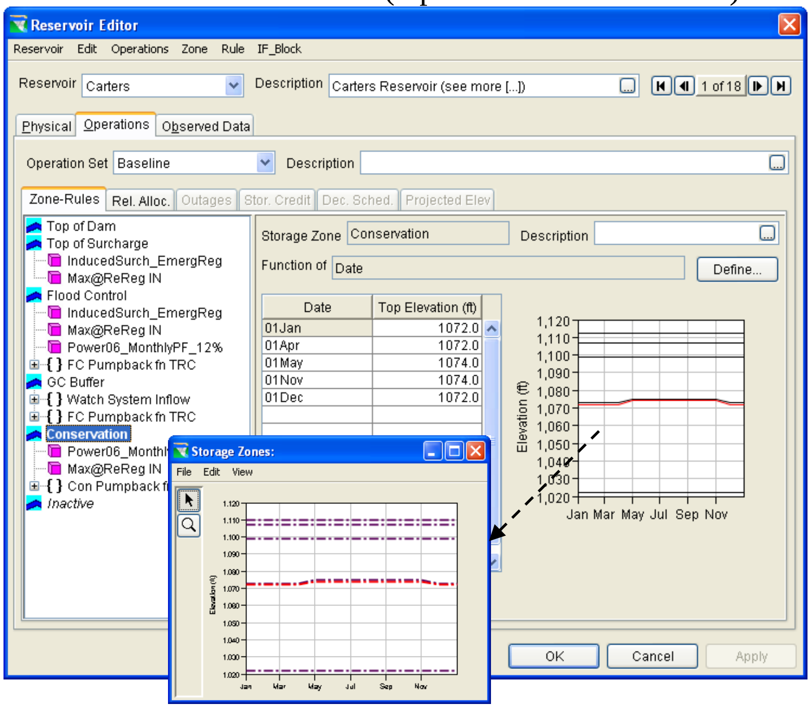


Figure A.10 Carters Reservoir Editor:
Operations Tab – Baseline OpSet Guide Curve

As shown in Figure A.11, the top of the Conservation zone for Baseline operations at Carters ReReg has been set to be the operational Guide Curve and is a constant 695' throughout the year.

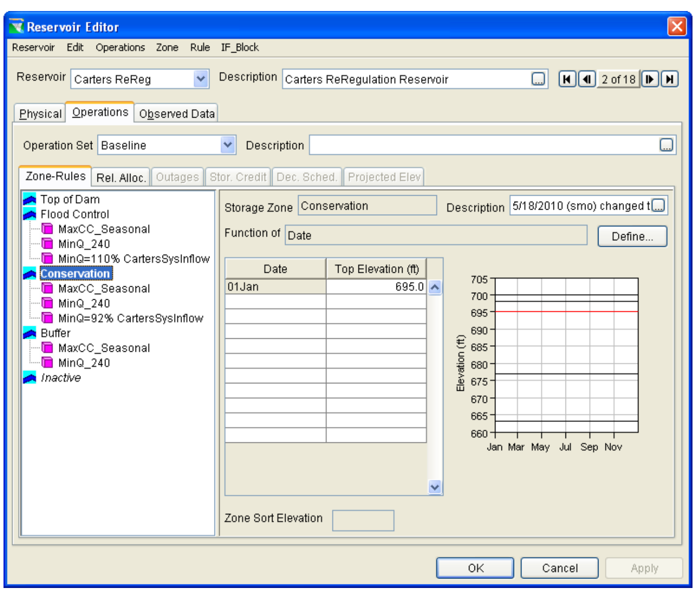


Figure A.11 Carters ReReg Reservoir Editor:
Operations Tab – Baseline OpSet Guide Curve

Figure A.12 shows a sequential release allocation approach specified for available outlets along Carters Dam. The available outlets are given an order of priority for release. The power plant unit gets the release first until it reaches release capacity. After the capacity through the powerhouse is reached, the remainder of the release goes through the emergency gated spillway and then through the sluice. The pump actually reflects water being pumped from the ReReg, not water being released from Carters to the ReReg.

Release Allocation:

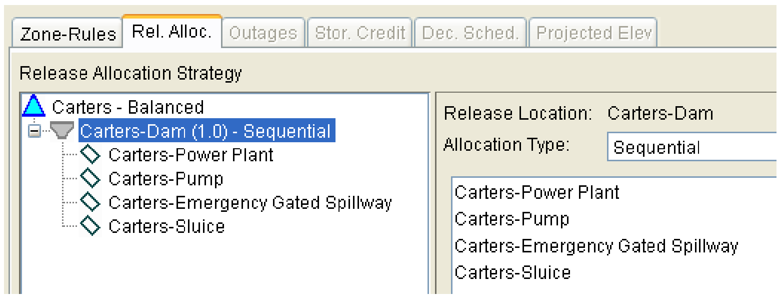


Figure A.12 Carters Reservoir Editor:
Operations Tab – Baseline OpSet – Release Allocation

Figure A.13 shows the sequential release allocation specified for Carters ReReg (where the single spillway outlet is shown).

Release Allocation:

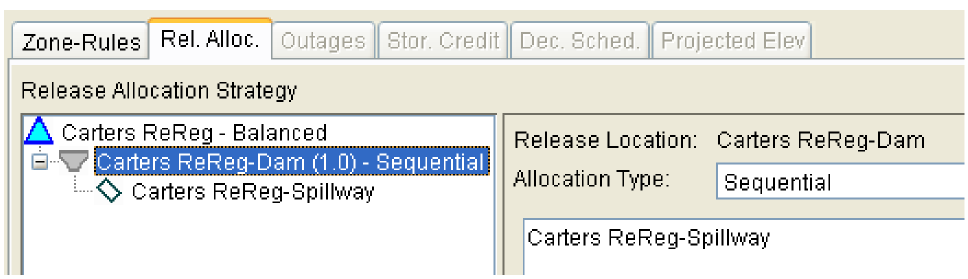


Figure A.13 Carters ReReg Reservoir Editor:
Operations Tab – Baseline OpSet – Release Allocation

B. Carters Reservoir -- Baseline Rules

Figure A.14 shows a set of operational rules specified for each zone that reflects the operation set named “Baseline” for Carters.

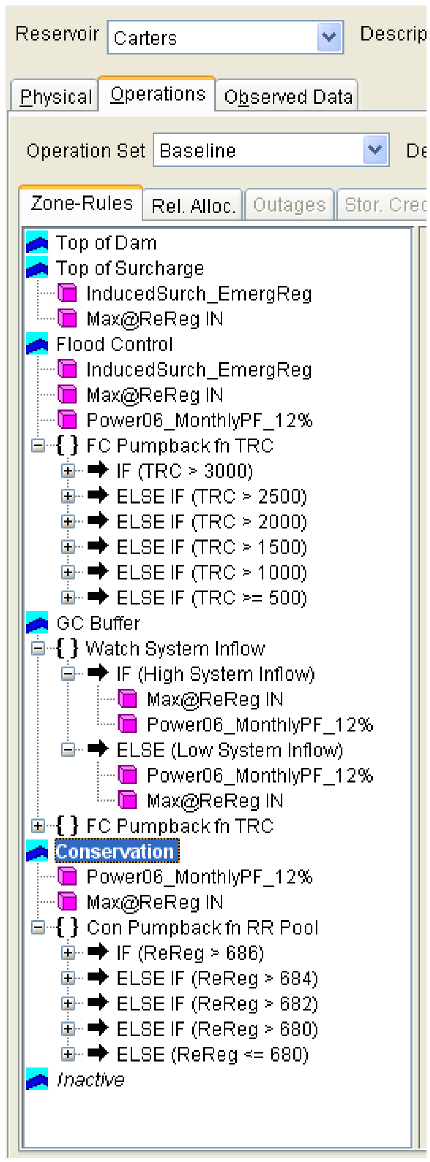


Figure A.14 Carters Reservoir Editor: Operations Tab – Baseline OpSet – Zones and Rules

1. Rule Illustrations

The content for each of these rules in the ResSim model are shown in Figure A.15 through Figure A.25. The logic and purpose for each operational rule is described in Section B.2 (which follows Figure A.25).

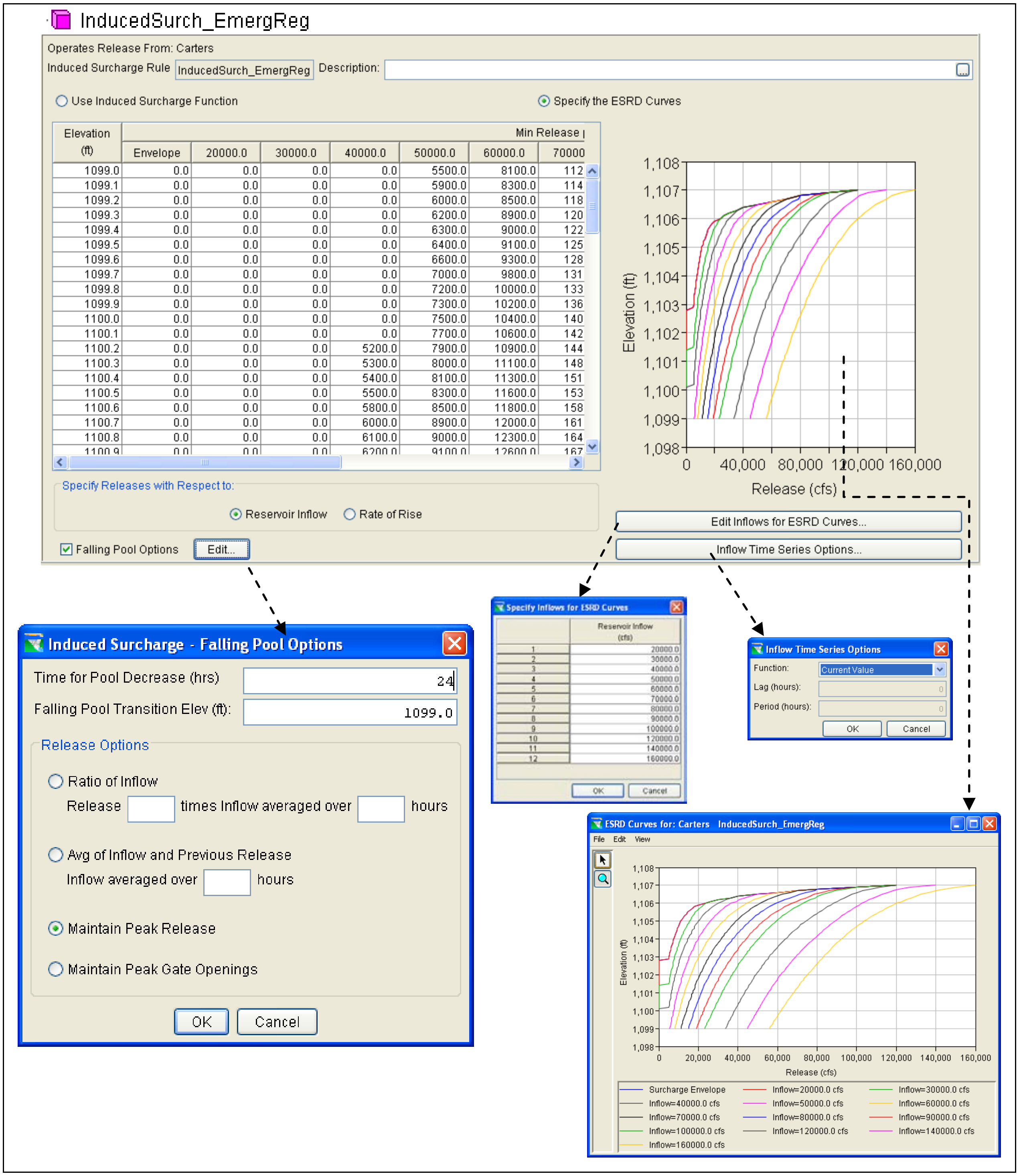


Figure A.15 Carters Reservoir Editor:
Operations Tab – Baseline OpSet – Induced Surcharge Rule

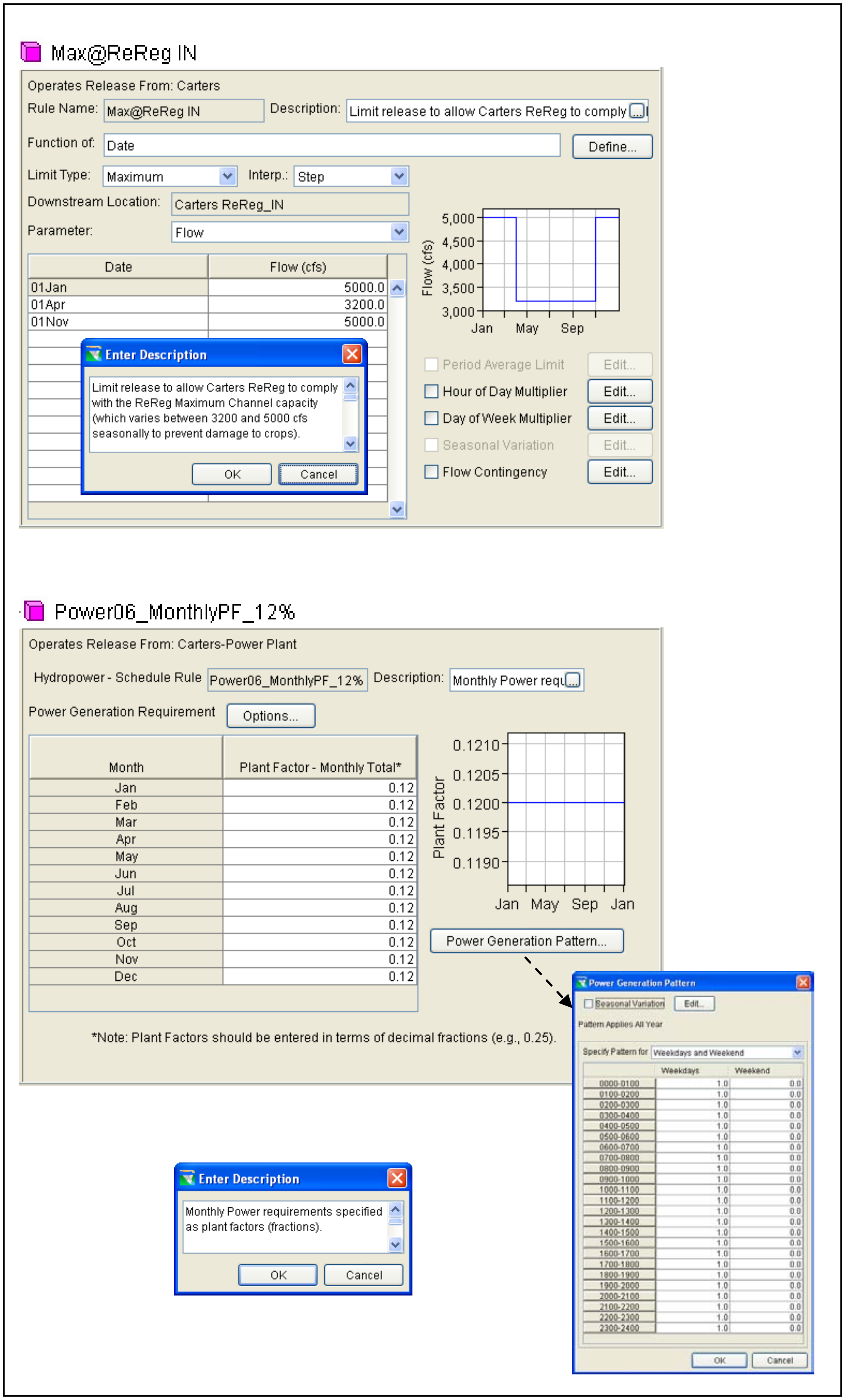


Figure A.16 Carters Reservoir Editor: Operations Tab – Baseline OpSet – Maximum and Hydropower Rules

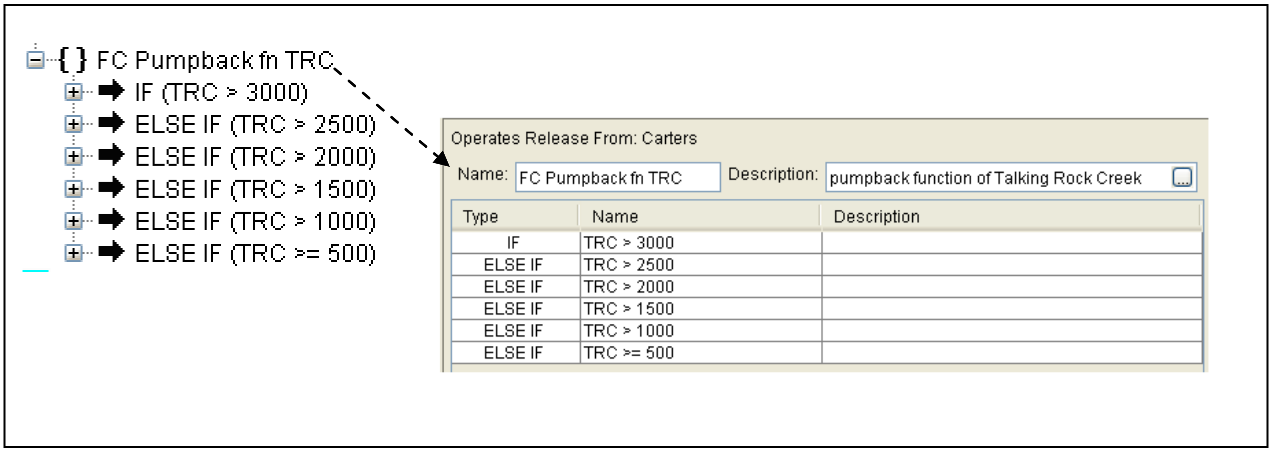


Figure A.17 Flood Control Pumpback – "Conditional Blocks" Function of Talking Rock Creek

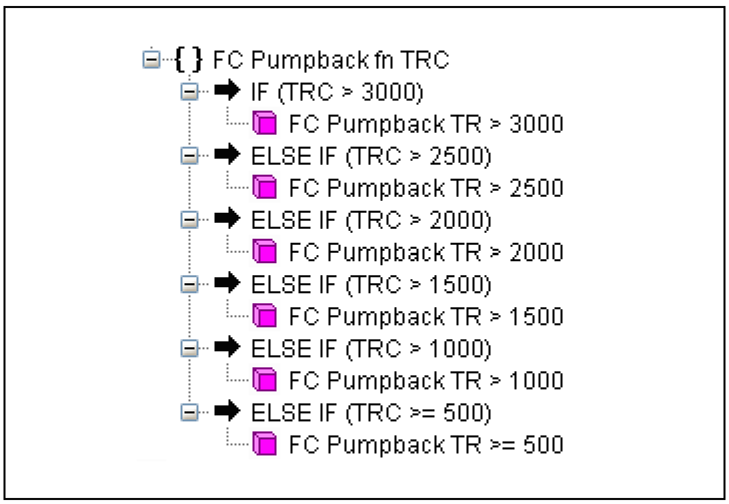


Figure A.18 Flood Control Pumpback – "IF-Blocks" and "Rules"

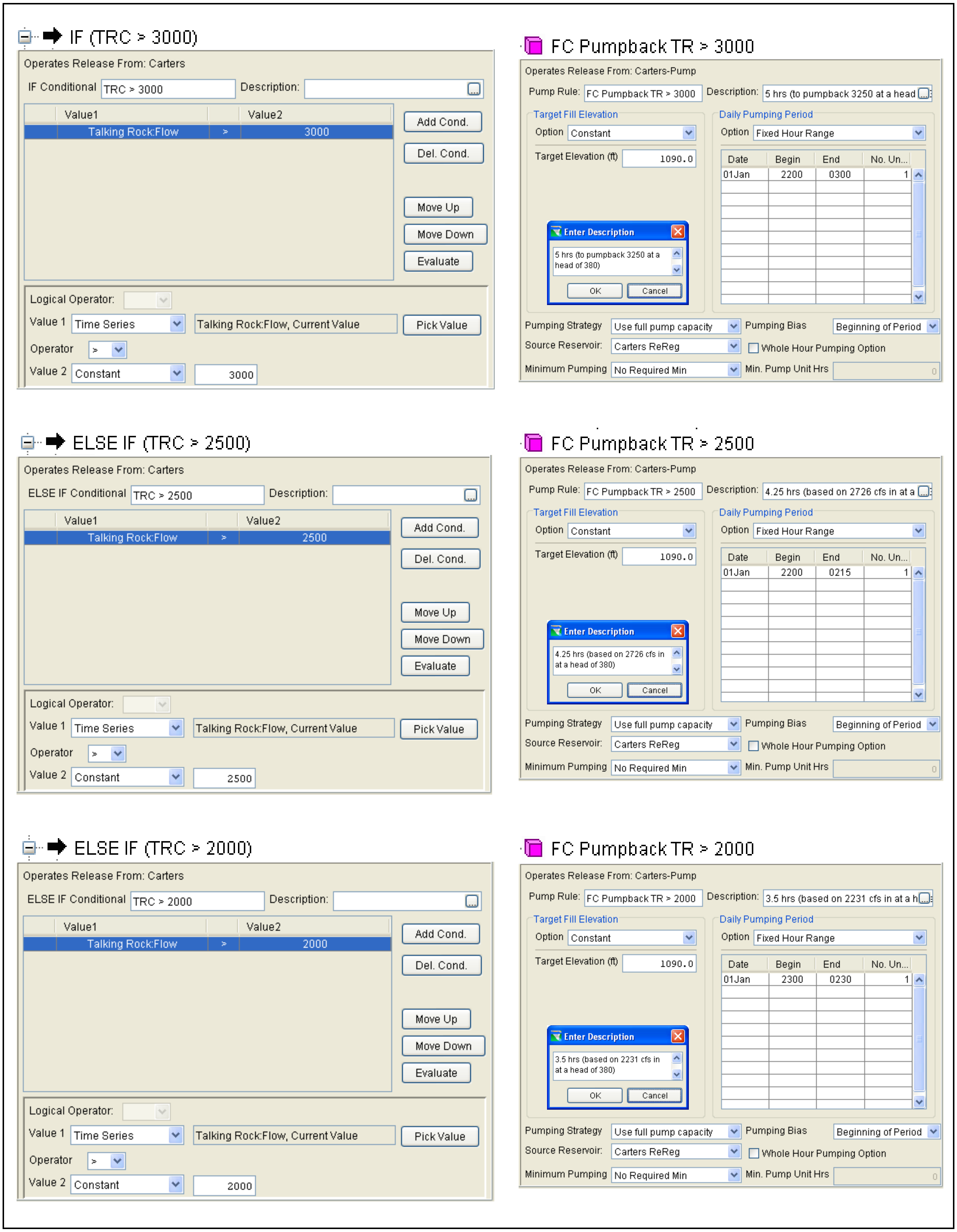


Figure A.19 Flood Control Pumpback – Pump Rules Based on Talking Rock Creek Flow ***(Part 1 of 2)***

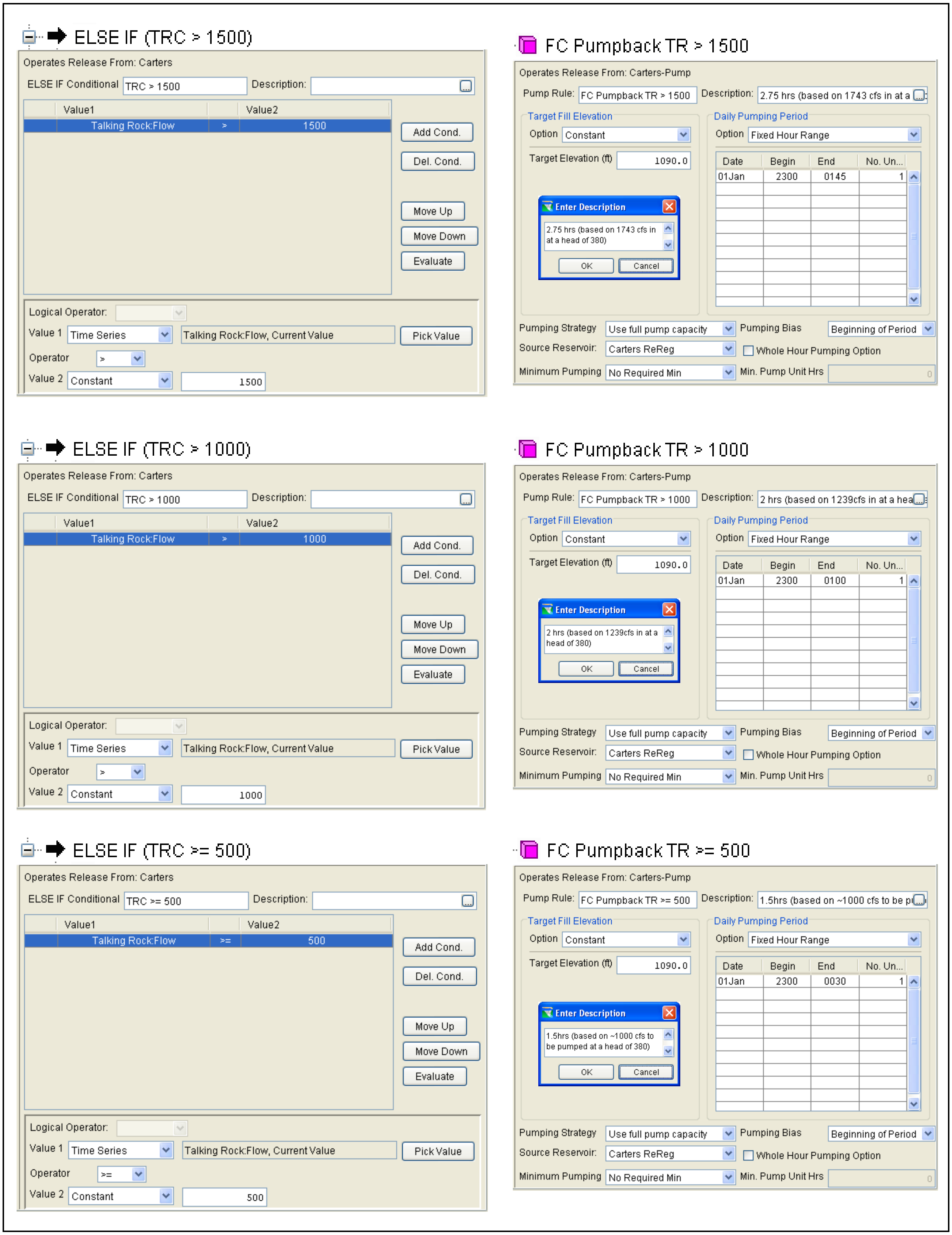


Figure A.20 Flood Control Pumpback – Pump Rules Based on Talking Rock Creek Flow ***(Part 2 of 2)***

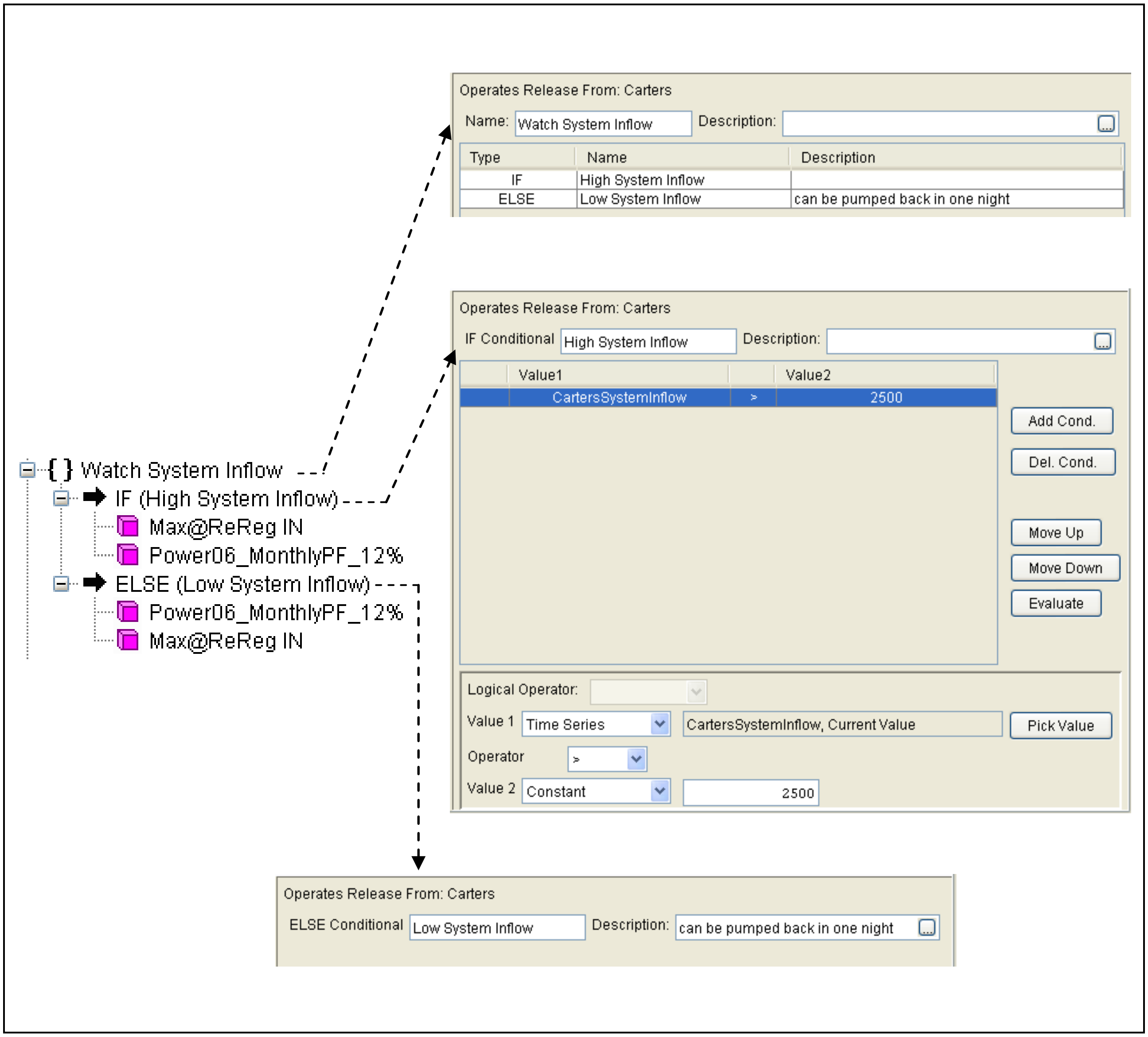


Figure A.21 GC Buffer (within the Lower Flood Pool) – Watch System Inflow

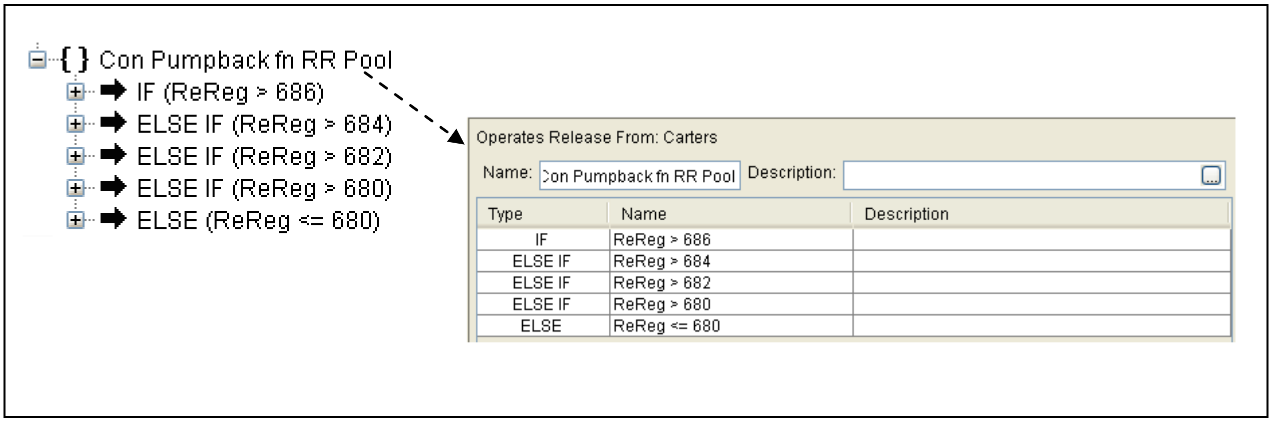


Figure A.22 Conservation Pumpback – “Conditional Blocks” Function of ReReg Pool Elevation

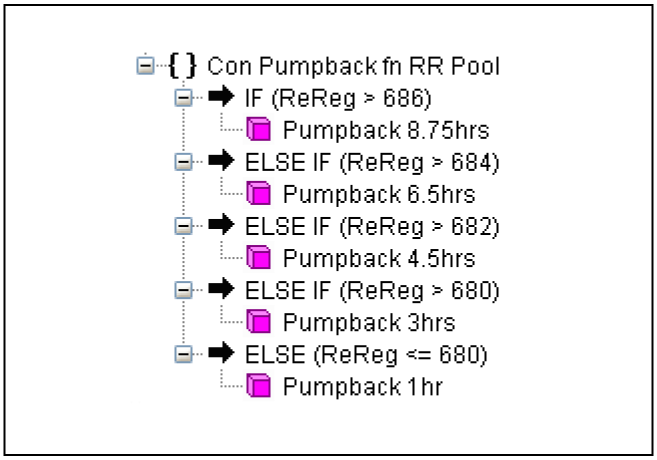


Figure A.23 Conservation Pumpback – “IF-Blocks” and “Rules”

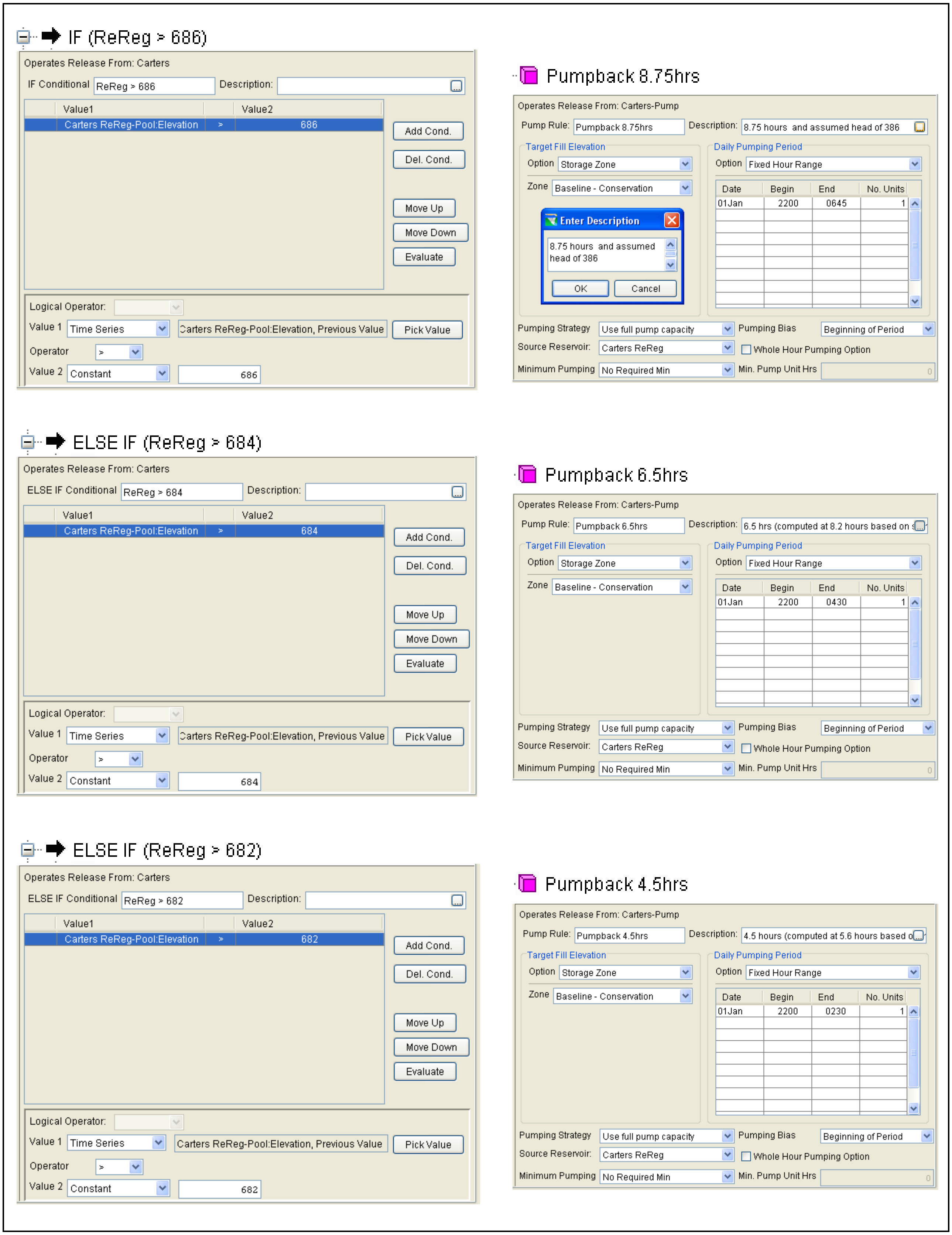


Figure A.24 Conservation Pumpback – Pump Rules Based on Talking Rock Creek Flow ***(Part 1 of 2)***

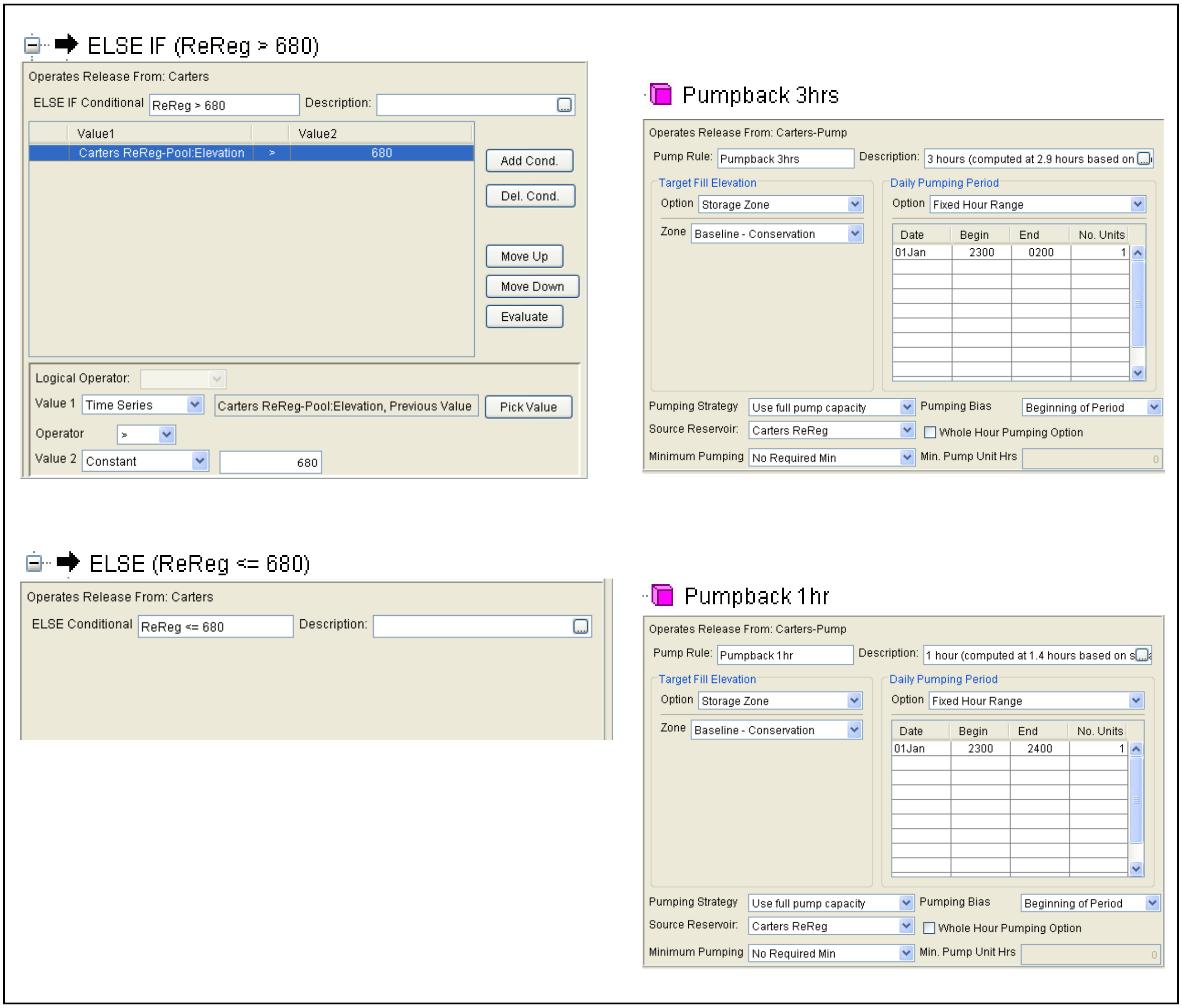


Figure A.25 Conservation Pumpback – Pump Rules Based on Talking Rock Creek Flow ***(Part 2 of 2)***

2. Rule Descriptions

a) InducedSurch_EmergReg

This rule (see Figure A.15) represents an induced surcharge operation for flood control. Induced surcharge operation is achieved by physically regulating the position of spillway gates. When the gate opening is reduced to limit release to less than free overflow (the fully-open position), water is intentionally surcharged behind the gates. Induced surcharge operation guidelines are derived from an envelope curve, which represents the relationship between a maximum allowable pool elevation and minimum required release for extreme flood events. For smaller flood inflows, the relationship between pool elevation and minimum required release can be derived using the surcharge envelope and a time of recession constant. A family of curves can be developed to cover the pool elevation vs. minimum release relationships for many different inflow values.

An induced surcharge rule in ResSim can be defined using a function or a family of curves. Since the induced surcharge rule at Carters is defined as a family of curves, the rule data reflects the surcharge envelope, as well as the pool elevation vs. minimum release relationships for a number of different inflows.

The induced surcharge rule also includes falling pool options, which indicate how to apply the induced surcharge operation when the pool is falling and when to transition out of induced surcharge operation. The **Time for Pool Decrease** (24 hours for Carters) is the required number of successive hours the reservoir pool level must be falling before transitioning from rising pool emergency spillway releases to falling pool releases. The **Falling Pool Transition Elev** (1099 ft for Carters) is the pool elevation below which the induced surcharge rule will no longer operate. The **Release Options** are to designate the method for computing falling pool releases. For Carters, the option of **Maintain Peak Release** is selected.

b) Max@ReReg IN

This rule (see Figure A.16) limits the inflow into Carters ReReg by setting seasonal maximum flow values into the downstream inflow junction of the Reregulation pool. These values can be exceeded by the induced surcharge function. The limit type is set to maximum and is interpolated as a step function. From April through October, the maximum flow limit is 3200 cfs while the remainder of the year the maximum flow limit is 5000 cfs.

c) *Power06_MonthlyPF_12%*

This rule (see Figure A.16) requires generation equivalent to about 3 hours per day on weekdays. It does this by specifying a monthly 12% plant factor and with a generation requirement pattern each hour of the day on weekdays (Monday through Friday) with no requirement for Saturday and Sunday.

d) *FC Pumpback fn TRC*

This conditional IF-Block structure (see Figure A.17 through Figure A.20) allows for specifying a relationship between the flow coming in from Talking Rock Creek and the number of hours to pump back water to Carters. Talking Rock Creek connects just downstream of the outlet at Carters. This pumpback function uses the flow at Talking Rock Creek to determine the number of hours of pumping that will occur each day. When Talking Rock Creek's flow is greater than 3000 cfs, the pump is operated at full capacity for 5 hrs. The amount of time the pump is operated becomes smaller as the flow in Talking Rock Creek decreases. At each increment of the conditional block, the target fill elevation to pump to is set to 1090 ft (which is nine feet below the top of the flood control pool). Since this pumping operation is considered for high flow conditions, this rule set is placed in the two lower flood control zones. Note that when the flow at Talking Rock Creek is below 500 cfs, then water is not pumped back into Carters Reservoir. Table A.03 summarizes the relationship between Talking Rock Creek flow and Carters pumping operations for high flow conditions.

Table A.03 Relationship Between Talking Rock Creek Flow and Carters Pumpback Hours in Flood Control Pool

Statement		Operation Time
IF	TRC > 3000	5.0 hrs
ELSE IF	TRC > 2500	4.25 hrs
ELSE IF	TRC > 2000	3.5 hrs
ELSE IF	TRC > 1500	2.75 hrs
ELSE IF	TRC > 1000	2.0 hrs
ELSE IF	TRC >= 500	1.5 hrs

e) Watch System Inflow:

Within a lower flood control zone named GC Buffer, this series of if-statements (see Figure A.21) looks at the inflow to Carters system. If the system inflow is high (> 2500 cfs), then the downstream control function rule for limiting the inflow into Carters ReReg has priority over the power generation requirement at Carters. If the inflow to Carters system is low, then the power generation requirement at Carters has a higher priority than the downstream control function rule for Carters Rereg. The Carters system inflow is computed using a state variable (CartersSystemInflow). The state variable sums the 4-day average of both the inflow into Carters and the Talking Rock flow. The 4-day average consists of the flows from the previous day, the flows from the current day, and the flows for the 2 days into the future.

f) Con Pumpback fn RR Pool

This conditional logic (see Figure A.22 through Figure A.25) is a function of the pool elevation at Carters ReReg and uses logical statements based on the ReReg's pool elevation to determine the appropriate pumping values. If the pool elevation is greater than 686 feet then the pump will operate at full capacity for 8.75 hours at night to pump water back into Carters Reservoir. When the ReReg's pool elevation is less than (or equal to) 680 feet, only 1 hour of pumping will occur. The relationship between pumping duration and the ReReg elevation is summarized in Table A.04.

Table A.04 Relationship of Carters ReReg Pool Elevation to Conservation Pumpback Operation at Carters

Statement		Operation Time
IF	ReReg > 686	8.75 hrs
ELSE IF	ReReg > 684	6.5 hrs
ELSE IF	ReReg > 682	4.5 hrs
ELSE IF	ReReg > 680	3.0 hrs
ELSE	ReReg <= 680	1.0 hrs

At each increment of the conditional block, the target fill elevation to pump to is set to the Top of the Conservation zone. Since this pumping operation is considered for normal and low flow conditions, this rule set is placed within the Conservation zone.

C. Carters ReReg -- Baseline Rules

Figure A.26 shows a set of operational rules specified for each zone that reflects the operation set named “Baseline” for Carters ReReg.

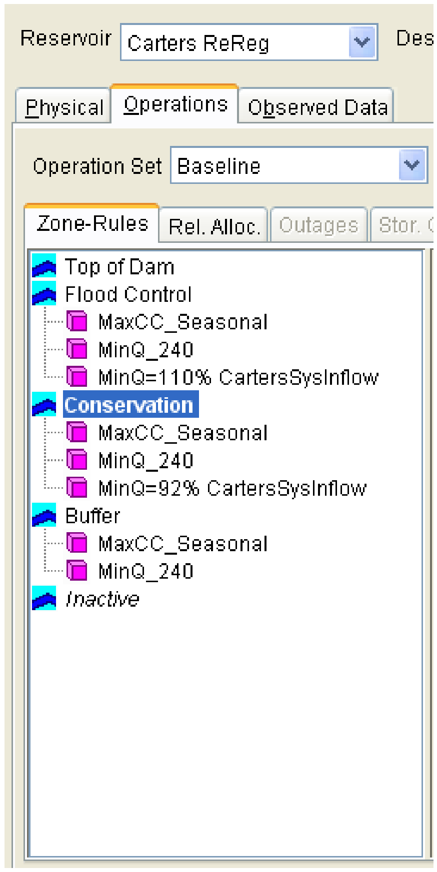


Figure A.26 Carters ReReg Reservoir Editor: Operations Tab – Baseline OpSet – Zones and Rules

1. Rule Illustrations

The content for each of these rules in the ResSim model are shown in Figure A.27. The logic and purpose for each operational rule is described below and in the Section C.2 (which follows Figure A.27).

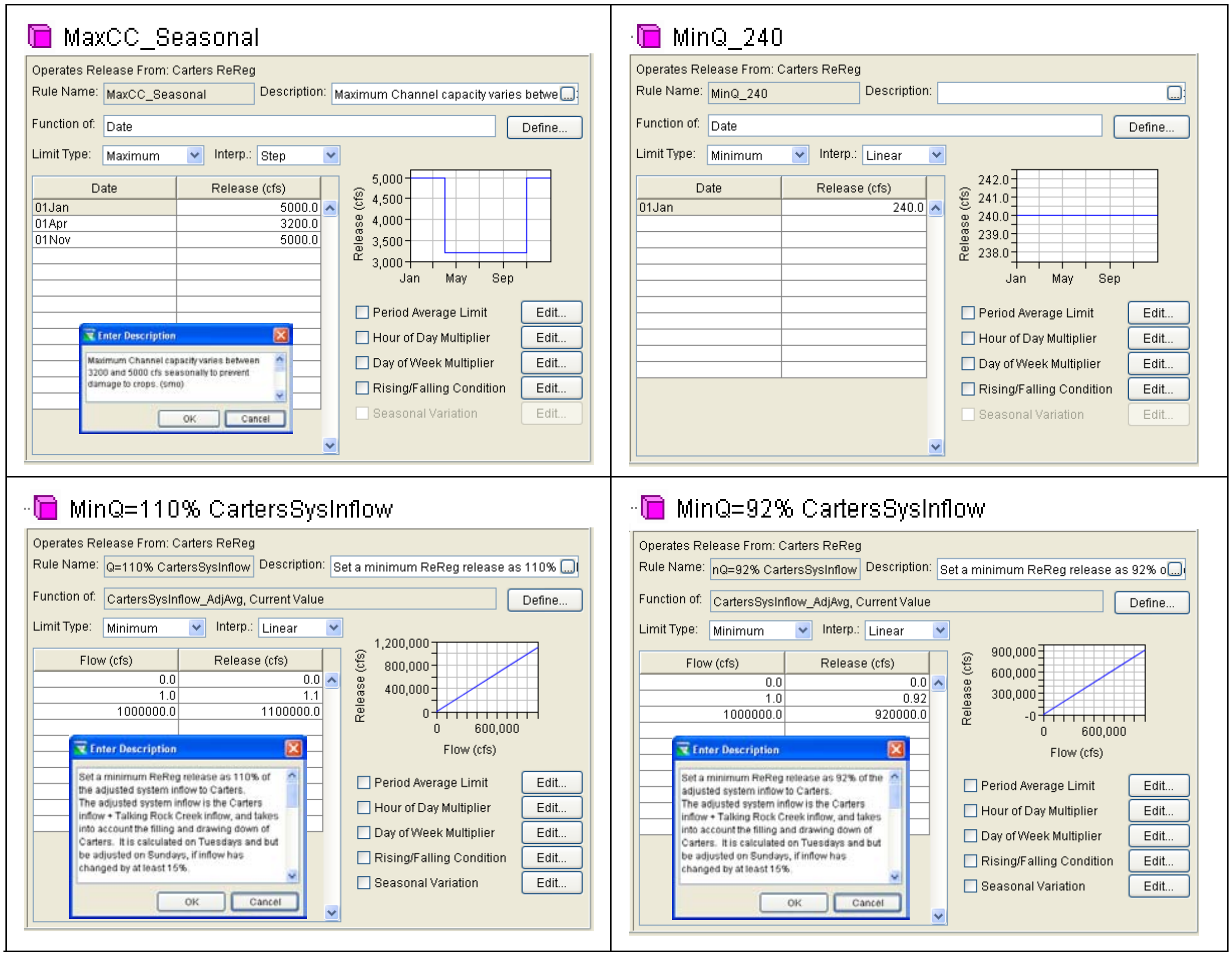


Figure A.27 Carters ReReg Reservoir Editor: Operations Tab – Baseline OpSet – Maximum and Minimum Rules

2. Rule Descriptions

a) MaxCC_Seasonal

To prevent damage to crops, this rule (see Figure A.27) limits the release from Carters ReReg by setting seasonal maximum flow values. The limit type is set to maximum and is interpolated as a step function. From April through October, the maximum flow limit is 3200 cfs while the remainder of the year the maximum flow limit is 5000 cfs.

b) MinQ_240

This rule (see Figure A.27) sets the minimum release from Carters ReReg to 240 cfs. The limit type is set to minimum and the constant flow value applies for the entire year.

c) MinQ=110% CartersSysInflow

This rule (see Figure A.27) is placed in the Flood Control zone and sets a minimum release from Carters ReReg to be 110% of the adjusted system inflow to Carters. The Carters adjusted system inflow is computed using a state variable (CartersSysInflow_AdjAvg). The adjusted system inflow is the Carters inflow + Talking Rock Creek inflow, and takes into account the filling and drawing down of Carters Reservoir. It is calculated on Mondays but can be adjusted on Thursdays if inflow has changed by at least 15%.

d) MinQ=92% CartersSysInflow

This rule (see Figure A.27) is placed in the Conservation zone and sets a minimum release from Carters ReReg to be 92% of the adjusted system inflow to Carters. The Carters adjusted system inflow is computed using a state variable (CartersSysInflow_AdjAvg). The adjusted system inflow is the Carters inflow + Talking Rock Creek inflow, and takes into account the filling and drawing down of Carters Reservoir. It is calculated on Mondays but can be adjusted on Thursdays if inflow has changed by at least 15%.

Alabama-Coosa-Tallapoosa (ACT) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update

[Baseline]

Appendix B – Allatoona Reservoir

March 2011 (DRAFT)

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Appendix B – Allatoona [Baseline] (DRAFT)

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Allatoona Reservoir

I. Overview

Allatoona Dam is operated by the Mobile District of the Corps of Engineers. It is located in Georgia about 32 miles northwest of Atlanta, GA along the Etowah River. It is a multiple purpose project with principal purposes of flood control, hydropower, navigation, water quality, water supply, fish and wildlife enhancement and recreation. The drainage area is 1,110 square miles. The dam is made of concrete and is 1250 ft long. The top of the dam is at an elevation of 880 ft. The pool lies within Bartow, Cobb and Cherokee counties. Its major flood protection area is Rome, Georgia, about 48 river miles downstream.

The dam has 3 outlets which are the spillway, the flood control sluice, and the power plant. The spillway consists of 11 gates with 9 gates being 40’ wide by 26’ high and 2 gates being 20’ wide by 26’ high. The crest of the spillway is at elevation 835 ft. The flood control sluice consists of 4 sluices that are 5’8”x10’0”. The power plant has a designed dependable capacity of 73 MW.

Figure B.01 shows the location of Allatoona Reservoir as it is represented in the HEC-ResSim model.

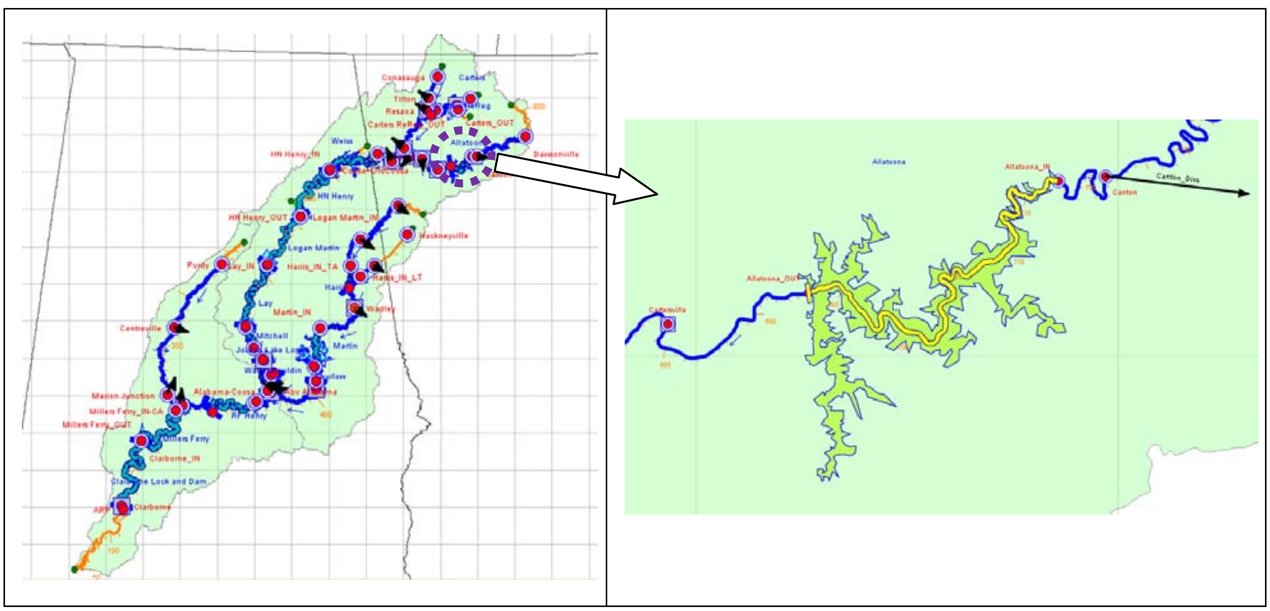


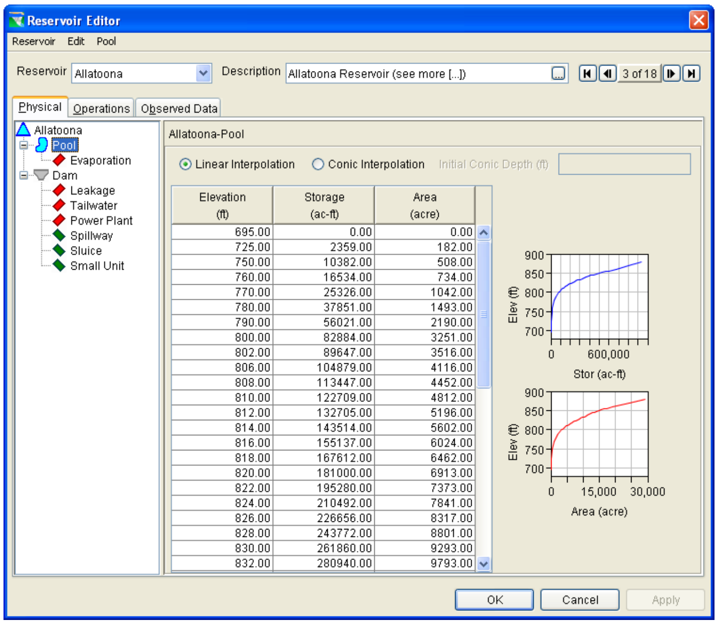
Figure B.01 HEC-ResSim Map Display Showing Location of Allatoona Reservoir

Figure B.02 shows a photo of Allatoona Dam.

Figure B.02 Photo of Allatoona Dam

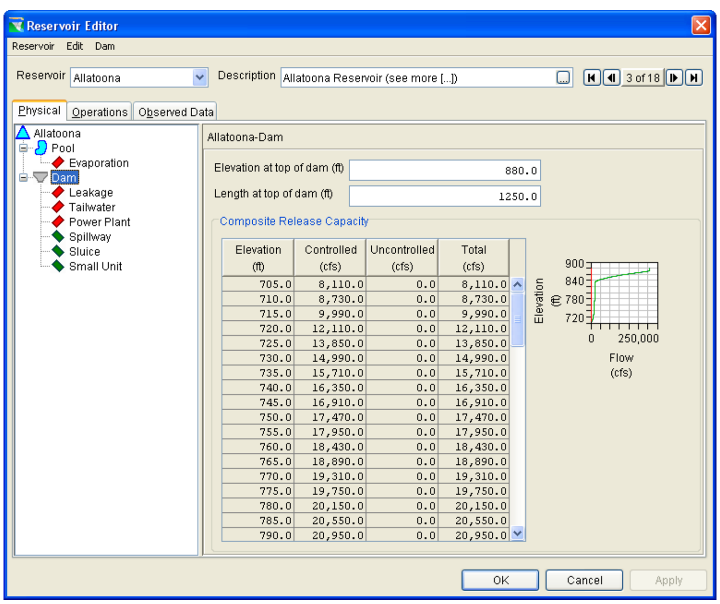
II. Physical Characteristics

The physical characteristics of each reservoir are separated between the "Pool" and the "Dam" in the ResSim model. The "elevation-storage-area" defines the pool as shown for Allatoona Reservoir in Figure B.03. Allatoona Dam consists of four types of outlets: (1) a gated spillway; (2) a sluice; (3) a small unit; and, (4) a power plant. Each of these outlets is defined in the model, and the Dam reflects the composite release capacity of all of the outlets as shown in Figure B.04.



Elevation (ft)	Storage (ac-ft)	Area (acre)
695.00	0.00	0.00
725.00	2359.00	182.00
750.00	10382.00	508.00
760.00	16534.00	734.00
770.00	25326.00	1042.00
780.00	37851.00	1493.00
790.00	56021.00	2190.00
800.00	82884.00	3251.00
802.00	89647.00	3516.00
806.00	104879.00	4116.00
808.00	113447.00	4452.00
810.00	122709.00	4812.00
812.00	132705.00	5196.00
814.00	143514.00	5602.00
816.00	155137.00	6024.00
818.00	167612.00	6462.00
820.00	181000.00	6913.00
822.00	195280.00	7373.00
824.00	210492.00	7841.00
826.00	226656.00	8317.00
828.00	243772.00	8801.00
830.00	261860.00	9293.00
832.00	280940.00	9793.00

Figure B.03 2009 Network…Reservoir Editor: Allatoona Physical Tab – Pool



Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
705.0	8,110.0	0.0	8,110.0
710.0	8,730.0	0.0	8,730.0
715.0	9,990.0	0.0	9,990.0
720.0	12,110.0	0.0	12,110.0
725.0	13,850.0	0.0	13,850.0
730.0	14,990.0	0.0	14,990.0
735.0	15,710.0	0.0	15,710.0
740.0	16,350.0	0.0	16,350.0
745.0	16,910.0	0.0	16,910.0
750.0	17,470.0	0.0	17,470.0
755.0	17,950.0	0.0	17,950.0
760.0	18,430.0	0.0	18,430.0
765.0	18,890.0	0.0	18,890.0
770.0	19,310.0	0.0	19,310.0
775.0	19,750.0	0.0	19,750.0
780.0	20,150.0	0.0	20,150.0
785.0	20,550.0	0.0	20,550.0
790.0	20,950.0	0.0	20,950.0

Figure B.04 2009 Network…Reservoir Editor: Allatoona Physical Tab –Dam

III. Baseline Operations

A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table B.01 shows the definition of Allatoona's "Baseline" operational zones, which consist of zones of flood control and conservation.

Table B.01 Zone Elevations for "Baseline" Operation Set

Allatoona	Baseline Top of Zone Elevation Values (feet)							
Seasons =	1-Jan	15-Jan	1-May	30-Jun	1-Oct	15-Dec	16-Dec	31-Dec
Zones:								
Top of Dam	880	880	880	880	880	880	880	880
Top of Surcharge	865	865	865	865	865	865	865	865
Flood Control	860	860	860	860	860	860	860	860
Conservation	823	823	840	840	840	linear	823	823
Zone 2	820	820	836	836	linear	820	820	820
Inactive	800	800	800	800	800	800	800	800

The top of two of the zones ("Conservation" and "Zone 2") vary seasonally. The top of the Conservation zone has been set to be the operational Guide Curve for Baseline operations (as shown in Figure B.05).

Guide Curve definition (top of **Conservation** zone)

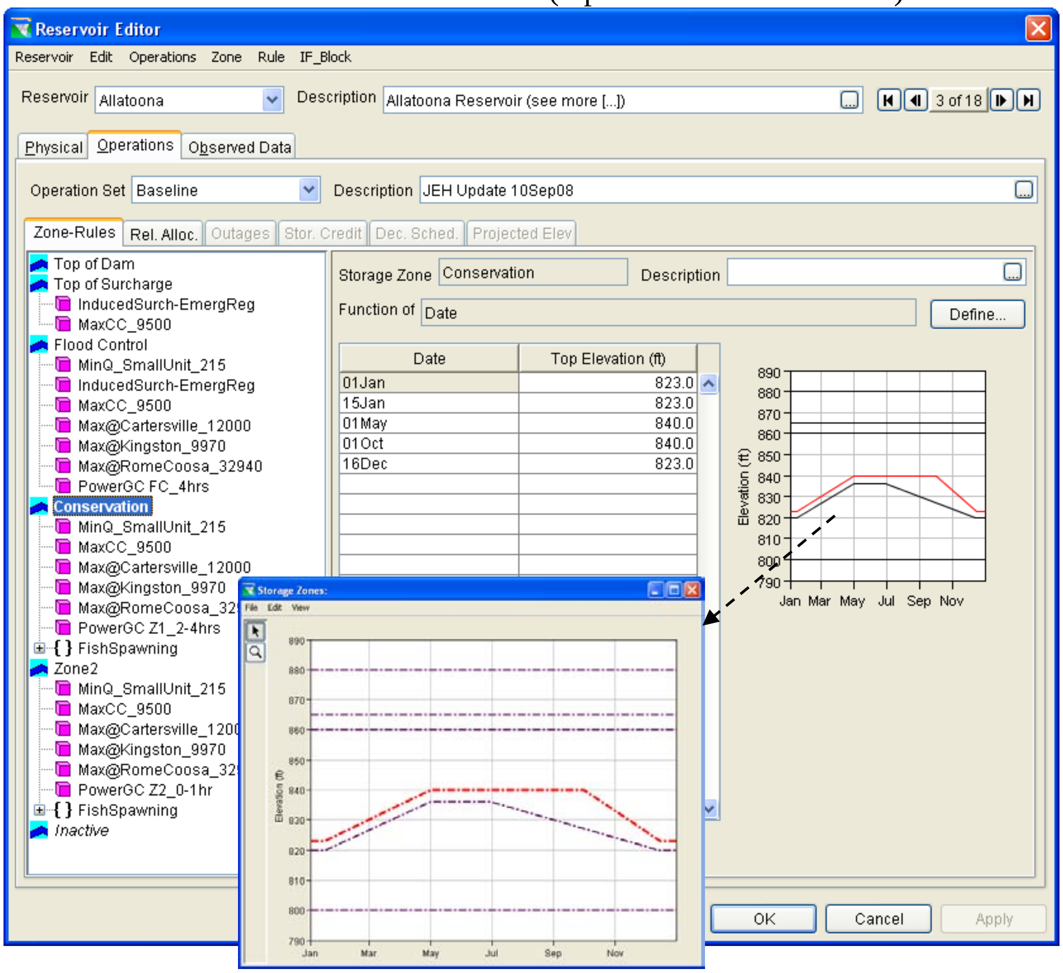


Figure B.05 Reservoir Editor: Operations Tab – Baseline OpSet – Guide Curve

Figure B.06 shows a sequential release allocation approach specified for available outlets along Allatoona Dam. The available outlets are given an order of priority for release. The small unit gets the release first until it reaches release capacity. The power plant gets the remainder of the release until it reaches capacity. After the capacity through the powerhouse is reached, the remainder of the release goes through the spillway and then the sluice.

Release Allocation:

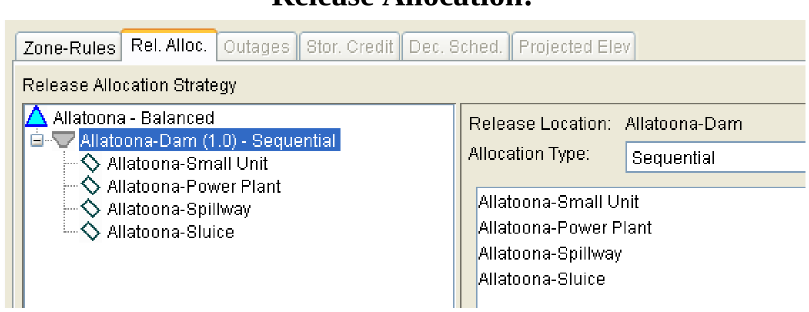


Figure B.06 Reservoir Editor: Operations Tab – Baseline OpSet – Release Allocation

B. Rule Illustrations

Figure B.07 shows a set of operational rules specified for each zone that reflects the operation set named "Baseline".

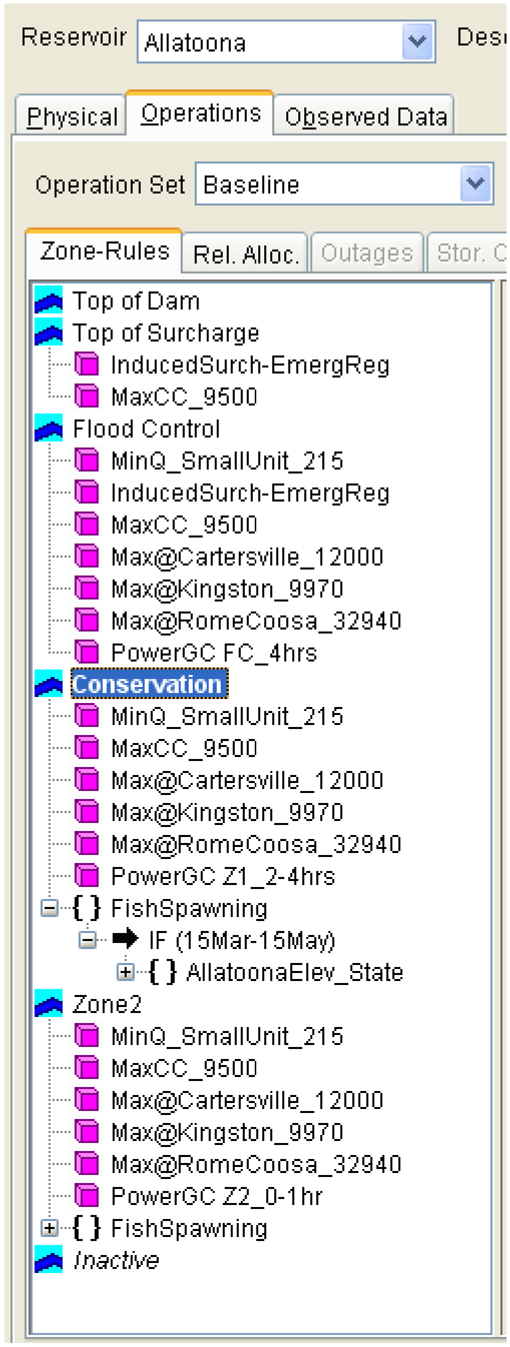


Figure B.07 Reservoir Editor: Operations Tab – Baseline OpSet – Zones and Rules

The content for each of these rules in the ResSim model are shown in Figure B.08 through Figure B.14. The logic and purpose for each operational rule is described in Section C.

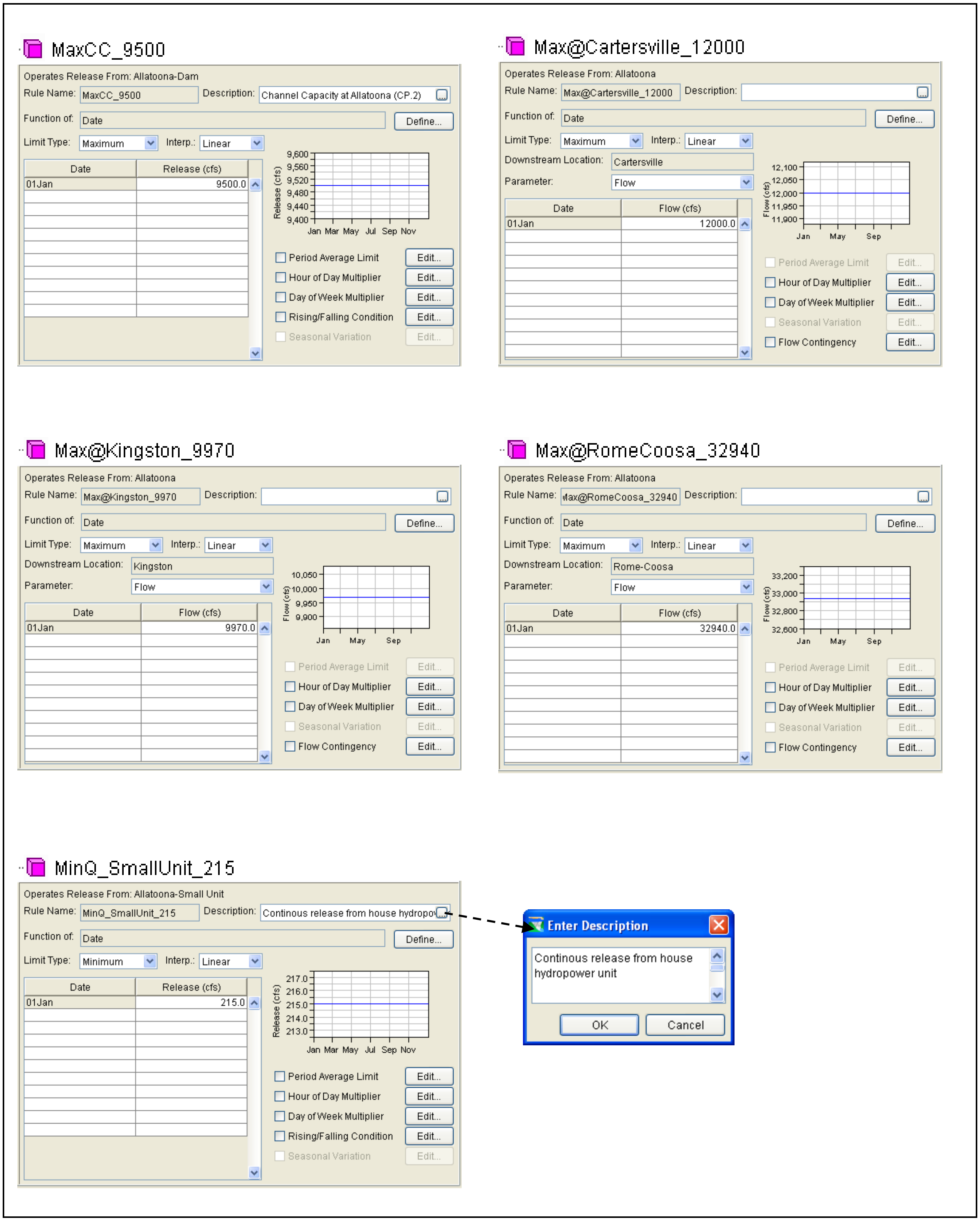


Figure B.08 Reservoir Editor: Operations Tab – Baseline OpSet – Maximum and Minimum Rules

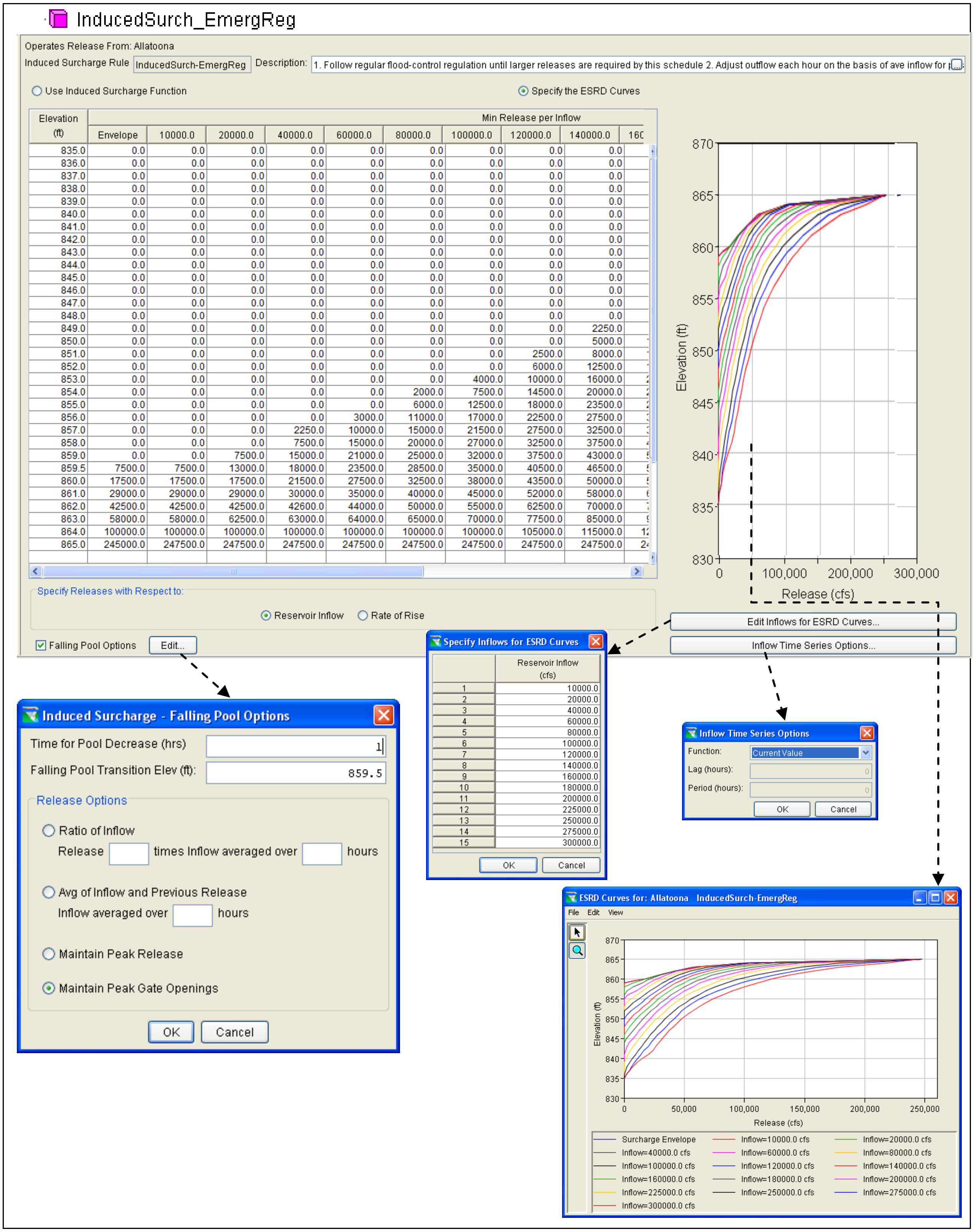


Figure B.09 Reservoir Editor: Operations Tab – Baseline OpSet – Induced Surcharge Rule

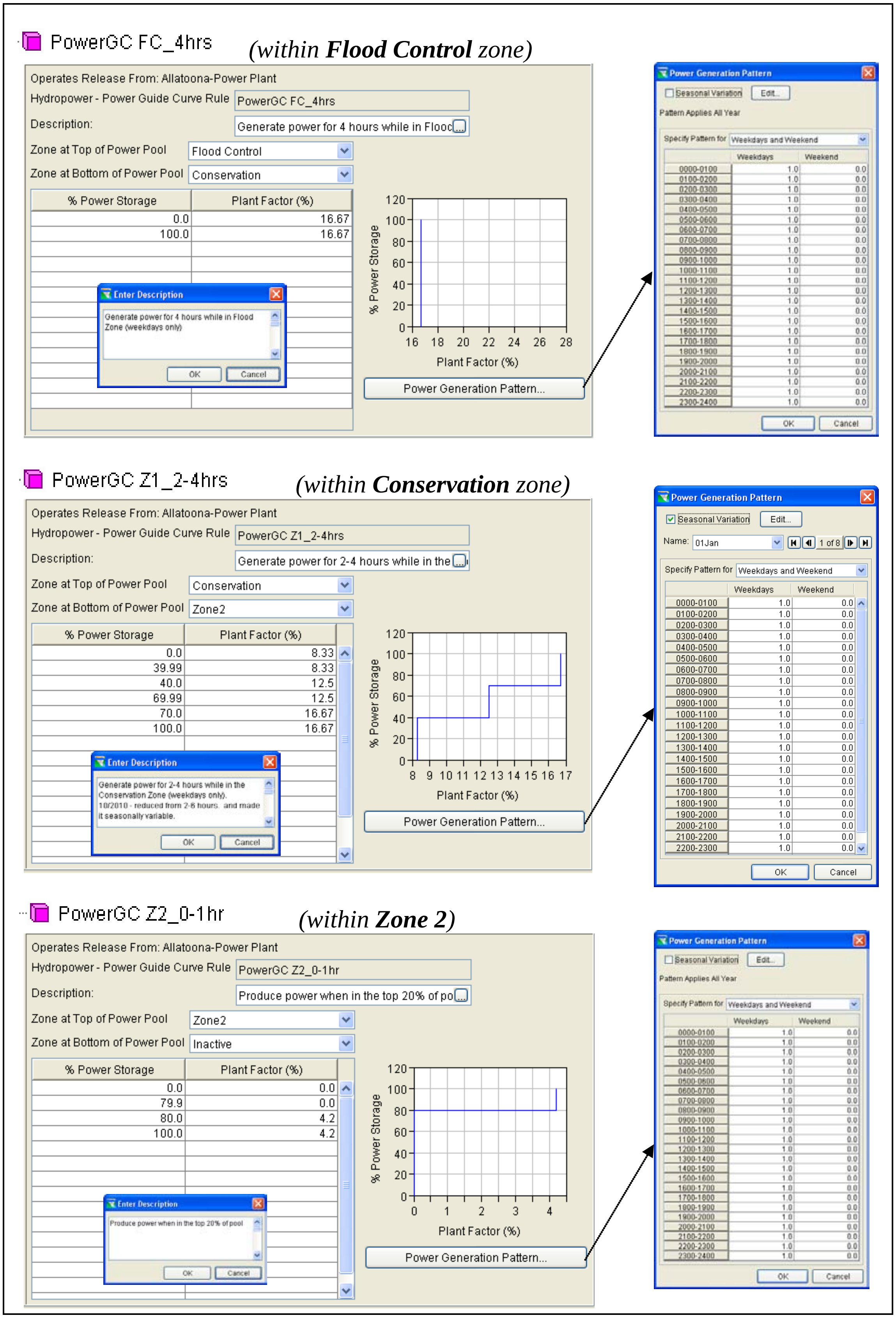


Figure B.10 Reservoir Editor: Operations Tab – Baseline OpSet – Hydropower Rules

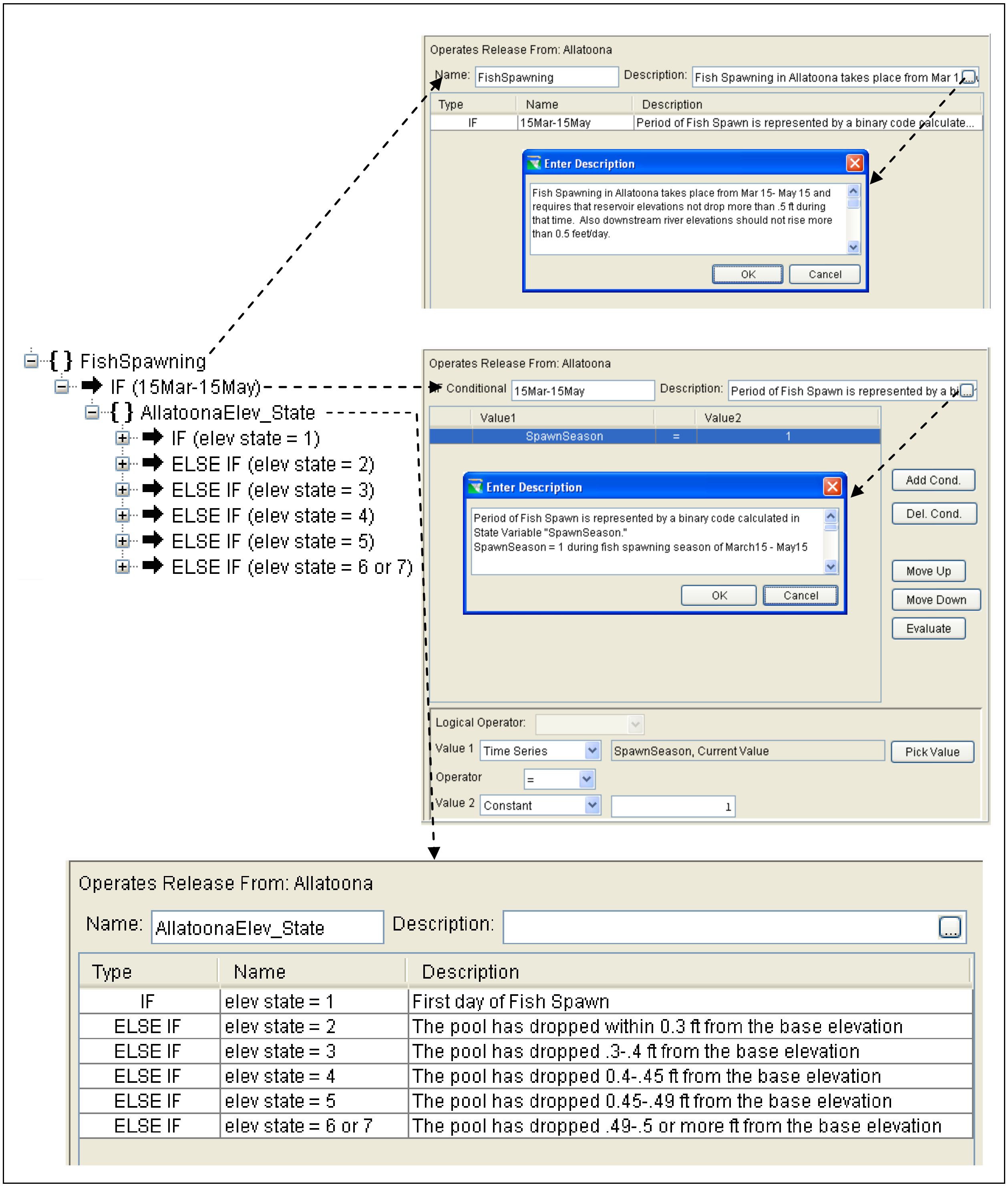


Figure B.11 Fish Spawning – "Conditional Blocks"

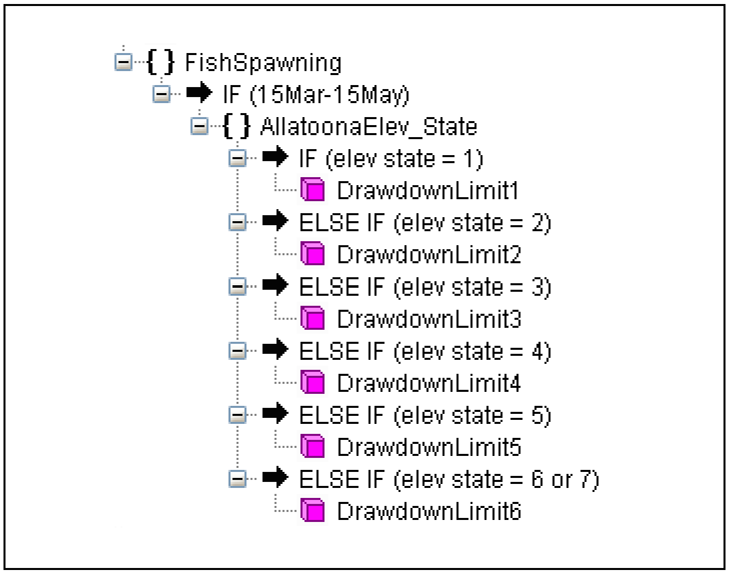


Figure B.12 Fish Spawning – “IF-Blocks” and “Rules”

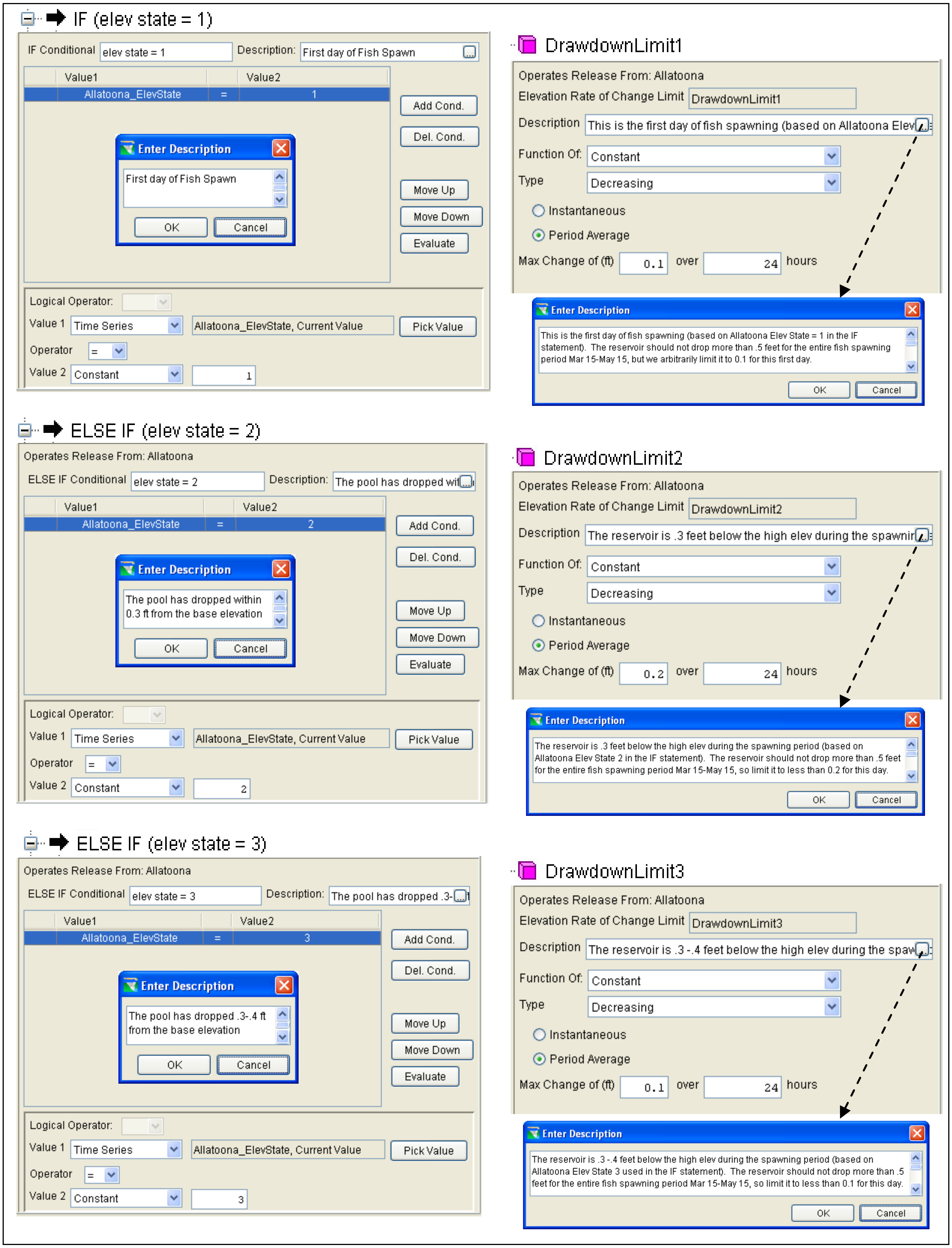


Figure B.13 Fish Spawning – Rules for "Allatoona_ElevState" Values (Part 1 of 2)

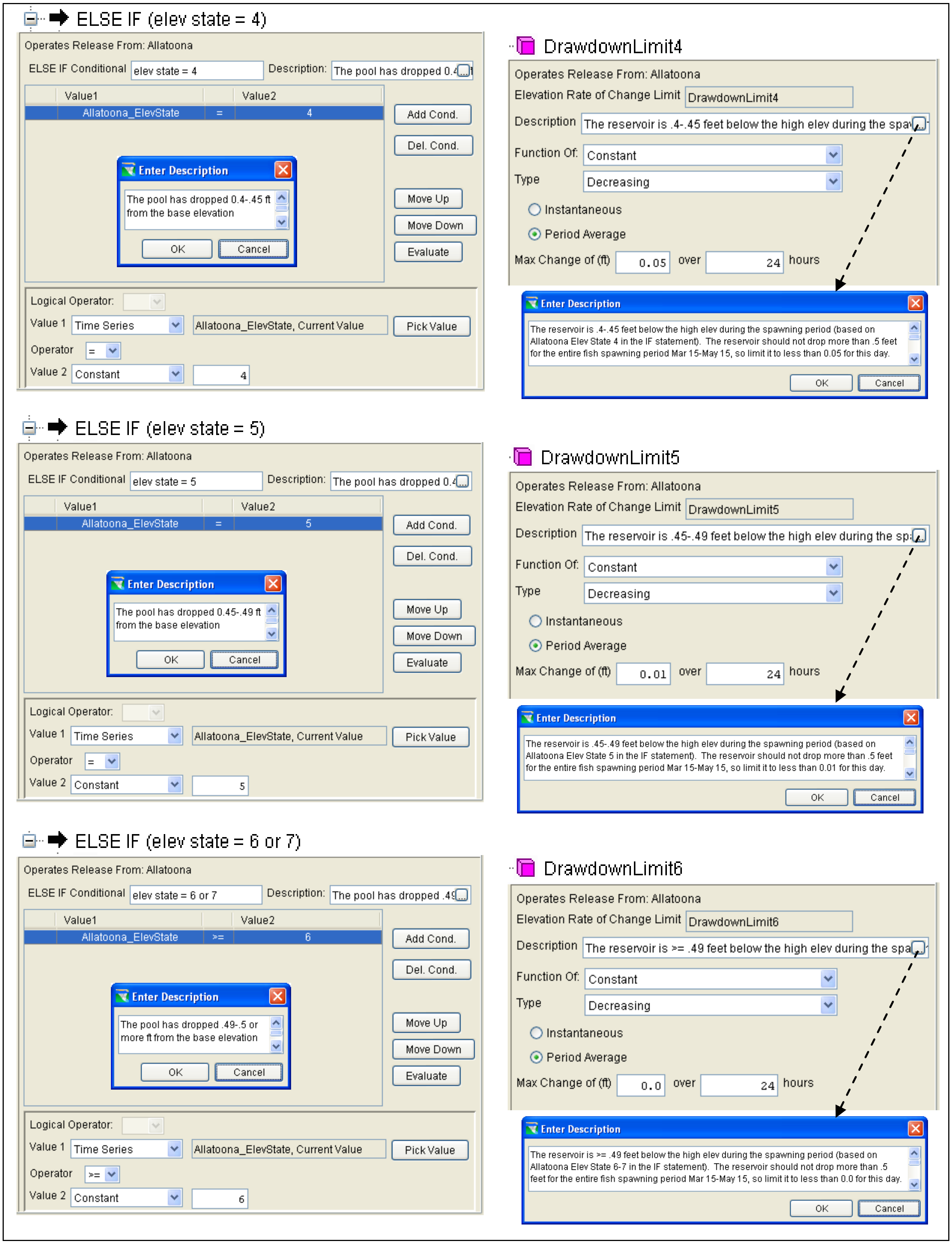


Figure B.14 Fish Spawning – Rules for "Allatoona_ElevState" Values (Part 2 of 2)

C. Rule Descriptions

1. MaxCC_9500

This rule (see Figure B.08) sets the maximum release from the dam based on the channel capacity at Allatoona. This maximum release is set to a constant of 9,500 cfs. This amount can be exceeded both in the Top of Surcharge zone and the Flood Control zone by the higher priority induced surcharge function.

2. Max@Cartersville_12000

This rule (see Figure B.08) is a downstream control function which sets the maximum flow at Cartersville to a constant 12,000 cfs. Cartersville is the junction downstream of Allatoona. Flows at this location can exceed 12,000 cfs based on intervening uncontrolled cumulative local inflows or through the higher priority induced surcharge function in the Flood Control zone.

3. Max@Kingston_9970

This rule (see Figure B.08) is a downstream control function which sets the maximum flow at Kingston to a constant 9,970 cfs. Kingston is the junction downstream of Cartersville. Flows at this location can exceed 9,970 cfs based on intervening uncontrolled cumulative local inflows or through the higher priority induced surcharge function in the Flood Control zone.

4. Max@RomeCoosa_32940

This rule (see Figure B.08) is a downstream control function which sets the maximum flow at RomeCoosa to a constant 32,940 cfs. RomeCoosa is located downstream of the confluence of the Etowah and Oostanaula Rivers. Flows at this location can exceed 32,940 cfs based on intervening uncontrolled cumulative local inflows or through the higher priority induced surcharge function in the Flood Control zone.

ResSim will determine the maximum release at each time step by using the lowest maximum value computed from the four rules above.

5. MinQ_SmallUnit_215

This rule (see Figure B.08) is a minimum release rule that is applied to the small unit outlet. The minimum release is set at a constant 215 cfs. This unit is used to provide the power for the dam and is also known as a house unit. This unit needs to be running at all times so its priority is set higher than the maximum release rules. This ensures that this release will still be made even when downstream regulating stages are exceeded.

6. InducedSurch_EmergReg

This rule (see Figure B.09) represents an induced surcharge operation for flood control. Induced surcharge operation is achieved by physically regulating the position of spillway gates. When the gate opening is reduced to limit release to less than free overflow (the fully-open position), water is intentionally surcharged behind the gates. Induced surcharge operation guidelines are derived from an envelope curve, which represents the relationship between a maximum allowable pool elevation and minimum required release for extreme flood events. For smaller flood inflows, the relationship between pool elevation and minimum required release can be derived using the surcharge envelope and a time of recession constant. A family of curves can be developed to cover the pool elevation vs. minimum release relationships for many different inflow values.

An induced surcharge rule in ResSim can be defined using a function or a family of curves. Since the induced surcharge rule at Allatoona is defined as a family of curves, the rule data reflects the surcharge envelope, as well as the pool elevation vs. minimum release relationships for a number of different inflows.

The induced surcharge rule also includes falling pool options, which indicate how to apply the induced surcharge operation when the pool is falling and when to transition out of induced surcharge operation. The **Time for Pool Decrease** (1 hour for AllatoonaCarters) is the required number of successive hours the reservoir pool level must be falling before transitioning from rising pool emergency spillway releases to falling pool releases. The **Falling Pool Transition Elev** (859.5 ft for Allatoona) is the pool elevation below which the induced surcharge rule will no longer operate. The **Release Options** are to designate the method for computing falling pool releases. For Allatoona, the option of **Maintain Peak Gate Openings** is selected.

7. PowerGC FC_4hrs

This rule (see Figure B.10) is a required power generation rule in the Flood Control zone. For this rule, the zone for power storage is defined from the top of Flood Control to the top of Conservation. For any value of percent full in this zone, the plant factor is set to 16.67%. The power generation pattern is set to 1 for all hours on weekdays (Monday through Friday) and set to zero for all hours on weekends. The purpose of this rule is to simulate 4 hours (16.67% of 24 hours) of power generation for each weekday with no required generation on the weekend. This generation can be reduced by the maximum release rules since those rules are at a higher priority.

8. PowerGC Z1_2-4hrs

This rule (see Figure B.10) is a required power generation rule in the Conservation zone. For this rule, the zone for power storage is defined from the top of Conservation to the top of Zone 2. The plant factor varies from 8.3% to 16.67% depending on the power storage. When less power storage is available, the plant factor is at 8.3% simulating 2 hours of generation. At the upper end of the percent full of power storage, the plant factor is at 16.67% simulating 4 hours of generation. One intermediate value is set at a plant factor of 12.5% (3 hours generation). The power generation pattern is set to 1 for all hours on weekdays (Monday through Friday) and set to zero for all hours on weekends in the months of January, March, July, August, September, November, and December. Power generation amounts are set to 50% on weekdays in February, 45% on weekdays in April and May, 85% on weekdays in June, and 130% on weekdays in October. This generation can be reduced by the maximum release rules since those rules are at a higher priority.

9. PowerGC Z2_0-1hr

This rule (see Figure B.10) is a required power generation rule in a subzone of the Conservation pool labeled Zone 2. For this rule, the zone for power storage is defined from the top of Zone 2 to the top of the Inactive zone. The plant factor varies from 0% (0 hours of generation) to 4.2% (1 hour of generation). The power generation pattern is again set to require generation only on the weekdays. This generation can be reduced by the maximum release rules since those rules are at a higher priority.

10. Fish Spawning

The IF-Blocks and rules (see Figure B.11 through Figure B.14) that are related to operation requirements for fish spawning represent the standing operating procedure (SOP) for fish management purpose that is described in SAM SOP 1130-2-9, entitled "Project Operations, Reservoir Regulation and Coordination for Fish Management Purposes, Mobile District, Corps of Engineers, Department of the Army, Draft, February 2005". In accordance with the procedures of SAM SOP 1130-2-9, during the spawning period, which is mid-March through mid-May for Lake Allatoona, the Corps shall operate for generally stable or rising reservoir levels. Generally stable or rising levels are defined as not lowering the reservoir levels by more than 6 inches, with the base elevation generally adjusted upward as levels rise due to increased inflows or refilling of the reservoir.

The steps used to implement the fish spawning operational requirements are as follows:

Step 1 – Define a state variable to track the base elevation during the fish spawning period. The base elevation is set at the pool elevation one day prior to the first day of the fish spawning period. During the spawning period, the base elevation is reset only when the pool rises. For details about the state variables, refer to Appendix L.

Step 2 – Define a state variable to track the lake state during the fish spawning period. The lake elevation state on the current day is determined based on the lake elevation drop from the base elevation (calculated as the base elevation minus the pool elevation on the previous day). The lake elevation state is defined as follows:

```
# State variable: Allatoona_ElevState
#  Code =0: Pool is rising
#        =1: The first day of the fish spawning
#        =2: The pool has dropped within 0.3 ft from the base elevation
#        =3: The pool has dropped within 0.3-0.4 ft from the base elevation
#        =4: The pool has dropped within 0.4-0.45 ft from the base elevation
#        =5: The pool has dropped within 0.45-0.49 ft from the base elevation
#        =6: The pool has dropped within 0.49-0.50 ft from the base elevation
#        =7: The pool has dropped more than 0.50 ft from the base elevation
```

The state variable ("Allatoona_ElevState") script for computing the lake level drop from the base elevation and for assigning a corresponding lake state indicator is described in Appendix L.

Step 3 – Define an IF_Block specifically for the fish spawning period and then apply a rule of "Elevation Rate of Change Limit" to the pool for each lake state (Figure B.11 and Figure B.12). To maintain a gradually dropping pool, the following "decreasing" limits of pool elevation changes within 24 hours are applied (Figure B.13 and Figure B.14):

Lake State	Cumulative Drop from Base Elevation (ft)	Limit of Pool Draw-down (ft)
0	n/a (pool is rising)	n/a
1	n/a (first day of fish spawning period)	0.1
2	<=0.3	0.2
3	>0.3 and <=0.4	0.1
4	>0.4 and <=0.45	0.05
5	>0.45 and <=0.49	0.01
6	>0.49 and <=0.50	0
7	>0.50	0

The ***Elevation Rate of Change Limit*** rules used to implement the fish spawning operational requirements are described below:

- ***DrawdownLimit1*** (see Figure B.13): This is the first day of fish spawning (based on Allatoona Elev State = 1 in the IF statement). The reservoir should not drop more than .5 feet for the entire fish spawning period Mar 15-May 15, but we arbitrarily limit it to 0.1 for this first day.
- ***DrawdownLimit2*** (see Figure B.13): The reservoir is .3 feet below the high elev during the spawning period (based on Allatoona Elev State 2 in the IF statement). The reservoir should not drop more than .5 feet for the entire fish spawning period Mar 15-May 15, so limit it to less than 0.2 for this day.
- ***DrawdownLimit3*** (see Figure B.13): The reservoir is .3 -.4 feet below the high elev during the spawning period (based on Allatoona Elev State 3 used in the IF statement). The reservoir should not drop more than .5 feet for the entire fish spawning period Mar 15-May 15, so limit it to less than 0.1 for this day.
- ***DrawdownLimit4*** (see Figure B.14): The reservoir is .4-.45 feet below the high elev during the spawning period (based on Allatoona Elev State 4 in the IF statement). The reservoir should not drop more than .5 feet for the entire fish spawning period Mar 15-May 15, so limit it to less than 0.05 for this day.

- ***DrawdownLimit5*** (see Figure B.14): The reservoir is .45-.49 feet below the high elev during the spawning period (based on Allatoona Elev State 5 in the IF statement). The reservoir should not drop more than .5 feet for the entire fish spawning period Mar 15-May 15, so limit it to less than 0.01 for this day.
- ***DrawdownLimit6*** (see Figure B.14): The reservoir is >= .49 feet below the high elev during the spawning period (based on Allatoona Elev State 6-7 in the IF statement). The reservoir should not drop more than .5 feet for the entire fish spawning period Mar 15-May 15, so limit it to less than 0.0 for this day.

Alabama-Coosa-Tallapoosa (ACT) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update

[Baseline]

Appendix C – Robert F Henry Lock and Dam

March 2011 (DRAFT)

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Appendix C – RF Henry [Baseline] (DRAFT)

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Robert F Henry Lock and Dam

I. Overview

Robert F. Henry Lock and Dam is owned by the Mobile District of the Corps of Engineers. It is located on the Alabama River 245.4 miles upstream of the mouth. Most of the dam and reservoir lies within Autauga County and the rest lies within Lowndes, Montgomery, and Elmore Counties. The operating purposes of the RF Henry Project are navigation and hydropower. There is no flood control storage in this project. Access and facilities are provided for recreation, but water is not normally controlled for that purpose.

The RF Henry project consists of a gravity-type dam with gated spillway supplemented by earth dikes, a navigation lock and control station, and an 82 mW power plant. The spillway has 11 tainter gates 50 ft wide and 35 ft high. It has a crest elevation of 91 feet. The lock chamber is 84 feet wide and 655 feet long.

Figure C.01 shows the location of Robert F Henry Lock and Dam as it is represented in the HEC-ResSim model.

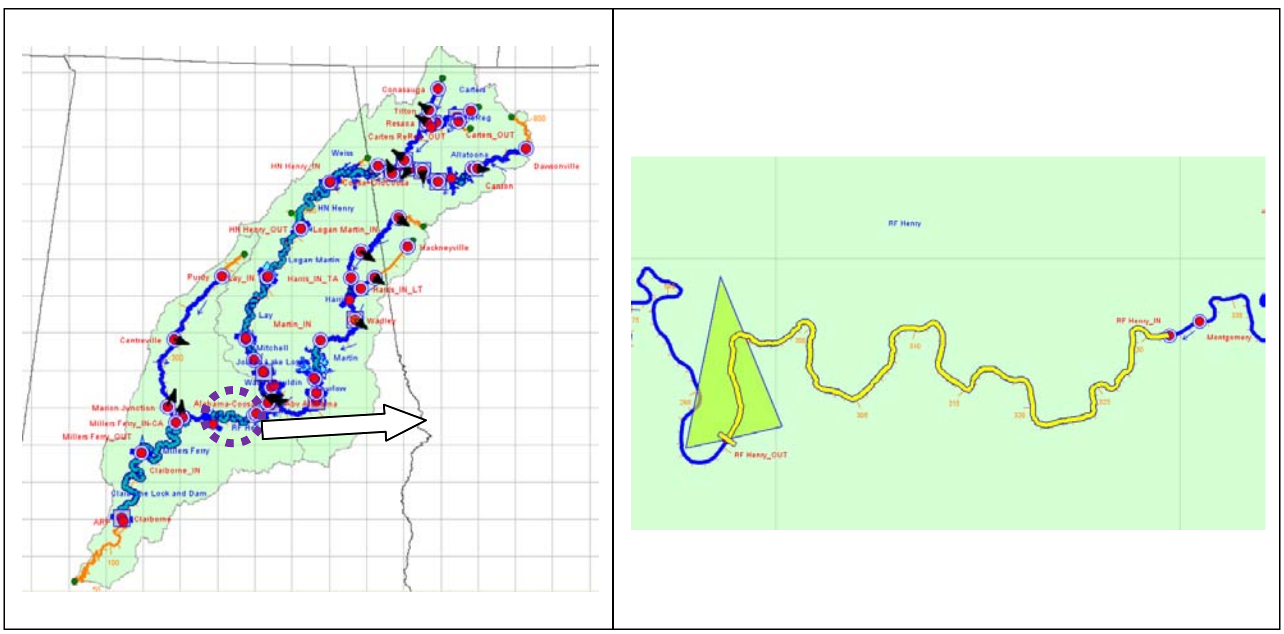


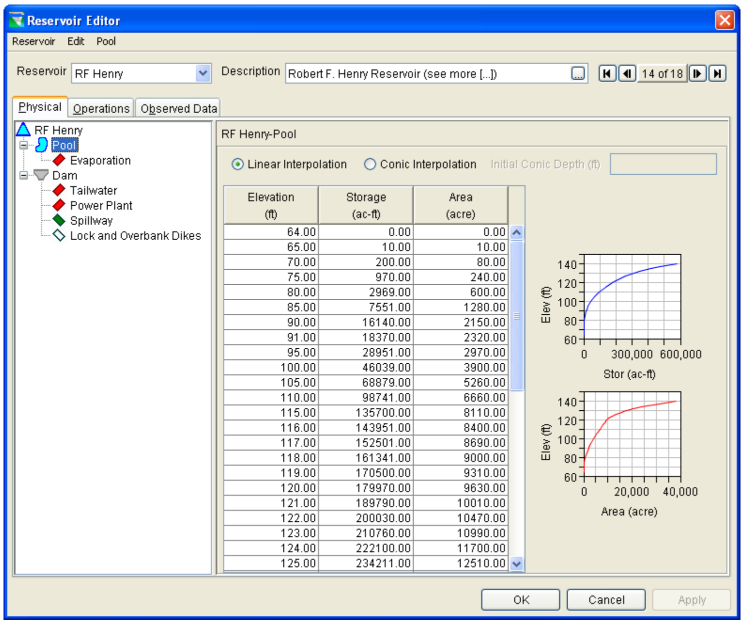
Figure C.01 HEC-ResSim Map Display Showing Location of RF HenryLock and Dam

Figure C.02 shows a photo of Robert F. Henry Lock and Dam.

Figure C.02 Photo of Robert F. Henry Lock and Dam

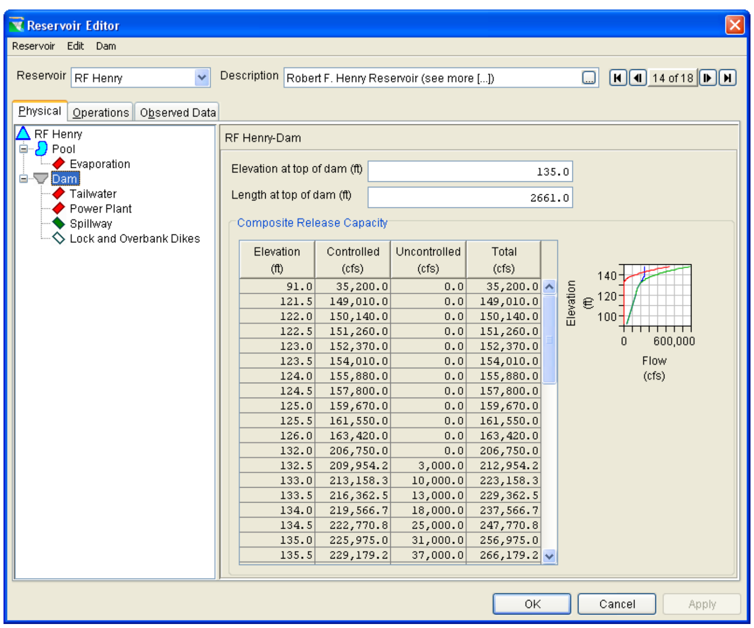
II. Physical Characteristics

The physical characteristics of each reservoir are separated between the "Pool" and the "Dam" in the ResSim model. The "elevation-storage-area" defines the pool as shown for RF Henry Reservoir in Figure C.03. RF Henry Dam consists of three types of outlets: (1) a controlled spillway; (2) an uncontrolled outlet representing the Lock and Overbank Dikes; and, (3) a power plant. Each of these outlets is defined in the model, and the Dam reflects the composite release capacity of all of the outlets as shown in Figure C.04.



Elevation (ft)	Storage (ac-ft)	Area (acre)
64.00	0.00	0.00
65.00	10.00	10.00
70.00	200.00	80.00
75.00	970.00	240.00
80.00	2969.00	600.00
85.00	7551.00	1280.00
90.00	16140.00	2150.00
91.00	18370.00	2320.00
95.00	28951.00	2970.00
100.00	46039.00	3900.00
105.00	68879.00	5260.00
110.00	98741.00	6660.00
115.00	135700.00	8110.00
116.00	143951.00	8400.00
117.00	152501.00	8690.00
118.00	161341.00	9000.00
119.00	170500.00	9310.00
120.00	179970.00	9630.00
121.00	189790.00	10010.00
122.00	200030.00	10470.00
123.00	210760.00	10990.00
124.00	222100.00	11700.00
125.00	234211.00	12510.00

Figure C.03 2009 Network…Reservoir Editor: RF Henry Physical Tab – Pool



Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
91.0	35,200.0	0.0	35,200.0
121.5	149,010.0	0.0	149,010.0
122.0	150,140.0	0.0	150,140.0
122.5	151,260.0	0.0	151,260.0
123.0	152,370.0	0.0	152,370.0
123.5	154,010.0	0.0	154,010.0
124.0	155,880.0	0.0	155,880.0
124.5	157,800.0	0.0	157,800.0
125.0	159,670.0	0.0	159,670.0
125.5	161,550.0	0.0	161,550.0
126.0	163,420.0	0.0	163,420.0
132.0	206,750.0	0.0	206,750.0
132.5	209,954.2	3,000.0	212,954.2
133.0	213,158.3	10,000.0	223,158.3
133.5	216,362.5	13,000.0	229,362.5
134.0	219,566.7	18,000.0	237,566.7
134.5	222,770.8	25,000.0	247,770.8
135.0	225,975.0	31,000.0	256,975.0
135.5	229,179.2	37,000.0	266,179.2

Figure C.04 2009 Network…Reservoir Editor: RF Henry Physical Tab –Dam

III. Baseline Operations

A. Operation Set

The zones for an operation set are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table C.01 shows the definition of RF Henry's "Baseline" operational zones, which consists of zones of flood control and conservation.

Table C.01 Zone Elevations for "Baseline" Operation Set

RF Henry	Baseline Top of Zone Elevation Values (feet)
Seasons =	1Jan - 31Dec
Zones:	
Top of Dam	135
Flood Control	125.1
Conservation	125
Operating Inactive	124
Inactive	122

The top of these operation zones are constant throughout the year, and the top of the Conservation zone has been set to be the Guide Curve (as shown in Figure C.05).

Guide Curve definition (top of **Conservation** zone)

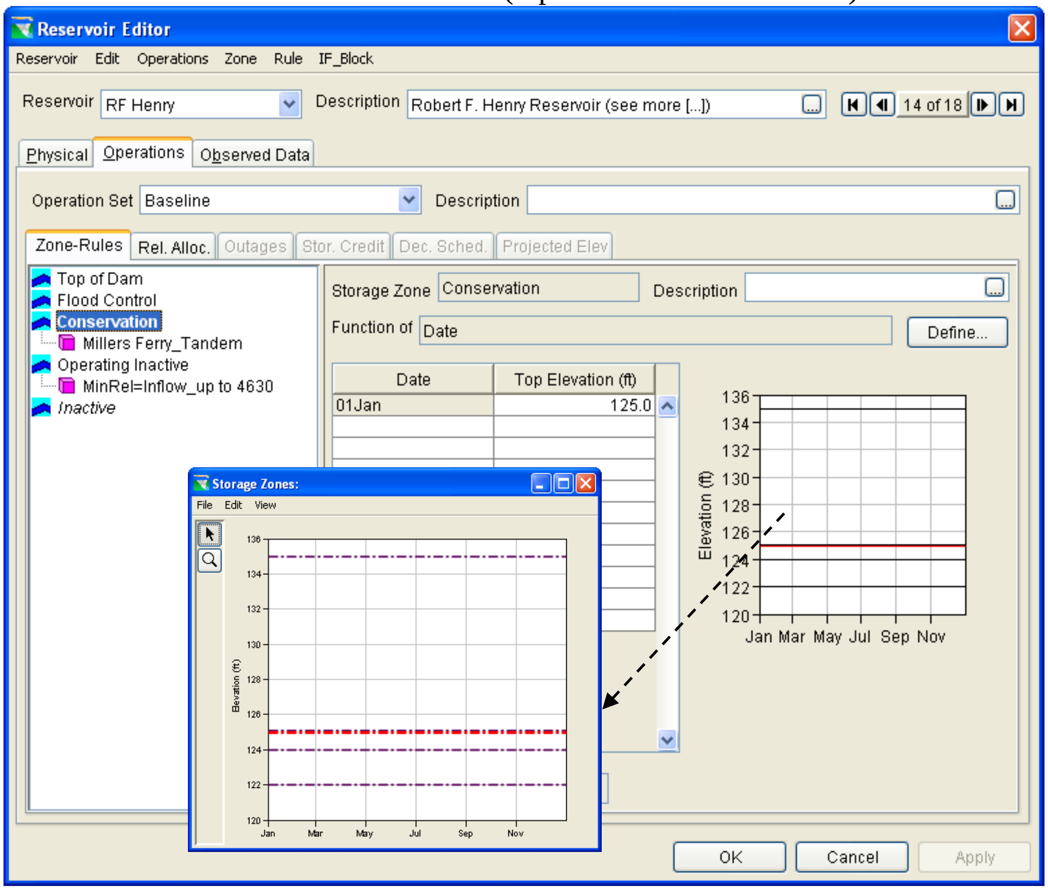


Figure C.05 Reservoir Editor: Operations Tab – Baseline OpSet – Guide Curve

Figure C.06 shows a sequential release allocation approach specified for available outlets along RF Henry Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The controlled spillway gets the remainder of the release until it reaches capacity.

Release Allocation:

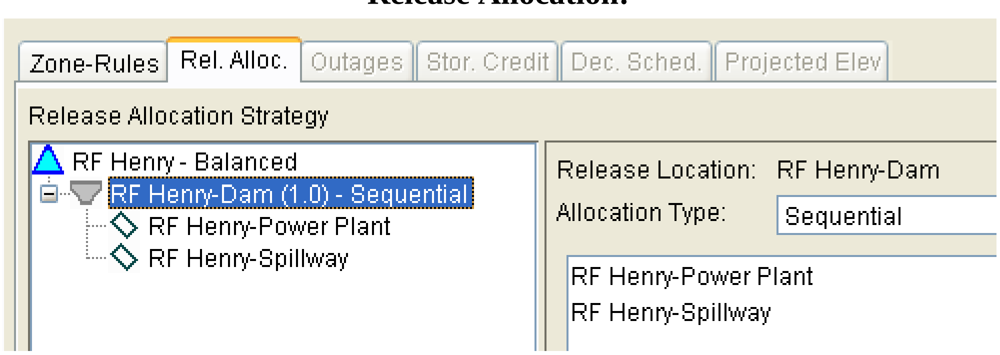


Figure C.06 Reservoir Editor: Operations Tab – Baseline OpSet – Release Allocation

B. Rule Illustrations

Figure C.07 shows the operational rules within the Conservation and Operating Inactive zones that reflects the operation set named "Baseline".

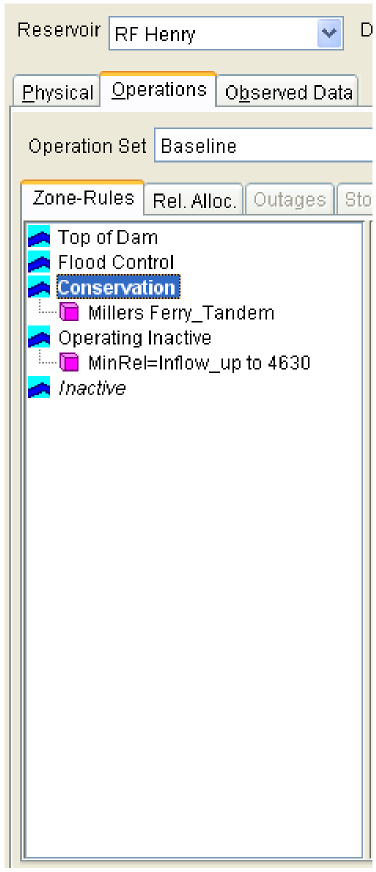


Figure C.07 Reservoir Editor: Operations Tab – Baseline OpSet – Zones and Rule

The content for each of these rules in the ResSim model are shown in Figure C.08. The logic and purpose for each operational rule is described in Section C.

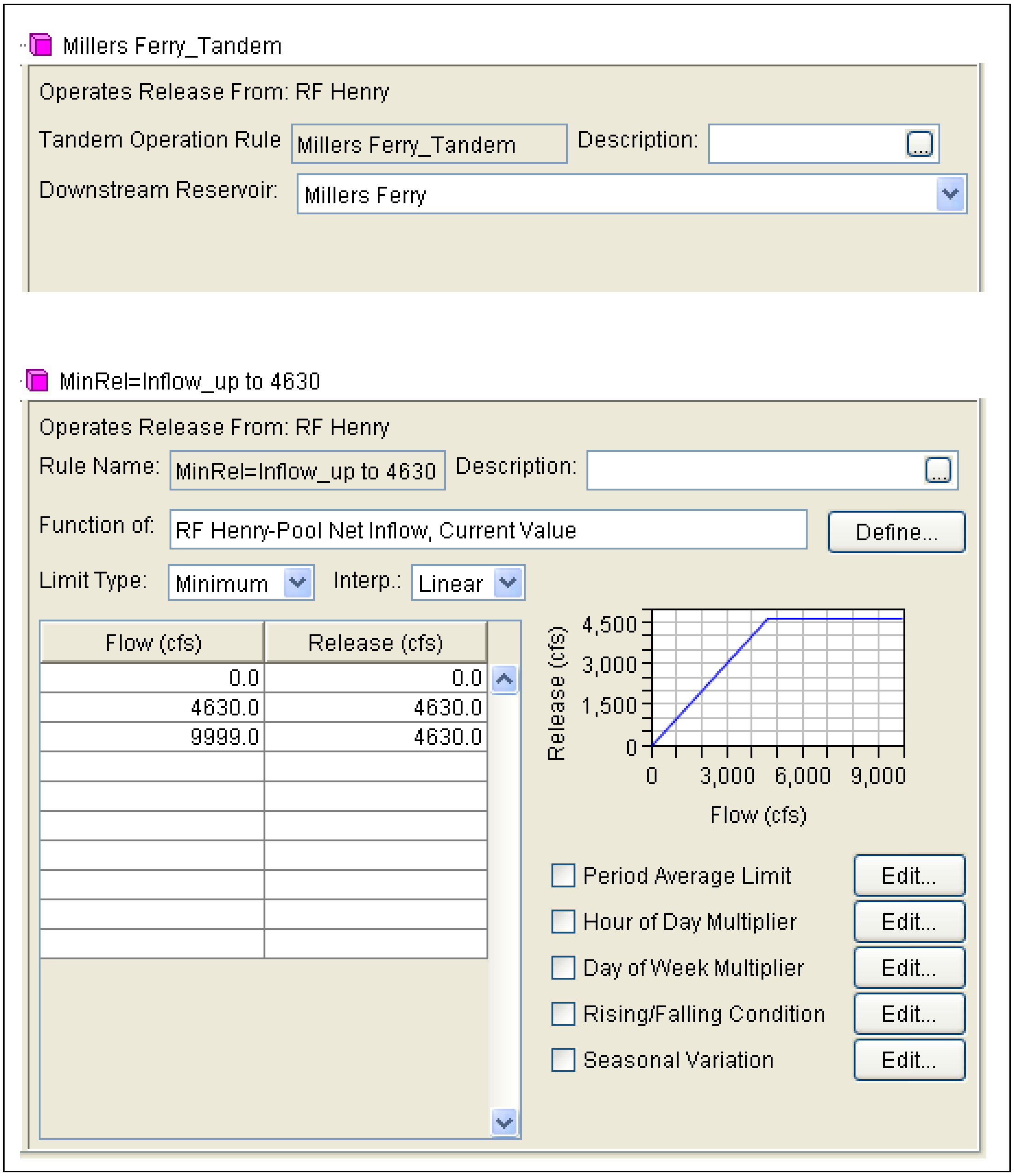


Figure C.08 Reservoir Editor: Operations Tab – Baseline OpSet – Rule Illustrations

C. Rule Descriptions

1. Millers Ferry_Tandem

This rule (see Figure C.08) reflects that RF Henry is to operate in tandem for Millers Ferry. This rule will balance the percent full in the RF Henry conservation pool with the percent full in the Millers Ferry conservation pool.

2. MinRel=Inflow_up to 4630

This rule (see Figure C.08) stabilizes releases from RF Henry when it is very low in the pool (when RF Henry gets to its "Operating Inactive" zone). This rule requires a minimum release of inflow up to 4630 cfs. When RF Henry's inflow is 4630 cfs or greater (which basically indicates JBT Goal is being met), then the minimum release from RF Henry is 4630 cfs.

Alabama-Coosa-Tallapoosa (ACT) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update

[Baseline]

Appendix D – Millers Ferry Lock and Dam

March 2011 (DRAFT)

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Appendix D – Millers Ferry [Baseline] (DRAFT)

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Millers Ferry Lock and Dam

I. Overview

Millers Ferry Lock and Dam is operated by the Mobile District of the U.S. Army Corps of Engineers. It is located in the southwestern part of the State of Alabama about 142 miles upstream of the mouth of the Alabama River. It is located about 10 miles northwest of Camden and 30 miles southwest of Selma. The reservoir lies within Wilcox and Dallas Counties. The total drainage area contributing flow at this location is 20,700 square miles. Miller Ferry serves as a major unit of the navigation system on the Alabama River and for the production of hydroelectric power. Other project purposes include recreation, fish and wildlife conservation, and wildlife mitigation.

Millers Dam is a concrete gravity-type dam with a gated spillway, supplemented by earth dikes, a navigation lock and control station, and a 75 MW power plant. The lock chamber is 84 ft wide and has a usable length of about 600 ft. The spillway consists of 17 tainter gates which are 50 ft wide by 35 ft high. The spillway crest elevation is 46.0 ft.

Figure D.01 shows the location of Millers Ferry Lock and Dam as it is represented in the HEC-ResSim model.

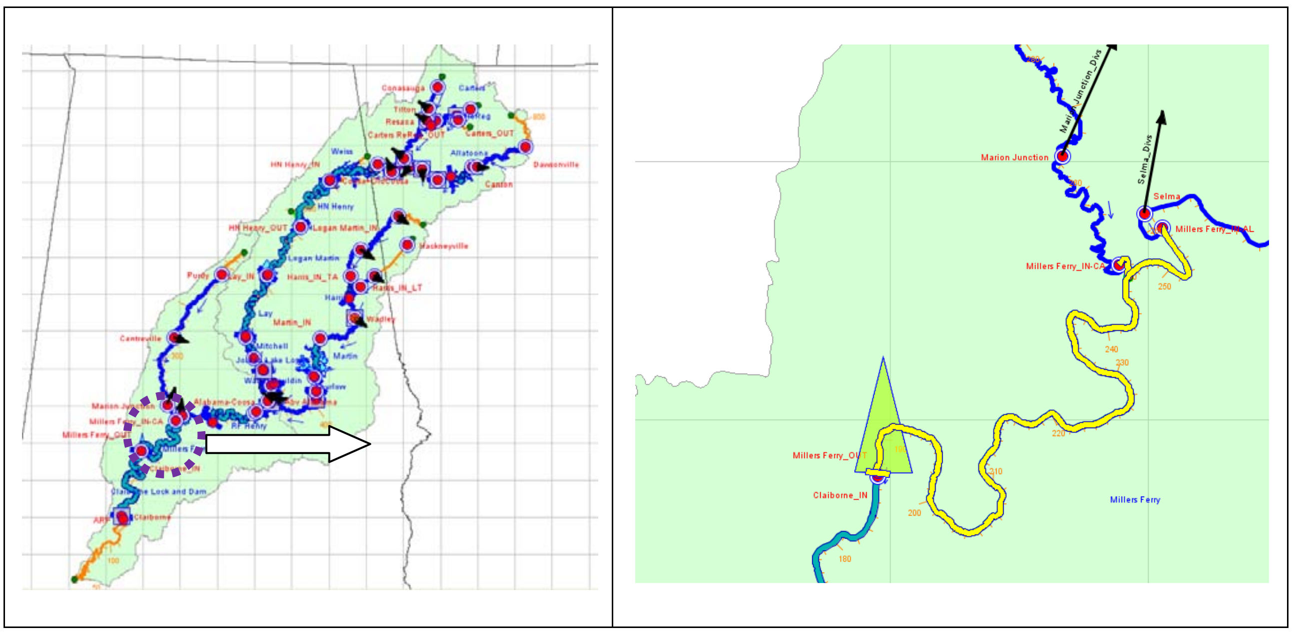


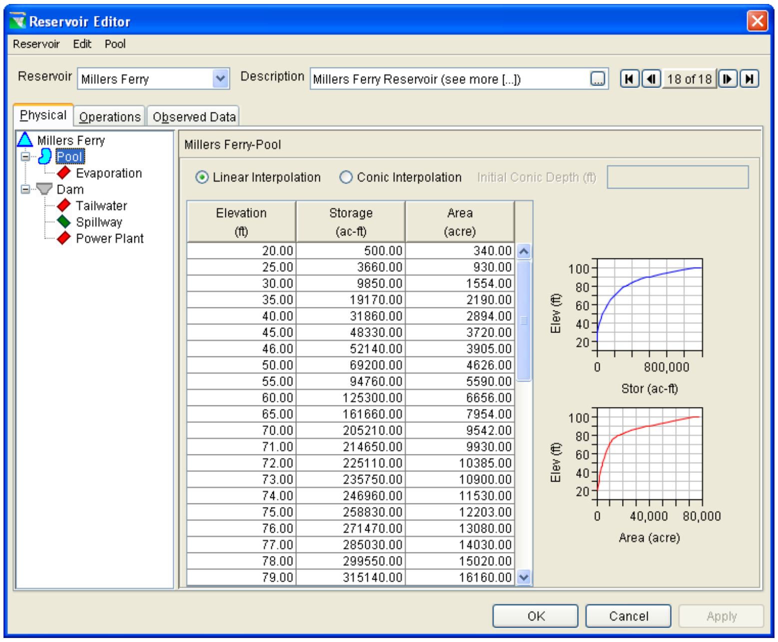
Figure D.01 HEC-ResSim Map Display Showing Location of Millers Ferry Lock and Dam

Figure D.02 shows a photo of Millers Ferry Lock and Dam.

Figure D.02 Photo of Millers Ferry Lock and Dam

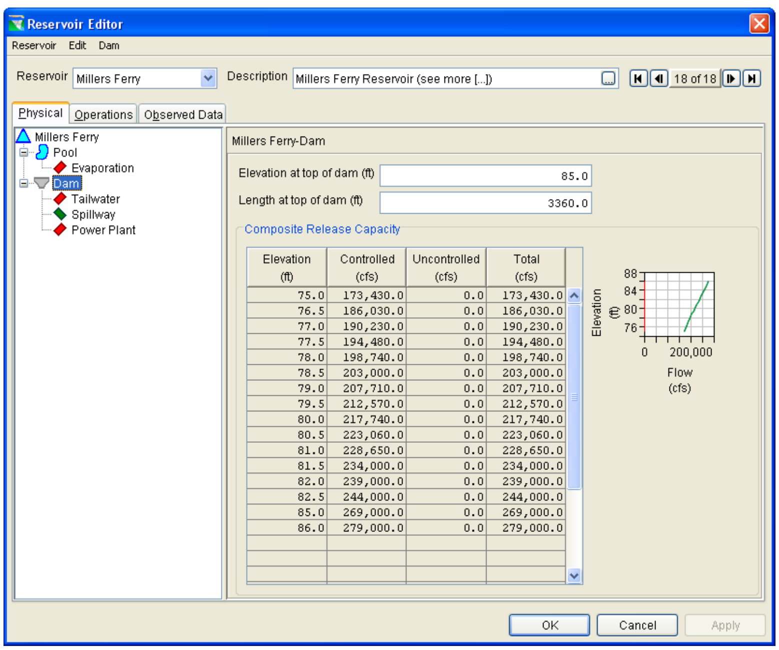
II. Physical Characteristics

The physical characteristics of each reservoir are separated between the “Pool” and the “Dam” in the ResSim model. The “elevation-storage-area” defines the pool as shown for Millers Ferry Lock and Dam in Figure D.03. Millers Ferry Dam consists of two types of outlets: (1) a controlled spillway; and, (2) a power plant. Each of these outlets is defined in the model, and the Dam reflects the composite release capacity of both of the outlets as shown in Figure D.04.



Elevation (ft)	Storage (ac-ft)	Area (acre)
20.00	500.00	340.00
25.00	3660.00	930.00
30.00	9850.00	1554.00
35.00	19170.00	2190.00
40.00	31860.00	2894.00
45.00	48330.00	3720.00
46.00	52140.00	3905.00
50.00	69200.00	4626.00
55.00	94760.00	5590.00
60.00	125300.00	6656.00
65.00	161660.00	7954.00
70.00	205210.00	9542.00
71.00	214650.00	9930.00
72.00	225110.00	10385.00
73.00	235750.00	10900.00
74.00	246960.00	11530.00
75.00	258830.00	12203.00
76.00	271470.00	13080.00
77.00	285030.00	14030.00
78.00	299550.00	15020.00
79.00	315140.00	16160.00

Figure D.03 2009 Network…Reservoir Editor: Millers Ferry Physical Tab – Pool



Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
75.0	173,430.0	0.0	173,430.0
76.5	186,030.0	0.0	186,030.0
77.0	190,230.0	0.0	190,230.0
77.5	194,480.0	0.0	194,480.0
78.0	198,740.0	0.0	198,740.0
78.5	203,000.0	0.0	203,000.0
79.0	207,710.0	0.0	207,710.0
79.5	212,570.0	0.0	212,570.0
80.0	217,740.0	0.0	217,740.0
80.5	223,060.0	0.0	223,060.0
81.0	228,650.0	0.0	228,650.0
81.5	234,000.0	0.0	234,000.0
82.0	239,000.0	0.0	239,000.0
82.5	244,000.0	0.0	244,000.0
85.0	269,000.0	0.0	269,000.0
86.0	279,000.0	0.0	279,000.0

Figure D.04 2009 Network…Reservoir Editor: Millers Ferry Physical Tab –Dam

III. Baseline Operations

A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table D.01 shows the definition of Millers Ferry's "Baseline" operational zones, which consists of zones of flood control and conservation.

Table D.01 Zone Elevations for "Baseline" Operation Set

Millers Ferry	Baseline Top of Zone Elevation Values (feet)
Seasons =	1Jan - 31Dec
Zones:	
Top of Dam	85
Flood Control	80.5
Conservation	80.4
Operating Inactive	78
Inactive	76.5

As shown in Figure D.05, the top of the Conservation zone for Baseline operations at Millers Ferry has been set to be the operational Guide Curve and is a constant 80.4' throughout the year.

Guide Curve definition (top of **Conservation** zone)

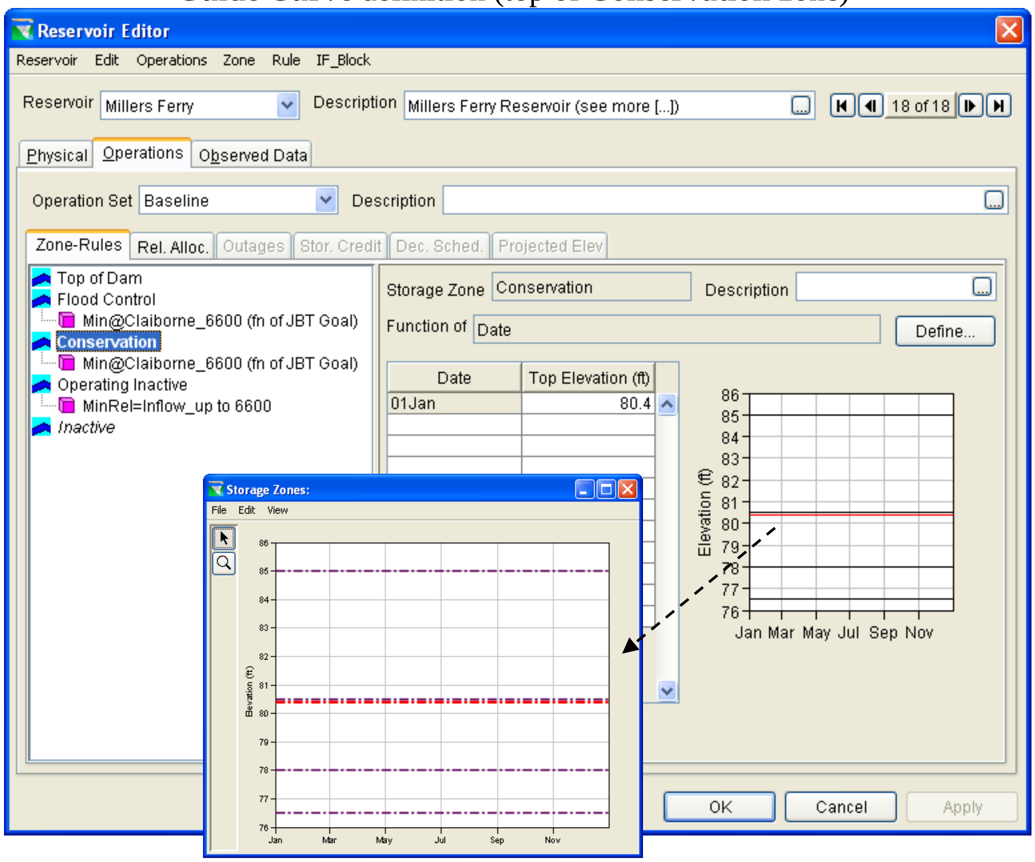


Figure D.05 Reservoir Editor: Operations Tab – Baseline OpSet – Guide Curve

Figure D.06 shows a sequential release allocation approach specified for available outlets along Millers Ferry Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. After the capacity through the powerhouse is reached, the remainder of the release goes through the controlled spillway.

Release Allocation:

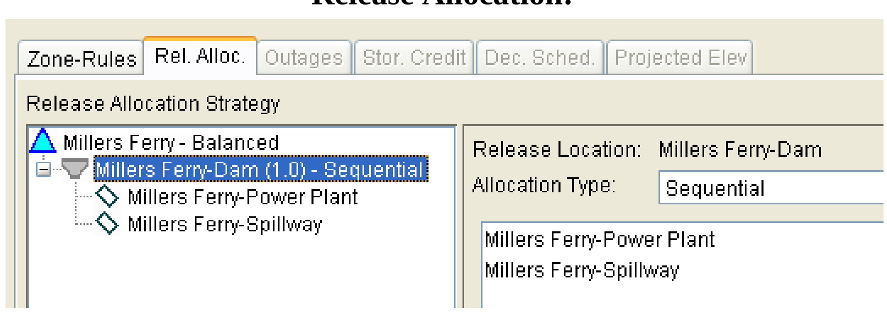


Figure D.06 Reservoir Editor: Operations Tab – Baseline OpSet – Release Allocation

B. Rule Illustrations

Figure D.07 shows a set of operational rules specified for each zone that reflects the operation set named “Baseline”.

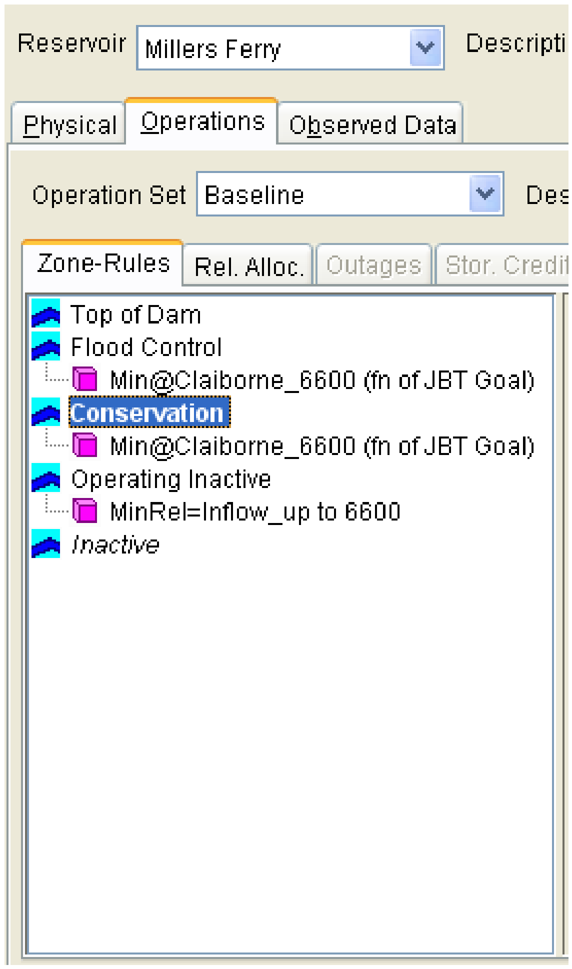


Figure D.07 Reservoir Editor: Operations Tab – Baseline OpSet – Zones and Rules

The content for each of these rules in the ResSim model are shown in Figure D.08, and the logic and purpose for each operational rule is described in the paragraphs that follow Figure D.08.

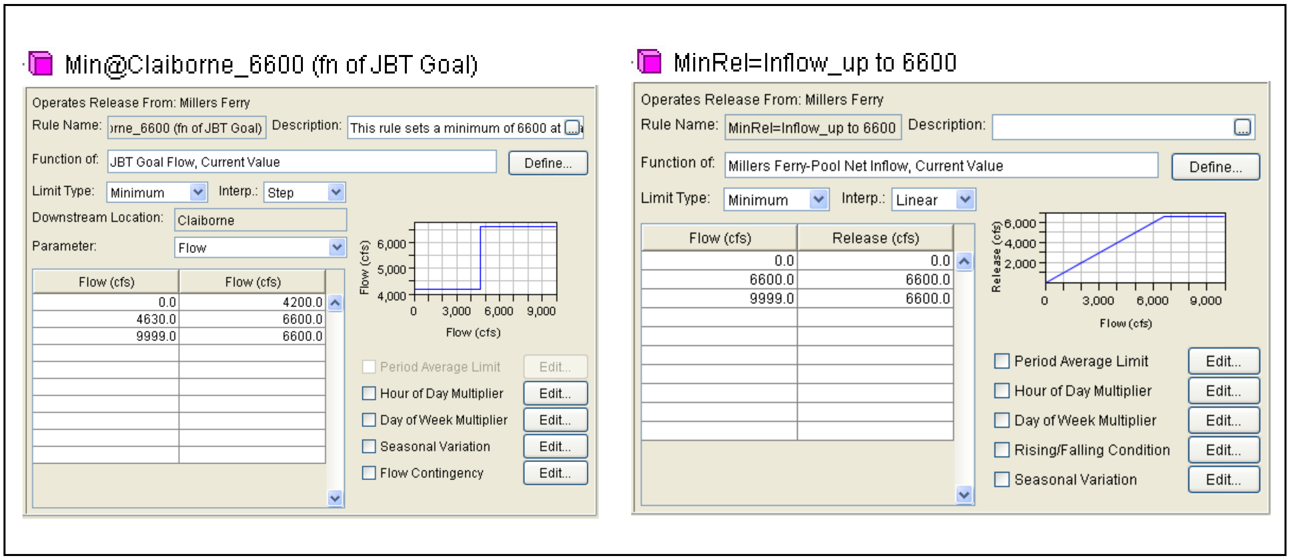


Figure D.08 Reservoir Editor: Operations Tab – Baseline OpSet – Minimum Rules

C. Rule Descriptions

1. Min@Claiborne_6600 (fn of JBT Goal)

This rule (see Figure D.08) is a minimum downstream control function rule at Claiborne that is a function of the current flow at the upstream location of JBT Goal. This rule sets a minimum of 6,600 cfs at Claiborne if the 4,630 cfs minimum at JBT Goal is being met. If it is not being met, the minimum at Claiborne then becomes 4,200 cfs. The function has been coded as a step function. This rule is applied in the Flood Control and Conservation zones.

2. MinRel=Inflow_up to 6600

This rule (see Figure D.08) sets the minimum flow from Millers Ferry based on inflow to that project. From 0.0 cfs inflow to 6,600 cfs inflow, the minimum release is set to inflow. For inflow values greater than 6,600 cfs, the minimum release stays constant at 6,600 cfs. This rule is applied in the Operating Inactive zone.

Alabama-Coosa-Tallapoosa (ACT) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update

[Baseline]

Appendix E – Weiss Reservoir

March 2011 (DRAFT)

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Appendix E – Weiss [Baseline] (DRAFT)

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Weiss Reservoir

I. Overview

Weiss Project is owned by the Alabama Power Company. It is located on the Coosa River 50 miles upstream of Gadsden, Alabama. The reservoir lies within Cherokee County, Alabama and Floyd County, Georgia. The principal purpose of Weiss dam is for the production of hydro power and to provide flood control benefits. The reservoir is also a source of water supply for domestic, agricultural, municipal and industrial use. It also provides recreational opportunities.

Weiss Project consists of a dam having a concrete gated spillway section with compacted earth abutment dikes. The spillway has 5 tainter gates 40 ft wide and 38 ft high and 1 tainter gate 16 ft wide and 22 ft high. The crest of the portion of spillway with 5 gates is at elevation 532.0 ft while the crest of the portion of spillway with 1 gate is at elevation 550.0 ft. There is also an 87.75 mW power plant at the project. The total drainage area above Weiss Dam is 5,270 square miles. The flood control storage is limited at Weiss and may not contribute a large reduction in peak flows during major flood events. The degree of control varies with the time of year.

Figure E.01 shows the location of Weiss Reservoir as it is represented in the HEC-ResSim model.

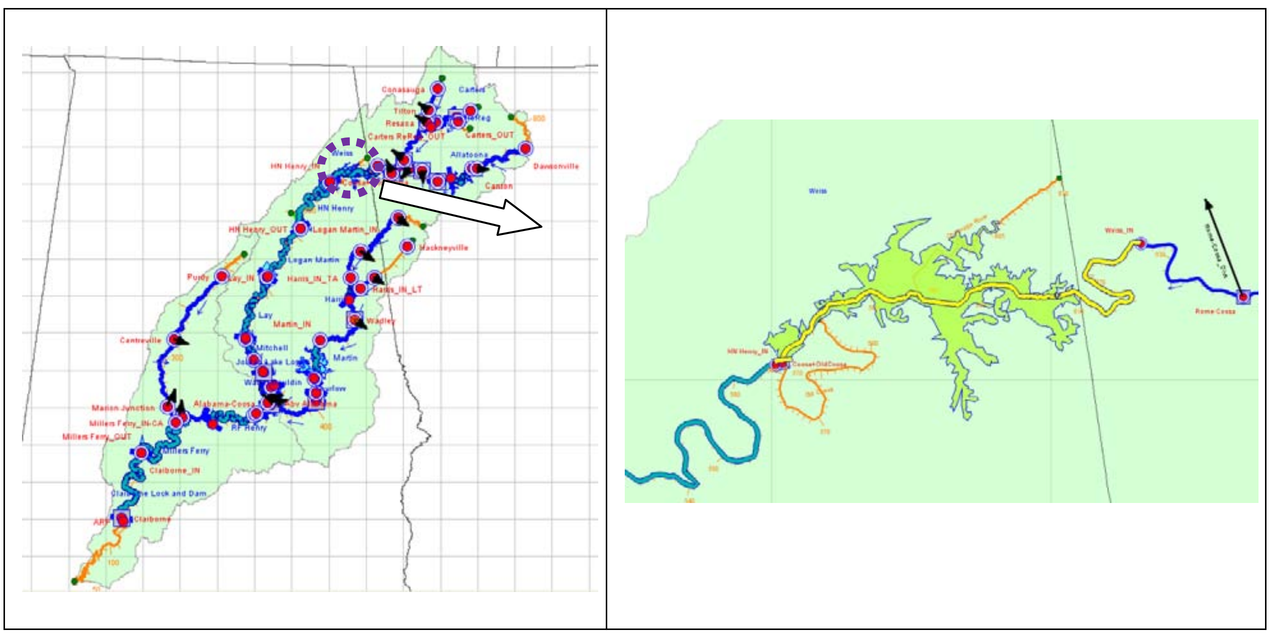


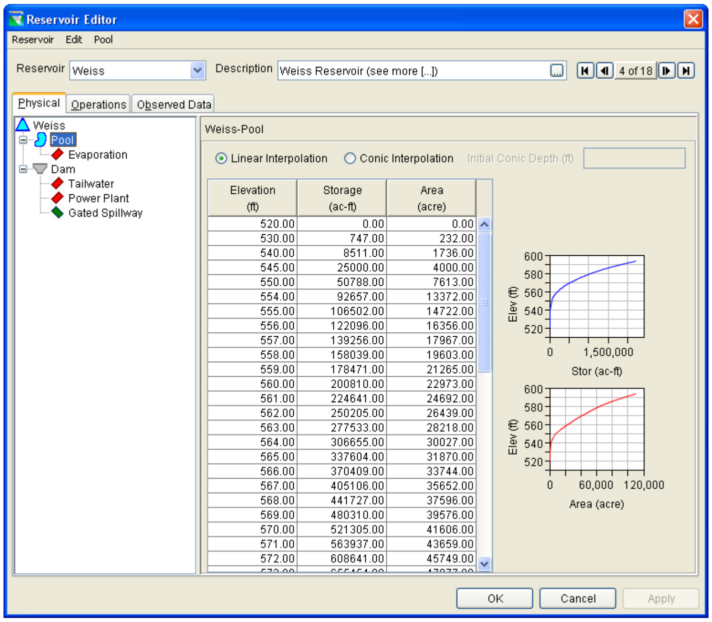
Figure E.01 HEC-ResSim Map Display Showing Location of Weiss Reservoir

Figure E.02 shows a photo of Weiss Dam.

Figure E.02 Photo of Weiss Dam

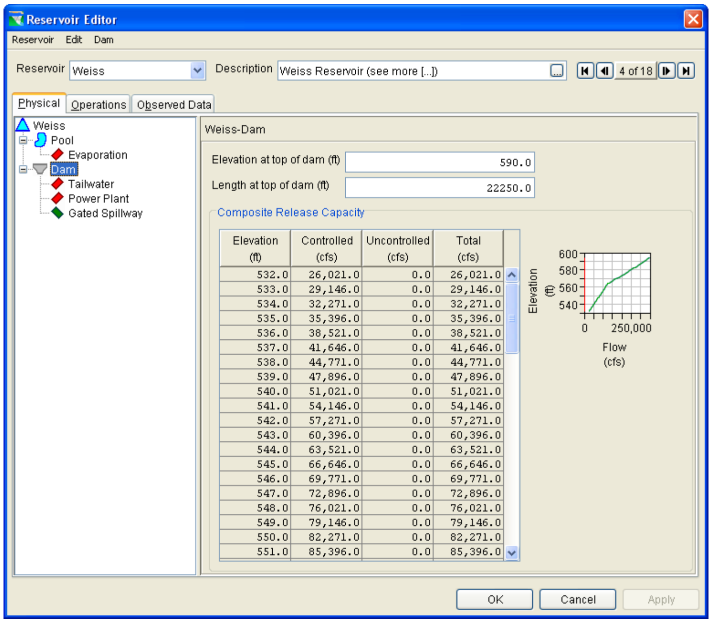
II. Physical Characteristics

The physical characteristics of each reservoir are separated between the "Pool" and the "Dam" in the ResSim model. The "elevation-storage-area" defines the pool as shown for Weiss Reservoir in Figure E.03. Weiss Dam consists of two types of outlets: (1) a gated spillway; and, (2) a power plant. Each of these outlets is defined in the model, and the Dam reflects the composite release capacity of all of the outlets as shown in Figure E.04.



Elevation (ft)	Storage (ac-ft)	Area (acre)
520.00	0.00	0.00
530.00	747.00	232.00
540.00	8511.00	1736.00
545.00	25000.00	4000.00
550.00	50788.00	7613.00
554.00	92657.00	13372.00
555.00	106502.00	14722.00
556.00	122096.00	16356.00
557.00	139256.00	17967.00
558.00	158039.00	19603.00
559.00	178471.00	21265.00
560.00	200810.00	22973.00
561.00	224641.00	24692.00
562.00	250205.00	26439.00
563.00	277533.00	28218.00
564.00	306655.00	30027.00
565.00	337604.00	31870.00
566.00	370409.00	33744.00
567.00	405106.00	35652.00
568.00	441727.00	37596.00
569.00	480310.00	39576.00
570.00	521305.00	41606.00
571.00	563937.00	43659.00
572.00	608641.00	45749.00

Figure E.03 2009 Network…Reservoir Editor: Weiss Physical Tab – Pool



Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
532.0	26,021.0	0.0	26,021.0
533.0	29,146.0	0.0	29,146.0
534.0	32,271.0	0.0	32,271.0
535.0	35,396.0	0.0	35,396.0
536.0	38,521.0	0.0	38,521.0
537.0	41,646.0	0.0	41,646.0
538.0	44,771.0	0.0	44,771.0
539.0	47,896.0	0.0	47,896.0
540.0	51,021.0	0.0	51,021.0
541.0	54,146.0	0.0	54,146.0
542.0	57,271.0	0.0	57,271.0
543.0	60,396.0	0.0	60,396.0
544.0	63,521.0	0.0	63,521.0
545.0	66,646.0	0.0	66,646.0
546.0	69,771.0	0.0	69,771.0
547.0	72,896.0	0.0	72,896.0
548.0	76,021.0	0.0	76,021.0
549.0	79,146.0	0.0	79,146.0
550.0	82,271.0	0.0	82,271.0
551.0	85,396.0	0.0	85,396.0

Figure E.04 2009 Network…Reservoir Editor: Weiss Physical Tab –Dam

III. Baseline Operations

A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table E.01 shows the definition of "Baseline" operational zones for Weiss Reservoir, which consists of zones of flood control and conservation. Both the flood control and conservation pools are divided into several operational zones.

Table E.01 Zone Elevations for "Baseline" Operation Set

Weiss	**Baseline** Top of **Zone Elevation** Values (feet)						
Seasons =	**1-Jan**	**1-Feb**	**1-May**	**1-Jun**	**1-Sep**	**1-Dec**	**31-Dec**
Zones:							
Top of Dam	590	590	590	590	590	590	590
Top of Surcharge	575	575	575	575	575	575	575
Flood Control	574	574	574	574	574	574	574
Conservation	558	linear	564	564	564	linear	558
Drought	556	556	linear	563	linear	556	556
Operating Inactive	552	552	552	552	552	552	552
Inactive	549	549	549	549	549	549	549

The top of two of the zones ("Conservation" and "Drought") vary seasonally. The top of the Conservation zone has been set to be the operational Guide Curve for Baseline operations (as shown in Figure E.05).

Guide Curve definition (top of **Conservation** zone)

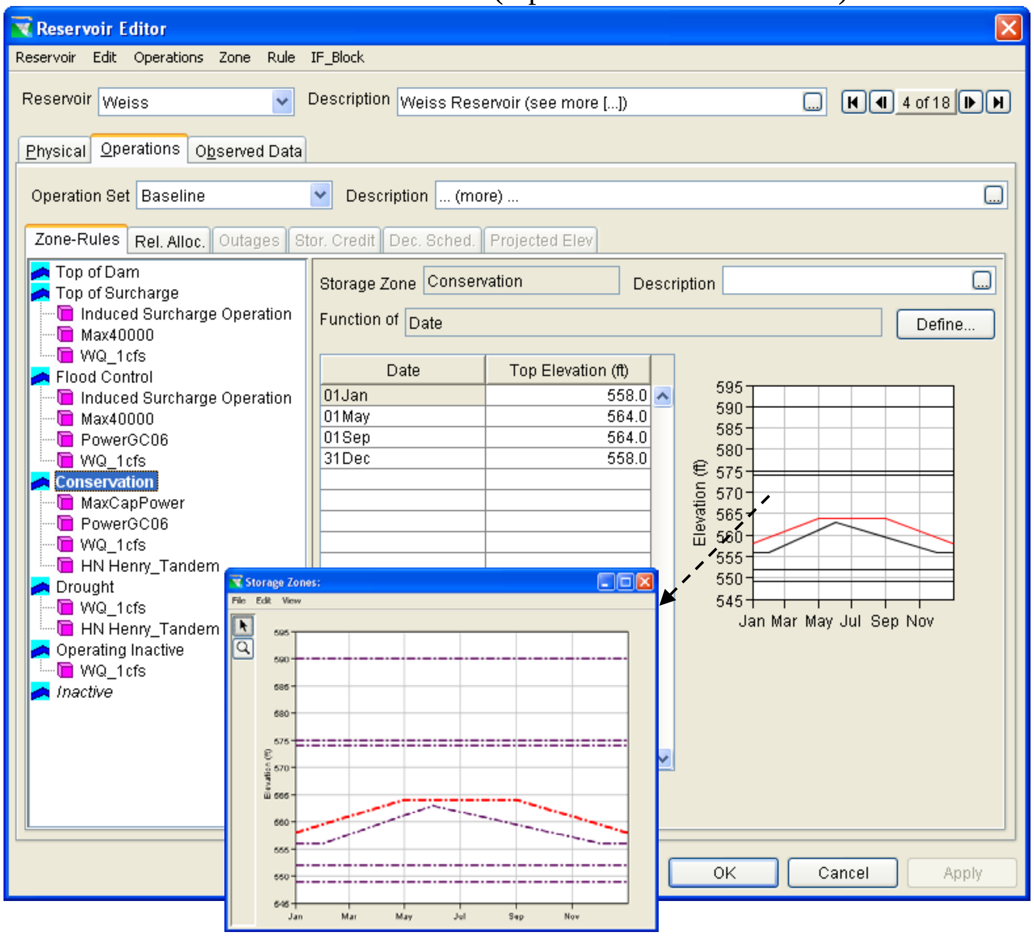


Figure E.05 Reservoir Editor: Operations Tab – Baseline OpSet – Guide Curve

Figure E.06 shows a sequential release allocation approach specified for available outlets along Weiss Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. After the capacity through the powerhouse is reached, the remainder of the release goes through the gated spillway.

Release Allocation:

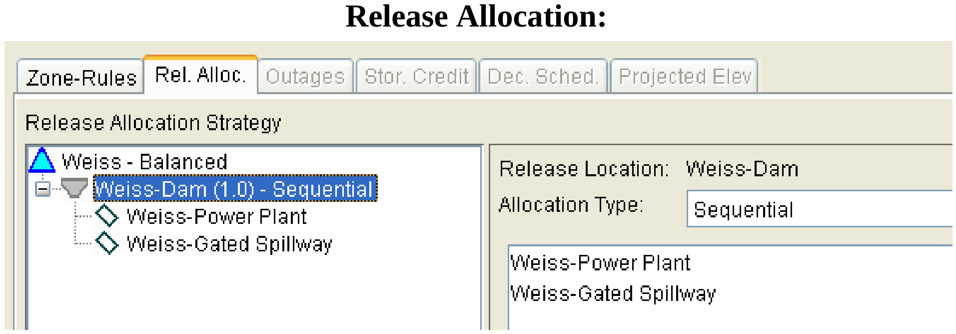


Figure E.06 Reservoir Editor: Operations Tab – Baseline OpSet – Release Allocation

B. Rule Illustrations

Figure E.07 shows a set of operational rules specified for each zone that reflects the operation set named “Baseline”.

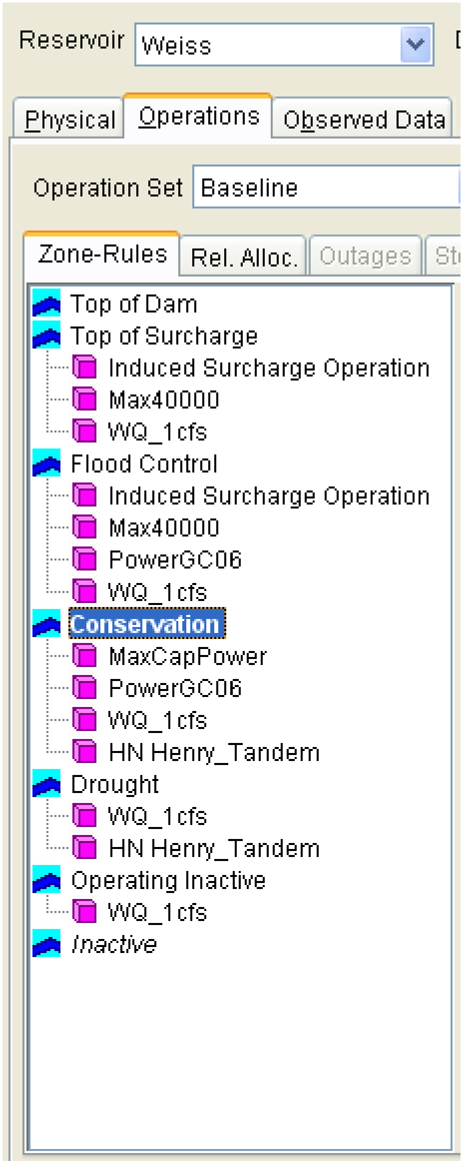


Figure E.07 Reservoir Editor: Operations Tab – Baseline OpSet – Zones and Rules

The content for each of these rules in the ResSim model is shown in Figure E.08 and Figure E.09. The logic and purpose for each operational rule is described in Section C.

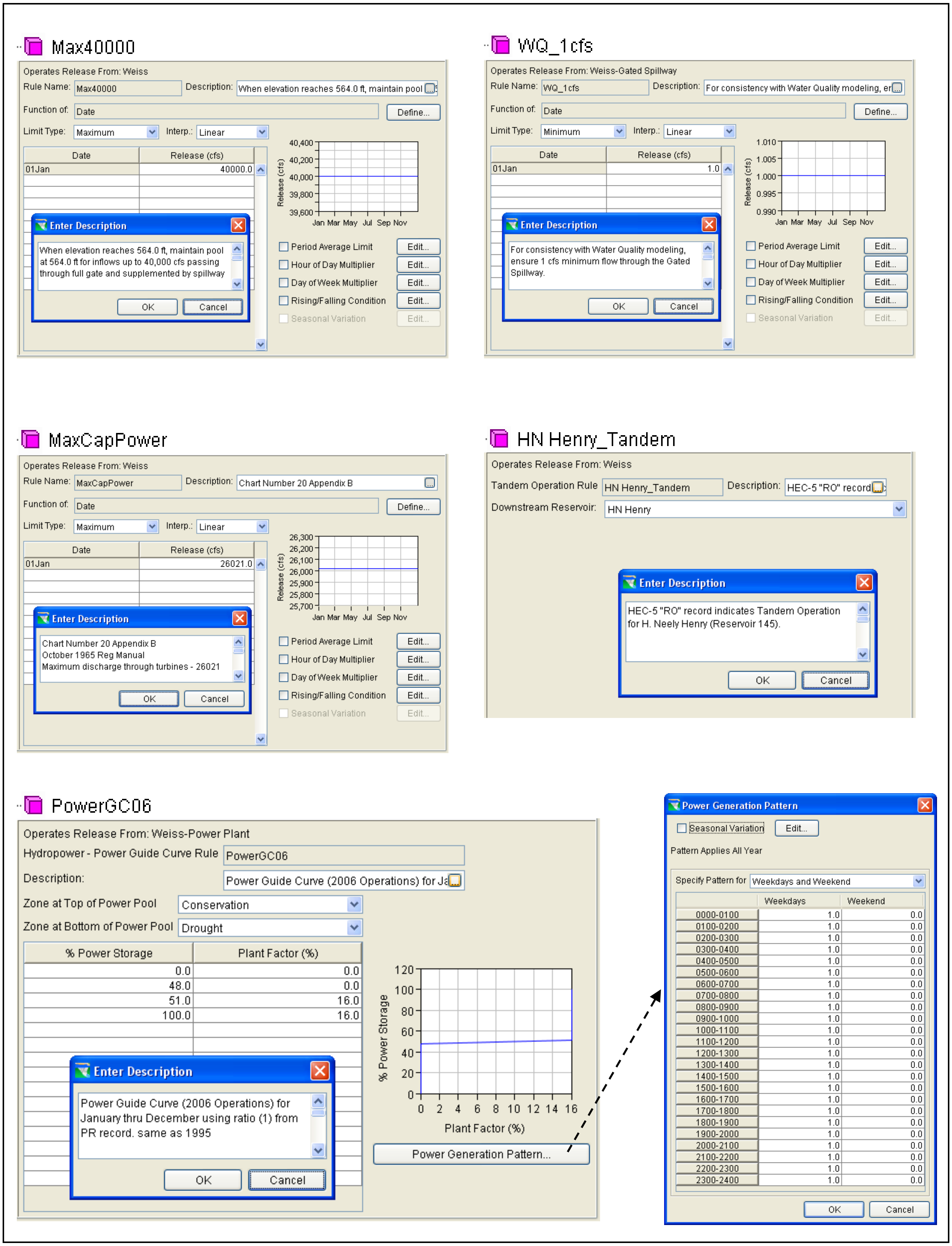


Figure E.08 Reservoir Editor: Operations Tab – Baseline OpSet – Max, Min, and Tandem Rules

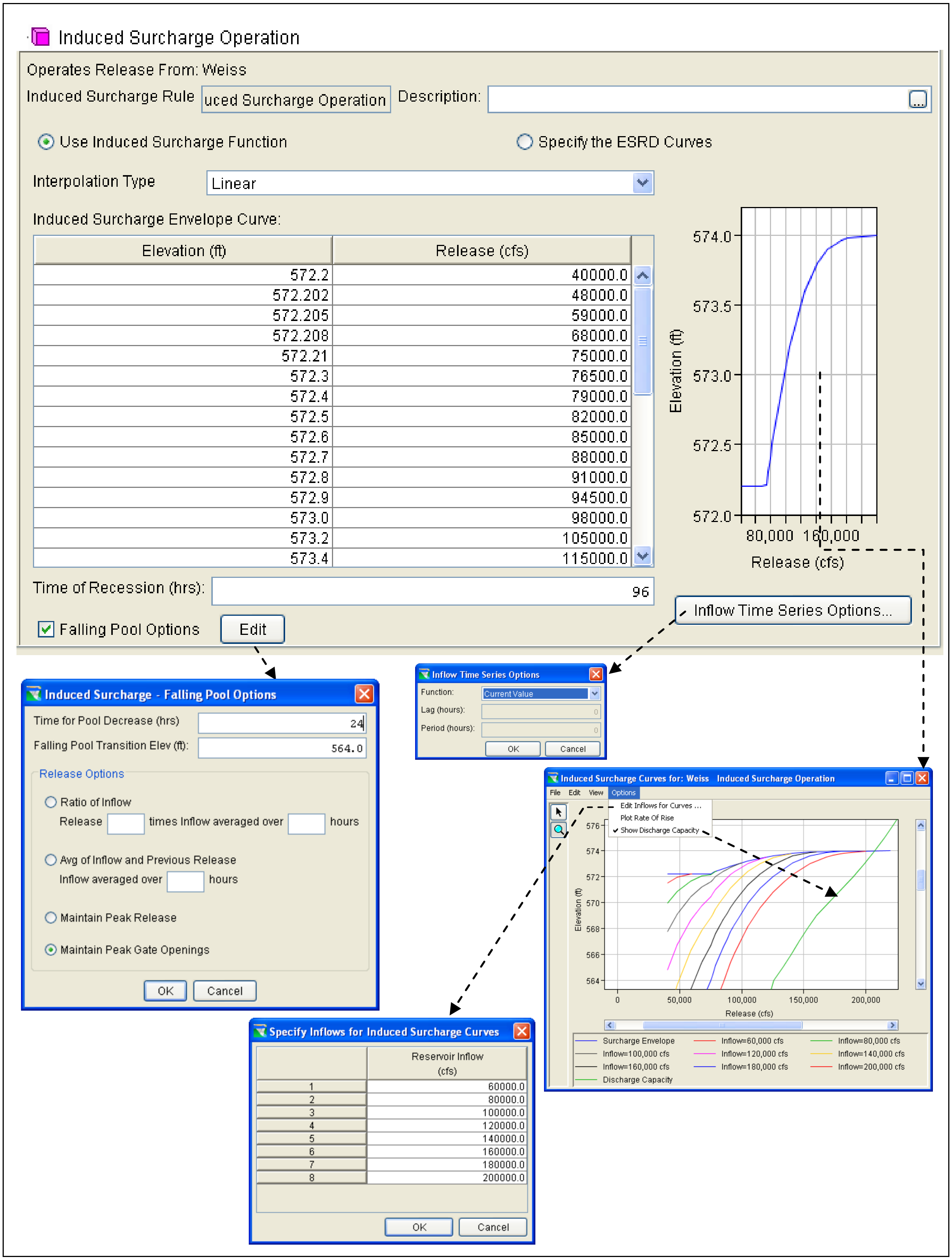


Figure E.09 Reservoir Editor: Operations Tab – Baseline OpSet – Induced Surcharge Rule

C. Rule Descriptions

1. *Max40000*

This rule (see Figure E.08) limits the release from Weiss Dam to 40,000 cfs. The higher priority Induced Surcharge function can cause this release to be exceeded in both the Top of Surcharge zone and the Flood Control zone.

2. *MaxCapPower*

This rule (see Figure E.08) sets the maximum release in the Conservation zone to 26,021 cfs. This value is the modeled release capacity for the power plant.

3. *WQ_1cfs*

This rule (see Figure E.08) requires a minimum of 1 cfs through the gated spillway at Weiss Dam. This rule in the ResSim model provides nominal discharge into the Weiss Old Channel to provide numerical stability for the water quality model used in the manual update study. The rule represents operations under terms of the license in effect during the modeling (December 2010), which imposes no minimum flow requirement in the Old Channel. The 1 cfs may be physically justified as leakage through the gated spillway, which is the only outlet flowing into the Old Channel.

4. *HN Henry_Tandem*

This rule (see Figure E.08) is used to balance the storage in Weiss with the storage in the downstream reservoir, HN Henry. The balance is done for each zone. For instance, if Weiss is in the conservation zone, ResSim will compute the percent full using the storage from top of Conservation to top of Drought and adjust flows to achieve the same percent full in that zone at HN Henry. The ability of ResSim to achieve this balance is limited by higher priority rules.

5. *PowerGC06*

This rule (see Figure E.08) is a required power generation rule that is applied in both the Flood Control zone and the Conservation zone. For this rule, the zone for power storage is defined from the top of Conservation to the top of Drought. The plant factor ranges from 0% (0 hours of required generation) at the lower elevations in this zone up to 16% (3.84 hours of required generation) at the upper elevations in this zone. The required generation pattern is set for weekdays only by setting the power generation pattern to 1 for all hours on weekdays (Monday through Friday) and to zero for all hours on weekends.

6. *Induced Surcharge Operation*

This rule (see Figure E.09) represents an induced surcharge operation for flood control. Induced surcharge operation is achieved by physically regulating the position of spillway gates. When the gate opening is reduced to limit release to less than free overflow (the fully-open position), water is intentionally surcharged behind the gates. Induced surcharge operation guidelines are derived from an envelope curve, which represents the relationship between a maximum allowable pool elevation and minimum required release for extreme flood events. For smaller flood inflows, the relationship between pool elevation and minimum required release can be derived using the surcharge envelope and a time of recession constant. A family of curves can be developed to cover the pool elevation vs. minimum release relationships for many different inflow values.

An induced surcharge rule in ResSim can be defined using a function or a family of curves. Since the induced surcharge rule at Weiss uses a function, then the rule requires an **Induced Surcharge Envelope Curve** and a **Time of Recession** (96 hrs used for Weiss). ResSim uses this information to calculate the pool elevation vs. minimum release relationship for any inflow. For the purposes of comparison to an induced surcharge chart in a Water Control Manual, or in order to check the calculated induced surcharge minimum flow values from a simulation, it is possible for the modeler to view the induced surcharge curves that ResSim generates. This is accomplished by double-clicking the induced surcharge function graph and adding a series of inflow values. Each inflow value entered will generate a curve depicting elevation vs. minimum release. The total outlet capacity can also be added to the chart. (The modeler should be aware that in the ResSim plot, the curves are drawn beyond the range to which they are actually applied in the model.)

The induced surcharge rule also includes falling pool options, which indicate how to apply the induced surcharge operation when the pool is falling and when to transition out of induced surcharge operation. The **Time for Pool Decrease** (24 hours for Weiss) is the required number of successive hours the reservoir pool level must be falling before transitioning from rising pool emergency spillway releases to falling pool releases. The **Falling Pool Transition Elev** (564 ft for Weiss) is the pool elevation below which the induced surcharge rule will no longer operate. The **Release Options** are to designate the method for computing falling pool releases. For Weiss, the option of **Maintain Peak Gate Openings** is selected.

Alabama-Coosa-Tallapoosa (ACT) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update

[Baseline]

Appendix F– H Neely Henry Reservoir

March 2011 (DRAFT)

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Appendix F – HN Henry [Baseline] (DRAFT)

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H Neely Henry Reservoir

I. Overview

The H. Neely Henry Project is operated by the Alabama Power Company. The dam is on the Coosa River about 27 miles downstream from the city of Gadsden, Alabama. The reservoir lies within St. Clair, Calhoun, Etowah and Cherokee Counties. The drainage area of HN Henry Dam is 1,330 square miles between HN Henry and Weiss, and the total drainage area is 6,600 square miles. The dam has a concrete gated spillway section with compacted earth abutment dikes. The crest of the spillway is at elevation 480 ft. The spillway contains 6 gates which are 40 ft wide and 29 ft high. The HN Henry project also contains a powerhouse.

The primary purpose of the dam is the production of hydropower for the Alabama Power Company. The reservoir is also a source of water supply for domestic, agricultural, municipal and industrial uses. This project also provides a large recreational area.

Figure F.01 shows the location of H Neely Henry Reservoir as it is represented in the HEC-ResSim model.

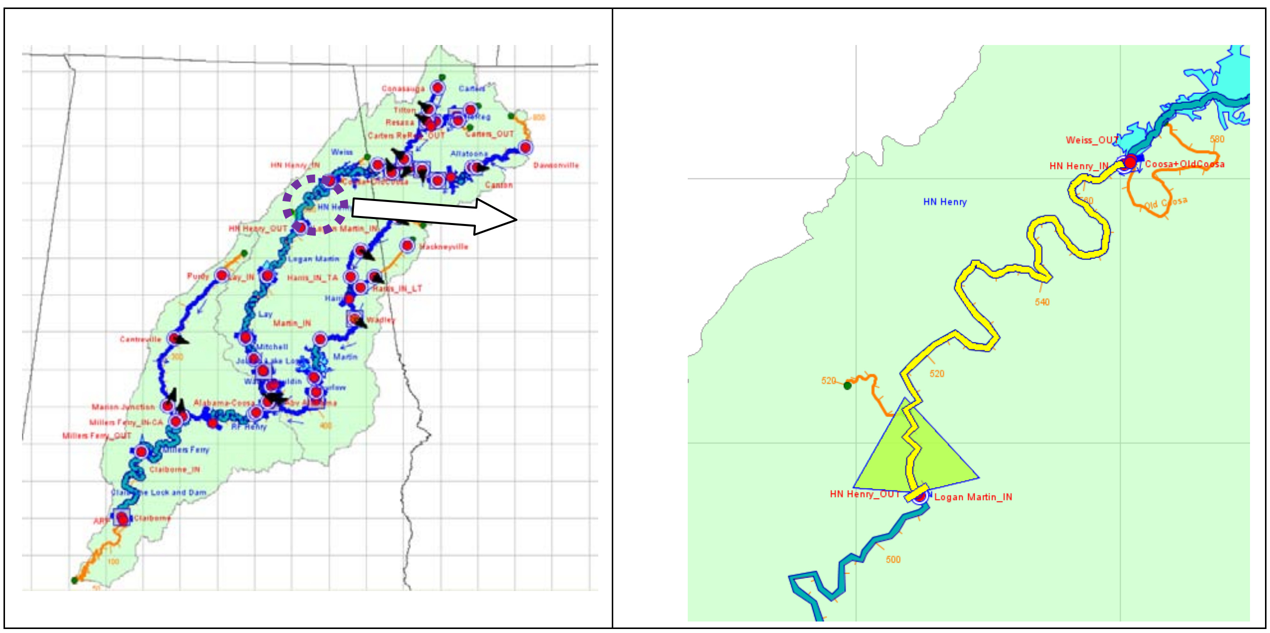


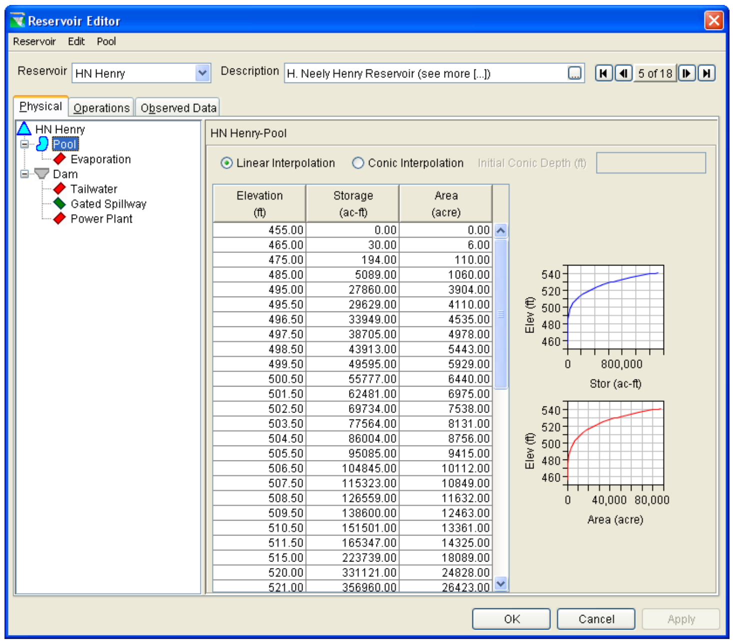
Figure F.01 HEC-ResSim Map Display Showing Location of HN Henry Reservoir

Figure F.02 shows a photo of H. Neely Henry Dam.

Figure F.02 Photo of H. Neely Henry Dam

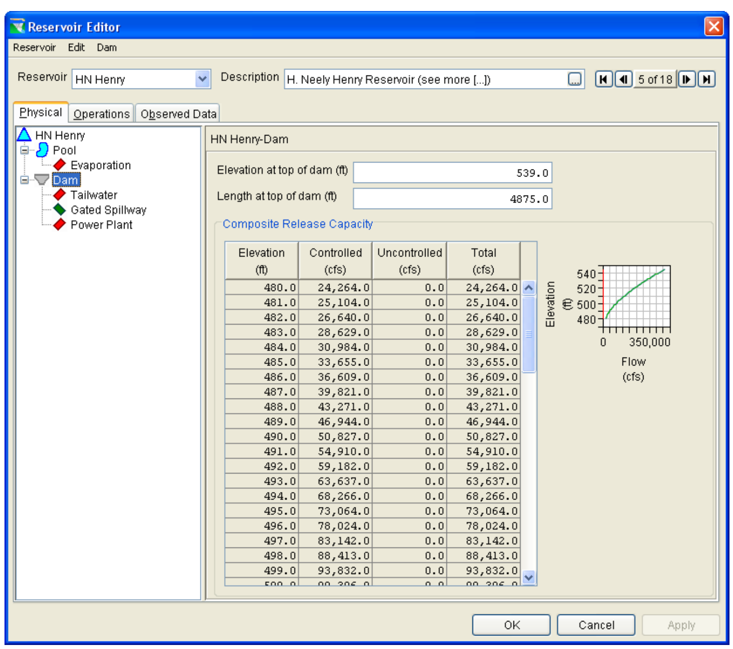
II. Physical Characteristics

The physical characteristics of each reservoir are separated between the "Pool" and the "Dam" in the ResSim model. The "elevation-storage-area" defines the pool as shown for HN Henry Reservoir in Figure F.03. HN Henry Dam consists of two types of outlets: (1) a gated spillway; and, (2) a power plant. Each of these outlets is defined in the model, and the Dam reflects the composite release capacity of all of the outlets as shown in Figure F.04.



Elevation (ft)	Storage (ac-ft)	Area (acre)
455.00	0.00	0.00
465.00	30.00	6.00
475.00	194.00	110.00
485.00	5089.00	1060.00
495.00	27860.00	3904.00
495.50	29629.00	4110.00
496.50	33949.00	4535.00
497.50	38705.00	4978.00
498.50	43913.00	5443.00
499.50	49595.00	5929.00
500.50	55777.00	6440.00
501.50	62481.00	6975.00
502.50	69734.00	7538.00
503.50	77564.00	8131.00
504.50	86004.00	8756.00
505.50	95085.00	9415.00
506.50	104845.00	10112.00
507.50	115323.00	10849.00
508.50	126559.00	11632.00
509.50	138600.00	12463.00
510.50	151501.00	13361.00
511.50	165347.00	14325.00
515.00	223739.00	18089.00
520.00	331121.00	24828.00
521.00	356960.00	26423.00

Figure F.03 2009 Network…Reservoir Editor: HN Henry Physical Tab – Pool



Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
480.0	24,264.0	0.0	24,264.0
481.0	25,104.0	0.0	25,104.0
482.0	26,640.0	0.0	26,640.0
483.0	28,629.0	0.0	28,629.0
484.0	30,984.0	0.0	30,984.0
485.0	33,655.0	0.0	33,655.0
486.0	36,609.0	0.0	36,609.0
487.0	39,821.0	0.0	39,821.0
488.0	43,271.0	0.0	43,271.0
489.0	46,944.0	0.0	46,944.0
490.0	50,827.0	0.0	50,827.0
491.0	54,910.0	0.0	54,910.0
492.0	59,182.0	0.0	59,182.0
493.0	63,637.0	0.0	63,637.0
494.0	68,266.0	0.0	68,266.0
495.0	73,064.0	0.0	73,064.0
496.0	78,024.0	0.0	78,024.0
497.0	83,142.0	0.0	83,142.0
498.0	88,413.0	0.0	88,413.0
499.0	93,832.0	0.0	93,832.0

Figure F.04 2009 Network…Reservoir Editor: HN Henry Physical Tab –Dam

III. Baseline Operations

A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table F.01 shows the definition of "Baseline" operational zones for HN Henry Reservoir, which consists of zones of flood control and conservation. The conservation pool is divided into several operational zones.

Table F.01 Zone Elevations for "Baseline" Operation Set

HN Henry	**Baseline** Top of **Zone Elevation** Values (feet)											
Seasons =	**1-Jan**	**1-Apr**	**17-Apr**	**30-Apr**	**1-May**	**31-May**	**30-Jun**	**31-Jul**	**7-Aug**	**1-Oct**	**1-Dec**	**31-Dec**
Zones:												
Top of Dam	539	*539*	*539*	*539*	*539*	*539*	*539*	*539*	*539*	*539*	*539*	*539*
Flood Control	508	*508*	*508*	*508*	*508*	*508*	*508*	*508*	*508*	*508*	*508*	*508*
Conservation	505	505	linear	linear	508	*508*	*508*	*508*	*508*	508	505	*505*
Drought	504	*504*	504	505	linear	507	505.7	504.3	504	*504*	*504*	504
Operating Inactive	503.5	*503.5*	*503.5*	*503.5*	*503.5*	*503.5*	*503.5*	*503.5*	*503.5*	*503.5*	*503.5*	*503.5*
Inactive	480	*480*	*480*	*480*	*480*	*480*	*480*	*480*	*480*	*480*	*480*	*480*

The top of two of the zones ("Conservation" and "Drought") vary seasonally. The top of the Conservation zone has been set to be the operational Guide Curve for Baseline operations (as shown in Figure F.05).

Guide Curve definition (top of **Conservation** zone)

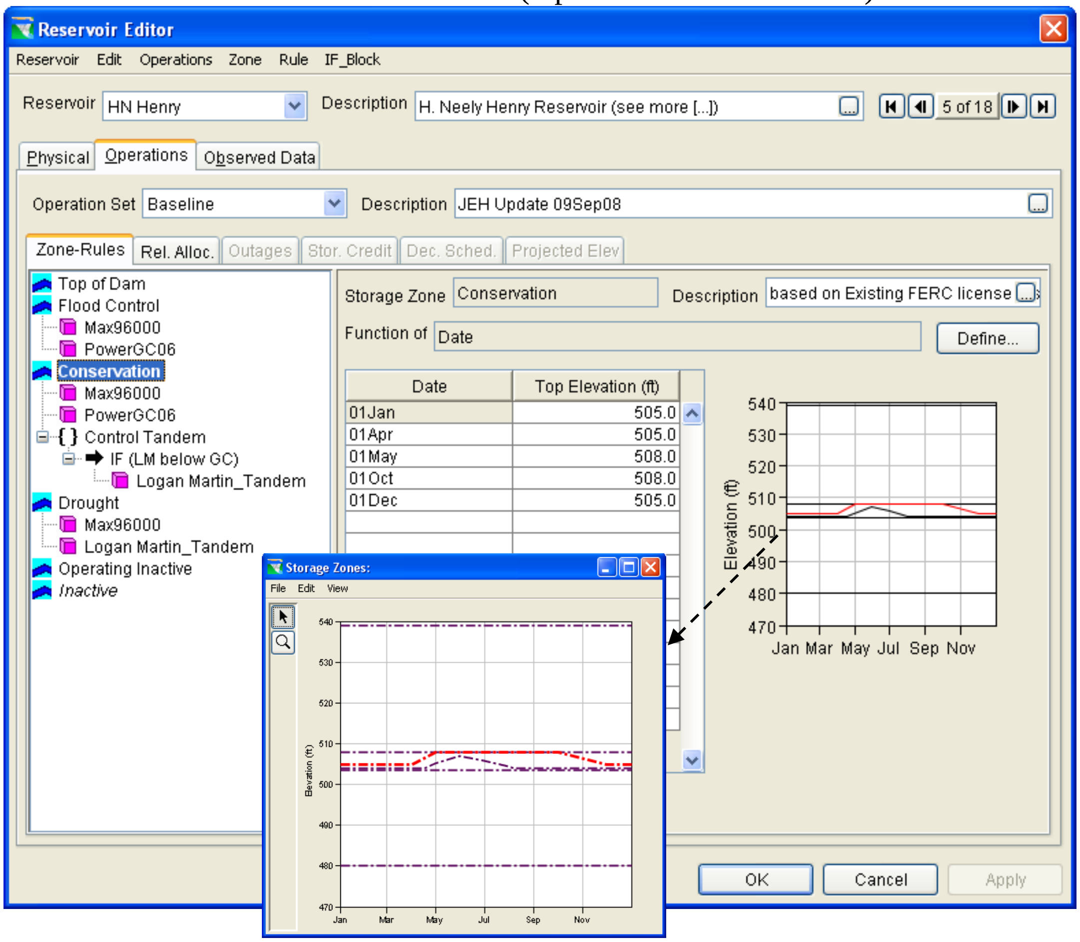


Figure F.05 Reservoir Editor: Operations Tab – Baseline OpSet – Guide Curve

Figure F.06 shows a sequential release allocation approach specified for available outlets along HN Henry Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. After the capacity through the powerhouse is reached, the remainder of the release goes through the gated spillway.

Release Allocation:

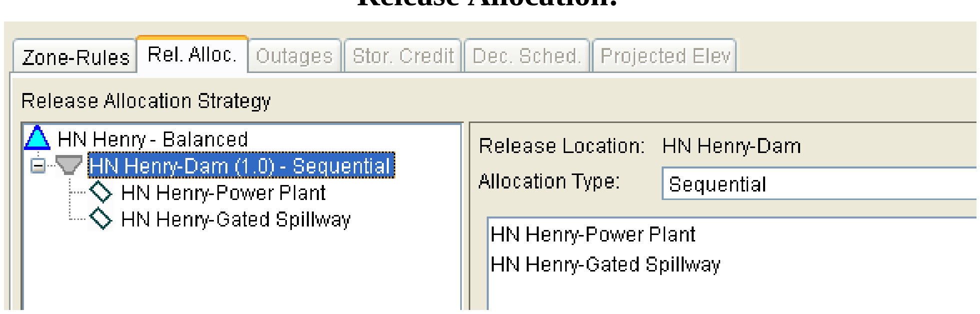


Figure F.06 Reservoir Editor: Operations Tab – Baseline OpSet – Release Allocation

B. Rule Illustrations

Figure F.07 shows a set of operational rules specified for each zone that reflects the operation set named "Baseline".

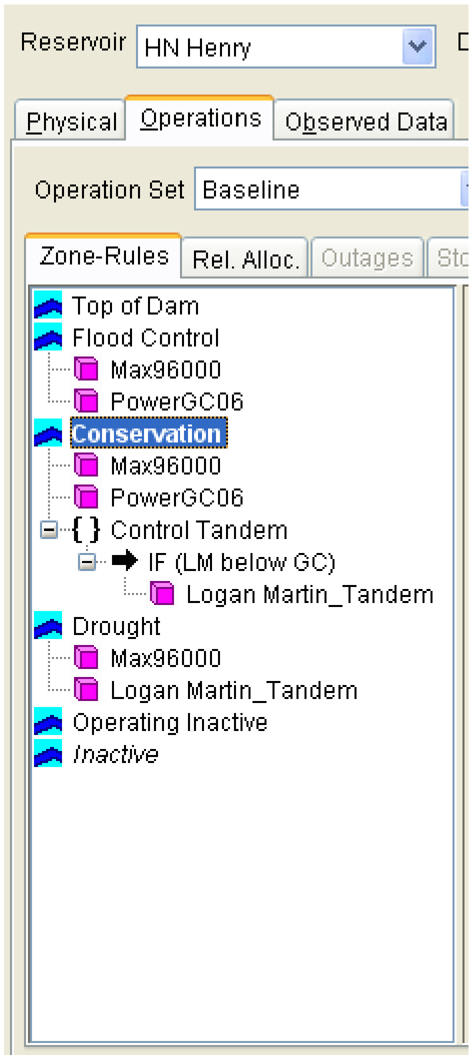


Figure F.07 Reservoir Editor: Operations Tab – Baseline OpSet – Zones and Rules

The content for each of these rules in the ResSim model are shown in Figure F.08. The logic and purpose for each operational rule is described in Section C.

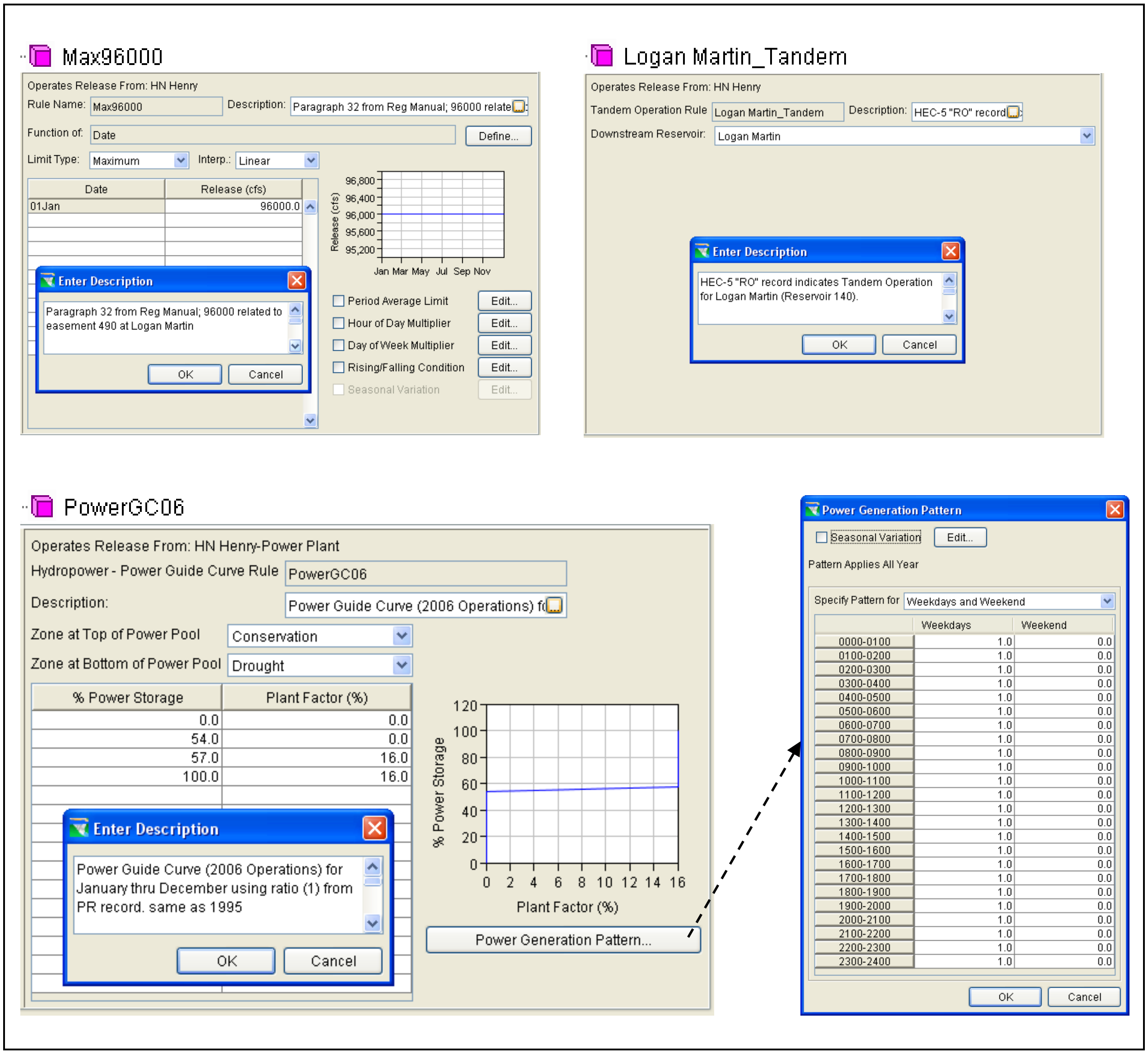


Figure F.08 Reservoir Editor: Operations Tab – Baseline OpSet – Max, Tandem, and Power Rules

C. Rule Descriptions

1. Max96000

This rule (see Figure F.08) sets the maximum release from HN Henry to 96,000 cfs. This rule is applied in the Flood Control, Conservation, and Drought zones.

2. Logan Martin_Tandem

This rule (see Figure F.08) is used to balance the storage in HN Henry with the storage in the downstream reservoir, Logan Martin. The balance is done for each zone. For instance, if HN Henry is in the conservation zone, ResSim will compute the percent full using the storage from top of Conservation to top of Drought and adjust flows to achieve the same percent full in that zone at Logan Martin. The ability of ResSim to achieve this balance is limited by higher priority rules. An IF_Block is included to prevent the tandem rule from activating when Logan Martin is within 0.025 ft of its guide curve.

3. PowerGC06

This rule (see Figure F.08) is applied in both the Flood Control and Conservation zone. Depending on the percent of power storage in use, the plant factor will vary from 0% to 16%. The top of the power pool is defined from the top of Conservation to the top of Drought. At the lower elevations in this zone, the plant factor is set to 0% (0 hrs required generation). In the upper elevations of this zone, the plant factor is set to 16% (3.84 hrs required generation). The generation is set to weekdays (Monday through Friday) only by setting the power generation pattern to 1 on weekdays and 0 on weekends.

Alabama-Coosa-Tallapoosa (ACT) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update

[Baseline]

Appendix G – Logan Martin Reservoir

March 2011 (DRAFT)

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Appendix G – Logan Martin [Baseline] (DRAFT)

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Logan Martin Reservoir

I. Overview

Logan Martin is owned by the Alabama Power Company. The project is located 99 river miles upstream of the confluence of the Coosa and Tallapoosa Rivers. It extends about 48.5 miles upstream on the Coosa River and is situated within Calhoun, St. Clair, and Talladega Counties. The total drainage area contributing flow at this location is 7700 square miles. The lake is primarily used for the production of hydropower and flood control. There is limited flood control storage in Logan Martin Lake, but it is used in conjunction with other power generating lakes owned by Alabama Power Company to attempt to minimize flooding. Other purposes include navigation flow augmentation, water quality, water supply and fish and wildlife.

The dam is a concrete gravity structure. It includes a spillway that has 6 tainter gates which are each 40 ft wide and 38 ft high. The crest elevation of the spillway is at 432 ft. The powerhouse has three generators and is rated for 134.6 MW.

Figure G.01 shows the location of Logan Martin Reservoir as it is represented in the HEC-ResSim model.

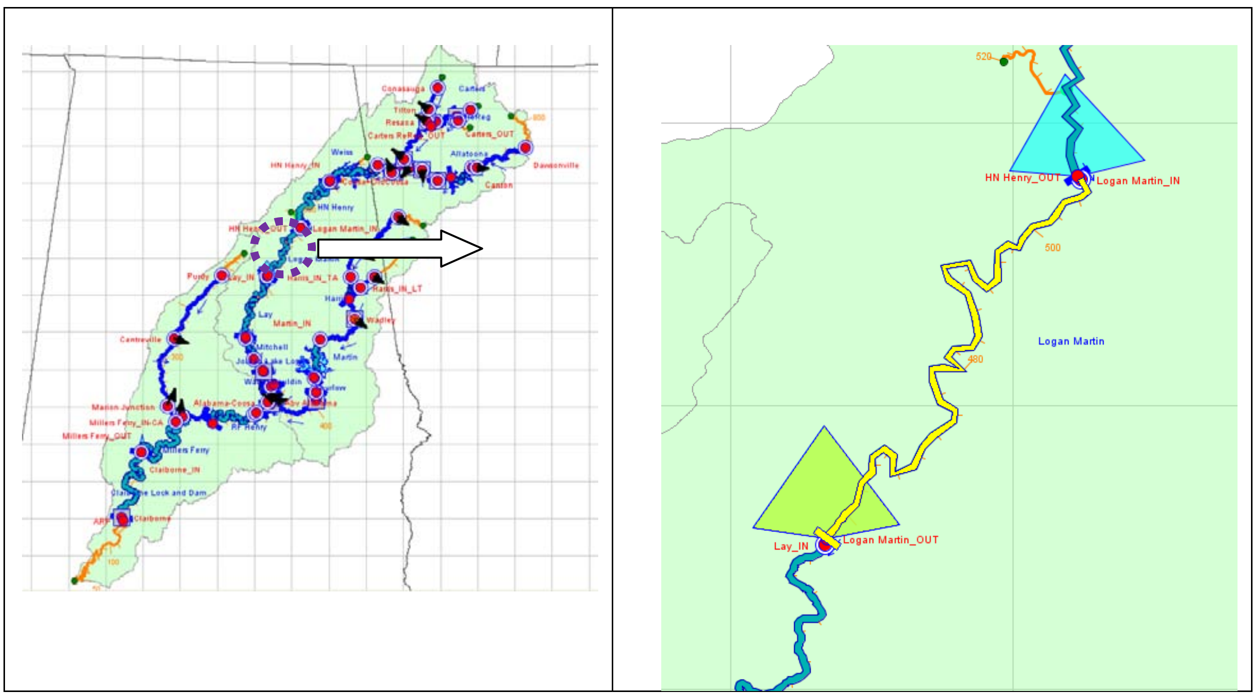


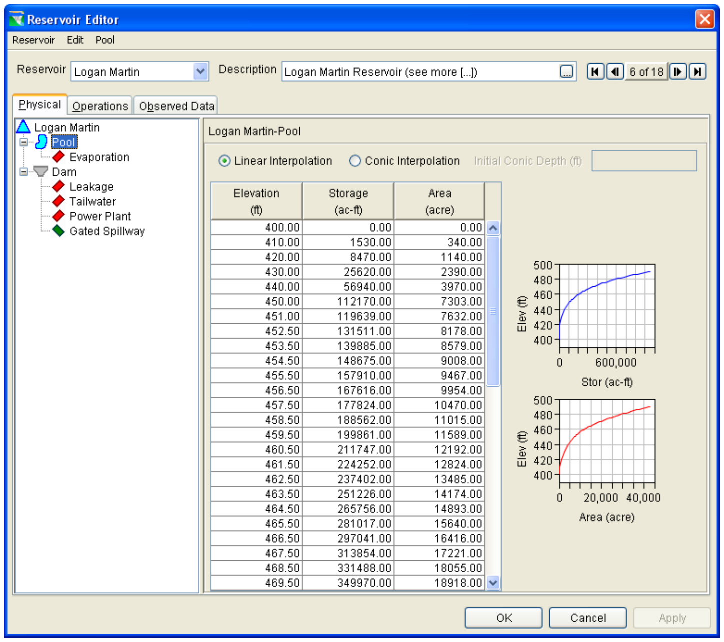
Figure G.01 HEC-ResSim Map Display Showing Location of Logan Martin Reservoir

Figure G.02 shows a photo of Logan Martin Dam.

Figure G.02 Photo of Logan Martin Dam

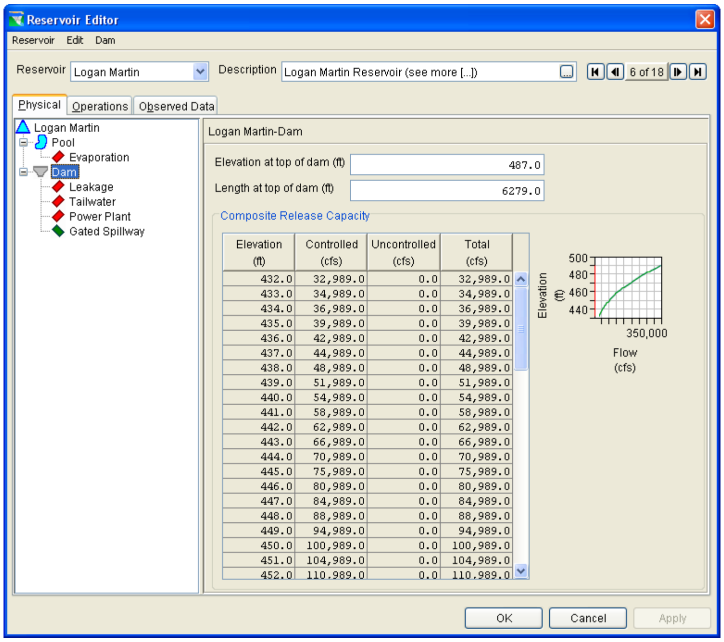
II. Physical Characteristics

The physical characteristics of each reservoir are separated between the "Pool" and the "Dam" in the ResSim model. The "elevation-storage-area" defines the pool as shown for Logan Martin Reservoir in Figure G.03. Logan Martin Dam consists of two types of outlets: (1) a gated spillway; and, (2) a power plant. Each of these outlets is defined in the model, and the Dam reflects the composite release capacity of all of the outlets as shown in Figure G.04.



Elevation (ft)	Storage (ac-ft)	Area (acre)
400.00	0.00	0.00
410.00	1530.00	340.00
420.00	8470.00	1140.00
430.00	25620.00	2390.00
440.00	56940.00	3970.00
450.00	112170.00	7303.00
451.00	119639.00	7632.00
452.50	131511.00	8178.00
453.50	139885.00	8579.00
454.50	148675.00	9008.00
455.50	157910.00	9467.00
456.50	167616.00	9954.00
457.50	177824.00	10470.00
458.50	188562.00	11015.00
459.50	199861.00	11589.00
460.50	211747.00	12192.00
461.50	224252.00	12824.00
462.50	237402.00	13485.00
463.50	251226.00	14174.00
464.50	265756.00	14893.00
465.50	281017.00	15640.00
466.50	297041.00	16416.00
467.50	313854.00	17221.00
468.50	331488.00	18055.00
469.50	349970.00	18918.00

Figure G.03 2009 Network…Reservoir Editor: Logan Martin Physical Tab – Pool



Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
432.0	32,989.0	0.0	32,989.0
433.0	34,989.0	0.0	34,989.0
434.0	36,989.0	0.0	36,989.0
435.0	39,989.0	0.0	39,989.0
436.0	42,989.0	0.0	42,989.0
437.0	44,989.0	0.0	44,989.0
438.0	48,989.0	0.0	48,989.0
439.0	51,989.0	0.0	51,989.0
440.0	54,989.0	0.0	54,989.0
441.0	58,989.0	0.0	58,989.0
442.0	62,989.0	0.0	62,989.0
443.0	66,989.0	0.0	66,989.0
444.0	70,989.0	0.0	70,989.0
445.0	75,989.0	0.0	75,989.0
446.0	80,989.0	0.0	80,989.0
447.0	84,989.0	0.0	84,989.0
448.0	88,989.0	0.0	88,989.0
449.0	94,989.0	0.0	94,989.0
450.0	100,989.0	0.0	100,989.0
451.0	104,989.0	0.0	104,989.0
452.0	110,989.0	0.0	110,989.0

Figure G.04 2009 Network…Reservoir Editor: Logan Martin Physical Tab –Dam

III. Baseline Operations

A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table G.01 shows the definition of "Baseline" operational zones for Logan Martin Reservoir, which consist of zones of flood control and conservation. The conservation pool is divided into several operational zones.

Table G.01 Zone Elevations for "Baseline" Operation Set

Logan Martin	Baseline Top of Zone Elevation Values (feet)							
Seasons =	1-Jan	1-Apr	9-May	1-Jun	1-Oct	1-Nov	1-Dec	31-Dec
Zones:								
Top of Dam	487	487	487	487	487	487	487	487
Flood Control	476.5	476.5	476.5	476.5	476.5	476.5	476.5	476.5
Conservation	460	460	465	465	465	462.1	linear	460
Drought	458	458	linear	462	linear	linear	458	458
Operating Inactive	456.25	456.25	456.25	456.25	456.25	456.25	456.25	456.25
Inactive	452.5	452.5	452.5	452.5	452.5	452.5	452.5	452.5

The top of two of the zones ("Conservation" and "Drought") vary seasonally. The top of the Conservation zone has been set to be the operational Guide Curve for Baseline operations (as shown in Figure G.05).

Guide Curve definition (top of **Conservation** zone)

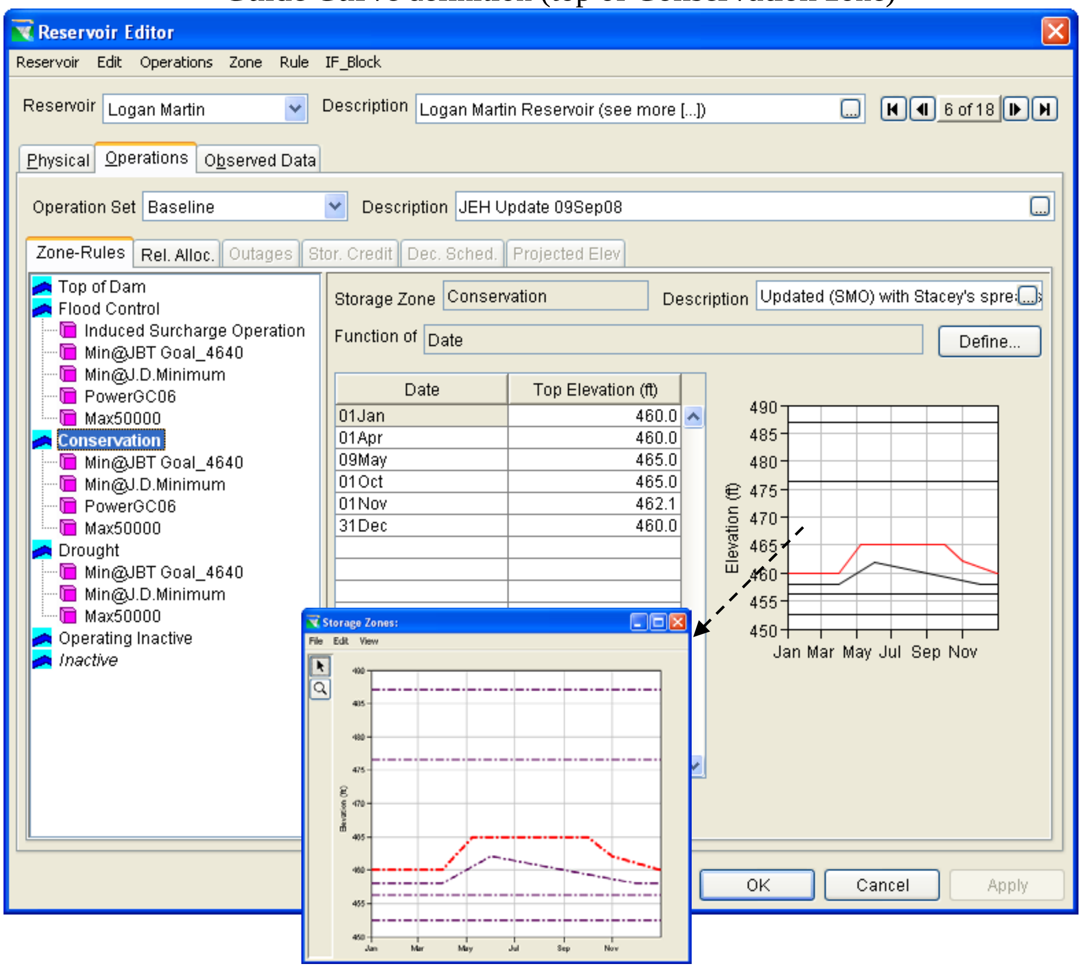


Figure G.05 Reservoir Editor: Operations Tab – Baseline OpSet – Guide Curve

Figure G.06 shows a sequential release allocation approach specified for available outlets along Logan Martin Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. After the capacity through the powerhouse is reached, the remainder of the release goes through the gated spillway.

Release Allocation:

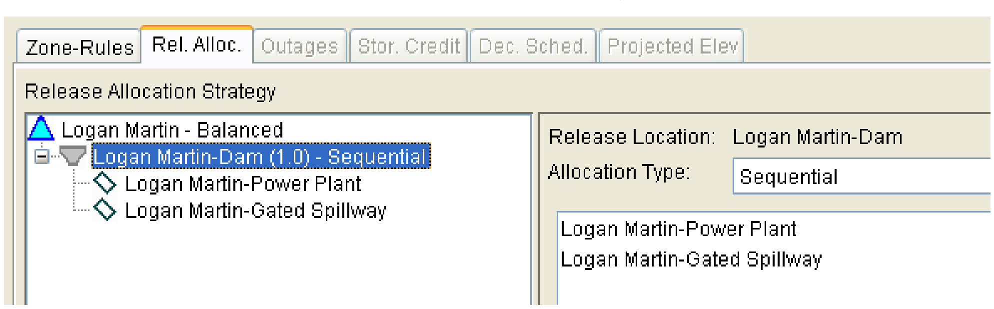


Figure G.06 Reservoir Editor: Operations Tab – Baseline OpSet – Release Allocation

B. Rule Illustrations

Figure G.07 shows a set of operational rules specified for each zone that reflects the operation set named "Baseline".

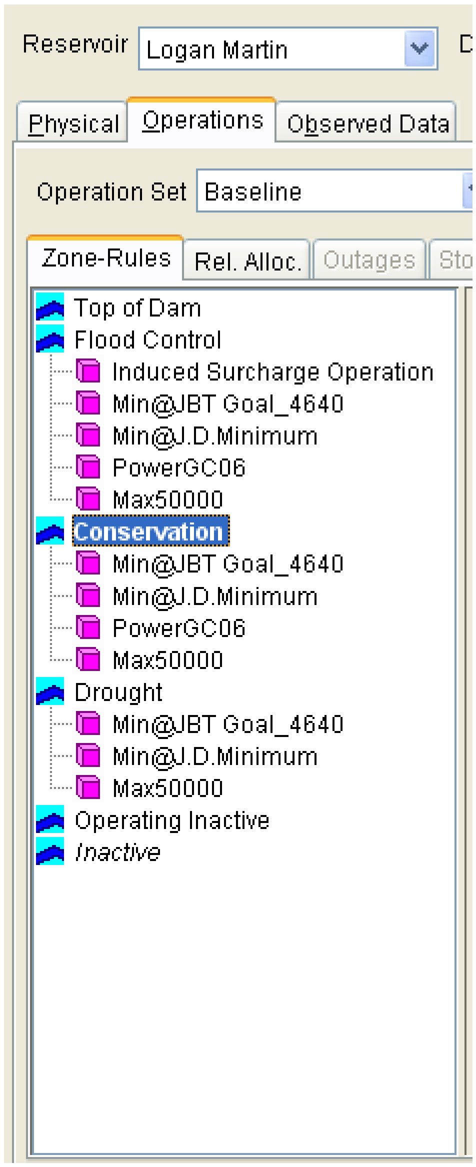


Figure G.07 Reservoir Editor: Operations Tab – Baseline OpSet – Zones and Rules

The content for each of these rules in the ResSim model are shown in Figure G.08 through Figure G.09. The logic and purpose for each operational rule is described in the paragraphs that follow Figure G.09.

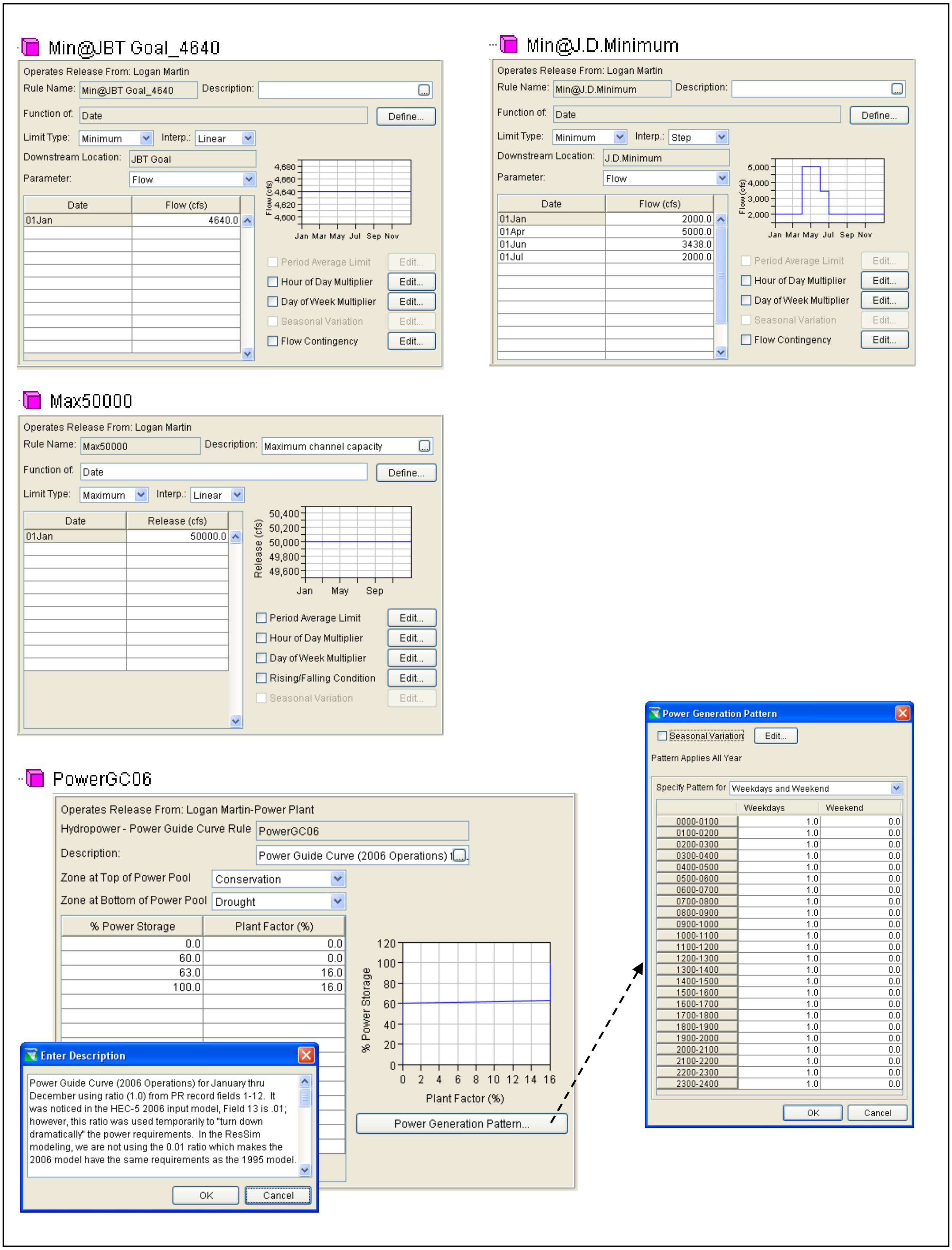


Figure G.08 Reservoir Editor: Operations Tab – Baseline OpSet – Min, Max, and Power Rules

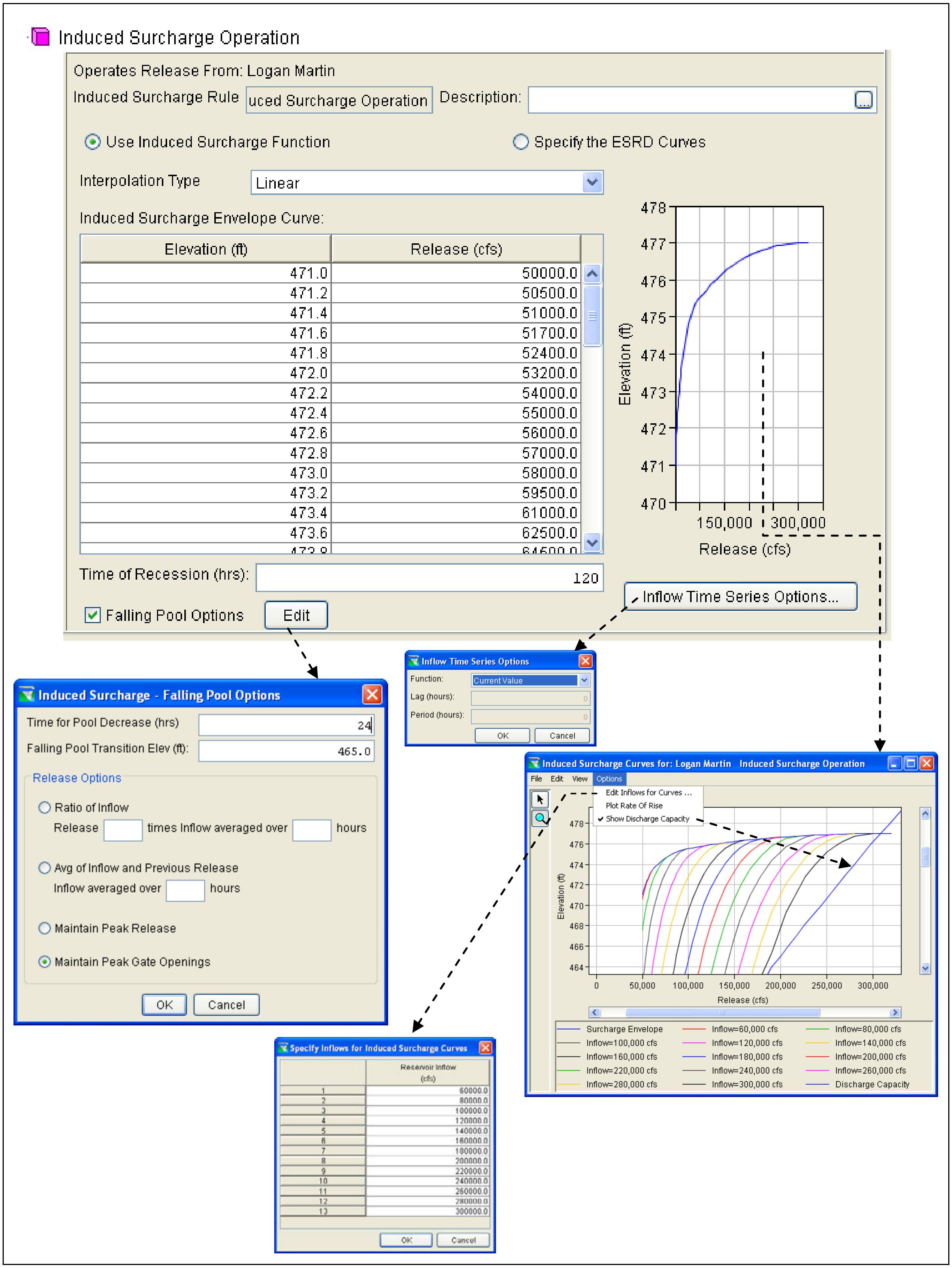


Figure G.09 Reservoir Editor: Operations Tab – Baseline OpSet – Induced Surcharge Rule

C. Rule Descriptions

1. Min@JBT Goal_4640

This rule (see Figure G.08) is a downstream control function rule that sets the minimum flow requirement at the downstream location named JBT Goal to a constant value of 4,640 cfs. This rule is applied in the Flood Control, Conservation, and Drought zones.

2. Min@J.D. Minimum

This rule (see Figure G.08) is a downstream control function rule that sets the minimum flow requirement at the downstream location named J.D. Minimum. This value varies from 2000 cfs to 5000 cfs throughout the year and is defined using a step function. This rule is applied in the Flood Control, Conservation, and Drought zones.

ResSim will take the larger of the above two minimum values at each time step to determine the minimum required release for downstream.

3. Max50000

This rule (see Figure G.08) sets the maximum release from Logan Martin to 50,000 cfs when in the flood control, conservation, and drought zones. When in the flood control zone, this release can be exceeded by the higher priority induced surcharge operation.

4. PowerGC06

This rule (see Figure G.08) is applied in both the Flood Control and Conservation zone. Depending on the percent of power storage in use, the plant factor will vary from 0% to 16%. The top of the power pool is defined from the top of Conservation to the top of Drought. At the lower elevations in this zone, the plant factor is set to 0% (0 hrs required generation). In the upper elevations of this zone, the plant factor is set to 16% (3.84 hrs required generation). The generation is set to weekdays (Monday through Friday) only by setting the power generation pattern to 1 on weekdays and 0 on weekends.

5. Induced Surcharge Operation

This rule (see Figure G.09) represents an induced surcharge operation for flood control. Induced surcharge operation is achieved by physically regulating the position of spillway gates. When the gate opening is reduced to limit release to less than free overflow (the fully-open position), water is intentionally surcharged behind the gates. Induced surcharge operation guidelines are derived from an envelope curve, which represents the relationship between a maximum allowable pool elevation and minimum required release for extreme flood events. For smaller flood inflows, the relationship between pool elevation and minimum required release can be derived using the surcharge envelope and a time of recession constant. A family of curves can be developed to cover the pool elevation vs. minimum release relationships for many different inflow values.

An induced surcharge rule in ResSim can be defined using a function or a family of curves. Since the induced surcharge rule at Logan Martin uses a function, then the rule requires an **Induced Surcharge Envelope Curve** and a **Time of Recession** (120 hrs used for Logan Martin). ResSim uses this information to calculate the pool elevation vs. minimum release relationship for any inflow. For the purposes of comparison to an induced surcharge chart in a Water Control Manual, or in order to check the calculated induced surcharge minimum flow values from a simulation, it is possible for the modeler to view the induced surcharge curves that ResSim generates. This is accomplished by double-clicking the induced surcharge function graph and adding a series of inflow values. Each inflow value entered will generate a curve depicting elevation vs. minimum release. The total outlet capacity can also be added to the chart. (The modeler should be aware that in the ResSim plot, the curves are drawn beyond the range to which they are actually applied in the model.)

The induced surcharge rule also includes falling pool options, which indicate how to apply the induced surcharge operation when the pool is falling and when to transition out of induced surcharge operation. The **Time for Pool Decrease** (24 hours for Logan Martin) is the required number of successive hours the reservoir pool level must be falling before transitioning from rising pool emergency spillway releases to falling pool releases. The **Falling Pool Transition Elev** (465 ft for Logan Martin) is the pool elevation below which the induced surcharge rule will no longer operate. The **Release Options** are to designate the method for computing falling pool releases. For Logan Martin, the option of **Maintain Peak Gate Openings** is selected.

Alabama-Coosa-Tallapoosa (ACT) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update

[Baseline]

Appendix H – Harris Reservoir

March 2011 (DRAFT)

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Appendix H – Harris [Baseline] (DRAFT)

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Harris Reservoir

I. Overview

RL Harris Dam is on the Tallapoosa River in Randolph County, Alabama. The reservoir is 24 miles long and extends up both the Tallapoosa and Little Tallapoosa Rivers and lies within Randolph and Clay Counties. Crooked Creek is just downstream of the dam. The dam is located half way between Montgomery, Alabama and Atlanta, Georgia. The total drainage area that contributes flow at this location is 1,453 square miles. The dam is owned and operated by the Alabama Power Company.

The project consists of a concrete gravity dam about 150 ft high and 1,142 ft long. It includes a 310 ft long spillway. The spillway contains 6 tainter gates each 40.5 ft wide and 40 ft high. The spillway crest elevation is 753.0 ft. The powerhouse contains two 67.5 MW units giving a total capacity of 135MW.

Figure H.01 shows the location of Harris Reservoir as it is represented in the HEC-ResSim model.

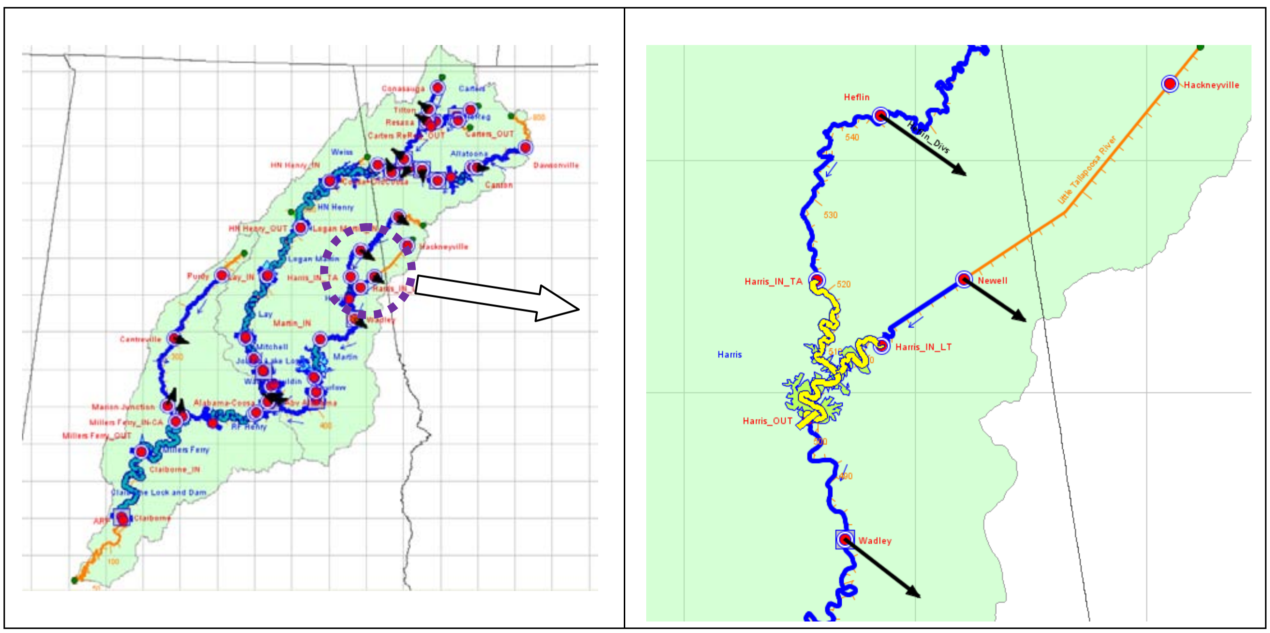


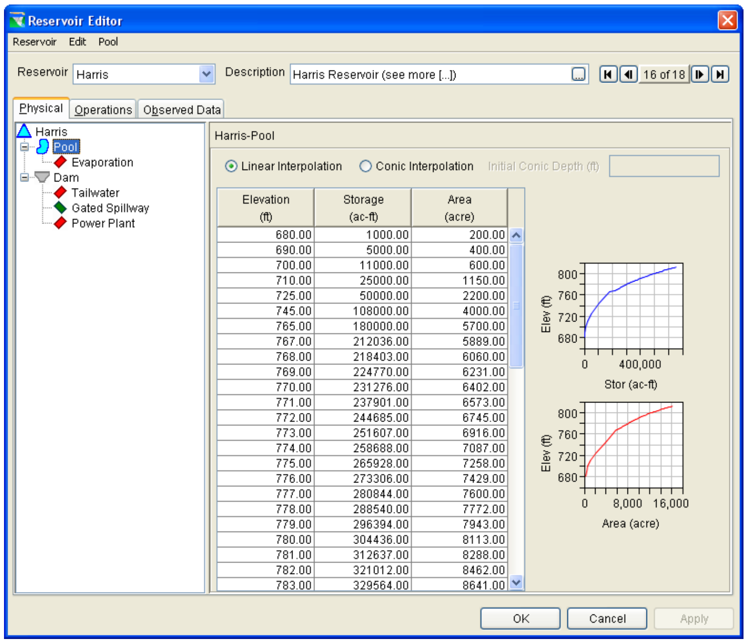
Figure H.01 HEC-ResSim Map Display Showing Location of Harris Reservoir

Figure H.02 shows a photo of RL Harris Dam.

Figure H.02 Photo of RL Harris Dam

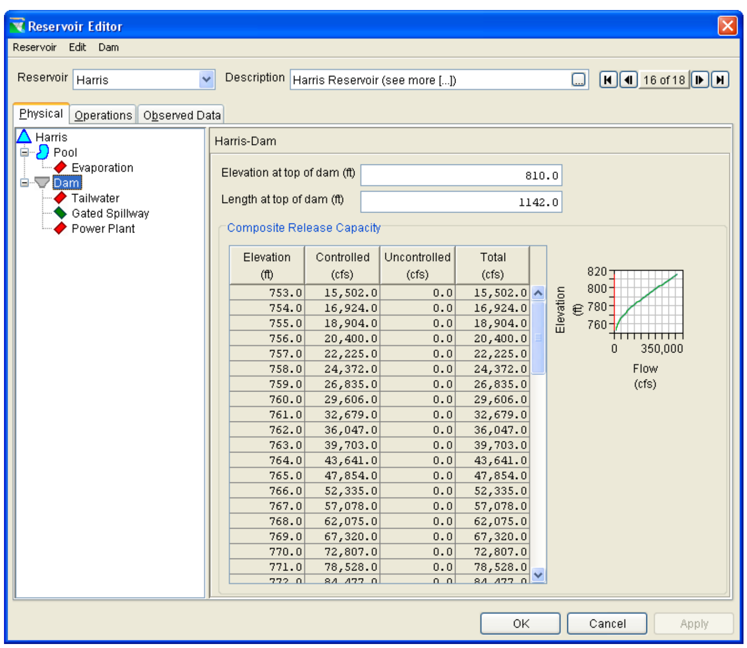
II. Physical Characteristics

The physical characteristics of each reservoir are separated between the "Pool" and the "Dam" in the ResSim model. The "elevation-storage-area" defines the pool as shown for Harris Reservoir in Figure H.03. Harris Dam consists of two types of outlets: (1) a gated spillway; and, (2) a power plant. Each of these outlets is defined in the model, and the Dam reflects the composite release capacity of all of the outlets as shown in Figure H.04.



Elevation (ft)	Storage (ac-ft)	Area (acre)
680.00	1000.00	200.00
690.00	5000.00	400.00
700.00	11000.00	600.00
710.00	25000.00	1150.00
725.00	50000.00	2200.00
745.00	108000.00	4000.00
765.00	180000.00	5700.00
767.00	212036.00	5889.00
768.00	218403.00	6060.00
769.00	224770.00	6231.00
770.00	231276.00	6402.00
771.00	237901.00	6573.00
772.00	244685.00	6745.00
773.00	251607.00	6916.00
774.00	258688.00	7087.00
775.00	265928.00	7258.00
776.00	273306.00	7429.00
777.00	280844.00	7600.00
778.00	288540.00	7772.00
779.00	296394.00	7943.00
780.00	304436.00	8113.00
781.00	312637.00	8288.00
782.00	321012.00	8462.00
783.00	329564.00	8641.00

Figure H.03 2009 Network…Reservoir Editor: Harris Physical Tab – Pool



Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
753.0	15,502.0	0.0	15,502.0
754.0	16,924.0	0.0	16,924.0
755.0	18,904.0	0.0	18,904.0
756.0	20,400.0	0.0	20,400.0
757.0	22,225.0	0.0	22,225.0
758.0	24,372.0	0.0	24,372.0
759.0	26,835.0	0.0	26,835.0
760.0	29,606.0	0.0	29,606.0
761.0	32,679.0	0.0	32,679.0
762.0	36,047.0	0.0	36,047.0
763.0	39,703.0	0.0	39,703.0
764.0	43,641.0	0.0	43,641.0
765.0	47,854.0	0.0	47,854.0
766.0	52,335.0	0.0	52,335.0
767.0	57,078.0	0.0	57,078.0
768.0	62,075.0	0.0	62,075.0
769.0	67,320.0	0.0	67,320.0
770.0	72,807.0	0.0	72,807.0
771.0	78,528.0	0.0	78,528.0
772.0	84,477.0	0.0	84,477.0

Figure H.04 2009 Network…Reservoir Editor: Harris Physical Tab –Dam

III. Baseline Operations

A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table H.01 shows the definition of "Baseline" operational zones for Harris Reservoir, which consist of zones of flood control and conservation. The conservation pool is divided into several operational zones.

Table H.01 Zone Elevations for "Baseline" Operation Set

Harris	Baseline Top of Zone Elevation Values (feet)					
Seasons =	1-Jan	1-Apr	1-May	1-Jun	1-Oct	1-Dec
Zones:						
Top of Dam	810	810	810	810	810	810
Flood Control	795	795	795	795	795	795
Conservation	785	785	793	793	793	785
Drought	781	781	linear	791	linear	781
Operating Inactive	770.5	770.5	770.5	770.5	770.5	770.5
Inactive	768	768	768	768	768	768

The top of two of the zones ("Conservation" and "Drought") vary seasonally. The top of the Conservation zone has been set to be the operational Guide Curve for Baseline operations (as shown in Figure H.05).

Guide Curve definition (top of **Conservation** zone)

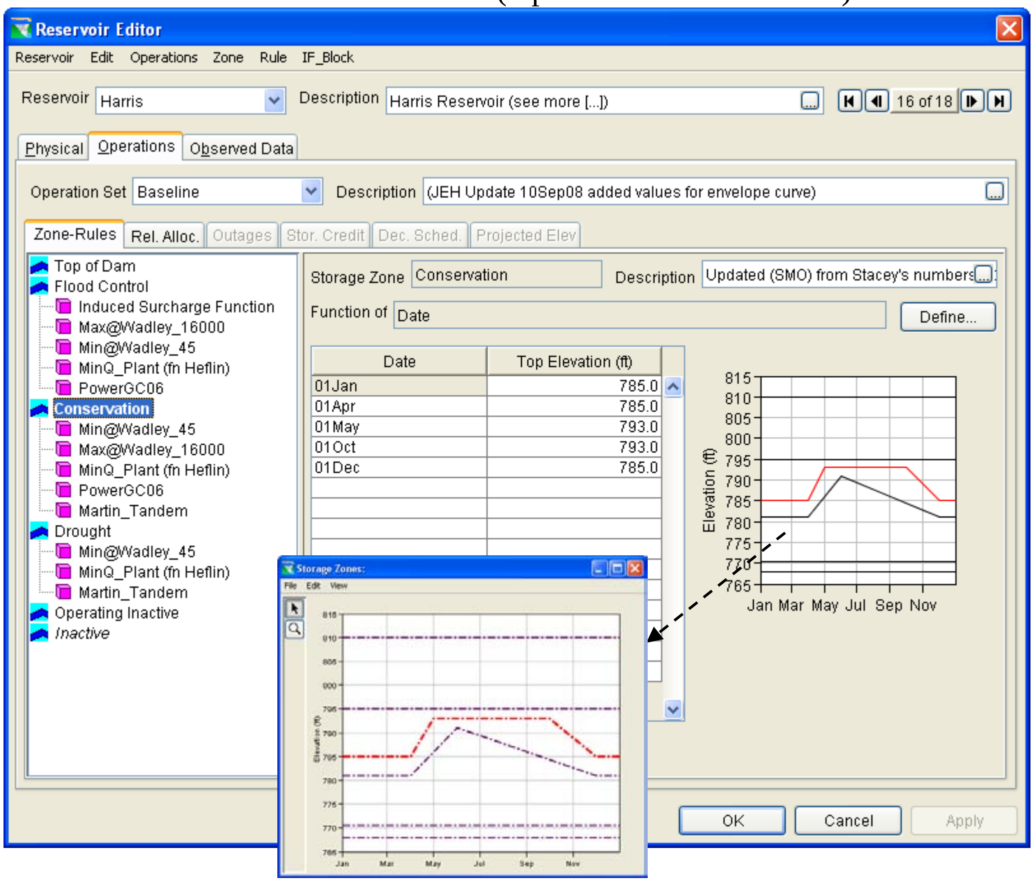


Figure H.05 Reservoir Editor: Operations Tab – Baseline OpSet – Guide Curve

Figure H.06 shows a sequential release allocation approach specified for available outlets along Harris Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. After the capacity through the powerhouse is reached, the remainder of the release goes through the gated spillway.

Release Allocation:

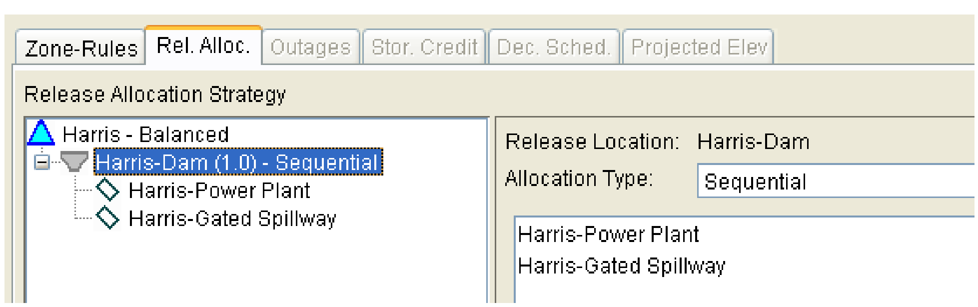


Figure H.06 Reservoir Editor: Operations Tab – Baseline OpSet – Release Allocation

B. Rule Illustrations

Figure H.07 shows a set of operational rules specified for each zone that reflects the operation set named “Baseline”.

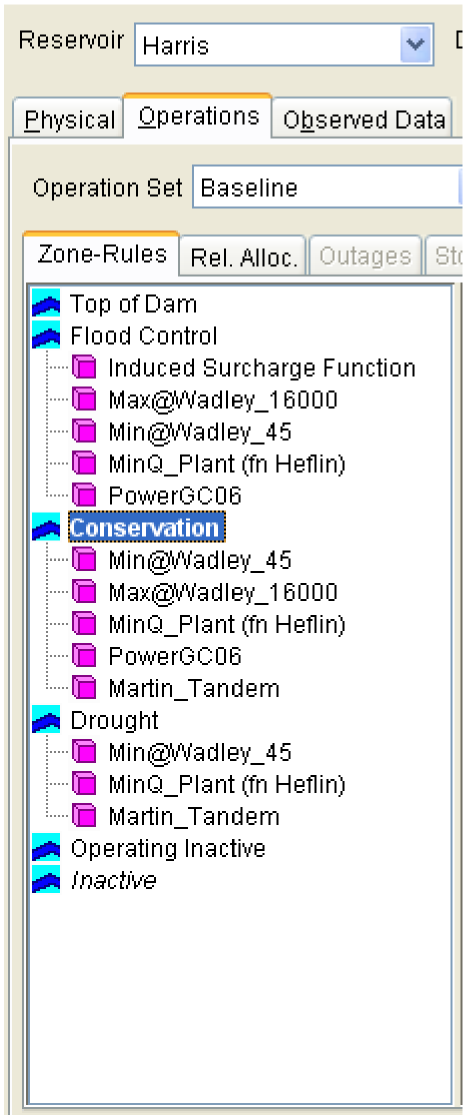


Figure H.07 Reservoir Editor: Operations Tab – Baseline OpSet – Zones and Rules

The content for each of these rules in the ResSim model are shown in Figure H.08 and Figure H.09. The logic and purpose for each operational rule is described in the paragraphs that follow Figure H.09.

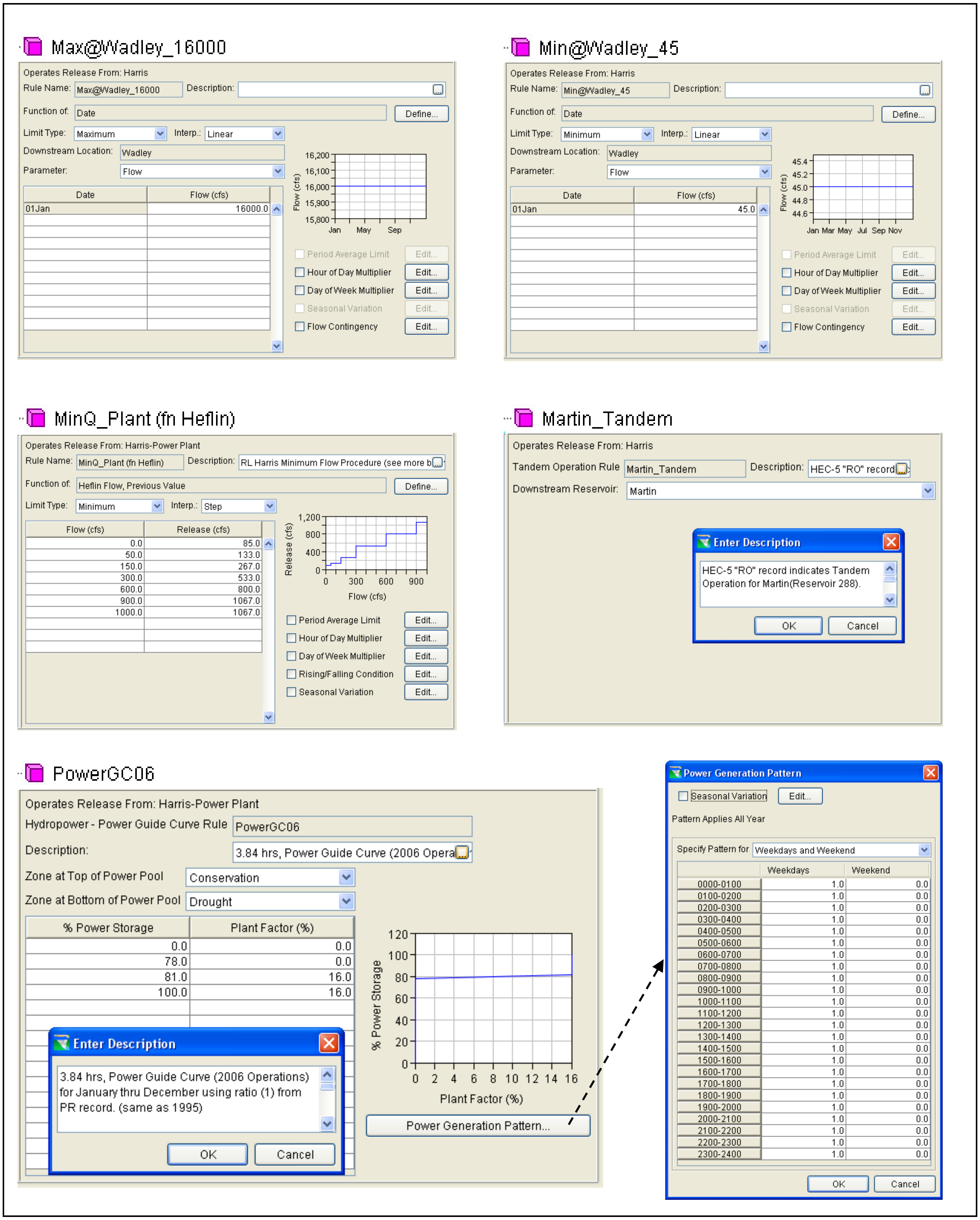


Figure H.08 Reservoir Editor: Operations Tab – Baseline OpSet – Max, Min, Tandem, and Power Rules

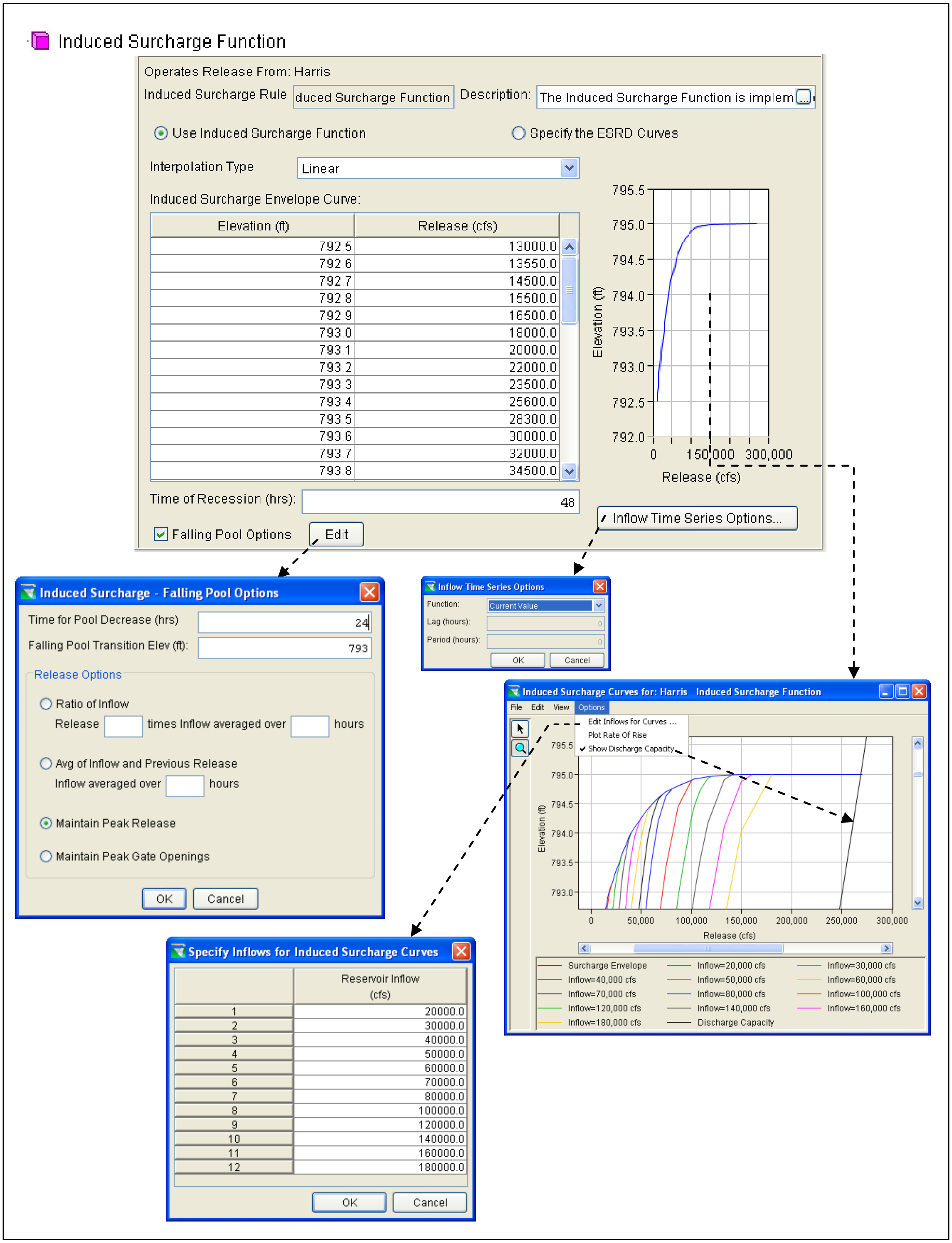


Figure H.09 Reservoir Editor: Operations Tab – Baseline OpSet – Induced Surcharge Rule

C. Rule Descriptions

1. Max@Wadley_16000

This rule (see Figure H.08) is a downstream control function rule that limits the maximum flow at Wadley to 16,000 cfs throughout the entire year. This rule is given in the Flood Control and Conservation zone. This maximum flow value at the downstream location can be exceeded due to intervening flows or through the activation of the induced surcharge function.

2. Min@Wadley_45

This rule (see Figure H.08) is a downstream control function rule that sets the minimum flow objective at Wadley to 45 cfs throughout the entire year. This rule is applied in the Flood Control, Conservation, and Drought zones.

3. MinQ_Plant (fn Heflin)

This rule (see Figure H.08) sets the minimum power plant release based on the previous time step flow at the upstream gage of Heflin. The required minimum release ranges from 85 cfs to 1,067 cfs and always exceeds the flow value at Heflin. This relationship is given as a step function. This rule is applied in the Flood Control, Conservation, and Drought zones.

4. Martin_Tandem

This rule (see Figure H.08) is used to balance the storage in Harris for the storage in the downstream reservoir, Martin. The balance is done for each zone. For instance, if Harris is in the conservation zone, ResSim will compute the percent full using the storage from top of Conservation to top of Drought and adjust flows to achieve the same percent full in that zone at Martin. The ability of ResSim to achieve this balance is limited by higher priority rules.

5. PowerGC06

This rule (see Figure H.08) is applied in both the Flood Control and Conservation zone. Depending on the percent of power storage in use, the plant factor will vary from 0% to 16%. The top of the power pool is defined from the top of Conservation to the top of Drought. At the lower elevations in this zone, the plant factor is set to 0% (0 hrs required generation). In the upper elevations of this zone, the plant factor is set to 16% (3.84 hrs required generation). The generation is set to weekdays (Monday through Friday) only by setting the power generation pattern to 1 on weekdays and 0 on weekends.

6. Induced Surcharge Function

This rule (see Figure H.09) represents an induced surcharge operation for flood control. Induced surcharge operation is achieved by physically regulating the position of spillway gates. When the gate opening is reduced to limit release to less than free overflow (the fully-open position), water is intentionally surcharged behind the gates. Induced surcharge operation guidelines are derived from an envelope curve, which represents the relationship between a maximum allowable pool elevation and minimum required release for extreme flood events. For smaller flood inflows, the relationship between pool elevation and minimum required release can be derived using the surcharge envelope and a time of recession constant. A family of curves can be developed to cover the pool elevation vs. minimum release relationships for many different inflow values.

An induced surcharge rule in ResSim can be defined using a function or a family of curves. Since the induced surcharge rule at Harris uses a function, then the rule requires an **Induced Surcharge Envelope Curve** and a **Time of Recession** (48 hrs used for Harris). ResSim uses this information to calculate the pool elevation vs. minimum release relationship for any inflow. For the purposes of comparison to an induced surcharge chart in a Water Control Manual, or in order to check the calculated induced surcharge minimum flow values from a simulation, it is possible for the modeler to view the induced surcharge curves that ResSim generates. This is accomplished by double-clicking the induced surcharge function graph and adding a series of inflow values. Each inflow value entered will generate a curve depicting elevation vs. minimum release. The total outlet capacity can also be added to the chart. (The modeler should be aware that in the ResSim plot, the curves are drawn beyond the range to which they are actually applied in the model.)

The induced surcharge rule also includes falling pool options, which indicate how to apply the induced surcharge operation when the pool is falling and when to transition out of induced surcharge operation. The **Time for Pool Decrease** (24 hours for Harris) is the required number of successive hours the reservoir pool level must be falling before transitioning from rising pool emergency spillway releases to falling pool releases. The **Falling Pool Transition Elev** (793 ft for Harris) is the pool elevation below which the induced surcharge rule will no longer operate. The **Release Options** are to designate the method for computing falling pool releases. For Harris, the option of **Maintain Peak Release** is selected.

Alabama-Coosa-Tallapoosa (ACT) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update

[Baseline]

Appendix I – Martin Reservoir

March 2011 (DRAFT)

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Appendix I – Martin [Baseline] (DRAFT)

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Martin Reservoir

I. Overview

Martin Dam is owned by the Alabama Power Company. At the time of construction during the 1920's, the 40,000 acre reservoir was the largest artificial body of water in existence. It is located on the Tallapoosa River near the town of Dadeville, Alabama. It is 8 miles upstream from Yates Dam and lies within Elmore and Tallapoosa Counties. The total area of watershed draining into the reservoir is 3,000 square miles.

The dam is a concrete gravity type 2,000 feet long and 168 feet high. There are twenty spillway gates which are 30 feet by 16 feet each. The dam also includes a powerhouse. The total generating capacity of the powerhouse is 182.5 MW. The primary purposes of the dam are the production of hydro power and flood control storage.

Figure I.01 shows the location of Martin Reservoir as it is represented in the HEC-ResSim model.

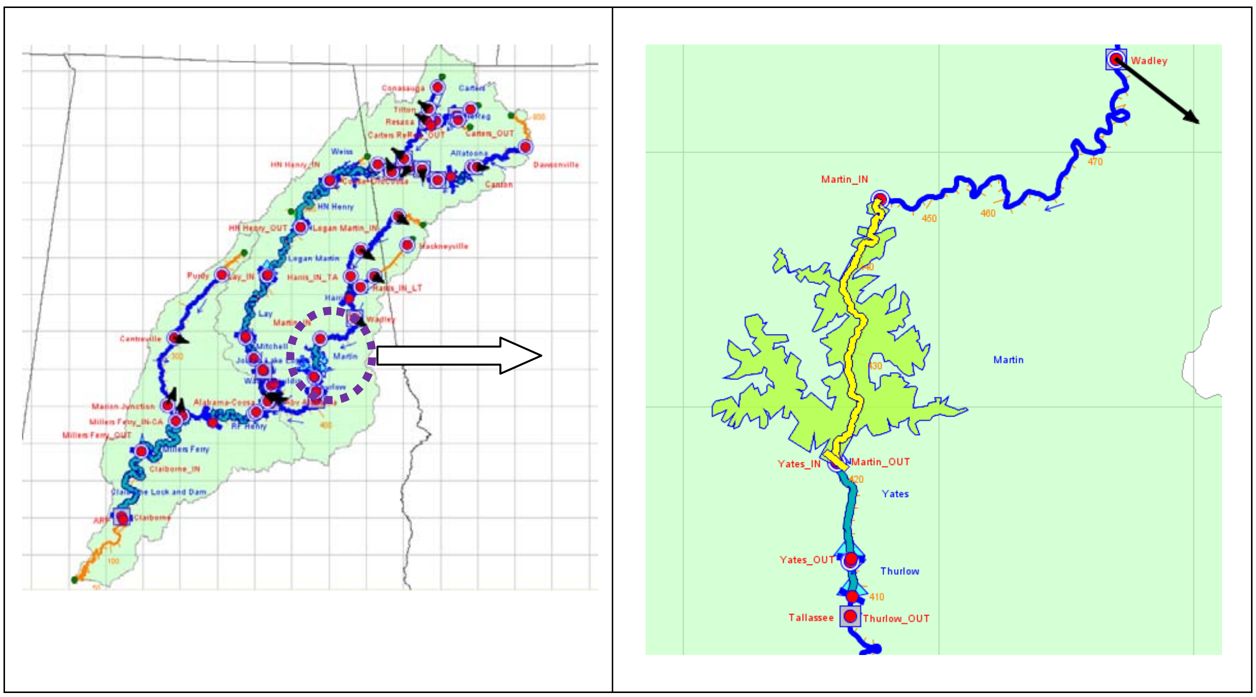


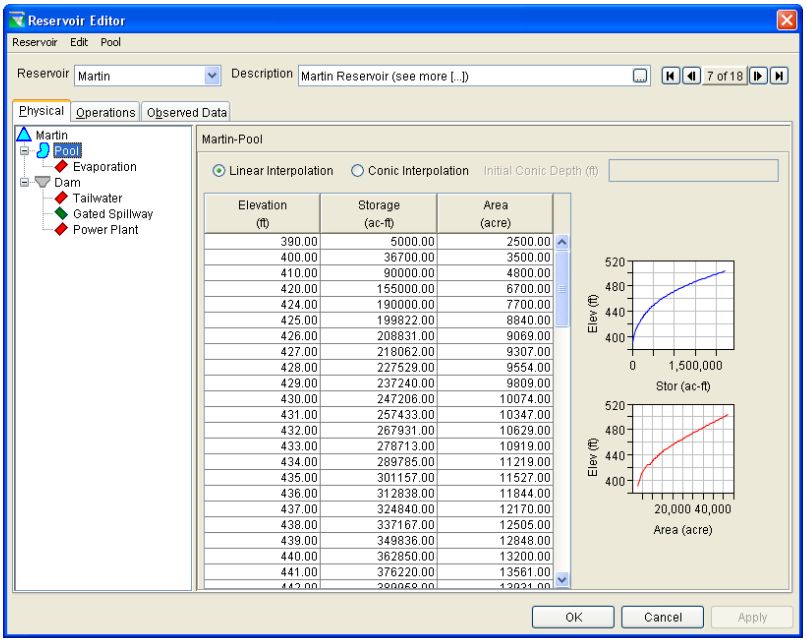
Figure I.01 HEC-ResSim Map Display Showing Location of Martin Reservoir

Figure I.02 shows a photo of Martin Dam.

Figure I.02 Photo of Martin Dam

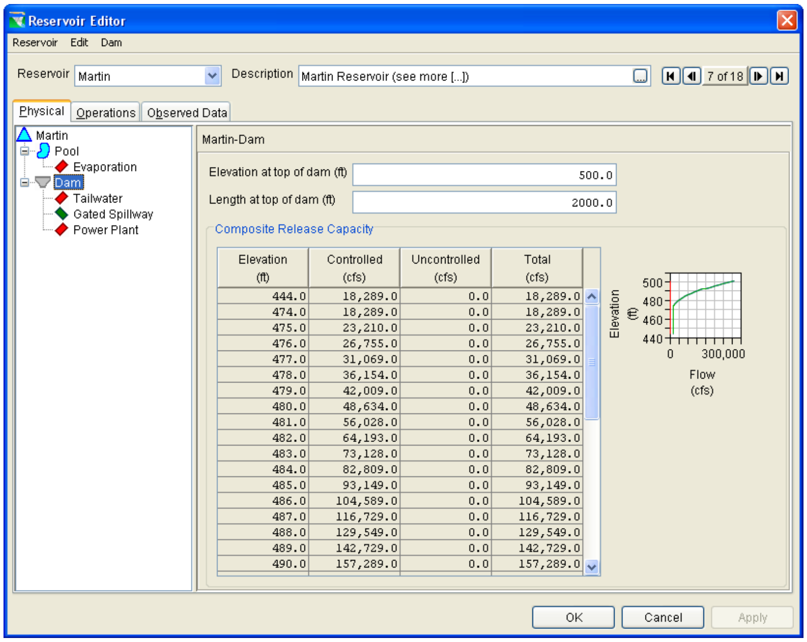
II. Physical Characteristics

The physical characteristics of each reservoir are separated between the "Pool" and the "Dam" in the ResSim model. The "elevation-storage-area" defines the pool as shown for Martin Reservoir in Figure I.03. Martin Dam consists of two types of outlets: (1) a gated spillway; and, (2) a power plant. Each of these outlets is defined in the model, and the Dam reflects the composite release capacity of all of the outlets as shown in Figure I.04.



Elevation (ft)	Storage (ac-ft)	Area (acre)
390.00	5000.00	2500.00
400.00	36700.00	3500.00
410.00	90000.00	4800.00
420.00	155000.00	6700.00
424.00	190000.00	7700.00
425.00	199822.00	8840.00
426.00	208831.00	9069.00
427.00	218062.00	9307.00
428.00	227529.00	9554.00
429.00	237240.00	9809.00
430.00	247206.00	10074.00
431.00	257433.00	10347.00
432.00	267931.00	10629.00
433.00	278713.00	10919.00
434.00	289785.00	11219.00
435.00	301157.00	11527.00
436.00	312838.00	11844.00
437.00	324840.00	12170.00
438.00	337167.00	12505.00
439.00	349836.00	12848.00
440.00	362850.00	13200.00
441.00	376220.00	13561.00

Figure I.03 2009 Network…Reservoir Editor: Martin Physical Tab – Pool



Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
444.0	18,289.0	0.0	18,289.0
474.0	18,289.0	0.0	18,289.0
475.0	23,210.0	0.0	23,210.0
476.0	26,755.0	0.0	26,755.0
477.0	31,069.0	0.0	31,069.0
478.0	36,154.0	0.0	36,154.0
479.0	42,009.0	0.0	42,009.0
480.0	48,634.0	0.0	48,634.0
481.0	56,028.0	0.0	56,028.0
482.0	64,193.0	0.0	64,193.0
483.0	73,128.0	0.0	73,128.0
484.0	82,809.0	0.0	82,809.0
485.0	93,149.0	0.0	93,149.0
486.0	104,589.0	0.0	104,589.0
487.0	116,729.0	0.0	116,729.0
488.0	129,549.0	0.0	129,549.0
489.0	142,729.0	0.0	142,729.0
490.0	157,289.0	0.0	157,289.0

Figure I.04 2009 Network…Reservoir Editor: Martin Physical Tab –Dam

III. Baseline Operations

A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table I.01 shows the definition of "Baseline" operational zones for Martin Reservoir, which consists of zones of flood control and conservation. The conservation pool is divided into several operational zones.

Table I.01 Zone Elevations for "Baseline" Operation Set

Martin	Baseline Top of Zone Elevation Values (feet)										
Seasons =	1-Jan	17-Feb	1-Mar	1-Apr	28-Apr	1-Jun	2-Sep	28-Sep	26-Oct	1-Nov	1-Dec
Zones:											
Top of Dam	500	500	500	500	500	500	500	500	500	500	500
Flood Control	490	490	490	490	490	490	490	490	490	490	490
Conservation	480	480	483.19	488.05	489.5	489.5	489.5	488.22	486.3	485.59	482.04
Drought	476	476	476	linear	linear	486	linear	linear	linear	linear	476
Operating Inactive	445.75	445.75	445.75	445.75	445.75	445.75	445.75	445.75	445.75	445.75	445.75
Inactive	444.5	444.5	444.5	444.5	444.5	444.5	444.5	444.5	444.5	444.5	444.5

The top of two of the zones ("Conservation" and "Drought") vary seasonally. The top of the Conservation zone has been set to be the operational Guide Curve for Baseline operations (as shown in Figure I.05).

Guide Curve definition (top of **Conservation** zone)

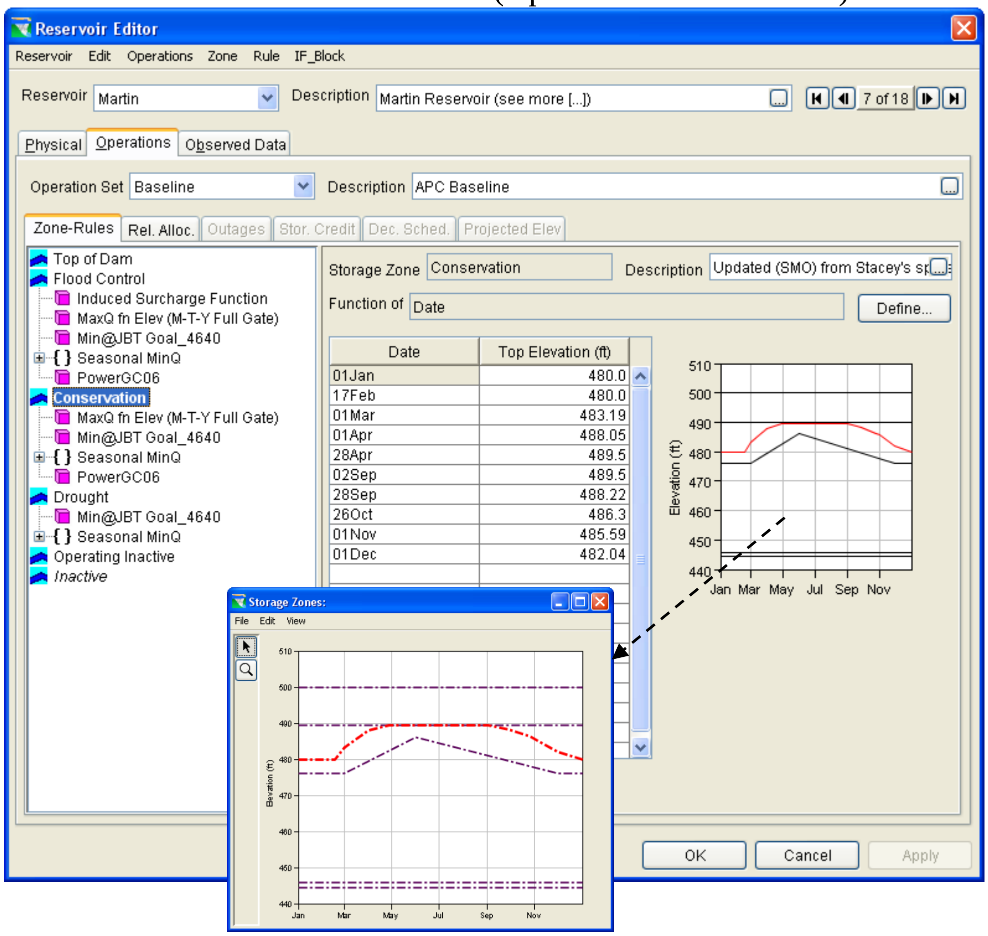


Figure I.05 Reservoir Editor: Operations Tab – Baseline OpSet – Guide Curve

Figure I.06 shows a sequential release allocation approach specified for available outlets along Martin Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. After the capacity through the powerhouse is reached, the remainder of the release goes through the gated spillway.

Release Allocation:

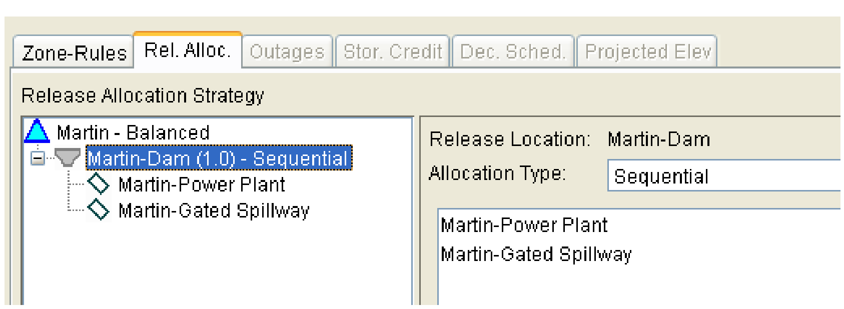


Figure I.06 Reservoir Editor: Operations Tab – Baseline OpSet – Release Allocation

B. Rule Illustrations

Figure I.07 shows a set of operational rules specified for each zone that reflects the operation set named “Baseline”.

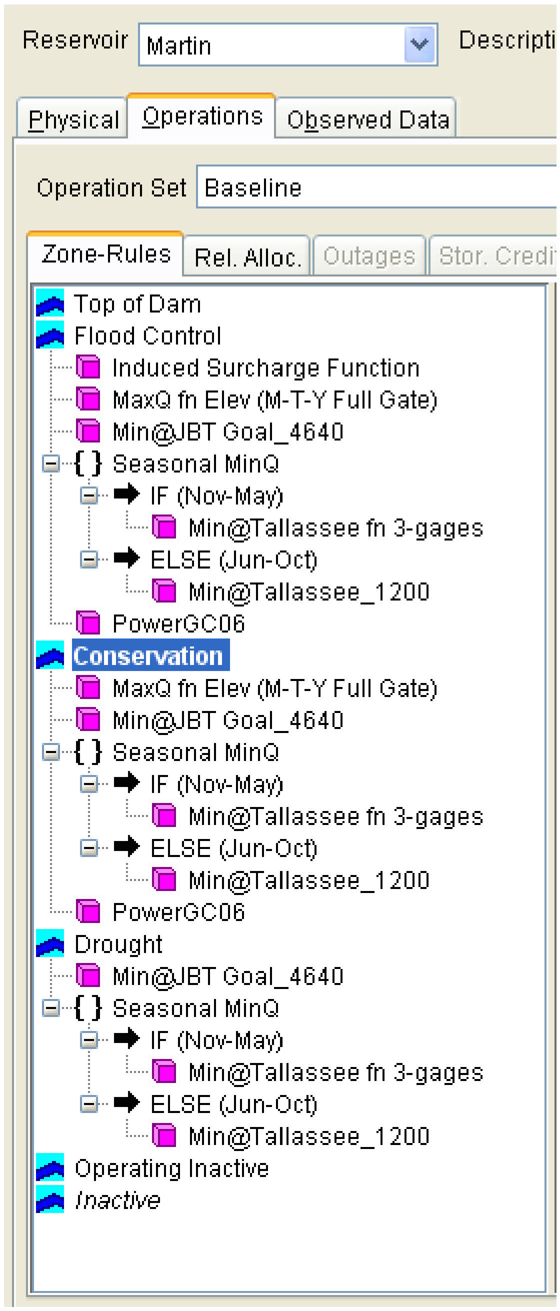


Figure I.07 Reservoir Editor: Operations Tab – Baseline OpSet – Zones and Rules

The content for each of these rules in the ResSim model are shown in Figure I.08 through Figure I.10. The logic and purpose for each operational rule is described in the paragraphs that follow Figure I.10.

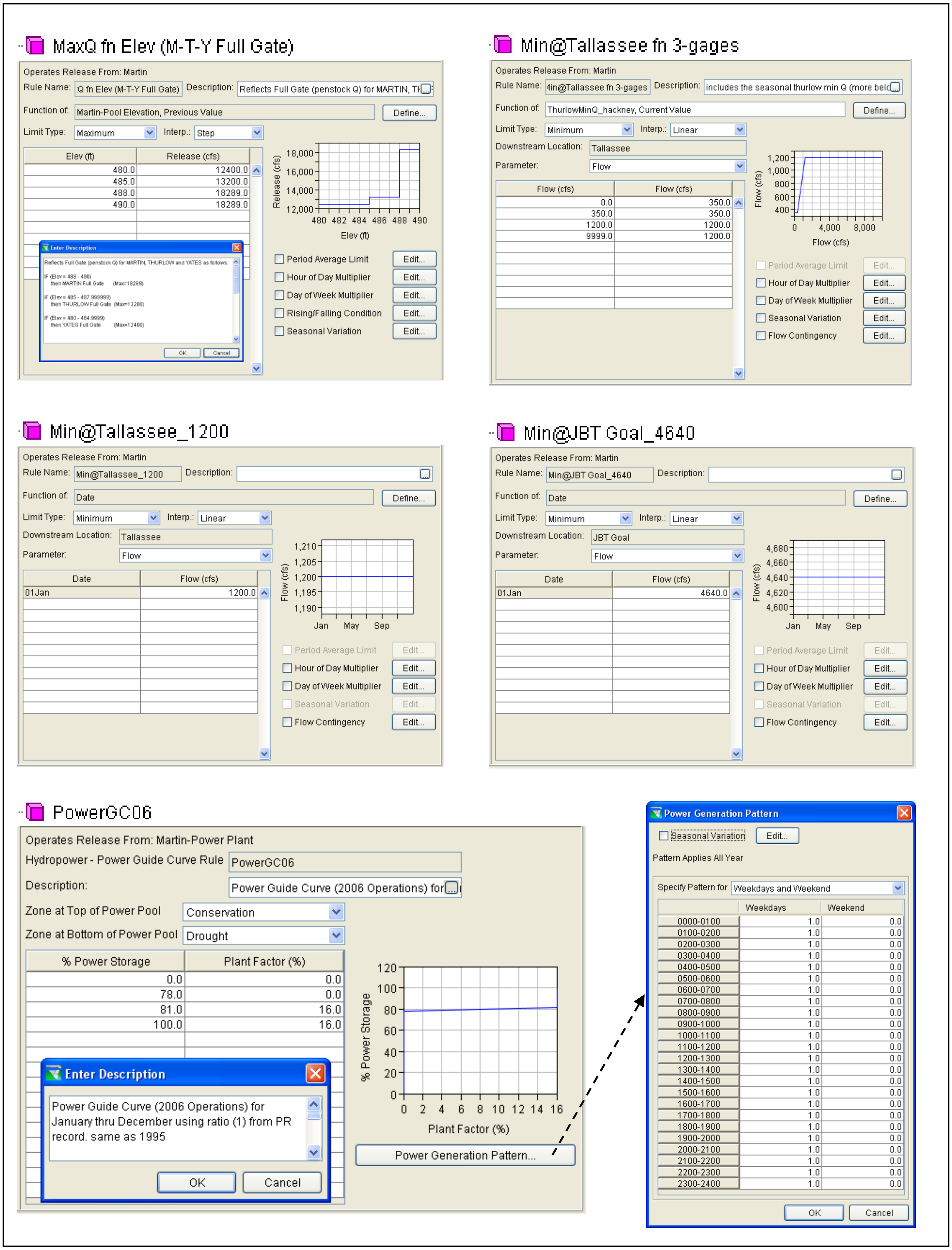


Figure I.08 Reservoir Editor: Operations Tab – Baseline OpSet – Max, Min, and Power Rules

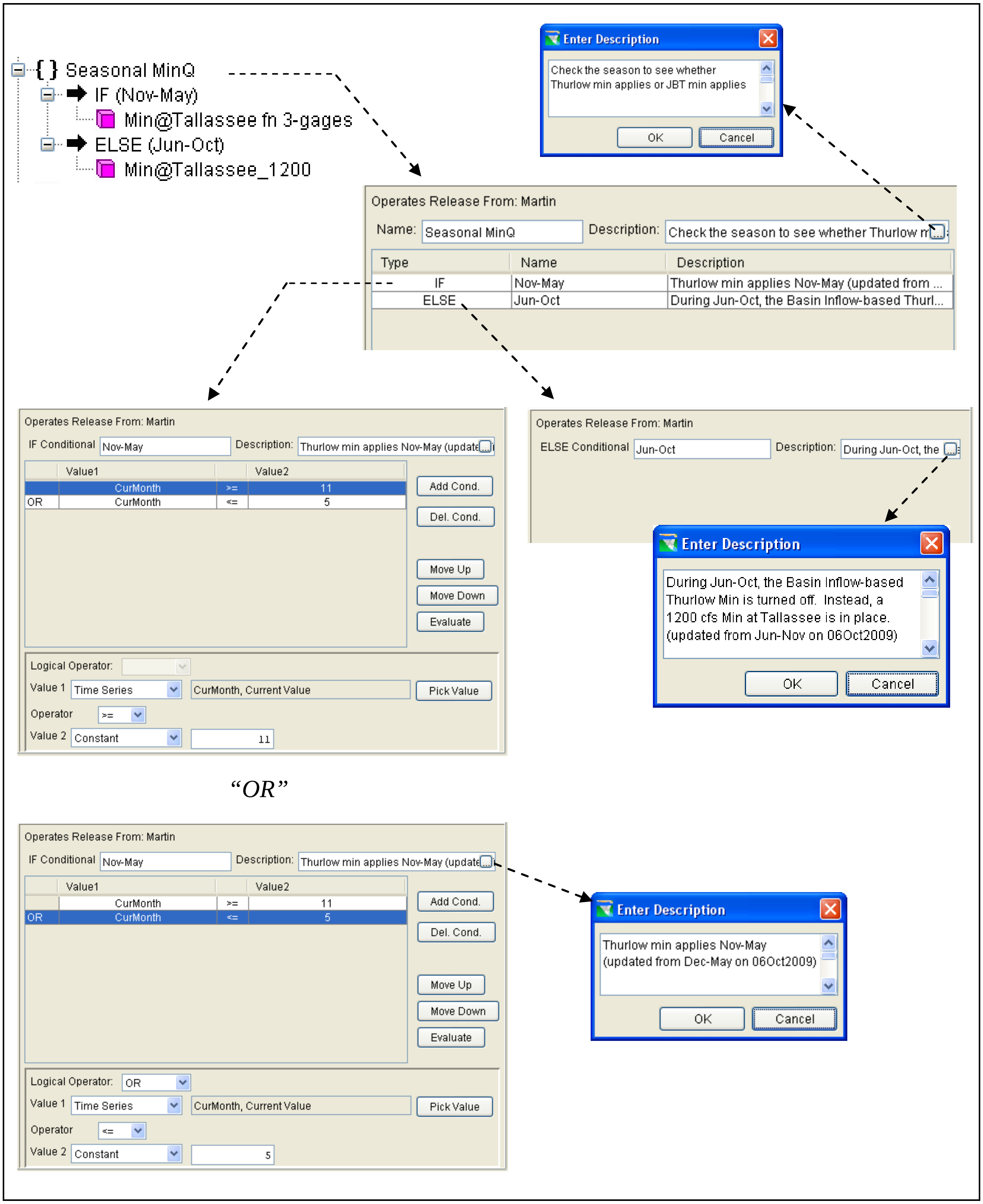


Figure I.09 Seasonal Min -- "Conditional Blocks"

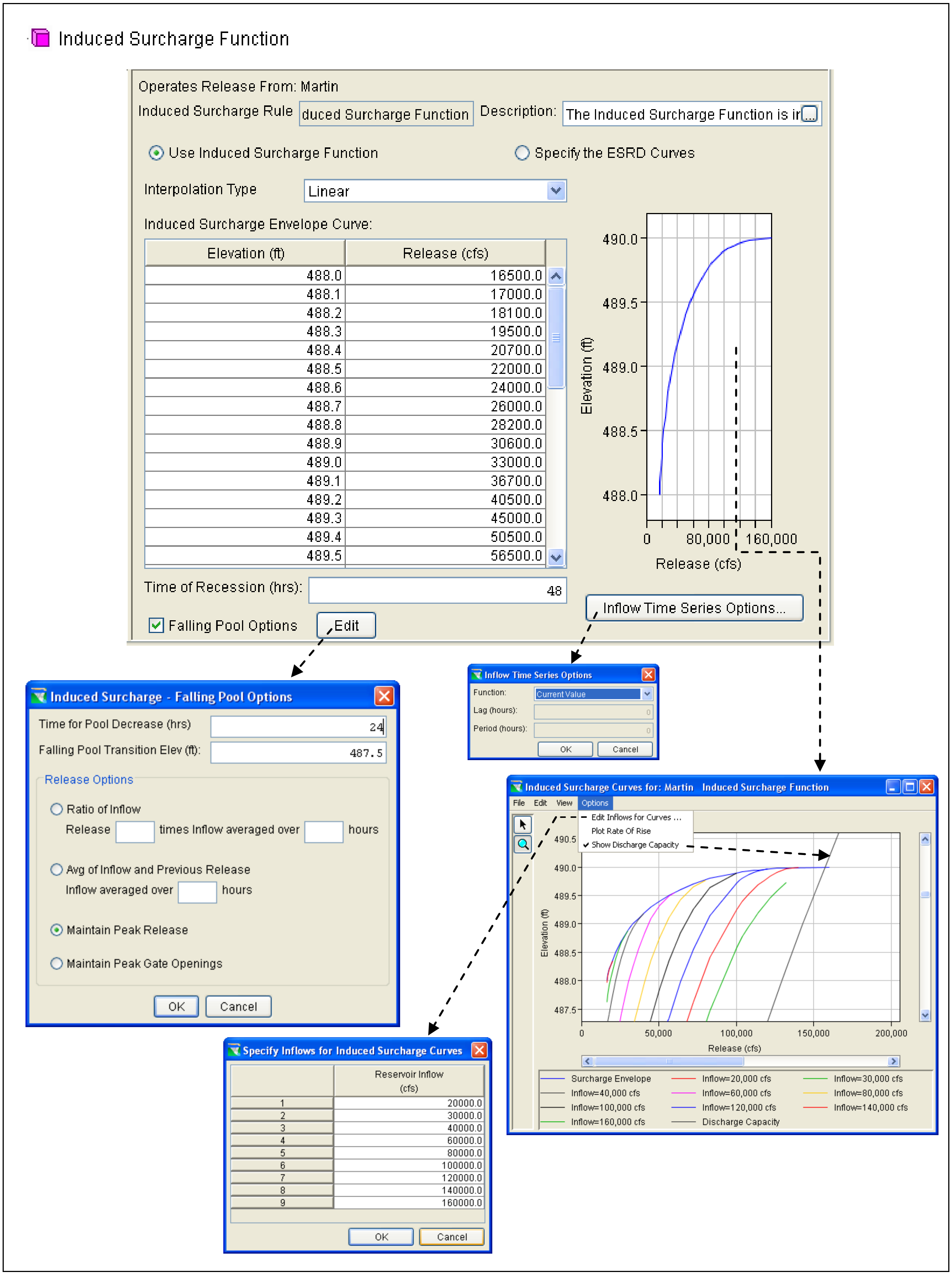


Figure I.10 Reservoir Editor: Operations Tab – Baseline OpSet – Induced Surcharge Rule

C. Rule Descriptions

1. MaxQ fn Elev (M-T-Y Full Gate)

This rule (see Figure I.08) is a maximum release rule from Martin Dam that is based on the previous value of the pool elevation at Martin. The maximum release ranges from 12,400 cfs to 18,289 cfs and increases with increasing pool elevation. The relationship between pool elevation and release is given as a step function. This rule is applied in the Flood Control and Conservation zones.

2. Min@Tallassee fn 3-gages

This rule (see Figure I.08) is applied in the months of November through May by the use of conditional logic statements (as shown in Figure I.09). The rule is a downstream rule that uses the state variable “ThurlowMinQ_hackney”. This state variable basically computes an average flow value based on the data at Heflin, Newell, and Hackneyville. More information can found on this state variable in Appendix L. The value of this state variable is then used to determine the minimum flow requirement for the downstream location Tallassee. The minimum downstream requirement is set to 350 cfs for state variable values from 0 cfs to 350 cfs. It is set equal to the state variable for values from 350 cfs to 1200 cfs and remains at 1200 cfs for state variable values exceeding that amount. This rule is applied in the Flood Control, Conservation, and Drought zones.

3. Min@Tallassee_1200

This rule (see Figure I.08) is applied in the months of June through October by the use of a logical statement (as shown in Figure I.09). The rule is a downstream control function that sets the minimum flow requirement at Tallassee to a constant 1,200 cfs. This rule is applied in the Flood Control, Conservation, and Drought zones.

4. Min@JBT Goal_4640

This rule (see Figure I.08) is a downstream control function rule that sets the minimum flow requirement at the downstream location named JBT Goal to a constant value of 4,640 cfs. This rule is applied in the Flood Control, Conservation, and Drought zones.

5. PowerGC06

This rule (see Figure I.08) is applied in both the Flood Control and Conservation zone. Depending on the percent of power storage in use, the plant factor will vary from 0% to 16%. The top of the power pool is defined from the top of Conservation to the top of Drought. At the lower elevations in this zone, the plant factor is set to 0% (0 hrs required generation). In the upper elevations of this zone, the plant factor is set to 16% (3.84 hrs required generation). The generation is set to weekdays (Monday through Friday) only by setting the power generation pattern to 1 on weekdays and 0 on weekends.

6. Induced Surcharge Function

This rule (see Figure I.10) represents an induced surcharge operation for flood control. Induced surcharge operation is achieved by physically regulating the position of spillway gates. When the gate opening is reduced to limit release to less than free overflow (the fully-open position), water is intentionally surcharged behind the gates. Induced surcharge operation guidelines are derived from an envelope curve, which represents the relationship between a maximum allowable pool elevation and minimum required release for extreme flood events. For smaller flood inflows, the relationship between pool elevation and minimum required release can be derived using the surcharge envelope and a time of recession constant. A family of curves can be developed to cover the pool elevation vs. minimum release relationships for many different inflow values.

An induced surcharge rule in ResSim can be defined using a function or a family of curves. Since the induced surcharge rule at Martin uses a function, then the rule requires an **Induced Surcharge Envelope Curve** and a **Time of Recession** (48 hrs used for Martin). ResSim uses this information to calculate the pool elevation vs. minimum release relationship for any inflow. For the purposes of comparison to an induced surcharge chart in a Water Control Manual, or in order to check the calculated induced surcharge minimum flow values from a simulation, it is possible for the modeler to view the induced surcharge curves that ResSim generates. This is accomplished by double-clicking the induced surcharge function graph and adding a series of inflow values. Each inflow value entered will generate a curve depicting elevation vs. minimum release. The total outlet capacity can also be added to the chart. (The modeler should be aware that in the ResSim plot, the curves are drawn beyond the range to which they are actually applied in the model.)

The induced surcharge rule also includes falling pool options, which indicate how to apply the induced surcharge operation when the pool is falling and when to transition out of induced surcharge operation. The **Time for Pool Decrease** (24 hours for Martin) is the required number of successive hours the reservoir pool level must be falling before transitioning from rising pool emergency spillway releases to falling pool releases. The **Falling Pool Transition Elev** (487.5 ft for Martin) is the pool elevation below which the induced surcharge rule will no longer operate. The **Release Options** are to designate the method for computing falling pool releases. For Martin, the option of **Maintain Peak Release** is selected.

Alabama-Coosa-Tallapoosa (ACT) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update

[Baseline]

Appendix J – Jordan Reservoir and Walter Bouldin Reservoir

March 2011 (DRAFT)

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Appendix J – Jordan & Bouldin [Baseline] (DRAFT)

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Jordan Reservoir

I. Overview – Jordan

The Jordan Project is on the Coosa River in central Alabama. It is owned and operated by the Alabama Power Company. The lake lies within Chilton, Coosa, and Elmore Counties. It stretches 18 miles upstream from Jordan Dam. The dam is approximately 19 miles above the confluence of the Coosa and Tallapoosa Rivers. There are 10,165 square miles of drainage area contributing flow at this location. The Bouldin project, located on a man-made canal off the Coosa River, also receives flow from Jordan Lake and discharges into the Coosa River. The main purpose of the lake is the production of hydro-electric power. Other purposes include navigation, water quality, water supply, recreation and fish and wildlife.

The project is operated in a run-of-river mode, where daily inflow equals the daily outflow. This is because there is no flood control storage in Jordan Lake. The project has a 1,330 ft long gated concrete spillway. The crest elevation for 724 ft of this spillway is at elevation 245 ft. This section has 18 radial gates that are 34 ft wide and 8 ft high. The other 606 ft has a crest elevation of 234 ft. This section has 17 vertical lift gates that are 30 ft wide and 18 ft high. The power plant contains four vertical turbine-generator units, each rated at 25.0 MW giving a total capacity of 100 MW.

Figure J.01 shows the location of Jordan Reservoir as it is represented in the HEC-ResSim model.

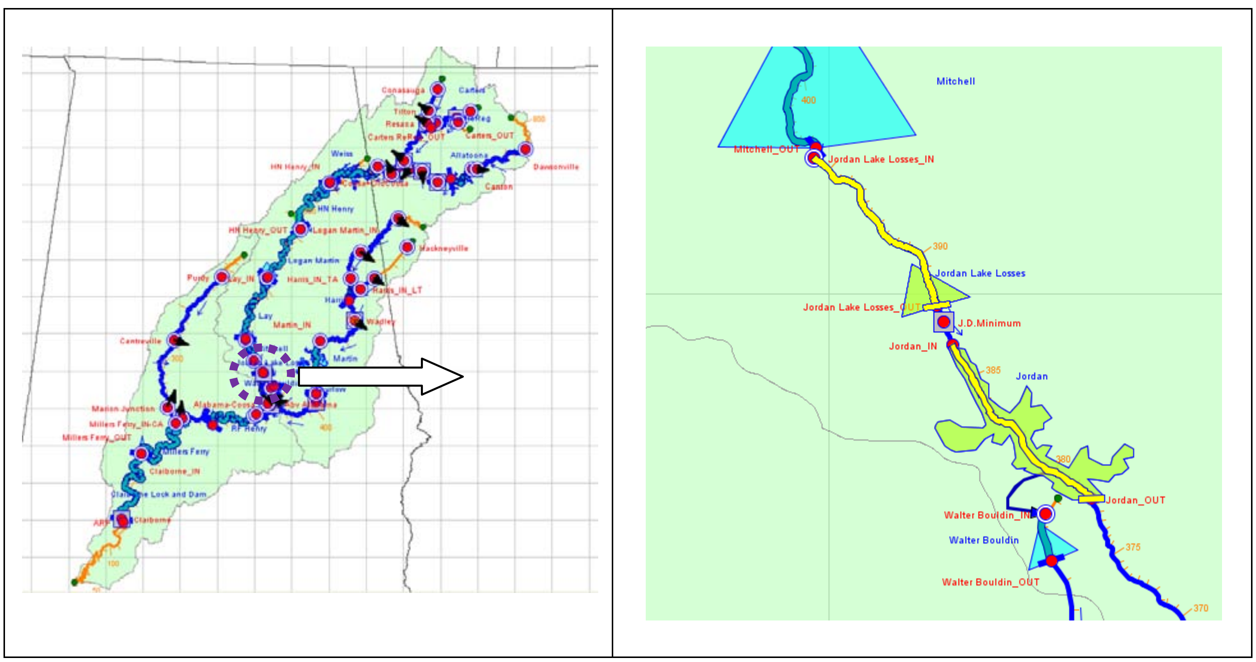


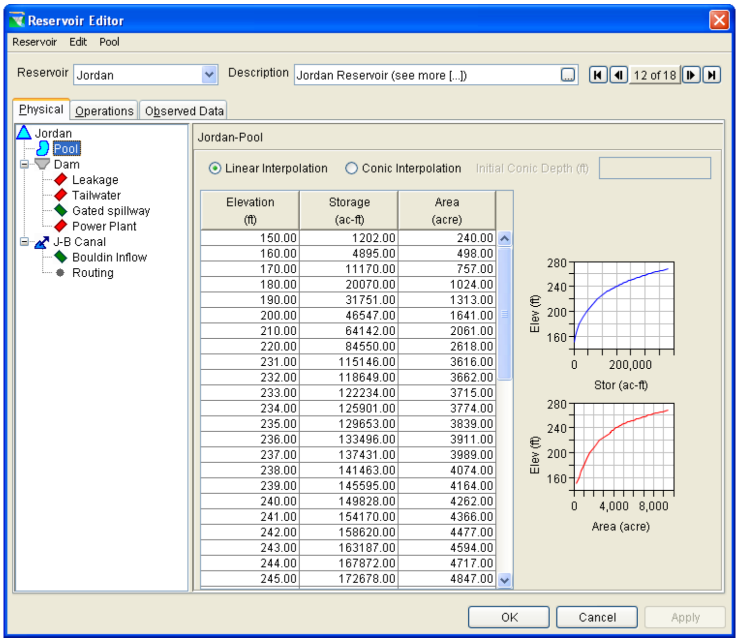
Figure J.01 HEC-ResSim Map Display Showing Location of Jordan Reservoir

Figure J.02 shows a photo of Jordan Dam.

Figure J.02 Photo of Jordan Dam

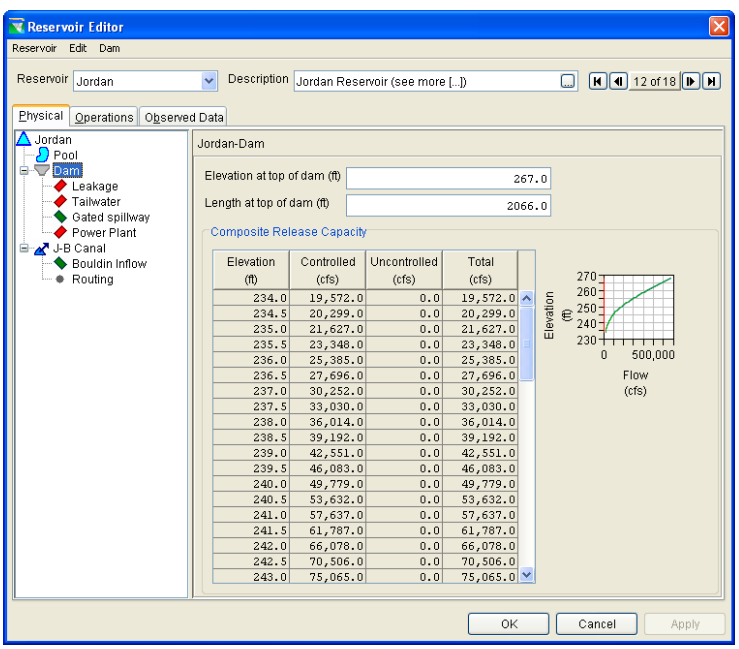
II. Physical Characteristics – Jordan

The physical characteristics of each reservoir are separated between the "Pool" and the "Dam" in the ResSim model. The "elevation-storage-area" defines the pool as shown for Jordan Reservoir in Figure J.03. Jordan Dam consists of two types of outlets: (1) a gated spillway; and, (2) a power plant. Each of these outlets is defined in the model, and the Dam reflects the composite release capacity of all of the outlets as shown in Figure J.04.



Elevation (ft)	Storage (ac-ft)	Area (acre)
150.00	1202.00	240.00
160.00	4895.00	498.00
170.00	11170.00	757.00
180.00	20070.00	1024.00
190.00	31751.00	1313.00
200.00	46547.00	1641.00
210.00	64142.00	2061.00
220.00	84550.00	2618.00
231.00	115146.00	3616.00
232.00	118649.00	3662.00
233.00	122234.00	3715.00
234.00	125901.00	3774.00
235.00	129653.00	3839.00
236.00	133496.00	3911.00
237.00	137431.00	3989.00
238.00	141463.00	4074.00
239.00	145595.00	4164.00
240.00	149828.00	4262.00
241.00	154170.00	4366.00
242.00	158620.00	4477.00
243.00	163187.00	4594.00
244.00	167872.00	4717.00
245.00	172678.00	4847.00

Figure J.03 2009 Network…Reservoir Editor: Jordan Physical Tab – Pool



Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
234.0	19,572.0	0.0	19,572.0
234.5	20,299.0	0.0	20,299.0
235.0	21,627.0	0.0	21,627.0
235.5	23,348.0	0.0	23,348.0
236.0	25,385.0	0.0	25,385.0
236.5	27,696.0	0.0	27,696.0
237.0	30,252.0	0.0	30,252.0
237.5	33,030.0	0.0	33,030.0
238.0	36,014.0	0.0	36,014.0
238.5	39,192.0	0.0	39,192.0
239.0	42,551.0	0.0	42,551.0
239.5	46,083.0	0.0	46,083.0
240.0	49,779.0	0.0	49,779.0
240.5	53,632.0	0.0	53,632.0
241.0	57,637.0	0.0	57,637.0
241.5	61,787.0	0.0	61,787.0
242.0	66,078.0	0.0	66,078.0
242.5	70,506.0	0.0	70,506.0
243.0	75,065.0	0.0	75,065.0

Figure J.04 2009 Network…Reservoir Editor: Jordan Physical Tab –Dam

The J-B Canal “diverted outlet” reflects a diversion to Bouldin Reservoir. (See Section V through Section VIII for the description of Walter Bouldin Reservoir and Section IX for a detailed description of the special operations in this region.) This diversion consists of a single controlled outlet representing the element that provides inflow into Bouldin. The composite release capacity of the diverted outlet is shown in Figure J.05.

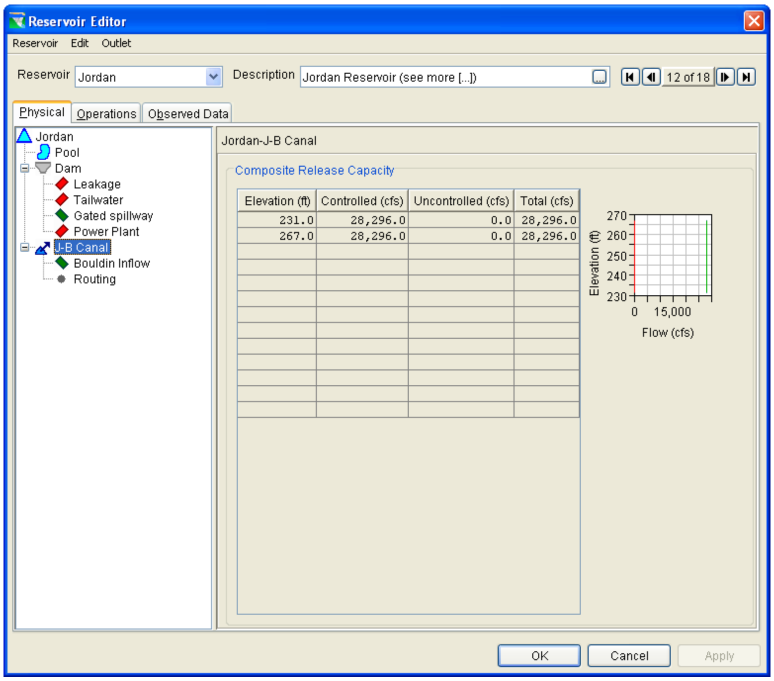


Figure J.05 2009 Network…Reservoir Editor: Jordan Physical Tab –Diverted Outlet

III. Baseline Operations – Jordan

A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table J.01 shows the definition of "Baseline" operational zones for Jordan Reservoir, which consists of zones above and below the conservation zone. Even though Jordan is in theory a run-of-river project, it contains a single rule to send water from Jordan to Bouldin, while making sure releases are provided to the Coosa River.

Table J.01 Jordan Zone Elevations for "Baseline" Operation Set

Jordan	**Baseline** Top of **Zone Elevation** Values (feet)
Seasons =	**1Jan - 31Dec**
Zones:	
Top of Dam	267
Conservation	252
Operating Inactive	249.5
Inactive	249

As shown in Figure J.06, the top of the Conservation zone has been set to be the operational Guide Curve and is a constant 252' throughout the year.

Guide Curve definition (top of **Conservation** zone)

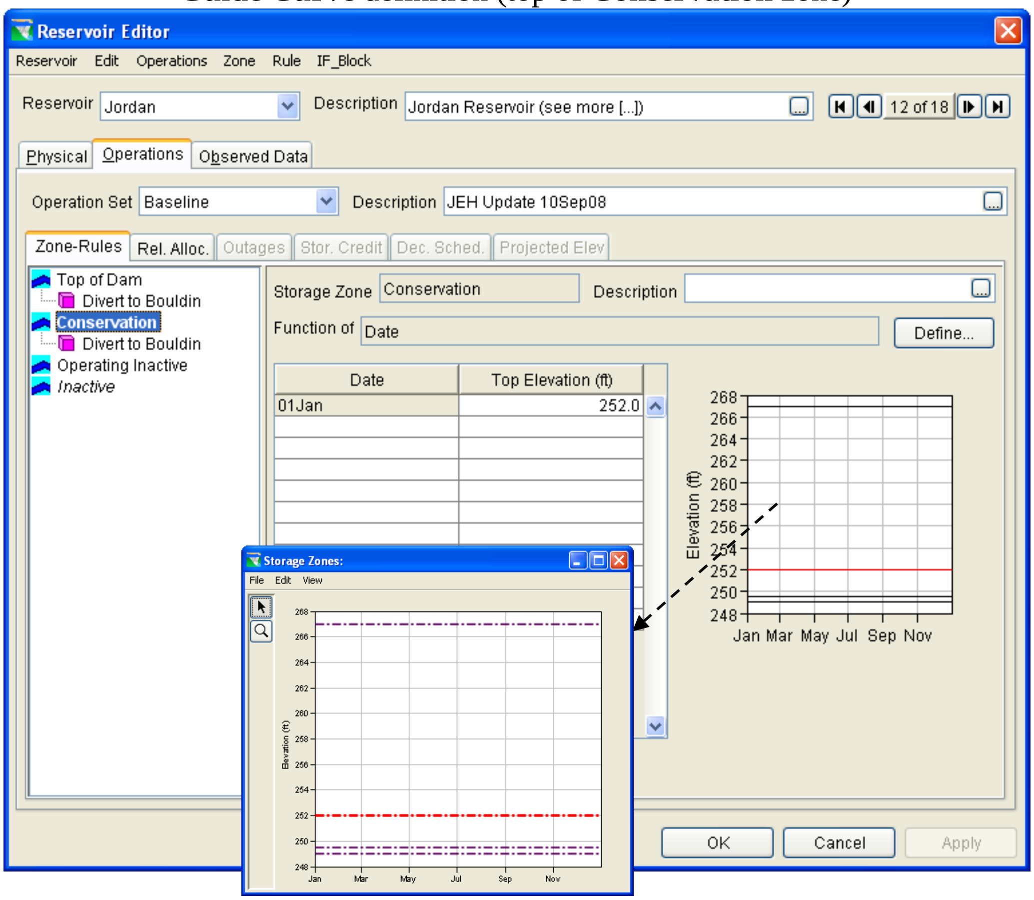
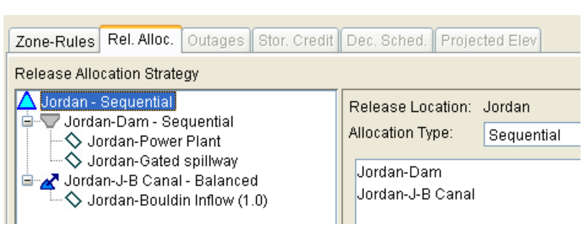


Figure J.06 Reservoir Editor: Operations Tab – Baseline OpSet – Guide Curve

Figure J.07 shows a sequential release allocation approach for releasing water from Jordan Reservoir—first through the Dam and then through the J-B Canal (left panel). The available outlets from Jordan Dam are also given an order of priority for release (right panel). The power plant gets the release first until it reaches release capacity. After the capacity through the powerhouse is reached, the remainder of the release goes through the gated spillway.

Release Allocation:



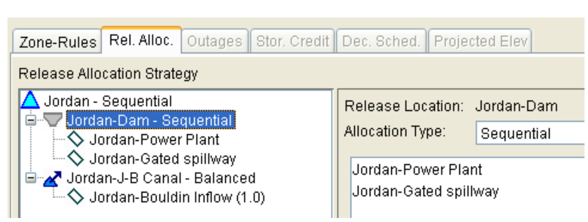


Figure J.07 Reservoir Editor: Operations Tab – Baseline OpSet – Release Allocations

B. Rule Illustrations

Figure J.08 shows a set of operational rules specified for each zone that reflects the operation set named “Baseline”.

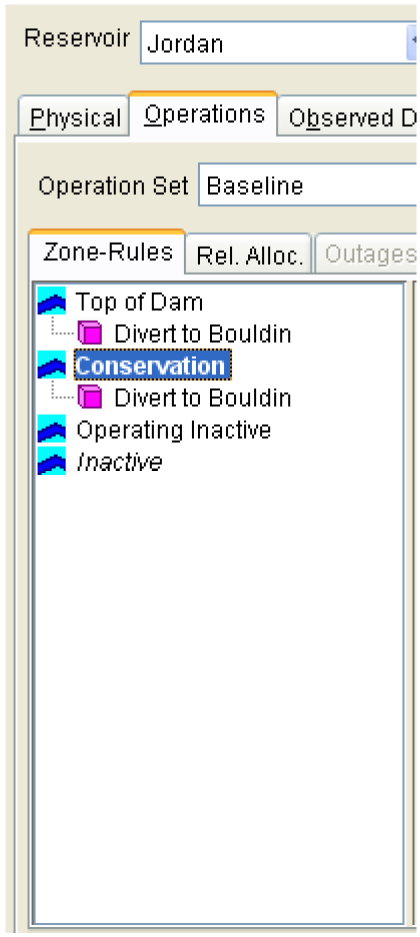


Figure J.08 Reservoir Editor: Operations Tab – Baseline OpSet – Zones and Rules

The content for the “Divert to Bouldin” rule in the ResSim model is shown in Figure J.09, and its logic and purpose is described following Figure J.09.

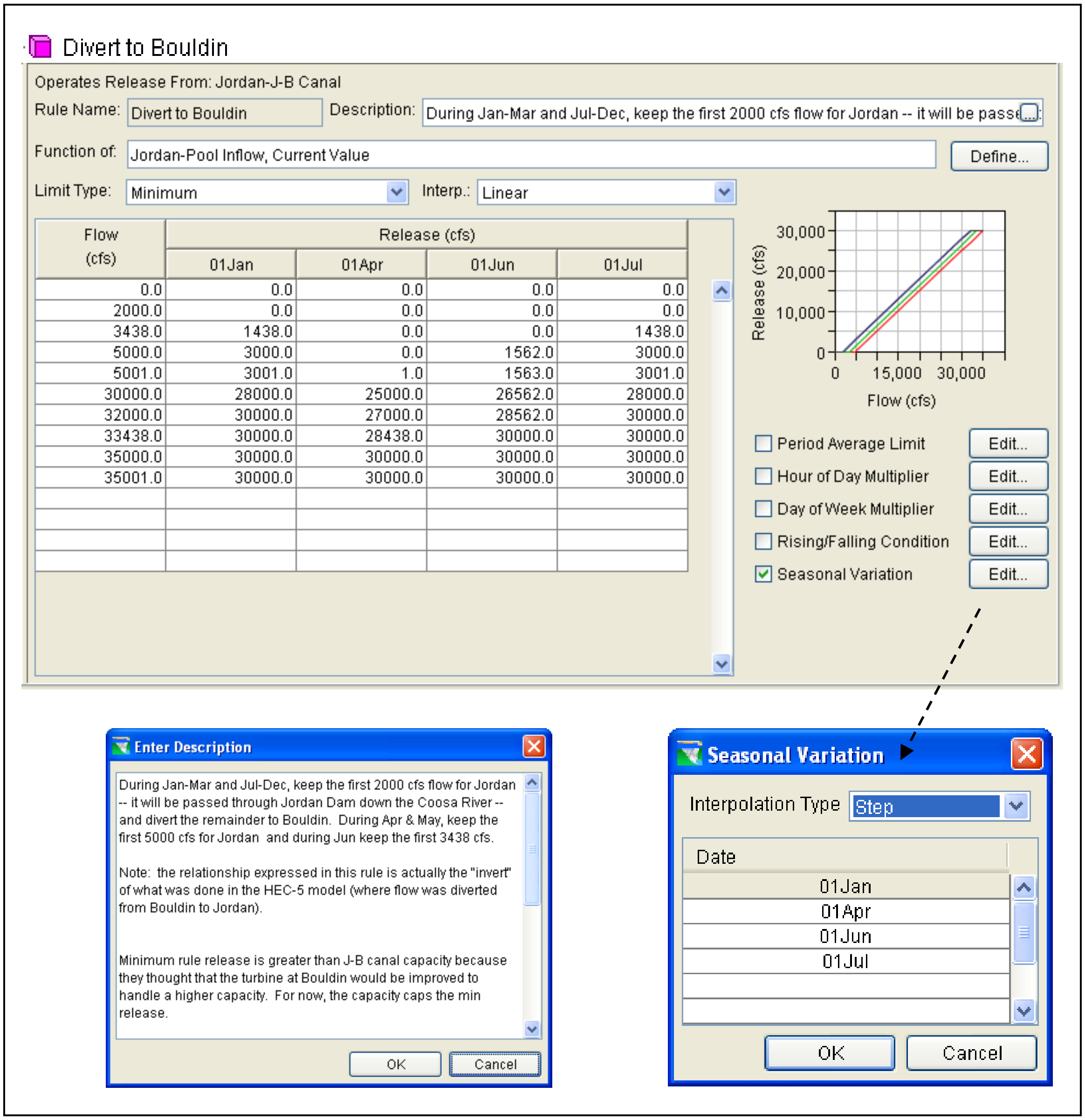


Figure J.09 Reservoir Editor: Operations Tab – Baseline OpSet – Minimum Rule

C. Rule Descriptions

1. Divert to Bouldin

There is only one rule (see Figure J.09) governing the operations at Jordan in the baseline operation set. It is a minimum release rule that is specific to the Jordan-Bouldin (J-B) Canal outlet. The minimum release is based on two variables. The first variable is the current value of the inflow into Jordan. Linear interpolation is used between the given values. The next variable is the time of year. This seasonal variation uses a step function. This rule is applied to the Top of Dam and Conservation zones.

After the release for this rule is determined, ResSim will determine release from Jordan Dam using guide curve operations. The pool should only drop into conservation pool if leakage exceeds inflow since the flow diverted into the canal is always less than inflow. The pool should not rise above top of Conservation unless the inflow exceeds the release capacity.

Walter Bouldin Reservoir

IV. Overview – Bouldin

The Bouldin project is owned by the Alabama Power Company. It is located in Elmore County on a man-made canal off the Coosa River. A 3-mile long forebay canal connects with Jordan Lake approximately one mile upstream from Jordan Dam. The water retaining structures at Bouldin have a total length of 9,428 ft. This length includes two earth embankments of 2,200 ft and 7,000 ft. The remaining 228 ft is a concrete intake section. There is no spillway structure at this project since the spillway at Jordan Dam serves both projects. The powerhouse contains three 75 MW units giving a total capacity of 225 MW.

Figure J.10 shows the location of Walter Bouldin Reservoir as it is represented in the HEC-ResSim model.

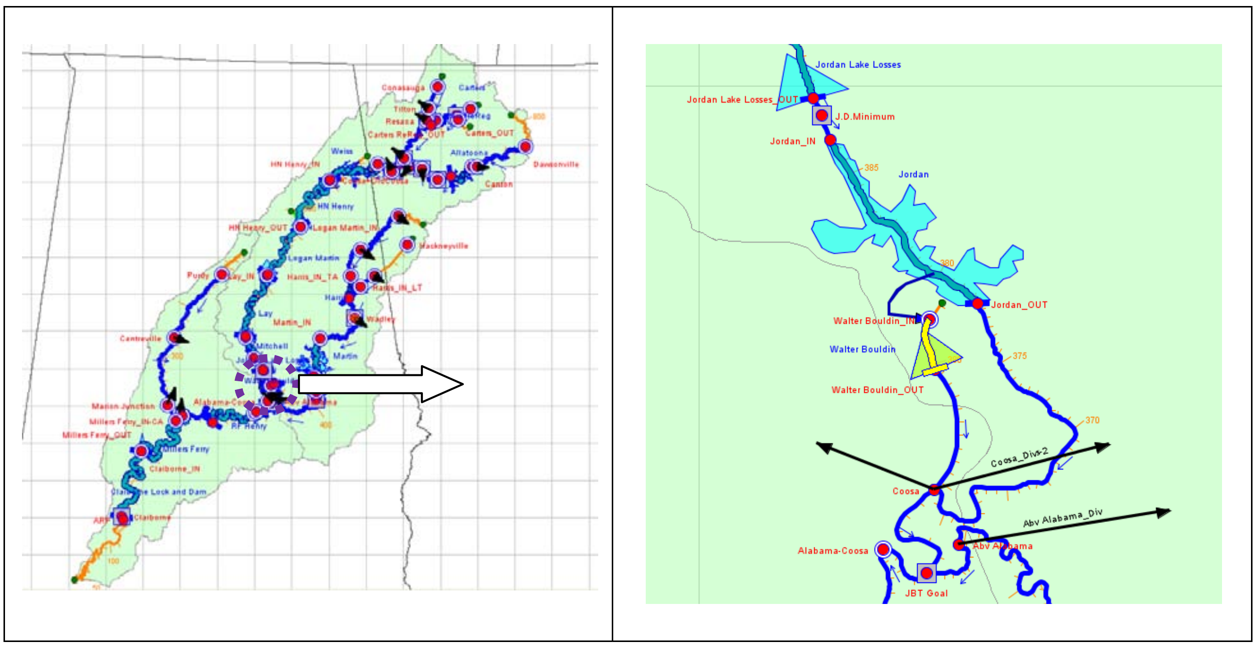


Figure J.10 HEC-ResSim Map Display Showing Location of Walter Bouldin Reservoir

Figure J.11 shows a photo of Bouldin Dam.

Figure J.11 Photo of Bouldin Dam

V. Physical Characteristics – Bouldin

The physical characteristics of each reservoir are separated between the “Pool” and the “Dam” in the ResSim model. The “elevation-storage-area” defines the pool as shown for Walter Bouldin Reservoir in Figure J.12. Bouldin Dam consists of a single outlet -- a power plant. The power plant outlet capacity is defined in the model, and the Dam reflects the composite release capacity as shown in Figure J.13.

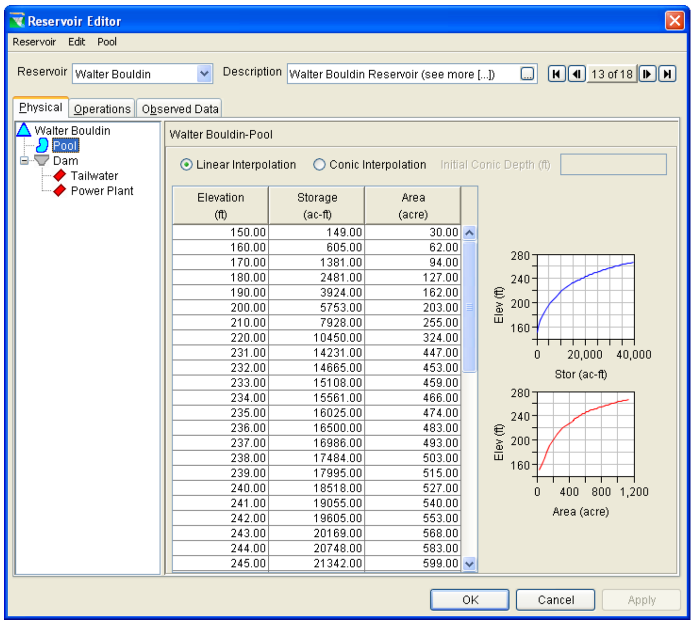


Figure J.12 2009 Network… Walter Bouldin Reservoir Editor: Physical Tab – Pool

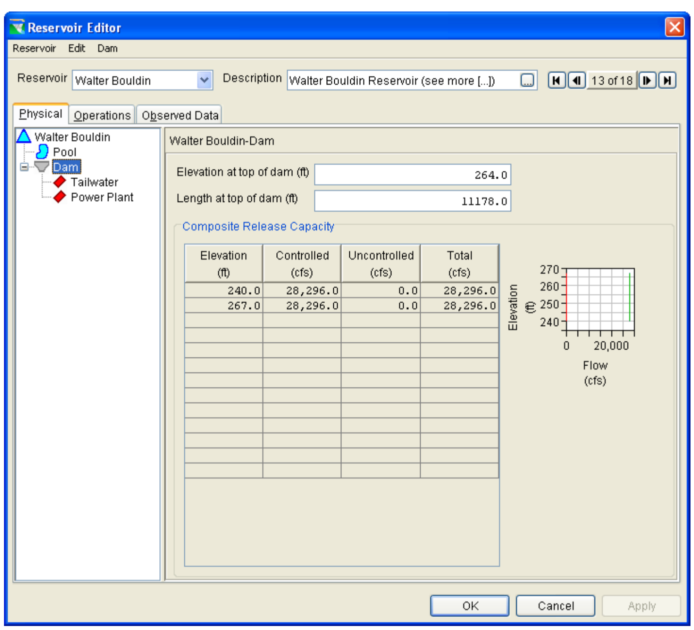


Figure J.13 2009 Network… Walter Bouldin Reservoir Editor: Physical Tab – Dam

VI. Baseline Operations – Bouldin

A. “Baseline” Operation Set

Table J.02 shows the definition of operational zones consisting of Top of Dam, Conservation, and Operating Inactive zone, as well as an Inactive zone.

Table J.02 Walter Bouldin Zone Elevations for “Baseline” Operation Set

Walter Bouldin	**Flow-thru** Top of **Zone Elevation** Values (feet)
Seasons =	**1Jan - 31Dec**
Zones:	
Top of Dam	264
Conservation	252
Operating Inactive	249.5
Inactive	249

The top of the operation zones are constant throughout the entire year (as shown in Figure J.14).

Guide Curve definition (top of **Conservation** zone)

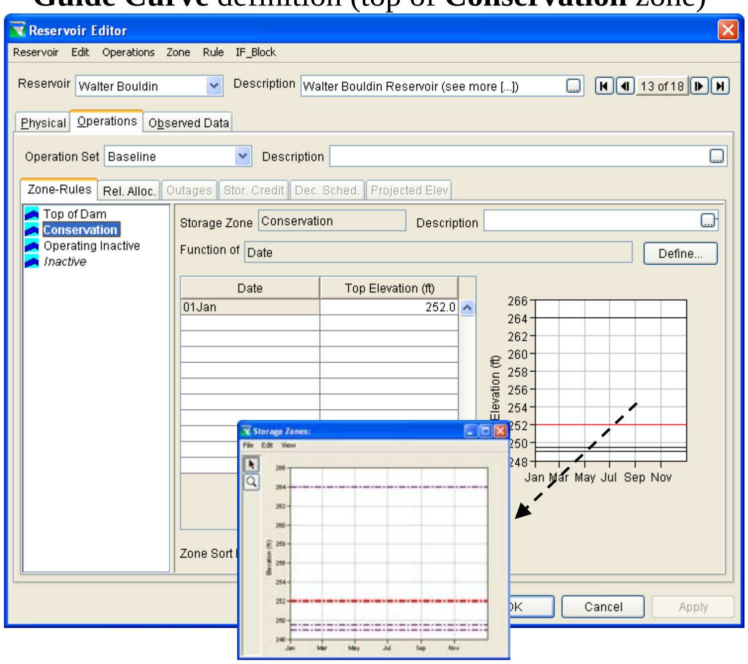


Figure J.14 Walter Bouldin Reservoir Editor: Operations Tab – “Baseline” Guide Curve

Figure J.15 shows a sequential release allocation approach specified for available outlets along Bouldin Dam. The available outlets are given an order of priority for release. The power plant gets the release until it reaches release capacity.

Release Allocation:

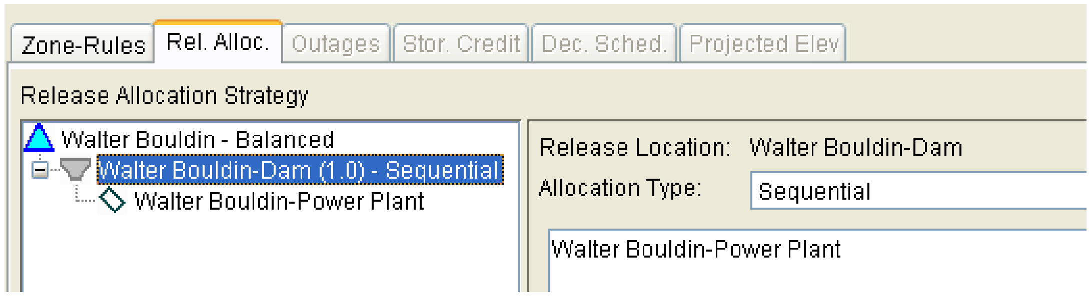


Figure J.15 Walter Bouldin Reservoir Editor: Operations Tab – "Baseline" Release Allocation

Figure J.16 shows a set of operational zones that reflects the operation set named "Baseline".

Figure J.16 Walter Bouldin Reservoir Editor: Operations Tab – "Baseline" Zones

The "Baseline" operation set for Walter Bouldin is the same as a "Flow-thru" operation set because it contains no rules of operation (thus, making it a flow through reservoir). All inflow coming into the project will be passed at each time step holding the pool at the top of Conservation. This project is supplied by a canal from Jordan Lake. The capacity of this canal is limited to the capacity of the power plant at Bouldin. Inflow into Walter Bouldin will only exceed the power plant capacity if the canal flow plus the local inflow into Bouldin exceeds 28,296 cfs.

VII. Special Modeling Considerations for the Jordan Region

The Jordan Lake area of the Alabama-Coosa-Tallapoosa basin is a complicated region in terms of water management. (See Figure J.17 for a map of the area, as modeled in ResSim.) The reservoirs in this region are owned and operated by Alabama Power Company. Along with meeting its hydropower generation requirements, the upstream reservoir, Logan Martin, operates to supply a minimum flow to the Coosa River below Jordan Reservoir, considering the effects of local inflow, evaporation, and diversions. Logan Martin Reservoir (on the Coosa River) and Martin Reservoir (on the Tallapoosa River) operate together "in parallel" to meet a minimum flow into the Alabama River, excluding the effects of local inflows above the confluence. These two minimum flow objectives are unaffected by basin conditions in current (Baseline) operations.

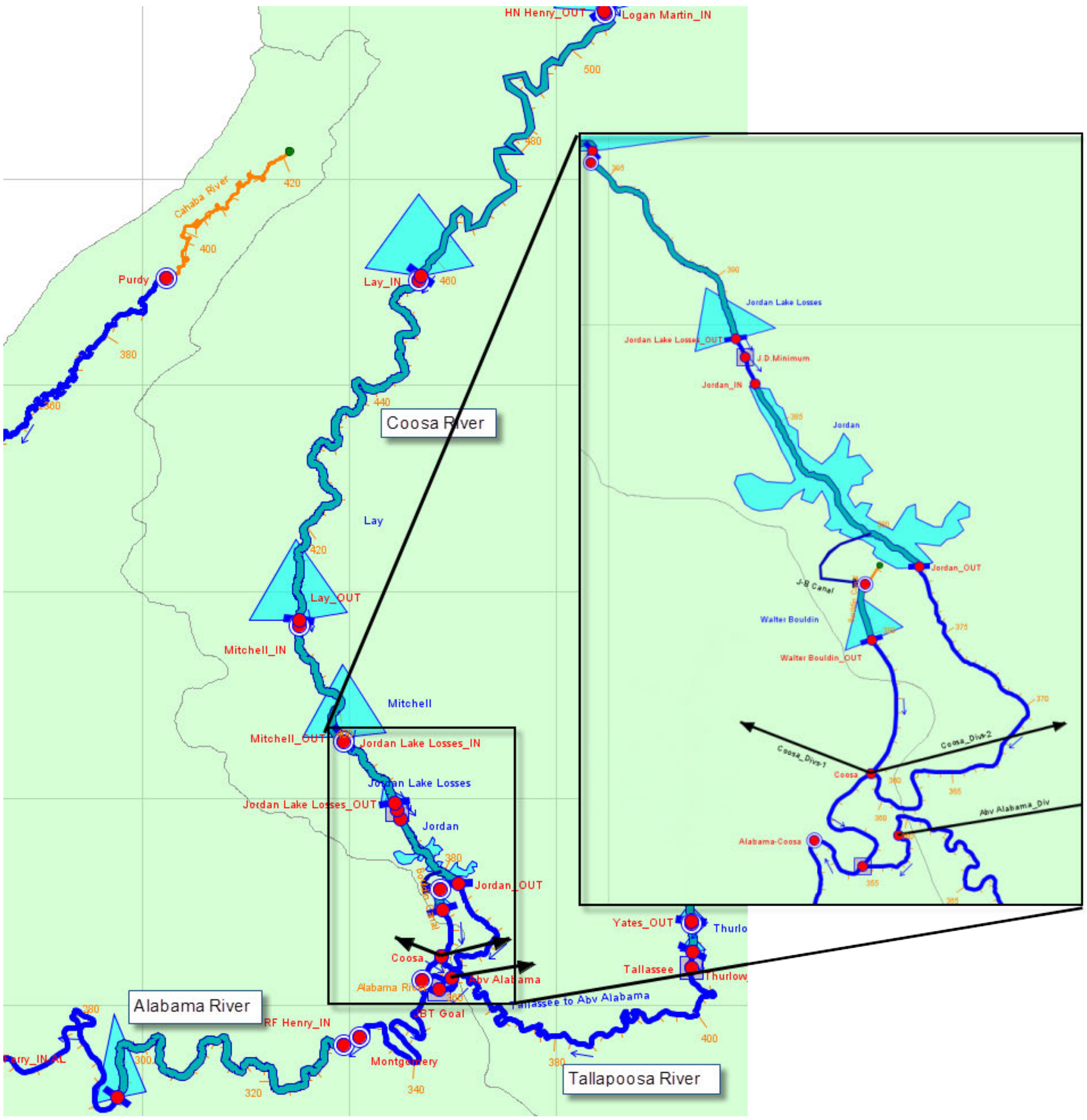


Figure J.17 ResSim Model of the ACT Basin: Confluence of the Coosa, Tallapoosa, and Alabama Rivers (with inset of the Jordan Lake region)

Walter Bouldin Reservoir is a newer hydropower reservoir constructed alongside the Jordan reservoir pool. The two reservoir pools are connected by an uncontrolled canal which makes the two reservoirs effectively one pool with two dams. The two dams are operated to maintain a constant pool throughout the year – they do this by releasing net inflow through the two dams. The allocation of the releases to the two dams is guided by the objective to maintain minimum flows in the main Coosa River channel.

Some specialized modeling techniques were used in ResSim to capture the operations in this region. First, Jordan Reservoir is modeled in ResSim with a diverted outlet that allows it to send water to Walter Bouldin Reservoir, which is then routed through a canal downstream of Walter Bouldin back to the Coosa River. Jordan can also make controlled releases through its dam to the main channel of the Coosa River. The Coosa River and the Bouldin Canal converge at the Coosa Junction in the model. (See Figure J.18 for an image and description of Jordan Reservoir and its outlets.) Since Jordan and Bouldin Reservoirs each maintain a constant pool, their total release in each timestep must equal their net inflow.

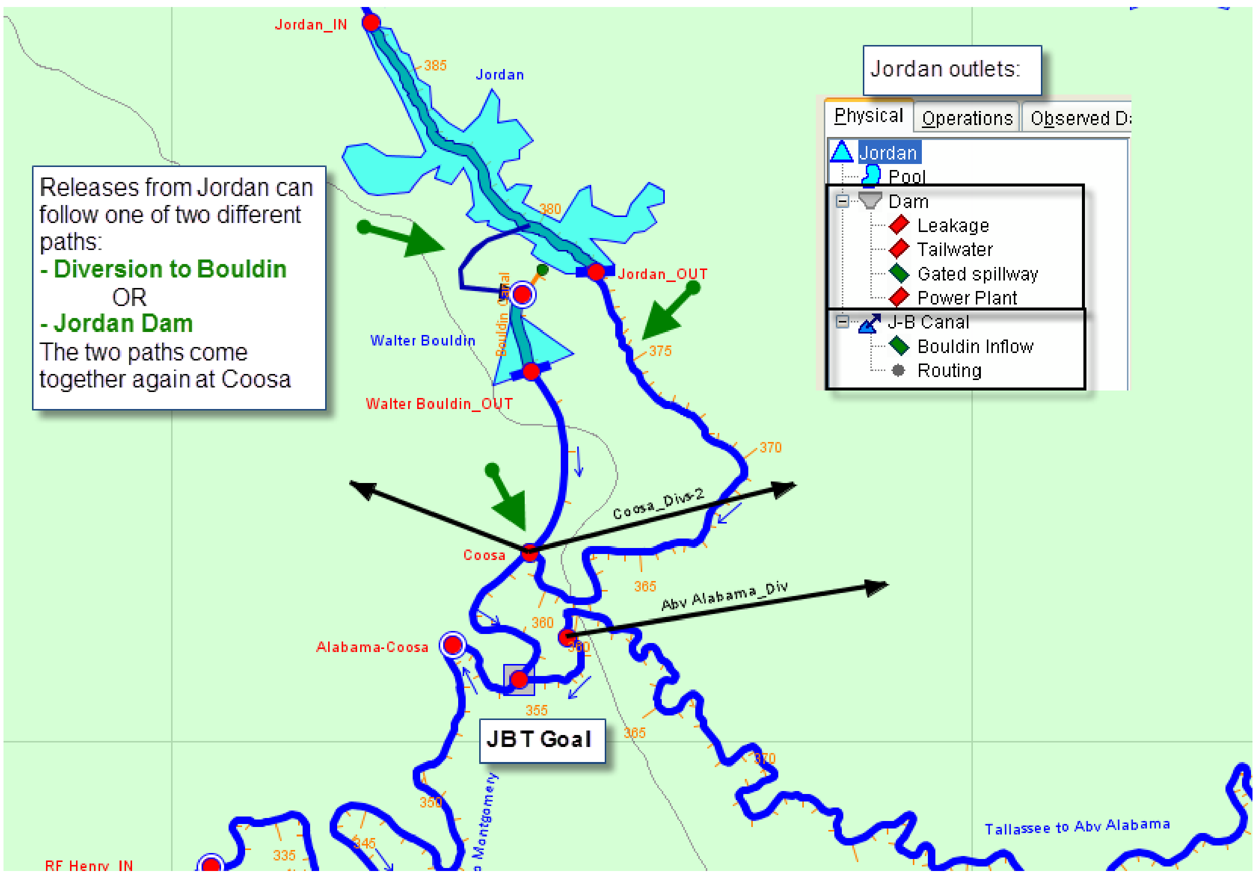


Figure J.18 ResSim Model of the Jordan Lake Region Depicting the Coosa River, the Bouldin Canal, and the Confluence of the Coosa, Tallapoosa, and Alabama Rivers (at JBT Goal)

Next, a "dummy" reservoir called "Jordan Lakes Losses" (previously shown in Figure J.17 inset) was created upstream of Jordan Reservoir to account for Jordan's local inflows, evaporation, and diversions. Located between the dummy reservoir and Jordan Reservoir is a node called J.D.Minimum (previously shown in Figure J.17 inset), which is used as the downstream control point for the Logan Martin's minimum flow objective at Jordan.

Finally, Jordan Reservoir releases through its dam, inflow up to the minimum Coosa channel flow requirement; if inflow is greater than the minimum Coosa requirement, the remainder - up to Bouldin's powerhouse capacity - is diverted to Bouldin for hydropower generation. Inflows to Jordan in excess of Bouldin's capacity and minimum Coosa flows are released from Jordan into the main Coosa channel.

Downstream of the Coosa Junction, is the confluence of the Coosa and Tallapoosa Rivers, which is labeled "JBT Goal" in the ResSim model. (JBT is an acronym for Jordan-Bouldin-Thurlow.) JBT Goal is used as the downstream control point for which Logan Martin and Martin operate to meet the minimum flows in the Alabama River. Local inflows to the lower reaches of the Coosa and Tallapoosa Rivers are brought into the Alabama River, just downstream of JBT Goal. This allows Logan Martin and Martin to operate for the inflow to the Alabama River without the effects of those local inflows.

Jordan is modeled as a flow-through reservoir, with the exception of a single rule that diverts most of Jordan's inflow to Walter Bouldin (where it is able to generate more power). The "Baseline" operation set for Jordan is shown in Figure J.19. The "Divert to Bouldin" rule diverts a fraction of all flows greater than the Coosa channel requirement to Bouldin.

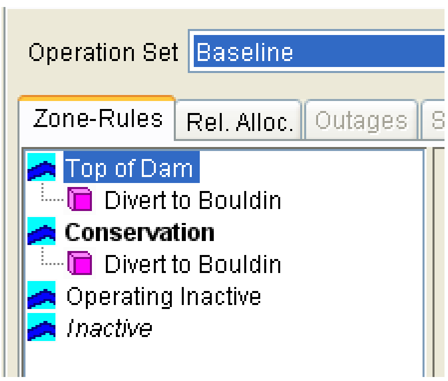


Figure J.19 Jordan "Baseline" Operation Set

To summarize the impact of the "Divert to Bouldin" rule (as previously shown in Figure J.09), during the months of January through March and July through December, the first 2,000 cfs of Jordan's inflow will be passed through Jordan Dam down the Coosa River, and the remainder of inflow will be diverted to Bouldin. During April and May the first 5,000 cfs will be passed through Jordan Dam with the remainder being diverted to Bouldin. During June the first 3,438 cfs will be passed through Jordan Dam, with the remainder being diverted to Bouldin.

Apalachicola-Chattahoochee-Flint (ACF) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update

[Baseline]

Appendix K – Flow-thru Reservoirs:

Lay, Mitchell, Yates, Thurlow, and Claiborne Lock & Dam

March 2011 (DRAFT)

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Appendix K – Flow-thru Reservoirs [Baseline] (DRAFT)

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"Flow-thru" Reservoirs

I. Lay

A. Overview

Lay Lake is owned by the Alabama Power Company. It is located on the Coosa River and lies within Chilton, Coosa, Shelby, St. Clair and Talladega Counties in Alabama. It is 51 river miles upstream of the confluence of the Coosa River and Tallapoosa River. The total drainage area contributing flow at this location is 9,087 square miles. The main purpose of this development is the production of hydro-electric power. Other purposes include water supply, recreation, and fish and wildlife. There is no flood control storage in Lay Lake and the project is operated in a run-of-river mode where the peak inflows are passed directly downstream.

The dam is 2,120 feet long and includes a gated spillway. The spillway contains 26 vertical lift gates that are 30 feet wide and 17 feet high. The powerhouse includes six units each rated for 29.5 MW giving a total capacity of 177 MW.

Figure K.01 shows the location of Lay Reservoir as it is represented in the HEC-ResSim model.

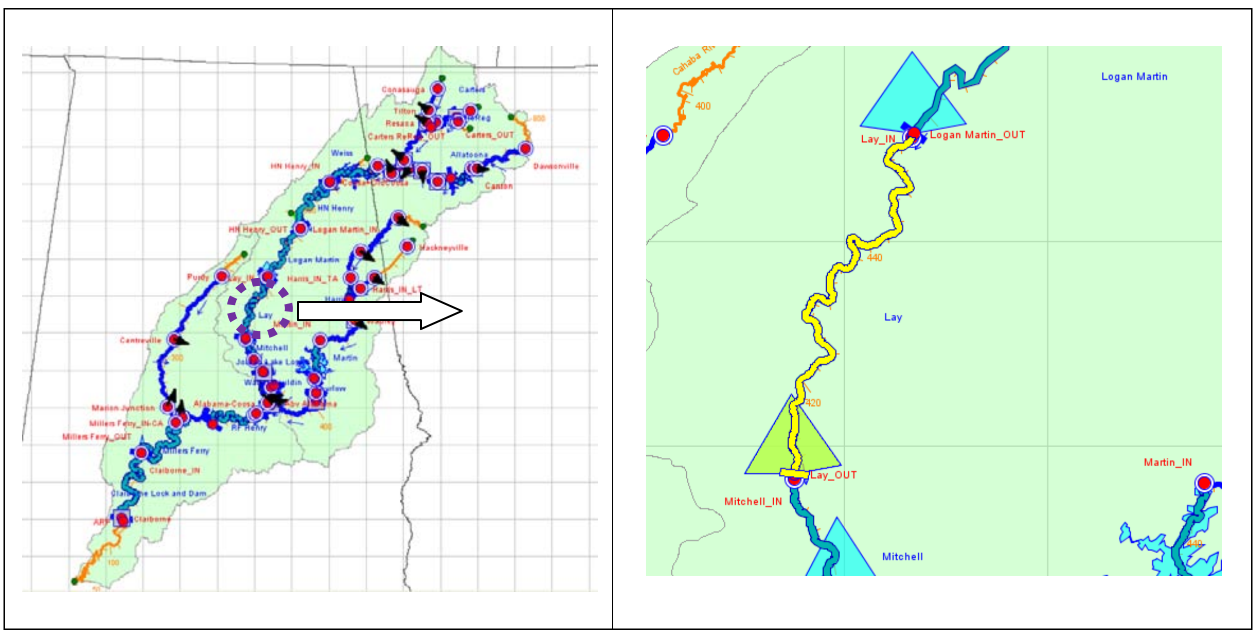

Figure K.01 HEC-ResSim Map Display Showing Location of Lay Reservoir

Figure K.02 shows a photo of Lay Dam.

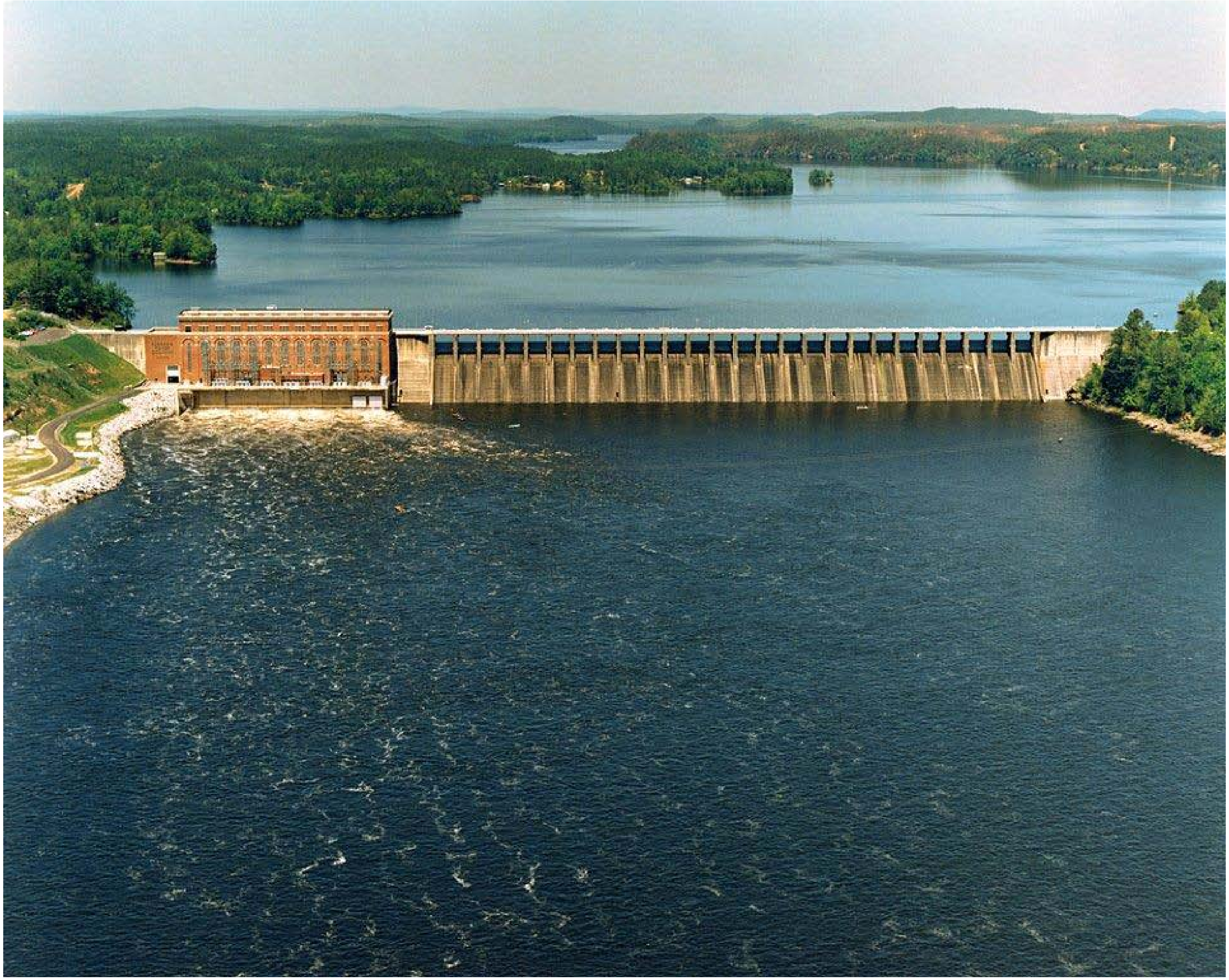

Figure K.02 Photo of Lay Dam

B. Physical Characteristics

The physical characteristics of each reservoir are separated between the "Pool" and the "Dam" in the ResSim model. The "elevation-storage-area" defines the pool as shown for Lay Reservoir in Figure K.03. Lay Dam consists of two types of outlets: (1) a gated spillway; and, (2) a power plant. Each of these outlets is defined in the model, and the Dam reflects the composite release capacity of all of the outlets as shown in Figure K.04.

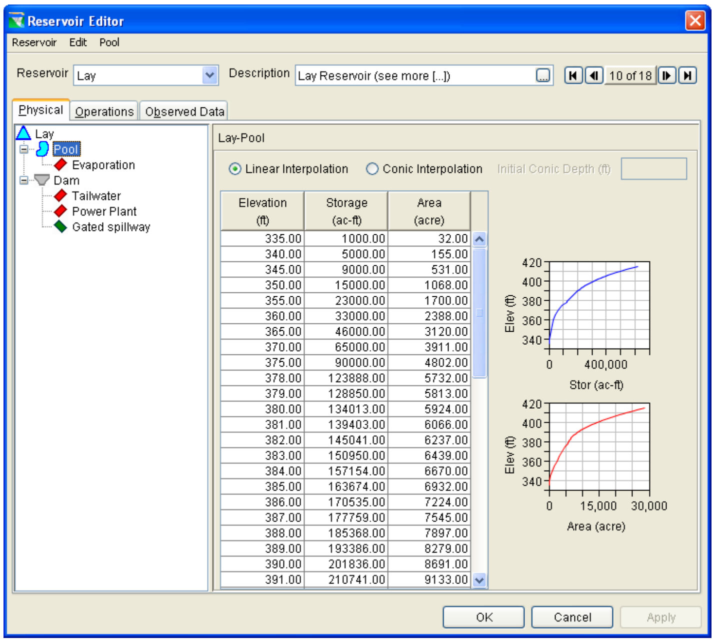

Figure K.03 2009 Network… Lay Reservoir Editor: Physical Tab – Pool

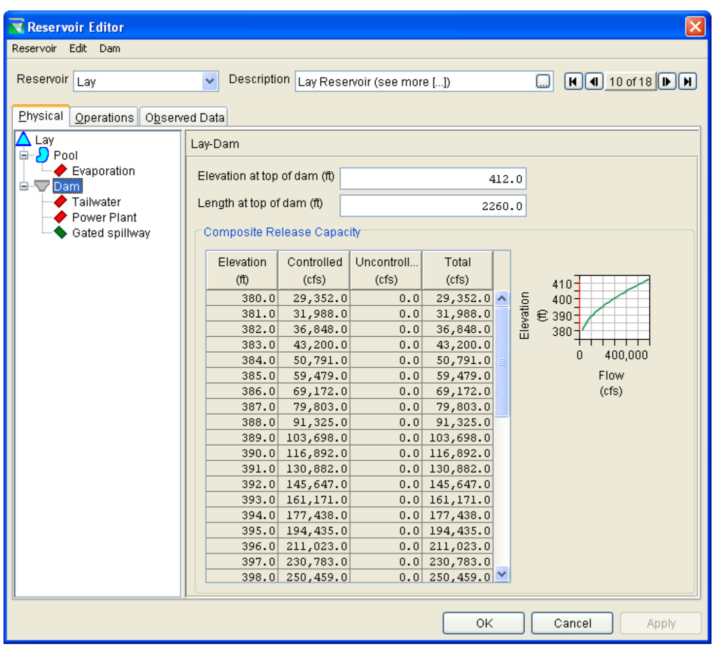

Figure K.04 2009 Network… Lay Reservoir Editor: Physical Tab – Dam

C. Baseline Operations

1. "Flow-thru" Operation Set

Table K.1 shows the definition of operational zones consisting of Top of Dam, Conservation, and Operating Inactive zone, as well as an Inactive zone.

Table K.1 Lay Zone Elevations for "Flow-thru" Operation Set

Lay	Flow-thru Top of Zone Elevation Values (feet)
Seasons =	1Jan - 31Dec
Zones:	
Top of Dam	412
Conservation	396
Operating Inactive	388
Inactive	386

The top of the operation zones are constant throughout the entire year (as shown in Figure K.05).

Guide Curve definition (top of **Conservation** zone)

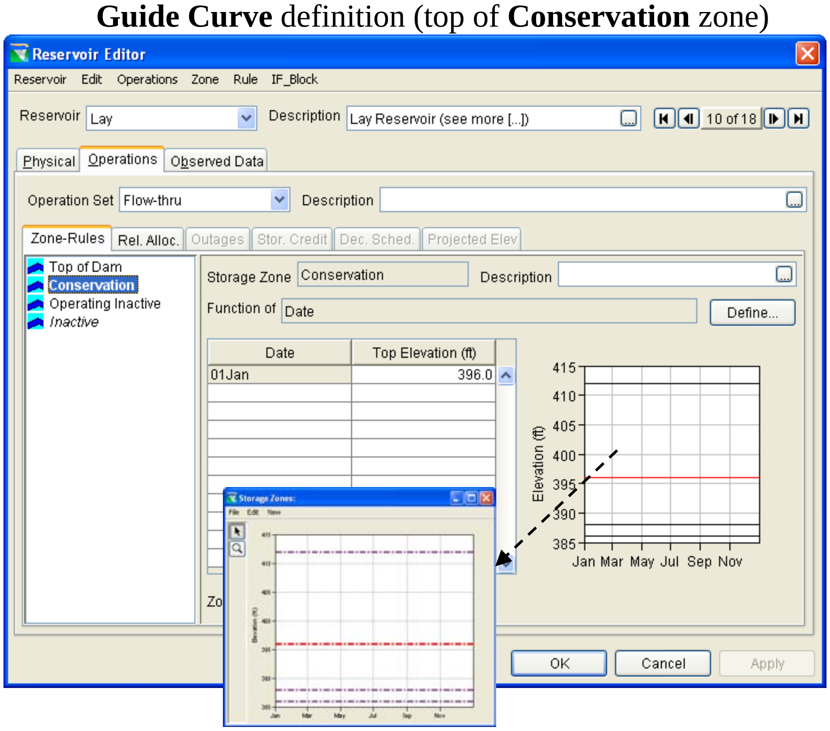

Figure K.05 Lay Reservoir Editor: Operations Tab – "Flow-thru" Guide Curve

Figure K.06 shows a sequential release allocation approach specified for available outlets along Lay Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. After the capacity through the powerhouse is reached, the remainder of the release goes through the gated spillway.

Release Allocation:

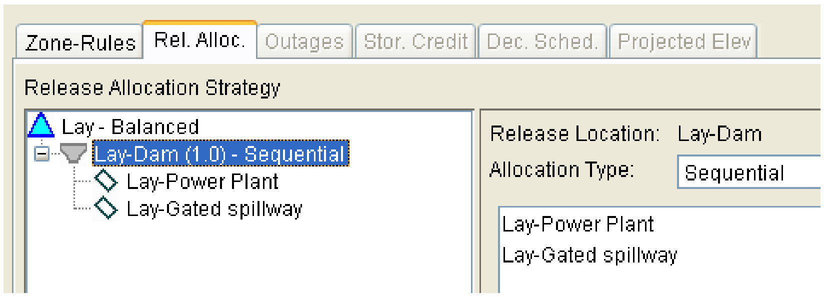

Figure K.06 Lay Reservoir Editor: Operations Tab – "Flow-thru" Release Allocation

Figure K.07 shows a set of operational zones that reflects the operation set named "Flow-thru".

Figure K.07 Lay Reservoir Editor: Operations Tab – "Flow-thru" Zones

The "Flow-thru" operation set for Lay Lake contains no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

II. Mitchell

A. Overview

The Mitchell project is owned by the Alabama Power Company. It is located on the Coosa River in the Chilton and Coosa Counties, Alabama. It is 37 river miles upstream of the confluence of the Coosa and Tallapoosa Rivers. The reservoir extends approximately 14 miles up from Mitchell Dam. The lake is used for hydroelectric generation, industrial and municipal water supply, water quality, recreation, and fish and wildlife. Mitchell is basically a run-of-river project where daily outflow equals daily inflow.

Mitchell Dam has a length of 1,264 feet with a gated concrete spillway. The spillway consists of 23 timber 30 ft wide and 15 ft high radial gates and three steel-faced 30 ft wide and 25 ft high radial gates. The spillway crest for the timber gates is at elevation 297 ft while the spillway crest for the steel-faced gates is at elevation 287 ft. The powerhouse is rated for 170 MW. This is made up by one 20MW unit in the old powerhouse and three 50MW units in the new powerhouse.

Figure K.08 shows the location of Mitchell Reservoir as it is represented in the HEC-ResSim model.

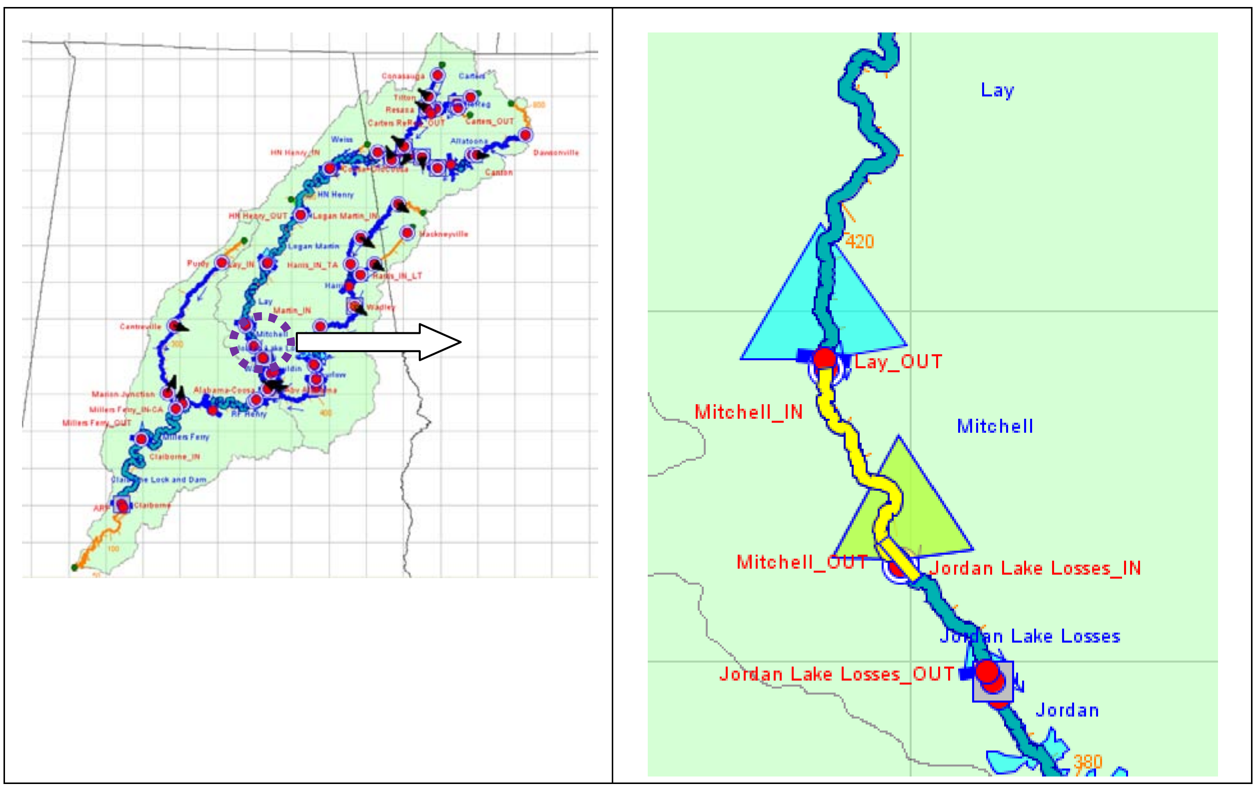

Figure K.08 HEC-ResSim Map Display Showing Location of Mitchell Reservoir

Figure K.09 shows a photo of Mitchell Dam.

Figure K.09 Photo of Mitchell Dam

B. Physical Characteristics

The physical characteristics of each reservoir are separated between the “Pool” and the “Dam” in the ResSim model. The “elevation-storage-area” defines the pool as shown for Mitchell Reservoir in Figure K.10. Mitchell Dam consists of two types of outlets: (1) a gated spillway; and, (2) a power plant. Each of these outlets is defined in the model, and the Dam reflects the composite release capacity of all of the outlets as shown in Figure K.11.

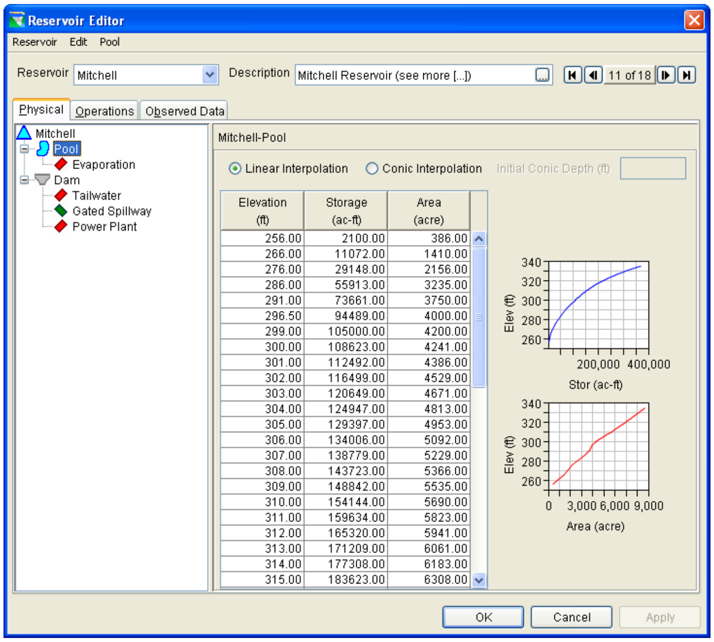

Figure K.10 2009 Network… Mitchell Reservoir Editor: Physical Tab – Pool

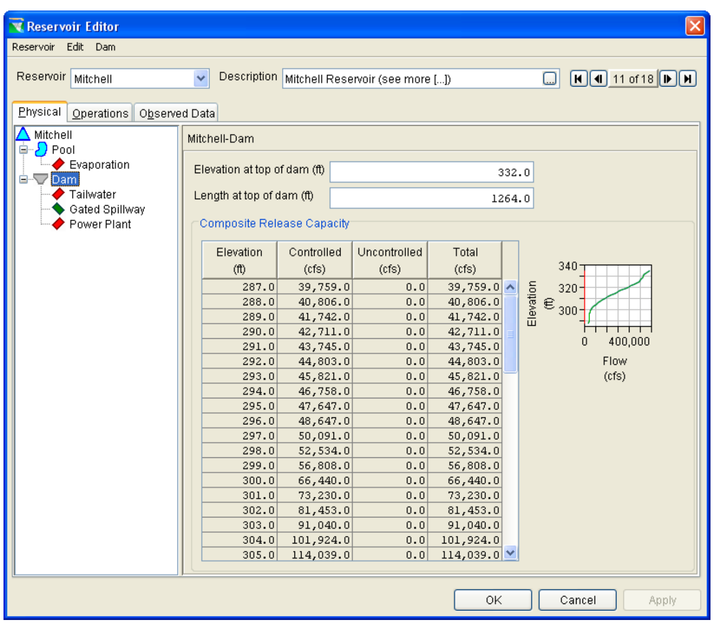

Figure K.11 2009 Network… Mitchell Reservoir Editor: Physical Tab – Dam

C. Baseline Operations

1. "Flow-thru" Operation Set

Table K.2 shows the definition of operational zones consisting of Top of Dam, Conservation, and Operating Inactive zone, as well as an Inactive zone.

Table K.2 Mitchell Zone Elevations for "Flow-thru" Operation Set

Mitchell	**Flow-thru** Top of **Zone Elevation** Values (feet)
Seasons =	**1Jan - 31Dec**
Zones:	
Top of Dam	332
Conservation	312
Operating Inactive	307
Inactive	302

The top of the operation zones are constant throughout the entire year (as shown in Figure K.12).

Guide Curve definition (top of **Conservation** zone)

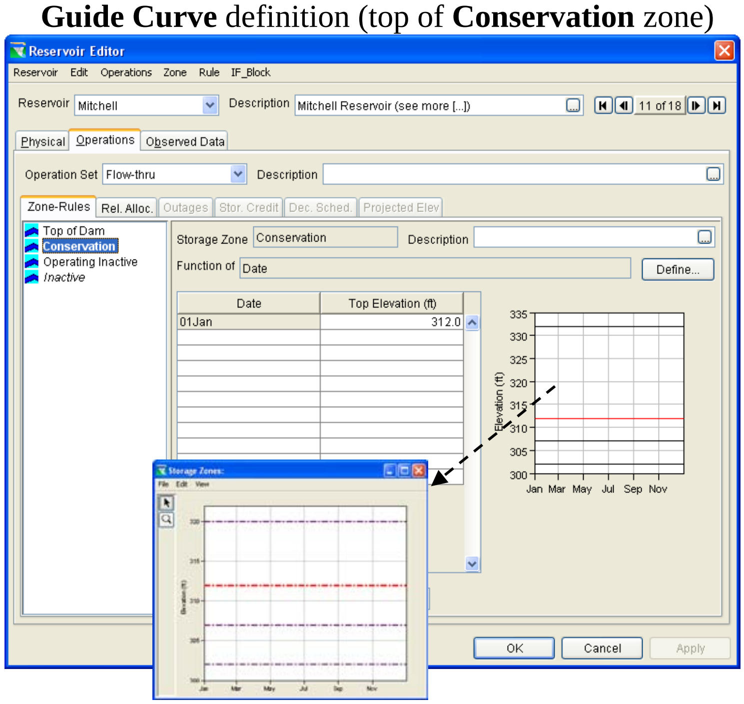

Figure K.12 Mitchell Reservoir Editor: Operations Tab – "Flow-thru" Guide Curve

Figure K.13 shows a sequential release allocation approach specified for available outlets along Mitchell Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. After the capacity through the powerhouse is reached, the remainder of the release goes through the gated spillway.

Release Allocation:

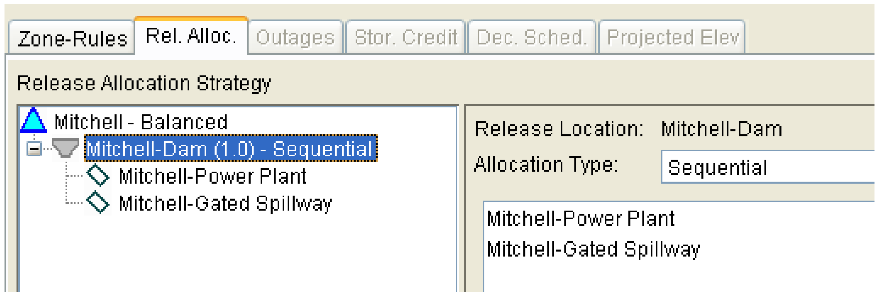

Figure K.13 Mitchell Reservoir Editor: Operations Tab – "Flow-thru" Release Allocation

Figure K.14 shows a set of operational zones that reflects the operation set named "Flow-thru".

Figure K.14 Mitchell Reservoir Editor: Operations Tab – "Flow-thru" Zones

The "Flow-thru" operation set for Mitchell Lake contains no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

III. Yates

A. Overview

Yates Reservoir impounds the Tallapoosa River near Tallassee between the reservoirs of Martin and Thurlow. The project is owned by Alabama Power Company. It is a small reservoir, relative to other Alabama Power Company impoundments. The power plant has a total nameplate capacity of 45.5 MW from 2 units. The reservoir also has an uncontrolled spillway.

Figure K.15 shows the location of Yates Reservoir as it is represented in the HEC-ResSim model.

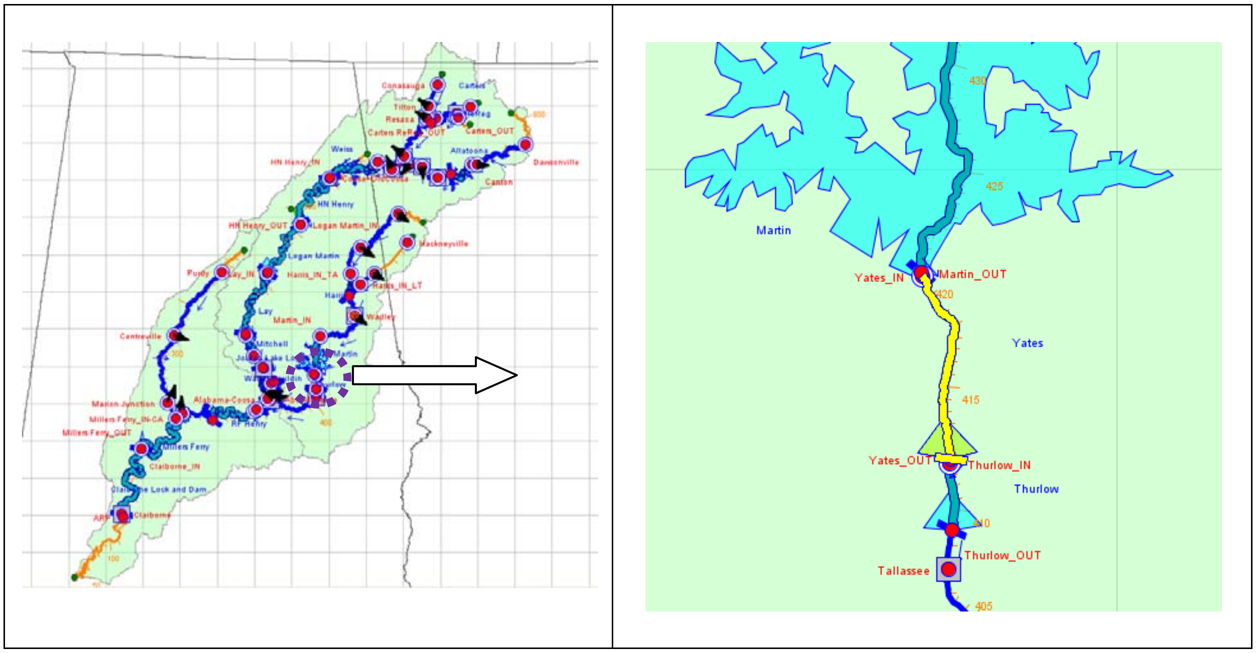

Figure K.15 HEC-ResSim Map Display Showing Location of Yates Reservoir

Figure K.16 shows a photo of Yates Dam.

Figure K.16 Photo of Yates Dam

B. Physical Characteristics

The physical characteristics of each reservoir are separated between the “Pool” and the “Dam” in the ResSim model. The “elevation-storage-area” defines the pool as shown for Yates Reservoir in Figure K.17. Yates Dam consists of two types of outlets: (1) an uncontrolled spillway; and, (2) a power plant. Each of these outlets is defined in the model, and the Dam reflects the composite release capacity of all of the outlets as shown in Figure K.18.

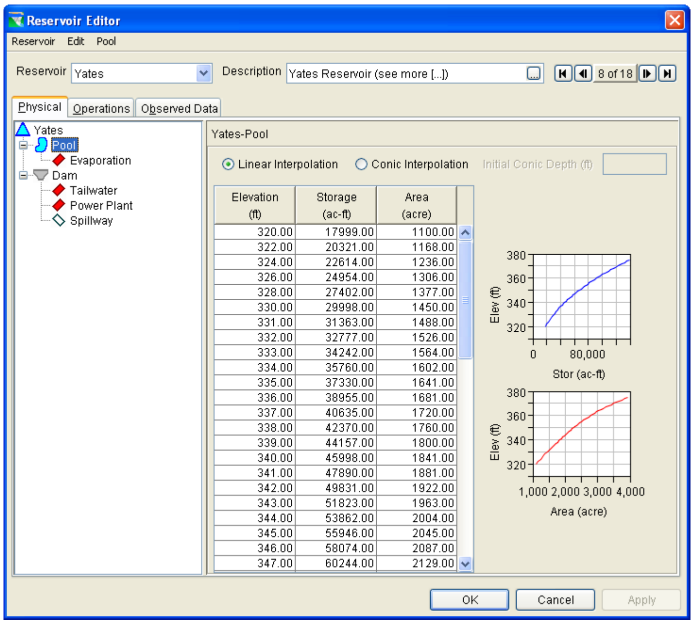

Figure K.17 2009 Network… Yates Reservoir Editor: Physical Tab – Pool

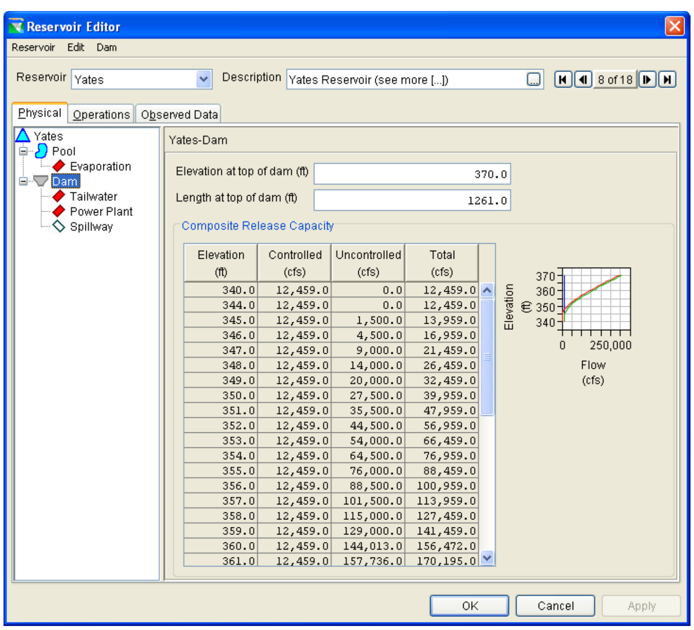

Figure K.18 2009 Network… Yates Reservoir Editor: Physical Tab – Dam

C. Baseline Operations

1. "Flow-thru" Operation Set

Table K.3 shows the definition of operational zones consisting of Top of Dam, Conservation, and Operating Inactive zone, as well as an Inactive zone.

Table K.3 Yates Zone Elevations for "Flow-thru" Operation Set

Yates	Flow-thru Top of Zone Elevation Values (feet)
Seasons =	1Jan - 31Dec
Zones:	
Top of Dam	370
Conservation	344
Operating Inactive	341
Inactive	340.5

The top of the operation zones are constant throughout the entire year (as shown in Figure K.19).

Guide Curve definition (top of **Conservation** zone)

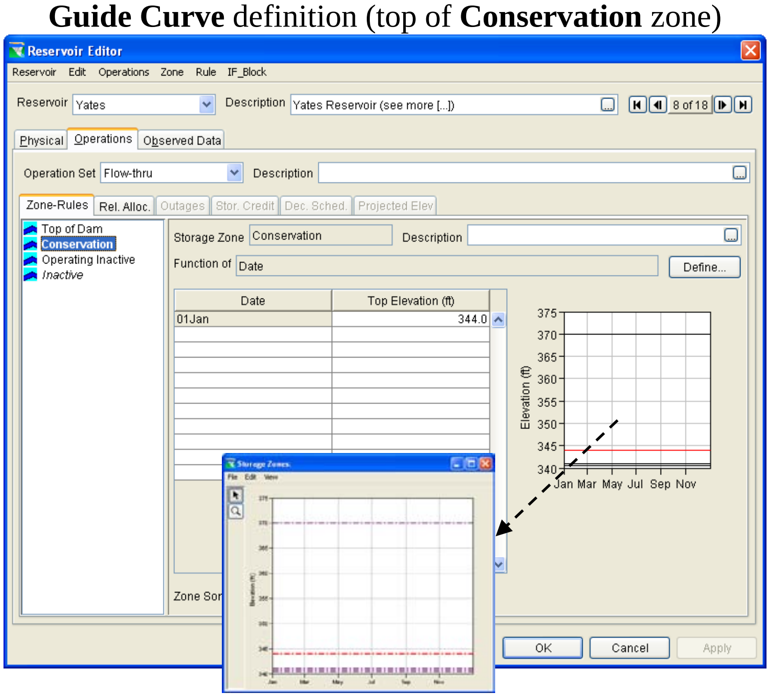

Figure K.19 Yates Reservoir Editor: Operations Tab – "Flow-thru" Guide Curve

Figure K.20 shows a sequential release allocation approach specified for available outlets along Yates Dam. The available outlets are given an order of priority for release. The power plant gets the release until it reaches release capacity. The uncontrolled outlet is not included in the allocation specification because it is not "controllable" (i.e., release is a function of elevation).

Release Allocation:

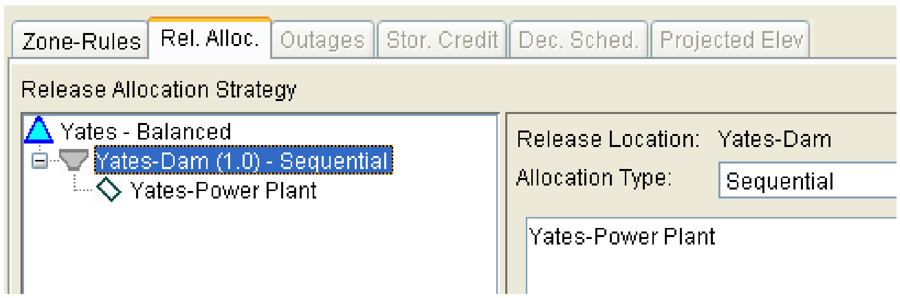

Figure K.20 Yates Reservoir Editor: Operations Tab – "Flow-thru" Release Allocation

Figure K.21 shows a set of operational zones that reflects the operation set named "Flow-thru".

Figure K.21 Yates Reservoir Editor: Operations Tab – "Flow-thru" Zones

The "Flow-thru" operation set for Yates Reservoir contains no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

IV. Thurlow

A. Overview

Thurlow is owned by the Alabama Power Company. It is the smallest reservoir in the chain of Alabama Power Company impoundments. The dam is located in east central Alabama about 30 miles northeast of Montgomery in the City of Tallassee on the Tallapoosa River. The reservoir is 574 acres and its main purpose is the production of hydro-electric power. Other uses include water supply and recreation. Thurlow is directly downstream of Yates Reservoir. The power plant has a total nameplate capacity of 85 MW from 3 units. The project also has a gated spillway.

Figure K.22 shows the location of Thurlow Reservoir as it is represented in the HEC-ResSim model.

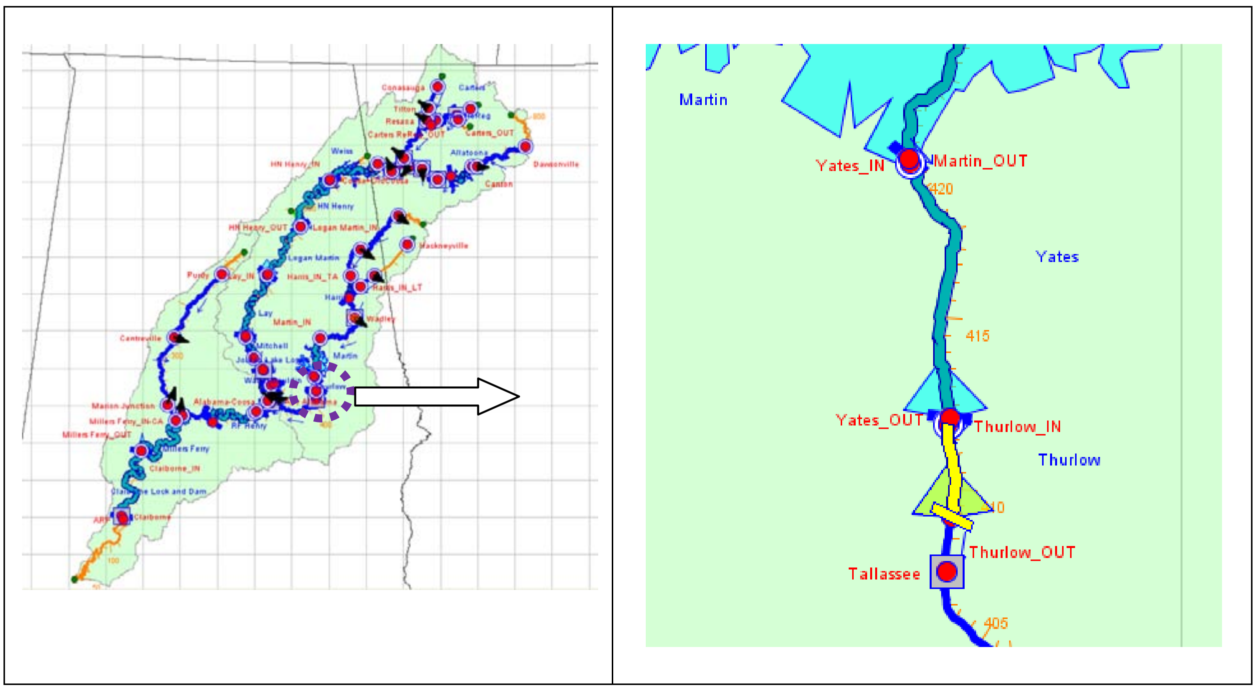

Figure K.22 HEC-ResSim Map Display Showing Location of Thurlow Reservoir

Figure K.23 shows a photo of Thurlow Dam.

Figure K.23 Photo of Thurlow Dam

B. Physical Characteristics

The physical characteristics of each reservoir are separated between the "Pool" and the "Dam" in the ResSim model. The "elevation-storage-area" defines the pool as shown for Thurlow Reservoir in Figure K.24. Thurlow Dam consists of two types of outlets: (1) a gated spillway; and, (2) a power plant. Each of these outlets is defined in the model, and the Dam reflects the composite release capacity of all of the outlets as shown in Figure K.25.

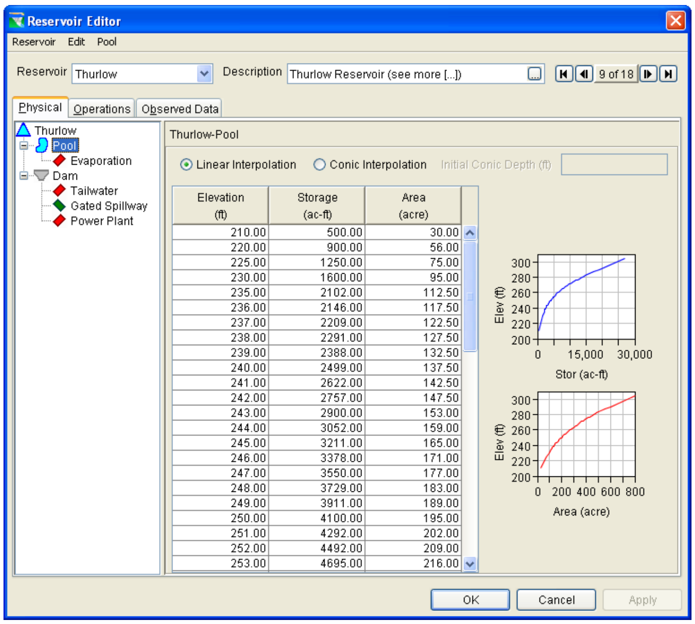

Figure K.24 2009 Network… Thurlow Reservoir Editor: Physical Tab – Pool

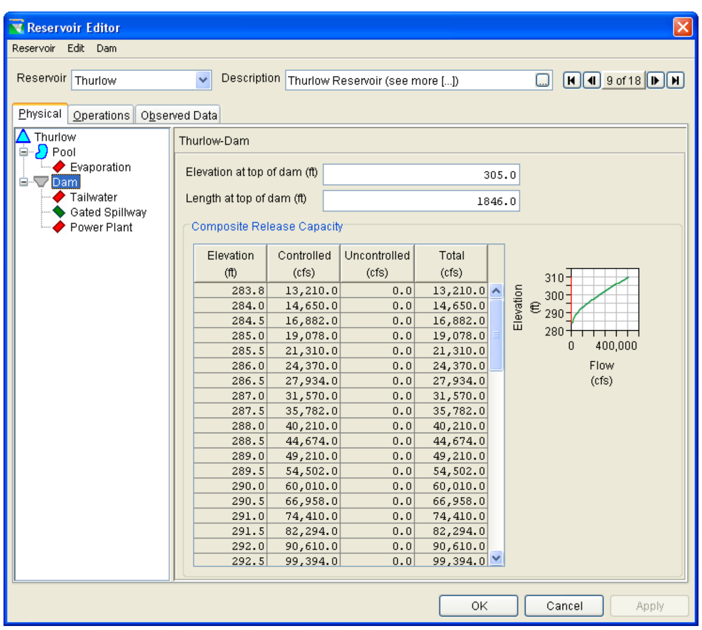

Figure K.25 2009 Network… Thurlow Reservoir Editor: Physical Tab – Dam

C. Baseline Operations

1. "Flow-thru" Operation Set

Table K.4 shows the definition of operational zones consisting of Top of Dam, Conservation, and Operating Inactive zone, as well as an Inactive zone.

Table K.4 Thurlow Zone Elevations for "Flow-thru" Operation Set

Thurlow	**Flow-thru** Top of **Zone Elevation** Values (feet)
Seasons =	**1Jan - 31Dec**
Zones:	
Top of Dam	305
Conservation	288
Operating Inactive	287
Inactive	286.7

The top of the operation zones are constant throughout the entire year (as shown in Figure K.26).

Guide Curve definition (top of **Conservation** zone)

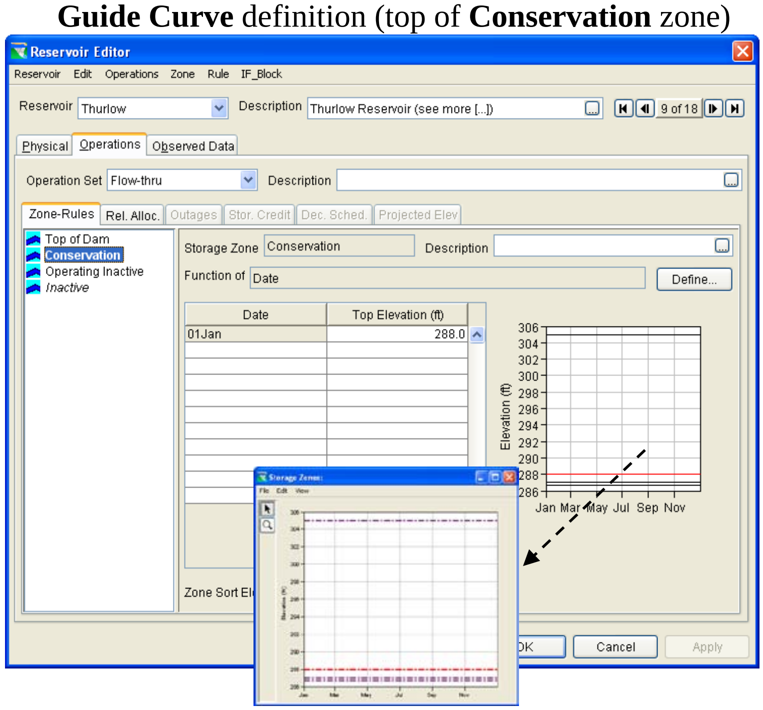

Figure K.26 Thurlow Reservoir Editor: Operations Tab – "Flow-thru" Guide Curve

Figure K.27 shows a sequential release allocation approach specified for available outlets along Thurlow Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. After the capacity through the powerhouse is reached, the remainder of the release goes through the gated spillway.

Release Allocation:

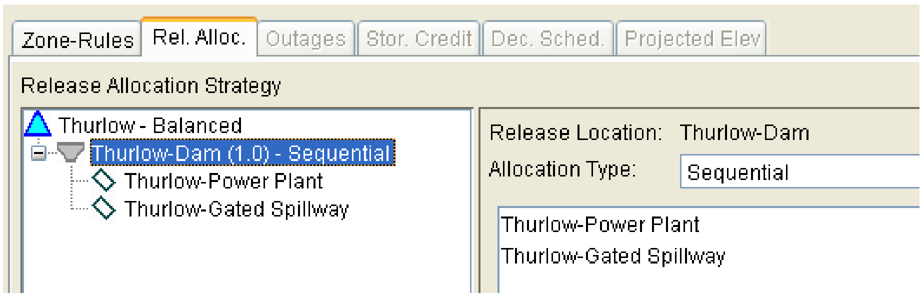

Figure K.27 Thurlow Reservoir Editor: Operations Tab – "Flow-thru" Release Allocation

Figure K.28 shows a set of operational zones that reflects the operation set named "Flow-thru".

Figure K.28 Thurlow Reservoir Editor: Operations Tab – "Flow-thru" Zones

The "Flow-thru" operation set for Thurlow Reservoir contains no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

V. Claiborne Lock and Dam

A. Overview

Claiborne Lock and Dam is operated by the Mobile District of the U.S. Army Corps of Engineers. The dam is located in the southwestern part of the State of Alabama approximately 82 miles above the mouth of the Alabama River. The drainage area from Millers Ferry to Claiborne is 820 square miles with a total drainage area of 21,473 square miles contributing flow at this location. The Claiborne Dam is primarily a navigation structure. It also reregulates the peaking power releases from the upstream Millers Ferry project providing navigable depths in the channel below Claiborne. The project is also used for water quality, public recreation, and fish and wildlife conservation.

The project consists of a concrete gravity-type dam with both a gated spillway section and a free overflow section, supplemented by earth dikes. It also contains a navigation lock and control station. The spillway has two sections. One section is a controlled broad crested weir with a crest elevation of 15 ft. This section is controlled by six tainter gates that are each 60 ft wide and 21 ft high. The other spillway section is an ogee type, free overflow that has a length of 500 ft and a crest elevation of 33 ft.

Figure K.29 shows the location of Claiborne L&D Reservoir as it is represented in the HEC-ResSim model.

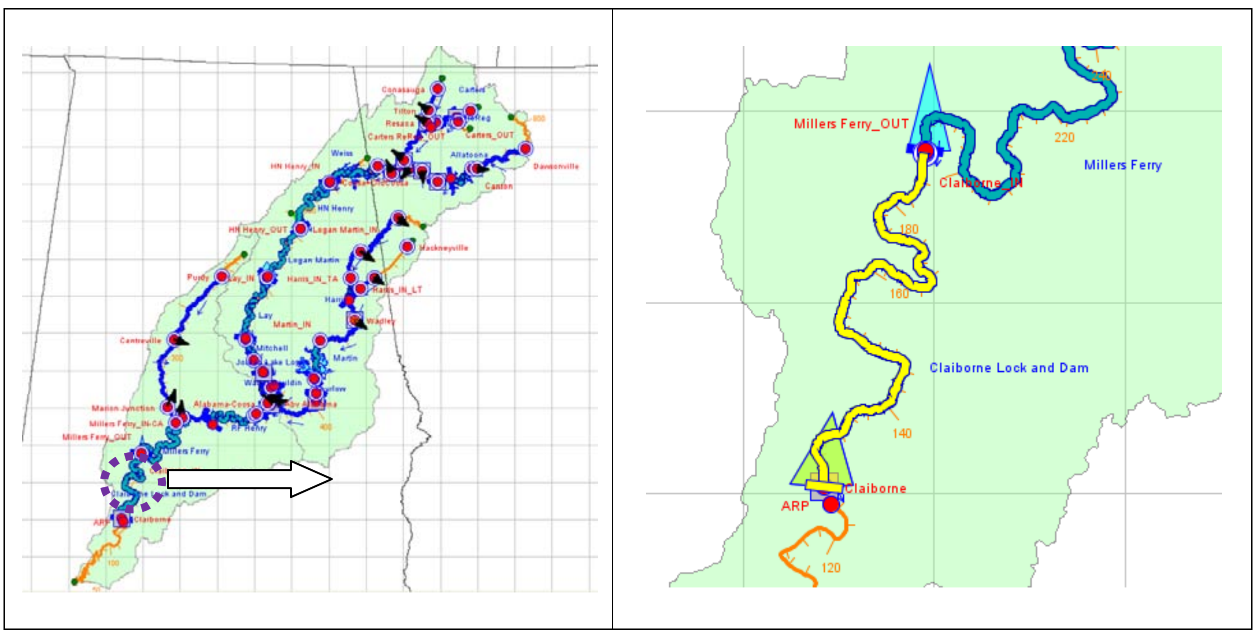

Figure K.29 HEC-ResSim Map Display Showing Location of Claiborne Lock and Dam Reservoir

Figure K.30 shows a photo of Claiborne Lock and Dam.

Figure K.30 Photo of Claiborne Lock and Dam

B. Physical Characteristics

The physical characteristics of each reservoir are separated between the "Pool" and the "Dam" in the ResSim model. The "elevation-storage-area" defines the pool as shown for Claiborne L&D Reservoir in Figure K.31. Claiborne Dam consists of two types of outlets: (1) a gated spillway; and, (2) a fixed crest spillway. Each of these outlets is defined in the model, and the Dam reflects the composite release capacity of all of the outlets as shown in Figure K.32.

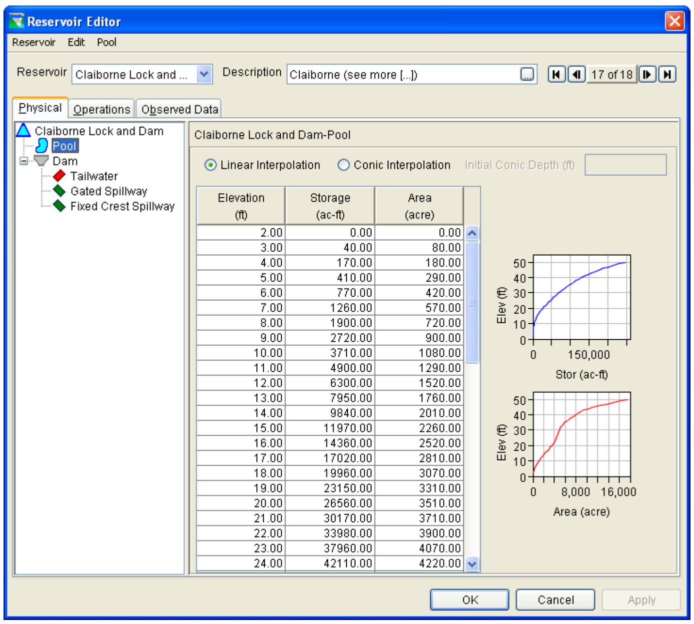

Figure K.31 2009 Network… Claiborne Lock & Dam Editor: Physical Tab – Pool

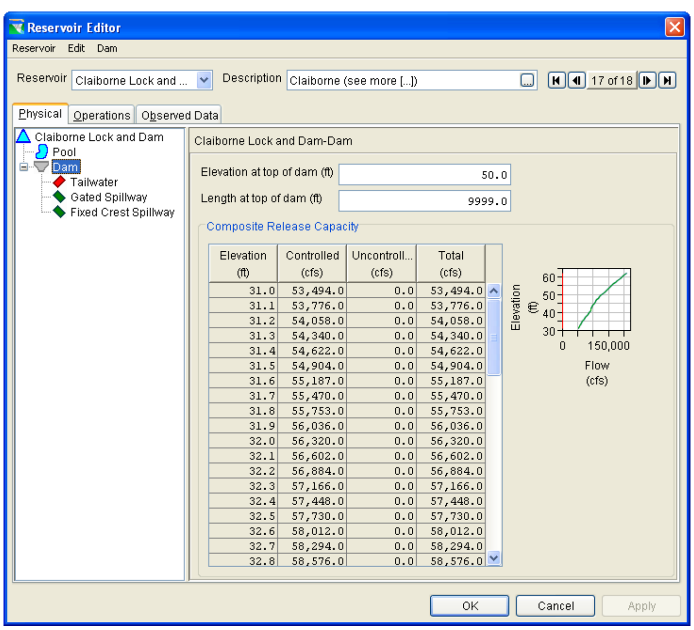

Figure K.32 2009 Network… Claiborne Lock & Dam Editor: Physical Tab – Dam

C. Baseline Operations

1. "Flow-thru" Operation Set

Table K.5 shows the definition of operational zones consisting of Top of Dam, Conservation, and Operating Inactive zone, as well as an Inactive zone.

Table K.5 Claiborne L&D Zone Elevations for "Flow-thru" Operation Set

Claiborne L&D	Flow-thru Top of Zone Elevation Values (feet)
Seasons =	1Jan - 31Dec
Zones:	
Top of Dam	50
Flood Control	36
Conservation	35
Inactive	32

The top of the operation zones are constant throughout the entire year (as shown in Figure K.33).

Guide Curve definition (top of **Conservation** zone)

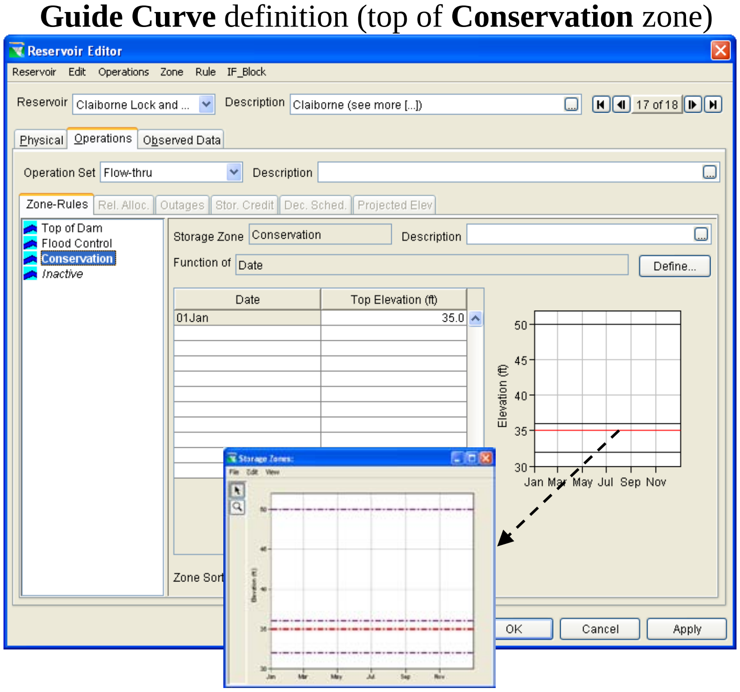

Figure K.33 Claiborne L&D Reservoir Editor: Operations Tab – "Flow-thru" Guide Curve

Releases from Claiborne will be made equally through the two controlled spillways (Gated Spillway and Fixed Crest Spillway). For modeling simplicity both are represented as controlled outlets. Therefore, the option for defining a release allocation was not needed since equal distribution is the default for allocating releases through the controlled outlets. Secondly, since Claiborne is modeled as a flow-thru reservoir detailed distributions of flow is not required. If future application of the ResSim model expects to capture the gated spillway operation, then the release allocation should be adjusted accordingly and the fixed crest spillway changed to uncontrolled.

Figure K.34 shows a set of operational zones that reflects the operation set named "Flow-thru".

Figure K.34 Claiborne L&D Reservoir Editor: Operations Tab – "Flow-thru" Zones

The "Flow-thru" operation set for Claiborne Lock & Dam Reservoir contains no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

Alabama-Coosa-Tallapoosa (ACT) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update

[Baseline]

Appendix L – State Variables and Utility Scripts

March 2011 (DRAFT)

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Appendix L – State Variables and Utility Scripts [Baseline] (DRAFT)

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Description of State Variables
(in the ACT Basin HEC-ResSim Model)

I. State Variables Introduction

Reservoir operation rules are often defined using variables that are not direct output of an HEC-ResSim model. HEC-ResSim uses Python scripting language with the HEC-ResSim API (Application Programming Interface) to customize program operation, plots, and operations in ways that cannot be accomplished directly through the program GUI. The state variable scripts define time-series state variables using model variables and other utility functions. Similar to model variables, state variables can then be available for defining operation rules and IF-Blocks.

It should be noted that the ACT models operating at a daily time step compute the storage values based on the previous day, not the current period. This design reflects the District's procedure for determining today's operations based on conditions observed at the beginning of the workday. Using values from yesterday as inputs to the calculations also simplifies the state variable script implementation, since then the data is not a function of the current release decision.

The following sections provide explanations of the state variables internal logic, and describe intended design purposes and relationships to rules and other state variables. The contents for all of the state variable scripts are included in the appendix.

II. State Variables in "Baseline" Alternative

There are a total of 23 state variables (Figure L.01) in the ACT basin Baseline model. Variables highlighted in yellow are the primary state variables, while those variables highlighted in pink are subordinate (placeholder) state variables that are calculated within the primary state variable scripts. The state variables are defined to establish operating rules for the following operational objectives in the baseline simulations:

- Fish spawning operational considerations at Allatoona
- Operation of Carters and Carters ReReg
- Minimum flow release targets for Martin
- Guide curve buffer for the HN Henry and Logan Martin tandem operation rule
- Power and energy requirements

CartersReRegCompositeZone	CartersActiveEnergyReq
CartersReReg_CompStor	CartersActivePowerReq
DayofWeek	HNHenryActiveEnergyReq
ThurlowBasinInflow	HNHenryActivePowerReq
MartinBasinInflow	HarrisActiveEnergyReq
ThurlowMinQ_hackney	HarrisActivePowerReq
DLR_Low_Composite_Stor	LoganMartinActivePowerReq
DLR_Low_State_Line_Q	LoganMartinActiveEnergyReq
DLR_CS_CON	MartinActiveEnergyReq
DLR_CS_DRT	MartinActivePowerReq
DLR_CS_OIA	WeissActiveEnergyReq
DLR_CS_CON_Active	WeissActivePowerReq
DLR_CS_DRT_Active	Allatoona_ElevState
DLR_CS_Actual	Allatoona_BaseElev
DLR_CS_Actual_Active	Allatoona_FSCompliance
DLR_SLQ_minRCflow	CartersSysInflow_AdjAvg
DLR_SLQ_SL7Q10	NAV_CheckBI
DLR_Low_Basin_Inflow	CurMonth
DLR_BI	SpawnSeason
DLR_BI_MinReq	NAV_BI_14d
DLR_Drought_Intensity_Level	DLR_BI_monAvg
DLR_Half_Yates_Inflow	DLR_SLQ_RC7d
DLR_minFlow_fn_Heflin_Yates	NAV_BI
NAV75_BI_MinReq	DLR_BI_14d
NAV90_BI_MinReq	Carters_Seasonal_Min
CartersSystemInflow	DLR_Low_State_Line_Q_rev
AllatoonaActiveEnergyReq	DLR_Drought_Intensity_Level_rev
AllatoonaActivePowerReq	LoganMartin_GCBuffer

Figure L.01 List of State Variables in the ACT Basin Baseline Alternative

A. State Variables Used for Fish Spawning Operational Considerations at Allatoona

In accordance with the procedures of SAM standing operating procedure (SOP) 1130-2-9, entitled "Project Operations, Reservoir Regulation and Coordination for Fish Management Purposes, Mobile District, Corps of Engineers, Department of the Army, Draft, February 2005," during the spawning periods, the Corps shall operate for generally stable or rising reservoir levels, and generally stable or gradually declining elevations in the ACT system, for approximately 4 to 6 weeks during the designated spawning period for the specified project area (Table L.01). Generally stable or rising levels are defined as not lowering the reservoir levels by more than 6 inches, with the base elevation generally adjusted upward as levels rise due to increased inflows or refilling of the reservoir. Generally stable or gradually declining river stages are defined as ramping down of ½ foot per day or less.

Table L.01 Fish Spawning Periods for Projects in the ACT Basin

Project	Principal Fish Spawning Period for Operational Consideration
Allatoona	15 March – 15 May

1. *State Variable – "SpawnSeason"*

The state variable, **"SpawnSeason"** determines whether or not it is fish spawning season and assigns a binary code for the value of the state variable. This state variable is located under FishSpawning rule in the Conservation zone and in Zone 2. During spawning season (March 15- May 15), the variable "SpawnSeas" is set to 1 (Figure L.02). When it is not spawning season, the variable, "SpawnSeas" is set to 0.

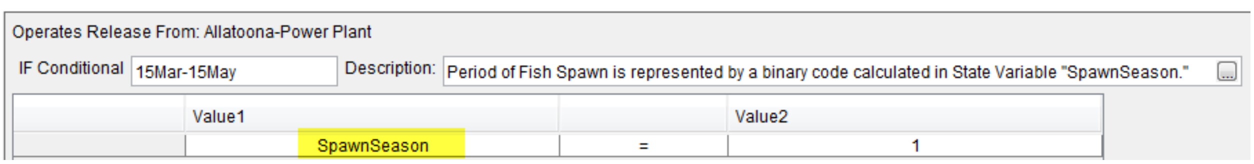


Figure L.02 Application of State Variable "SpawnSeason"

When the "SpawnSeas" value is 1, then a series of rules that are dependent upon the elevation of the Allatoona reservoir are used to control the release from Allatoona. These rules use another state variable, **"Allatoona_ElevState"**, which is described in the next section.

2. *State Variable – "Allatoona_ElevState"*

The state variable, **"Allatoona_ElevState"** is used to operate the release from Allatoona during fish spawning season when in the Conservation Zone and in Zone 2. This state variable sets the base elevation for Allatoona at the start of spawning season and determines the elevation state during spawning season and assigns a code based on that state (Figure L.03). The lake elevation state at the current time step is determined by the drop in lake elevation from the base elevation. The lake elevation state is defined as follows:

```
# State variable: Allatoona_Elev_State
#  Code =0: Pool is rising
#         =1: The first day of the fish spawning
#         =2: The pool has dropped within 0.3 ft from the base elevation
#         =3: The pool has dropped within 0.3-0.4 ft from the base elevation
#         =4: The pool has dropped within 0.4-0.45 ft from the base elevation
#         =5: The pool has dropped within 0.45-0.49 ft from the base elevation
#         =6: The pool has dropped within 0.49-0.50 ft from the base elevation
#         =7: The pool has dropped more than 0.50 ft from the base elevation
```

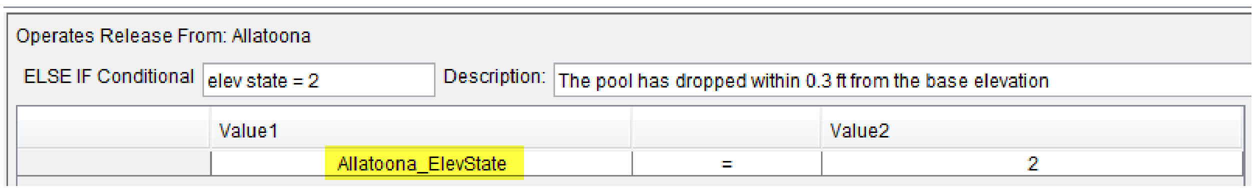


Figure L.03 Application of State Variable "Allatoona_ElevState"

The first step in this script is to set the base elevation as the elevation at the start of Spawning Season (March 15th). This is done by finding the pool elevation on March 15th and assigning it to the place holder state variable, **"Allatoona_BaseElev**".

```
if (curMon==3) and (curDay == 15):
        ELEV_TS = network.getTimeSeries("Reservoir","Allatoona", "Pool", "Elev")
        ELEV = ELEV_TS.getPreviousValue(currentRuntimestep)
        BaseElev = ELEV
        Code =1
        BaseELEV_StVar=network.getStateVariable("Allatoona_BaseElev")
        BaseELEV_StVar.setValue(currentRuntimestep,BaseElev)
        currentVariable.setValue(currentRuntimestep,Code)
```

Depending on the amount of lake elevation drop from the base elevation, a maximum draw-down limit is specified for the current time step. For example, if the elevation at the current time step is 0.3-0.4 feet below the set base elevation, then the current lake elevation state is 3 and the maximum lake elevation drop allowed for the current day is 0.1 feet (Figure L.04).

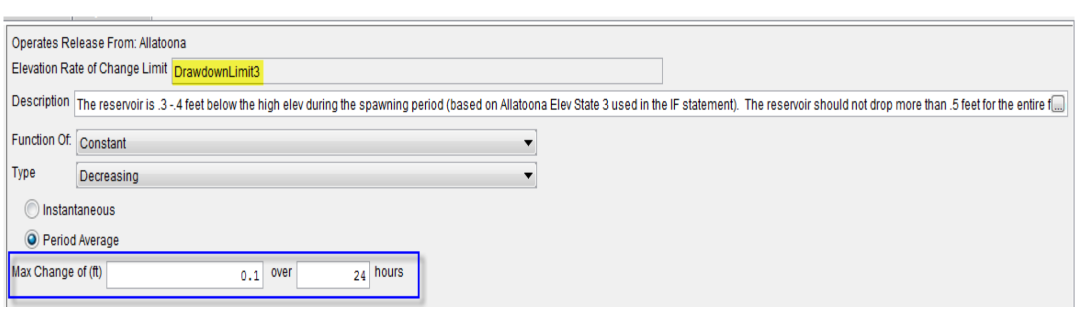


Figure L.04 Maximum Drawdown Limit in Allatoona Based on Elevation State

If the elevation for the current time step is higher than the base elevation value, then the base elevation value is reset to the current elevation. This indicates a rising pool and the code is set to zero:

```
if BaseELEV_Pre < ELEV:
        BaseELEV_Cur=ELEV
        Code=0
```

"Allatoona_ElevState" counts the numbers of days during the fish spawning periods that the fish spawning requirements are met and places that number in the state variable place holder, **"Allatoona_FSCompliance"**. The count increases by one if the cumulative pool elevation drop from the base elevation is not greater than 6 inches.

```
Days_StVar= network.getStateVariable("Allatoona_FSCompliance")
Num=1 # first day is automatically compliant
Days_StVar.setValue(currentRuntimestep,Num)

Days_StVar= network.getStateVariable("Allatoona_FSCompliance")
Days_StVar_TS= Days_StVar.getTimeSeries()
Count_Pre=Days_StVar_TS.getPreviousValue(currentRuntimestep)
if Code <=6:
        Count_Cur=Count_Pre+1
else:
        Count_Cur=Count_Pre
Days_StVar.setValue(currentRuntimestep,Count_Cur)
```

B. State Variables Used for Operation of Carters and Carters ReReg

Two state variable scripts are used to compute the system inflow into Carters and Carters ReReg reservoirs (Figure L.05). The state variables, **"CartersSystemInflow"** and **"CartersSysInflow_AdjAvg"** are used to calculate a moving multi-day average of Carters inflow and Talking Rock inflow (which is a stream that comes in between Carters and Carters ReReg) to set rule priority at Carters and a minimum release requirement at Carters ReReg.

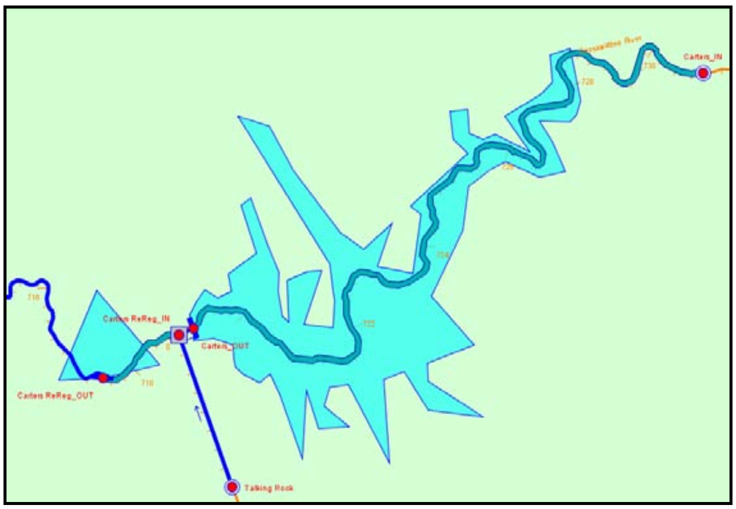


Figure L.05 Carters and Carters ReReg Reservoir System

1. State Variable – "CartersSystemInflow"

"CartersSystemInflow" is used in the operation of Carters in the GC (Guide Curve) Buffer Zone under the "Watch System Inflow" logical statement (Figure L.06). This logical statement is used for determining the priority of the downstream control function rule and the required power generation rule. When the sum of **Carters In** and **Talking Rock** are greater than 2,500 cfs (High System Inflow), the downstream control rule, "Max@ReReg IN" is a higher priority rule than the power rule, "Power06_MonthlyPF_12%". This limits the release from Carters to allow Carters ReReg to comply with the ReReg Maximum Channel capacity. When the sum of **Carters In** and **Talking Rock** are below 2,500 cfs (Low System Inflow), then the Watch System Inflow IF statement switches to the ELSE condition and the required power generation is a higher priority rule than the downstream control function. When this happens, power is generated at Carters even if it causes the downstream maximum to be exceeded.

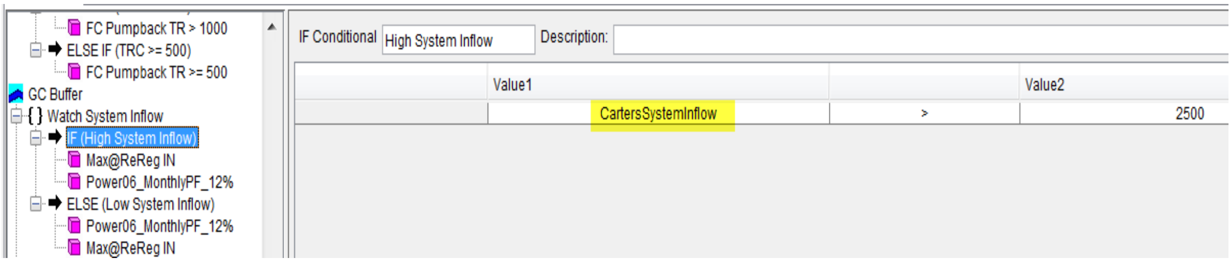


Figure L.06 Application of State Variable "CartersSystemInflow"

The **"CartersSystemInflow"** state variable first calculates the 4-day running average (1 day back and 2 days forward plus the current time step) of Carters In:

```
CartersIn = network.getTimeSeries("Junction","Carters_IN", "", "Flow") .
        getPeriodAverage ((currentRuntimestep.getStep()+2), 4)
```

It should be noted that CartersIn represents the inflow to the Carters reservoir. Because it is a headwater reservoir, the inflow to the reservoir for the entire simulation time window is known. Next it calculates the 4-day running average of Talking Rock Creek:

```
TalkingRockIn = network.getTimeSeries("Junction","Talking Rock", "", "Flow") .
        getPeriodAverage((currentRuntimestep.getStep()+2), 4)
```

Then it sums the 4-day average from both Carters In and Talking Rock Creek for the current timestep:

```
sumInflow=CartersIn+TalkingRockIn
```

2. State Variable – "CartersSysInflow_AdjAvg"

The **"CartersSysInflow_AdjAvg"** state variable is used in the operation of Carters ReReg in the Flood Control and Conservation Zones (Figure L.07). The "MinQ=110% CartersSysInflow" rule in the Flood Control Zone sets a minimum ReReg release as 110% of the adjusted system inflow to Carters. The "MinQ=92% CartersSysInflow" rule in the Conservation Zone sets a minimum ReReg release as 92% of the adjusted system inflow to Carters. The adjusted system inflow is the Carters inflow + Talking Rock Creek inflow, and takes into account the filling and drawing down of Carters. It is calculated on Mondays and adjusted on Thursdays, if inflow has changed by at least 15%.

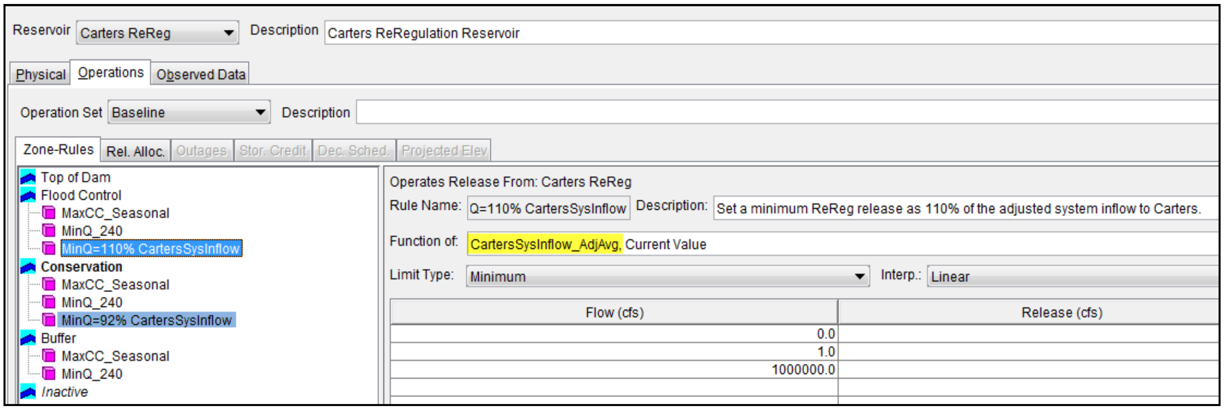


Figure L.07 Application of State Variable "CartersSysInflow_AdjAvg"

The **"CartersSysInflow_AdjAvg"** state variable is similar to the **"CartersSystemInflow"** state variable, but calculates the 7-day running average (looks forward 3 days and back 3 days) of Carters In and Talking Rock inflows.

```
CartersIn = network.getTimeSeries("Junction","Carters_IN",
        "","Flow").getPeriodAverage((currentRuntimestep.getStep()+3), 7)
TalkingRockIn = network.getTimeSeries("Junction","Talking Rock", "",
        "Flow").getPeriodAverage((currentRuntimestep.getStep()+3), 7)
sumInflow=(CartersIn+TalkingRockIn)
```

The state variable determines what month and day of the week the current time step is using the following equations:

```
day_of_week=currentRuntimestep.getHecTime().dayOfWeek()
month = currentRuntimestep.month()
```

On Mondays, the Carters ReReg minimum release requirement is computed using the sum of the 7-day average inflows for Carters and Talking Rock Creek and adding an adjustment factor based on the current month. If the month is November, the adjustment factor is 109 cfs. If the month is April, the adjustment factor is -109 cfs. The value of 109 cfs is the rate of the rising and falling Conservativion pool of Carters. All other months have an adjustment factor of zero.

```
adjust_inflow = 0
if month == 11: adjust_inflow = 109
if month == 4: adjust_inflow = -109
if (day_of_week == 1) :  # Mon
        minRel = sumInflow + adjust_inflow
```

On Thursdays, this minimum release is again computed. If this computation gives a result that has a difference of 15% or more from the current value for the minimum release, this new computation value becomes the new minimum release.

```
elif (day_of_week==4 ) :  # Thursday
        newsum = sumInflow+adjust_inflow
        minRel = currentVariable.getPreviousValue(currentRuntimestep)
        changerate = abs(newsum - minRel)/minRel
        if (changerate > 0.15): minRel = newsum
```

If it has less than a 15% difference, the minimum release value remains the same.

```
else:
        minRel = currentVariable.getPreviousValue(currentRuntimestep)
```

If the pool elevation at Carters is low (meaning that the current pool elevation is less than 1 foot below top of conservation), the minimum release at Carters (minRel) is reduced to 240 cfs to allow Carters to refill.

```
CartersElev =network.getTimeSeries("Reservoir","Carters", "Pool",
        "Elev").getPreviousValue(currentRuntimestep)
CartersConZone = network.getTimeSeries("Reservoir","Carters", "Conservation", "Elev-
        ZONE").getPreviousValue(currentRuntimestep)
CartersConZoneTolerance = CartersConZone - 1
if CartersElev < CartersConZoneTolerance :
        minRel = 240
```

C. State Variables Used for Minimum Flow Release Targets of Martin

The minimum release from Martin uses the state variable, **"CurMonth"** to determine the current month of the time step which controls the release from Martin. From November through May, the minimum downstream requirement at Tallassee is a function of 3 gages: Hackneyville, Heflin, and Newell (Figure L.08). During the rest of the year (June-October), a constant target minimum of 1,200 cfs at the Tallassee gage (downstream of Thurlow) is used.

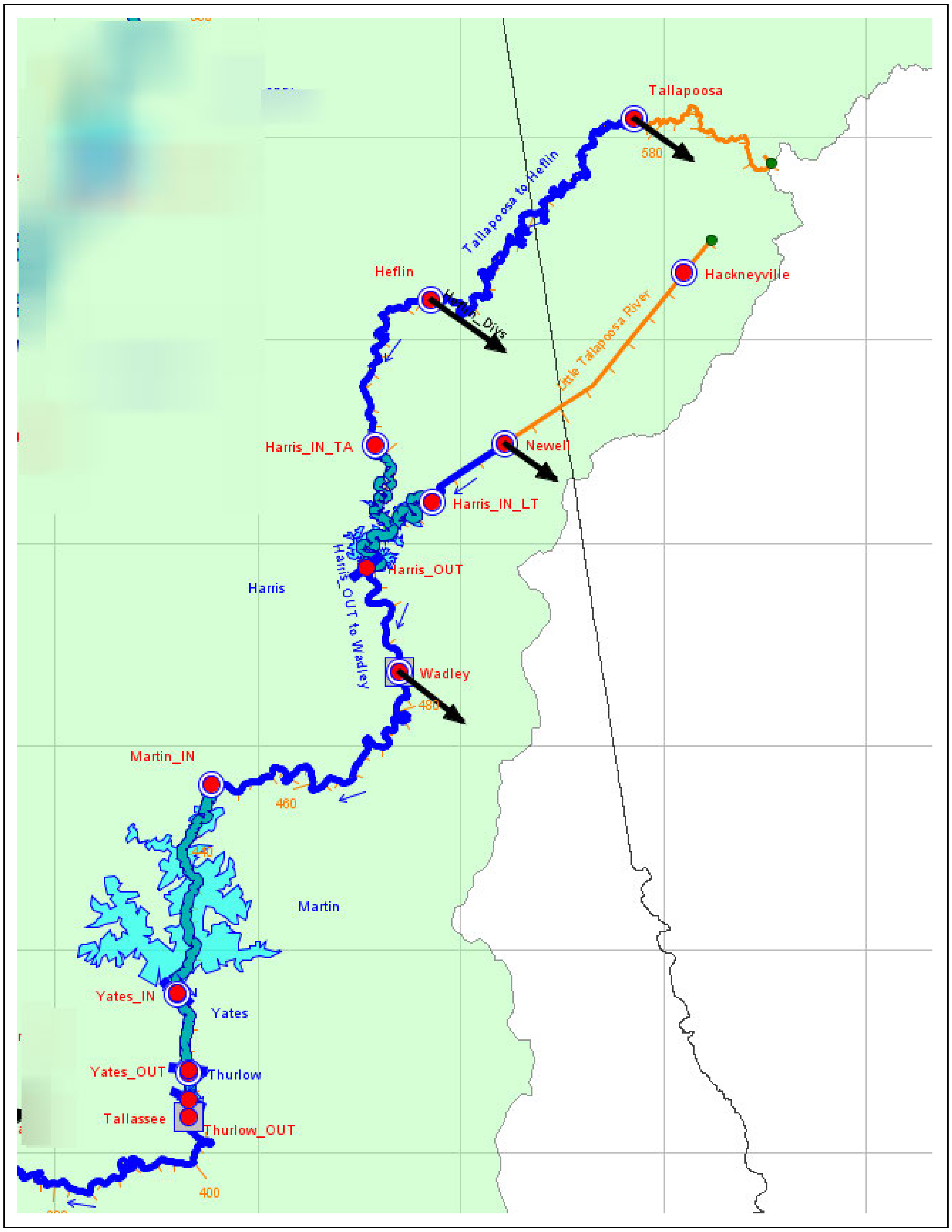


Figure L.08 Schematic of Martin Reservoir System

1. State Variable – "CurMonth"

The state variable, **"CurMonth"** is calculated in the "Seasonal MinQ" conditional block in the Flood Control, Conservation, and Drought Zones of Martin (Figure L.09). The state variable is used to determine the current month of the time step.

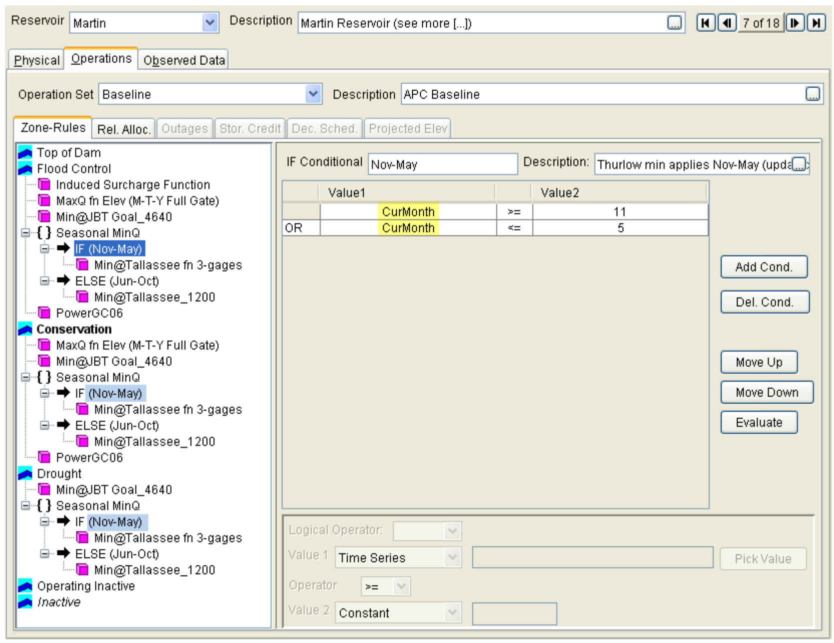


Figure L.09 Application of the State Variable "CurMonth"

If the state variable **"CurMonth"** is greater than or equal to 11 or less than or equal to 5 (the current month is between November and May), then the rule "Min@Tallassee fn 3-gages" is used to determine the minimum release from Martin. If "CurMonth" is between 6 and 10 (June-October), then the "Min@Tallasee_1200" rule is used instead.

2. State Variable – "ThurlowMinQ_hackney"

If the month is determined with the **"CurMonth"** state variable to be between November and May, then the state variable, **"ThurlowMinQ_hackney"** is used in the "Min@Tallassee fn 3-gages" rule (Figure L.10).

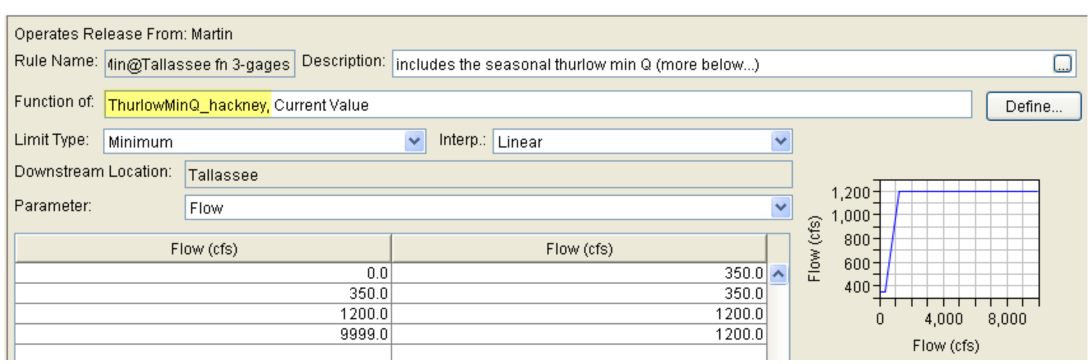


Figure L.10 Application of the State Variable "ThurlowMinQ_hackney"

The state variable, **"ThurlowMinQ_hackney"** is used to determine the flow requirement at the downstream location Tallassee. The 3-gage flow is based on the area weighted average of three gages. The first step in the state variable script checks the day of the week:

```
dayOfWeek = currentRuntimestep.getDayOfWeek()
```

If the day of the week is 2 (Tuesday) then a new minimum flow is calculated. If the day of the week is not Tuesday, then the minimum value stays set at the value from the previous Tuesday.

```
if dayOfWeek == 2 :
```

The next step in the script calculates the 7-day running average for three flow gages upstream of Harris-- Heflin, Newell, and Hackneyville (as previously shown Figure L.08) and divides by the contributing areas (Table L.02) to determine the weighted average of each gage:

```
heflinTS = network.getTimeSeries("Junction","Heflin", "", "Flow")
heflinWeightedAve = heflinTS.getPeriodAverage( currentRuntimestep.getStep(), 7 ) / heflinArea

newellTS = network.getTimeSeries("Junction","Newell", "", "Flow")
newellWeightedAve = newellTS.getPeriodAverage( currentRuntimestep.getStep(), 7 ) / newellArea

hackneyTS = network.getTimeSeries("Junction","Hackneyville", "", "Flow")
hackneyWeightedAve = hackneyTS.getPeriodAverage( currentRuntimestep.getStep(), 7 ) / hackneyArea
```

Table L.02 Drainage Areas for Flow Gages Upstream of Harris

Gage Location	Area (square miles)
Heflin	448
Newell	406
Hackney	190
Wadley-Martin (combined area between Wadley and Martin)	1325

The next step insures that the individual basin inflows are not negative:

```
if heflinWeightedAve < 0 :
  heflinWeightedAve = 0
if newellWeightedAve < 0 :
  newellWeightedAve = 0
if hackneyWeightedAve <= 0 :
  hackneyWeightedAve = 0
```

If the Hackneyville data is less than zero, then valid data is not available, so the number of gages used in the minimum flow calculation changes from 3 to 2.

Next the weighted average basin inflow (cfs/sq mile) is calculated:

```
basinInflow = ( heflinWeightedAve + newellWeightedAve + hackneyWeightedAve ) / num_gages
```

The storage values are then set based on the month. February, March, and April are the only three months with storage values. All other months are set to zero.

```
if curMonth == 2 :
  storValue = -0.3698
elif curMonth == 3 :
  storValue = -0.8854
elif curMonth == 4 :
  storValue = -0.8854
else :
  storValue = 0
```

The appropriate storage value is then applied to the weighted average basin inflow as an adjustment. If this result is less than .7273, the target minimum flow is set by the equation given below. If this result is greater than or equal to .7273, the target minimum flow is set to 1200 cfs.

```
if (basinInflow + storValue) < 0.7273 :
  targetMinQ = 3300 * ( basinInflow + storValue) / 2
else :
  targetMinQ = 1200
```

The target minimum flow must stay between 350 to 1200 cfs, so the following script is added:

```
if targetMinQ < 350 :
  targetMinQ = 350
elif targetMinQ > 1200 :
  targetMinQ = 1200
```

The rule curve from the applied state variable in the “Min@Tallassee fn 3-gages” rule is shown in Figure L.11. The minimum release is set to 350 cfs for state variable values between 0 and 350. It is set to the state variable value for state variable values between 350 and 1200. The final line of this rule sets the minimum release to 1200 cfs for state variable values above 1200. However, this state variable should not send out a value greater than 1200.

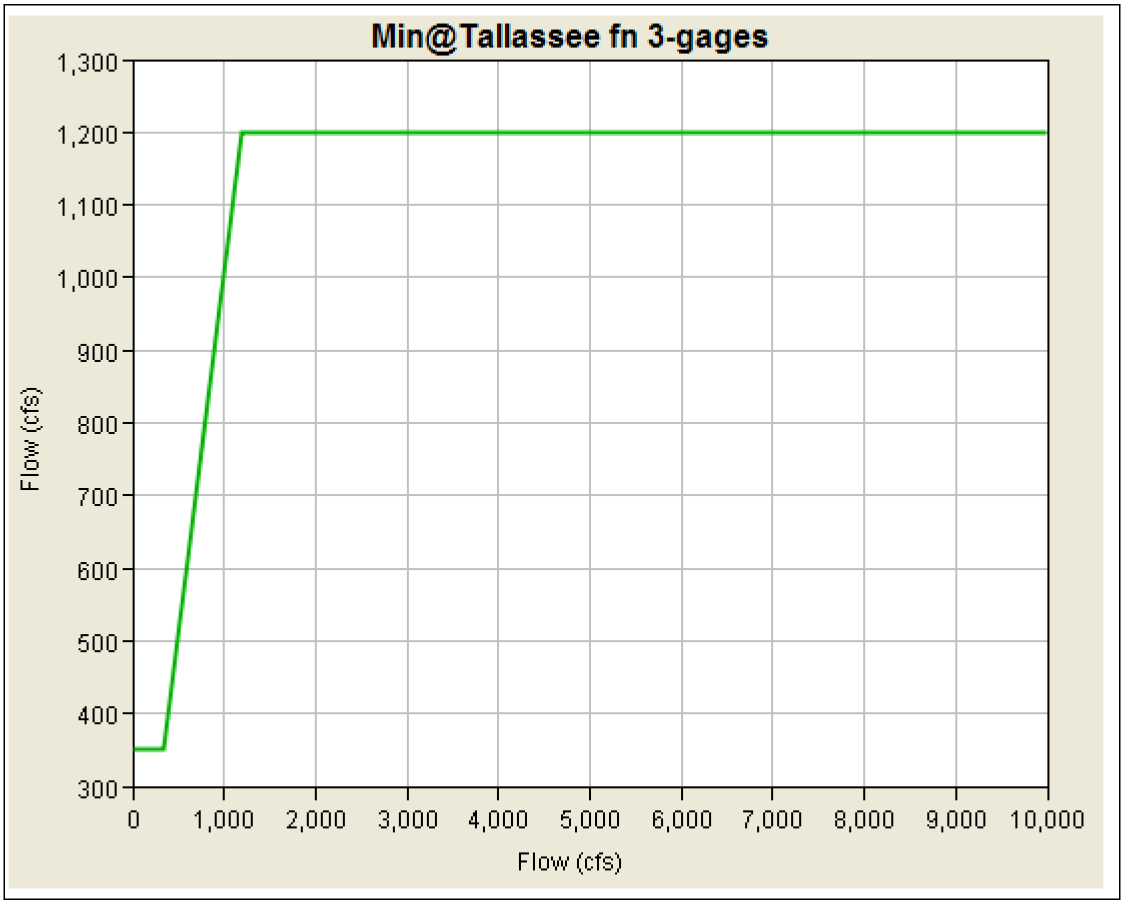


Figure L.11 Martin's Downstream Minimum Requirement Rule for Tallassee (as a Function of Flow from 3 Gages)

D. State Variables Used for Guide Curve Buffer on Logan Martin for HN Henry Tandem Operation

A single state variable, **“LoganMartin_GCBuffer”**, is used in the operation of HN Henry in the Conservation Zone (Figure L.12). This state variable determines when the “Logan Martin_Tandem” rule should be operated for HN Henry.

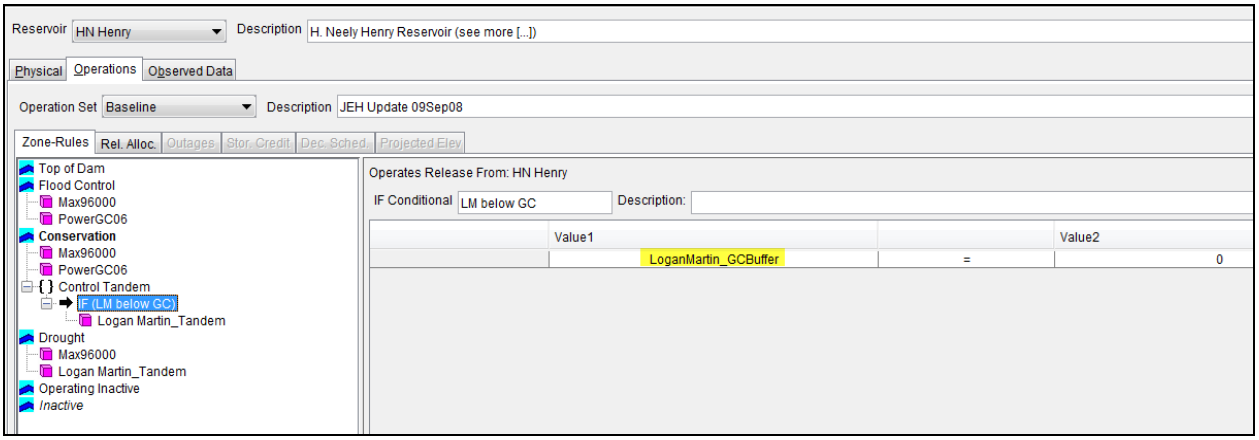


Figure L.12 Tandem Operation Function

1. State Variable – “LoganMartin_GCBuffer”

The state variable “LoganMartin_GCBuffer” is used to determine whether the reservoir at Logan Martin is at or above the guide curve using a tolerance of .025 ft below the top of the guide curve.

```
lmPool = network.getTimeSeries("Reservoir","Logan Martin", "Pool",
        "Elev").getPreviousValue(currentRuntimestep)
lmGC =network.getTimeSeries("Reservoir","Logan Martin", "Conservation", "Elev-
        ZONE").getPreviousValue(currentRuntimestep)
tol = 0.025
```

It calculates the current state of the reservoir by assessing if the current Logan Martin Pool elevation is within .025 ft of the guide curve when the pool is in conservation or is above the top of conservation.

```
lmGC = lmGC-tol
if lmPool>lmGC:
        curState=1
else:
        curState=0
```

If the value of “LoganMartin_GCBuffer” is equal to 0, then the “Logan Martin_Tandem” rule will be used. If Logan Martin pool elevation is above the conservation zone or within .025 of the guide curve when in the conservation zone (state variable set to 1), then the reservoirs are not operated in tandem.

E. State Variables Used for Power and Energy Requirements

These state variables are used to calculate resulting power and energy requirements for each project. They are necessary because ResSim tracks the energy and power required output separately for each power rule implemented in each zone, but only one has actual output for a given day. These state variables combine the separate output for each zone so that one dataset shows the power or energy requirement regardless of which zone the reservoir occupied. The purpose of this state variable is to look at the comparison of the required power generation based on the rules governing power generation with the actual power generation.

All the work is done in the “CartersActivePowerReq” state variable, simply for the convenience of the script writing. It determines active power and active energy required for Allatoona, Carters, HN Henry, Harris, Logan Martin, Martin and Weiss. The values are computed as a post-process (i.e., check “Always Compute This Variable”).

1. State Variable – “CartersActivePowerReq”

The power rules and requirements change from zone to zone and from project to project, so this script is used to calculate actual power requirements based on the current alternative and zone. The first step checks the current alternative in order to determine which set of zones and rules should be used:

```
curAlt = currentVariable.getSystem().getAlternative().getName()

if curAlt[0] == "_" :
    curAlt = curAlt[1:11]
```

The script then sets up a list of zones and associated power rules for each project according to the guide curves listed in the following table (Table L.03).

Table L.03 Power Rules for Each Zone at Each Project

Zone	Rule Name
Allatoona – Baseline Alternative	
Top of Dam (TOD)- Surcharge	(No Power Rule)
Flood Control (FC)	PowerGC FC_4hrs
Conservation (Con)	PowerGC Z1_2-4hrs
Zone 2 (Z2)	PowerGC Z2_0-1hrs
Inactive	(No Power Rule)
Carters – all Alternatives	
Top of Dam (TOD)- Surcharge	(No Power Rule)
Flood Control (FC)	Power06_MonthlyPF_12%
GC Buffer (GC)	Power06_MonthlyPF_12%
Conservation (Con)	Power06_MonthlyPF_12%
Inactive	(No Power Rule)
Weiss – all Alternatives	
Top of Dam (TOD)- Surcharge	(No Power Rule)
Flood Control (FC)	PowerGC06
Conservation (Con)	PowerGC06
Drought	(No Power Rule)
Operating Inactive- Inactive	(No Power Rule)
HN Henry – all Alternatives	
Top of Dam (TOD)	(No Power Rule)
Flood Control (FC)	PowerGC06
Conservation (Con)	PowerGC06
Drought- Inactive	(No Power Rule)
Logan Martin – all Alternatives	
Top of Dam (TOD)- Surcharge	(No Power Rule)
Flood Control (FC)	PowerGC06
Conservation (Con)	PowerGC06
Drought	(No Power Rule)
Operating Inactive- Inactive	(No Power Rule)
Martin – all Alternatives	
Top of Dam (TOD)	(No Power Rule)
Flood Control (FC)	PowerGC06
Conservation (Con)	PowerGC06
Drought	(No Power Rule)
Operating Inactive- Inactive	(No Power Rule)
Harris – all Alternatives	
Top of Dam (TOD)	(No Power Rule)
Flood Control (FC)	PowerGC06
Conservation (Con)	PowerGC06
Drought	(No Power Rule)
Operating Inactive- Inactive	(No Power Rule)

Allatoona is the only project with different power guide curves for each zone. The "PowerGC FC_4hrs" rule in the Flood Control zone uses a plant factor of 16.67% to give the equivalent of 4 hours of power generation each day. This requirement is in effect for 0-100% power storage in use (Figure L.13). The zone at the top of the power pool is the Flood Control zone and the zone at the bottom of the power pool is the Conservation zone.

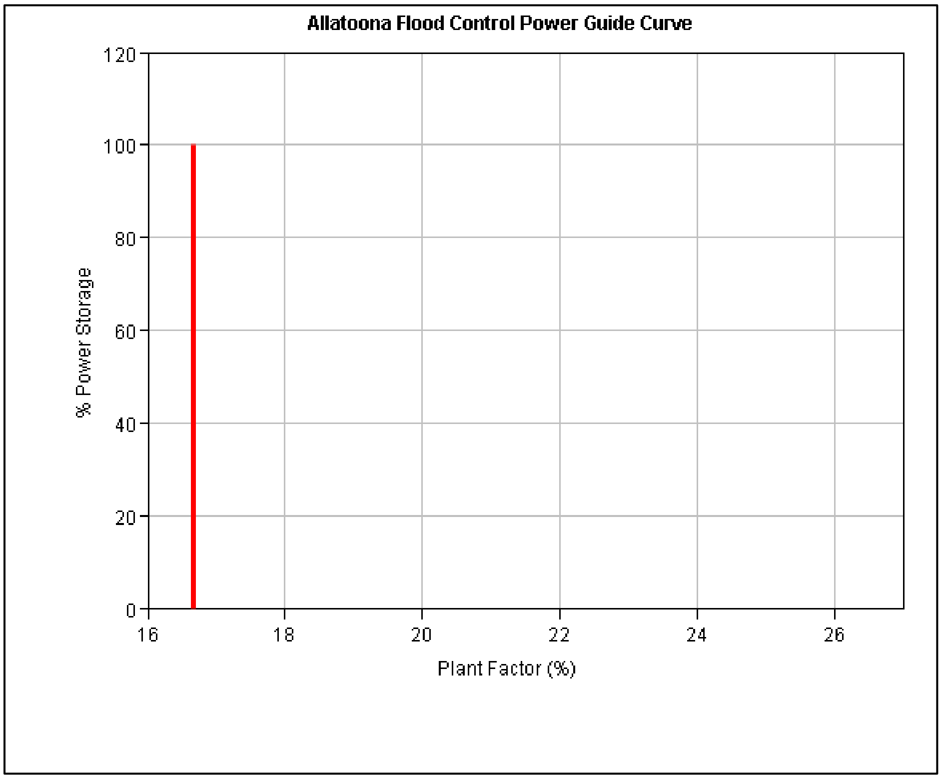


Figure L.13 PowerGC FC_4hrs Guide Curve

When Allatoona is in the Conservation zone, the "PowerGC Z1_2-4hrs" rule generates power for two to four hours, depending on the amount of power storage in use (Figure L.14). When the amount of power storage is below 40%, a plant factor of 8.33% (2 hours) is used. From 40-69.99% of power storage in use, a plant factor of 12.5% (3 hours) is used. From 70-100% a plant factor of 16.67% (4 hours) is used. The zone at the top of the power pool is the Conservation zone and the zone at the bottom of the power pool is Zone 2.

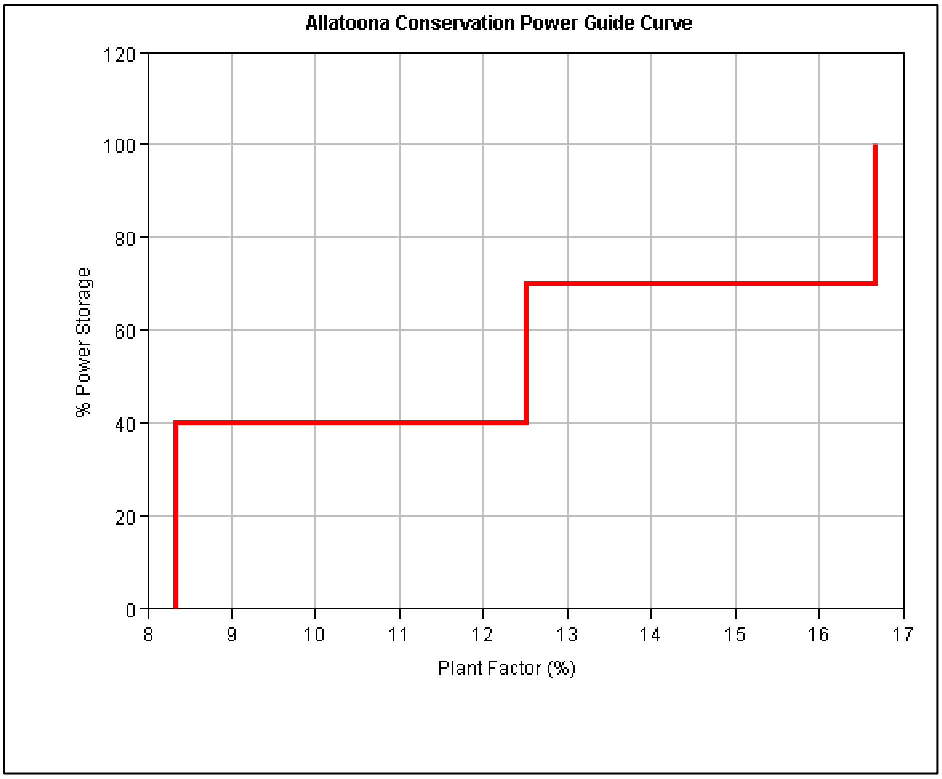


Figure L.14 PowerGC Z1_2-4hrs Guide Curve

The "PowerGC Z2_0-1hrs" rule is activated when Allatoona is in Zone 2 (Figure L.15). [Note: there is no Zone 3, so Zone 3 in the script is set to Zone 2]. The power guide curve requires generation only when the top 20% of power storage is in use. Below this amount, no power generation is required. A plant factor of 4.2% is used in the top 20% of the power pool to give the equivalent of 1 hour of generation each day. The zone at the top of the power pool is Zone 2 and the zone at the bottom of the power pool is the Inactive zone.

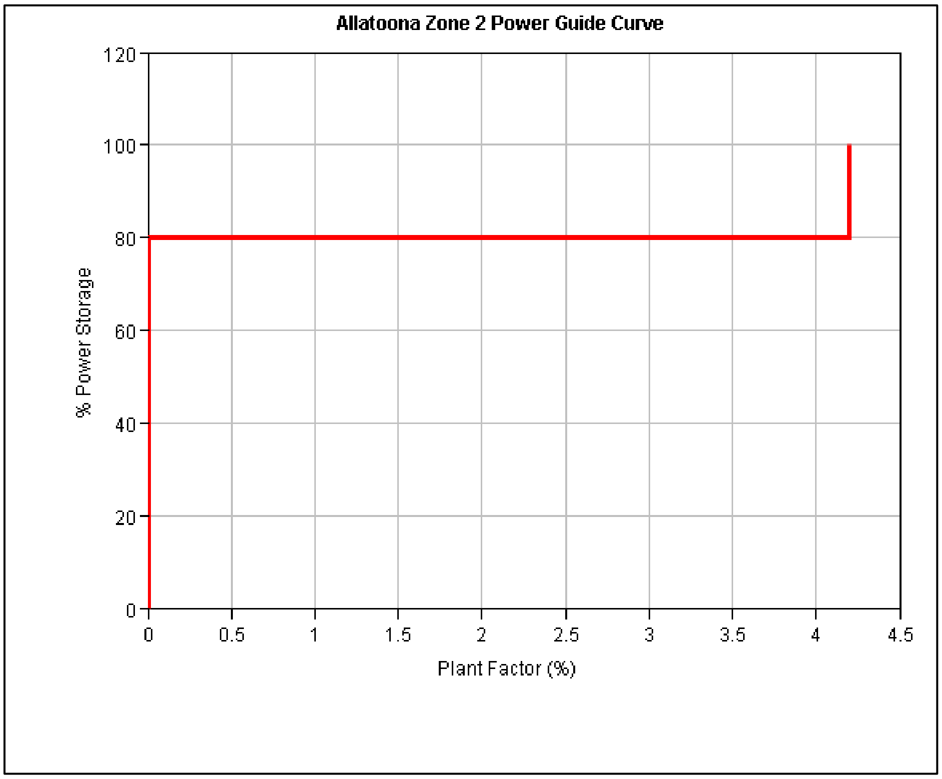


Figure L.15 PowerGC Z2_0-1hrs Guide Curve

Carters uses the same rule to define the guide curve for the Flood Control, GC Buffer, and Conservation zones. The "Power06_MonthlyPF_12%" rule specifies the monthly power requirement using a 12% plant factor (2.88 hours of power per day). This is a constant value for each month (Figure L.16).

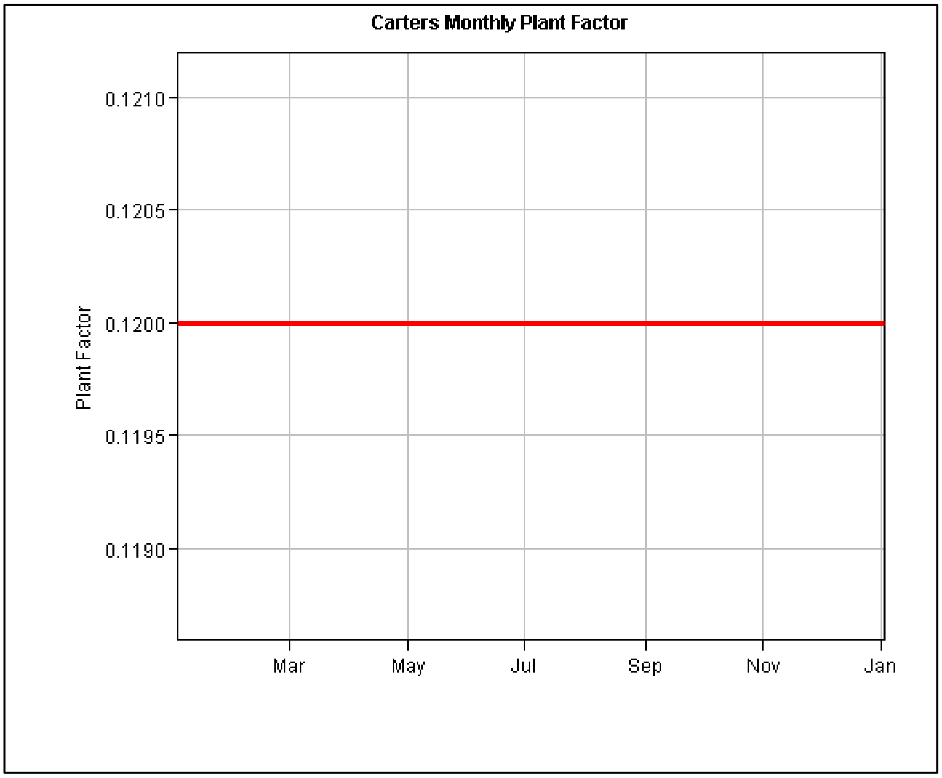


Figure L.16 Power06_MonthlyPF_12% Guide Curve

The “PowerGC06” guide curve is used to set the amount of power generated at the remaining projects in the Flood Control and Conservation zones (Figure L.17). From 0-48% of power storage in use, the guide curve sets the plants factor at 0%. From 51-100% power storage in use, it uses a plant factor of 16% (3.84 hours of power generation per day).

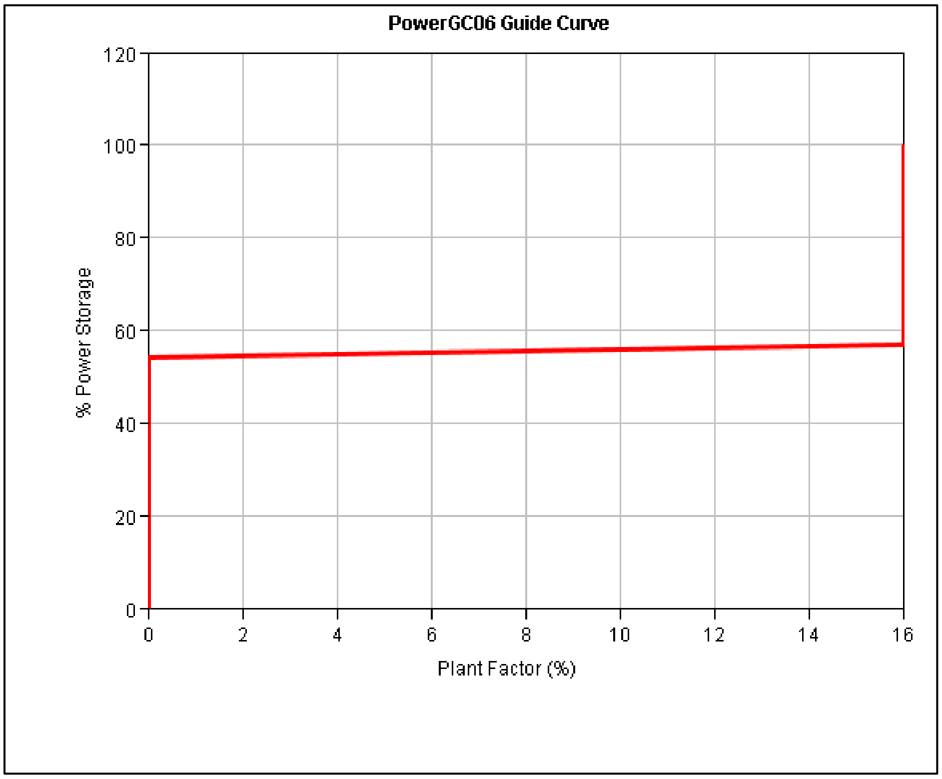


Figure L.17 PowerGC06 Guide Curve

After the power rules associated with each zone are defined for all of the power producing projects, the script calls for the zone elevations at the current run time step and the pool elevation for the previous run time step.

```
CartersFC = network.getTimeSeries("Reservoir","Carters", "Flood Control", "Elev-ZONE")
CartersInactive = network.getTimeSeries("Reservoir","Carters", "Inactive", "Elev-ZONE")
WeissFC = network.getTimeSeries("Reservoir","Weiss", "Flood Control", "Elev-ZONE")
WeissDrought = network.getTimeSeries("Reservoir","Weiss", "Drought", "Elev-ZONE")
HNHenryFC = network.getTimeSeries("Reservoir","HN Henry", "Flood Control", "Elev-ZONE")
HNHenryDrought = network.getTimeSeries("Reservoir","HN Henry", "Drought", "Elev-ZONE")
LoganMartinFC = network.getTimeSeries("Reservoir","Logan Martin", "Flood Control", "Elev-ZONE")
LoganMartinDrought = network.getTimeSeries("Reservoir","Logan Martin", "Drought", "Elev-ZONE")
MartinFC = network.getTimeSeries("Reservoir","Martin", "Flood Control", "Elev-ZONE")
MartinDrought = network.getTimeSeries("Reservoir","Martin", "Drought", "Elev-ZONE")
HarrisFC = network.getTimeSeries("Reservoir","Harris", "Flood Control", "Elev-ZONE")
HarrisDrought = network.getTimeSeries("Reservoir","Harris", "Drought", "Elev-ZONE")
```

```
Carters_Elev = network.getTimeSeries("Reservoir","Carters", "Pool",
        "Elev").getPreviousValue(currentRuntimestep)
Allatoona_Elev = network.getTimeSeries("Reservoir","Allatoona", "Pool",
        "Elev").getPreviousValue(currentRuntimestep)
Weiss_Elev = network.getTimeSeries("Reservoir","Weiss", "Pool",
        "Elev").getPreviousValue(currentRuntimestep)
HNHenry_Elev = network.getTimeSeries("Reservoir","HN Henry", "Pool",
        "Elev").getPreviousValue(currentRuntimestep)
LoganMartin_Elev = network.getTimeSeries("Reservoir","Logan Martin", "Pool",
        "Elev").getPreviousValue(currentRuntimestep)
Martin_Elev = network.getTimeSeries("Reservoir","Martin", "Pool",
        "Elev").getPreviousValue(currentRuntimestep)
Harris_Elev = network.getTimeSeries("Reservoir","Harris", "Pool",
        "Elev").getPreviousValue(currentRuntimestep)
```

It determines in which zone the pool lies and then assigns the corresponding power rule (or no power rule for certain zones).

```
if Carters_Elev > CartersFC.getCurrentValue(currentRuntimestep)  :
        CartersRule = CartersTODRule
elif Carters_Elev > CartersInactive.getCurrentValue(currentRuntimestep)
        CartersRule = CartersConRule
else :
        CartersRule = CartersInactiveRule

if Allatoona_Elev > AllatoonaFC.getCurrentValue(currentRuntimestep)  :
        AllatoonaRule = AllatoonaTODRule
elif Allatoona_Elev > (AllatoonaCon.getCurrentValue(currentRuntimestep) + .001) :
        AllatoonaRule = AllatoonaFCRule
elif Allatoona_Elev > AllatoonaZ2.getCurrentValue(currentRuntimestep) :
        AllatoonaRule = AllatoonaConRule
elif Allatoona_Elev > AllatoonaZ3.getCurrentValue(currentRuntimestep) :
        AllatoonaRule = AllatoonaZ2Rule
elif Allatoona_Elev > AllatoonaInactive.getCurrentValue(currentRuntimestep)
        AllatoonaRule = AllatoonaZ3Rule
else :
        AllatoonaRule = AllatoonaInactiveRule

if Weiss_Elev > WeissFC.getCurrentValue(currentRuntimestep)  :
        WeissRule = WeissTODRule
elif Weiss_Elev > WeissDrought.getCurrentValue(currentRuntimestep)
        WeissRule = WeissConRule
else :
        WeissRule = WeissInactiveRule

if HNHenry_Elev > HNHenryFC.getCurrentValue(currentRuntimestep)
        HNHenryRule = HNHenryTODRule
elif HNHenry_Elev > HNHenryDrought.getCurrentValue(currentRuntimestep)
        HNHenryRule = HNHenryConRule
else :
        HNHenryRule = HNHenryInactiveRule
```

```
if LoganMartin_Elev > LoganMartinFC.getCurrentValue(currentRuntimestep)
        LoganMartinRule = LoganMartinTODRule
elif LoganMartin_Elev > LoganMartinDrought.getCurrentValue(currentRuntimestep) :
        LoganMartinRule = LoganMartinConRule
else :
        LoganMartinRule = LoganMartinInactiveRule

if Martin_Elev > MartinFC.getCurrentValue(currentRuntimestep)  :
        MartinRule = MartinTODRule
elif Martin_Elev > MartinDrought.getCurrentValue(currentRuntimestep) :
        MartinRule = MartinConRule
else :
        MartinRule = MartinInactiveRule

if Harris_Elev > HarrisFC.getCurrentValue(currentRuntimestep)  :
        HarrisRule = HarrisTODRule
elif Harris_Elev > HarrisDrought.getCurrentValue(currentRuntimestep) :
        HarrisRule = HarrisConRule
else :
        HarrisRule = HarrisInactiveRule
```

Finally, based on the active power rules, the state variable “CartersActivePowerReq” returns the values of the required power and energy to the following state variables:

- AllatoonaActivePowerReg
- AllatoonaActiveEnergyReg
- CartersActiveEnergyReg
- HNHenryActivePowerReg
- HNHenryActiveEnergyReg
- HarrisActivePowerReg
- HarrisActiveEnergyReg
- LoganMartinActivePowerReg
- LoganMartinActiveEnergyReg
- MartinActivePowerReg
- MartinActiveEnergyReg
- WeissActivePowerReg
- WeissActiveEnergyReg

III. Contents of State Variable Scripts

State Variable – Allatoona_BaseElev

```
#####
##### STATE VARIABLE SCRIPT INITIALIZATION SECTION
#####

from hec.script import Constants
#
# initialization function. optional.
# set up tables and other things that only need to be performed once at the start of the compute.
#
# variables that are passed to this script during the compute initialization:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network
#
def initStateVariable(currentVariable, network):
	# return Constants.TRUE if the initialization is successful and Constants.FALSE if it failed.
	# Returning Constants.FALSE will halt the compute.
	return Constants.TRUE

#####
##### STATE VARIABLE SCRIPT COMPUTATION SECTION
#####

# Base Allatoona elevation at the beginning of the fish spawning period (March 15). Determined in the state variable, AllatoonaElevState

#####
##### STATE VARIABLE SCRIPT CLEANUP SECTION
#####

from hec.script import Constants
#
# script to be run only once, at the end of the compute. optional.

# variables that are available to this script during the compute:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network

# The following represents an undefined value in a time series:
#	Constants.UNDEFINED

# add your code here...
```

State Variable – Allatoona_ElevState

```
#####
##### STATE VARIABLE SCRIPT INITIALIZATION SECTION
#####

from hec.script import Constants
#
# initialization function. optional.
# set up tables and other things that only need to be performed once at the start of the compute.
#
# variables that are passed to this script during the compute initialization:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network
#
def initStateVariable(currentVariable, network):
	# return Constants.TRUE if the initialization is successful and Constants.FALSE if it failed.
	# Returning Constants.FALSE will halt the compute.
	return Constants.TRUE

#####
##### STATE VARIABLE SCRIPT COMPUTATION SECTION
#####

# 7/02/2010 smo.  Based on the WalterFGeorge script in ACF model
# Create a code to track the lake state due to rising/falling during the fish spawning period for Allatoona
# 15March - 15May = 1 Spawning
# Other times = 2  Non-Spawning

# State variable: Allatoona_Elev_State
#  Code =0: Pool is rising
#	=1: The first day of the fish spawning
#	=2: The pool has dropped within 0.3 ft from the base elevation
#	=3: The pool has dropped within 0.3-0.4 ft from the base elevation
#	=4: The pool has dropped within 0.4-0.45 ft from the base elevation
#	=5: The pool has dropped within 0.45-0.49 ft from the base elevation
#	=6: The pool has dropped within 0.49-0.50 ft from the base elevation
#	=7: The pool has dropped more than 0.50 ft from the base elevation
```

```
from hec.model import RunTimeStep

curMon = currentRuntimestep.getHecTime().month()
curDay = currentRuntimestep.getHecTime().day()

# Set the base lake elevation at the beginning of the fish spawning period - March 15
# defined as "BaseElev"

if (curMon==3) and (curDay == 15):
        ELEV_TS = network.getTimeSeries("Reservoir","Allatoona", "Pool", "Elev")
        ELEV = ELEV_TS.getPreviousValue(currentRuntimestep)
        BaseElev = ELEV
        Code =1
        BaseELEV_StVar=network.getStateVariable("Allatoona_BaseElev")
        BaseELEV_StVar.setValue(currentRuntimestep,BaseElev)
        currentVariable.setValue(currentRuntimestep,Code)

# Count the number of days that the fish spawning requirements are met.
        Days_StVar= network.getStateVariable("Allatoona_FSCompliance")
        Num=1 # first day is automatically compliant
        Days_StVar.setValue(currentRuntimestep,Num)


# Starting on the second day of the spawning period (Mar 16) and going until May 15th
if (curMon==3 and curDay>15) or (curMon==4) or (curMon==5 and curDay <=15):
    ELEV_TS = network.getTimeSeries("Reservoir","Allatoona", "Pool", "Elev")
    ELEV = ELEV_TS.getPreviousValue(currentRuntimestep)
    BaseELEV_StVar=network.getStateVariable("Allatoona_BaseElev")
    BaseELEV_StVar_TS=BaseELEV_StVar.getTimeSeries()
    # get previous value of the base elevation which will be the minimum elev.
    BaseELEV_Pre=BaseELEV_StVar_TS.getPreviousValue(currentRuntimestep)

    # if the elev for the current timestep is higher than the previous base elevation, reset the base.
    if BaseELEV_Pre < ELEV:
        BaseELEV_Cur=ELEV
        Code=0

    else :
        BaseELEV_Cur=BaseELEV_Pre

        Diff=BaseELEV_Pre - ELEV
```

```
		if Diff <=0.3:
			Code=2
		elif Diff >0.3 and Diff<=0.4:
			Code=3
		elif Diff >0.4 and Diff<=0.45:
			Code=4
		elif Diff >0.45 and Diff<=0.49:
			Code=5
		elif Diff >0.49 and Diff<=0.50:
			Code=6
		else:
			Code=7

	Days_StVar= network.getStateVariable("Allatoona_FSCompliance")
	Days_StVar_TS= Days_StVar.getTimeSeries()
	Count_Pre=Days_StVar_TS.getPreviousValue(currentRuntimestep)
	if Code <=6:
		Count_Cur=Count_Pre+1
	else:
		Count_Cur=Count_Pre
	Days_StVar.setValue(currentRuntimestep,Count_Cur)

	currentVariable.setValue(currentRuntimestep,Code)

	BaseELEV_StVar.setValue(currentRuntimestep, BaseELEV_Cur)

#####
##### STATE VARIABLE SCRIPT CLEANUP SECTION
#####

from hec.script import Constants
#
# script to be run only once, at the end of the compute. optional.

# variables that are available to this script during the compute:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network

# The following represents an undefined value in a time series:
#	Constants.UNDEFINED

# add your code here...
```

State Variable – Allatoona_FSCompliance

```
#####
##### STATE VARIABLE SCRIPT INITIALIZATION SECTION
#####

from hec.script import Constants
#
# initialization function. optional.
# set up tables and other things that only need to be performed once at the start of the compute.
#
# variables that are passed to this script during the compute initialization:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network
#
def initStateVariable(currentVariable, network):
	# return Constants.TRUE if the initialization is successful and Constants.FALSE if it failed.
	# Returning Constants.FALSE will halt the compute.
	return Constants.TRUE

#####
##### STATE VARIABLE SCRIPT COMPUTATION SECTION
#####

# Determined in the state variable, AllatoonaElevState

#####
##### STATE VARIABLE SCRIPT CLEANUP SECTION
#####

from hec.script import Constants
#
# script to be run only once, at the end of the compute. optional.

# variables that are available to this script during the compute:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network

# The following represents an undefined value in a time series:
#	Constants.UNDEFINED

# add your code here...
```

State Variable – CartersActivePowerReq

```
#####
##### STATE VARIABLE SCRIPT INITIALIZATION SECTION
#####

from hec.script import Constants
#
# initialization function. optional.
# set up tables and other things that only need to be performed once at the start of the compute.
#
# variables that are passed to this script during the compute initialization:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network
#
def initStateVariable(currentVariable, network):
	# return Constants.TRUE if the initialization is successful and Constants.FALSE if it failed.
	# Returning Constants.FALSE will halt the compute.
	return Constants.TRUE

#####
##### STATE VARIABLE SCRIPT COMPUTATION SECTION
#####

######################################################
# Because power rules (and requirements) change from zone to zone,
#  this script is used to calculate actual power requirement.
#
# May 2010, SMO (based on the Jan 2010 ACF BufordActivePower script)
# Aug 2010, MBH revised Carters power rule name to reflect 12% (unsure of 12% name)
#
######################################################
######################################################
# Calculates Active Power and Active Energy Required for:
#	Carters
#	Allatoona
#	Weiss
#	HN Henry
#	Logan Martin
#	Martin
#	Harris
######################################################
```

```
# ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~#
# WARNING:                                  #
# This script could change a lot if zones and rules change #
#
# Do NOT turn this script for alts & trials other than Baseline
#
# ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~#


# Get the current alternative in order to determine
# which set of zones and rules should be used.
# This returns a value like this:
#  Baseline--:Baseline--
#  _Baseline1-:Baseline-- for a trial
curAlt = currentVariable.getSystem().getAlternative().getName()
#print curAlt[0], "curalt0", curAlt[1], "curalt1", curAlt[2], "curalt2", curAlt[1:2], "1-2"
if curAlt[0] == "_" :
    #print "it's a trial"
    curAlt = curAlt[1:11] # Get rid of the leading underscore.
    #print curAlt, "new curAlt"

#if curAlt[0:8] == "Baseline" :
#           print "AAAAAAA"
#           print curAlt[0:10], "0-10"
#           print "TURN OFF CARTERSACTIVEPOWERREQ state variable if you are not running Baseline"
#           sys.exit()

##################################################
# Set up a List of zones & associated power rules
# Includes Zone & Rule Defs for Baseline -
# Allatoona is the only reservoir with differences between Baseline and other Alts
# Allatoona is special because the number of zones varies dependent on the Alternative.
# For Allatoona, set the zone definitions too.
##################################################
if curAlt[0:8] == "Baseline" or curAlt[0:10] == "DroughtPln" :
# updated for the newly reduced baseline power


            #Allatoona
            # Top of Dam - Surcharge
            AllatoonaTODRule = "No Power Rule"
```

```
        # Flood Control
        AllatoonaFCRule = "Power Plant-PowerGC FC_4hrs"
        # Conservation
        AllatoonaConRule = "Power Plant-PowerGC Z1_2-4hrs"
        # Zone 2
        AllatoonaZ2Rule = "Power Plant-PowerGC Z2_0-1hr"
        AllatoonaZ3Rule = "Power Plant-PowerGC Z2_0-1hr"  # since there is no Zone3, the Zone3 rule is set as the same as zone 2.
        # Inactive
        AllatoonaInactiveRule = "No Power Rule"

        AllatoonaFC = network.getTimeSeries("Reservoir","Allatoona", "Flood Control", "Elev-ZONE")
        AllatoonaCon = network.getTimeSeries("Reservoir","Allatoona", "Conservation", "Elev-ZONE")
        AllatoonaZ2 = network.getTimeSeries("Reservoir","Allatoona", "Zone2", "Elev-ZONE")
        AllatoonaZ3 = network.getTimeSeries("Reservoir","Allatoona", "Zone2", "Elev-ZONE") # make Allatoona Zone3 = Zone2, b/c there is no Zone 3.
        AllatoonaInactive = network.getTimeSeries("Reservoir","Allatoona", "Inactive", "Elev-ZONE")

elif curAlt[0:7] == "Burkett" :
        ##################################################
        # Set up a List of zones & associated power rules
        # Includes Zone & Rule Defs for Baseline -  Allatoona is the only reservoir with differences between Baseline and other Alts
        ##################################################

        #Allatoona
        # Top of Dam - Surcharge
        AllatoonaTODRule = "No Power Rule"
        # Flood Control
        AllatoonaFCRule = "Power Plant-PowerGC FC_6hrs"
        # Conservation
        AllatoonaConRule = "Power Plant-PowerGC Z1_6hrs"
        # Zone 2
        AllatoonaZ2Rule = "Power Plant-PowerGC Z2_4hrs"
        # Zone 3
        AllatoonaZ3Rule = "Power Plant-PowerGC Z3_2hrs"
        # Inactive
        AllatoonaInactiveRule = "No Power Rule"

        AllatoonaFC = network.getTimeSeries("Reservoir","Allatoona", "Flood Control", "Elev-ZONE")
        AllatoonaCon = network.getTimeSeries("Reservoir","Allatoona", "Conservation", "Elev-ZONE")
        AllatoonaZ2 = network.getTimeSeries("Reservoir","Allatoona", "Zone2", "Elev-ZONE")
        AllatoonaZ3 = network.getTimeSeries("Reservoir","Allatoona", "Zone3", "Elev-ZONE")
        AllatoonaInactive = network.getTimeSeries("Reservoir","Allatoona", "Inactive", "Elev-ZONE")
```

```
elif curAlt[0:6] == "RPlanG" : #RPlanG uses Burkette D at Allatoona

        #Allatoona
        # Top of Dam - Surcharge
        AllatoonaTODRule = "No Power Rule"
        # Flood Control
        AllatoonaFCRule = "Power Plant-PowerGC FC_4hrs_Seasonal"
        # Conservation
        AllatoonaConRule = "Power Plant-PowerGC Z1_4hrs_Seasonal"
        # Zone 2
        AllatoonaZ2Rule = "Power Plant-PowerGC Z2_3hrs_Seasonal"
        # Zone 3
        AllatoonaZ3Rule = "Power Plant-PowerGC Z3_0-2hrs_Seasonal"
        # Inactive
        AllatoonaInactiveRule = "No Power Rule"

        AllatoonaFC = network.getTimeSeries("Reservoir","Allatoona", "Flood Control", "Elev-ZONE")
        AllatoonaCon = network.getTimeSeries("Reservoir","Allatoona", "Conservation", "Elev-ZONE")
        AllatoonaZ2 = network.getTimeSeries("Reservoir","Allatoona", "Zone2", "Elev-ZONE")
        AllatoonaZ3 = network.getTimeSeries("Reservoir","Allatoona", "Zone3", "Elev-ZONE")
        AllatoonaInactive = network.getTimeSeries("Reservoir","Allatoona", "Inactive", "Elev-ZONE")

elif curAlt[0:5] == "RPlan" : #RPlan alts use Burkett B or Burkette C at Allatoona

        #Allatoona
        # Top of Dam - Surcharge
        AllatoonaTODRule = "No Power Rule"
        # Flood Control
        AllatoonaFCRule = "Power Plant-PowerGC FC_4hrs"
        # Conservation
        AllatoonaConRule = "Power Plant-PowerGC Z1_4hrs"
        # Zone 2
        AllatoonaZ2Rule = "Power Plant-PowerGC Z2_3hrs"
        # Zone 3
        AllatoonaZ3Rule = "Power Plant-PowerGC Z3_0-2hrs"
        # Inactive
        AllatoonaInactiveRule = "No Power Rule"

        AllatoonaFC = network.getTimeSeries("Reservoir","Allatoona", "Flood Control", "Elev-ZONE")
        AllatoonaCon = network.getTimeSeries("Reservoir","Allatoona", "Conservation", "Elev-ZONE")
        AllatoonaZ2 = network.getTimeSeries("Reservoir","Allatoona", "Zone2", "Elev-ZONE")
```

```
        AllatoonaZ3 = network.getTimeSeries("Reservoir","Allatoona", "Zone3", "Elev-ZONE")
        AllatoonaInactive = network.getTimeSeries("Reservoir","Allatoona", "Inactive", "Elev-ZONE")

elif curAlt[0:5] == "Drago" :

        #Allatoona
        # Top of Dam - Surcharge
        AllatoonaTODRule = "No Power Rule"
        # Flood Control
        AllatoonaFCRule = "Power Plant-PowerGC FC_6hrs"
        # Conservation
        AllatoonaConRule = "Power Plant-PowerGC Z1_2-4hrs"
        # Zone 2
        AllatoonaZ2Rule = "Power Plant-PowerGC Z2_0-2hrs"
        AllatoonaZ3Rule = "No Power Rule"
        # Inactive
        AllatoonaInactiveRule = "No Power Rule"

        AllatoonaFC = network.getTimeSeries("Reservoir","Allatoona", "Flood Control", "Elev-ZONE")
        AllatoonaCon = network.getTimeSeries("Reservoir","Allatoona", "Conservation", "Elev-ZONE")
        AllatoonaZ2 = network.getTimeSeries("Reservoir","Allatoona", "Zone2", "Elev-ZONE")
        AllatoonaZ3 = network.getTimeSeries("Reservoir","Allatoona", "Zone3", "Elev-ZONE")
        AllatoonaInactive = network.getTimeSeries("Reservoir","Allatoona", "Inactive", "Elev-ZONE")

##~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

# For any alternative
if 1 == 1:
        #######################
        #  Zone & Rule Defs applying to all Alternatives
        #######################
        # Carters
        # Top of Dam - Surcharge
        CartersTODRule = "No Power Rule"
        # Flood Control
        CartersFCRule = "Power Plant-Power06_MonthlyPF_12%"
        # GC Buffer
        CartersGCRule = "Power Plant-Power06_MonthlyPF_12%"
        # Conservation
        CartersConRule = "Power Plant-Power06_MonthlyPF_12%"
        # Inactive
        CartersInactiveRule = "No Power Rule"
```

```
#Weiss
# Top of Dam - Surcharge
WeissTODRule = "No Power Rule"
# Flood Control
WeissFCRule = "Power Plant-PowerGC06"
# Conservation
WeissConRule = "Power Plant-PowerGC06"
# Drought
WeissDroughtRule = "No Power Rule"
# Operating Inactive - Inactive
WeissInactiveRule = "No Power Rule"

#HN Henry
# Top of Dam
HNHenryTODRule = "No Power Rule"
# Flood Control
HNHenryFCRule = "Power Plant-PowerGC06"
# Conservation
HNHenryConRule = "Power Plant-PowerGC06"
# Drought - Inactive
HNHenryInactiveRule = "No Power Rule"

#Logan Martin
# Top of Dam - Surcharge
LoganMartinTODRule = "No Power Rule"
# Flood Control
LoganMartinFCRule = "Power Plant-PowerGC06"
# Conservation
LoganMartinConRule = "Power Plant-PowerGC06"
# Drought
LoganMartinDroughtRule = "No Power Rule"
# Operating Inactive - Inactive
LoganMartinInactiveRule = "No Power Rule"

#Martin
# Top of Dam
MartinTODRule = "No Power Rule"
# Flood Control
MartinFCRule = "Power Plant-PowerGC06"
# Conservation
MartinConRule = "Power Plant-PowerGC06"
```

```
    # Drought
    MartinDroughtRule = "No Power Rule"
    # Operating Inactive - Inactive
    MartinInactiveRule = "No Power Rule"

    #Harris
    # Top of Dam
    HarrisTODRule = "No Power Rule"
    # Flood Control
    HarrisFCRule = "Power Plant-PowerGC06"
    # Conservation
    HarrisConRule = "Power Plant-PowerGC06"
    # Drought
    HarrisDroughtRule = "No Power Rule"
    # Operating Inactive - Inactive
    HarrisInactiveRule = "No Power Rule"
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

# Get Zone values

CartersFC = network.getTimeSeries("Reservoir","Carters", "Flood Control", "Elev-ZONE")
#CartersCon = network.getTimeSeries("Reservoir","Carters", "Conservation", "Elev-ZONE")
CartersInactive = network.getTimeSeries("Reservoir","Carters", "Inactive", "Elev-ZONE")
WeissFC = network.getTimeSeries("Reservoir","Weiss", "Flood Control", "Elev-ZONE")
#WeissCon = network.getTimeSeries("Reservoir","Weiss", "Conservation", "Elev-ZONE")
WeissDrought = network.getTimeSeries("Reservoir","Weiss", "Drought", "Elev-ZONE")
HNHenryFC = network.getTimeSeries("Reservoir","HN Henry", "Flood Control", "Elev-ZONE")
#HNHenryCon = network.getTimeSeries("Reservoir","HN Henry", "Conservation", "Elev-ZONE")
HNHenryDrought = network.getTimeSeries("Reservoir","HN Henry", "Drought", "Elev-ZONE")
LoganMartinFC = network.getTimeSeries("Reservoir","Logan Martin", "Flood Control", "Elev-ZONE")
#LoganMartinCon = network.getTimeSeries("Reservoir","Logan Martin", "Conservation", "Elev-ZONE")
LoganMartinDrought = network.getTimeSeries("Reservoir","Logan Martin", "Drought", "Elev-ZONE")
MartinFC = network.getTimeSeries("Reservoir","Martin", "Flood Control", "Elev-ZONE")
#MartinCon = network.getTimeSeries("Reservoir","Martin", "Conservation", "Elev-ZONE")
MartinDrought = network.getTimeSeries("Reservoir","Martin", "Drought", "Elev-ZONE")
HarrisFC = network.getTimeSeries("Reservoir","Harris", "Flood Control", "Elev-ZONE")
#HarrisCon = network.getTimeSeries("Reservoir","Harris", "Conservation", "Elev-ZONE")
HarrisDrought = network.getTimeSeries("Reservoir","Harris", "Drought", "Elev-ZONE")
# Get previous elev for each Reservoir
Carters_Elev = network.getTimeSeries("Reservoir","Carters", "Pool", "Elev").getPreviousValue(currentRuntimestep)
Allatoona_Elev = network.getTimeSeries("Reservoir","Allatoona", "Pool", "Elev").getPreviousValue(currentRuntimestep)
Weiss_Elev = network.getTimeSeries("Reservoir","Weiss", "Pool", "Elev").getPreviousValue(currentRuntimestep)
```

```
HNHenry_Elev = network.getTimeSeries("Reservoir","HN Henry", "Pool", "Elev").getPreviousValue(currentRuntimestep)
LoganMartin_Elev = network.getTimeSeries("Reservoir","Logan Martin", "Pool", "Elev").getPreviousValue(currentRuntimestep)
Martin_Elev = network.getTimeSeries("Reservoir","Martin", "Pool", "Elev").getPreviousValue(currentRuntimestep)
Harris_Elev = network.getTimeSeries("Reservoir","Harris", "Pool", "Elev").getPreviousValue(currentRuntimestep)

# ------------Set the correct Rule based on the Active Zone------------- #
#print "###", CartersCon.getCurrentValue(currentRuntimestep)
#if Carters_Elev > CartersCon.getCurrentValue(currentRuntimestep) :    # Above Con Zone


if Carters_Elev > CartersFC.getCurrentValue(currentRuntimestep)  :    # Above FC Zone
   CartersRule = CartersTODRule
elif Carters_Elev > CartersInactive.getCurrentValue(currentRuntimestep) :     # Above Inactive
   CartersRule = CartersConRule
else :                                                                        # Inactive
   CartersRule = CartersInactiveRule

if Allatoona_Elev > AllatoonaFC.getCurrentValue(currentRuntimestep)  :    # Above FC Zone
   AllatoonaRule = AllatoonaTODRule
# This line allows a small tolerance for encroachment into the flood zone
# at which the conservation pool's power requirement is used
elif Allatoona_Elev > (AllatoonaCon.getCurrentValue(currentRuntimestep) + .001) :     # Above Con
   AllatoonaRule = AllatoonaFCRule
elif Allatoona_Elev > AllatoonaZ2.getCurrentValue(currentRuntimestep) :     # Above Zone 2
   AllatoonaRule = AllatoonaConRule
elif Allatoona_Elev > AllatoonaZ3.getCurrentValue(currentRuntimestep) :     # Above Zone 3
   AllatoonaRule = AllatoonaZ2Rule
elif Allatoona_Elev > AllatoonaInactive.getCurrentValue(currentRuntimestep) :     # Above Inactive
   AllatoonaRule = AllatoonaZ3Rule
else :                                                                        # Inactive
   AllatoonaRule = AllatoonaInactiveRule

if Weiss_Elev > WeissFC.getCurrentValue(currentRuntimestep)  :    # Above FC Zone
   WeissRule = WeissTODRule
elif Weiss_Elev > WeissDrought.getCurrentValue(currentRuntimestep) :     # Above Drought
   WeissRule = WeissConRule
else :                                                                        # Drought and below
   WeissRule = WeissInactiveRule

if HNHenry_Elev > HNHenryFC.getCurrentValue(currentRuntimestep)  :    # Above FC Zone
   HNHenryRule = HNHenryTODRule
elif HNHenry_Elev > HNHenryDrought.getCurrentValue(currentRuntimestep) :     # Above Drought
```

```
    HNHenryRule = HNHenryConRule
else :                                                                  # Drought and below
    HNHenryRule = HNHenryInactiveRule

if LoganMartin_Elev > LoganMartinFC.getCurrentValue(currentRuntimestep)  :    # Above FC Zone
    LoganMartinRule = LoganMartinTODRule
elif LoganMartin_Elev > LoganMartinDrought.getCurrentValue(currentRuntimestep) :     # Above Drought
    LoganMartinRule = LoganMartinConRule
else :                                                                  # Drought and below
    LoganMartinRule = LoganMartinInactiveRule

if Martin_Elev > MartinFC.getCurrentValue(currentRuntimestep)  :    # Above FC Zone
    MartinRule = MartinTODRule
elif Martin_Elev > MartinDrought.getCurrentValue(currentRuntimestep) :     # Above Drought
    MartinRule = MartinConRule
else :                                                                  # Drought and below
    MartinRule = MartinInactiveRule

if Harris_Elev > HarrisFC.getCurrentValue(currentRuntimestep)  :    # Above FC Zone
    HarrisRule = HarrisTODRule
elif Harris_Elev > HarrisDrought.getCurrentValue(currentRuntimestep) :     # Above Drought
    HarrisRule = HarrisConRule
else :                                                                  # Drought and below
    HarrisRule = HarrisInactiveRule


# ------------ END Set the correct Rule based on the Active Zone ------------- #

# ------------ Get the Power Required & Energy Required based on rule --------------#
if CartersRule == "No Power Rule" :
    CartersPowerReq = 0
    CartersEnergyReq = 0
else :
    CartersPowerReq = network.getTimeSeries("Reservoir","Carters", CartersRule, "Power-REQUIRED").getCurrentValue(currentRuntimestep)
    CartersEnergyReq = network.getTimeSeries("Reservoir","Carters", CartersRule, "Energy-REQUIRED").getCurrentValue(currentRuntimestep)


if AllatoonaRule == "No Power Rule" :
    AllatoonaPowerReq = 0
    AllatoonaEnergyReq = 0
```

```
else :
   AllatoonaPowerReq = network.getTimeSeries("Reservoir","Allatoona", AllatoonaRule, "Power-REQUIRED").getCurrentValue(currentRuntimestep)
   AllatoonaEnergyReq = network.getTimeSeries("Reservoir","Allatoona", AllatoonaRule, "Energy-REQUIRED").getCurrentValue(currentRuntimestep)

if WeissRule == "No Power Rule" :
   WeissPowerReq = 0
   WeissEnergyReq = 0
else :
   WeissPowerReq = network.getTimeSeries("Reservoir","Weiss", WeissRule, "Power-REQUIRED").getCurrentValue(currentRuntimestep)
   WeissEnergyReq = network.getTimeSeries("Reservoir","Weiss", WeissRule, "Energy-REQUIRED").getCurrentValue(currentRuntimestep)

if HNHenryRule == "No Power Rule" :
   HNHenryPowerReq = 0
   HNHenryEnergyReq = 0
else :
   HNHenryPowerReq = network.getTimeSeries("Reservoir","HN Henry", HNHenryRule, "Power-REQUIRED").getCurrentValue(currentRuntimestep)
   HNHenryEnergyReq = network.getTimeSeries("Reservoir","HN Henry", HNHenryRule, "Energy-REQUIRED").getCurrentValue(currentRuntimestep)

if LoganMartinRule == "No Power Rule" :
   LoganMartinPowerReq = 0
   LoganMartinEnergyReq = 0
else :
   LoganMartinPowerReq = network.getTimeSeries("Reservoir","Logan Martin", LoganMartinRule, "Power-
REQUIRED").getCurrentValue(currentRuntimestep)
   LoganMartinEnergyReq = network.getTimeSeries("Reservoir","Logan Martin", LoganMartinRule, "Energy-
REQUIRED").getCurrentValue(currentRuntimestep)

if MartinRule == "No Power Rule" :
   MartinPowerReq = 0
   MartinEnergyReq = 0
else :
   MartinPowerReq = network.getTimeSeries("Reservoir","Martin", MartinRule, "Power-REQUIRED").getCurrentValue(currentRuntimestep)
   MartinEnergyReq = network.getTimeSeries("Reservoir","Martin", MartinRule, "Energy-REQUIRED").getCurrentValue(currentRuntimestep)

if HarrisRule == "No Power Rule" :
   HarrisPowerReq = 0
   HarrisEnergyReq = 0
else :
   HarrisPowerReq = network.getTimeSeries("Reservoir","Harris", HarrisRule, "Power-REQUIRED").getCurrentValue(currentRuntimestep)
   HarrisEnergyReq = network.getTimeSeries("Reservoir","Harris", HarrisRule, "Energy-REQUIRED").getCurrentValue(currentRuntimestep)
```

```
# -----------------------------------------
# Required Set Power & Energy
# -----------------------------------------
currentVariable.setValue(currentRuntimestep, CartersPowerReq)
network.getStateVariable("CartersActiveEnergyReq").setValue(currentRuntimestep, CartersEnergyReq)
network.getStateVariable("AllatoonaActivePowerReq").setValue(currentRuntimestep, AllatoonaPowerReq)
network.getStateVariable("AllatoonaActiveEnergyReq").setValue(currentRuntimestep, AllatoonaEnergyReq)
network.getStateVariable("WeissActivePowerReq").setValue(currentRuntimestep, WeissPowerReq)
network.getStateVariable("WeissActiveEnergyReq").setValue(currentRuntimestep, WeissEnergyReq)
network.getStateVariable("HNHenryActivePowerReq").setValue(currentRuntimestep, HNHenryPowerReq)
network.getStateVariable("HNHenryActiveEnergyReq").setValue(currentRuntimestep, HNHenryEnergyReq)
network.getStateVariable("LoganMartinActivePowerReq").setValue(currentRuntimestep, LoganMartinPowerReq)
network.getStateVariable("LoganMartinActiveEnergyReq").setValue(currentRuntimestep, LoganMartinEnergyReq)
network.getStateVariable("MartinActivePowerReq").setValue(currentRuntimestep, MartinPowerReq)
network.getStateVariable("MartinActiveEnergyReq").setValue(currentRuntimestep, MartinEnergyReq)
network.getStateVariable("HarrisActivePowerReq").setValue(currentRuntimestep, HarrisPowerReq)
network.getStateVariable("HarrisActiveEnergyReq").setValue(currentRuntimestep, HarrisEnergyReq)

#####
##### STATE VARIABLE SCRIPT CLEANUP SECTION
#####

from hec.script import Constants
#
# script to be run only once, at the end of the compute. optional.

# variables that are available to this script during the compute:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network

# The following represents an undefined value in a time series:
#	Constants.UNDEFINED

# add your code here...
```

State Variable – CartersSysInflow_AdjAvg

```
#####
##### STATE VARIABLE SCRIPT INITIALIZATION SECTION
#####

from hec.script import Constants
#
# initialization function. optional.
# set up tables and other things that only need to be performed once at the start of the compute.
#
# variables that are passed to this script during the compute initialization:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network
#
def initStateVariable(currentVariable, network):
	# return Constants.TRUE if the initialization is successful and Constants.FALSE if it failed.
	# Returning Constants.FALSE will halt the compute.
	return Constants.TRUE

#####
##### STATE VARIABLE SCRIPT COMPUTATION SECTION
#####

# edited Oct 26 2010 smo
# This uses a 7-day running average which looks back 3 days and forward 3.

CartersIn = network.getTimeSeries("Junction","Carters_IN", "", "Flow").getPeriodAverage((currentRuntimestep.getStep()+3), 7)
TalkingRockIn = network.getTimeSeries("Junction","Talking Rock", "", "Flow").getPeriodAverage((currentRuntimestep.getStep()+3), 7)
sumInflow=(CartersIn+TalkingRockIn)


#  HecTime.dayOfWeek returns an integer, 1=Sunday, 2=Monday, etc
# day_of_week=currentRuntimestep.getHecTime().dayOfWeek()


# HecTime dayOfWeek is off by a day, so use Runtimestep instead
# Runtimestep Day of Week:	0=Sun; 1=Mon; 2=Tue; 3=Wed; 4=Thu; 5=Fri; 6=Sat
day_of_week = currentRuntimestep.getDayOfWeek()
month = currentRuntimestep.month()
```

```
# adjust avg inflow by flow needed in April and November to deal with rising/falling con pool
# 109 cfs = rate of drawdown of Carters in Nov in cfs-days
adjust_inflow = 0
if month == 11: adjust_inflow = 109
if month == 4: adjust_inflow = -109
if (day_of_week == 1) :  # Monday
	minRel = sumInflow + adjust_inflow
elif (day_of_week==4 ) :  # Thursday
	newsum = sumInflow+adjust_inflow
	minRel = currentVariable.getPreviousValue(currentRuntimestep)
	changerate = abs(newsum - minRel)/minRel
	if (changerate > 0.15): minRel = newsum
else:
	minRel = currentVariable.getPreviousValue(currentRuntimestep)
# print "day, date", day_of_week, currentRuntimestep.dateTimeString()

# If Carters pool is low, it needs to fill, so reduce the minRel to 240.
CartersElev =network.getTimeSeries("Reservoir","Carters", "Pool", "Elev").getPreviousValue(currentRuntimestep)
CartersConZone = network.getTimeSeries("Reservoir","Carters", "Conservation", "Elev-ZONE").getPreviousValue(currentRuntimestep)
CartersConZoneTolerance = CartersConZone - 1
if CartersElev < CartersConZoneTolerance :
	minRel = 240

currentVariable.setValue(currentRuntimestep, minRel)

#####
##### STATE VARIABLE SCRIPT CLEANUP SECTION
#####

from hec.script import Constants
#
# script to be run only once, at the end of the compute. optional.

# variables that are available to this script during the compute:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network

# The following represents an undefined value in a time series:
#	Constants.UNDEFINED

# add your code here...
```

State Variable – CartersSystemInflow

```
#####
##### STATE VARIABLE SCRIPT INITIALIZATION SECTION
#####

from hec.script import Constants
#
# initialization function. optional.
# set up tables and other things that only need to be performed once at the start of the compute.
#
# variables that are passed to this script during the compute initialization:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network
#
def initStateVariable(currentVariable, network):
	# return Constants.TRUE if the initialization is successful and Constants.FALSE if it failed.
	# Returning Constants.FALSE will halt the compute.
	return Constants.TRUE

#####
##### STATE VARIABLE SCRIPT COMPUTATION SECTION
#####

# This uses a 4-day running average which looks back 1 day and forward 2.

CartersIn = network.getTimeSeries("Junction","Carters_IN", "", "Flow").getPeriodAverage((currentRuntimestep.getStep()+2), 4)
TalkingRockIn = network.getTimeSeries("Junction","Talking Rock", "", "Flow").getPeriodAverage((currentRuntimestep.getStep()+2), 4)
sumInflow=CartersIn+TalkingRockIn
currentVariable.setValue(currentRuntimestep, sumInflow)

#####
##### STATE VARIABLE SCRIPT CLEANUP SECTION
#####

from hec.script import Constants
#
# script to be run only once, at the end of the compute. optional.
```

```
# variables that are available to this script during the compute:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network

# The following represents an undefined value in a time series:
#	Constants.UNDEFINED

# add your code here...
```

State Variable – CurMonth

```
#####
##### STATE VARIABLE SCRIPT INITIALIZATION SECTION
#####

from hec.script import Constants
#
# initialization function. optional.
# set up tables and other things that only need to be performed once at the start of the compute.
#
# variables that are passed to this script during the compute initialization:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network
#
def initStateVariable(currentVariable, network):
	# return Constants.TRUE if the initialization is successful and Constants.FALSE if it failed.
	# Returning Constants.FALSE will halt the compute.
	return Constants.TRUE

#####
##### STATE VARIABLE SCRIPT COMPUTATION SECTION
#####

# calculate the current month for use in the following IF tests:
#
#  Baseline operations at Martin
#	MinQ fn 3-Gages -> Nov - May
#  DLR operations at Martin
#	DIL=1: Min@Talla_0.5*YatesInflow -> May - Dec
#	DIL=2: Min@Talla_0.5*YatesInflow -> May - Sept
#
# SMO 8/23/2010

curMonth = currentRuntimestep.month()
# print curMonth

currentVariable.setValue(currentRuntimestep, curMonth)
```

```
#####
##### STATE VARIABLE SCRIPT CLEANUP SECTION
#####

from hec.script import Constants
#
# script to be run only once, at the end of the compute. optional.

# variables that are available to this script during the compute:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network

# The following represents an undefined value in a time series:
#	Constants.UNDEFINED

# add your code here...
```

State Variable – LoganMartin_GCBuffer

```
#####
##### STATE VARIABLE SCRIPT INITIALIZATION SECTION
#####

from hec.script import Constants
#
# initialization function. optional.
# set up tables and other things that only need to be performed once at the start of the compute.
#
# variables that are passed to this script during the compute initialization:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network
#
def initStateVariable(currentVariable, network):
	# return Constants.TRUE if the initialization is successful and Constants.FALSE if it failed.
	# Returning Constants.FALSE will halt the compute.
	return Constants.TRUE

#####
##### STATE VARIABLE SCRIPT COMPUTATION SECTION
#####

# determine if logan martin is at or above its guide curve within a tolerance.

lmPool = network.getTimeSeries("Reservoir","Logan Martin", "Pool", "Elev").getPreviousValue(currentRuntimestep)
lmGC =network.getTimeSeries("Reservoir","Logan Martin", "Conservation", "Elev-ZONE").getPreviousValue(currentRuntimestep)
tol = 0.025

lmGC = lmGC-tol
if lmPool>lmGC:
	curState=1
else:
	curState=0
currentVariable.setValue(currentRuntimestep,curState)
```

```
#####
##### STATE VARIABLE SCRIPT CLEANUP SECTION
#####

from hec.script import Constants
#
# script to be run only once, at the end of the compute. optional.

# variables that are available to this script during the compute:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network

# The following represents an undefined value in a time series:
#	Constants.UNDEFINED

# add your code here...
```

State Variable – SpawnSeason

```
#####
##### STATE VARIABLE SCRIPT INITIALIZATION SECTION
#####

from hec.script import Constants
#
# initialization function. optional.
# set up tables and other things that only need to be performed once at the start of the compute.
#
# variables that are passed to this script during the compute initialization:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network
#
def initStateVariable(currentVariable, network):
	# return Constants.TRUE if the initialization is successful and Constants.FALSE if it failed.
	# Returning Constants.FALSE will halt the compute.
	return Constants.TRUE

#####
##### STATE VARIABLE SCRIPT COMPUTATION SECTION
#####

# calculate whether or not is is fish spawning season at Allatoona
# Spawning Season is 15 Mar - 15 May
# 8/2010 - SMO


from hec.model import RunTimeStep

#----------Month Stuff----------
prevRTS = RunTimeStep(currentRuntimestep)
prevRTS.setStep(currentRuntimestep.getPrevStep())
curMonth = currentRuntimestep.month()
 # since timestep is reported at 24:00, look at the previous timestep to get the current day
curDayofMon = prevRTS.getHecTime().day()

# if month is April
if ( curMonth == 4 ) :
    SpawnSeas = 1
```

```
# else if month is March and day is at least 15th
elif ( curMonth == 3 and curDayofMon >= 15 ) :
   SpawnSeas = 1
# else if month is May and day is 16th or earlier
elif ( curMonth == 5 and curDayofMon <= 15 ) :
   SpawnSeas = 1
# else Not Spawn Season
else :
   SpawnSeas = 0

currentVariable.setValue(currentRuntimestep, SpawnSeas)

#####
##### STATE VARIABLE SCRIPT CLEANUP SECTION
#####

from hec.script import Constants
#
# script to be run only once, at the end of the compute. optional.

# variables that are available to this script during the compute:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network

# The following represents an undefined value in a time series:
#	Constants.UNDEFINED

# add your code here...
```

State Variable – ThurlowMinQ_hackney

```
#####
##### STATE VARIABLE SCRIPT INITIALIZATION SECTION
#####

from hec.script import Constants
#
# initialization function. optional.
# set up tables and other things that only need to be performed once at the start of the compute.
#
# variables that are passed to this script during the compute initialization:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network
#
def initStateVariable(currentVariable, network):
	# return Constants.TRUE if the initialization is successful and Constants.FALSE if it failed.
	# Returning Constants.FALSE will halt the compute.
	return Constants.TRUE

#####
##### STATE VARIABLE SCRIPT COMPUTATION SECTION
#####

# Calculate Thurlow Minimum Flow based on APC procedure
# 01/04/2010 SMO based on discussions during Oct 2009
# Uses the original definition of basin Inflow (Hackneyville where gage flow is available)
# - Hackneyville data was obtained from USGS.
# - No data is available from 01Oct1970 - 30Sep1985.  During this period, basin inflow is a 7-day weighted average of Heflin and Newell flows only.
# - The decision to do this was made during the early Oct 2009 meeting when James was in Davis.

# Check day of the week.  A new MinQ is only set on Tuesdays.
dayOfWeek = currentRuntimestep.getDayOfWeek()

# If today is Tuesday, do the algebra to calculate a new MinQ
if dayOfWeek == 2 :
```

```
  # Drainage basin areas in square miles.  WadleyMartin is the contributing basin between Wadley and Martin.
  # Wadley = 1675; Martin = 3000

  heflinArea = 448
  newellArea = 406
  hackneyArea = 190
  wadleyMartinArea = 1325
  num_gages = 3

  # Get the 7-day running average values for Heflin, Newell, & Martin.
  # Get the inflow per sq mile value by dividing each by its contributing area.
  # Get the total flow at Heflin and Newell (gage flow)
  # Get the local flow at Hackneyville using USGS gage data when available

  heflinTS = network.getTimeSeries("Junction","Heflin", "", "Flow")
  heflinWeightedAve = heflinTS.getPeriodAverage( currentRuntimestep.getStep(), 7 ) / heflinArea
  newellTS = network.getTimeSeries("Junction","Newell", "", "Flow")
  newellWeightedAve = newellTS.getPeriodAverage( currentRuntimestep.getStep(), 7 ) / newellArea

  hackneyTS = network.getTimeSeries("Junction","Hackneyville", "", "Flow")
  hackneyWeightedAve = hackneyTS.getPeriodAverage( currentRuntimestep.getStep(), 7 ) / hackneyArea
  # print "hackney@@@@@", currentRuntimestep.dateTimeString(), hackneyTS.getCurrentValue(currentRuntimestep), hackneyWeightedAve

#  hackneyTS = network.findJunction("Martin_IN").getLocalFlowTimeSeries("Martin_IN_LOC")
#  hackneyWeightedAve = martinTS.getPeriodAverage( currentRuntimestep.getStep(), 7 ) / hackneyArea

  # make sure the individual basin inflows are not negative
  if heflinWeightedAve < 0 :
    heflinWeightedAve = 0
  if newellWeightedAve < 0 :
    newellWeightedAve = 0
  if hackneyWeightedAve <= 0 :
    hackneyWeightedAve = 0
    # if Hackneyville data is less than 0, then we don't have valid data
    # so we are only averaging inflows from two gages.
    num_gages = 2

  # calculate the weighted average basin inflow (cfs/sq mi)
  basinInflow = ( heflinWeightedAve + newellWeightedAve + hackneyWeightedAve ) / num_gages

  # print "BI= ", basinInflow
```

```
  # Check the current month and set corresponding "Storage" Value

  curMonth = currentRuntimestep.month()
  if curMonth == 2 :
    storValue = -0.3698
  elif curMonth == 3 :
    storValue = -0.8854
  elif curMonth == 4 :
    storValue = -0.8854
  else :
    storValue = 0

  # Calculate the target MinQ
  if (basinInflow + storValue) < 0.7273 :
    targetMinQ = 3300 * ( basinInflow + storValue) / 2
  else :
    targetMinQ = 1200

  # Restrict the targetMinQ so that it is never greater than 1200 or less than 350 cfs.
  if targetMinQ < 350 :
    targetMinQ = 350
  elif targetMinQ > 1200 :
    targetMinQ = 1200

# If today is not Tuesday, set Thurlow MinQ to the previous value.
else :

  # Get previous value of Thurlow MinQ
  targetMinQ = currentVariable.getPreviousValue(currentRuntimestep)

# set Thurlow MinQ
currentVariable.setValue(currentRuntimestep, targetMinQ)

# set Ave Weighted Basin Inflow (as a check only)
# if you use these state variables, you must make sure they are being calculated on non-Tuesdays
# network.getStateVariable("ThurlowBasinInflow").setValue(currentRuntimestep, basinInflow)
# network.getStateVariable("MartinBasinInflow").setValue(currentRuntimestep, martinWeightedAve)
```

```
#####
##### STATE VARIABLE SCRIPT CLEANUP SECTION
#####

from hec.script import Constants
#
# script to be run only once, at the end of the compute. optional.

# variables that are available to this script during the compute:
#	currentVariable - the StateVariable that holds this script
#	network - the ResSim network

# The following represents an undefined value in a time series:
#	Constants.UNDEFINED

# add your code here...
```

IV. Utility Scripts for Analyzing Results

Plotting script "buttons" are shown in Figure L.18 and Report script "buttons" are shown in Figure L.19.

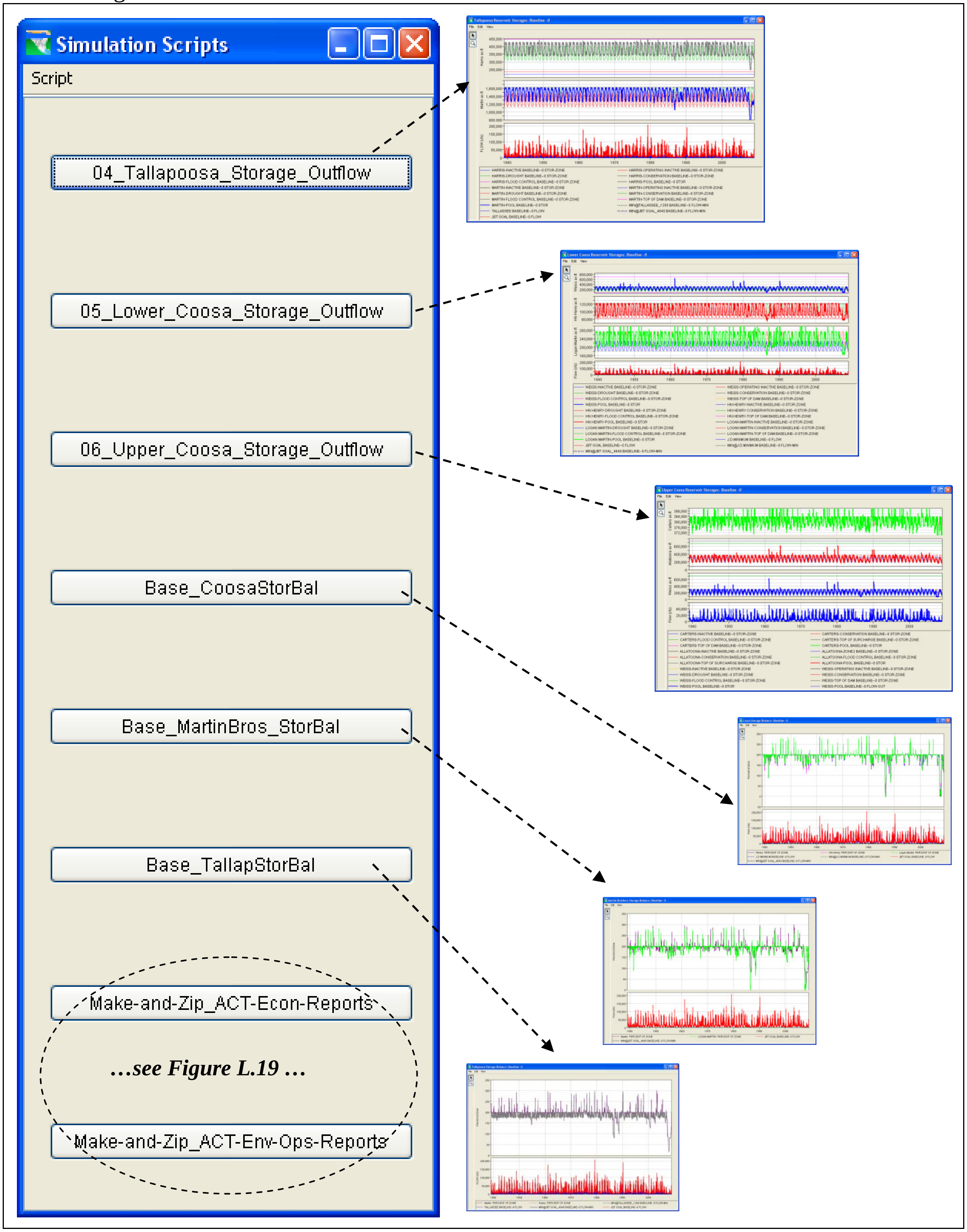


Figure L.18 Plotting Scripts in Simulation Module

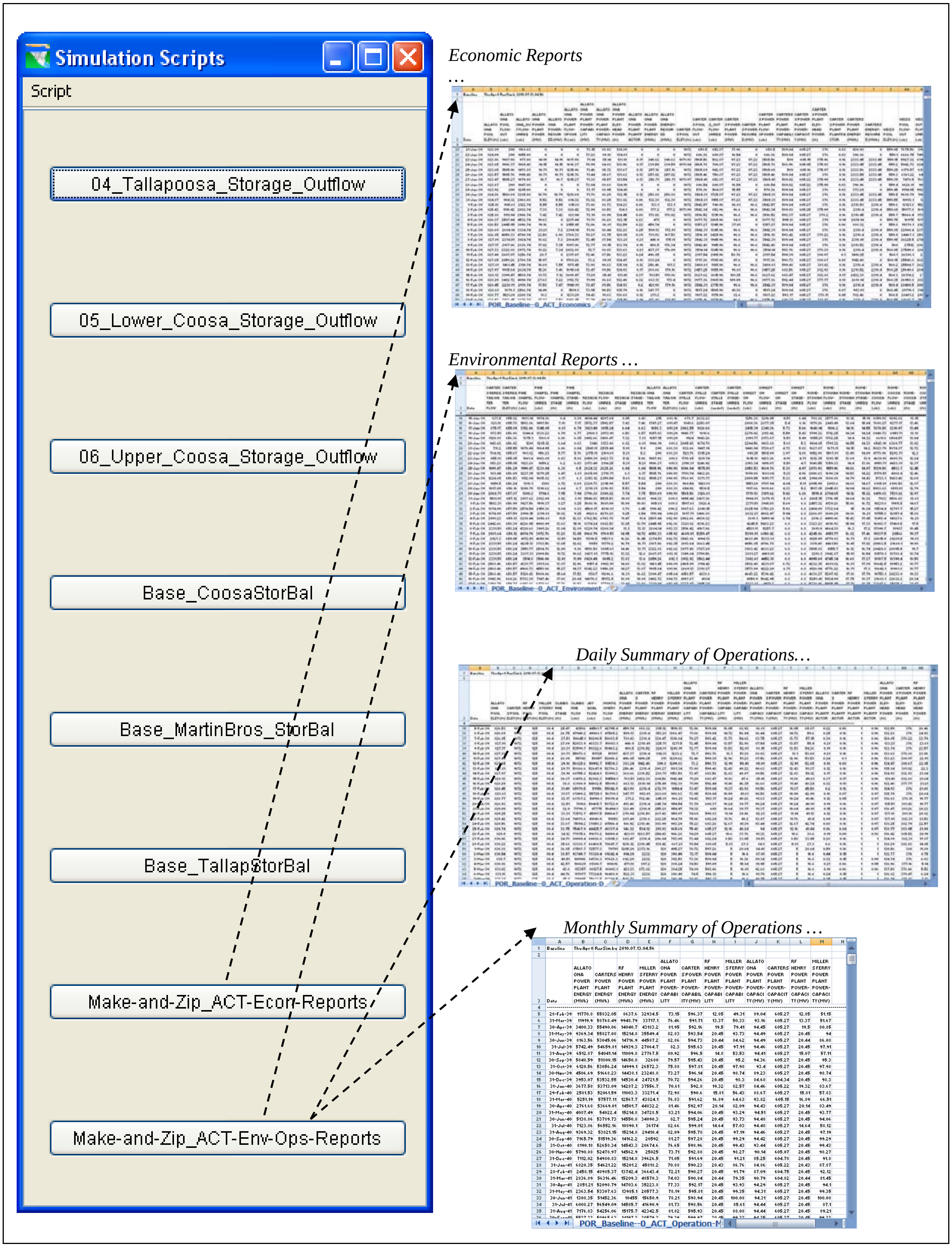


Figure L.19 Make-and-Zip Report Scripts in Simulation Module

A. Scripts for Plotting Results

Several scripts were developed for plotting simulation results for the ACT watershed. The following sections show the script editor, followed by a plot for the "Baseline" period-of-record results. Following the plot, the complete contents of the script are included in a table.

1. 04_Tallapoosa_Storage_Outflow

Figure L.20 reflects the Script Editor for the plotting script named "04_Tallapoosa_Storage_Outflow".

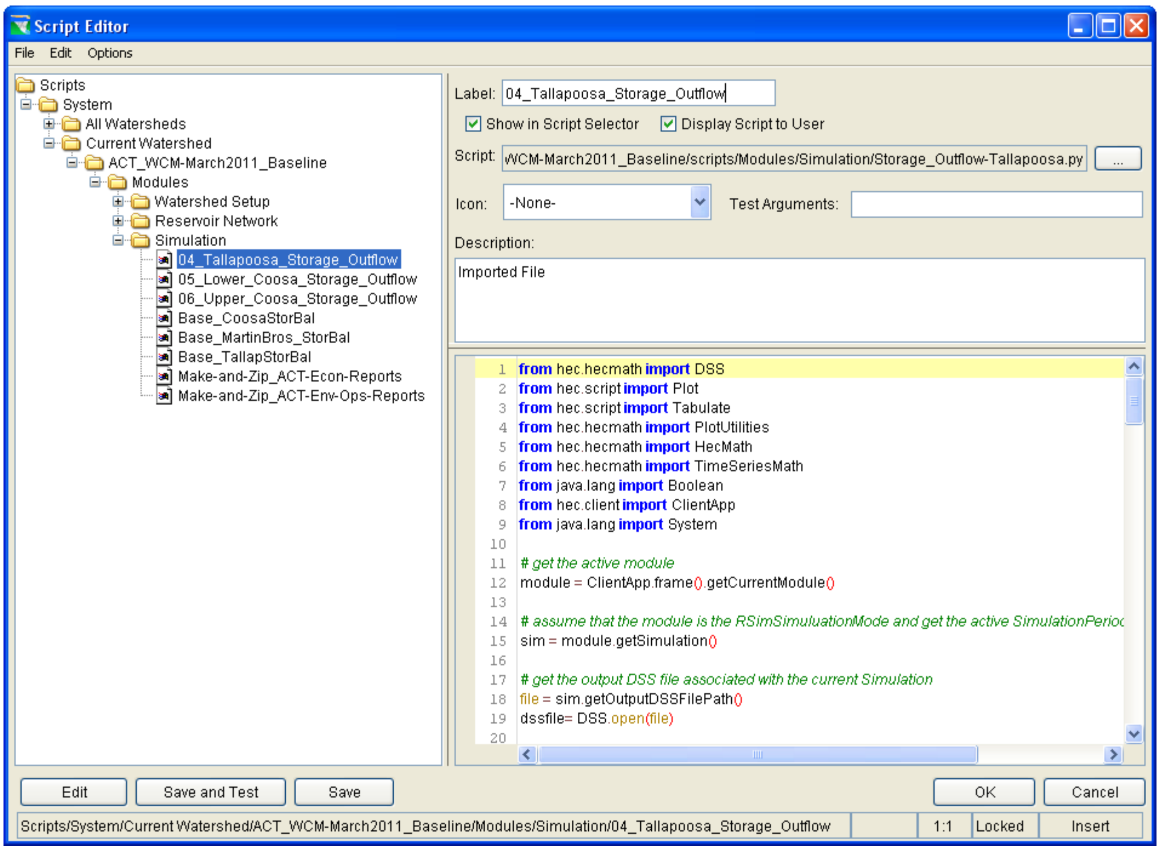


Figure L.20 Script Editor for "04_Tallapoosa_Storage_Outflow" Plot Script

Figure L.21 shows a plot generated by the script named "04_Tallapoosa_Storage_Outflow"for the "Baseline" alternative for the period of record simulation results.

Table L.04 contains the complete contents of the script named "04_Tallapoosa_Storage_Outflow".

Figure L.21 Plot from "04_Tallapoosa_Storage_Outflow" Script Showing Period-of-Record "Baseline" Results

Table L.04 Contents of Plotting Script "04_Tallapoosa_Storage_Outflow"

```
# name=04_Tallapoosa_Storage_Outflow
# description=Imported File
# displayinmenu=false
# displaytouser=true
# displayinselector=true
from hec.hecmath import DSS
from hec.script import Plot
from hec.script import Tabulate
from hec.hecmath import PlotUtilities
from hec.hecmath import HecMath
from hec.hecmath import TimeSeriesMath
from java.lang import Boolean
from hec.client import ClientApp
from java.lang import System

# get the active module
module = ClientApp.frame().getCurrentModule()

# assume that the module is the RSimSimuluationMode and get the active SimulationPeriod
sim = module.getSimulation()

# get the output DSS file associated with the current Simulation
file = sim.getOutputDSSFilePath()
dssfile= DSS.open(file)

# get the start and end date strings from the Simulation and set the time window for plotting
startDate = sim.getStartDateString()
endDate = sim.getEndDateString()
dssfile.setTimeWindow(startDate, endDate)

# get the first run selected with a check mark in Simulation Tree, assume there is at least one (add error check later)
nameVec = module.getRssRunNames(Boolean.TRUE)

# this is a simple error check for now to be sure there is at least one result checked in the tree- needs improvement
if nameVec.size() == 0:
	noResultsToPlot

runname = nameVec.get(0).toString()

# retrieve the model output time series - note the Dpart is not important
harStorTS = dssfile.read("//HARRIS-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
marStorTS = dssfile.read("//MARTIN-POOL/STOR/01JAN1939/1DAY/" + runname + "/")

tlsReleaseTS = dssfile.read("//TALLASSEE/FLOW/01JAN1939/1DAY/" + runname + "/")
tlsRuleTS = dssfile.read("//MIN@TALLASSEE_1200/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")
jbtReleaseTS = dssfile.read("//JBT GOAL/FLOW/01JAN1939/1DAY/" + runname + "/")
jbtRuleTS = dssfile.read("//MIN@JBT GOAL_4640/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")
```

```
harStorZ0TS = dssfile.read("//HARRIS-INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
harStorZ1TS = dssfile.read("//HARRIS-OPERATING INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
harStorZ2TS = dssfile.read("//HARRIS-DROUGHT/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
harStorZ3TS = dssfile.read("//HARRIS-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
harStorZ4TS = dssfile.read("//HARRIS-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
harStorZ5TS = dssfile.read("//HARRIS-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")

marStorZ0TS = dssfile.read("//MARTIN-INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
marStorZ1TS = dssfile.read("//MARTIN-OPERATING INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
marStorZ2TS = dssfile.read("//MARTIN-DROUGHT/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
marStorZ3TS = dssfile.read("//MARTIN-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
marStorZ4TS = dssfile.read("//MARTIN-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
marStorZ5TS = dssfile.read("//MARTIN-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")

# override path parts to simplify legend
# location and version can be set to anything, but the parameter name "PERCENT OF CON" is used in the template
# if you want to change the parameter name, you must also change the template
#rusPCTS.setLocation("RUSSELL")
#rusPCTS.setParameterPart("PERCENT OF CON")
#rusPCTS.setVersion("")
#rusPCTS.setUnits("%")


# create the plot and plot objects
thePlot = Plot.newPlot()
layout = Plot.newPlotLayout()

vp0 = layout.addViewport()
vp0.setAxisName("Y1", "HAR")
vp0.setAxisLabel("Y1", "Harris ac-ft")
vp1 = layout.addViewport()
vp1.setAxisName("Y1", "MAR")
vp1.setAxisLabel("Y1", "Martin ac-ft")
vp2 = layout.addViewport()

# add the plot objects and initialize the plot

vp1.addCurve("Y1", marStorZ0TS.getData())
vp1.addCurve("Y1", marStorZ1TS.getData())
vp1.addCurve("Y1", marStorZ2TS.getData())
vp1.addCurve("Y1", marStorZ3TS.getData())
vp1.addCurve("Y1", marStorZ4TS.getData())
vp1.addCurve("Y1", marStorZ5TS.getData())
vp1.addCurve("Y1", marStorTS.getData())

vp0.addCurve("Y1", harStorZ0TS.getData())
vp0.addCurve("Y1", harStorZ1TS.getData())
vp0.addCurve("Y1", harStorZ2TS.getData())
vp0.addCurve("Y1", harStorZ3TS.getData())
vp0.addCurve("Y1", harStorZ4TS.getData())
```

```
vp0.addCurve("Y1", harStorTS.getData())

vp2.addCurve("Y1", tlsRuleTS.getData())
vp2.addCurve("Y1", tlsReleaseTS.getData())
vp2.addCurve("Y1", jbtRuleTS.getData())
vp2.addCurve("Y1", jbtReleaseTS.getData())

thePlot.configurePlotLayout(layout)
thePlot.setSize(1024,710)
thePlot.setLocation(0,0)
thePlot.showPlot()

harStorTSCurve = thePlot.getCurve(harStorTS)
harStorTSCurve.setLineColor("127,127,127")
harStorTSCurve.setLineWidth(2)

marStorTSCurve = thePlot.getCurve(marStorTS)
marStorTSCurve.setLineColor("Blue")
marStorTSCurve.setLineWidth(2)

tlsPZTSCurve = thePlot.getCurve(tlsReleaseTS)
tlsPZTSCurve.setLineColor("Blue")
tlsPZTSCurve.setLineWidth(1.5)

tlsRuleCurve = thePlot.getCurve(tlsRuleTS)
tlsRuleCurve.setLineColor("Black")
tlsRuleCurve.setLineWidth(1)
tlsRuleCurve.setLineStyle("Dot")

jbtPZTSCurve = thePlot.getCurve(jbtReleaseTS)
jbtPZTSCurve.setLineColor("Red")
jbtPZTSCurve.setLineWidth(1.5)

jbtRuleCurve = thePlot.getCurve(jbtRuleTS)
jbtRuleCurve.setLineColor("Black")
jbtRuleCurve.setLineWidth(1)
jbtRuleCurve.setLineStyle("Dash")

# set plot title with run name
thePlot.setTitle("Tallapoosa Reservoir Storages: " + runname)
vp0a = thePlot.getViewport(0)
lyAxis0 = vp0a.getAxis("Y1")
lyAxis0.setScaleLimits(200000,450000)
vp1a = thePlot.getViewport(1)
lyAxis1 = vp1a.getAxis("Y1")
lyAxis1.setScaleLimits(800000,1800000)
```

2. 05_Lower_Coosa_Storage_Outflow

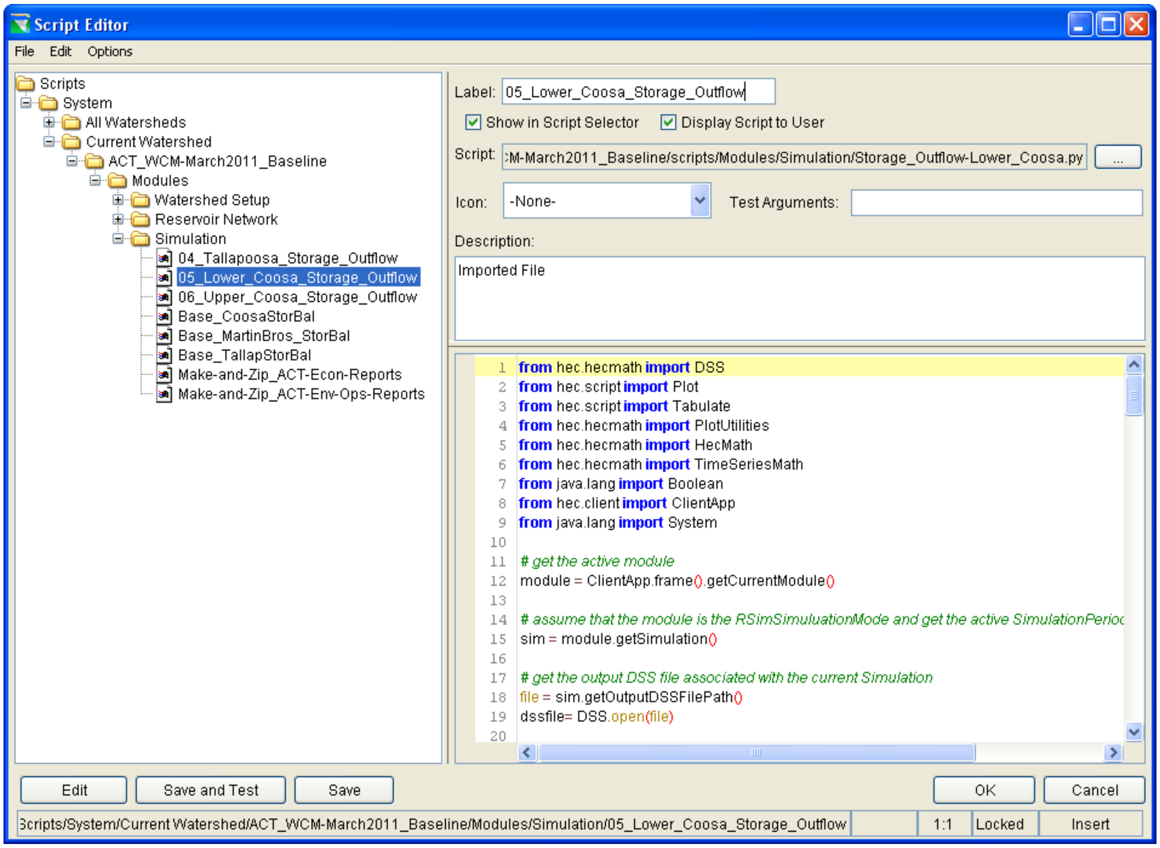


Figure L.22 Script Editor for "05_Lower_Coosa_Storage_Outflow" Plot Script

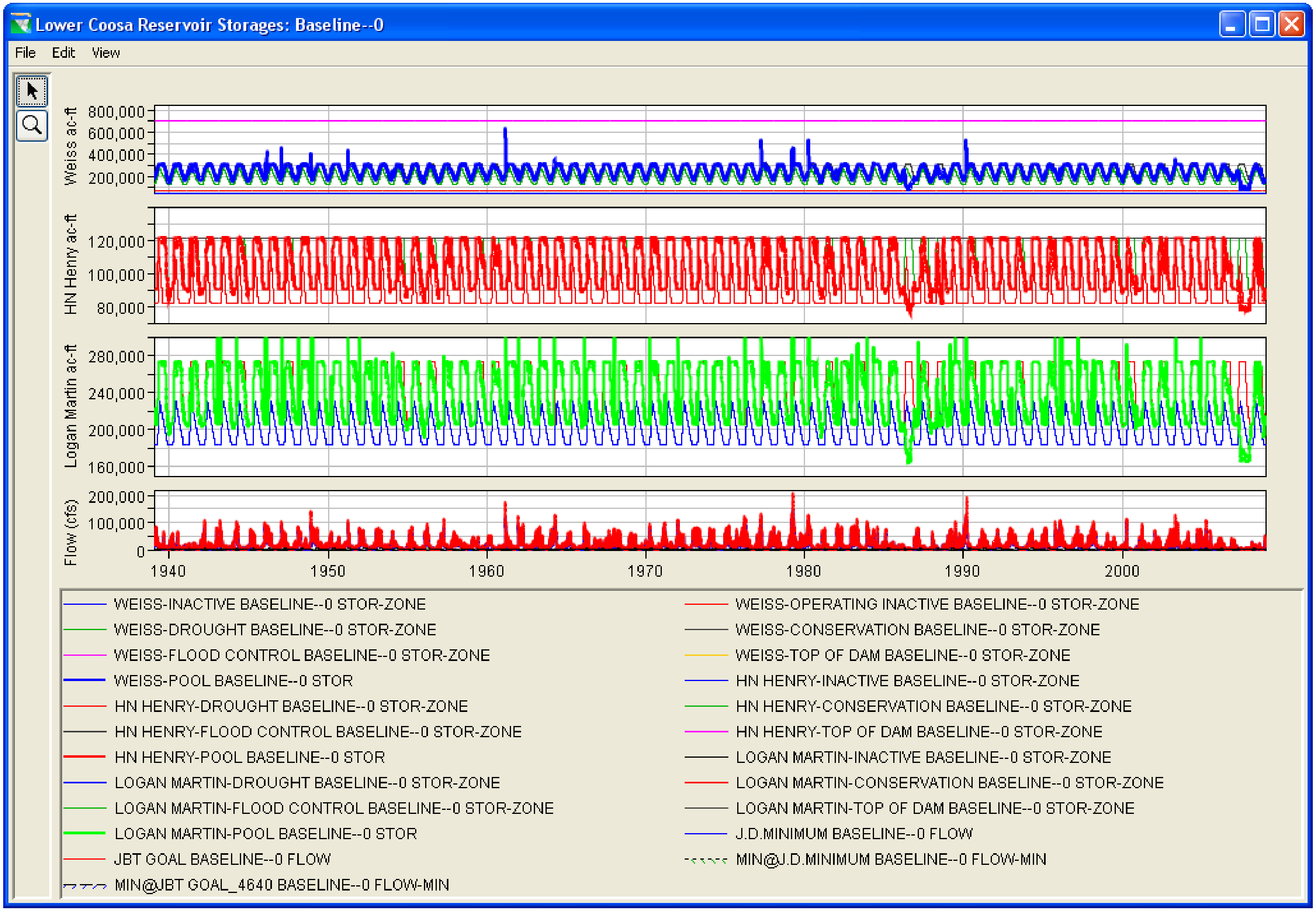


Figure L.23 Plot from "05_Lower_Coosa_Storage_Outflow" Script Showing Period-of-Record "Baseline" Results

Table L.05 Contents of Plotting Script "05_Lower_Coosa_Storage_Outflow"

```
# name=05_Lower_Coosa_Storage_Outflow
# description=Imported File
# displayinmenu=false
# displaytouser=true
# displayinselector=true
from hec.hecmath import DSS
from hec.script import Plot
from hec.script import Tabulate
from hec.hecmath import PlotUtilities
from hec.hecmath import HecMath
from hec.hecmath import TimeSeriesMath
from java.lang import Boolean
from hec.client import ClientApp
from java.lang import System

# get the active module
module = ClientApp.frame().getCurrentModule()

# assume that the module is the RSimSimuluationMode and get the active SimulationPeriod
sim = module.getSimulation()

# get the output DSS file associated with the current Simulation
file = sim.getOutputDSSFilePath()
dssfile= DSS.open(file)

# get the start and end date strings from the Simulation and set the time window for plotting
startDate = sim.getStartDateString()
endDate = sim.getEndDateString()
dssfile.setTimeWindow(startDate, endDate)

# get the first run selected with a check mark in Simulation Tree, assume there is at least one (add error check later)
nameVec = module.getRssRunNames(Boolean.TRUE)

# this is a simple error check for now to be sure there is at least one result checked in the tree- needs improvement
if nameVec.size() == 0:
        noResultsToPlot

runname = nameVec.get(0).toString()

# retrieve the model output time series - note the Dpart is not important
wssStorTS = dssfile.read("//WEISS-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
hnhStorTS = dssfile.read("//HN HENRY-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
lomStorTS = dssfile.read("//LOGAN MARTIN-POOL/STOR/01JAN1939/1DAY/" + runname + "/")

jdmReleaseTS = dssfile.read("//J.D.MINIMUM/FLOW/01JAN1939/1DAY/" + runname + "/")
jbtReleaseTS = dssfile.read("//JBT GOAL/FLOW/01JAN1939/1DAY/" + runname + "/")
jdmRuleTS = dssfile.read("//MIN@J.D.MINIMUM/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")
```

```
jbtRuleTS = dssfile.read("//MIN@JBT GOAL_4640/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")

wssStorZ0TS = dssfile.read("//WEISS-INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wssStorZ1TS = dssfile.read("//WEISS-OPERATING INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wssStorZ2TS = dssfile.read("//WEISS-DROUGHT/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wssStorZ3TS = dssfile.read("//WEISS-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wssStorZ4TS = dssfile.read("//WEISS-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wssStorZ5TS = dssfile.read("//WEISS-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")

hnhStorZ0TS = dssfile.read("//HN HENRY-INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
hnhStorZ1TS = dssfile.read("//HN HENRY-DROUGHT/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
hnhStorZ2TS = dssfile.read("//HN HENRY-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
hnhStorZ3TS = dssfile.read("//HN HENRY-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
hnhStorZ4TS = dssfile.read("//HN HENRY-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")

lomStorZ0TS = dssfile.read("//LOGAN MARTIN-INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
lomStorZ1TS = dssfile.read("//LOGAN MARTIN-DROUGHT/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
lomStorZ2TS = dssfile.read("//LOGAN MARTIN-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
lomStorZ3TS = dssfile.read("//LOGAN MARTIN-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
lomStorZ4TS = dssfile.read("//LOGAN MARTIN-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")


# override path parts to simplify legend
# location and version can be set to anything, but the parameter name "PERCENT OF CON" is used in the template
# if you want to change the parameter name, you must also change the template
#rusPCTS.setLocation("RUSSELL")
#rusPCTS.setParameterPart("PERCENT OF CON")
#rusPCTS.setVersion("")
#rusPCTS.setUnits("%")


# create the plot and plot objects
thePlot = Plot.newPlot()
layout = Plot.newPlotLayout()

vp0 = layout.addViewport()
vp0.setAxisName("Y1", "WSS")
vp0.setAxisLabel("Y1", "Weiss ac-ft")
vp1 = layout.addViewport()
vp1.setAxisName("Y1", "HNH")
vp1.setAxisLabel("Y1", "HN Henry ac-ft")
vp2 = layout.addViewport()
vp2.setAxisName("Y1", "LOM")
vp2.setAxisLabel("Y1", "Logan Martin ac-ft")
vp3 = layout.addViewport()

# add the plot objects and initialize the plot
vp0.addCurve("Y1", wssStorZ0TS.getData())
vp0.addCurve("Y1", wssStorZ1TS.getData())
vp0.addCurve("Y1", wssStorZ2TS.getData())
vp0.addCurve("Y1", wssStorZ3TS.getData())
```

```
vp0.addCurve("Y1", wssStorZ4TS.getData())
vp0.addCurve("Y1", wssStorZ5TS.getData())
vp0.addCurve("Y1", wssStorTS.getData())

vp1.addCurve("Y1", hnhStorZ0TS.getData())
vp1.addCurve("Y1", hnhStorZ1TS.getData())
vp1.addCurve("Y1", hnhStorZ2TS.getData())
vp1.addCurve("Y1", hnhStorZ3TS.getData())
vp1.addCurve("Y1", hnhStorZ4TS.getData())
vp1.addCurve("Y1", hnhStorTS.getData())

vp2.addCurve("Y1", lomStorZ0TS.getData())
vp2.addCurve("Y1", lomStorZ1TS.getData())
vp2.addCurve("Y1", lomStorZ2TS.getData())
vp2.addCurve("Y1", lomStorZ3TS.getData())
vp2.addCurve("Y1", lomStorZ4TS.getData())
vp2.addCurve("Y1", lomStorTS.getData())

vp3.addCurve("Y1", jdmReleaseTS.getData())
vp3.addCurve("Y1", jbtReleaseTS.getData())
vp3.addCurve("Y1", jdmRuleTS.getData())
vp3.addCurve("Y1", jbtRuleTS.getData())

thePlot.configurePlotLayout(layout)
thePlot.setSize(1024,710)
thePlot.setLocation(0,0)
thePlot.showPlot()

lomStorTSCurve = thePlot.getCurve(lomStorTS)
lomStorTSCurve.setLineColor("Green")
lomStorTSCurve.setLineWidth(2)

wssStorTSCurve = thePlot.getCurve(wssStorTS)
wssStorTSCurve.setLineColor("Blue")
wssStorTSCurve.setLineWidth(2)

hnhStorTSCurve = thePlot.getCurve(hnhStorTS)
hnhStorTSCurve.setLineColor("Red")
hnhStorTSCurve.setLineWidth(2)


jdmPZTSCurve = thePlot.getCurve(jdmReleaseTS)
jdmPZTSCurve.setLineColor("Blue")
jdmPZTSCurve.setLineWidth(1.5)

jbtPZTSCurve = thePlot.getCurve(jbtReleaseTS)
jbtPZTSCurve.setLineColor("Red")
jbtPZTSCurve.setLineWidth(1.5)

jdmRuleCurve = thePlot.getCurve(jdmRuleTS)
jdmRuleCurve.setLineColor("Black")
```

```
jdmRuleCurve.setLineWidth(1)
jdmRuleCurve.setLineStyle("Dot")

jbtRuleCurve = thePlot.getCurve(jbtRuleTS)
jbtRuleCurve.setLineColor("Black")
jbtRuleCurve.setLineWidth(1)
jbtRuleCurve.setLineStyle("Dash")

# set plot title with run name
thePlot.setTitle("Lower Coosa Reservoir Storages: " + runname)

vp0a = thePlot.getViewport(0)
lyAxis0 = vp0a.getAxis("Y1")
lyAxis0.setScaleLimits(50000,850000)
vp1a = thePlot.getViewport(1)
lyAxis1 = vp1a.getAxis("Y1")
lyAxis1.setScaleLimits(70000,140000)
vp2a = thePlot.getViewport(2)
lyAxis2 = vp2a.getAxis("Y1")
lyAxis2.setScaleLimits(150000,300000)
```

3. 06_Upper_Coosa_Storage_Outflow

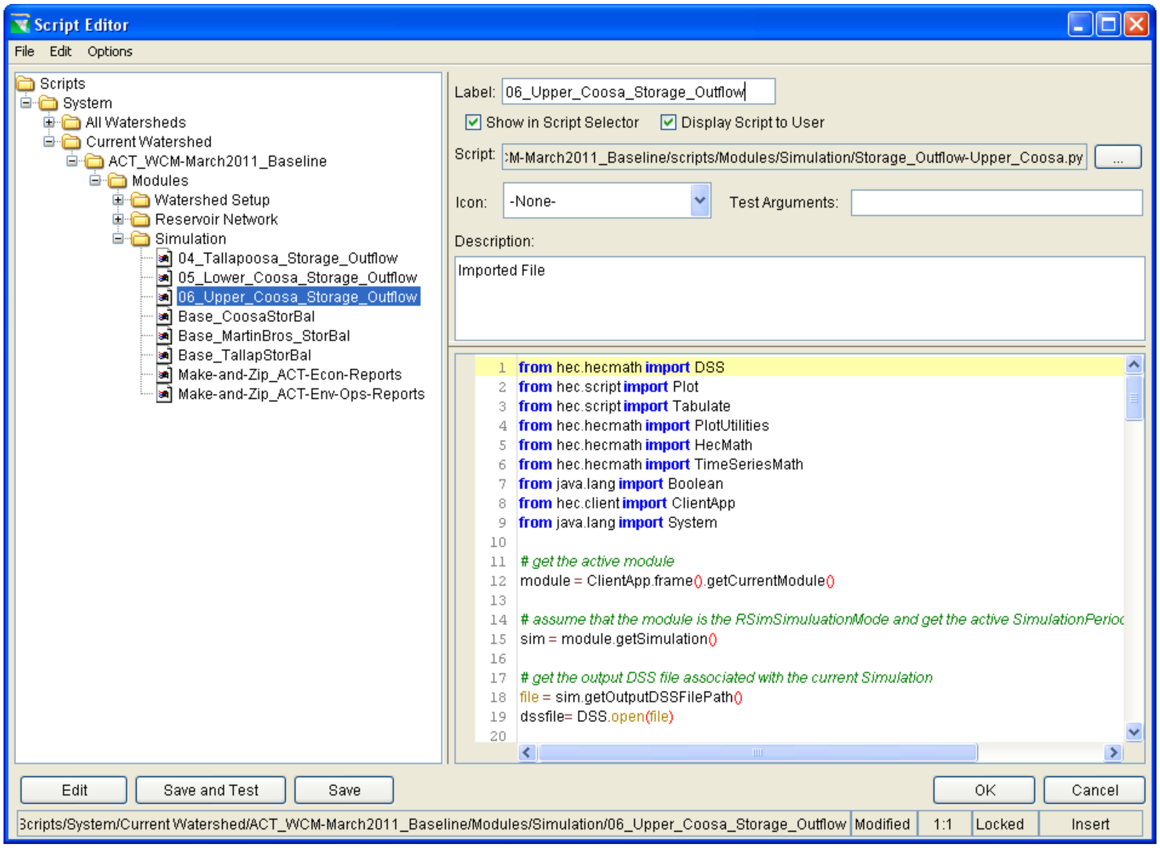


Figure L.24 Script Editor for “06_Upper_Coosa_Storage_Outflow” Plot Script

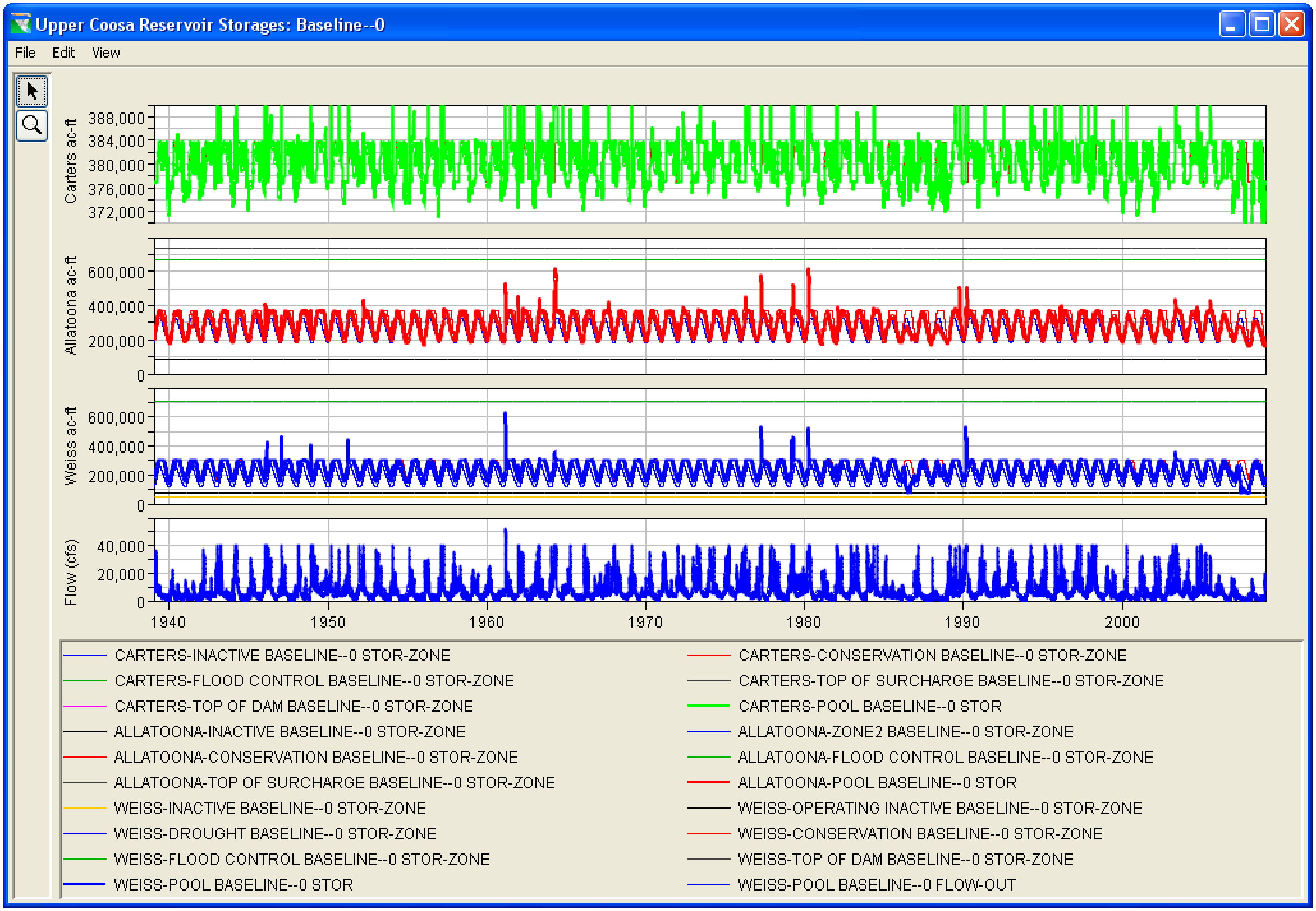


Figure L.25 Plot from "06_Upper_Coosa_Storage_Outflow" Script Showing Period-of-Record "Baseline" Results

Table L.06 Contents of Plotting Script "06_Upper_Coosa_Storage_Outflow"

```
# name=06_Upper_Coosa_Storage_Outflow
# description=Imported File
# displayinmenu=false
# displaytouser=true
# displayinselector=true
from hec.hecmath import DSS
from hec.script import Plot
from hec.script import Tabulate
from hec.hecmath import PlotUtilities
from hec.hecmath import HecMath
from hec.hecmath import TimeSeriesMath
from java.lang import Boolean
from hec.client import ClientApp
from java.lang import System

# get the active module
module = ClientApp.frame().getCurrentModule()

# assume that the module is the RSimSimuluationMode and get the active SimulationPeriod
sim = module.getSimulation()

# get the output DSS file associated with the current Simulation
file = sim.getOutputDSSFilePath()
dssfile= DSS.open(file)

# get the start and end date strings from the Simulation and set the time window for plotting
startDate = sim.getStartDateString()
endDate = sim.getEndDateString()
dssfile.setTimeWindow(startDate, endDate)

# get the first run selected with a check mark in Simulation Tree, assume there is at least one (add error check later)
nameVec = module.getRssRunNames(Boolean.TRUE)

# this is a simple error check for now to be sure there is at least one result checked in the tree- needs improvement
if nameVec.size() == 0:
        noResultsToPlot

runname = nameVec.get(0).toString()

# retrieve the model output time series - note the Dpart is not important
carStorTS = dssfile.read("//CARTERS-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
ataStorTS = dssfile.read("//ALLATOONA-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
wssStorTS = dssfile.read("//WEISS-POOL/STOR/01JAN1939/1DAY/" + runname + "/")

wssReleaseTS = dssfile.read("//WEISS-POOL/FLOW-OUT/01JAN1939/1DAY/" + runname + "/")

carStorZ0TS = dssfile.read("//CARTERS-INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
```

```
carStorZ1TS = dssfile.read("//CARTERS-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
carStorZ2TS = dssfile.read("//CARTERS-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
carStorZ3TS = dssfile.read("//CARTERS-TOP OF SURCHARGE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
carStorZ4TS = dssfile.read("//CARTERS-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")

ataStorZ0TS = dssfile.read("//ALLATOONA-INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
ataStorZ1TS = dssfile.read("//ALLATOONA-ZONE2/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
ataStorZ2TS = dssfile.read("//ALLATOONA-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
ataStorZ3TS = dssfile.read("//ALLATOONA-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
ataStorZ4TS = dssfile.read("//ALLATOONA-TOP OF SURCHARGE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
ataStorZ5TS = dssfile.read("//ALLATOONA-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")

wssStorZ0TS = dssfile.read("//WEISS-INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wssStorZ1TS = dssfile.read("//WEISS-OPERATING INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wssStorZ2TS = dssfile.read("//WEISS-DROUGHT/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wssStorZ3TS = dssfile.read("//WEISS-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wssStorZ4TS = dssfile.read("//WEISS-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wssStorZ5TS = dssfile.read("//WEISS-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")

# override path parts to simplify legend
# location and version can be set to anything, but the parameter name "PERCENT OF CON" is used in the template
# if you want to change the parameter name, you must also change the template
#rusPCTS.setLocation("RUSSELL")
#rusPCTS.setParameterPart("PERCENT OF CON")
#rusPCTS.setVersion("")
#rusPCTS.setUnits("%")


# create the plot and plot objects
thePlot = Plot.newPlot()
layout = Plot.newPlotLayout()


vp0 = layout.addViewport()
vp0.setAxisName("Y1", "CAR")
vp0.setAxisLabel("Y1", "Carters ac-ft")
vp1 = layout.addViewport()
vp1.setAxisName("Y1", "ATA")
vp1.setAxisLabel("Y1", "Allatoona ac-ft")
vp2 = layout.addViewport()
vp2.setAxisName("Y1", "WSS")
vp2.setAxisLabel("Y1", "Weiss ac-ft")
vp3 = layout.addViewport()



# add the plot objects and initialize the plot

vp2.addCurve("Y1", wssStorZ0TS.getData())
vp2.addCurve("Y1", wssStorZ1TS.getData())
vp2.addCurve("Y1", wssStorZ2TS.getData())
```

```
vp2.addCurve("Y1", wssStorZ3TS.getData())
vp2.addCurve("Y1", wssStorZ4TS.getData())
vp2.addCurve("Y1", wssStorZ5TS.getData())
vp2.addCurve("Y1", wssStorTS.getData())

vp1.addCurve("Y1", ataStorZ0TS.getData())
vp1.addCurve("Y1", ataStorZ1TS.getData())
vp1.addCurve("Y1", ataStorZ2TS.getData())
vp1.addCurve("Y1", ataStorZ3TS.getData())
vp1.addCurve("Y1", ataStorZ4TS.getData())
vp1.addCurve("Y1", ataStorTS.getData())

vp0.addCurve("Y1", carStorZ0TS.getData())
vp0.addCurve("Y1", carStorZ1TS.getData())
vp0.addCurve("Y1", carStorZ2TS.getData())
vp0.addCurve("Y1", carStorZ3TS.getData())
vp0.addCurve("Y1", carStorZ4TS.getData())
vp0.addCurve("Y1", carStorTS.getData())

vp3.addCurve("Y1", wssReleaseTS.getData())

thePlot.configurePlotLayout(layout)
thePlot.setSize(1024,710)
thePlot.setLocation(0,0)
thePlot.showPlot()


carStorTSCurve = thePlot.getCurve(carStorTS)
carStorTSCurve.setLineColor("Green")
carStorTSCurve.setLineWidth(2)

wssStorTSCurve = thePlot.getCurve(wssStorTS)
wssStorTSCurve.setLineColor("Blue")
wssStorTSCurve.setLineWidth(2)

ataStorTSCurve = thePlot.getCurve(ataStorTS)
ataStorTSCurve.setLineColor("Red")
ataStorTSCurve.setLineWidth(2)

wssPZTSCurve = thePlot.getCurve(wssReleaseTS)
wssPZTSCurve.setLineColor("Blue")
wssPZTSCurve.setLineWidth(1.5)

# set plot title with run name
thePlot.setTitle("Upper Coosa Reservoir Storages: " + runname)

vp0a = thePlot.getViewport(0)
lyAxis0 = vp0a.getAxis("Y1")
lyAxis0.setScaleLimits(370000,390000)
vp1a = thePlot.getViewport(1)
lyAxis1 = vp1a.getAxis("Y1")
```

```
lyAxis1.setScaleLimits(0,800000)
vp2a = thePlot.getViewport(2)
lyAxis2 = vp2a.getAxis("Y1")
lyAxis2.setScaleLimits(0,800000)
```

4. Base_CoosaStorBal

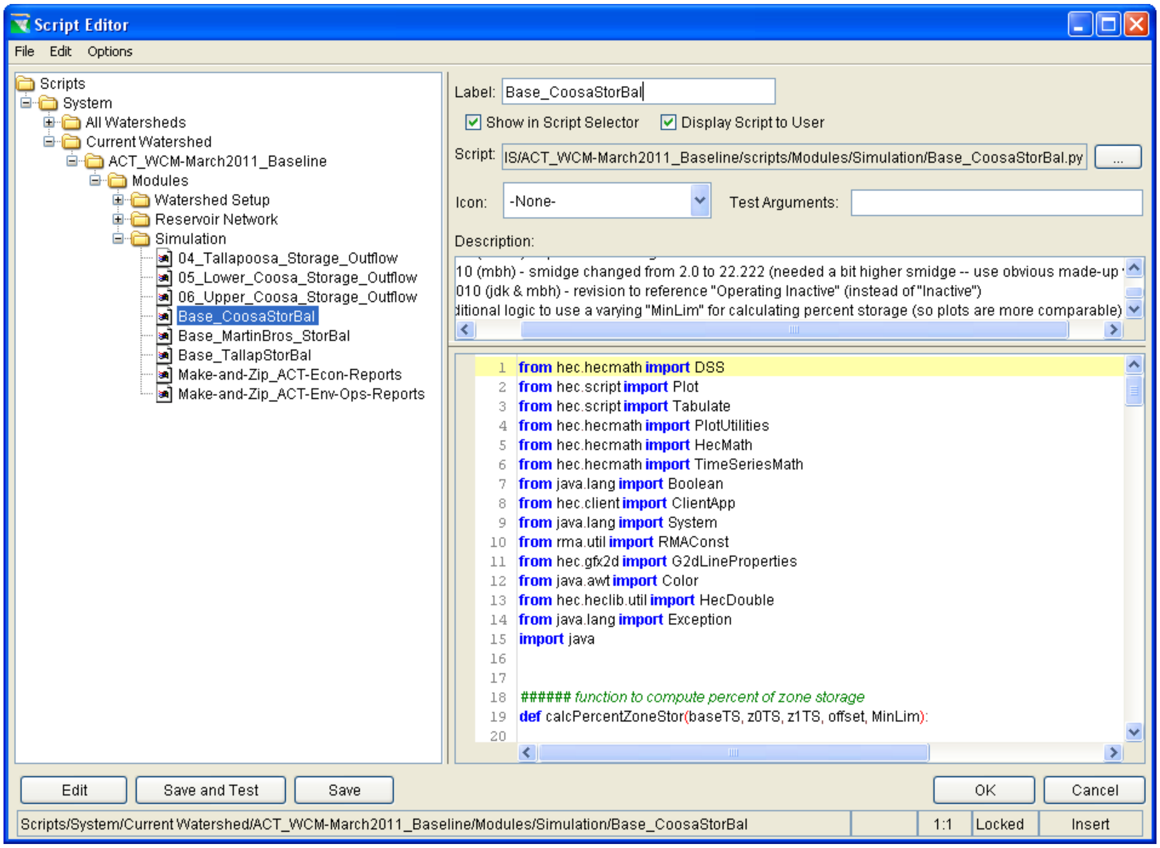


Figure L.26 Script Editor for "Base_CoosaStorBal" Plot Script

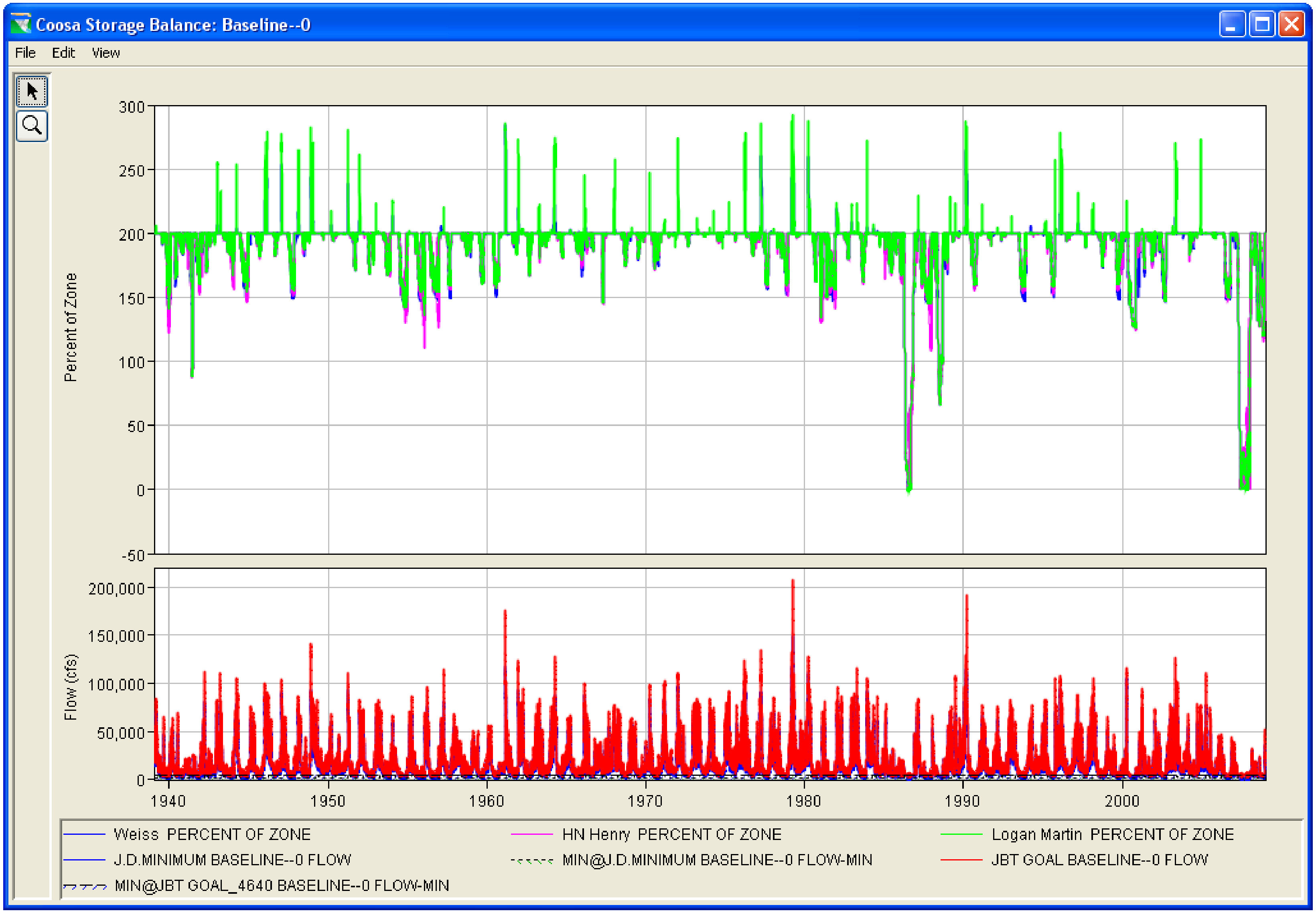


Figure L.27 Plot from "Base_CoosaStorBal" Script Showing Period-of-Record "Baseline" Results

Table L.07 Contents of Plotting Script "Base_CoosaStorBal"

```
# name=Base_CoosaStorBal
# description=Storage Balance for Weiss, HN Henry, Logan Martin
# description=8/17/2010 (mmm) - updated to distinguish between coincident zones.
# description=8/26/2010 (mbh) - smidge changed from 2.0 to 22.222 (needed a bit higher smidge -- use obvious made-up value)
# description=11/23/2010 (jdk & mbh) - revision to reference "Operating Inactive" (instead of "Inactive")
# description =       and additional logic to use a varying "MinLim" for calculating percent storage (so plots are more comparable)
# displayinmenu=false
# displaytouser=true
# displayinselector=true
from hec.hecmath import DSS
from hec.script import Plot
from hec.script import Tabulate
from hec.hecmath import PlotUtilities
from hec.hecmath import HecMath
from hec.hecmath import TimeSeriesMath
from java.lang import Boolean
from hec.client import ClientApp
from java.lang import System
from rma.util import RMAConst
from hec.gfx2d import G2dLineProperties
from java.awt import Color
from hec.heclib.util import HecDouble
from java.lang import Exception
import java


###### function to compute percent of zone storage
def calcPercentZoneStor(baseTS, z0TS, z1TS, offset, MinLim):


	tmpuz = z1TS.add(22.222)   # add a smidge of storage to upper zone in case coincident with lower zone, in order to avoid
fuzz

	tmpts = baseTS.subtract(z0TS).divide(tmpuz.subtract(z0TS)).multiply(100).screenWithMaxMin(MinLim,100,99999,True,-901,"R")
	tmpts = tmpts.replaceSpecificValues(HecDouble(-901),HecDouble(HecMath.UNDEFINED))
	try:
		tmpts.checkTimeSeries(tmpts.getContainer())
	except java.lang.Exception:
		return tmpts

	return tmpts.add(offset)


###### function to compute percent of zone storage
def mergeTS(z0TS, z1TS):
```

```
        print "Attempting mergeTS"

        try:
                z0TS.checkTimeSeries(z0TS.getContainer())
        except java.lang.Exception:
                print "Caught hec.hecmath.HecMathException on z0TS"
                return z1TS

        try:
                z1TS.checkTimeSeries(z1TS.getContainer())
        except java.lang.Exception:
                print "Caught hec.hecmath.HecMathException on z1TS"
                return z0TS

        tmpts = z0TS.mergeTimeSeries(z1TS)
        return tmpts


###### main routine

# get the active module
module = ClientApp.frame().getCurrentModule()

# assume that the module is the RSimSimuluationMode and get the active SimulationPeriod
sim = module.getSimulation()

# get the output DSS file associated with the current Simulation
file = sim.getOutputDSSFilePath()
dssfile= DSS.open(file)

# get the start and end date strings from the Simulation and set the time window for plotting
startDate = sim.getStartDateString()
endDate = sim.getEndDateString()
dssfile.setTimeWindow(startDate, endDate)

# get the first run selected with a check mark in Simulation Tree, assume there is at least one (add error check later)
nameVec = module.getRssRunNames(Boolean.TRUE)

# this is a simple error check for now to be sure there is at least one result checked in the tree- needs improvement
if nameVec.size() == 0:
        noResultsToPlot

runname = nameVec.get(0).toString()

# retrieve the model output time series - note the Dpart is not important
wesStorTS = dssfile.read("//WEISS-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
hnhStorTS = dssfile.read("//HN HENRY-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
lomStorTS = dssfile.read("//LOGAN MARTIN-POOL/STOR/01JAN1939/1DAY/" + runname + "/")

jdmReleaseTS = dssfile.read("//J.D.MINIMUM/FLOW/01JAN1939/1DAY/" + runname + "/")
jdmRuleTS = dssfile.read("//MIN@J.D.MINIMUM/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")
```

```
jbtReleaseTS = dssfile.read("//JBT GOAL/FLOW/01JAN1939/1DAY/" + runname + "/")
jbtRuleTS = dssfile.read("//MIN@JBT GOAL_4640/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")

wesStorZ0TS = dssfile.read("//WEISS-Operating INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wesStorZ1TS = dssfile.read("//WEISS-DROUGHT/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wesStorZ2TS = dssfile.read("//WEISS-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wesStorZ3TS = dssfile.read("//WEISS-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
wesStorZ4TS = dssfile.read("//WEISS-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")

hnhStorZ0TS = dssfile.read("//HN HENRY-Operating INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
hnhStorZ1TS = dssfile.read("//HN HENRY-DROUGHT/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
hnhStorZ2TS = dssfile.read("//HN HENRY-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
hnhStorZ3TS = dssfile.read("//HN HENRY-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
hnhStorZ4TS = dssfile.read("//HN HENRY-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")

lomStorZ0TS = dssfile.read("//LOGAN MARTIN-Operating INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
lomStorZ1TS = dssfile.read("//LOGAN MARTIN-DROUGHT/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
lomStorZ2TS = dssfile.read("//LOGAN MARTIN-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
lomStorZ3TS = dssfile.read("//LOGAN MARTIN-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
lomStorZ4TS = dssfile.read("//LOGAN MARTIN-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")


# calculate the percent of zone time series using HecMath routines
wesPZ0TS = calcPercentZoneStor(wesStorTS, wesStorZ0TS, wesStorZ1TS, 0, 0)
wesPZ1TS = calcPercentZoneStor(wesStorTS, wesStorZ1TS, wesStorZ2TS, 100, 0)
wesPZ2TS = calcPercentZoneStor(wesStorTS, wesStorZ2TS, wesStorZ3TS, 200, 0)
wesPZ3TS = calcPercentZoneStor(wesStorTS, wesStorZ3TS, wesStorZ4TS, 300, 0)

wesPZTS = mergeTS(wesPZ0TS, wesPZ1TS)
wesPZTS = mergeTS(wesPZTS,  wesPZ2TS)
wesPZTS = mergeTS(wesPZTS,  wesPZ3TS)

hnhPZ0TS = calcPercentZoneStor(hnhStorTS, hnhStorZ0TS, hnhStorZ1TS, 0, -0.02)
hnhPZ1TS = calcPercentZoneStor(hnhStorTS, hnhStorZ1TS, hnhStorZ2TS, 100, 0)
hnhPZ2TS = calcPercentZoneStor(hnhStorTS, hnhStorZ2TS, hnhStorZ3TS, 200, 0)
hnhPZ3TS = calcPercentZoneStor(hnhStorTS, hnhStorZ3TS, hnhStorZ4TS, 300, 0)

hnhPZTS = mergeTS(hnhPZ0TS, hnhPZ1TS)
hnhPZTS = mergeTS(hnhPZTS,  hnhPZ2TS)
hnhPZTS = mergeTS(hnhPZTS,  hnhPZ3TS)

lomPZ0TS = calcPercentZoneStor(lomStorTS, lomStorZ0TS, lomStorZ1TS, 0, -3.5)
lomPZ1TS = calcPercentZoneStor(lomStorTS, lomStorZ1TS, lomStorZ2TS, 100, 0)
lomPZ2TS = calcPercentZoneStor(lomStorTS, lomStorZ2TS, lomStorZ3TS, 200, 0)
lomPZ3TS = calcPercentZoneStor(lomStorTS, lomStorZ3TS, lomStorZ4TS, 300, 0)

lomPZTS = mergeTS(lomPZ0TS, lomPZ1TS)
lomPZTS = mergeTS(lomPZTS,  lomPZ2TS)
lomPZTS = mergeTS(lomPZTS,  lomPZ3TS)
```

```
# override path parts to simplify legend
# location and version can be set to anything, but the parameter name "PERCENT OF CON" is used in the template
# if you want to change the parameter name, you must also change the template
wesPZTS.setLocation("Weiss")
wesPZTS.setParameterPart("PERCENT OF ZONE")
wesPZTS.setVersion("")
wesPZTS.setUnits("%")

hnhPZTS.setLocation("HN Henry")
hnhPZTS.setParameterPart("PERCENT OF ZONE")
hnhPZTS.setVersion("")
hnhPZTS.setUnits("%")

lomPZTS.setLocation("Logan Martin")
lomPZTS.setParameterPart("PERCENT OF ZONE")
lomPZTS.setVersion("")
lomPZTS.setUnits("%")

# create the plot and plot objects
thePlot = Plot.newPlot()
layout = Plot.newPlotLayout()

vp0 = layout.addViewport(200)
vp1 = layout.addViewport(100)

vp0.setAxisLabel("Y1", "Percent of Zone")
# vp1.setAxisLabel("Y1", "Flow")

vp0.addCurve("Y1", wesPZTS.getData())
vp0.addCurve("Y1", hnhPZTS.getData())
vp0.addCurve("Y1", lomPZTS.getData())


vp1.addCurve("Y1", jdmReleaseTS.getData())
vp1.addCurve("Y1", jdmRuleTS.getData())
vp1.addCurve("Y1", jbtReleaseTS.getData())
vp1.addCurve("Y1", jbtRuleTS.getData())


thePlot.configurePlotLayout(layout)
thePlot.setSize(1024,710)
thePlot.setLocation(0,0)
thePlot.showPlot()

# configure curves
wesPZTSCurve = thePlot.getCurve(wesPZTS)
wesPZTSCurve.setLineColor("Blue")
wesPZTSCurve.setLineWidth(1.5)

hnhPZTSCurve = thePlot.getCurve(hnhPZTS)
hnhPZTSCurve.setLineColor("Magenta")
```

```
hnhPZTSCurve.setLineWidth(1.5)

lomPZTSCurve = thePlot.getCurve(lomPZTS)
lomPZTSCurve.setLineColor("Green")
lomPZTSCurve.setLineWidth(1.5)

jdmPZTSCurve = thePlot.getCurve(jdmReleaseTS)
jdmPZTSCurve.setLineColor("Blue")
jdmPZTSCurve.setLineWidth(1.5)

jdmRuleCurve = thePlot.getCurve(jdmRuleTS)
jdmRuleCurve.setLineColor("Black")
jdmRuleCurve.setLineWidth(1)
jdmRuleCurve.setLineStyle("Dot")

jbtPZTSCurve = thePlot.getCurve(jbtReleaseTS)
jbtPZTSCurve.setLineColor("Red")
jbtPZTSCurve.setLineWidth(1.5)

jbtRuleCurve = thePlot.getCurve(jbtRuleTS)
jbtRuleCurve.setLineColor("Black")
jbtRuleCurve.setLineWidth(1)
jbtRuleCurve.setLineStyle("Dash")

# set plot title with run name
thePlot.setTitle("Coosa Storage Balance: " + runname)
```

5. Base_MartinBros_StorBal

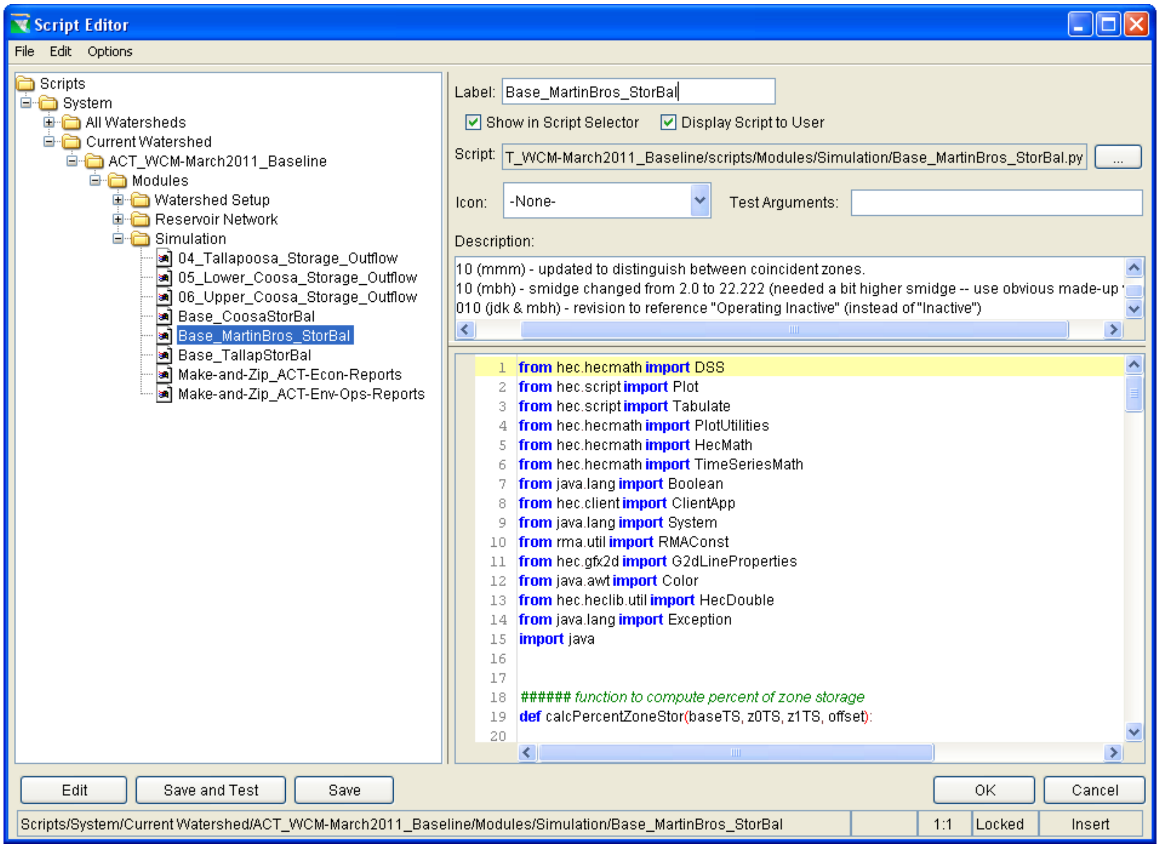


Figure L.28 Script Editor for "Base_MartinBros_StorBal" Plot Script

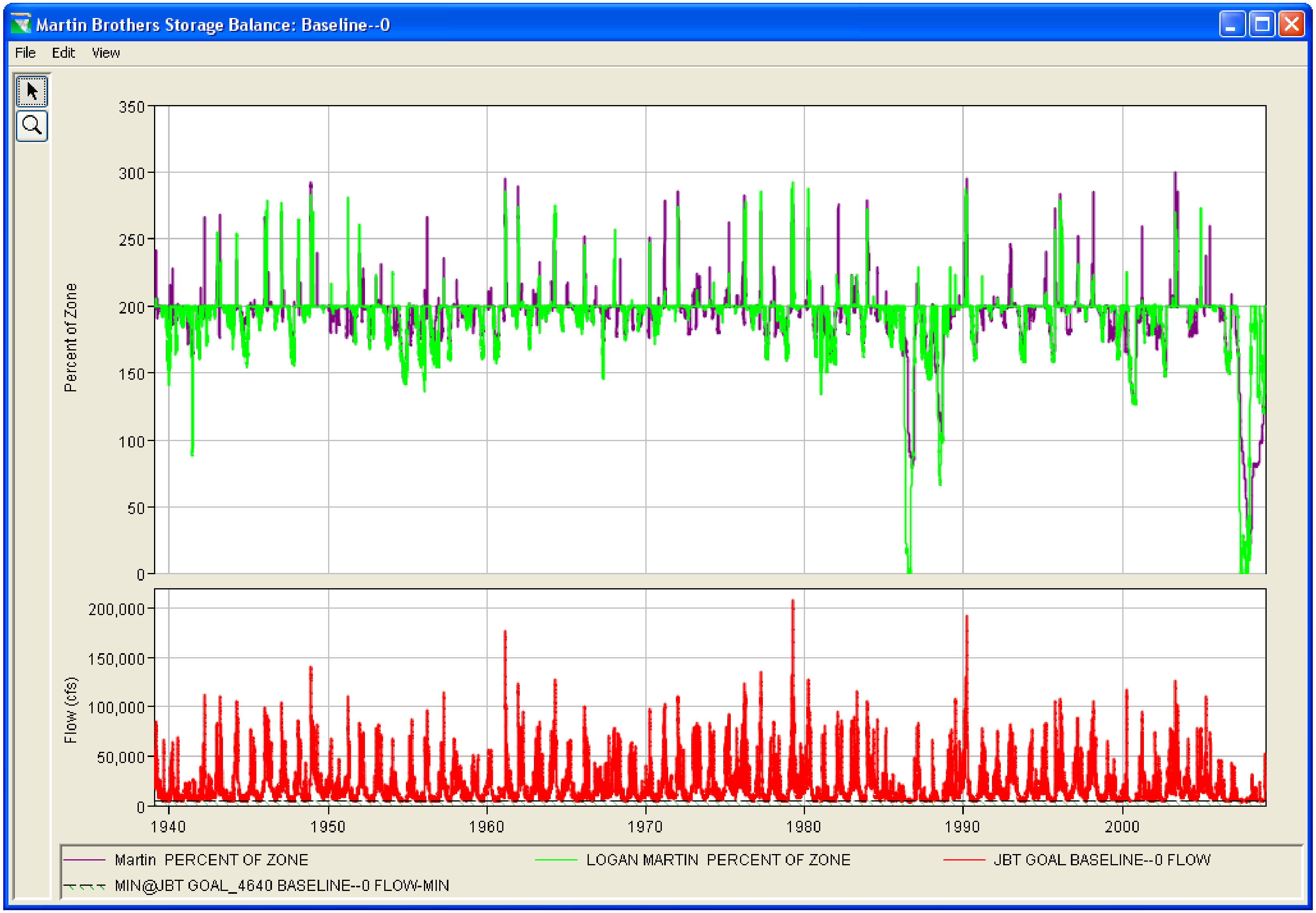


Figure L.29 Plot from "Base_MartinBros_StorBal" Script Showing Period-of-Record "Baseline" Results

Table L.08 Contents of Plotting Script "Base_MartinBros_StorBal"

```
# name=Base_MartinBros_StorBal
# description=Storage Balance for Logan Martin, Martin
# description=8/17/2010 (mmm) - updated to distinguish between coincident zones.
# description=8/26/2010 (mbh) - smidge changed from 2.0 to 22.222 (needed a bit higher smidge -- use obvious made-up value)
# description=11/23/2010 (jdk & mbh) - revision to reference "Operating Inactive" (instead of "Inactive")
# displayinmenu=false
# displaytouser=true
# displayinselector=true
from hec.hecmath import DSS
from hec.script import Plot
from hec.script import Tabulate
from hec.hecmath import PlotUtilities
from hec.hecmath import HecMath
from hec.hecmath import TimeSeriesMath
from java.lang import Boolean
from hec.client import ClientApp
from java.lang import System
from rma.util import RMAConst
from hec.gfx2d import G2dLineProperties
from java.awt import Color
from hec.heclib.util import HecDouble
from java.lang import Exception
import java


###### function to compute percent of zone storage
def calcPercentZoneStor(baseTS, z0TS, z1TS, offset):


	tmpuz = z1TS.add(22.222)   # add a smidge of storage to upper zone in case coincident with lower zone, in order to avoid
fuzz

	tmpts = baseTS.subtract(z0TS).divide(tmpuz.subtract(z0TS)).multiply(100).screenWithMaxMin(0,100,99999,True,-901,"R")
	tmpts = tmpts.replaceSpecificValues(HecDouble(-901),HecDouble(HecMath.UNDEFINED))
	try:
		tmpts.checkTimeSeries(tmpts.getContainer())
	except java.lang.Exception:
		return tmpts

	return tmpts.add(offset)


###### function to compute percent of zone storage
def mergeTS(z0TS, z1TS):


	print "Attempting mergeTS"
```

```
        try:
                z0TS.checkTimeSeries(z0TS.getContainer())
        except java.lang.Exception:
                print "Caught hec.hecmath.HecMathException on z0TS"
                return z1TS

        try:
                z1TS.checkTimeSeries(z1TS.getContainer())
        except java.lang.Exception:
                print "Caught hec.hecmath.HecMathException on z1TS"
                return z0TS

        tmpts = z0TS.mergeTimeSeries(z1TS)
        return tmpts


###### main routine

# get the active module
module = ClientApp.frame().getCurrentModule()

# assume that the module is the RSimSimuluationMode and get the active SimulationPeriod
sim = module.getSimulation()

# get the output DSS file associated with the current Simulation
file = sim.getOutputDSSFilePath()
dssfile= DSS.open(file)

# get the start and end date strings from the Simulation and set the time window for plotting
startDate = sim.getStartDateString()
endDate = sim.getEndDateString()
dssfile.setTimeWindow(startDate, endDate)

# get the first run selected with a check mark in Simulation Tree, assume there is at least one (add error check later)
nameVec = module.getRssRunNames(Boolean.TRUE)

# this is a simple error check for now to be sure there is at least one result checked in the tree- needs improvement
if nameVec.size() == 0:
        noResultsToPlot

runname = nameVec.get(0).toString()

# retrieve the model output time series - note the Dpart is not important
marStorTS = dssfile.read("//MARTIN-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
lomStorTS = dssfile.read("//LOGAN MARTIN-POOL/STOR/01JAN1939/1DAY/" + runname + "/")

jbtReleaseTS = dssfile.read("//JBT GOAL/FLOW/01JAN1939/1DAY/" + runname + "/")
jbtRuleTS = dssfile.read("//MIN@JBT GOAL_4640/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")

marStorZ0TS = dssfile.read("//MARTIN-Operating INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
```

```
marStorZ1TS = dssfile.read("//MARTIN-DROUGHT/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
marStorZ2TS = dssfile.read("//MARTIN-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
marStorZ3TS = dssfile.read("//MARTIN-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
marStorZ4TS = dssfile.read("//MARTIN-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")

lomStorZ0TS = dssfile.read("//LOGAN MARTIN-Operating INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
lomStorZ1TS = dssfile.read("//LOGAN MARTIN-DROUGHT/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
lomStorZ2TS = dssfile.read("//LOGAN MARTIN-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
lomStorZ3TS = dssfile.read("//LOGAN MARTIN-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
lomStorZ4TS = dssfile.read("//LOGAN MARTIN-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")


# calculate the percent of zone time series using HecMath routines
marPZ0TS = calcPercentZoneStor(marStorTS, marStorZ0TS, marStorZ1TS, 0)
marPZ1TS = calcPercentZoneStor(marStorTS, marStorZ1TS, marStorZ2TS, 100)
marPZ2TS = calcPercentZoneStor(marStorTS, marStorZ2TS, marStorZ3TS, 200)
marPZ3TS = calcPercentZoneStor(marStorTS, marStorZ3TS, marStorZ4TS, 300)

marPZTS = mergeTS(marPZ0TS, marPZ1TS)
marPZTS = mergeTS(marPZTS,  marPZ2TS)
marPZTS = mergeTS(marPZTS,  marPZ3TS)

lomPZ0TS = calcPercentZoneStor(lomStorTS, lomStorZ0TS, lomStorZ1TS, 0)
lomPZ1TS = calcPercentZoneStor(lomStorTS, lomStorZ1TS, lomStorZ2TS, 100)
lomPZ2TS = calcPercentZoneStor(lomStorTS, lomStorZ2TS, lomStorZ3TS, 200)
lomPZ3TS = calcPercentZoneStor(lomStorTS, lomStorZ3TS, lomStorZ4TS, 300)

lomPZTS = mergeTS(lomPZ0TS, lomPZ1TS)
lomPZTS = mergeTS(lomPZTS,  lomPZ2TS)
lomPZTS = mergeTS(lomPZTS,  lomPZ3TS)

# override path parts to simplify legend
# location and version can be set to anything, but the parameter name "PERCENT OF CON" is used in the template
# if you want to change the parameter name, you must also change the template
marPZTS.setLocation("Martin")
marPZTS.setParameterPart("PERCENT OF ZONE")
marPZTS.setVersion("")
marPZTS.setUnits("%")

lomPZTS.setLocation("LOGAN MARTIN")
lomPZTS.setParameterPart("PERCENT OF ZONE")
lomPZTS.setVersion("")
lomPZTS.setUnits("%")

# create the plot and plot objects
thePlot = Plot.newPlot()
layout = Plot.newPlotLayout()

vp0 = layout.addViewport(200)
vp1 = layout.addViewport(100)
```

```
vp0.setAxisName("Y1", "Percent of Zone")
vp1.setAxisName("Y1", "JBT Goal Flow")

vp0.addCurve("Y1", marPZTS.getData())
vp0.addCurve("Y1", lomPZTS.getData())

vp1.addCurve("Y1", jbtReleaseTS.getData())
vp1.addCurve("Y1", jbtRuleTS.getData())

thePlot.configurePlotLayout(layout)
thePlot.setSize(1024,710)
thePlot.setLocation(0,0)
thePlot.showPlot()

# configure curves
marPZTSCurve = thePlot.getCurve(marPZTS)
marPZTSCurve.setLineColor("Purple")
marPZTSCurve.setLineWidth(1.5)

lomPZTSCurve = thePlot.getCurve(lomPZTS)
lomPZTSCurve.setLineColor("Green")
lomPZTSCurve.setLineWidth(1.5)


jbtPZTSCurve = thePlot.getCurve(jbtReleaseTS)
jbtPZTSCurve.setLineColor("Red")
jbtPZTSCurve.setLineWidth(1.5)

jbtRuleCurve = thePlot.getCurve(jbtRuleTS)
jbtRuleCurve.setLineColor("Black")
jbtRuleCurve.setLineWidth(1)
jbtRuleCurve.setLineStyle("Dash")

vp0 = thePlot.getViewport(0)
uyAxis = vp0.getAxis("Y1")
uyAxis.setLabel("Percent of Zone")

# set plot title with run name
thePlot.setTitle("Martin Brothers Storage Balance: " + runname)
```

6. Base_TallapStorBal

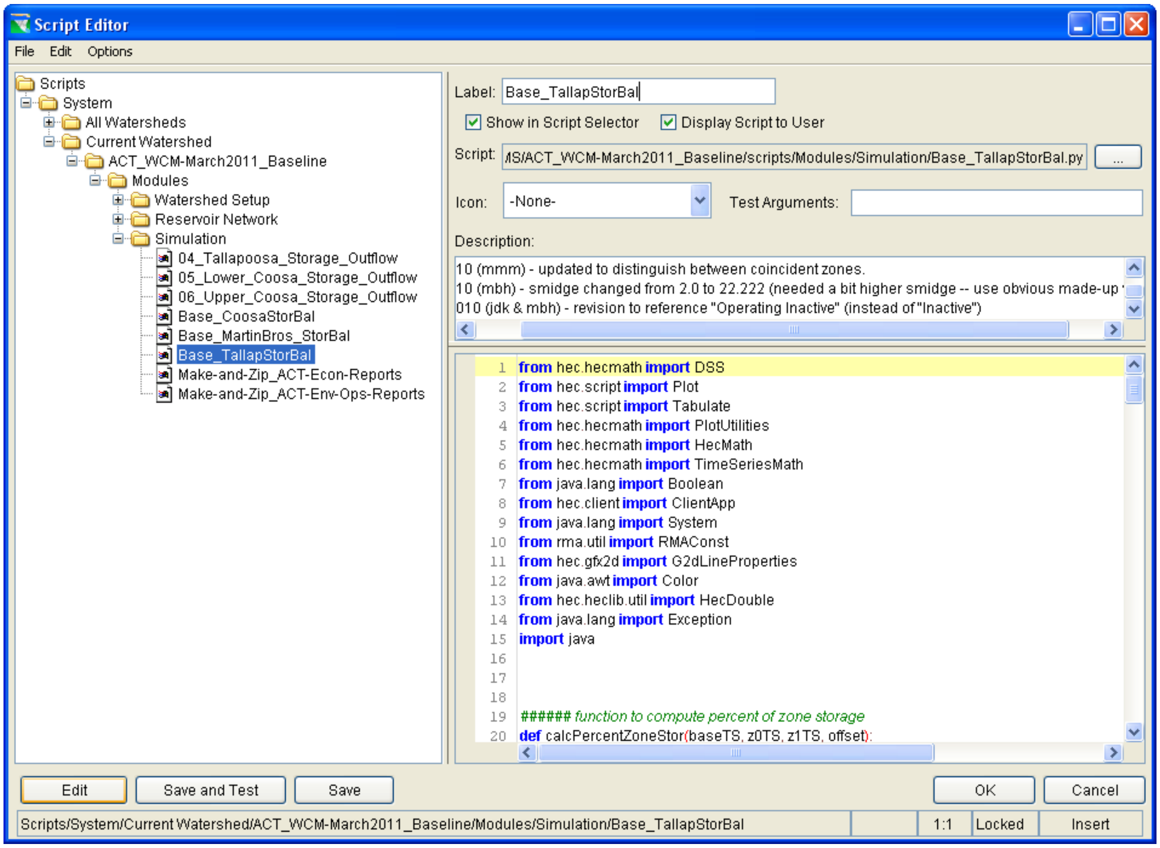


Figure L.30 Script Editor for "Base_TallapStorBal" Plot Script

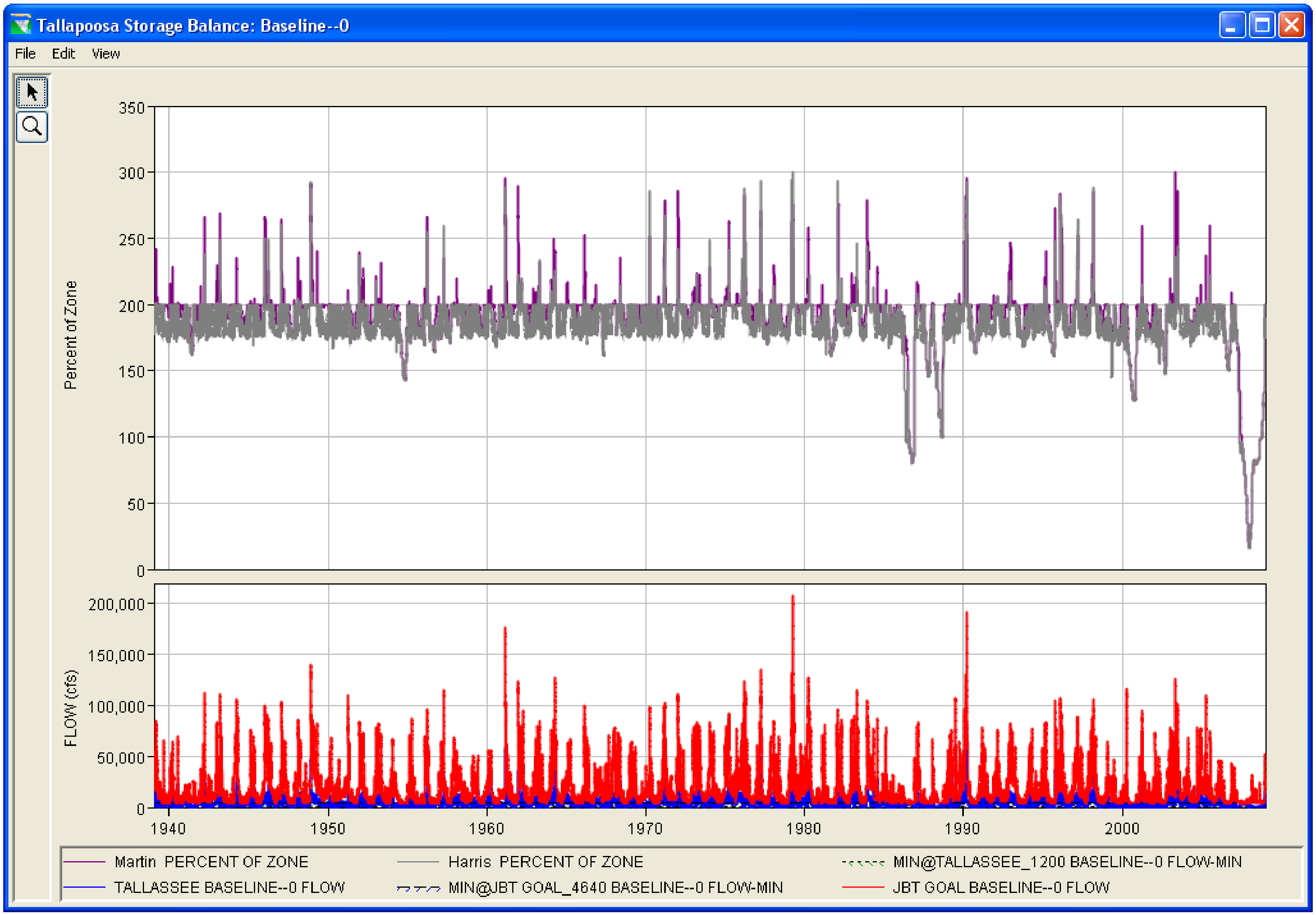


Figure L.31 Plot from "Base_TallapStorBal" Script Showing Period-of-Record "Baseline" Results

Table L.09 Contents of Plotting Script "Base_TallapStorBal"

```
# name=Base_TallapStorBal
# description=Storage Balance for Harris, Martin
# description=8/17/2010 (mmm) - updated to distinguish between coincident zones.
# description=8/26/2010 (mbh) - smidge changed from 2.0 to 22.222 (needed a bit higher smidge -- use obvious made-up value)
# description=11/23/2010 (jdk & mbh) - revision to reference "Operating Inactive" (instead of "Inactive")
# displayinmenu=false
# displaytouser=true
# displayinselector=true
from hec.hecmath import DSS
from hec.script import Plot
from hec.script import Tabulate
from hec.hecmath import PlotUtilities
from hec.hecmath import HecMath
from hec.hecmath import TimeSeriesMath
from java.lang import Boolean
from hec.client import ClientApp
from java.lang import System
from rma.util import RMAConst
from hec.gfx2d import G2dLineProperties
from java.awt import Color
from hec.heclib.util import HecDouble
from java.lang import Exception
import java



###### function to compute percent of zone storage
def calcPercentZoneStor(baseTS, z0TS, z1TS, offset):


	tmpuz = z1TS.add(22.222)   # add a smidge of storage to upper zone in case coincident with lower zone, in order to avoid 
fuzz

	tmpts = baseTS.subtract(z0TS).divide(tmpuz.subtract(z0TS)).multiply(100).screenWithMaxMin(0,100,99999,True,-901,"R")
	tmpts = tmpts.replaceSpecificValues(HecDouble(-901),HecDouble(HecMath.UNDEFINED))
	try:
		tmpts.checkTimeSeries(tmpts.getContainer())
	except java.lang.Exception:
		return tmpts

	return tmpts.add(offset)


###### function to compute percent of zone storage
def mergeTS(z0TS, z1TS):
```

```
        print "Attempting mergeTS"

        try:
                z0TS.checkTimeSeries(z0TS.getContainer())
        except java.lang.Exception:
                print "Caught hec.hecmath.HecMathException on z0TS"
                return z1TS

        try:
                z1TS.checkTimeSeries(z1TS.getContainer())
        except java.lang.Exception:
                print "Caught hec.hecmath.HecMathException on z1TS"
                return z0TS

        tmpts = z0TS.mergeTimeSeries(z1TS)
        return tmpts


###### main routine

# get the active module
module = ClientApp.frame().getCurrentModule()

# assume that the module is the RSimSimuluationMode and get the active SimulationPeriod
sim = module.getSimulation()

# get the output DSS file associated with the current Simulation
file = sim.getOutputDSSFilePath()
dssfile= DSS.open(file)

# get the start and end date strings from the Simulation and set the time window for plotting
startDate = sim.getStartDateString()
endDate = sim.getEndDateString()
dssfile.setTimeWindow(startDate, endDate)

# get the first run selected with a check mark in Simulation Tree, assume there is at least one (add error check later)
nameVec = module.getRssRunNames(Boolean.TRUE)

# this is a simple error check for now to be sure there is at least one result checked in the tree- needs improvement
if nameVec.size() == 0:
        noResultsToPlot

runname = nameVec.get(0).toString()

# retrieve the model output time series - note the Dpart is not important
marStorTS = dssfile.read("//MARTIN-POOL/STOR/01JAN1939/1DAY/" + runname + "/")
harStorTS = dssfile.read("//HARRIS-POOL/STOR/01JAN1939/1DAY/" + runname + "/")

tlsReleaseTS = dssfile.read("//TALLASSEE/FLOW/01JAN1939/1DAY/" + runname + "/")
tlsRuleTS = dssfile.read("//MIN@TALLASSEE_1200/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")
jbtReleaseTS = dssfile.read("//JBT GOAL/FLOW/01JAN1939/1DAY/" + runname + "/")
```

```
jbtRuleTS = dssfile.read("//MIN@JBT GOAL_4640/FLOW-MIN/01JAN1939/1DAY/" + runname + "/")

marStorZ0TS = dssfile.read("//MARTIN-Operating INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
marStorZ1TS = dssfile.read("//MARTIN-DROUGHT/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
marStorZ2TS = dssfile.read("//MARTIN-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
marStorZ3TS = dssfile.read("//MARTIN-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
marStorZ4TS = dssfile.read("//MARTIN-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")

harStorZ0TS = dssfile.read("//HARRIS-Operating INACTIVE/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
harStorZ1TS = dssfile.read("//HARRIS-DROUGHT/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
harStorZ2TS = dssfile.read("//HARRIS-CONSERVATION/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
harStorZ3TS = dssfile.read("//HARRIS-FLOOD CONTROL/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")
harStorZ4TS = dssfile.read("//HARRIS-TOP OF DAM/STOR-ZONE/01JAN1939/1DAY/" + runname + "/")


# calculate the percent of zone time series using HecMath routines
marPZ0TS = calcPercentZoneStor(marStorTS, marStorZ0TS, marStorZ1TS, 0)
marPZ1TS = calcPercentZoneStor(marStorTS, marStorZ1TS, marStorZ2TS, 100)
marPZ2TS = calcPercentZoneStor(marStorTS, marStorZ2TS, marStorZ3TS, 200)
marPZ3TS = calcPercentZoneStor(marStorTS, marStorZ3TS, marStorZ4TS, 300)

marPZTS = mergeTS(marPZ0TS, marPZ1TS)
marPZTS = mergeTS(marPZTS,  marPZ2TS)
marPZTS = mergeTS(marPZTS,  marPZ3TS)

harPZ0TS = calcPercentZoneStor(harStorTS, harStorZ0TS, harStorZ1TS, 0)
harPZ1TS = calcPercentZoneStor(harStorTS, harStorZ1TS, harStorZ2TS, 100)
harPZ2TS = calcPercentZoneStor(harStorTS, harStorZ2TS, harStorZ3TS, 200)
harPZ3TS = calcPercentZoneStor(harStorTS, harStorZ3TS, harStorZ4TS, 300)

harPZTS = mergeTS(harPZ0TS, harPZ1TS)
harPZTS = mergeTS(harPZTS,  harPZ2TS)
harPZTS = mergeTS(harPZTS,  harPZ3TS)

# override path parts to simplify legend
# location and version can be set to anything, but the parameter name "PERCENT OF CON" is used in the template
# if you want to change the parameter name, you must also change the template
marPZTS.setLocation("Martin")
marPZTS.setParameterPart("PERCENT OF ZONE")
marPZTS.setVersion("")
marPZTS.setUnits("%")

harPZTS.setLocation("Harris")
harPZTS.setParameterPart("PERCENT OF ZONE")
harPZTS.setVersion("")
harPZTS.setUnits("%")

# create the plot and plot objects
thePlot = Plot.newPlot()
layout = Plot.newPlotLayout()
```

```
vp0 = layout.addViewport(200)
vp1 = layout.addViewport(100)

#marPZTSObj = PlotUtilities.createPlotDataObject(marPZTS)
#harPZTSObj = PlotUtilities.createPlotDataObject(harPZTS)

#tlsReleaseTSObj = PlotUtilities.createPlotDataObject(tlsReleaseTS)
#tlsRuleTSObj = PlotUtilities.createPlotDataObject(tlsRuleTS)
#jbtReleaseTSObj = PlotUtilities.createPlotDataObject(jbtReleaseTS)
#jbtRuleTSObj = PlotUtilities.createPlotDataObject(jbtRuleTS)

# add the plot objects and initialize the plot
#glp = G2dLineProperties()
#glp.setLineColor(Color(0,200,0))
#glp.setLineWidth(1.5)
#glp.setLinePattern(glp.DOT_STYLE_PATTERN)
#vp0.addCurve("Y1", marPZTSObj, glp)

#glp = G2dLineProperties()
#glp.setLineColor(Color(127,127,127))
#glp.setLineWidth(1.5)
#vp0.addCurve("Y1", harPZTSObj, glp)

#glp = G2dLineProperties()
#glp.setLineColor(Color(0,0,0))
#glp.setLineWidth(1.5)
#glp.setLinePattern(glp.DOT_STYLE_PATTERN)
#vp1.addCurve("Y1", tlsRuleTSObj)

#vp1.addCurve("Y1", tlsReleaseTSObj)

#glp = G2dLineProperties()
#glp.setLineColor(Color(200,0,200))
#glp.setLineWidth(1.5)
#glp.setLinePattern(glp.DASH_STYLE_PATTERN)
#vp1.addCurve("Y1", jbtRuleTSObj)

#vp1.addCurve("Y1", jbtReleaseTSObj)


vp0.addCurve("Y1", marPZTS.getData())
vp0.addCurve("Y1", harPZTS.getData())

vp1.addCurve("Y1", tlsRuleTS.getData())
vp1.addCurve("Y1", tlsReleaseTS.getData())
vp1.addCurve("Y1", jbtRuleTS.getData())
vp1.addCurve("Y1", jbtReleaseTS.getData())

thePlot.configurePlotLayout(layout)
thePlot.setSize(1024,710)
thePlot.setLocation(0,0)
```

```
thePlot.showPlot()

# configure curves
marPZTSCurve = thePlot.getCurve(marPZTS)
marPZTSCurve.setLineColor("Purple")
marPZTSCurve.setLineWidth(1.5)

harPZTSCurve = thePlot.getCurve(harPZTS)
harPZTSCurve.setLineColor("127,127,127")
harPZTSCurve.setLineWidth(1.5)

tlsPZTSCurve = thePlot.getCurve(tlsReleaseTS)
tlsPZTSCurve.setLineColor("Blue")
tlsPZTSCurve.setLineWidth(1.5)

tlsRuleCurve = thePlot.getCurve(tlsRuleTS)
tlsRuleCurve.setLineColor("Black")
tlsRuleCurve.setLineWidth(1)
tlsRuleCurve.setLineStyle("Dot")

jbtPZTSCurve = thePlot.getCurve(jbtReleaseTS)
jbtPZTSCurve.setLineColor("Red")
jbtPZTSCurve.setLineWidth(1.5)

jbtRuleCurve = thePlot.getCurve(jbtRuleTS)
jbtRuleCurve.setLineColor("Black")
jbtRuleCurve.setLineWidth(1)
jbtRuleCurve.setLineStyle("Dash")


# set plot title with run name
thePlot.setTitle("Tallapoosa Storage Balance: " + runname)
#print vp0.getAxisName("Y1")
#print vp1.getAxisName("Y1")

vp0 = thePlot.getViewport(0)
uyAxis = vp0.getAxis("Y1")
uyAxis.setLabel("Percent of Zone")
```

B. Reports

Four report templates and two report generation scripts were developed to create "comma-separated-value" (csv) files to tabulate results for the ACT watershed simulations. Figure L.32 illustrates the "reports" folder location within the watershed tree, as well as the contents of the folder. The four report templates are named "ACT_Economics", "ACT_Environmental", "ACT_Operation-Daily", and "ACT_Operation-Monthly". The zipped files were generated by the report generation scripts. The naming convention of the zipped files includes the name of the report template, following by the date and time that the reports were generated. These zipped files contain the appropriate "csv" file.

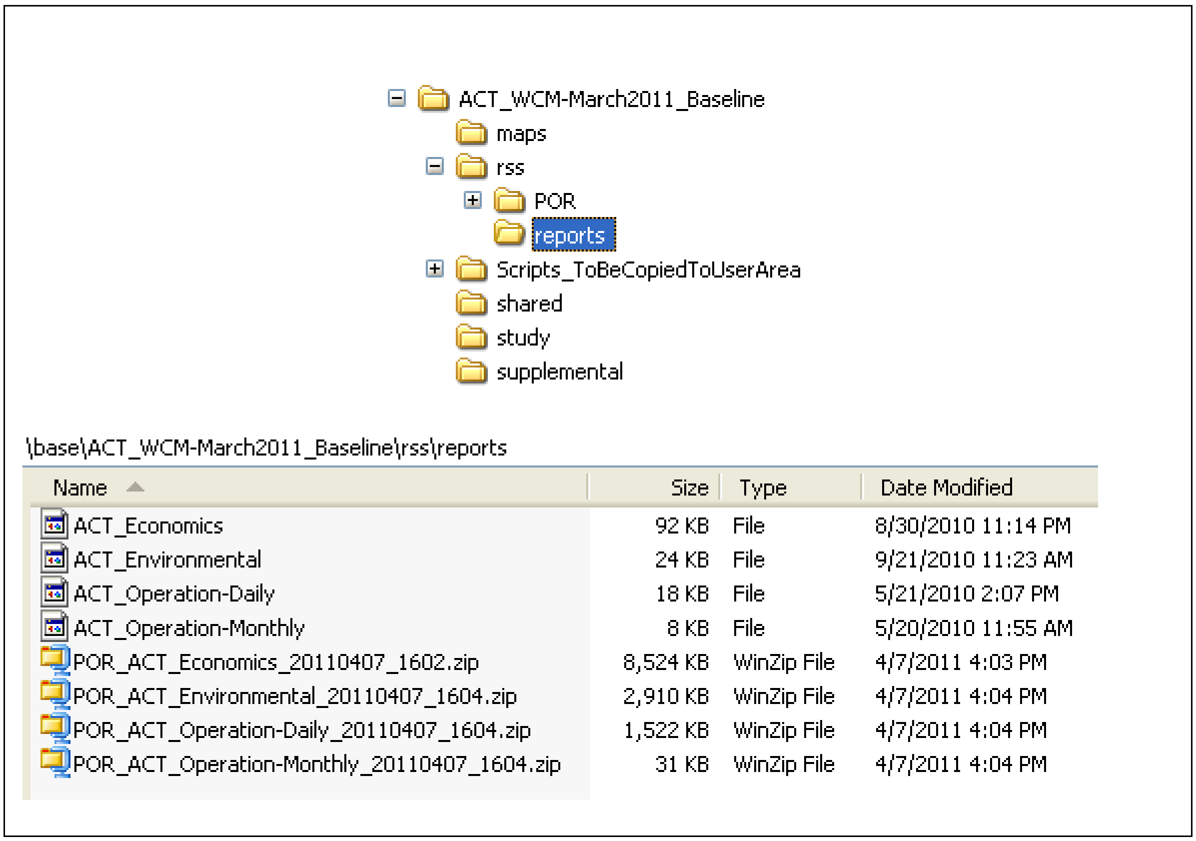


Figure L.32 Folder "reports" with Utility Script Report Templates and Zipped-up Reports Containing Results

The following sections show the script editor, followed by an example portion of the reports for the "Baseline" period-of-record results. Following the report snapshot is the complete contents of the report generation script.

1. Make-and-Zip_ACT-Econ-Reports

Figure L.33 reflects the Script Editor for the report script named "Make-and-Zip_ACT-Econ-Reports".

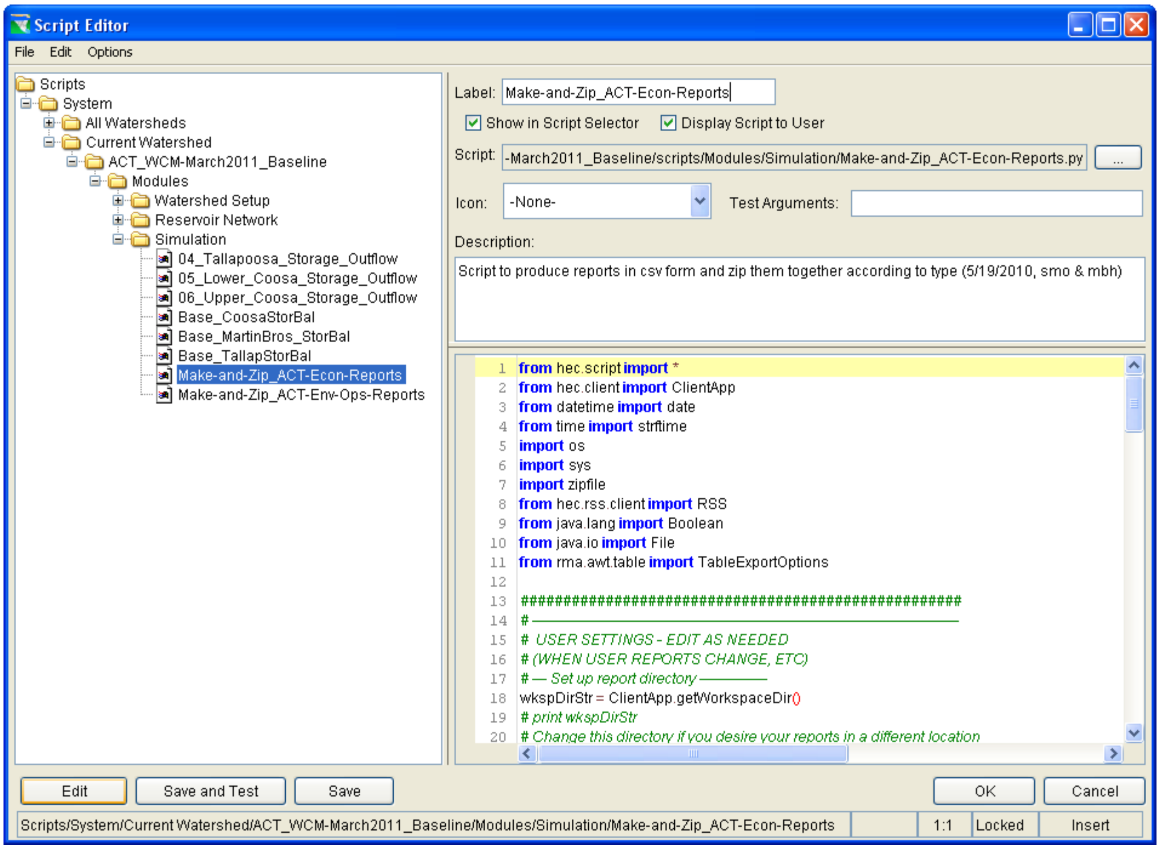


Figure L.33 Script Editor for "Make-and-Zip_ACT-Econ-Reports" Report Script

Figure L.34 shows an example snapshot (i.e. a portion) of the report generated by the script named "Make-and-Zip_ACT-Econ-Reports" for the "Baseline" alternative for the period of record simulation results.

Table L.10 contains the complete contents of the script named "Make-and-Zip_ACT-Econ-Reports".

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Baseline	Thu Apr 0	RorSim b	2010.07.13.04.56									
2													
3	Date	ALLATOONA POOL ELEV (ft)	ALLATOONA POOL FLOW-OUT (cfs)	ALLATOONA_OUTFLOW-UNREG (cfs)	ALLATOONA POWER PLANT POWER (MW)	ALLATOONA POWER-REQUIRED (MW)	ALLATOONA POWER PLANT FLOW-QPOWER (cfs)	ALLATOONA POWER PLANT POWER-CAPABILITY (MW)	ALLATOONA POWER PLANT POWER-CAPACITY (MW)	ALLATOONA POWER PLANT ELEV-HEAD POWER (ft)	ALLATOONA POWER PLANT PLANTFACTOR	ALLATOONA POWER PLANT ENERGY (MWh)	ALLATOONA ENERGY-REQUIRED (MWh)
4	------------------------------												
20	21-Jan-39	823.89	290	1168.68	0	0	0	73.15	88.93	134.39	0	0	0
21	22-Jan-39	824.09	290	1055.08	0	0	0	73.28	89.18	134.61	0	0	0
22	23-Jan-39	823.86	1907.98	977.08	14.19	14.19	1617.98	71.14	85.14	131.18	0.17	340.62	340.63
23	24-Jan-39	823.65	1906.37	1065.48	14.15	14.15	1616.37	70.99	84.88	130.96	0.17	339.59	339.59
24	25-Jan-39	823.65	1505.96	1478.88	10.71	10.71	1215.96	71.46	85.72	131.67	0.13	257.16	257.16
25	26-Jan-39	823.57	1505.76	1195.48	10.71	10.71	1215.76	71.44	85.67	131.63	0.13	257.02	257.02
26	27-Jan-39	823.47	1505.27	1079.08	10.7	10.7	1215.27	71.38	85.57	131.54	0.13	256.71	256.71
27	28-Jan-39	823.67	290	1047.08	0	0	0	73.04	88.68	134.19	0	0	0
28	29-Jan-39	823.92	290	1205.08	0	0	0	73.17	88.95	134.41	0	0	0
29	30-Jan-39	824.36	1508.69	3285.08	10.79	10.79	1218.69	71.78	86.29	132.15	0.12	258.88	258.88
30	31-Jan-39	824.87	904.32	2968.08	5.52	5.52	614.32	72.82	88.25	133.82	0.06	132.38	132.38
31	1-Feb-39	825.18	905.61	2122.74	5.55	5.55	615.61	73.06	88.73	134.23	0.06	133.1	133.1
32	2-Feb-39	825.43	1110.42	2082.74	7.38	7.38	820.42	72.99	88.58	134.1	0.08	177.2	177.2
33	3-Feb-39	825.88	1111.94	2906.74	7.42	7.42	821.94	73.19	88.99	134.45	0.08	178.02	178.02
34	4-Feb-39	826.37	2507.44	4532.74	19.63	0	2217.44	71.78	86.28	132.15	0.23	471	0
35	5-Feb-39	826.53	2445.95	3096.74	19.16	0	2155.95	72.06	86.81	132.59	0.22	459.74	0
36	6-Feb-39	826.69	2684.14	3334.74	21.21	7.2	2394.14	71.86	86.44	132.28	0.25	509.13	172.91
37	7-Feb-39	826.85	4050.33	4700.74	32.58	6.98	3760.33	70.27	83.75	129.85	0.39	781.93	167.53
38	8-Feb-39	827.01	2374.51	3024.74	18.62	7.3	2084.51	72.45	87.54	133.21	0.21	446.9	175.11
39	9-Feb-39	827.17	2187.06	2836.74	17.02	7.35	1897.06	72.77	88.15	133.74	0.19	408.5	176.34
40	10-Feb-39	827.33	2322.88	2972.74	18.22	7.34	2032.88	72.7	88.03	133.63	0.21	437.37	176.09
41	11-Feb-39	827.49	2607.07	3256.74	20.7	0	2317.07	72.46	87.56	133.23	0.24	496.85	0
42	12-Feb-39	827.65	2059.26	2708.74	15.97	0	1769.26	73.2	89.01	134.47	0.18	383.24	0
43	13-Feb-39	827.81	1461.45	2110.74	10.69	7.55	1171.45	73.98	90.63	135.84	0.12	256.46	181.3
44	14-Feb-39	827.97	1985.64	2634.74	15.36	7.46	1695.64	73.47	89.56	134.93	0.17	368.66	179.16
45	15-Feb-39	828.13	3899.47	4580.74	31.73	7.12	3609.47	71.29	85.41	131.41	0.37	761.51	170.86
46	16-Feb-39	828.29	3402.72	4090.74	27.63	7.22	3112.72	71.99	86.68	132.48	0.32	663.13	173.4
47	17-Feb-39	828.45	2230.91	2918.74	17.58	7.47	1940.91	73.47	89.56	134.93	0.2	421.98	179.16
48	18-Feb-39	828.61	1879.1	2566.74	14.49	0	1589.1	73.95	90.58	135.79	0.16	347.77	0
49	19-Feb-39	828.77	1521.29	2208.74	11.3	0	1231.29	74.43	91.63	136.68	0.12	271.2	0

	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
3	CARTERS POOL ELEV (ft)	CARTERS POOL FLOW-OUT (cfs)	CARTERS_OUT FLOW-UNREG (cfs)	CARTERS POWER PLANT POWER (MW)	CARTERS POWER REQUIRED (MW)	CARTERS POWER PLANT FLOW-QPOWER (cfs)	CARTERS POWER PLANT POWER-CAPABILITY (MW)	CARTERS POWER PLANT POWER-CAPACITY (MW)	CARTERS POWER PLANT ELEV-HEAD POWER (ft)	CARTERS POWER PLANT PLANTFACTOR	CARTERS POWER PLANT ENERGY (MWh)	CARTERS ENERGY-REQUIRED (MWh)	WEISS POOL ELEV (ft)	WEISS POOL FLOW-OUT (cfs)	WEIS OUT FLO UNR (cfs
20	1072	658.5	652.87	17.96	0	658.5	589.04	605.27	376	0.03	430.98	0	559.05	7675.56	816
21	1072	606.36	600.87	16.54	0	606.36	589.04	605.27	376	0.03	396.86	0	559.1	6666.75	749
22	1071.93	3565.56	582.87	97.23	97.23	3565.56	589	605.15	375.96	0.16	2333.45	2333.45	559.15	5927.32	674
23	1071.94	3565.78	709.87	97.23	97.23	3565.78	588.96	605.05	375.93	0.16	2333.45	2333.45	559.2	5942.73	624
24	1072	3565.69	942.87	97.23	97.23	3565.69	589	605.16	375.97	0.16	2333.56	2333.45	559.25	6179.57	618
25	1072	3565.46	750.87	97.23	97.23	3565.46	589.04	605.27	376	0.16	2333.55	2333.45	559.3	6361.22	64
26	1071.97	3565.41	652.87	97.23	97.23	3565.41	589.02	605.22	375.99	0.16	2333.45	2333.45	559.35	7478.5	768
27	1072	606.54	600.87	16.54	0	606.54	589.02	605.22	375.99	0.03	396.96	0	559.4	8626.11	90
28	1072	570.36	564.87	15.55	0	570.36	589.04	605.27	376	0.03	373.29	0	559.45	9114.05	992
29	1072	3565.31	1725.87	97.23	97.23	3565.31	589.04	605.27	376	0.16	2333.45	2333.45	559.5	9680.79	110
30	1072	3565.31	1155.87	97.23	97.23	3565.31	589.04	605.27	376	0.16	2333.45	2333.45	559.55	10913.1	1
31	1072	3542.57	740.96	96.61	96.6	3542.57	589.04	605.27	376	0.16	2318.58	2318.4	559.6	13121.3	152
32	1071.99	3542.34	652.96	96.6	96.6	3542.34	589.03	605.25	375.99	0.16	2318.4	2318.4	559.65	15077.8	169
33	1072	3516.52	1315.96	96.6	96.6	3516.52	593.37	605.27	378.2	0.16	2318.45	2318.4	559.7	15666.4	173
34	1072	3077.72	3065.96	84.8	0	3077.72	595.13	605.27	379	0.14	2035.14	0	559.75	16975	187
35	1072	1357.27	1345.96	37.01	0	1357.27	589.04	605.27	376	0.06	888.32	0	559.8	19378.1	212
36	1072	3542.31	1345.96	96.6	96.6	3542.31	589.04	605.27	376	0.16	2318.4	2318.4	559.85	22000.4	237
37	1072	3516.18	3425.96	96.6	96.6	3516.18	593.42	605.27	378.22	0.16	2318.4	2318.4	559.9	24467.1	258
38	1072	3542.31	1945.96	96.6	96.6	3542.31	589.04	605.27	376	0.16	2318.41	2318.4	559.95	26225.5	274
39	1072	3542.48	1145.96	96.6	96.6	3542.48	589.04	605.27	376	0.16	2318.52	2318.4	560	27512	286
40	1072	3514.14	1345.96	96.6	96.6	3514.14	593.76	605.27	378.38	0.16	2318.4	2318.4	560.05	27549.8	286
41	1072	2117.54	2105.96	58.76	0	2117.54	599.39	605.27	380.97	0.1	1410.25	0	560.1	26308.1	2
42	1072	1717.36	1705.96	47.6	0	1717.36	598.73	605.27	380.67	0.08	1142.48	0	560.15	25548.8	262
43	1072	3480.61	1105.96	96.6	96.6	3480.61	599.48	605.27	381.02	0.16	2318.4	2318.4	560.2	25504.7	262
44	1072	3457.25	1855.96	96.61	96.6	3457.25	603.56	605.27	382.93	0.16	2318.52	2318.4	560.25	25640.6	264
45	1072	3627.62	3615.96	101.35	96.6	3627.62	603.47	605.27	382.88	0.17	2432.38	2318.4	560.3	26174.2	27
46	1072	3977.36	3965.96	109.09	96.6	3977.36	592.44	605.27	377.77	0.18	2618.14	2318.4	560.35	26958.8	282
47	1072	3542.31	2715.96	96.6	96.6	3542.31	589.04	605.27	376	0.16	2318.4	2318.4	560.4	28400.5	300
48	1072	1517.24	1505.96	41.38	0	1517.24	589.04	605.27	376	0.07	993.01	0	560.45	29719.1	314
49	1072	1187.22	1175.96	32.6	0	1187.22	593.17	605.27	378.11	0.05	782.46	0	560.5	28481.2	299

POR_Baseline--0_ACT_Economics

Figure L.34 Example Snapshot from Report "POR_Baseline--0_ACT_Economics" Containing "Baseline" Period-of-Record Results

Table L.10 Contents of Report Script "Make-and-Zip_ACT-Econ-Reports"

```
# name=Make-and-Zip_ACT-Econ-Reports
# description=Script to produce reports in csv form and zip them together according to type (5/19/2010, smo & mbh)
# displayinmenu=true
# displaytouser=true
# displayinselector=true
from hec.script import *
from hec.client import ClientApp
from datetime import date
from time import strftime
import os
import sys
import zipfile
from hec.rss.client import RSS
from java.lang import Boolean
from java.io import File
from rma.awt.table import TableExportOptions

####################################################
# ------------------------------------------------------------------------------------------
#  USER SETTINGS - EDIT AS NEEDED
# (WHEN USER REPORTS CHANGE, ETC)
# --- Set up report directory --------------
wkspDirStr = ClientApp.getWorkspaceDir()
# print wkspDirStr
# Change this directory if you desire your reports in a different location
# RepDir = "C:/temp/"
RepDir = wkspDirStr + "/rss/reports/"

# --- Set list of Reports to produce and zip up --------
# Change this list  if you want to generate different user reports
# However, if too many reports are added, the script might RUN OUT OF MEMORY
RepList = [ "ACT_Economics"]
# [ "BasinInflow", "COE_Generation", "Operations" ]
# ------------------------------------------------------------------------------------------
####################################################

# --- get the active module ------------------------------------------
module = ClientApp.frame().getCurrentModule()
sim = module.getSimulation()
print "YYYYYYYY", sim, sim.getName()
# --- assumes we're in the Simulation mode
simMode = RSS.frame().getCurrentMode()

MessageBox.showPlain( " Generating reports may take awhile for long Simulations that contain many checked Alternatives. \
      \n Press OK to Generate Reports (& Package 'em up).  \n\n Thanks and Have a Great Day!", "For Your Information...")

# To make the files for ALL CHECKED Simulations
# --------------------------------------------------------------------------------
SimTree = module.getSimulationTree()
checkedRunVec = SimTree.getSelectedRuns() # just checked runs
# checkedRunNameVec = module.getRssRunNames(Boolean.TRUE) # just checked run Names
```

```
# RunVec = sim.getSimulationRuns() # all runs, checked or unchecked

# this is a simple error check for now to be sure there is at least one result in the tree
if checkedRunVec.size() == 0:
    MessageBox.showPlain( "No Simulations checked."  , "Error")
    sys.exit() #don't know why this doesn't exit cleanly


# --- Get current time -----------
timeStamp = strftime("%Y%m%d_%H%M")
#print timeStamp
#print date.today()


# ---------------------------------------------------------------------------------
# Generate Reports for each of the checked alternatives
#  and zip them up, grouped according to report type
# ---------------------------------------------------------------------------------
for Run in checkedRunVec :

  # set the run as the active run
  module.setActiveRun(Run)

  for Rep in RepList :

      # open the report
      userReport = simMode.displayUserReportByName(Rep, 0)
      #print "---------------------", userReport, sim, Run
      # open the report
      if userReport != None:
          # where to save it
          csvFilename = RepDir + sim.getName() + "_" + Run.getName() + "_" + Rep + ".csv"
          Repfile = File(csvFilename)
          #  what options to use
          opts = TableExportOptions()
          # comma separated
          opts.delimiter = ','
          # write it out
          userReport.getReportPanel().exportReportAction(Repfile, opts)
          # close the report
          userReport.setVisible(0)

          # ------------------------------------------------------------------------------------------------------------------
--------------------
          # For some reason, the zipfile append option isn't working, therefore, all this code is commented out
          #  Instead, all the csv files are being written into the zipfile at the same time at the end of the script.
          # zip up the file
          #zipName = RepDir + sim.getName() + "_" + Rep + "_" + timeStamp +  ".zip"
          #if os.path.exists(zipName) :
          #   z = zipfile.ZipFile(zipName, "a")
          #else :
          #   z = zipfile.ZipFile(zipName, "w")
          #z.write(csvFilename)
```

```
          #z.close()
          # clean up csv files
          #os.remove(csvFilename)
          # -------------------------------------------------------------------------------------------------------------------
--------------------



# write all the csv files into the appropriate zipfiles
# -----------------------------------------------------------------
for Rep in RepList :
     zipName = RepDir + sim.getName() + "_" + Rep + "_" + timeStamp +  ".zip"
     z = zipfile.ZipFile(zipName, "w", zipfile.ZIP_DEFLATED)

     for Run in checkedRunVec :
          csvFilename = RepDir + sim.getName() + "_" + Run.getName() + "_" + Rep + ".csv"
          z.write(csvFilename, os.path.basename(csvFilename))
          os.remove(csvFilename)

     z.close()

MessageBox.showPlain( "Reports have successfully been zipped and written to this location: \n     %s" % RepDir, "Reports
Generated and Collected into Zip File(s)")
```

2. Make-and-Zip_ACT-Env-Ops-Reports

Figure L.35 reflects the Script Editor for the report script named "Make-and-Zip_ACT-Env-Ops-Reports".

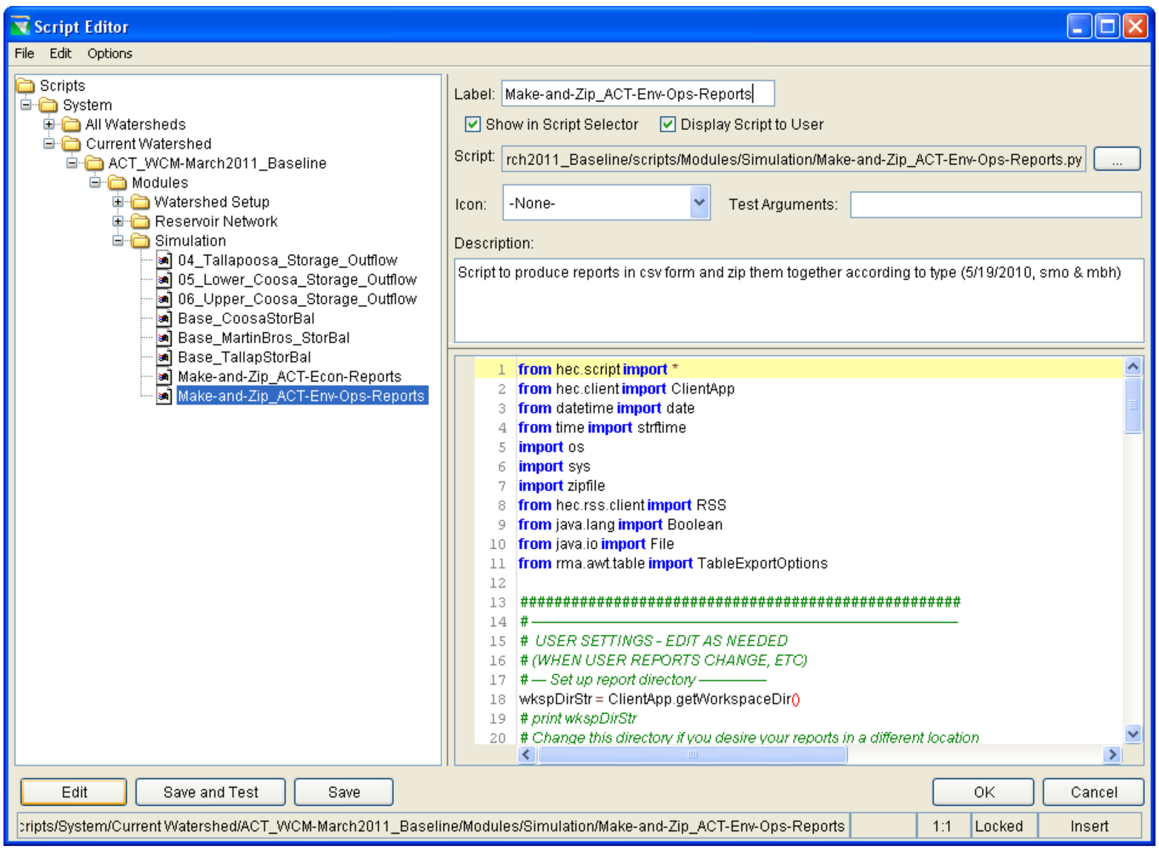


Figure L.35 Script Editor for "Make-and-Zip_ACT-Env-Ops-Reports" Report Script

Figure L.36, Figure L.37, and Figure L.38 show example snapshots (i.e. a portion) of each of the environmental and operations reports (daily and monthly) generated by the script named "Make-and-Zip_ACT-Env-Ops-Reports" for the "Baseline" alternative for the period of record simulation results.

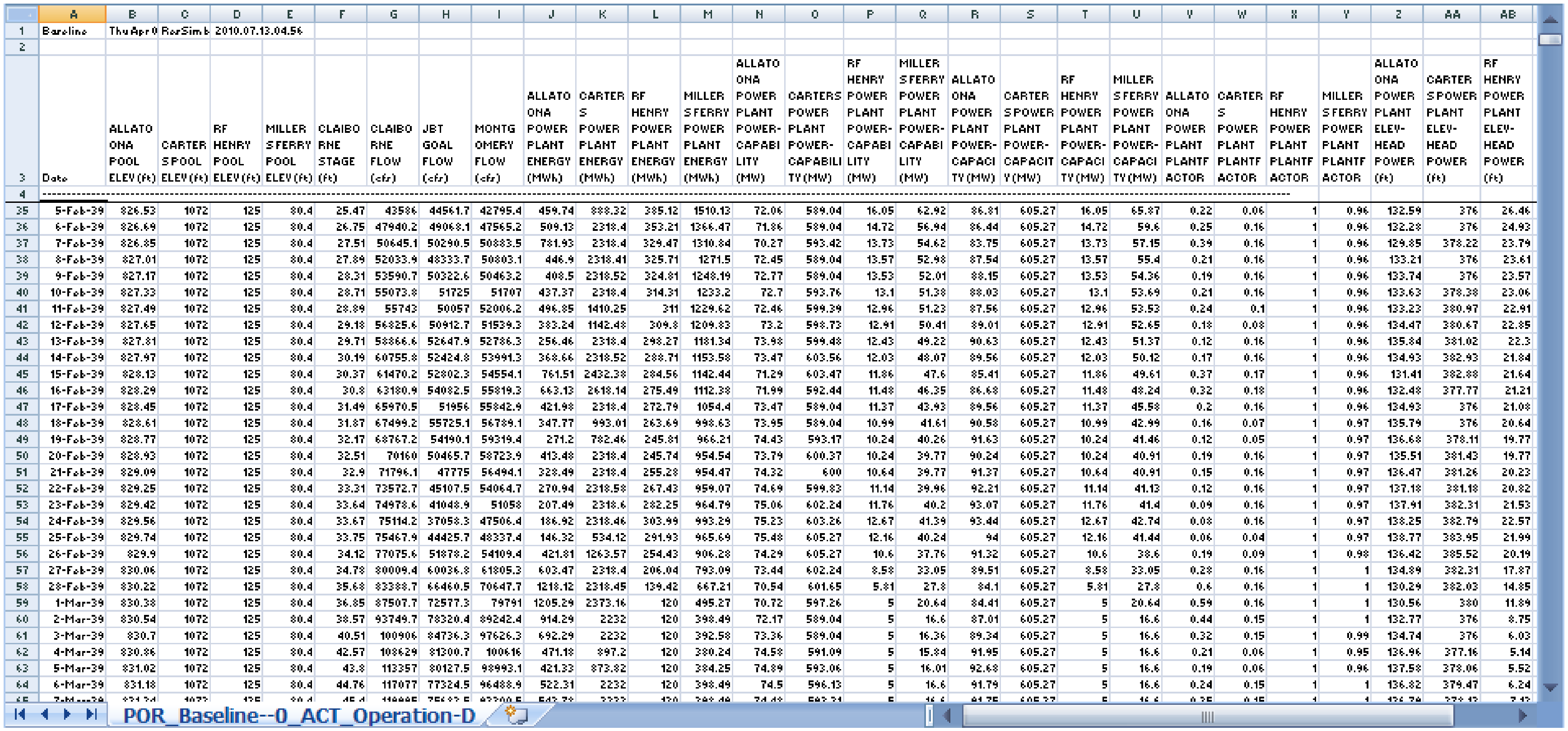
Table L.11 contains the complete contents of the script named "Make-and-Zip_ACT-Env-Ops-Reports".

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Baseline	Thu Apr 0	ResSim b	2010.07.13.04.56											
2															
3	Date	CARTERS REREG TAILWATER FLOW	CARTERS REREG TAILWATER ELEV(ft)	PINE CHAPEL FLOW (cfs)	PINE CHAPEL FLOW-UNREG (cfs)	PINE CHAPEL STAGE (ft)	PINE CHAPEL STAGE-UNREG (ft)	RESACA FLOW (cfs)	RESACA FLOW-UNREG (cfs)	RESACA STAGE (ft)	RESACA STAGE-UNREG (ft)	ALLATOONA TAILWATER FLOW	ALLATOONA TAILWATER ELEV(ft)	CARTERSVILLE FLOW (cfs)	CARTERSVILLE FLOW-UNREG (cfs)
4	------------														
14	15-Jan-39	837.5	655.82	1981.14	1974.86	8.4	8.39	4014.44	4297.64	8.05	8.43	215	688.16	678.7	2632.23
15	16-Jan-39	821.18	655.78	1503.86	1497.56	7.18	7.17	3572.37	3592.57	7.43	7.46	1747.27	691.47	1841.6	2253.07
16	17-Jan-39	875.17	655.89	1352.06	1345.85	6.81	6.79	3021.49	3015.24	6.64	6.63	1658.3	691.29	2062.55	1826.68
17	18-Jan-39	973.51	656.08	1344.4	1338.23	6.79	6.77	2980.1	2973.91	6.58	6.57	1657.03	691.29	1948.77	1818.6
18	19-Jan-39	1129.88	656.36	1375.1	1368.9	6.86	6.85	3492.66	3486.47	7.32	7.31	1657.15	691.29	1924	1943.26
19	20-Jan-39	943.62	656.02	1291	1285.12	6.64	6.63	3140	3133.98	6.82	6.81	1906.19	691.8	2095.43	1674.78
20	21-Jan-39	711.2	655.55	1070.44	1064.95	6.06	6.04	2541.11	2535.44	5.91	5.9	290	688.38	932.66	1447.19
21	22-Jan-39	764.92	655.67	961.82	956.33	5.77	5.76	2175.11	2169.61	5.31	5.3	290	688.38	521.76	1315.24
22	23-Jan-39	855.81	655.85	1061.4	1003.89	6.03	5.88	2059.39	2023.73	5.12	5.06	1907.98	691.8	1718.65	1211.74
23	24-Jan-39	853.23	655.85	1123.28	1059.2	6.2	6.03	2173.49	2114.25	5.31	5.21	1906.37	691.8	2110.31	1246.92
24	25-Jan-39	1091.47	656.29	1190.47	1238.04	6.38	6.5	2624.32	2625.26	6.04	6.04	1505.96	690.98	1806.04	1575.51
25	26-Jan-39	981.44	656.09	1227.35	1279.25	6.47	6.61	2665.09	2710.71	6.1	6.17	1505.76	690.98	1701.74	1462.26
26	27-Jan-39	1224.65	656.53	1112.04	1085.82	6.17	6.1	2353.12	2359.54	5.61	5.62	1505.27	690.98	1768.98	1371.77
27	28-Jan-39	1059.5	656.24	1318.1	1308	6.72	6.69	2329.73	2315.99	5.57	5.54	290	688.38	960.54	1421.81
28	29-Jan-39	1017.09	656.16	1290.79	1310.62	6.64	6.7	2310.31	2316.93	5.53	5.54	290	688.38	654.92	1530.5
29	30-Jan-39	2060.71	657.87	1800.3	1794.8	7.95	7.94	3796.38	3800.32	7.74	7.75	1508.69	690.98	1565.56	3126.61
30	31-Jan-39	1581.01	657.12	2187.62	2182.09	8.92	8.91	5540.03	5535.53	10.01	10.01	904.32	689.8	1495.44	3487.36
31	1-Feb-39	1503.31	656.99	1927.56	1919.37	8.27	8.25	5608.16	5601.09	10.09	10.08	905.61	689.8	1597.61	3026.4
32	2-Feb-39	1874.09	657.59	2574.54	2150.36	9.84	8.83	4560.17	4310.81	8.78	8.45	1110.42	690.2	1807.63	2841.15
33	3-Feb-39	1874.09	657.59	2990.15	2319.81	10.82	9.25	4928.6	4378.28	9.25	8.54	1111.94	690.21	1817.71	3406.88
34	4-Feb-39	2991.23	659.13	3289.44	3656.61	11.5	12.33	6762.52	6703.78	11.47	11.4	2507.44	692.98	2962.66	4930.32
35	5-Feb-39	2442.66	658.39	4226.95	4908.99	13.63	15.16	8374.24	8882.53	13.25	13.79	2445.95	692.86	3321.82	4316.23
36	6-Feb-39	2331.51	658.24	4320.68	3901.26	13.84	12.89	8229.74	8260.34	13.1	13.13	2684.14	693.33	3516.42	4167.06
37	7-Feb-39	2981.64	659.12	4074.79	3972.76	13.28	13.05	9960.79	9769.51	14.95	14.72	4050.33	695.92	4609.01	5259.47
38	8-Feb-39	2927.3	659.05	4172.51	4659.96	13.51	14.59	11310.5	11537.6	16.26	16.45	2374.51	692.72	3543.86	4194.13
39	9-Feb-39	2331.51	658.24	4235.13	3783.56	13.65	12.62	11851	11770.2	16.79	16.71	2187.06	692.35	3013.64	3663.45
40	10-Feb-39	2331.51	658.24	3551.77	2584.76	12.09	9.86	9518.58	8805.61	14.46	13.71	2322.88	692.62	3077.48	3727.29
41	11-Feb-39	2331.51	658.24	3387.31	2909.56	11.72	10.62	8437.81	7775.18	13.32	12.6	2607.07	693.18	3149.84	3799.56
42	12-Feb-39	2331.51	658.24	3514.8	3506.06	12.01	11.99	8920.49	8695.2	13.83	13.6	2059.26	692.1	2912.92	3562.44
43	13-Feb-39	2568.46	658.57	4331.77	3931.66	13.87	12.96	9157.4	8902.91	14.08	13.82	1461.45	690.89	2465.09	3114.42
44	14-Feb-39	2568.46	658.57	4960.73	4558.06	15.27	14.37	9342.23	8956.29	14.27	13.87	1985.64	691.96	2669.13	3318.27
45	15-Feb-39	2568.46	658.57	5129.43	5989.06	15.64	17.52	11367	11696.6	16.31	16.62	3899.47	695.64	4158.57	4831.8
46	16-Feb-39	3943.96	660.26	5783.39	7147.46	17.08	20.04	14070.8	15172.5	18.89	19.89	3402.72	694.73	4197.67	4884

	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
3	CARTERSVILLE STAGE (undef)	CARTERSVILLE STAGE-UNREG (undef)	KINGSTON FLOW (cfs)	KINGSTON FLOW-UNREG (cfs)	KINGSTON STAGE (ft)	KINGSTON STAGE-UNREG (ft)	ROME-ETOWAH FLOW (cfs)	ROME-ETOWAH FLOW-UNREG (cfs)	ROME-ETOWAH STAGE (ft)	ROME-ETOWAH STAGE-UNREG (ft)	ROME-COOSA FLOW (cfs)	ROME-COOSA FLOW-UNREG (cfs)	ROME-COOSA STAGE (ft)
14			1256.38	3210.05	4.51	6.44	788.82	2577.86	13.12	15.19	6859.93	9292.62	13.15
15			2080.36	2877.35	5.4	6.16	1170.26	2441.49	13.64	15.04	7608.27	9277.17	13.46
16			2415.39	2341.36	5.73	5.66	1648.14	1986.2	14.18	14.55	7670.58	8210.97	13.49
17			2270.02	2113.42	5.59	5.43	1799.32	1712.25	14.34	14.24	6940.73	6951.71	13.18
18			2191.77	2173.67	5.51	5.49	1855.21	1782.25	14.4	14.32	6611.6	6584.57	13.04
19			2294.56	1983.88	5.61	5.3	1984.65	1791.32	14.55	14.33	6543.19	6369.77	13.02
20			1448.94	1729.67	4.73	5.03	1627.07	1671.11	14.15	14.2	5823.79	5874.87	12.72
21			841.35	1565.09	3.97	4.86	1052.98	1567.01	13.49	14.09	4778.96	5293.71	12.3
22			1615.18	1433.36	4.91	4.71	1212.35	1393.15	13.69	13.9	4630.91	4801.78	12.24
23			2193.34	1419.07	5.51	4.7	1848.55	1359.33	14.4	13.86	4951.71	4433.81	12.37
24			2058.53	1669.78	5.38	4.97	2078.93	1551.96	14.66	14.07	5139.58	4583.7	12.45
25			1899.08	1661.84	5.21	4.96	2006.63	1690.34	14.58	14.22	5179.51	4860.4	12.46
26			2009.55	1651.77	5.33	4.95	2194.09	1880.88	14.79	14.43	5733.1	5431.48	12.69
27			1551.29	1797.94	4.84	5.11	2095.99	2093.6	14.68	14.67	6185.01	6186.58	12.87
28			1117.66	1889.66	4.33	5.2	1517.85	2045.03	14.04	14.62	5983.63	6511.01	12.79
29			1719.93	3109.62	5.02	6.36	1595.4	2704.65	14.12	15.32	6419.83	7531.82	12.97
30			1994.91	3879.11	5.31	6.8	2065.15	3716.95	14.64	16.32	7933	9586.03	13.61
31			2371.51	3941.08	5.69	6.8	2457.32	4139.26	15.06	16.72	10231.8	11911.5	14.67
32			2625.94	3758.28	5.93	6.8	2404.09	3732.64	15	16.34	11534.4	12797.7	15.27
33			2632.21	4082.47	5.94	6.8	2266.07	3600.29	14.86	16.21	11755.8	12857.4	15.38
34			3618.1	5491.14	6.74	6.8	2816.3	4499.06	15.43	17.05	13413.4	14827.6	16.21
35			4245.5	5483.23	6.8	6.8	3323.28	4810.93	15.94	17.33	16003.7	17469.5	17.5
36			4521.11	5257.7	6.8	6.8	3691.9	4664.38	16.3	17.2	17890.7	18987	18.45
37			5399.91	6050.42	6.8	6.8	4245.06	4951.77	16.82	17.46	19837.5	20566	19.37
38			4683.49	5333.81	6.8	6.8	4125.99	4779.83	16.71	17.3	20615.9	21289.5	19.81
39			4056.85	4706.78	6.8	6.8	3811.48	4461.58	16.41	17.02	20963.5	21660.1	19.98
40			3983.42	4633.23	6.8	6.8	3505.83	4155.7	16.12	16.74	20420.8	20895.5	19.7
41			3831.27	4481.01	6.8	6.8	3243.1	3942.87	15.91	16.54	18570.1	18788.4	18.74
42			3802.61	4452.18	6.8	6.8	4095.69	4745.34	16.68	17.27	18187.5	18399.4	18.58
43			3582.48	4231.87	6.72	6.8	4232.35	4881.82	16.81	17.39	18642.5	18953.2	18.77
44			3573.09	4222.29	6.71	6.8	4126.94	4776.22	16.71	17.3	18642.1	18961.8	18.77
45			4643.22	5310.42	6.8	6.8	4638.27	5297.92	17.18	17.79	19753.1	20233.9	19.33
46			4959.9	5642.95	6.8	6.8	5258.41	5934.09	17.75	18.37	21688.1	22632.2	20.34

POR_Baseline--0_ACT_Environment

Figure L.36 Example Snapshot from Report "POR_Baseline--0_ACT_Environmental" Containing "Baseline" Period-of-Record Results



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
1	Baseline	Thu Apr 0	ResSim b	2010.07.13.04.56																								
2																												
3	Date	ALLATOONA POOL ELEV (ft)	CARTERS POOL ELEV (ft)	RF HENRY POOL ELEV (ft)	MILLERS FERRY POOL ELEV (ft)	CLAIBORNE STAGE (ft)	CLAIBORNE FLOW (cfs)	JBT GOAL FLOW (cfs)	MONTGOMERY FLOW (cfs)	ALLATOONA POWER PLANT ENERGY (MWh)	CARTERS POWER PLANT ENERGY (MWh)	RF HENRY POWER PLANT ENERGY (MWh)	MILLERS FERRY POWER PLANT ENERGY (MWh)	ALLATOONA POWER PLANT POWER-CAPABILITY (MW)	CARTERS POWER PLANT POWER-CAPABILITY (MW)	RF HENRY POWER PLANT POWER-CAPABILITY (MW)	MILLERS FERRY POWER PLANT POWER-CAPABILITY (MW)	ALLATOONA POWER PLANT POWER-CAPACITY (MW)	CARTERS POWER PLANT POWER-CAPACITY (MW)	RF HENRY POWER PLANT POWER-CAPACITY (MW)	MILLERS FERRY POWER PLANT POWER-CAPACITY (MW)	ALLATOONA POWER PLANT PLANTFACTOR	CARTERS POWER PLANT PLANTFACTOR	RF HENRY POWER PLANT PLANTFACTOR	MILLERS FERRY POWER PLANT PLANTFACTOR	ALLATOONA POWER PLANT ELEV-HEAD POWER (ft)	CARTERS POWER PLANT ELEV-HEAD POWER (ft)	RF HENRY POWER PLANT ELEV-HEAD POWER (ft)
4	--																											
35	5-Feb-39	826.53	1072	125	80.4	25.47	43586	44561.7	42795.4	459.74	888.32	385.12	1510.13	72.06	589.04	16.05	62.92	86.81	605.27	16.05	65.87	0.22	0.06	1	0.96	132.59	376	26.46
36	6-Feb-39	826.69	1072	125	80.4	26.75	47940.2	49068.1	47565.2	509.13	2318.4	353.21	1366.47	71.86	589.04	14.72	56.94	86.44	605.27	14.72	59.6	0.25	0.16	1	0.96	132.28	376	24.93
37	7-Feb-39	826.85	1072	125	80.4	27.51	50645.1	50290.5	50883.5	781.93	2318.4	329.47	1310.84	70.27	593.42	13.73	54.62	83.75	605.27	13.73	57.15	0.39	0.16	1	0.96	129.85	378.22	23.79
38	8-Feb-39	827.01	1072	125	80.4	27.89	52033.9	48333.7	50803.1	446.9	2318.41	325.71	1271.5	72.45	589.04	13.57	52.98	87.54	605.27	13.57	55.4	0.21	0.16	1	0.96	133.21	376	23.61
39	9-Feb-39	827.17	1072	125	80.4	28.31	53590.7	50322.6	50463.2	408.5	2318.52	324.81	1248.19	72.77	589.04	13.53	52.01	88.15	605.27	13.53	54.36	0.19	0.16	1	0.96	133.74	376	23.57
40	10-Feb-39	827.33	1072	125	80.4	28.71	55073.8	51725	51707	437.37	2318.4	314.31	1233.2	72.7	593.76	13.1	51.38	88.03	605.27	13.1	53.69	0.21	0.16	1	0.96	133.63	378.38	23.06
41	11-Feb-39	827.49	1072	125	80.4	28.89	55743	50057	52006.2	496.85	1410.25	311	1229.62	72.46	599.39	12.96	51.23	87.56	605.27	12.96	53.53	0.24	0.1	1	0.96	133.23	380.97	22.91
42	12-Feb-39	827.65	1072	125	80.4	29.18	56825.6	50912.7	51539.3	383.24	1142.48	309.8	1209.83	73.2	598.73	12.91	50.41	89.01	605.27	12.91	52.65	0.18	0.08	1	0.96	134.47	380.67	22.85
43	13-Feb-39	827.81	1072	125	80.4	29.71	58866.6	52647.9	52786.3	256.46	2318.4	298.27	1181.34	73.98	599.48	12.43	49.22	90.63	605.27	12.43	51.37	0.12	0.16	1	0.96	135.84	381.02	22.3
44	14-Feb-39	827.97	1072	125	80.4	30.19	60755.8	52424.8	53991.3	368.66	2318.52	288.71	1153.58	73.47	603.56	12.03	48.07	89.56	605.27	12.03	50.12	0.17	0.16	1	0.96	134.93	382.93	21.84
45	15-Feb-39	828.13	1072	125	80.4	30.37	61470.2	52802.3	54554.1	761.51	2432.38	284.56	1142.44	71.29	603.47	11.86	47.6	85.41	605.27	11.86	49.61	0.37	0.17	1	0.96	131.41	382.88	21.64
46	16-Feb-39	828.29	1072	125	80.4	30.8	63180.9	54082.5	55819.3	663.13	2618.14	275.49	1112.38	71.99	592.44	11.48	46.35	86.68	605.27	11.48	48.24	0.32	0.18	1	0.96	132.48	377.77	21.21
47	17-Feb-39	828.45	1072	125	80.4	31.49	65970.5	51956	55842.9	421.98	2318.4	272.79	1054.4	73.47	589.04	11.37	43.93	89.56	605.27	11.37	45.58	0.2	0.16	1	0.96	134.93	376	21.08
48	18-Feb-39	828.61	1072	125	80.4	31.87	67499.2	55725.1	56789.1	347.77	993.01	263.69	998.63	73.95	589.04	10.99	41.61	90.58	605.27	10.99	42.99	0.16	0.07	1	0.97	135.79	376	20.64
49	19-Feb-39	828.77	1072	125	80.4	32.17	68767.2	54190.1	59319.4	271.2	782.46	245.81	966.21	74.43	593.17	10.24	40.26	91.63	605.27	10.24	41.46	0.12	0.05	1	0.97	136.68	378.11	19.77
50	20-Feb-39	828.93	1072	125	80.4	32.51	70160	50465.7	58723.9	413.48	2318.4	245.74	954.54	73.79	600.37	10.24	39.77	90.24	605.27	10.24	40.91	0.19	0.16	1	0.97	135.51	381.43	19.77
51	21-Feb-39	829.09	1072	125	80.4	32.9	71796.1	47775	56494.1	328.49	2318.4	255.28	954.47	74.32	600	10.64	39.77	91.37	605.27	10.64	40.91	0.15	0.16	1	0.97	136.47	381.26	20.23
52	22-Feb-39	829.25	1072	125	80.4	33.31	73572.7	45107.5	54064.7	270.94	2318.58	267.43	959.07	74.69	599.83	11.14	39.96	92.21	605.27	11.14	41.13	0.12	0.16	1	0.97	137.18	381.18	20.82
53	23-Feb-39	829.42	1072	125	80.4	33.64	74978.6	41048.9	51058	207.49	2318.6	282.25	964.79	75.06	602.24	11.76	40.2	93.07	605.27	11.76	41.4	0.09	0.16	1	0.97	137.91	382.31	21.53
54	24-Feb-39	829.56	1072	125	80.4	33.67	75114.2	37058.3	47506.4	186.92	2318.46	303.99	993.29	75.23	603.26	12.67	41.39	93.44	605.27	12.67	42.74	0.08	0.16	1	0.97	138.25	382.79	22.57
55	25-Feb-39	829.74	1072	125	80.4	33.75	75467.9	44425.7	48337.4	146.32	534.12	291.93	965.69	75.48	605.27	12.16	40.24	94	605.27	12.16	41.44	0.06	0.04	1	0.97	138.77	383.95	21.99
56	26-Feb-39	829.9	1072	125	80.4	34.12	77075.6	51878.2	54109.4	421.81	1263.57	254.43	906.28	74.29	605.27	10.6	37.76	91.32	605.27	10.6	38.6	0.19	0.09	1	0.98	136.42	385.52	20.19
57	27-Feb-39	830.06	1072	125	80.4	34.78	80009.4	60036.8	61805.3	603.47	2318.4	206.04	793.09	73.44	602.24	8.58	33.05	89.51	605.27	8.58	33.05	0.28	0.16	1	1	134.89	382.31	17.87
58	28-Feb-39	830.22	1072	125	80.4	35.68	83388.7	66460.5	70647.7	1218.12	2318.45	139.42	667.21	70.54	601.65	5.81	27.8	84.1	605.27	5.81	27.8	0.6	0.16	1	1	130.29	382.03	14.85
59	1-Mar-39	830.38	1072	125	80.4	36.85	87507.7	72577.3	79791	1205.29	2373.16	120	495.27	70.72	597.26	5	20.64	84.41	605.27	5	20.64	0.59	0.16	1	1	130.56	380	11.89
60	2-Mar-39	830.54	1072	125	80.4	38.57	93749.7	78320.4	89242.4	914.29	2232	120	398.49	72.17	589.04	5	16.6	87.01	605.27	5	16.6	0.44	0.15	1	1	132.77	376	8.75
61	3-Mar-39	830.7	1072	125	80.4	40.51	100906	84736.3	97626.3	692.29	2232	120	392.58	73.36	589.04	5	16.36	89.34	605.27	5	16.6	0.32	0.15	1	0.99	134.74	376	6.03
62	4-Mar-39	830.86	1072	125	80.4	42.57	108629	81300.7	100616	471.18	897.2	120	380.24	74.58	591.09	5	15.84	91.95	605.27	5	16.6	0.21	0.06	1	0.95	136.96	377.16	5.14
63	5-Mar-39	831.02	1072	125	80.4	43.8	113357	80127.5	98993.1	421.33	873.82	120	384.25	74.89	593.06	5	16.01	92.68	605.27	5	16.6	0.19	0.06	1	0.96	137.58	378.06	5.52
64	6-Mar-39	831.18	1072	125	80.4	44.76	117077	77324.5	96488.9	522.31	2232	120	398.49	74.5	596.13	5	16.6	91.79	605.27	5	16.6	0.24	0.15	1	1	136.82	379.47	6.24

POR_Baseline--0_ACT_Operation-D

Figure L.37 Example Snapshot from Report "POR_Baseline--0_ACT_Operation-Daily" Containing "Baseline" Period-of-Record Results

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Baseline	Thu Apr 07 16	ResSim bu	2010.07.13.04.56										
2														
3	Date	ALLATOONA POWER PLANT ENERGY (MWh)	CARTERS POWER PLANT ENERGY (MWh)	RF HENRY POWER PLANT ENERGY (MWh)	MILLERS FERRY POWER PLANT ENERGY (MWh)	ALLATOONA POWER PLANT POWER-CAPABILITY (MW)	CARTERS POWER PLANT POWER-CAPABILI TY (MW)	RF HENRY POWER PLANT POWER-CAPABILI TY (MW)	MILLERS FERRY POWER PLANT POWER-CAPABILI TY (MW)	ALLATOONA POWER PLANT POWER-CAPACITY (MW)	CARTERS POWER PLANT POWER-CAPACIT Y (MW)	RF HENRY POWER PLANT POWER-CAPACIT Y (MW)	MILLERS FERRY POWER PLANT POWER-CAPACIT Y (MW)	
4	--													
5	28-Feb-39	11770.75	55832.05	8637.6	32934.47	73.15	596.37	12.85	49.31	89.04	605.27	12.85	51.15	
6	31-Mar-39	11919.88	58768.49	9948.79	33717.08	76.46	591.71	13.37	50.33	93.16	605.27	13.37	51.67	
7	30-Apr-39	3400.33	55490.06	14040.71	43183.18	81.95	592.16	19.5	79.41	94.45	605.27	19.5	80.85	
8	31-May-39	9369.34	55827.08	15214.8	35549.39	82.83	593.54	20.45	93.73	94.49	605.27	20.45	94	
9	30-Jun-39	8163.56	53045.06	14716.92	44587.23	82.86	594.73	20.44	84.62	94.49	605.27	20.44	86.08	
10	31-Jul-39	5742.49	54659.81	14939.34	27064.69	82.3	595.63	20.45	97.91	94.46	605.27	20.45	97.91	
11	31-Aug-39	6512.87	54041.14	11009.8	27767.53	80.92	596.5	14.8	53.53	94.41	605.27	15.07	57.11	
12	30-Sep-39	5848.59	51800.15	14650.81	32679.97	79.57	595.43	20.45	95.2	94.36	605.27	20.45	95.3	
13	31-Oct-39	6120.56	53056.24	14999.11	26572.28	75.88	597.81	20.45	97.98	93.4	605.27	20.45	97.98	
14	30-Nov-39	4506.69	51668.23	14438.05	23248.8	73.27	596.14	20.45	98.74	89.23	605.27	20.45	98.74	
15	31-Dec-39	3953.07	53532.55	14530.39	24721.51	70.72	594.26	20.45	98.3	84.68	604.34	20.45	98.3	
16	31-Jan-40	3677.58	53713.09	14287.24	37556.68	70.61	592.8	19.32	82.57	84.46	605.22	19.32	83.67	
17	29-Feb-40	2581.53	52061.59	11003.33	33271.42	72.98	590.6	15.81	56.43	88.67	605.27	15.81	57.83	
18	31-Mar-40	5251.19	57577.11	12567.67	43824.05	76.83	591.62	16.89	64.63	93.82	605.15	16.89	66.51	
19	30-Apr-40	2761.68	53669.01	14501.69	44832.19	81.46	592.97	20.14	82.09	94.43	605.27	20.14	83.49	
20	31-May-40	4087.49	54022.4	15214.8	34728.49	83.21	594.06	20.45	93.29	94.51	605.27	20.45	93.77	
21	30-Jun-40	5138.86	53789.73	14550.79	34090.29	82.7	595.24	20.45	93.73	94.48	605.27	20.45	94.06	
22	31-Jul-40	7123.86	56552.16	10890.14	36173.98	82.66	599.01	14.64	57.03	94.48	605.27	14.64	58.12	
23	31-Aug-40	9369.32	53821.15	15214.8	29410.44	82.09	595.78	20.45	97.19	94.46	605.27	20.45	97.19	
24	30-Sep-40	7165.79	51519.36	14162.17	20591.96	81.27	597.28	20.45	99.29	94.42	605.27	20.45	99.29	

POR_Baseline--0_ACT_Operation-M

Figure L.38 Example Snapshot from Report "POR_Baseline--0_ACT_Operation-Monthly" Containing Monthly Summaries of "Baseline" Period-of-Record Results

Table L.11 Contents of Report Script "Make-and-Zip_ACT-Env-Ops-Reports"

```
# name=Make-and-Zip_ACT-Env-Ops-Reports
# description=Script to produce reports in csv form and zip them together according to type (5/19/2010, smo & mbh)
# displayinmenu=true
# displaytouser=true
# displayinselector=true
from hec.script import *
from hec.client import ClientApp
from datetime import date
from time import strftime
import os
import sys
import zipfile
from hec.rss.client import RSS
from java.lang import Boolean
from java.io import File
from rma.awt.table import TableExportOptions

####################################################
# ------------------------------------------------------------------------------------------
#  USER SETTINGS - EDIT AS NEEDED
# (WHEN USER REPORTS CHANGE, ETC)
# --- Set up report directory --------------
wkspDirStr = ClientApp.getWorkspaceDir()
# print wkspDirStr
# Change this directory if you desire your reports in a different location
# RepDir = "C:/temp/"
RepDir = wkspDirStr + "/rss/reports/"

# --- Set list of Reports to produce and zip up --------
# Change this list  if you want to generate different user reports
# However, if too many reports are added, the script might RUN OUT OF MEMORY
RepList = ["ACT_Environmental", "ACT_Operation-Daily", "ACT_Operation-Monthly"]
# [ "BasinInflow", "COE_Generation", "Operations" ]
# ------------------------------------------------------------------------------------------
####################################################

# --- get the active module -------------------------------------------
module = ClientApp.frame().getCurrentModule()
sim = module.getSimulation()
print "YYYYYYYY", sim, sim.getName()
# --- assumes we're in the Simulation mode
simMode = RSS.frame().getCurrentMode()

MessageBox.showPlain( " Generating reports may take awhile for long Simulations that contain many checked Alternatives. \
      \n Press OK to Generate Reports (& Package 'em up).  \n\n Thanks and Have a Great Day!", "For Your Information...")

# To make the files for ALL CHECKED Simulations
# ------------------------------------------------------------------------------
```

```
SimTree = module.getSimulationTree()
checkedRunVec = SimTree.getSelectedRuns() # just checked runs
# checkedRunNameVec = module.getRssRunNames(Boolean.TRUE) # just checked run Names
# RunVec = sim.getSimulationRuns() # all runs, checked or unchecked

# this is a simple error check for now to be sure there is at least one result in the tree
if checkedRunVec.size() == 0:
    MessageBox.showPlain( "No Simulations checked."  , "Error")
    sys.exit() #don't know why this doesn't exit cleanly


# --- Get current time -----------
timeStamp = strftime("%Y%m%d_%H%M")
#print timeStamp
#print date.today()


# ---------------------------------------------------------------------------------
# Generate Reports for each of the checked alternatives
#  and zip them up, grouped according to report type
# ---------------------------------------------------------------------------------
for Run in checkedRunVec :

  # set the run as the active run
  module.setActiveRun(Run)

  for Rep in RepList :

      # open the report
      userReport = simMode.displayUserReportByName(Rep, 0)
      #print "---------------------", userReport, sim, Run
      # open the report
      if userReport != None:
          # where to save it
          csvFilename = RepDir + sim.getName() + "_" + Run.getName() + "_" + Rep + ".csv"
          Repfile = File(csvFilename)
          #  what options to use
          opts = TableExportOptions()
          # comma separated
          opts.delimiter = ','
          # write it out
          userReport.getReportPanel().exportReportAction(Repfile, opts)
          # close the report
          userReport.setVisible(0)

          # -------------------------------------------------------------------------------------------------------------------------
--------------------
          # For some reason, the zipfile append option isn't working, therefore, all this code is commented out
          #  Instead, all the csv files are being written into the zipfile at the same time at the end of the script.
          # zip up the file
          #zipName = RepDir + sim.getName() + "_" + Rep + "_" + timeStamp +  ".zip"
          #if os.path.exists(zipName) :
          #   z = zipfile.ZipFile(zipName, "a")
          #else :
          #   z = zipfile.ZipFile(zipName, "w")
```

```
          #z.write(csvFilename)
          #z.close()
          # clean up csv files
          #os.remove(csvFilename)
          # ---------------------------------------------------------------------------------------------------------------
--------------------



# write all the csv files into the appropriate zipfiles
# ------------------------------------------------------------------
for Rep in RepList :
     zipName = RepDir + sim.getName() + "_" + Rep + "_" + timeStamp +  ".zip"
     z = zipfile.ZipFile(zipName, "w", zipfile.ZIP_DEFLATED)

     for Run in checkedRunVec :
          csvFilename = RepDir + sim.getName() + "_" + Run.getName() + "_" + Rep + ".csv"
          z.write(csvFilename, os.path.basename(csvFilename))
          os.remove(csvFilename)

     z.close()

MessageBox.showPlain( "Reports have successfully been zipped and written to this location: \n     %s" % RepDir, "Reports 
Generated and Collected into Zip File(s)")
```

Alabama-Coosa-Tallapoosa (ACT) Watershed

HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update

Addendum - Response to Comments

9 July 2014

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I. Introduction

This document is an addendum to the March 2011 report, "ACT HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update." The March 2011 report describes reservoir system modeling activities performed in support of the Mobile District Water Control Manual Update for the Alabama-Coosa-Tallapoosa (ACT) River Basin (Figure 1). The reservoir system model performs simulations of project operations for a baseline condition. In concept, the Water Control Manual Update required only comparing alternatives for relative differences in the results, but in practice, the plan formulation process depended on results being as realistic as possible, to provide feedback regarding serious and complex questions posed along the way. Additionally, the Mobile District intends to apply models developed under this study for other purposes, including cooperative follow-up activities with stakeholders, and operational use for real-time water control. Consequently, the baseline reservoir system model eventually grew to include the detailed physical characteristics (as available) and almost all the operational rules used at each project in the system.

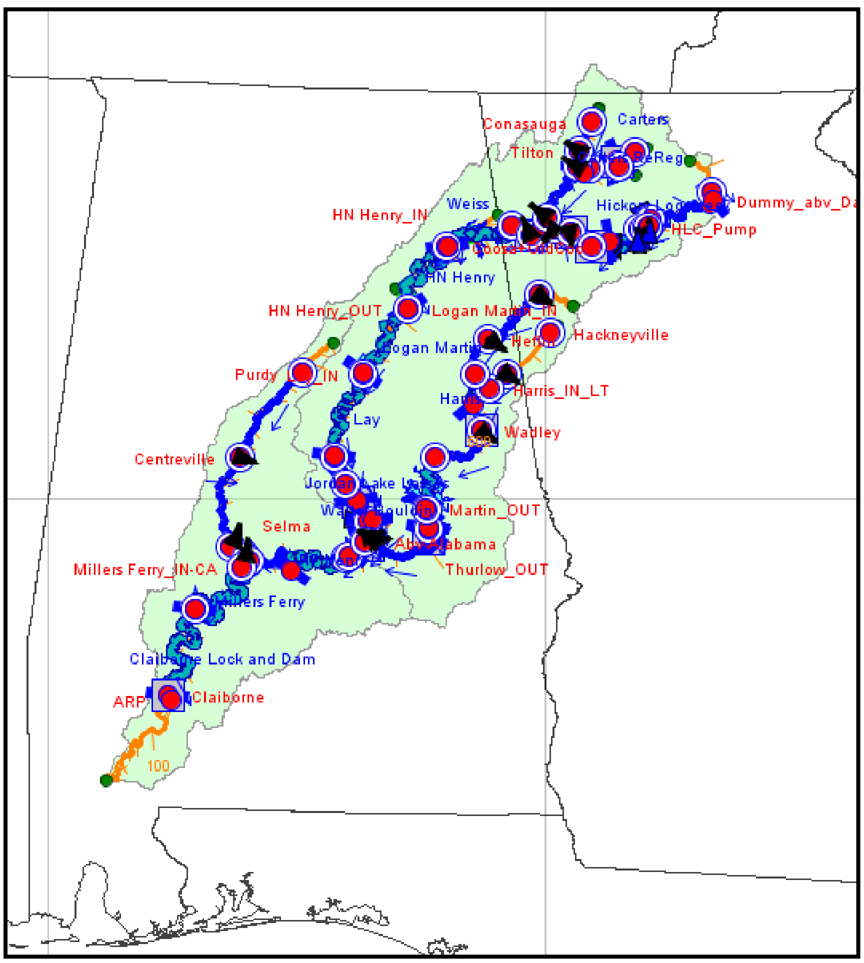


Figure 1. HEC-ResSim Network Module – 2013 Network including Hickory Log Creek Reservoir

The primary output of the original reservoir system modeling activities consisted of 70 years (1939-2008) of continuously simulated, daily time step, lake levels and river flows throughout the ACT basin. Project Delivery team members evaluated the impact of these results in terms of economic, environmental, and operational improvements or disadvantages. In addition, public comments on the draft Environmental Impact Statement (EIS) were considered. The comments and recommendations received from this review instigated several minor changes to the model and few major updates. The most significant changes included updating the unimpaired flow and extending the timeframe to 1939-2012, adding a new reservoir, Hickory Log Creek Reservoir, to the model network, defining potential operating plans for it, and evaluating its impact on the operation of Allatoona reservoir and the rest of the ACT system. This addendum was written to document all model changes that were made in response to comments received as part of the Water Control Manual Update EIS process required under the National Environmental Policy Act (NEPA).

A. Overview of Model Changes Described in this Report

One significant update to the model was the addition of the recently constructed (2007) Hickory Log Creek Reservoir. The description of network changes and physical properties of the reservoir are described in **Section II. Modeling Hickory Log Creek Reservoir.** Details about the operations of Hickory Log Creek Reservoir and the related background and assumptions are provided in **Section III. Description of Hickory Log Creek Operations**. As well as incorporating Hickory Log Creek Reservoir operations into the model, water supply withdrawals from Allatoona Lake under alternatives (other than the no action alternative) were adjusted for modeling purposes to reflect available storage under existing water supply storage contracts, measured by the storage accounting system USACE employs at those reservoirs. The new model is called ACT-WCM_HLC, reflecting the addition of Hickory Log Creek (HLC) Reservoir.

A number of other modifications were made to the model and are described in **Section IV. Other Model Updates**. These modifications include revisions to the operations, updated input data, and minor corrections for modeling errors. Changes were made in the representation of induced surcharge rules, Carters flood control operation, and the Alabama River navigation template. Some updates of reservoirs operated by Alabama Power Company (APC) were also made.

Finally, two new alternatives were added for the purpose of sensitivity analysis. These alternatives are described in **Section** V**. Sensitivity Runs.**

All of these changes necessitated the development of a new network, new model input files, and new alternatives. These updates are described throughout this report.

B. HEC-ResSim Improvements

The updated modeling was performed in a new version of HEC-ResSim. Model results delivered in 2011 were computed in HEC-ResSim 3.1 RC 3 build 42. The April 2014 model results were computed using HEC-ResSim 3.2 Dev, December 2013 Build 3.2.1.22. Although this newer version of ResSim has not yet been officially released, it offers important advantages over ResSim 3.1, including new features, enhancements, bug fixes, and improved algorithms. The most important advantage of ResSim 3.2 is the improved compute block logic, which brought period of record compute times from approximately six hours to under two hours for Baseline and under one hour for the other alternatives. Other advantages include improved handling of seasonal data during leap years, improved Carters pump-back operation, improved downstream control rule logic, especially with respect to rate of change rules and routing, improved evaporation and area calculations, and updated zone boundary logic.

II. Modeling Hickory Log Creek Reservoir

The Hickory Log Creek Dam and Reservoir is the newest locally constructed water supply project in the ACT Basin. It is located on a small tributary to the upper Etowah River, upstream of Allatoona Reservoir. The dam and reservoir is a joint project of the Cob County-Marietta Water Authority (CCMWA) and the city of Canton that will serve as an additional water supply source. Construction was permitted in 2004, and the reservoir was filled in 2010. The project is on Hickory Log Creek in Cherokee County, near the City of Canton, Georgia, and about 1.4 mi upstream of the creek’s confluence with the Etowah River. The dam is approximately 950 ft wide and 180 ft high, making it one of the largest dams in the state not built by USACE or the Georgia Power Company (CCMWA 2010). The dam impounds approximately 17,700 ac-ft of usable storage. It is designed as an off-channel pumped-storage reservoir since the drainage area of Hickory Log Creek is insufficient to supply enough inflow to support the intended operation of the project. The Hickory Log Creek project is permitted by Georgia Environmental Protection Division (EPD) for withdrawals for the purpose of filling the reservoir up to 39 million gallons per day (mgd) from the Etowah River for the purpose of filling the reservoir. Water is stored in the reservoir to be shared by the city of Canton and CCMWA. In addition to the dam and reservoir, the project includes an intake and pump station, and a pipeline to transport water between the reservoir and the Etowah River. The total storage in Hickory Log Creek Reservoir is equivalent to about 6 percent of the conservation storage in Allatoona Reservoir.

Since this reservoir currently exists and is permitted to be operated, it was desirable to include it in the ACT model. Figure 2 shows the model with the 2009 network in the region of Hickory Log Creek. Figure 3 shows the 2013 network, which was updated to include Hickory Log Creek Reservoir. Changes were made to the stream alignment and the representation of local flows, diversions, and return flows. This section describes these changes and others made to add Hickory Log Creek Reservoir to the ACT model.

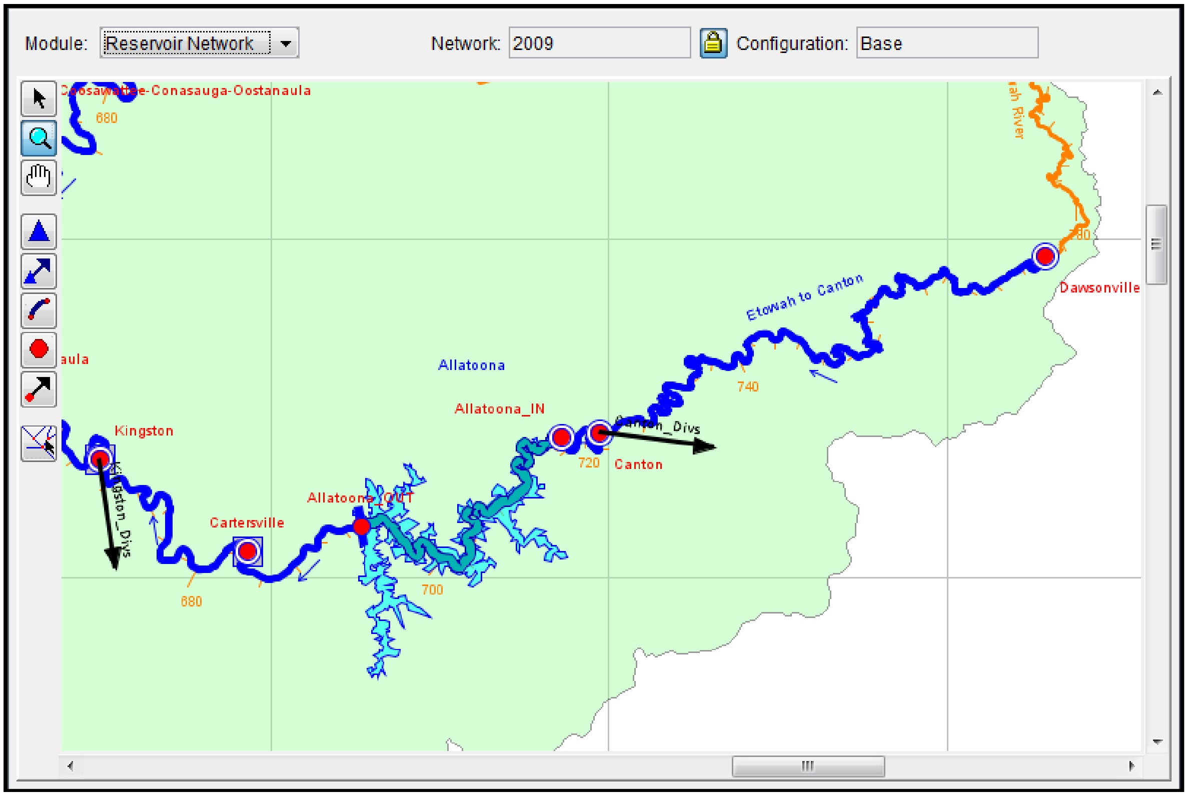


Figure 2. Upper Etowah River in the 2009 Network

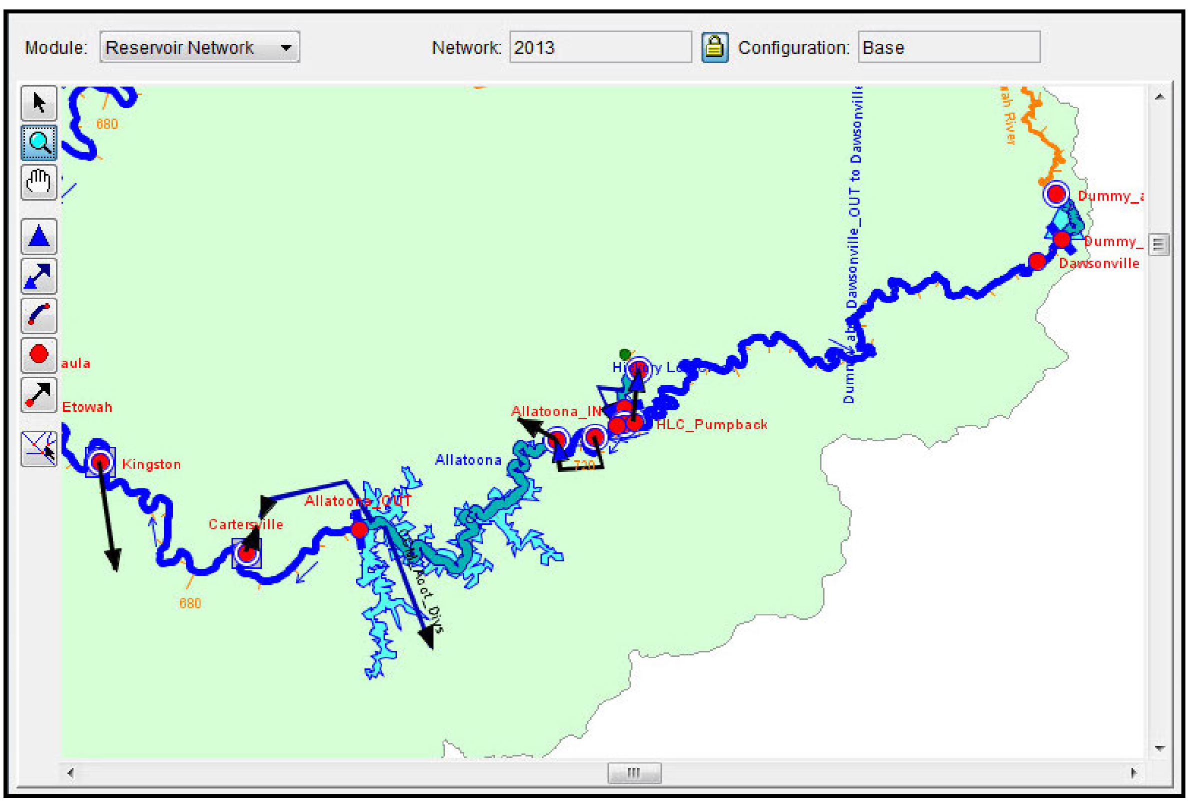


Figure 3. Upper Etowah River in the 2013 Network: including new diversions and Hickory Log Creek Reservoir

A. Distribution of Local Inflows and Withdrawals

The placement of local inflows and diversions was altered when Hickory Log Creek Reservoir was added to the model. In the 2009 network, all local flows, withdrawals, and return flows occurring above Allatoona were lumped and located at the inflow junction to Allatoona. This worked well, because there were few calculations occurring upstream of Allatoona – only some routing between the upper-most node at Dawsonville, and Allatoona. For the updated 2013 network, these flows were separated according to type and location and distributed accordingly. This allowed for more detailed calculations upstream of Allatoona. The changes are described below.

A dummy reservoir was added upstream of Dawsonville (explained in Section II.B, below) and inflow to the Dawsonville junction was simply moved up to the inflow of the dummy reservoir (Figure 5). The routing that took place between Dawsonville to Canton (original reach name "Etowah to Canton") was placed between Dawsonville and the HLC Pump location (Figure 6). No routing is modeled between this pump location and Allatoona Reservoir since the total travel time in this reach is less than 1 day.

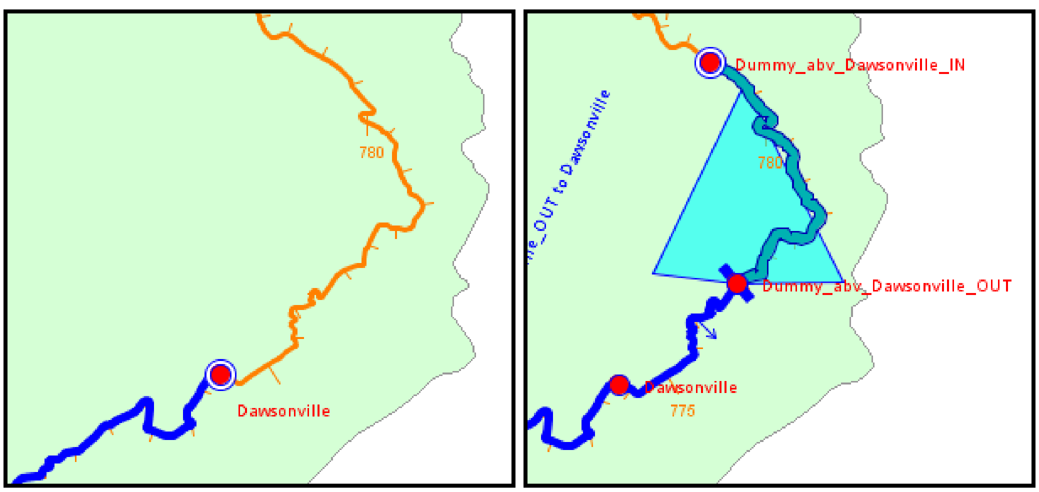


Figure 4. A dummy reservoir above Dawsonville was added to the 2013 Network (right). It did not exist in the 2009 network (left).

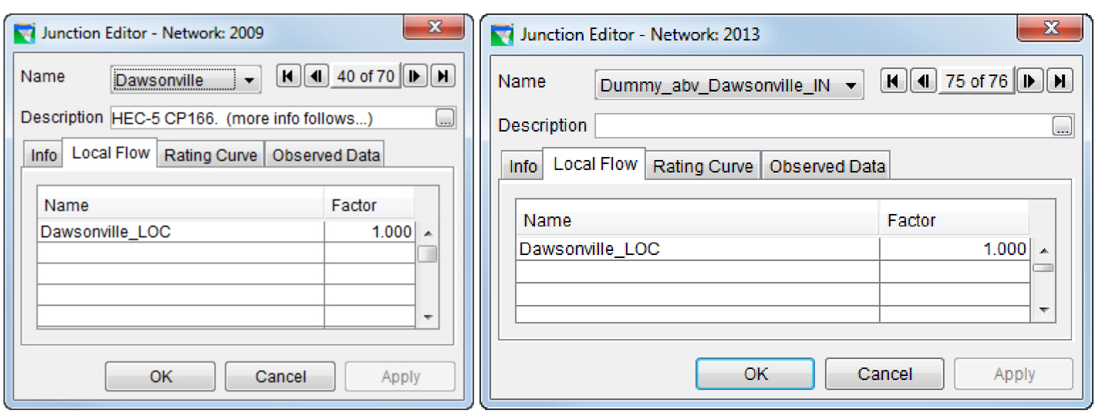


Figure 5. Local inflows at Dawsonville were moved to the inflow node of the Dummy_abv_Dawsonville Reservoir. This has no impact on operations of the watershed.

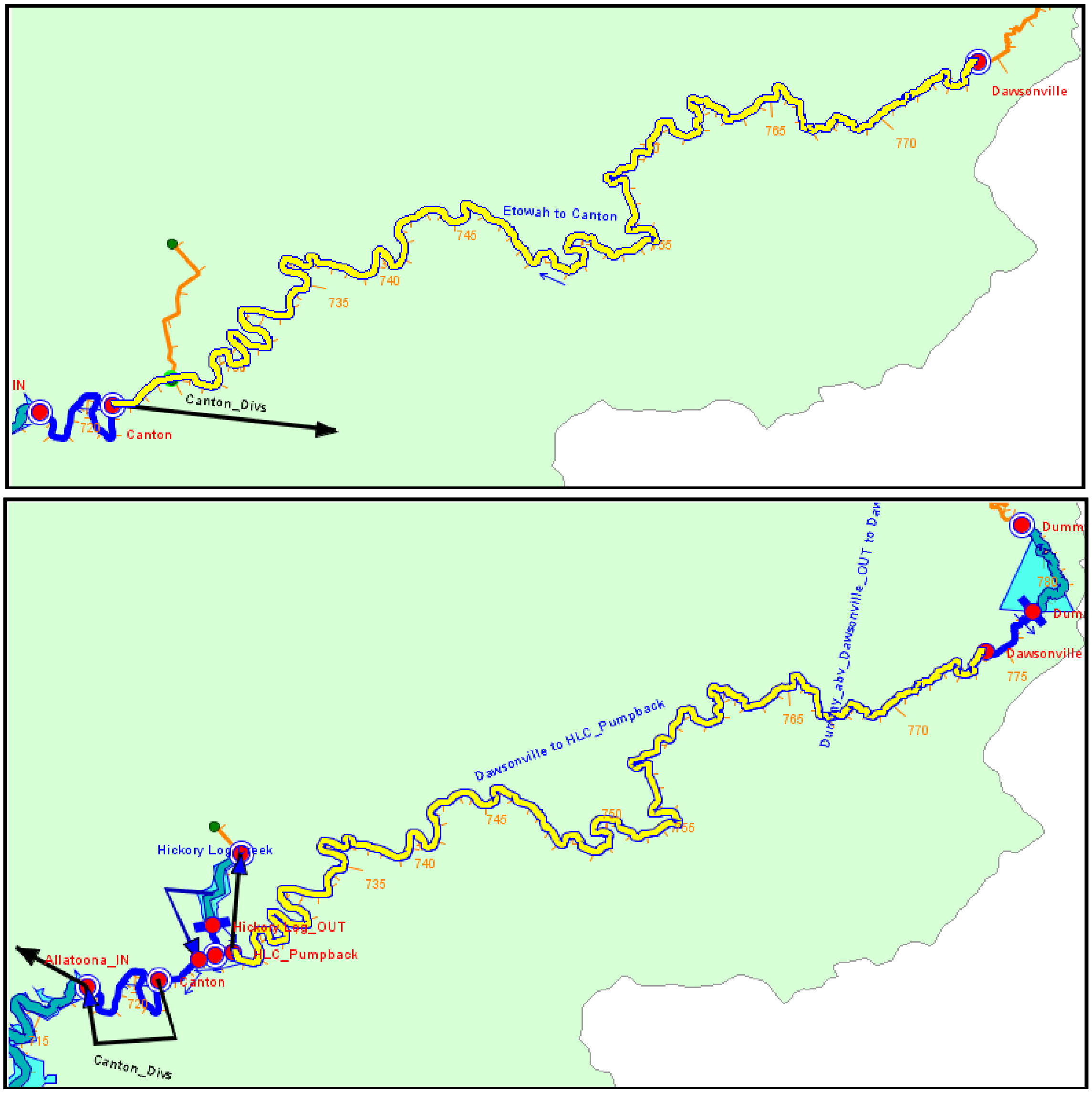


Figure 6. Highlighted in yellow is the reach with routing in the 2009 network (top) versus the 2013 network (bottom).

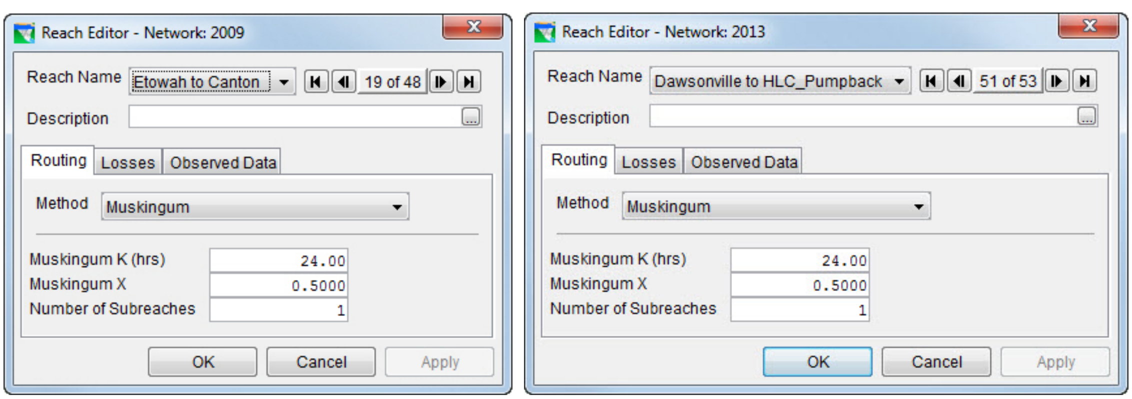


Figure 7. The routing between Dawsonville and Allatoona is all represented in a single, large reach which is slightly different in the 2009 vs. the 2013 network.

The 2009 network did not explicitly model Hickory Log Creek. In order to add Hickory Log Creek Reservoir to the 2013 network, a stream representing Hickory Log Creek was added to the stream alignment and Hickory Log Creek Reservoir (HLCR) was added on the stream (Figure 8). The pump from the Etowah River into HLCR was added as a diversion from the Etowah River above the Hickory Creek confluence, and a diverted outlet was added to the reservoir to represent the pipeline and handle the water supply withdrawals from water supply storage accounts.

In the 2009 network, the local inflow between Dawsonville and Canton was input at Canton. For the 2013 network, this time-series of local inflow had to be divided between Canton, the Hickory Log Creek inflow node, and the Etowah-Hickory Log Creek junction, as is indicated by the red arrows in Figures 8 and 9 and described in Table 1.

There were a number of changes made to the representation of diversions and return flows on the Etowah River between Hickory Log Creek and Allatoona Reservoir. In the 2009 network, a diversion element is used to represent the City of Canton's withdrawal at Canton. All other diversions and return flows in the area are lumped into a time-series on the local flow tab at the Allatoona inflow node. In order to individually represent specific diversions and return flows (Cobb-County Marietta Water Authority, the City of Canton, and Cartersville), the lumped time-series were split out into the individual parts and represented separately in the 2013 network (Figure 10).

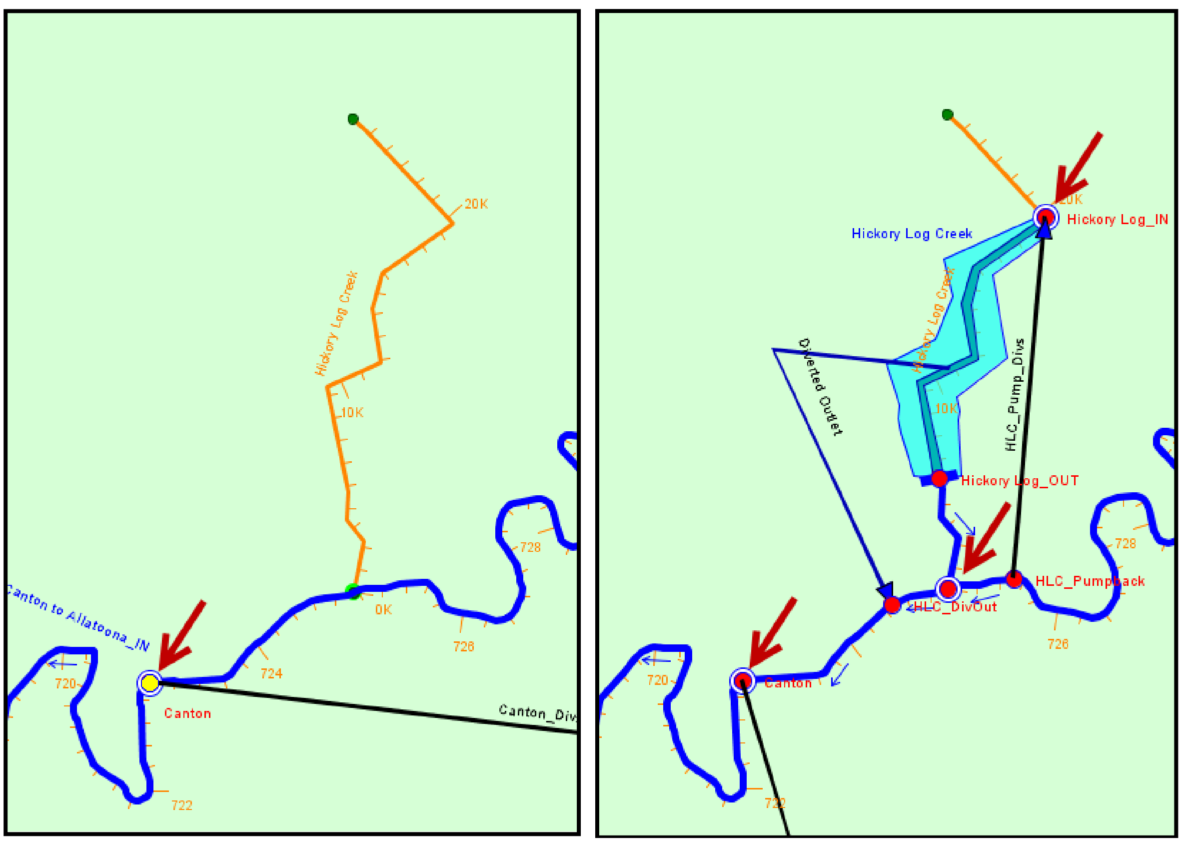


Figure 8. These images show the representation of the Etowah River with (2013 network, right) and without (2009 network, left) Hickory Log Creek Reservoir. They also depict the nodes at which Canton local inflow are input in each network (red arrows).

Table 1. The total local flow at Canton was redistributed to incorporate Hickory Log Creek into the model. Flow was divided between the HLC-Etowah confluence, HLC inflow, and Canton, based on drainage area.

Location	Drainage Area (sq mi)	Fraction of “Canton_LOC” Inflow
Dawsonville Gage	107	-
HLC Confluence	600	0.958
HLC Dam	8.2	0.016
Canton Gage	613	0.026

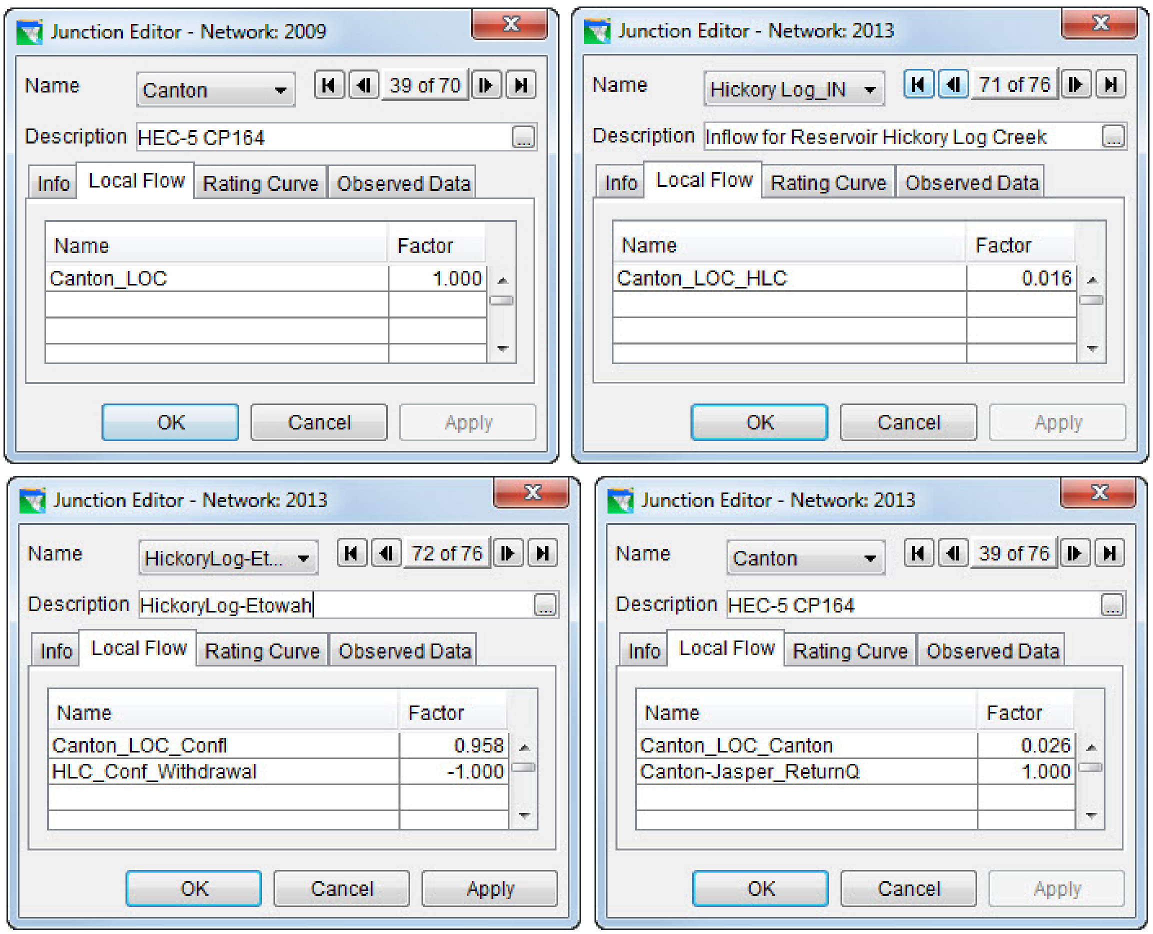


Figure 9. The Canton local inflow was placed entirely at Canton in the 2009 network. In the 2013 network, it was proportioned across three different nodes, based on drainage area.

In the 2009 network, the Allatoona_IN junction includes a time-series labeled “Allatoona_IN_DIV”, modeled with a factor of negative one (Figure 11). This factor means that rather than adding the time-series of flow at that node, the model is subtracting it, i.e., it is a diversion. The Allatoona_IN_DIV time-series includes diversions for the City of Cartersville, Cobb County-Marietta Water Authority (CCMWA), the City of Canton, the Etowah Water and Sewer Authority, Gold Kist, Inc., the City of Jasper, and the Cherokee County Water and Sewerage Authority. This time-series also includes return flows for CCMWA, the Canton Water Pollution Control Plant, Fulton County, Cherokee County, Woodstock, and the City of Jasper. In the 2013 network, these time-series are separately represented as diversion elements, or local inflows (or diversions) at Allatoona_IN, Canton, and the confluence of Hickory Log Creek with the Etowah River. A summary of this information is included in Table 2.

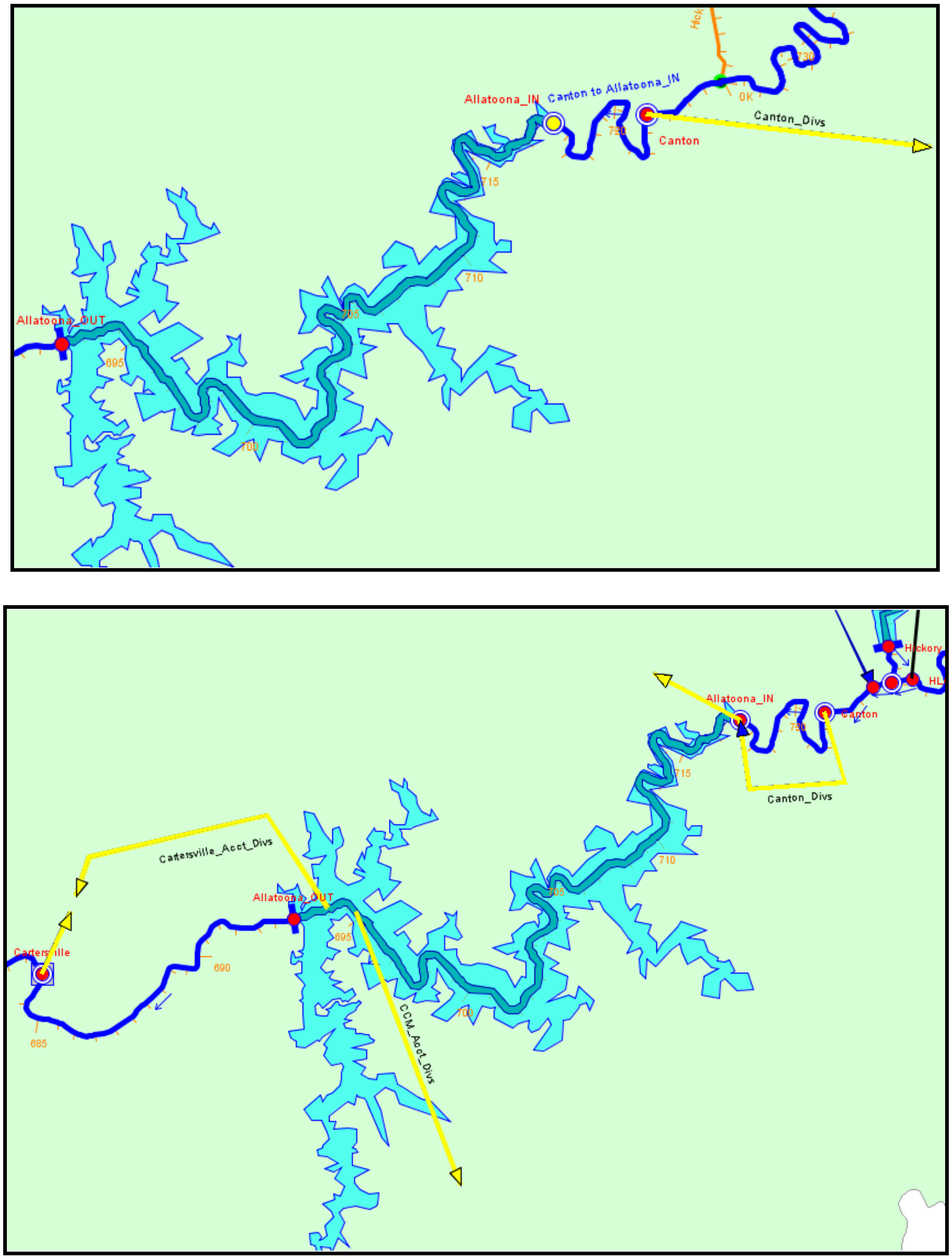


Figure 10. These images show the diversion elements between Hickory Log Creek and Allatoona Reservoir in the 2009 network (top) and the 2013 network (bottom).

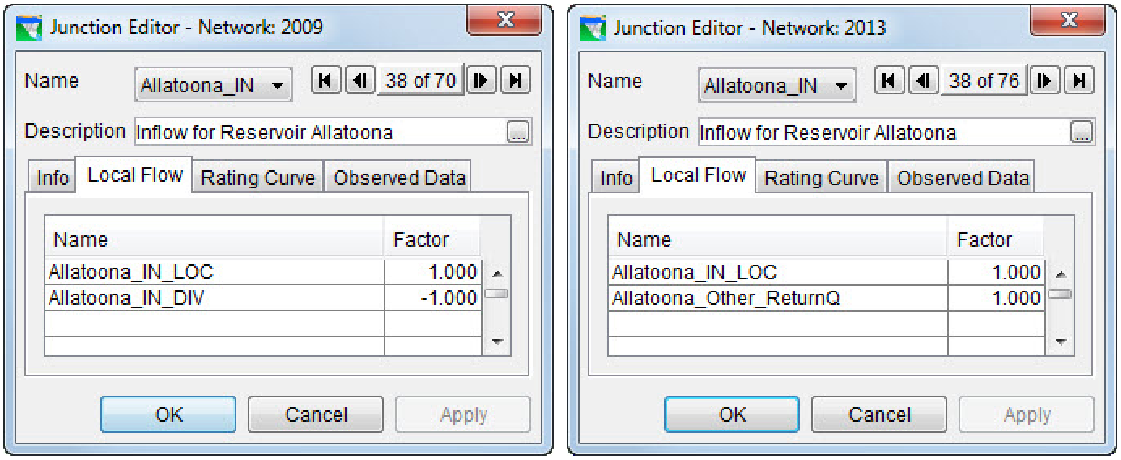


Figure 11. In the 2009 network (left), all water use between HLC and Allatoona Dam was lumped into the Allatoona_IN_DIV time-series. In the 2013 network (right), only some of the return flows are represented at this junction.

Table 2. The 2009 and 2013 network representation of diversions and return flows between HLC and Allatoona Dam

2009 Network	**2013 Network**	
City of Canton Diversion		
Diversion element at Canton	Diversion element at Canton with a return flow at Allatoona_IN	
All Diversions and Return flows between Hickory Log Creek and Allatoona Dam		
Water use is summed and accounted for in a single **Allatoona_IN_DIV** time-series at the Allatoona_IN node, the elements of which are listed below.	Portions of the **Allatoona_IN_DIV** time-series are distributed at different nodes in the form of diversion elements and negative local inflows as described below.	
Allatoona_IN_DIV	***Location***	***Format***
Withdrawals		
City of Cartersville Water Department	Allatoona Reservoir	Diverted outlet
Cobb County-Marietta Water Authority*	Allatoona Reservoir*	Diverted outlet
	Canton*	Diversion w/return flow
Etowah Water & Sewer Authority	HLC-Etowah Confluence	HLC-Conf Withdrawal
Gold Kist, Inc		
Cherokee County Water & Sewerage Authority		
City of Jasper		
Return Flows		
CCMWA - Northwest WPCP (Lake Allatoona)	Allatoona_IN	Allatoona-CCMWA ReturnQ
CCMWA - Noonday Creek WPCP (Lake Allatoona)		
Canton WPCP	Allatoona_IN	Allatoona-Other ReturnQ
Cherokee County Water & Sewerage Authority		
Woodstock WPCP		
Fulton County - Little River WPCP		
City of Jasper	Canton	Canton-Jasper_ReturnQ

* The 2013 network allows for CCMWA withdrawals at two different locations

B. Dummy Reservoir above Dawsonville

In order to accommodate impacts of the addition of HLCR and updating to ResSim v3.2, a new "dummy" reservoir was added in the upper system, above Dawsonville. This reservoir does not represent a physical entity and is strictly a modeling technique. The "Dummy_abv_Dawsonville" reservoir passes inflow, so it does not impact the system, but it uses "dummy rules" to force certain computations and to retrieve external time-series, making them available to the rest of the model. "Dummy rules" do not change the flow-thru operation of the reservoir; they simply trigger other things to happen in the model. Two rules are used to force computations. "Dummy_Force Main HLC SV" forces the computation of the "Accounting_HLCmain" state variable, which is used to calculate storage accounting (at Allatoona and HLCR), diversions, and return flows for Canton, CCMWA, and Cartersville, as well as the pump flow into HLCR. This ensures that the calculated variables are available to the elements that need them in the first compute block. "Dummy_Force Compute Block" forces all of the Etowah down to Allatoona to be in the same (first) compute block. Allatoona's releases must be part of the first compute block because they must be known by the water supply storage accounting state variable, which must be calculated to obtain the pump flow into HLCR among other things. Figure 12 depicts the Operations tab of the Dummy_abv_Dawsonville Reservoir Editor.

The rules "Get CCM_demand", "Get Alla_Cartv_demand", and "Get_Canton_demand" retrieve external time-series for the demands for the three water supply storage account holders. These demands are used in the "Accounting_HLCmain" state variable.

The rules "Get_Canton_dummy", "Get_HLC_Conf_WD_dummy", "Get_Jasper_returnQ_dummy" retrieve other external time-series used by the "Accounting_HLCmain" state variable. These external time-series are also brought in at local flow junctions but are not accessible to the state variable. They are secondary versions of the same time-series that are brought into the model in via the Alternative Editor.

In the 2011 ACT daily model, Hackneyville gage flow was brought in as a local flow at a node that was detached from the system. The 3.2 version of ResSim divides the compute blocks differently, and Hackneyville data wasn't being read prior to the calculation of the state variable that uses it. The dummy rule "Get_Hackneyville_dummy" retrieves Hackneyville data during the first compute block, making it available to the "ThurlowMinQ_hackney" state variable. The Hackneyville node (which was an unattached, dummy node) was deleted from the 2013 network.

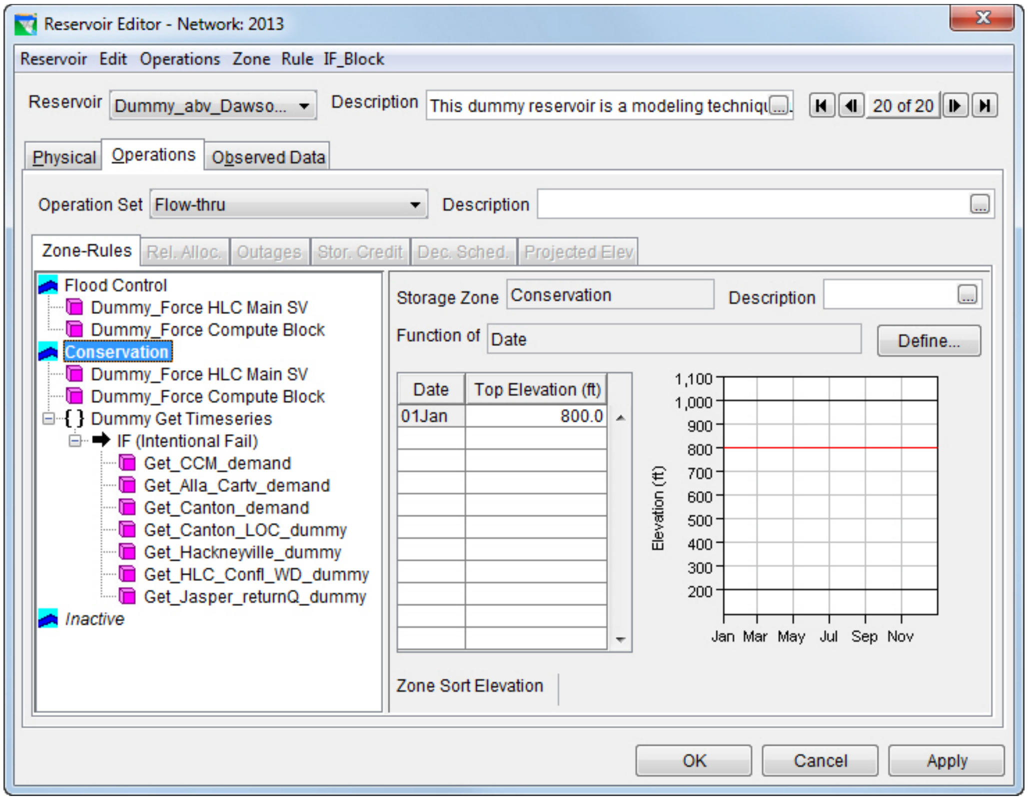


Figure 12. A dummy If-block is used to bring in external time series. It does not affect the operation of Hickory Log Creek Reservoir.

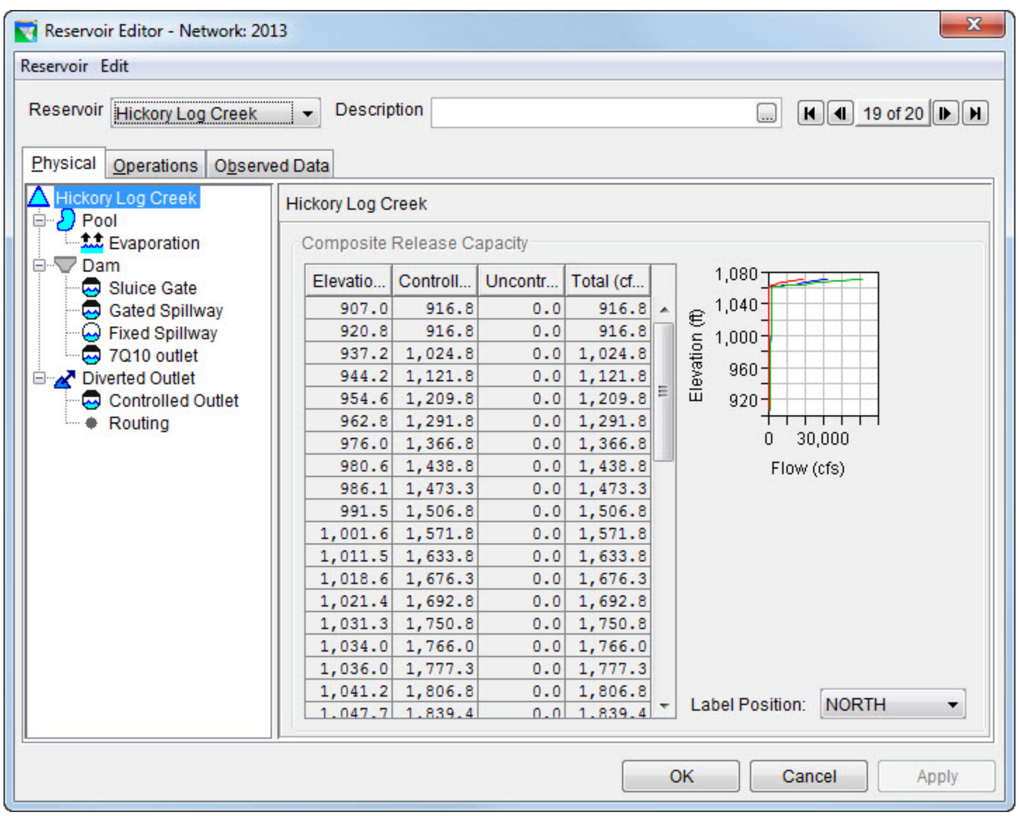
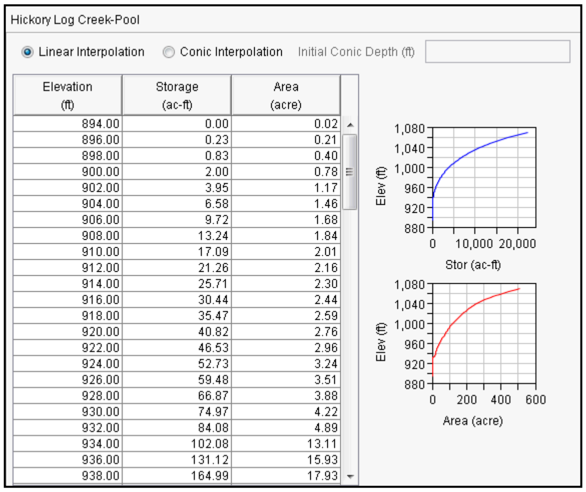


Figure 13. Hickory Log Creek Physical tab of the Reservoir Editor.

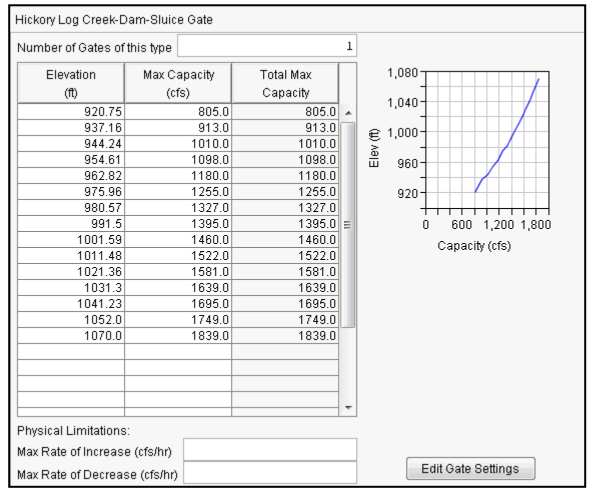
C. Physical Properties of Hickory Log Creek

Hickory Log Creek Reservoir has a full volume of 17701 acre-feet and area of 411 acres, at an elevation of 1060 feet (Figure 14a). The reservoir has three controlled outlets: a sluice gate with a 42 inch intake pipe and intakes at 907, 986.12, 1018.6, and 1047.73 feet (Figure 14b.), an 8-inch diameter gate at 1036 feet to provide minimum flows to Hickory Log Creek (Figure 14c.), a spillway with 110-foot Obermeyer crest gates (Figure 14d.). There are also 68 feet of uncontrolled fixed ogee crest (Figure 14e.) on either side of the Obermeyer crest. Hickory Log Creek also has a pump station used to fill the reservoir from the Etowah River and to make releases for the water account holders (Figure 14f.). The pump station has three pumps of 13 MGD each, a maximum pump rate of 60.33 cfs. The reservoir may release up to 70 mgd (108.29 cfs) though the pump station to meet demands of water account holders.



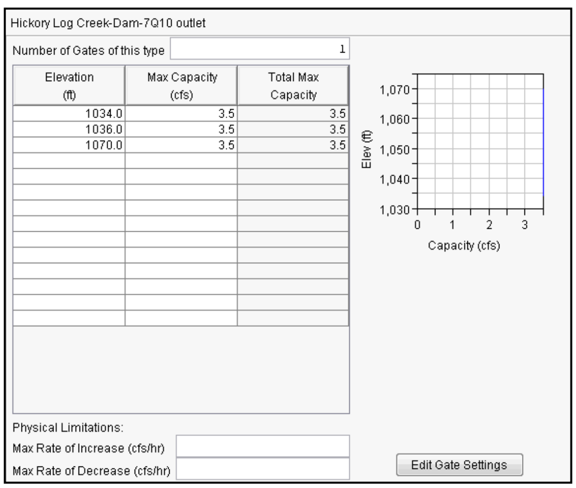
Elevation (ft)	Storage (ac-ft)	Area (acre)
894.00	0.00	0.02
896.00	0.23	0.21
898.00	0.83	0.40
900.00	2.00	0.78
902.00	3.95	1.17
904.00	6.58	1.46
906.00	9.72	1.68
908.00	13.24	1.84
910.00	17.09	2.01
912.00	21.26	2.16
914.00	25.71	2.30
916.00	30.44	2.44
918.00	35.47	2.59
920.00	40.82	2.76
922.00	46.53	2.96
924.00	52.73	3.24
926.00	59.48	3.51
928.00	66.87	3.88
930.00	74.97	4.22
932.00	84.08	4.89
934.00	102.08	13.11
936.00	131.12	15.93
938.00	164.99	17.93

a) Elevation-Storage-Area



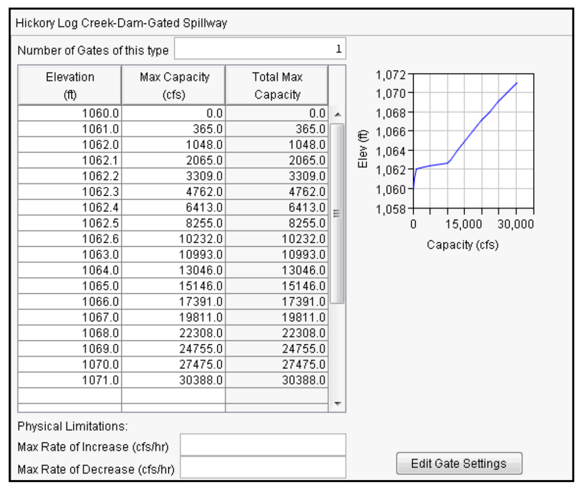
Elevation (ft)	Max Capacity (cfs)	Total Max Capacity
920.75	805.0	805.0
937.16	913.0	913.0
944.24	1010.0	1010.0
954.61	1098.0	1098.0
962.82	1180.0	1180.0
975.96	1255.0	1255.0
980.57	1327.0	1327.0
991.5	1395.0	1395.0
1001.59	1460.0	1460.0
1011.48	1522.0	1522.0
1021.36	1581.0	1581.0
1031.3	1639.0	1639.0
1041.23	1695.0	1695.0
1052.0	1749.0	1749.0
1070.0	1839.0	1839.0

b) Sluice Gate



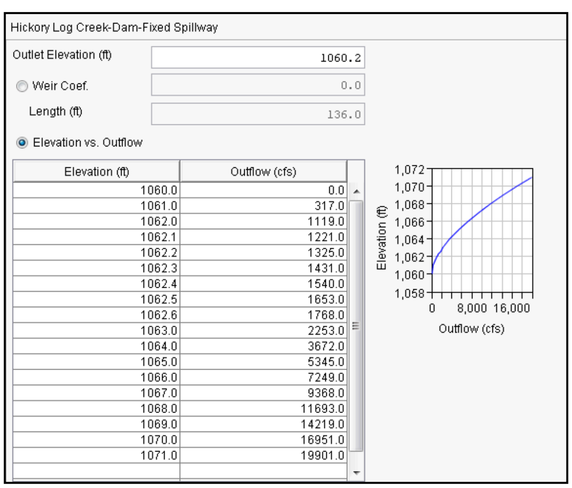
Elevation (ft)	Max Capacity (cfs)	Total Max Capacity
1034.0	3.5	3.5
1036.0	3.5	3.5
1070.0	3.5	3.5

c) Minimum Instream Flow Gate



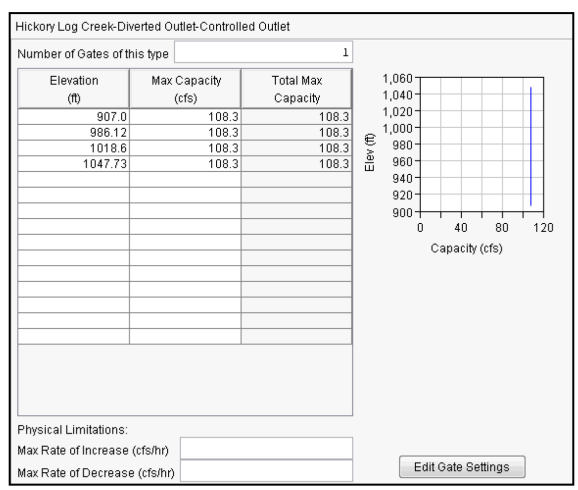
Elevation (ft)	Max Capacity (cfs)	Total Max Capacity
1060.0	0.0	0.0
1061.0	365.0	365.0
1062.0	1048.0	1048.0
1062.1	2065.0	2065.0
1062.2	3309.0	3309.0
1062.3	4762.0	4762.0
1062.4	6413.0	6413.0
1062.5	8255.0	8255.0
1062.6	10232.0	10232.0
1063.0	10993.0	10993.0
1064.0	13046.0	13046.0
1065.0	15146.0	15146.0
1066.0	17391.0	17391.0
1067.0	19811.0	19811.0
1068.0	22308.0	22308.0
1069.0	24755.0	24755.0
1070.0	27475.0	27475.0
1071.0	30388.0	30388.0

d) Gated Obermeyer Crest Spillway



Elevation (ft)	Outflow (cfs)
1060.0	0.0
1061.0	317.0
1062.0	1119.0
1062.1	1221.0
1062.2	1325.0
1062.3	1431.0
1062.4	1540.0
1062.5	1653.0
1062.6	1768.0
1063.0	2253.0
1064.0	3672.0
1065.0	5345.0
1066.0	7249.0
1067.0	9368.0
1068.0	11693.0
1069.0	14219.0
1070.0	16951.0
1071.0	19901.0

e) Fixed Ogee Crest Spillway



Elevation (ft)	Max Capacity (cfs)	Total Max Capacity
907.0	108.3	108.3
986.12	108.3	108.3
1018.6	108.3	108.3
1047.73	108.3	108.3

f) Pump Station Outlet

Figure 14. Hickory Log Creek Reservoir physical properties

III.Description of Hickory Log Creek Operations

Hickory Log Creek Reservoir (HLCR) is located on Hickory Log Creek, a tributary to the Etowah River, a few miles upstream of the City of Canton and Allatoona Reservoir. Water supply reliability is of concern in this area. Two water users, CCMWA and the City of Cartersville, hold water supply storage accounts at Allatoona Reservoir. The Mobile District has employed a storage accounting methodology at Allatoona Reservoir that tracks multiple storage accounts, applying a proportion of inflows and losses, as well as direct withdrawals by specific users, to each account. The proportioning of the reservoir is described further in Section III A. This accounting has indicated that neither CCMWA nor Cartersville has sufficient storage to consistently meet withdrawal demands equivalent to the greatest demand year on record, 2006. The City of Canton is another water user in the area with a growing demand and interest in securing a more reliable water supply that will accommodate increasing demands.

The historical high year (2006) demands were used in this analysis because 2006 was the year of highest net withdrawals from the ACT Basin and the year of greatest stress on the system from water withdrawals. The 2006 withdrawals from Allatoona Lake are higher than withdrawals in other years, but may be indicative of increasing demands. In order to illustrate the limitations of the current storage accounts, a demo scenario was run using current accounting and 2006 demands. Figure 15 shows modeled shortages to the Canton, CCMWA, and Cartersville demands for the period of record. These values were determined by modeling a scenario in which Hickory Log Creek Reservoir was operated as an amenity flow-through reservoir and storage accounts at Allatoona were not overdrawn. The scenario set demands at their 2006 levels, assuming that the (historical maximum) withdrawals of the year 2006 were made in every year during the model run. CCMWA shows frequent shortages of large amounts, and Cartersville shows shortages during some of the drought years. Canton was able to fully meet its 2006 demands.

In January 2013, the State of Georgia submitted a revised request for additional storage space at Allatoona; however, a reallocation study will not be undertaken until the Water Control Manual Update is complete, and reallocation alternatives at Allatoona were not considered in this report. The construction of HLCR was another approach to addressing the issue of water shortages. HLCR was constructed as a joint venture between the City of Canton and the Cobb County-Marietta Water Authority (CCMWA) in effort to secure better water supply reliability. The reservoir's storage space is divided between the entities with Canton entitled to 25% and CCMWA entitled to 75%. This storage space is distinct from CCMWA's storage account at the federal Allatoona Reservoir. Prior to the construction of HLCR, Canton did not have a reservoir storage account, but it did have a permit issued by the State of Georgia to withdraw water from the Etowah River upstream of Allatoona.

The Hickory Log Creek impoundment was completed in 2007 and the pump station was completed in 2008. The City of Canton currently holds a permit from the Georgia Department of Natural Resources Environmental Protection Division to pump water from the Etowah River to fill HLCR (EPD #028-1491-05, new 2008). The City of Canton is permitted to make withdrawals from the Etowah in excess of their original permitted amount (EPD #028-1491-04, modified 2008), assuming the 7Q10 flow can still be passed. While releases from the Canton account at HLCR could be used to supplement the natural Etowah flow at Canton's intake, Canton 2006 demands can be fully met without relying on HLCR. Releases can be made from CCMWA's account at HLCR, but the Authority does not currently hold the permits and infrastructure necessary for withdrawals and conveyance of water from intake facilities on the Etowah River, upstream of Allatoona, as contemplated in the original HLCR permit application. For these reasons, HLCR currently utilizes the pump station to keep the pool full, but otherwise is operating as a flow-through reservoir, without making specific releases for downstream withdrawals, pending determination of an approved operating plan.

The Baseline/No Action alternative models current conditions, with 2006 water supply demands; all other alternatives model the permitted conditions, with 2006 water supply demands. This means that in the Baseline alternative, Hickory Log Creek Reservoir is effectively operated as an amenity flow-through reservoir. It releases inflow and pumps only to make up for losses due to evaporation. No specific releases are made for the storage account holders, however Allatoona allows the full withdrawal of demand, even when CCMWA and/or Cartersville have exhausted their storage accounts, according to the Mobile District accounting methodology. Other alternatives limit withdrawals from Allatoona to what is available in the storage accounts, and HLCR is allowed to supplement Etowah River natural flow for Canton's withdrawal, in accordance with the 2008 Georgia-issued permit. Since Canton's original permit from Georgia for withdrawals from the Etowah River is sufficient to meet the 2006 demands, it never needs to draw upon supplement releases from HLCR. Therefore HLCR is effectively operated an amenity flow-thru reservoir. Should a scenario be run with greatly increased Canton demands, it would be able to draw on supplemental releases from HLCR.

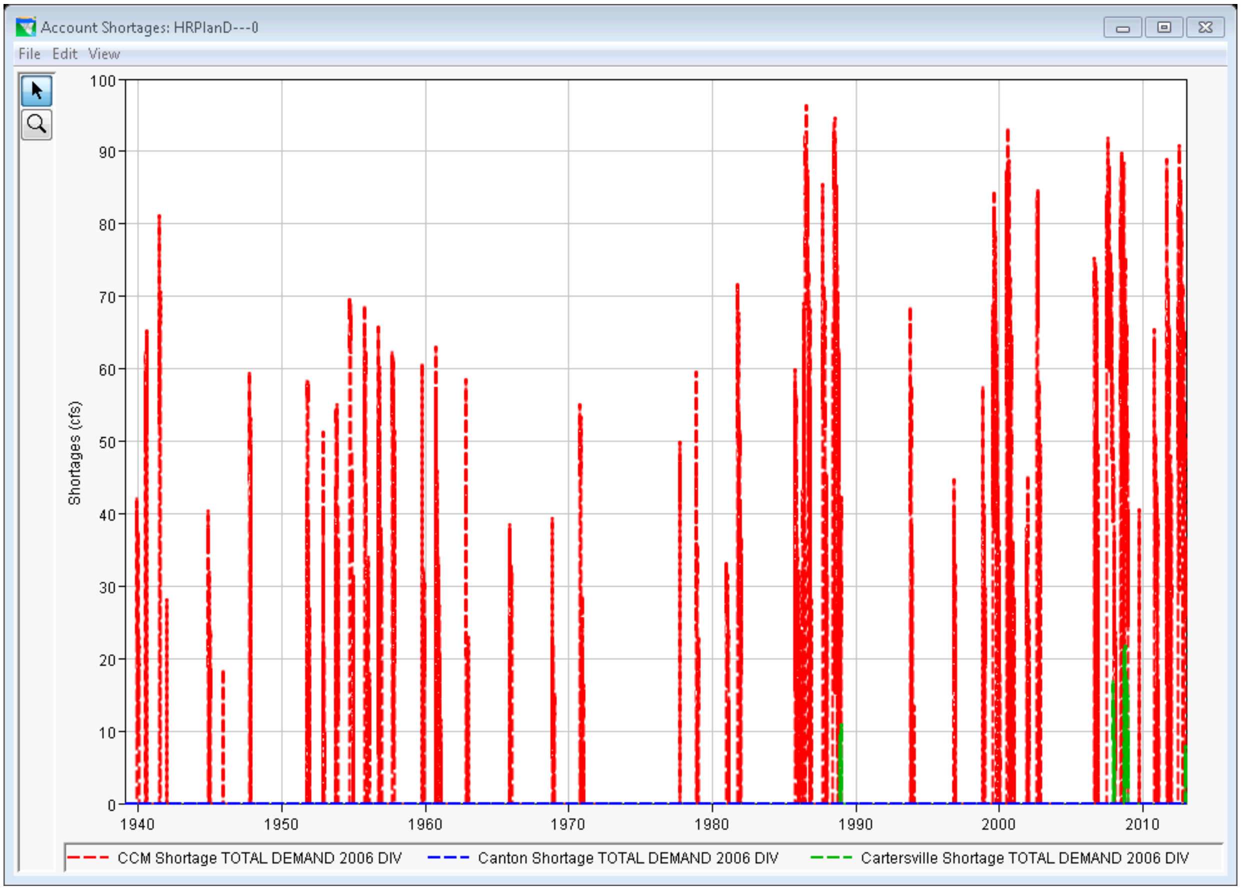


Figure 15. Shortages to CCMWA, Canton, and Cartersville if HLCR is not operated to supply water

A. Storage Accounts at Hickory Log Creek Reservoir and Allatoona

Table 3 shows the allocation of the Hickory Log Creek Reservoir pool and Allatoona Reservoir pool between different account holders. Net inflow is distributed to the accounts based on the percent of pool. Releases from Allatoona for purposes other than CCMWA or Cartersville withdrawals are debited from the Corps of Engineers (COE) account.

Table 3. Storage Accounts and Anticipated Yield values at HLCR and Allatoona

Location	Percent of pool	Storage Volume (acre-feet)	Anticipated Yield (mgd)
Hickory Log Creek Reservoir			
Conservation Pool (elev: 982.3'-1060')		13,308	
CCMWA	75%	9,981	33
Canton	25%	3,327	11
Allatoona			
Conservation Pool (elev: 800'-840')		284,589	
COE[1]	93.14%	265,066	
CCMWA	4.62%	13,148	34.5[2]
Cartersville	2.24%	6,375	16.76[2]

[1] Corps of Engineers – represents conservation storage used for multiple purposes
[2] from current Water Supply Storage Contract

B. Demands

In order to conduct ResSim modeling, annual water supply withdrawal figures needed to be determined. Actual annual withdrawal rates have varied in recent years, and withdrawals during the year 2006 represented the greatest annual demand in the 1939-2008 period. Although withdrawals have been less in other years, including the period since 2006, the 2006 withdrawals were selected as most representative of "current" demand for the purpose of ResSim modeling. This demand best reflects the near term future demand.

Accordingly, the 2006 net water withdrawals were used to represent the demands for Canton, CCMWA, and Cartersville. The year's average monthly values were divided by the number of days per month to obtain a time-series of monthly varying average daily values. The values were repeated and applied to each calendar year in the simulation. In other words, the simulated diversions for 1939 are the same as 2012 and every year in between. Table 4 and Figure 16 depict the demands used in the model.

Table 4. Modeled Demands for Canton, CCMWA, and Cartersville

Location	Modeled Demands	Range (cfs)	Range (mgd)
Canton	2006 monthly demands	21.7 - 28.9	14 – 18.7
CCWMA	2006 monthly demands	51.8 - 97.3	33.5 – 62.9
Cartersville	2006 monthly demands	18.8 - 25.1	12.2 – 16.2

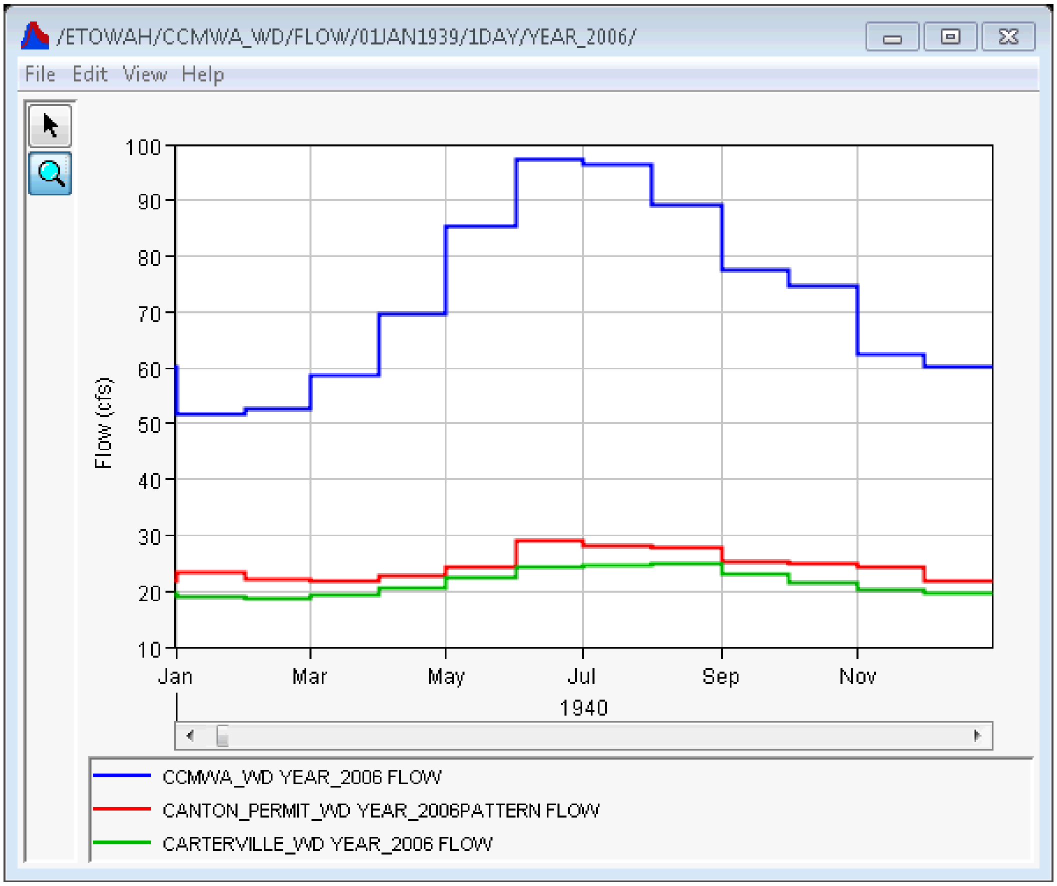


Figure 16. Modeled Demands for Canton, CCMWA, and Cartersville

C. Modeling Assumptions for Water Supply Storage Accounts

As described in the previous section, the 2006 demands were used to determine water supply withdrawals for the purpose of ResSim modeling. Hickory Log Creek Reservoir operations were modeled to represent its current operations for the Baseline/No Action alternative, and to represent its proposed operations, *in accordance with existing permits and infrastructure,* for all other alternatives. The primary modeling assumptions (summarized in Table 5) for operating HLCR and meeting the demands for Canton, CCMWA, and Cartersville are as follows:

Baseline/No Action (Current operations):

HLCR operated as an amenity flow-through reservoir.
The Baseline/No Action alternative operates HLCR as it is currently operated: as an amenity flow-through reservoir. While a “flow-through reservoir” has no operational rules and simply releases inflow, an “amenity flow-through reservoir” has a few minor operating rules. In the case of HLCR, the operation aims to keep a full pool while releasing to meet 7Q10 flow requirements and pumping from the Etowah to make up for evaporative losses.

Occasional Allatoona water supply storage account overdrafts.
Both CCMWA and Cartersville have at times made withdrawals that exceeded the amount of storage available in their allocated storage at Allatoona, according to the Mobile District's storage accounting methodology. The 2006 demands – reflecting the greatest reported water supply withdrawals from Allatoona and used to represent "current" withdrawals for purpose of the Water Control Manual Update and NEPA analysis – would result in periodic exceedances. The Baseline/No Action modeled approach captures these exceedances to best reflect what is currently happening in the basin, under the modeling assumptions outlined above.

<u>All other alternatives (Proposed and permitted operations):</u>

Operate HLCR to provide supplemental releases as necessary, based on existing permits and infrastructure.
HLCR was constructed in connection with a Clean Water Act (CWA) Section 404 permit, in order to provide water supply for the City of Canton and the CCMWA, based on a plan for CCMWA to build infrastructure to convey water from the City of Canton to CCMWA's water treatment plants. While Canton has an intake on the Etowah River, the infrastructure to convey water to CCMWA's treatment plants does not currently exist. Subsequent to the CWA permit issuance, CCMWA has proposed an alternate mode of operations that would involve the use of Allatoona as a flow-through conveyance for releases from HLCR that could be withdrawn from CCMWA's existing storage account at Allatoona. Because this proposal would involve additional technical and policy determinations by the Corps, and a subsequent federal action based on those determinations that would be beyond the scope of the ACT Water Control Manual Update, the latter proposal was not modeled for this report. Since CCMWA has not constructed intake facilities and infrastructure at Canton, and because the Corps will not be in a position to make a determination regarding CCMWA's proposed operation of HLCR in conjunction with Allatoona before completion of the ACT Water Control Manual Update, the model assumes CCMWA will not make withdrawals from its HLCR account. The modeled assumptions do assume that the City of Canton may make withdrawals from its HLCR account, but projected demand is never high enough to require these releases. Therefore, although the alternatives model HLCR as a water supply reservoir for the City of Canton, the modeled operations for the alternatives *effectively* result in HLCR being operated as an amenity flow-through facility, passing inflows, with releases to meet 7Q10 flows, and pumping from the Etowah to make up for evaporative losses.

Apply storage accounting to limit modeled withdrawals from Allatoona to available water supply storage.
Both CCMWA and Cartersville have at times made withdrawals that exceeded the amount of storage available in the allocated storage accounts at Allatoona, according to the Mobile District's storage accounting methodology. The 2006 demand – reflecting the greatest reported water supply withdrawals from Allatoona and used to represent "current" withdrawals for the purpose of the Water Control Manual Update and NEPA analysis – would result in periodic exceedances, which are indicated in the Baseline/No

Action alternative. The Corps recognizes that the State of Georgia has requested additional water supply storage in Lake Allatoona, as well as policy changes that could affect the yield of existing storage, but those requests would involve additional technical and policy determinations by the Corps, and subsequent federal actions based on those determinations that would be beyond the scope of the ACT Water Control Manual Update. Accordingly, for alternatives other than the Baseline/No-Action alternative, the ResSim model assumes that withdrawals will be made only from available water supply storage as measured by the Mobile District's current storage accounting methodology. Therefore, the ResSim model for the alternatives does not allow storage accounts to be overdrawn, and withdrawals are limited to what is available in the accounts.

Table 5. Summary of assumptions for storage accounting at Allatoona and Hickory Log Creek Reservoirs

Alternative	Demands	Allatoona Account	HLCR Releases	Pump to keep HLCR full
Baseline/No Action	2006	allow overdraw	• meet 7Q10 • Qout = Qin	make up: • evaporation
All other Alternatives	2006[1]	limit withdrawals to account storage	• meet 7Q10 • Canton account [2]	make up: • evaporation • anything released for Canton

[1] For the sensitivity analysis discussed in Section V, below, "RPlanG30" demand is based on projection increases to 2006 demand for the year 2031.
[2] Canton demands are never large enough to require releases from HLCR.

D. Canton, CCMWA, and Cartersville Withdrawals and Return Flows

Withdrawals and return flows for the three storage account holders in Allatoona and HLCR are calculated based on demand, Etowah natural flow, and account balance. These calculations are modeled with the use of a single state variable script, "Accounting_HLCmain". This state variable is described in **Section VIII. Water Supply Storage Accounting** State Variable.

The City of Canton demands are met at the intake from the Etowah River at Canton. In the model, the City of Canton's withdrawals are met by a diversion at Canton, which has a fixed 64% return flow to Allatoona_IN (Figure 17).

1) **Etowah natural flow**
The City of Canton may withdraw up to their original permitted value of 5.45 mgd (8.4 cfs) from the natural flow in the Etowah River. Based on the updated permit, Canton can also withdraw an additional amount up to a total maximum monthly average of 18.7 mgd (28.9 cfs) as long as it can pass the instream 7Q10 of 250 cfs.

2) **HLCR account**
After taking the water available in the Etowah River, if Canton still has unmet demand, it will draw from its account at HLCR. Any releases from HLCR will be routed down the Etowah and withdrawn at the intake at Canton.

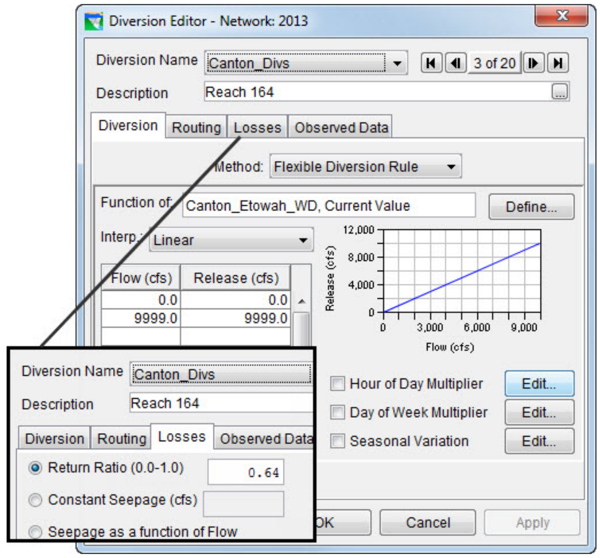


Figure 17. Canton diversion with return flow ratio

CCMWA demands are met through withdrawals from its account at Allatoona. This is modeled with a diverted outlet from Allatoona. Return flows are represented by a diversion at Allatoona_IN. The calculated return flow is input as a negative value. Figure 18 shows the Cartersville diverted outlet rule "CCMWA_Qo" (based on state variable "Allatoona_CCM_Q") and the return flow flexible diversion rule (based on state variable "Allatoona_CCM_Qreturn").

Cartersville demands are met through its account at Allatoona. This is modeled with a diverted outlet at Allatoona. Return flows are represented as a diversion from the City of Cartersville. Figure 19 shows the Cartersville diverted outlet rule "Cartersville_Qo" (based on state variable "Allatoona_CCM_Q") and the return flow flexible diversion rule (based on state variable "Allatoona_CCM_Qreturn").

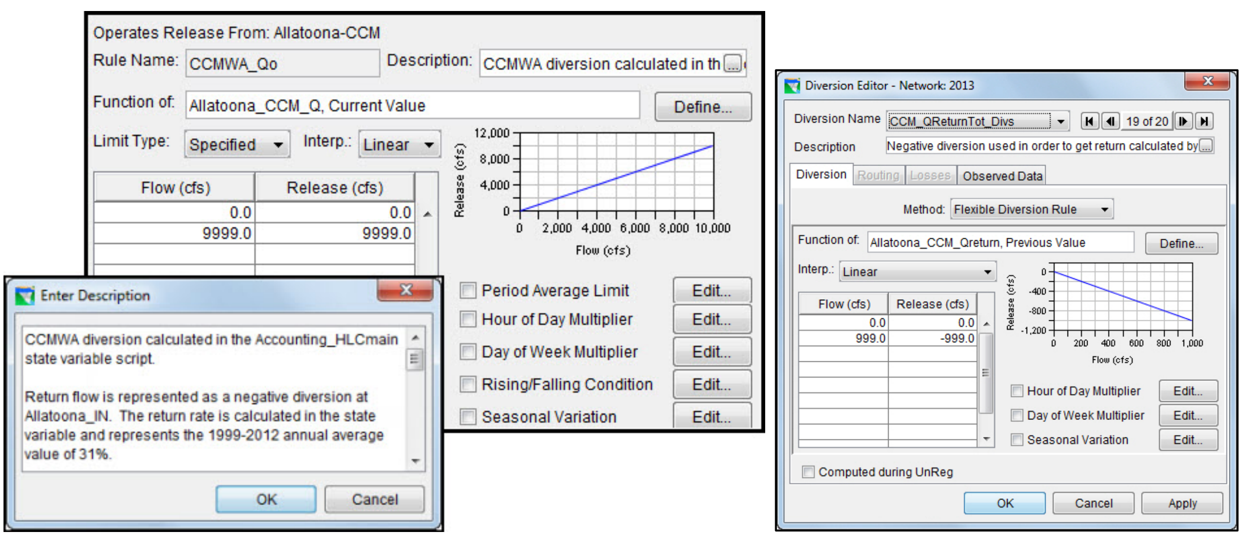


Figure 18. CCMWA diverted outlet rule at Allatoona and CCMWA return flow modeled as a negative diversion based on the state variable Allatoona_CCM_Qreturn.

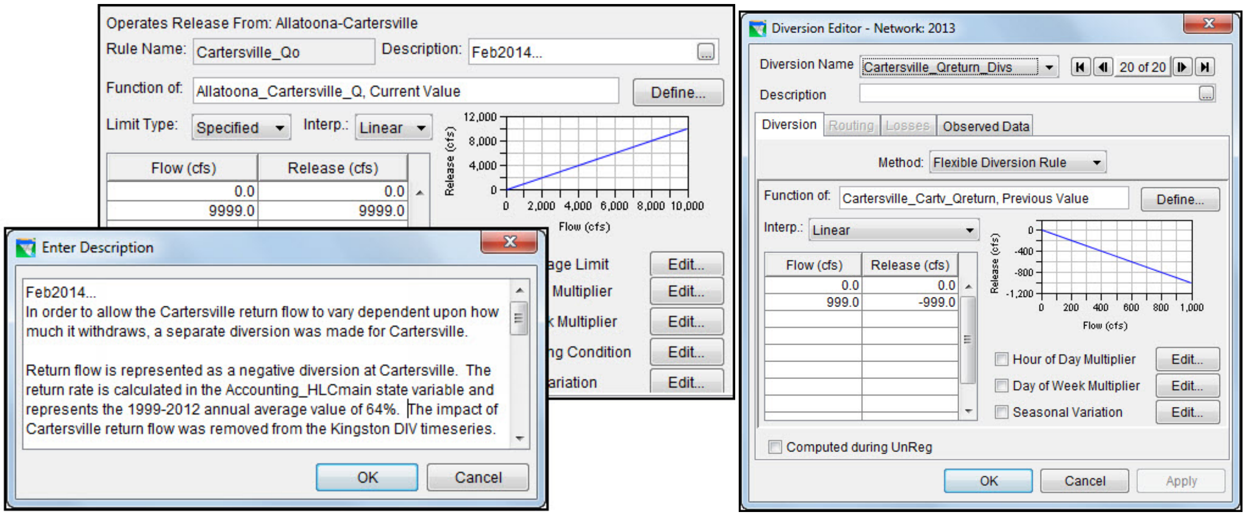


Figure 19. Cartersville diversion rule at Allatoona and Cartersville return flow modeled as a negative diversion at Cartersville based on the state variable Cartersville_Cartv_Qreturn.

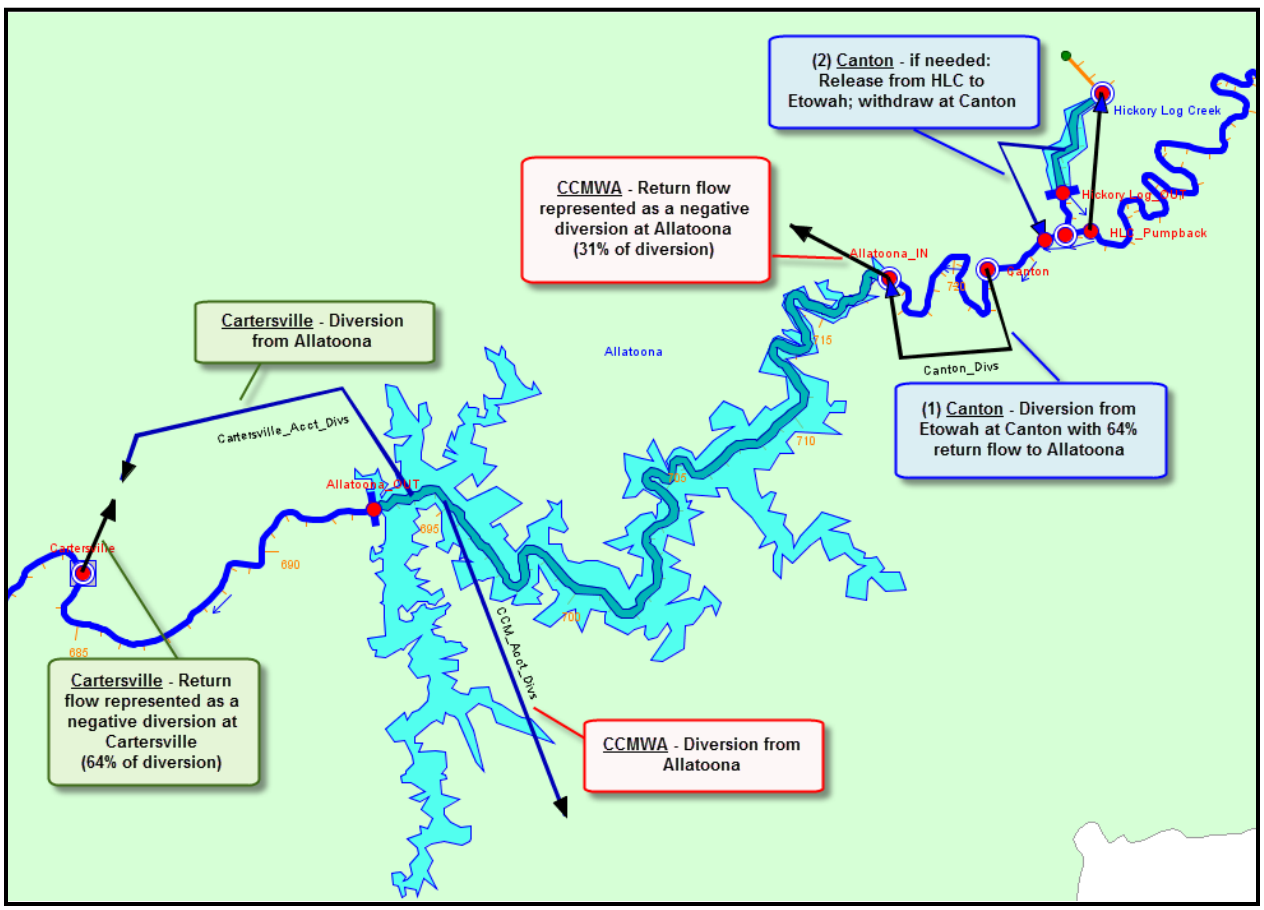


Figure 20. Prioritization of Canton, CCMWA, and Cartersville withdrawals

E. Hickory Log Creek Pump Operation

When inflow is insufficient to keep Hickory Log Creek Reservoir full, it can be filled by pumping water from the Etowah River (EPD Permit #028-1491-05). Figure 21 shows the modeled representation of HLCR's pump. Model assumptions are as follows:

1) **The pump is turned off when HLCR is making releases from its storage accounts.**
   Releases for water account holders are passed through the pump station, so account releases and pumping cannot happen at the same time. The decision to release or pump (or neither) is made on a daily basis in the model.

2) **The pump is used to maintain HLCR at the top of its Conservation Pool (1060 feet).**
   Both accounts are full when HLCR is at the top of Conservation.

3) **The maximum permitted pump diversion is 60.333 cfs.**
   The Environmental Protection Division permit allows for no more than 39 mgd (60.333 cfs).

4) **The minimum pass-by requirement is the lesser of the 7Q10 (300 cfs) or natural flow in the Etowah River.**
   In the model, the pump station is represented upstream of the confluence of the Etowah River and Hickory Log Creek, although in reality, it is located just downstream of the confluence. Modeling the pump below the reservoir would cause a circular dependency between reservoir and pump inflow and outflow. However, the determination of water available to pump is made based on the flow downstream of the confluence.

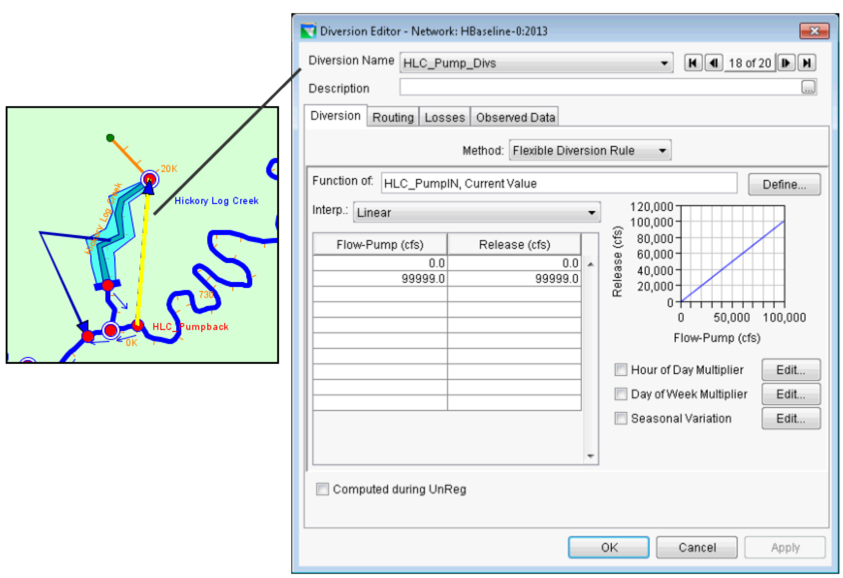


Figure 21. Hickory Log Creek Reservoir pump represented as a diversion

F. Other Hickory Log Creek Operation Assumptions

The Hickory Log Creek "Storage Accounting" Operation Set is used for all alternatives. It includes a rule for providing a minimum flow to the river, and a rule for determining outflow from the storage accounts. The latter rule is based on a state variable, "Accounting_HLCmain", which calculates releases based on the active alternative. This flexibility makes the Operation Set appropriate for use whether one or two storage accounts are in use or the reservoir is only used as an amenity flow-thru. Figure 22 shows the "Storage Accounting" Operation Set. The "Accounting_HLCmain" logic is described in detail in **Section VIII. Water Supply Storage Accounting** State Variable.

Minimum Flow from Hickory Log Creek Dam
A minimum of the lesser of 7Q10 (3.5 cfs) or inflow must be passed from Hickory Log Creek Dam. This operation is modeled using the "MinQ_instream" (Figure 23) rule in all zones.

Evaporation
Evaporation at Hickory Log Creek Reservoir was assumed to be proportional to the evaporation at Allatoona. The Allatoona evaporation rate time-series was used at HLCR.

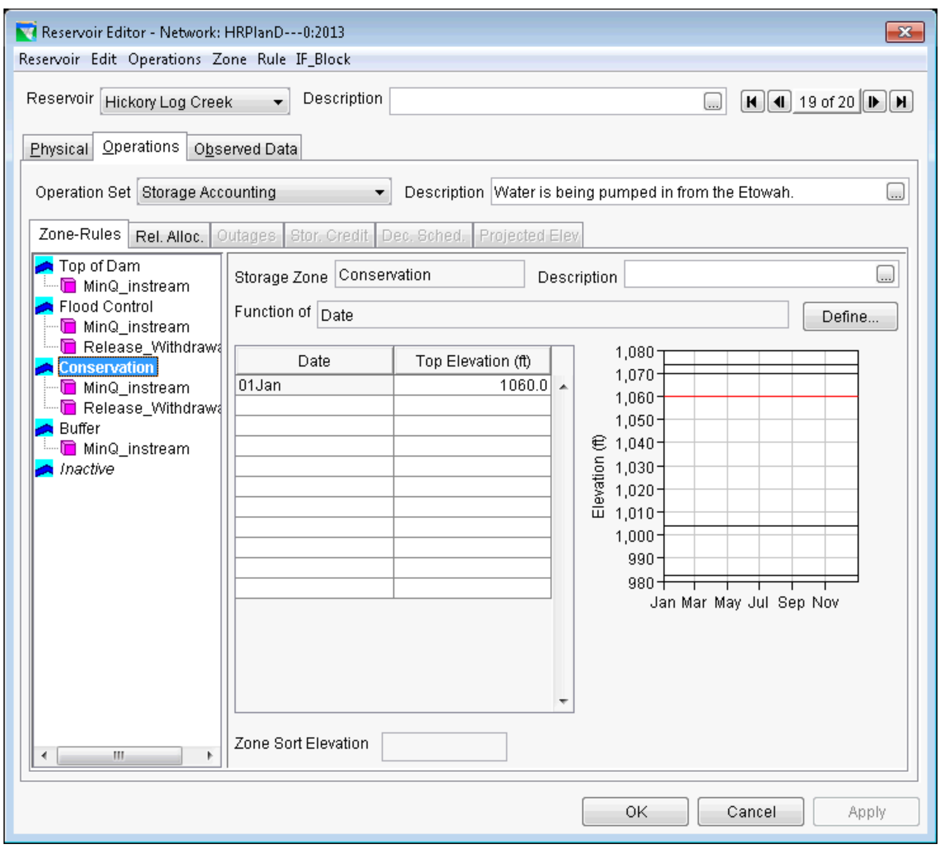


Figure 22. Hickory Log Creek Reservoir "Storage Accounting" Operation Set

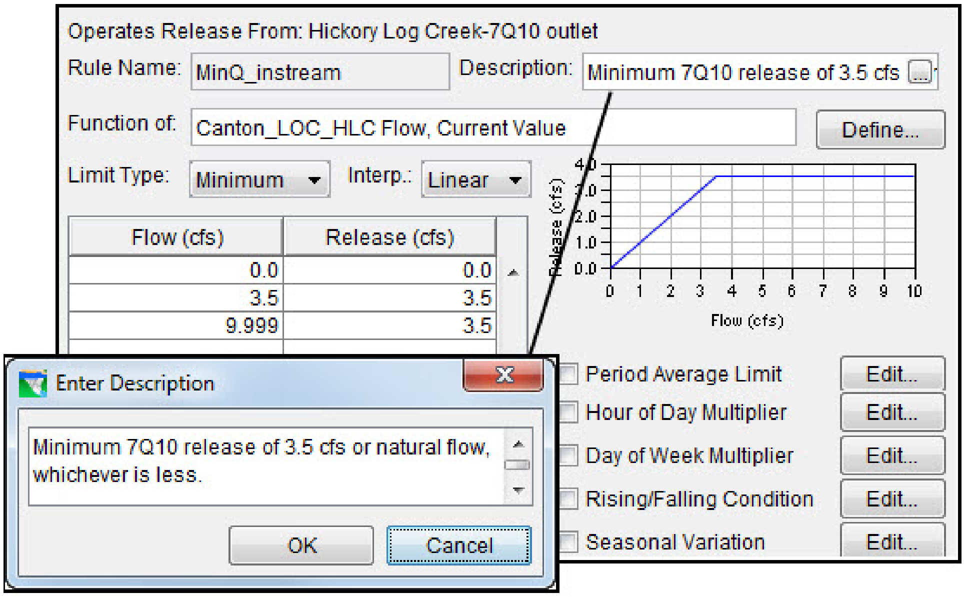


Figure 23. Minimum release from Hickory Log Creek Reservoir for meeting instream 7Q10

Releases for Storage Account Holders

The "Release_Withdrawal" rule sends any releases for storage account holders through a diverted outlet. Its calculations are based on the state variable "HLC_Acct_Out". (HLCR's actual diverted outlet is the same as the pump station, but it is represented as a separate entity in the model.)

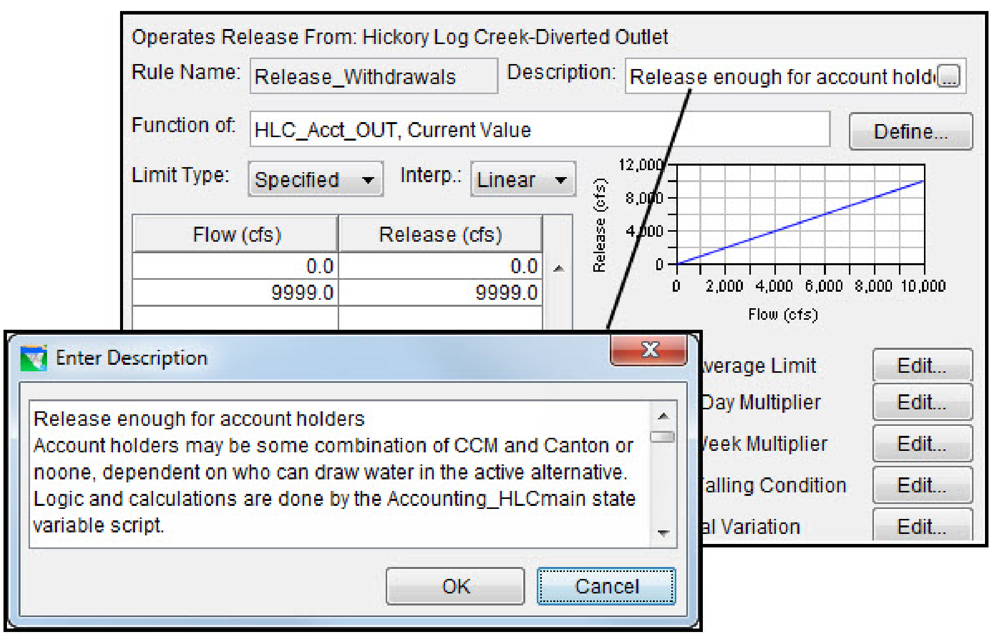


Figure 24. Hickory Log Creek Reservoir's diverted outlet releases are based on the "HLC_Acct_OUT" state variable

IV. Other Model Updates

Aside from the significant model change to account for Hickory Log Creek, several other modifications and corrections were made.

A. Updated Data

Some model input data was updated and all it was extended through the end of 2012. The USGS gage data for Hackneyville, observed data, and lookback data were updated and extended accordingly. The unimpaired flows were updated to address comments submitted by the states of Alabama and Georgia. The Alabama water use data for calendar year 2012 is provisional. Although the ResSim model runs extend through year 2012, the impact analysis only includes the period 1939-2011. *The model results for 2012 are provided for informational purposes only.*

B. Model Corrections

In August 2011, the following corrections were made to the model:

The Allatoona "PowerGC Z2_0-1hr" rule was corrected to call for Power operation on weekdays only. This modification only impacted Baseline operations.

The Induced Surcharge rule at Allatoona was corrected to have a Time for Pool Decrease of 24 hours instead of 1 hour. This change is present in all alternatives, but has little to no impact on the results.

RF Henry's variable power capacity was increased to represent four turbines instead of one. This impacted all alternatives.

In 2013, the operations for all alternatives besides Baseline were updated allowing Jordan to divert to Bouldin regardless of drought conditions.

C. Induced Surcharge Rules

The Induced Surcharge rules at Allatoona and Cartersville were updated. These rules were represented by specifying the Emergency Spillway Release Diagram curves rather than using an Induced Surcharge function. Originally, all values were filled out, even if they were set to zero. The table was updated so that blank cells are used to represent values that are not important to the lookup. Numbers greater than inflow were also deleted. These changes are present in all alternatives. It has no impact on the results, because ResSim corrects for this anyway. ResSim automatically restricts the induced surcharge release to be no greater than inflow, and it outputs a message about the correction. So the change is for clarity and clean modeling, even though it doesn't affect the end results.

D. Carters Flood Control Operation

The Carters-Carters ReReg flood control operation was changed from a seasonal maximum channel capacity rule (varied from 3,200 to 5,000 cfs) to a constant maximum capacity of 5,000 cfs. This change was instigated by personal communication between Jonathan Atwell of NOAA and Hydrologist Kent Frantz of the Peachtree City Weather Service. The County Emergency Manager agreed that increasing the maximum flow to 5,000 during the growing season would not be a problem. For both Baseline and Seasonal Operation Sets at Carters ReReg, the seasonal maximum channel capacity rule was replaced with "MaxCC_5000", which has a constant maximum of 5000 cfs (Figure 25). For both Baseline and Seasonal Operation Sets at Carters the "Max@ReReg IN" rule was updated from a seasonally varying maximum to a constant max of 5000 cfs (Figure 25).

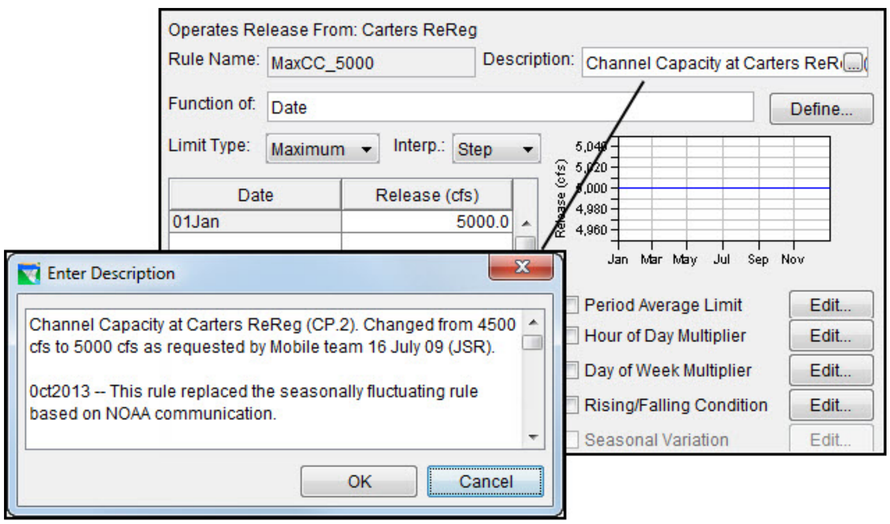


Figure 25. Channel capacity downstream of Carters ReReg was updated to a constant 5000 cfs.

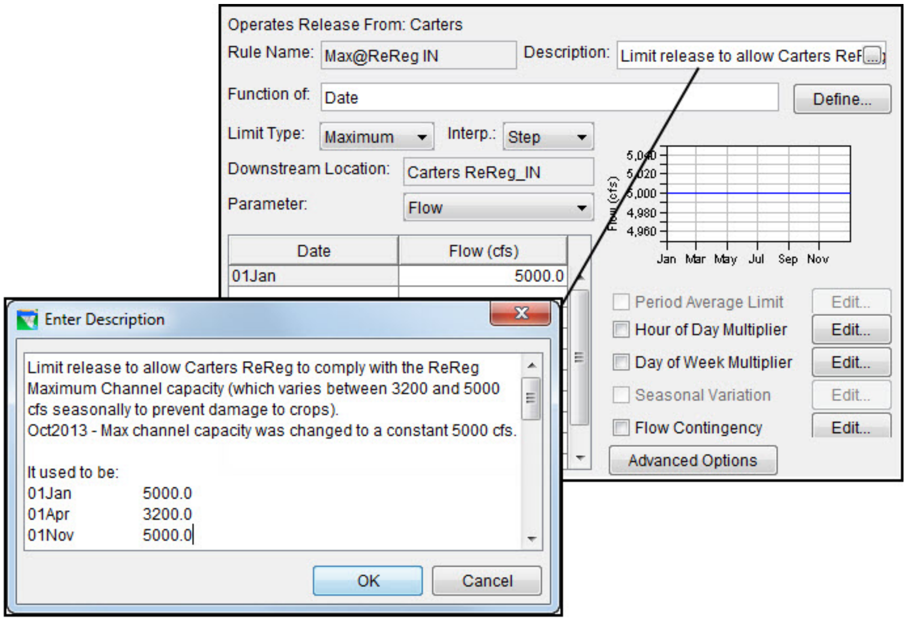


Figure 26. Carters' Max@ReReg IN was updated to a constant 5000 cfs.

E. Alabama River Navigation Template

The Alabama River Navigation Template was revised to better reflect post-dredging conditions. SAM's Operations Division requested the representation of a more gradual filling of the channel in the November-December time period.

During the public comment period, Operations Division expressed some concern regarding the adopted navigation template for the Alabama River. The current template shows that the channel fills in almost immediately in November. Operations believes there is a gradual fill-in of the channel.

Operations provided two sets of graphs to support their position. The "tailwater chart project" set of graphs takes into effect both water surface elevations and channel bottom surveys. The "control depth" set of charts is based on the established "design low" water surface elevation profile, which means the "control depth" set of charts is based on the channel bottom surveys, only without regard to actual water surface elevation.

Water Management spent some time reviewing the charts, particularly the annual "Depth of Available Channel at Design Low Water Surface Elevation". The navigation template used in the modeling to support the ACT WCM update indicates a rapid channel refill in the month of November. The charts reveal different response depending on the flow conditions. It appears the channel refill is considerably slower during low-flow and high flow years. During normal flow years the fill-in rate is slightly higher. However, in all cases it is obvious that the Alabama River channel does not fill in as abruptly as was indicated in the original navigation template used for the modeling.
Therefore, the navigation template was modified to show a more gradual filling in of the channel during the months of November and December. Figure 27 depicts the original

navigation template used, and Figure 28 shows the updated template, reflecting the gradual fill. Operations concurred with this adjustment via e-mail 20 Nov 2013.

The changes to the template impacted several tables of navigation targets, which were updated in the "NAV_CheckBI" state variable.

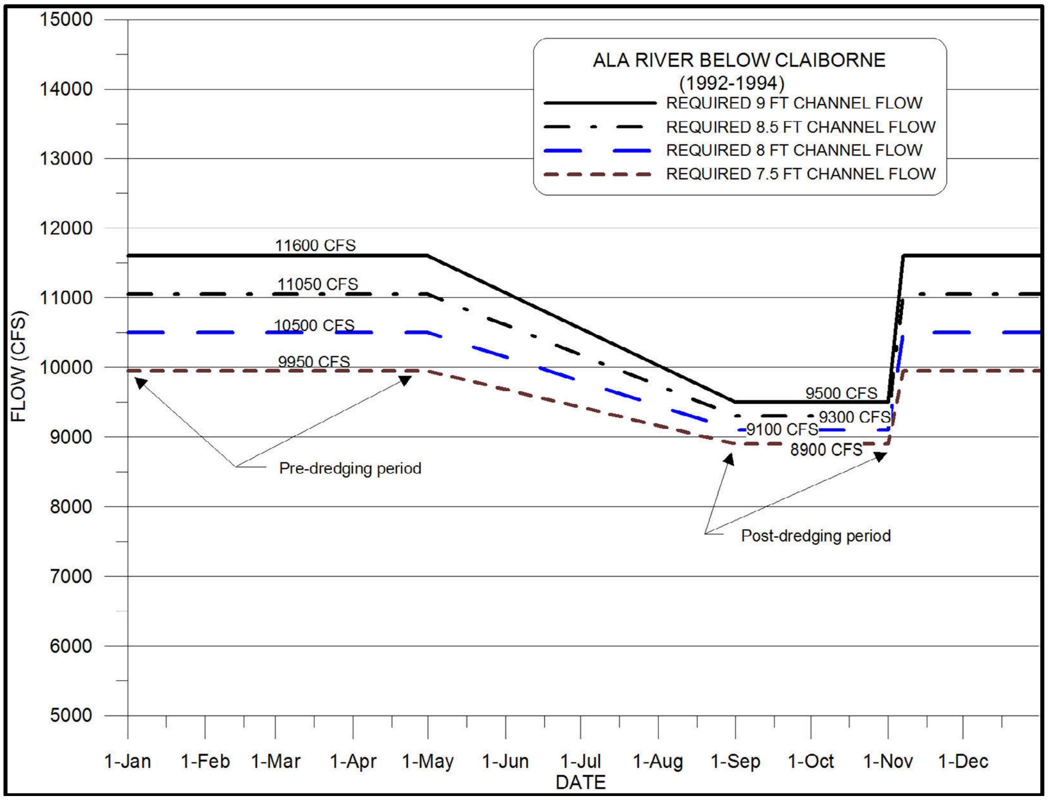


Figure 27. This navigation template for the Alabama River suggested a rapid filling in of the dredged channel in November.

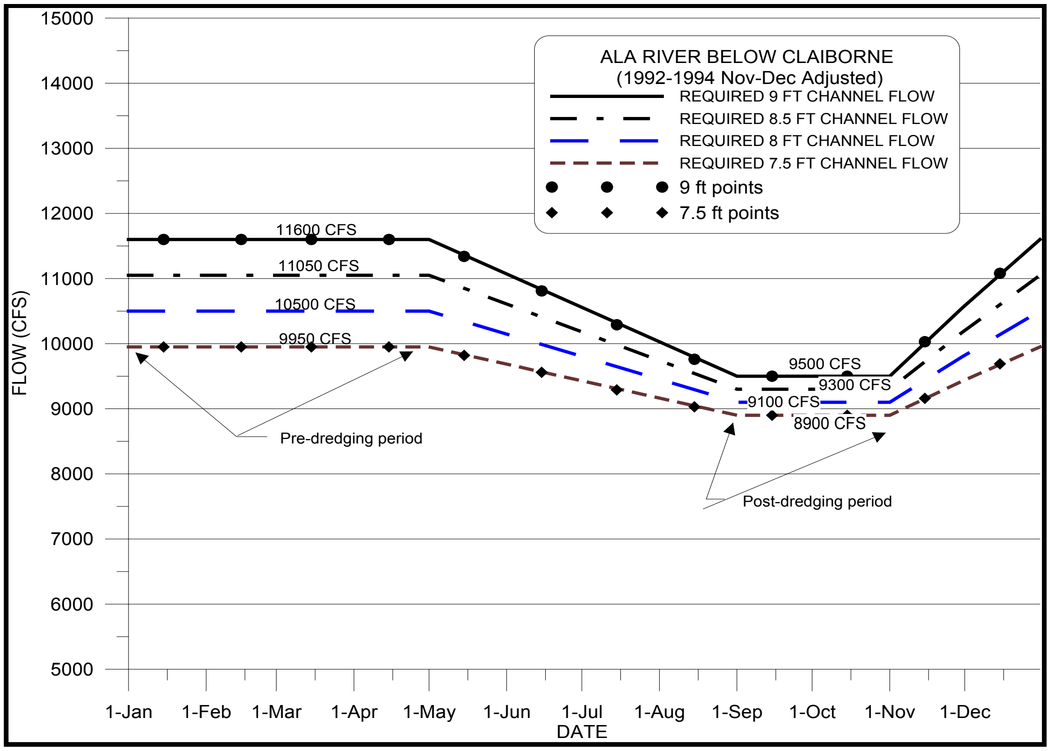


Figure 28. The new navigation template for the Alabama River uses a more realistic gradual sedimentation of the dredged channel.

Table 6. Original and Revised Prorated Navigation Targets (in cfs); represented at JBT Goal in the model. Values in blue are different.

	Original Prorated Navigation Target				Revised Prorated Navigation Target			
Month	9' Navigation Target	**9' APC Navigation Target**	7.5' Claiborne Target	**7.5' APC Navigation Target**	9' Navigation Target	**9' APC Navigation Target**	7.5' Claiborne Target	**7.5' APC Navigation Target**
Jan	11,600	9,280	9,950	7,960	11,600	9,280	9,950	7,960
Feb	11,600	9,280	9,950	7,960	11,600	9,280	9,950	7,960
Mar	11,600	9,280	9,950	7,960	11,600	9,280	9,950	7,960
Apr	11,600	9,280	9,950	7,960	11,600	9,280	9,950	7,960
May	11,100	8,880	9,740	7,792	**11,340**	**9,072**	**9,820**	**7,856**
Jun	10,600	8,480	9,530	7,624	**10,810**	**8,648**	**9,560**	**7,648**
Jul	10,100	8,080	9,320	7,456	**10,290**	**8,232**	**9,290**	**7,432**
Aug	9,600	7,680	9,110	7,288	**9,760**	**7,808**	**9,030**	**7,224**
Sep	9,100	7,280	8,900	7,120	**9,500**	**7,600**	**8,900**	**7,120**
Oct	9,100	7,280	8,900	7,120	**9,500**	**7,600**	**8,900**	**7,120**
Nov	11,600	9,280	9,950	7,960	**10,030**	**8,024**	**9,160**	**7,328**
Dec	11,600	9,280	9,950	7,960	**11,080**	**8,864**	**9,690**	**7,752**

Table 7. Original and revised Basin Inflow requirements

	Original Basin Inflow to meet Navigation Channel						Revised Basin Inflow to meet Navigation Channel					
Month	9' APC Nav. Target	Monthly Historic Storage Usage	Req. Basin Inflow	7.5' APC Nav. Target	Monthly Historic Storage Usage	Req. Basin Inflow	9' APC Nav. Target	Monthly Historic Storage Usage	Req. Basin Inflow	7.5' APC Nav. Target	Monthly Historic Storage Usage	Req. Basin Inflow
Jan	9,280	-994	**10,274**	7,960	-994	**8,954**	9,280	-994	**10,274**	7,960	-994	**8,954**
Feb	9,280	-1,894	**11,174**	7,960	-1,894	**9,854**	9,280	-1,894	**11,174**	7,960	-1,894	**9,854**
Mar	9,280	-3,028	**12,308**	7,960	-3,028	**10,988**	9,280	-3,028	**12,308**	7,960	-3,028	**10,988**
Apr	9,280	-3,786	**13,066**	7,960	-3,786	**11,746**	9,280	-3,786	**13,066**	7,960	-3,786	**11,746**
May	8,880	-499	**9,379**	7,792	-499	**8,291**	9,072	-499	**9,571**	7,856	-499	**8,355**
Jun	8,480	412	**8,068**	7,624	412	**7,212**	8,648	412	**8,236**	7,648	412	**7,236**
Jul	8,080	749	**7,331**	7,456	749	**6,707**	8,232	749	**7,483**	7,432	749	**6,683**
Aug	7,680	1,441	**6,239**	7,288	1,441	**5,847**	7,808	1,441	**6,367**	7,224	1,441	**5,783**
Sep	7,280	1,025	**6,255**	7,120	1,025	**6,095**	7,600	1,025	**6,575**	7,120	1,025	**6,095**
Oct	7,280	2,118	**5,162**	7,120	2,118	**5,002**	7,600	2,118	**5,482**	7,120	2,118	**5,002**
Nov	9,280	2,263	**7,017**	7,960	2,263	**5,697**	8,024	2,263	**5,761**	7,328	2,263	**5,065**
Dec	9,280	1,789	**7,491**	7,960	1,789	**6,171**	8,864	1,789	**7,075**	7,752	1,789	**5,963**

F. Alabama Power Company Recommended Changes

Elevation-Area-Storage Curves

Elevation-Area-Storage curves for Alabama Power Company (APC) reservoirs were updated to the latest values. These changes were minor, primarily due to making refinements to the conversion factor. A document emailed 28Oct2013 by Christy Nix of APC explained:

"The units of measure for volume utilized by Alabama Power Company are cfs-days. The units of measure for volume utilized by the Corp of Engineers (COE) are acre-feet. Throughout the years, conversion errors have been introduced when moving between the two units of measure. In order to have consistent numbers between APC and COE, the EVA tables that reside in Alabama Power's current database were extracted and converted from cfs-days to acre-feet by the factor 1.9835. In many instances, these curves did not cover the full range needed by the RES SIM model. The extensions for the curves were taken from either a reservoir regulation manual or from the RES SIM Excel spreadsheet. These numbers were converted from acre-feet to cfs-days by the factor 1.9835."

The Power Plant outlet elevation at HN Henry was changed from 480 ft (elevation of spillway crest) to 500 ft., which is the correct unit limit.

The Logan Martin Power Plant outlet minimum elevation was changed from 452.0 ft to 452.5 ft to match the Inactive elevation.

The Jordan Power Plant outlet elevation range was corrected from 248-268 ft to 249-267 ft.

The Martin Power Plant outlet maximum elevation was corrected from 490 ft to 500 ft., to match the Top of Dam elevation.

The Harris Dam length was changed from 1,142 ft. to 3,242 ft. to include all of the non-overflow sections of the dams, which had not been completely counted previously.

Basin Inflow Drought Plan Trigger

Christy Nix of APC made adjustments to the Basin Inflow table used to determine drought triggers. In a 26Mar2012 email, she described the approach to the calculations:

"I made them based off a non leap year. We use a day of year system for following the rule curve, so all of our Rule Curves have 366 values. In a non leap year, the 366th value is just not used.
Based off day of year, I looked up the corresponding volume for the start of each month. For example for January at Weiss, (Feb 1st volume – Jan 1st volume)/31 days. Then for February at Weiss (Mar 1st volume – Feb 1st volume)/28 days.
So on and so on. There are some slight changes on the first months, most is on the bottom where I had previously counted to the last day of the month, which doesn't capture all the volume."

Table 8. Original and Revised Basin Inflow Table

	Original Basin Inflow Table					Revised Basin Inflow Table (Mar2012)					
Month	Coosa Filling Volume	Tallapoosa Filling Volume	Total Filling Volume	4640 Release	*Total Basin Inflow Needed	Coosa Filling Volume	Tallapoosa Filling Volume	Total Filling Volume	4640 Release	*Total Basin Inflow Needed	Delta Basin Inflow
Jan	629	0	629	4640	5269	628	0	628	4640	5268	1
Feb	647	1968	2615	4640	7255	626	1968	2594	4640	7234	21
Mar	603	2900	3503	4640	8143	603	2900	3503	4640	8143	0
Apr	1683	2585	4268	4640	8908	1683	2585	4269	4640	8909	-1
May	242	0	242	4640	4882	248	0	248	4640	4888	-6
Jun	0	0	0	4640	4640	0	0	0	4640	4640	0
Jul	0	0	0	4640	4640	0	0	0	4640	4640	0
Aug	0	0	0	4640	4640	0	0	0	4640	4640	0
Sep	-602	-1304	-1906	4640	2734	-612	-1304	-1916	4640	2724	10
Oct	-1331	-2073	-3403	4640	1237	-1371	-2132	-3503	4640	1137	100
Nov	-888	-2659	-3547	4640	1093	-920	-2748	-3667	4640	973	120
Dec	-810	-1053	-1863	4640	2777	-821	-1126	-1946	4640	2694	83

G. Martin and Logan Martin Tandem Operation for Baseline

In reviewing model results, it was found that in the Baseline/No Action alternative, Logan Martin and Martin didn't appear to be drawing down together during the major drought periods (particularly 1986 and 2007). (See 1986 and 1988 in Figure 29.) During these periods, Logan Martin was being emptied more rapidly than Martin, and JBT goal was being missed, even though Martin still had water (and should have been providing for JBT goal). Additionally, there were periods when it appeared that JBT goal was being overshot by a consistent amount. The results were reviewed further to determine whether or not these oddities were explainable and correct.

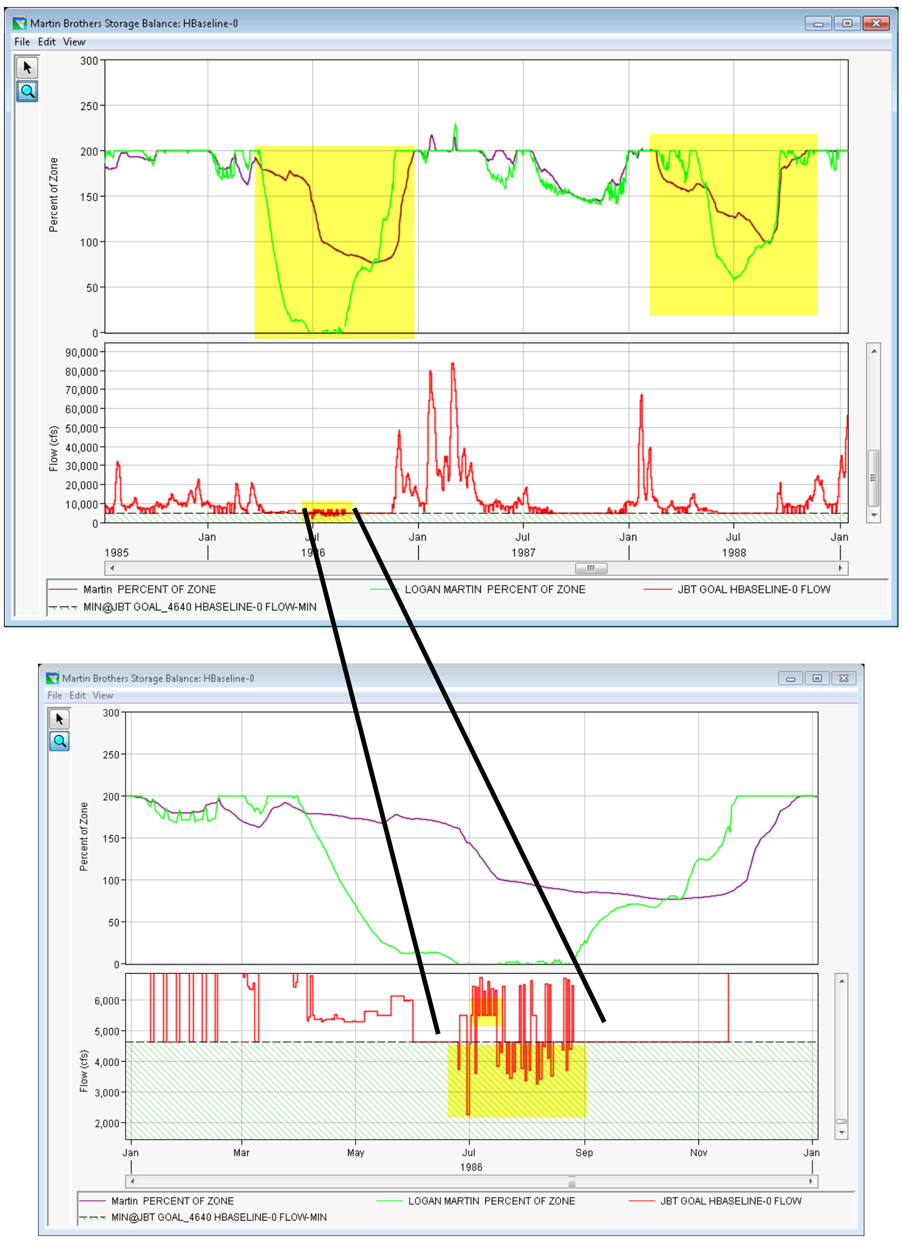


Figure 29. Storage balance between Martin and Logan Martin during periods of unbalanced drawdown

It was determined that Logan Martin draws down much faster than Martin primarily because it is providing for the J.D. Minimum downstream control rule. Since J.D. Minimum is sometimes greater than JBT Goal (April – May, Figure 30), when Logan Martin meets the J.D. Minimum (which it alone is responsible for), JBT Goal is automatically met and Martin does not have to release anything to help. Therefore, Logan Martin can draw down much faster than Martin during April – May. This operation is correct.

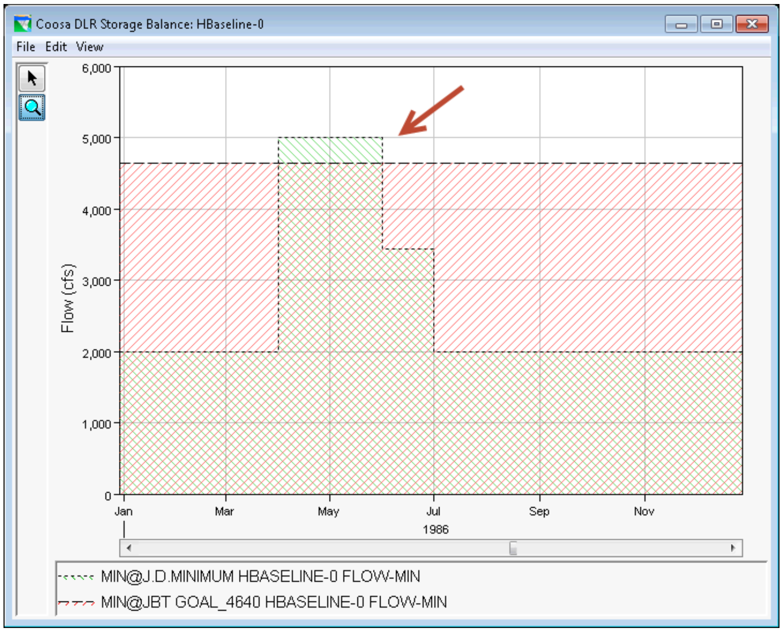


Figure 30. JD Minimum is greater than JBT Goal in April and May.

The occasions when Martin had plenty of water but JBT goal was missed, were happening because Martin was not getting an accurate calculation of the JBT Goal need. Logan Martin's releases are calculated first in the compute block, and Martin relies on Logan Martin to initiate the first calculation of this rule. This can mean that if Logan Martin does not compute a release for JBT Goal (e.g., when Logan Martin is in its Operating Inactive pool and the rule is turned off), Martin does not calculate JBT Goal on its own. So when Logan Martin empties, it is possible that no reservoir is operating to meet JBT Goal. This is a mistake in ResSim logic.

There are also occasions when JBT Goal's need is exceeded. That can happen when Logan Martin is operating for a higher demand at J.D. Minimum, which is correct operation, but it can also happen when Martin has inaccurate information about what is being released from the Coosa. This is a shortcoming in ResSim logic.

Sometimes there is a lot of oscillation around meeting JBT Goal. The tandem operation of Weiss, HN Henry, and Logan Martin cause the oscillation to be seen in all three reservoirs, and it happens when one of them is sitting on a zone boundary. Better Zone Boundary logic in ResSim could avoid these large oscillations.

The following adjustments were made to improve the JBT Goal and system operations:

1) An If Block was added to HN Henry to help smooth Zone Boundary-related oscillations, which affect tandem operations with Logan Martin (Figure 31). Logan Martin's Operating Inactive pool is at 456.25 feet. This If Block allows HN Henry to perform tandem operations for Logan Martin, even when HN Henry is in its operating inactive pool, but only if Logan Martin is not lower than 0.25 feet below its operating inactive pool. The effect of this rule is significant for smoothing operations. It does not cause HN Henry to draw into its Operating Inactive pool more than 0.22 feet, and the drawing on Operating Inactive only occurs twice in the period of record.

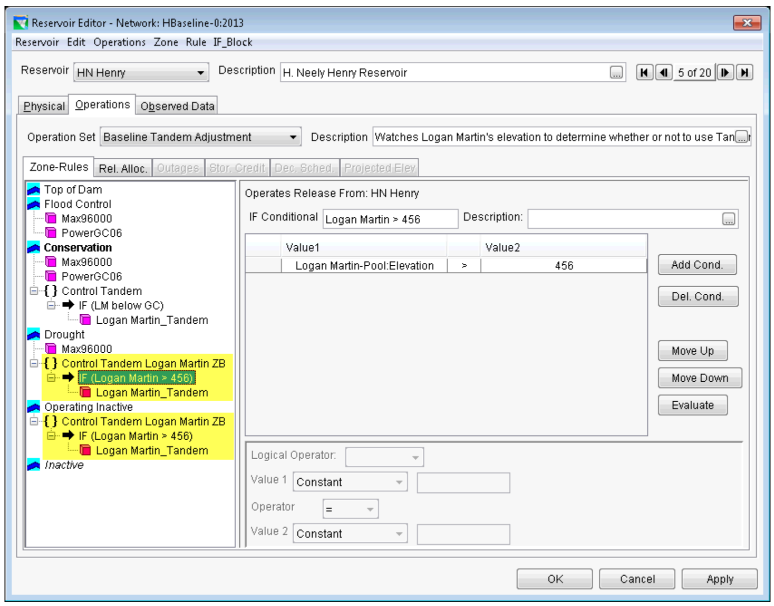


Figure 31. New If Block at HN Henry to help smooth zone boundary-related oscillations

2) An If Block was added to Logan Martin to force it to operate for JBT Goal only when it is at least 0.5 feet above its inactive pool (Figure 32). Otherwise, the JBT Goal rule is turned off at Logan Martin.

3) An If Block was added to Martin to help it better respond to Logan Martin (Figure 33). When Logan Martin is too low to operate for JBT Goal, a new downstream rule is used for Martin. This rule is only used in the Martin reservoir, so it does not rely on Logan Martin to initiate the calculation of the JBT Goal downstream control rule. This allows ResSim to avoid the problem of the downstream control rule shutting off for BOTH Logan Martin and Martin when Logan Martin is below Operating Inactive.

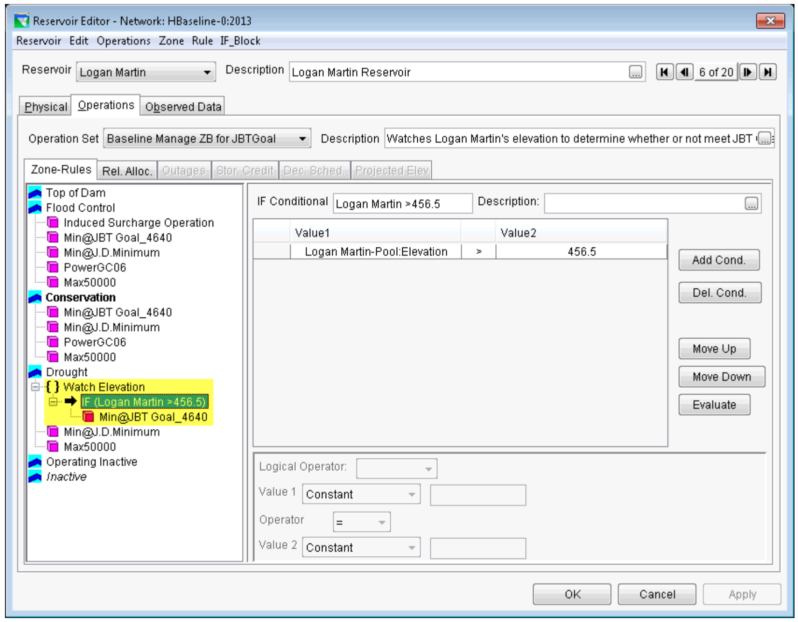


Figure 32. New If Block at Logan Martin to allow it to stop operating for JBT goal when pool gets too low

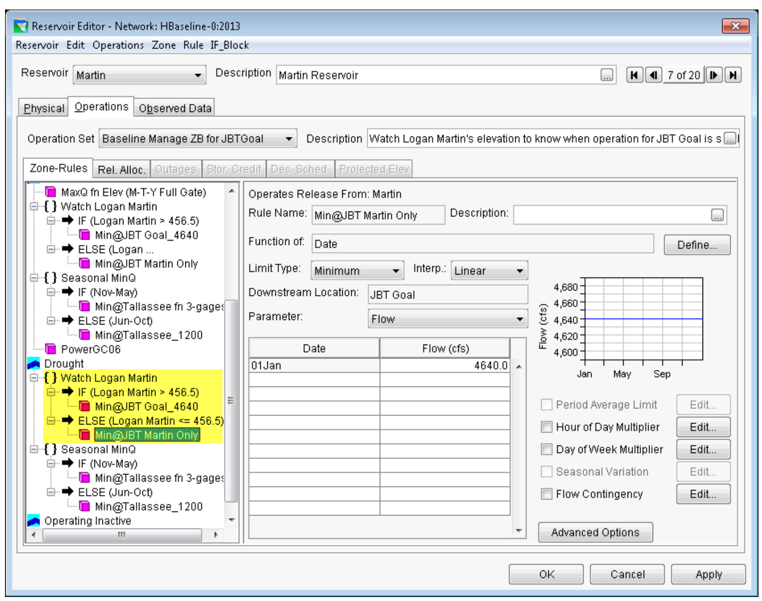


Figure 33. New If Block at Martin to recognize when Logan Martin is not operating for JBT Goal

4) Under ResSim Compute Options, the minimum number of passes was changed from 2 to 6. (Downstream control logic forces the minimum number of passes up to 4, so this change represents a total increase of 2 passes.) Run time increased from 1,855 seconds to 3,414 seconds, an increase of about 80%. This allowed Martin to get a better estimate of what was being released from the Coosa.

The resulting improvements to JBT Goal operation are smooth and consistent (Figure 34). The operation does not overshoot the goal, except as required by the operation for JDMin. (Compare Figure 34 with Figure 29.)

These changes were only necessary for the Baseline/No Action alternative, which is the only alternative that has trouble with Logan Martin's pool getting down to Operating Inactive. It is possible that increasing the number of passes for all alternatives would smooth results everywhere, but it is also possible that this would just shift periods of oscillation slightly. All other alternatives are doing well with meeting JBT Goal, so it was decided that the potential benefits of increasing the number of passes for all alternatives did not justify the additional time it would take to run them.

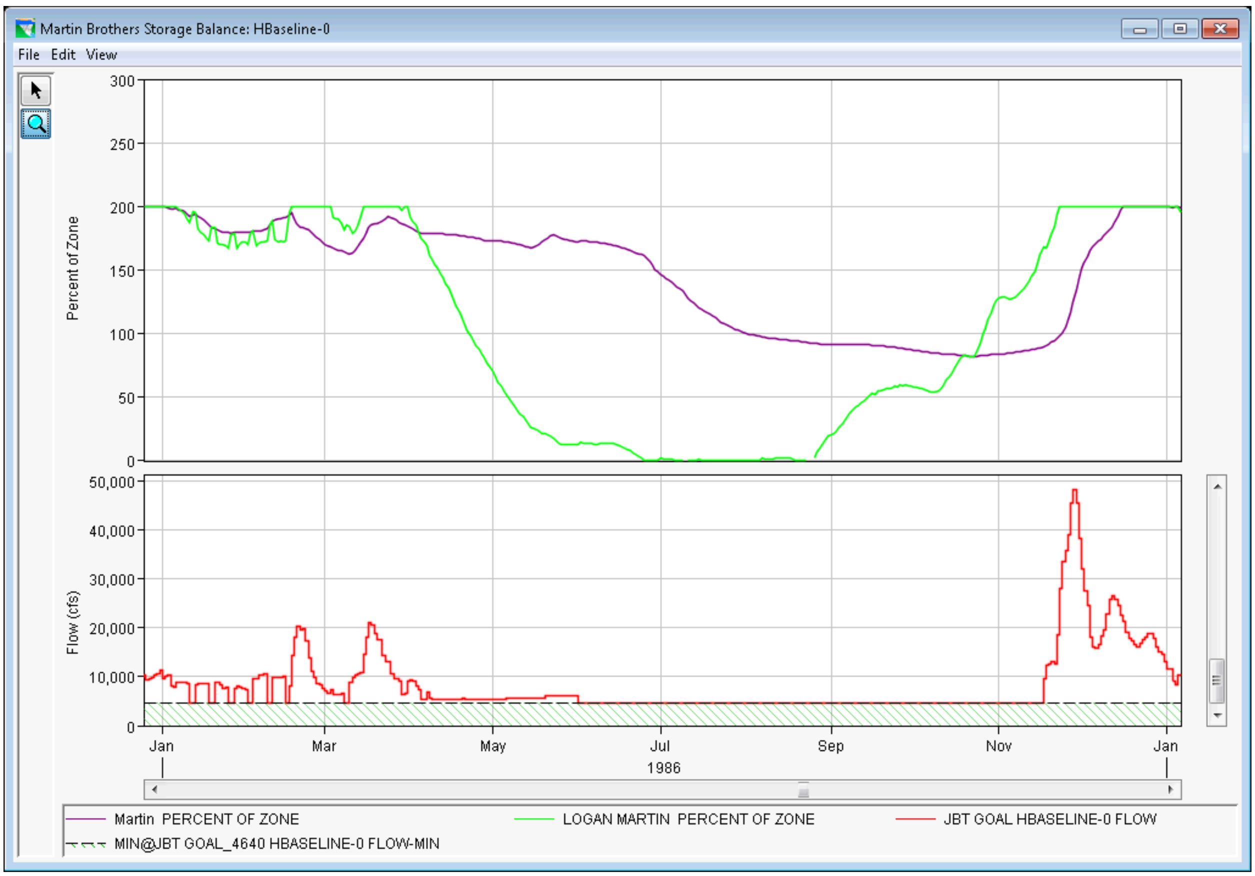


Figure 34. Improved operation for JBT Goal

H. Thurlow Flow-Through Operation

Thurlow Dam was constructed in 1930. It has a power plant and 36 5-foot flashboards resting at a crest elevation of 283.85 feet. Daily average flows and daily instantaneous reservoir elevation are available beginning in 1994. It is very difficult to interpret the daily data to see when the flashboards actually fall and are reset, but APC reports that they fall between 289.75 feet and 290.25 feet (source: 3/24/2011 email from Stacy Graham of APC).

In a daily time-step model, the flashboard operation is too fine to capture. A rough approximation of operations is accomplished by treating Thurlow as a flow-through reservoir. The Conservation Pool was set at a constant elevation of 288 feet, which was the value provided by APC as the operating pool level. (As seen in the observed data, the actual operation of the pool appears to generally fluctuate between 286.7 - 288.0 feet with some extreme highs and lows between 282 - 292 feet.) The power plant was modeled at a capacity of 78.5 MW.

The outlet capacity of Thurlow is very high compared with its storage capacity. This can cause some storage integration issues for ResSim when dealing with flood events. It is possible to drain the pool in a single time step. While ResSim 3.1 RC4 build 42 manages these events well, ResSim 3.2 build 22 tends to calculate an insufficient release capacity, causing the pool to rise above the Top of Dam, which then causes the pool to completely drain in the next time step. This occurred during six or seven large events in most alternatives. Otherwise the reservoir passes inflow. Figure 35 shows the spiky results of these operations.

A few adjustments were made to the model in order to better handle these large events within ResSim 3.2. The Top of Dam elevation was changed from 305 feet to 306 feet to allow enough operational room. The 306 foot elevation and associated storage and area are dummy numbers that allow ResSim room for storage calculations. During large inflow events, the model allows the pool to rise, and inflow is released until the pool returns to guide curve. When the pool is above conservation, spillway releases are kept at 90% of the previous days' release in order to prevent oscillations. The inactive pool elevation was changed from 286.7 feet to 283.85 feet (which is the dam crest when flashboards are down).

The pool still rises to an unrealistic level, but now it no longer is followed by draining the pool. ResSim's calculation of head is only a rough approximation (given that the actual pool fluctuates quite a bit, but ResSim models it at a steady value), but during the high flow events, the head is likely overestimated. It was recommended that the pool elevation be assumed to remain at 288 feet for the entire period of record, so new values of head should be calculated for those six or seven events that trigger the pool to fill. Figure 37 shows the rise in elevation as well as the flow data for the modeled results (green) and the observed data (red). Figure 38 shows the modeled head. You can see that during the observed event, a much higher flow was passed and the pool did not rise as much.

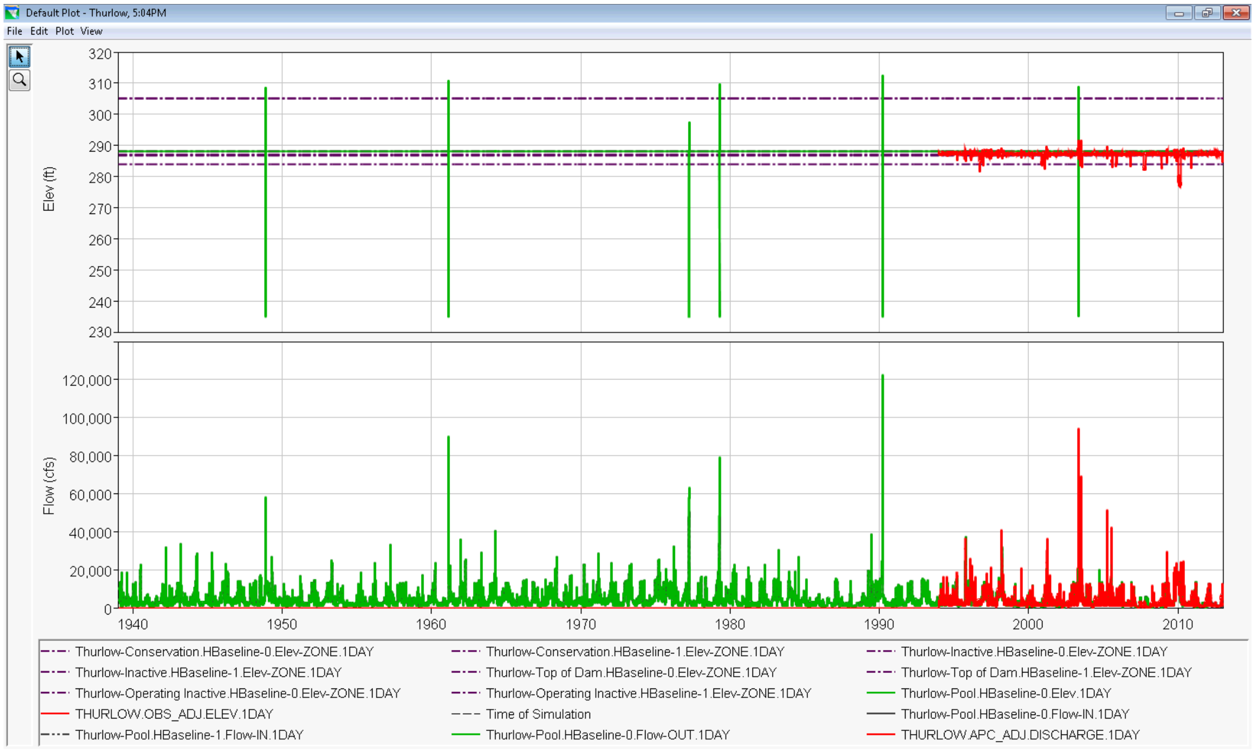


Figure 35. Operation of Thurlow Reservoir when run in ResSim 3.2 prior to making the adjustments that avoid overtopping or draining the reservoir.

Figure 36. Six major events that cause Thurlow's pool to rise above 288 feet after making model adjustments

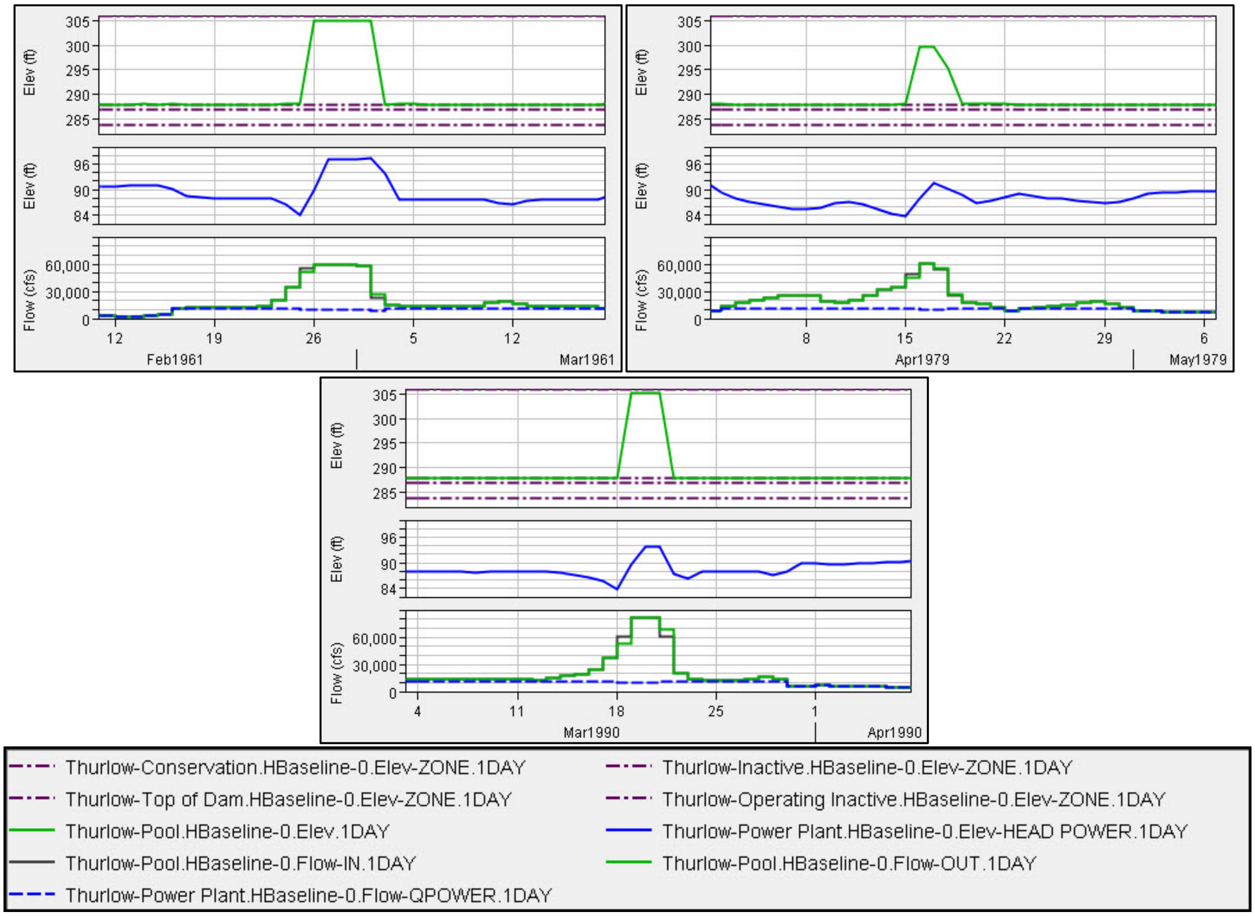


Figure 37. Increase in Thurlow pool elevation and associated rise in head during three of the large events.

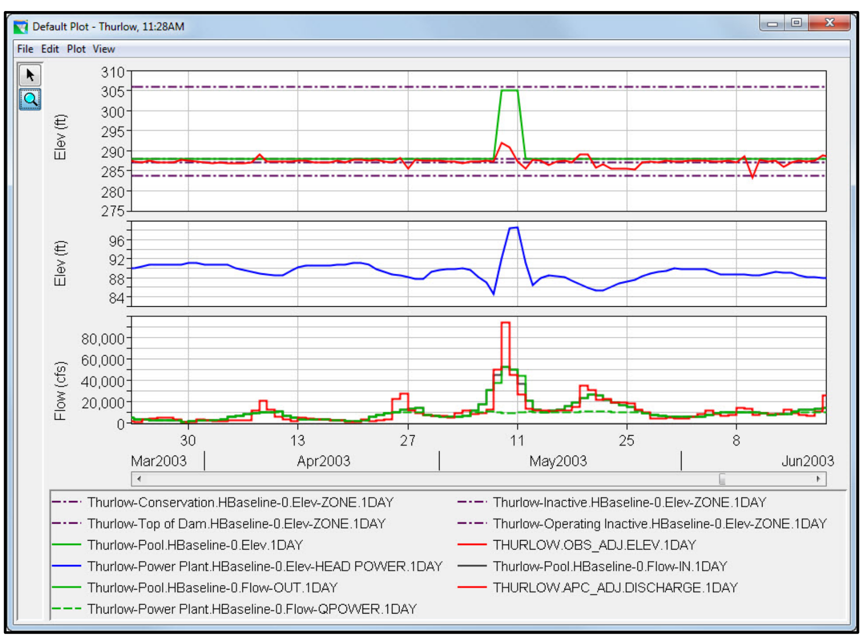


Figure 38. Change in head at Thurlow when pool increases to near Top of Dam

V. Sensitivity Runs

Sensitivity runs were developed to represent two scenarios: a decreased inflow scenario considers the possible effect of climate change, and an increased demands scenario represents probable demand conditions for the year 2030.

Alternative HRPlanG85 represented the climate change scenario with an inflow volume reduced to 85%. All operational rules and goals remained the same. Table 9 shows how the inflows were adjusted, using a combination of inflow multipliers and new time-series.

Table 9. Inflow time-series for HRPlanG85 were adjusted using inflow multipliers or by mapping new external time-series.

Inflow Time-Series Adjusted for Reduced Hydrology	
Inflow Multiplier x 0.85	
Newell_LOC	Mitchell_IN_LOC
Tallapoosa_LOC	Montgomery_LOC
Heflin_LOC	RF Henry_IN_LOC
Wadley_LOC	Selma_LOC
Martin_IN_LOC	Centreville_LOC
Yates_IN_LOC	Purdy_LOC
Thurlow_IN_LOC	Marion Junction_LOC
Carters_IN_LOC	Walter Bouldin_IN_LOC
Pine Chapel_LOC	Jordan_IN_LOC
Conasauga_LOC	Harris_IN_LOC
Tilton_LOC	Carters ReReg_IN_LOC
Resaca_LOC	Tallassee_LOC
Canton_LOC_Canton	Coosa_LOC
Allatoona_IN_LOC	Cartersville_LOC (0.44 x Kingston LocQ)
Kingston_LOC (0.56 x Kingston LocQ)	Rome-Oostan_LOC (0.81 x Rome-Coosa LocQ)
Rome-Etowah_LOC	Millers Ferry_IN-AL_LOC (MF x 0.95)
Rome-Coosa_LOC (0.19 x Rome-Coosa LocQ)	Millers Ferry_IN-CA_LOC (MF x 0.05)
Weiss_IN_LOC	Claiborne_LOC
HN Henry_IN_LOC	Canton_LOC_HLC
Logan Martin_IN_LOC	Canton_LOC_Confl
Lay_IN_LOC	Dawsonville_LOC
New TS Record x 0.85	
Canton_LOC_dummy	Hackneyville_dummy

Alternative HRPlanG30 represents the 2030 demand scenario with demands increased to 127.4% of 2006 demands. The 127.4% was estimated using the 10-year compound annual growth rate (1.010132) for the ACT basin determined in the 2008 Section 134 Information Report. All operational rules and goals remained the same, including limitation, for modeling purposes, of withdrawals from Allatoona Lake to the amount of storage available in existing water supply storage agreements according to the USACE storage accounting methodology. Table 10 shows how the demands were adjusted, using a combination of inflow multipliers and new time-series.

Table 10. Demand time-series for HRPlanG30 were adjusted using inflow multipliers or by mapping new external time-series.

Demands Adjusted to 2030 Levels	
Inflow Multiplier x 1.274	
Carters_IN_DIV	Thurlow_IN_DIV
Allatoona_CCMWA_ReturnQ	RF Henry_IN_DIV
Weiss_IN_DIV	Harris_IN_DIV
HN Henry_IN_DIV	Jordan_IN_DIV
Logan Martin_IN_DIV	Millers Ferry_IN_DIV
Martin_IN_DIV	Claiborne_IN_DIV
Lay_IN_DIV	HLC_Conf_Withdrawal
Mitchell_IN_DIV	Canton-Jasper_ReturnQ
Yates_IN_DIV	Allatoona_Other_ReturnQ
New TS Record x 1.274	
Tilton_Divs-Tilton_Divs Cntrl	Centreville_Divs-Centreville_Divs Cntrl
Tilton_Divs	Centreville_Divs
Resaca_Divs-Resaca_Divs Cntrl	Marion Junction_Divs-Marion Junction_Divs Cntrl
Resaca_Divs	Marion Junction_Divs
Canton_Divs-Canton_Divs Cntrl	Coosa_Divs-1-Coosa_Divs-1 Cntrl
Kingston_Divs-Kingston_Divs Cntrl	Coosa_Divs
Kingston_Divs	Rome-Oostanaula_Divs-Rome-Oostanaula_Divs Cntrl
Rome-Etowah_Divs-Rome-Etowah_Divs Cntrl	Rome-Oostanaula_Divs
Rome-Etowah_Divs	Abv Alabama_Div-Abv Alabama_Div Cntrl
Tallapoosa_Divs-Tallapoosa_Divs Cntrl	Abv Alabama_Div
Tallapoosa_Divs	Coosa_Divs-2-Coosa_Divs-2 Cntrl
Heflin_Divs-Heflin_Divs Cntrl	Coosa_Divs-2
Heflin_Divs	Rome-Coosa_Divs-Rome-Coosa_Divs Cntrl
Newell_Divs-Newell_Divs Cntrl	Rome-Coosa_Divs
Newell_Divs	CCM_Canton_Divs-CCM_Canton_Divs Cntrl
Wadley_Divs-Wadley_Divs Cntrl	CCM_demand
Wadley_Divs	Allatoona_Cartersville_demand
Selma_Divs-Selma_Divs Cntrl	Canton_demand
Selma_Divs	CCM_QReturnTot_Divs-Cntrl

VI. Results of Modeling

Each simulated alternative produces daily results including reservoir release (distributed by outlet) and storage, and streamflow at all locations throughout the model. To assist with the analysis of so many results, scripted plot templates and report generation templates were created to provide on-demand illustrations of the state of various reservoir systems operations. Figure 39 shows the list of custom scripts used for plotting results, and Figure 40 shows the list of custom scripts used for building reports.

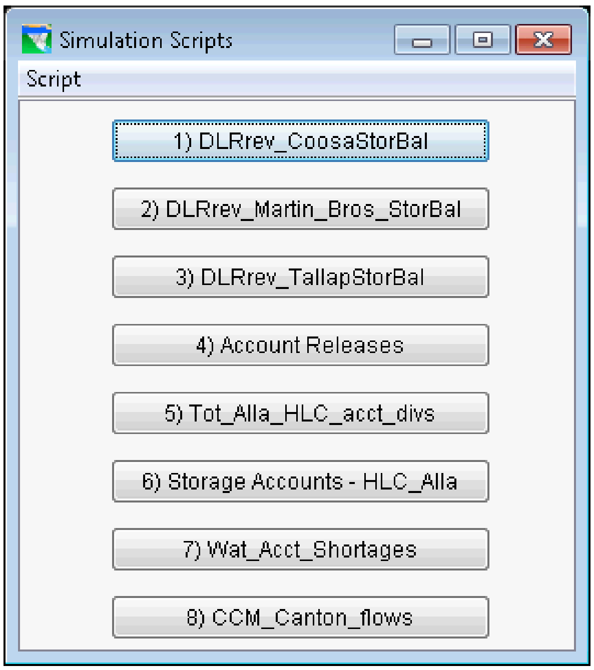


Figure 39. Simulation Scripts for Generating Plots

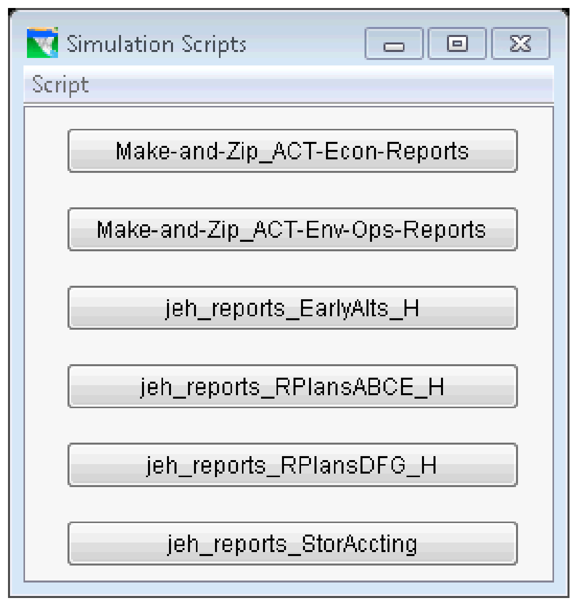


Figure 40. Simulation Scripts for Generating Reports

VII. Description of References and Supporting Material

Oke, A. Letter to Gene Hobgood, Mayor, City of Canton. 12 Sep. 2008. Re: *Surface Water Withdrawal Permits #028-1491-04 (Modified), #028-1491-05 (New)*. from the Georgia Department of Natural Resources.

- Describes modified permit for the withdrawal of water from the Etowah River at Canton (*#028-1491-04)* and the new permit to pump water from the Etowah River into Hickory Log Creek Reservoir (*#028-1491-05).*

Page, G.M. Letter to Col. Steven J. Roemhildt. 26 Aug. 2010. Re: *Hickory Log Creek Reservoir – Special Condition #15*. From the Cobb County-Marietta Water Authority.

- Details the proposed operation of Hickory Log Creek Reservoir.

Roemhildt, Col. S.J. Letter to Glen M. Page. 11 Sep. 2012. Re: *June 22, 2012 letter regarding whether CCMWA will be able to comply with Allatoona Water Storage Contract*. From the USACE, Mobile District.

- Discusses Allatoona storage contract and Hickory Log Creek. Notes CCMWA's desire for a reallocation study, but the Water Control Manual Update will be completed first.

Turner, J.H. Letter to Jo Ellen Darcy, Asst. Sec. of the Army for C.W. 24 Jan. 2013. Re: *Lake – Allatoona – Request for Final Agency Action*. From the Office of the Governor of the State of Georgia.

- Request to allow Hickory Log Creek releases for to be routed through Allatoona.

USACE, Mobile District. *Alabama-Coosa-Tallapoosa (ACT) Watershed. HEC-ResSim Modeling of Reservoir Operations in Support of Water Control Manual Update. (Draft)* Mar. 2011.

- Documentation of the 2011 ACT ResSim model.

USACE, Mobile District. *Municipal, Industrial, Power and Agricultural Water Use Inventory. Comprehensive Study for the Apalachicola-Chattahoochee-Flint and Alabama-Coosa-Tallapoosa Basins. Vol. II: Surface Water Withdrawal Inventory*. Nov. 1994. p. 51

- Shows CCMWA's permit to withdraw from Allatoona reservoir.

USACE, Mobile District. Power point presentation. *Hickory Log Creek Dam Site Visit with Corrections*. 25 Jul. 2012.

- Gives physical descriptions of HLCR, outlet capacities, etc.

USACE, Mobile District. *Section 134 – Information Report. Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint River Basins.* Sep. 2008. p. 28

- Gives a table of annual projected demands through the year 2031.

VIII. Water Supply Storage Accounting State Variable

Hickory Log Creek Water Accounting/Pumpback & Allatoona Water Accounting
Water accounting for Hickory Log Creek Reservoir (HLCR) and Allatoona, as well as the calculation of the pumped amount into HLCR is computed in the state variable **Accounting_HLCmain**.

This master state variable determines the values for the following slave state variables:

State Variable	Units	Description
Allatoona_CCM_stor	Volume (AF)	End of previous period's Storage in CCM's Allatoona account
Allatoona_CCM_stor_int	Volume (AF)	Interim Storage in CCM's Allatoona account (withdrawals have been taken but inflows are not yet accounted for)
Allatoona_Cartersville_stor	Volume (AF)	End of previous period's Storage in Carterville's Allatoona account
Allatoona_Cartversville_ stor_int	Volume (AF)	Interim Storage in Cartersville's Allatoona account (withdrawals have been taken but inflows are not yet accounted for)
HLC_CCM_stor	Volume (AF)	End of previous period's Storage in CCM's HLC account
HLC_CCM_stor_int	Volume (AF)	Interim Storage in CCM's HLC account (withdrawals have been taken but inflows are not yet accounted for)
HLC_Canton_stor	Volume (AF)	End of previous period's Storage in Canton's HLC account
HLC_Canton_stor_int	Volume (AF)	Interim Storage in Canton's HLC account (withdrawals have been taken but inflows are not yet accounted for)
Allatoona_CCM_Q	Flow (cfs)	Release from CCM's Allatoona account
Allatoona_Cartersville_Q	Flow (cfs)	Release from Cartersville's Allatoona account
HLC_CCM_Q	Flow (cfs)	Release from CCM's HLC account
HLC_Canton_Q	Flow (cfs)	Release from Canton's HLC account
Allatoona_CCM_Qreturn	Flow (cfs)	CCM's return flow to the Allatoona_IN junction (=31% total CCM withdrawals from all locations)
Cartersville_Cartv_Qreturn	Flow (cfs)	Cartersville's return flow to the Cartersville junction (=64% total Cartersville withdrawals from Allatoona)
HLC_Acct_OUT	Flow (cfs)	Total HLC release for CCM and Canton
HLC_PumpIN	Flow (cfs)	Pumped value from Etowah river into HLC
Canton_Etowah_WD	Flow (cfs)	Canton Total withdrawal from the Etowah at Canton (includes any release from Canton's HLC account)
CCM_Etowah_WD	Flow (cfs)	CCM Total withdrawal from the Etowah at Canton (includes any release from CCM's HLC account)

The following text steps through the Main part of the Accounting_HLCmain state variable script, describing the logic:

ASSUMPTIONS

- The approximation of natural flow in the Etowah may be off if HLCR stores inflow, but inflow is such a small value, this is not likely to make a difference.

- The system will be operated such that if there is limited water in the Etowah, Canton's demand is a higher priority than the demand to pump into HLCR. In the script, what is available to pump into HLCR is dependent on how much Canton takes downstream.

- If the demand at Canton were increased beyond the Etowah's ability to supply it, withdrawals would be made from HLCR for Canton.

- There is no routing between HLCR and Allatoona, and there is no lag in return flow for Canton, CCWMA, or Cartersville.

- If CCMWA had infrastructure to withdraw water from the Etowah, an assumed priority for meeting demand would need to be established. The script currently assumes that all demands would be met at Allatoona until the account reached "nearly" empty before withdrawals would be taken from the Etowah or HLCR.

SET UP ALTERNATIVE GROUPS

Before making any calculations, alternative Groups are established. The Script behavior can change depending on the alternative being computed. The logic of the script depends on which groups the alternative falls into.

AltGroup_HLCAmenity = ["HBaseline"]
If HLCR is operated as an Amenity Lake, it does not release to provide water for account holders. It pumps water from the Etowah only to make up for evaporation. Only the Baseline/No Action alternative is operated like this. (A note with regard to model results: While all alternatives other than Baseline/No Action allow Canton to use its account at HLCR, Canton's demand is never high enough to require releases from HLCR. Therefore, HLCR is effectively operated as an amenity flow-through reservoir for all alternatives. However, if the Canton demand were increased for any alternative other than Baseline, this script would allow Canton to draw from its account at HLCR.)

AltGroup_AllaUnlimited = ["HBaseline"]
The script is generally set up to make calculations based on the Mobile District's storage accounting methodology. This "AltGroup_AllaUnlimited" setting overrides the storage accounting for the Baseline/No Action, such that there is no limit on CCMWA or Cartersville withdrawals from Allatoona. In the Baseline/No Action alternative,

CCMWA and Cartersville continue to draw water from Allatoona even when their storage accounts are empty, according to the Mobile District's storage accounting methodology.

SCRIPT LOGIC

1. **INTIALIZATION - Initialize and Set Up Variables**
   a. **Constants**
   Storage accounts are always considered full when the pool is at the Top of Conservation. These values represent each account's percent of the reservoir's conservation pool volume.
   Alla_CCM_acctFULL = 13148.01 AF – 4.62% of Allatoona's Conservation Pool
   Alla_Cartv_acctFULL = 6374.79 AF – 2.24% of Allatoona's Conservation Pool
   HLC_CCM_acctFULL = 9980.87 AF – 75% of HLC's Conservation Pool
   HLC_Cant_acctFULL = 3326.96 AF – 25% of HLC's Conservation Pool

   Hickory Log Creek Reservoir (HLCR) total volume when at Top of Conservation Pool (including inactive storage):
   HLCTotVol = 17701.75 AF

   Conversion factor cfs-days to AF
   cfs2AF = 1.9835

   b. **Inflows, Outflows**
   QCantonLOC_cur – current Canton local
   QCantonLOC_prev – previous Canton local
   QHLC_in_cur – current HLCR local inflow (0.016xCantonLOC)
   QHLC_in_prev – previous HLCR local inflow
   QAlla_in_prev – previous Allatoona inflow

   QHLC_dam_prev – previous Hickory Log Creek release from Dam
   QHLC_PumpINprev – previous Hickory Log Creek pump inflow

   c. **Elevation, Storage**
   Alla_elev_prev – previous Allatoona elevation
   HLCstor_prev – previous Hickory Log Creek Reservoir storage

   d. **Evaporation**
   Evaporation is stored as a negative when precipitation exceeds evaporation.
   QAlla_evap_prev – previous Allatoona evaporation
   QHLC_evap_cur – current HLCR evaporation
   QHLC_evap_prev – previous HLCR evaporation

   e. **Demands**
   QCCMdemand – current Cobb County-Marietta Water Authority (CCMWA) demand

QAlla_Cartvdemand – current Cartersville demand (always withdrawn from Allatoona)
QCantondemand – current City of Canton demand

f. Initialize Storage Accounts
Alla_CCM_acct_prev – previous CCMWA storage in account at Allatoona
Alla_Cartv_acct_prev – previous Cartersville storage in account at Allatoona
HLC_CCM_acct_prev – previous CCMWA storage in account at HLCR
HLC_Cant_acct_prev – previous Canton storage in account at HLCR

These account balances are interim values written out by the script in the previous timestep and do not yet include the inflow for the last time period.

Although a reasonable approximation of the current timestep's inflow can be obtained, it is not known with certainty until the end of the timestep. Therefore, the final value calculated by the state variable isn't always the same as the value that is calculated when the relevant compute block is finished. When the relevant compute block (the one that includes Allatoona and HLC) finishes, the diversion values and the pumpback values are set in the model, but the final values written to DSS may differ, and in fact, do differ in some circumstances.

Therefore the interim storage values from the last time step are retrieved, and then in Step 2, they are adjusted to set the final value that reflects the inflow.

Alla_CCM_acct_int – interim CCMWA storage in account at Allatoona
Alla_Cartv_acct_int – interim Cartersville storage in account at Allatoona
HLC_CCM_acct_int – interim CCMWA storage in account at HLCR
HLC_Canton_acct_int – interim Canton storage in account at HLCR

2. STORAGE ACCOUNTING – BEGINNING OF TIMESTEP - Determine the storage in the accounts at the end of previous time-step based on refill values.

HLC inflow can be known or reasonably approximated, but current inflow to Allatoona is unknown. Only the previous value is known with certainty. Additionally, sometimes the actual HLC pump value is different than what was calculated in the last compute of the state variable.
So, today's release is based on yesterday's ending storage, not including today's inflow. The current inflow is added at the beginning of the next timestep and the resulting storage is saved for the end of the previous timestep.

a. Calculate the HLC storage at the end of the previous time step
Refill from previous timestep = inflow - evap - main gate releases + pumped inflow. (Anything withdrawn from the storage accounts in this timestep is managed at the end of the script.)

HLC_acct_refill *= (HLC_Qin_prev - QHLC_evap_prev - QHLC_dam_prev + QHLC_PumpINprev)*

HLC has two accounts, CCMWA and Canton. Distribute the inflow to the accounts in a 25/75 split.

HLC_CCM_refill *= 0.75*HLC_acct_refill*

HLC_Cant_refill *= 0.25*HLC_acct_refill*

If there is more inflow than needed for one account, the other account gets the excess added to their proportion of the inflow.

*if 0.75*HLC_acct_refill > (HLC_CCM_acctFULL- HLC_CCM_acct_prev) :*

HLC_CCM_refill *= (HLC_CCM_acctFULL - HLC_CCM_acct_prev)*

HLC_Cant_refill *= HLC_acct_refill - HLC_CCM_refill*

*if 0.25*HLC_acct_refill > (HLC_Cant_acctFULL - HLC_Cant_acct_prev) :*

HLC_Cant_refill *= (HLC_Cant_acctFULL - HLC_Cant_acct_prev)*

HLC_CCM_refill *= HLC_acct_refill - HLC_Cant_refill*

Prevent accounts from going negative. (probably unnecessary.)
CCM acct is greater of 0 and previous balance + 75% refill.

HLC_CCM_acct *= max(0, (HLC_CCM_acct_prev + HLC_CCM_refill))*

Canton acct is greater of 0 and previous account + 25% refill.

HLC_Cant_acct *= max(0, (HLC_Cant_acct_prev + HLC_Cant_refill))*

Prevent accounts from overtopping FULL.

HLC_Cant_acct *= min(HLC_Cant_acctFULL, HLC_Cant_acct)*

HLC_CCM_acct *= min(HLC_CCM_acctFULL, HLC_CCM_acct)*

b. Store HLC account values for previous timestep

HLC_CCM_acct_SV = network.getStateVariable("HLC_CCM_acct")
HLC_CCM_acct_SV.setValue(prevRTS, HLC_CCM_acct)
HLC_Cant_acct_SV = network.getStateVariable("HLC_Canton_acct")
HLC_Cant_acct_SV.setValue(prevRTS, HLC_Cant_acct)

c. Calculate Allatoona account storage at the end of the previous time step

Evaporation is taken out of inflow and must be divvied up to the accounts. (Note, negative evaporation represents precipitation.)

Alla_acct_refill *= (QAlla_in_prev - QAlla_evap_prev)*cfs2AF*

Allatoona has two water supply storage accounts, CCMWA and Cartersville. The rest of the volume of conservation storage is used by the Corps to fulfill multiple authorized purposes, excluding the CCMWA and Cartersville accounts. (The Corps' account is not explicitly tracked in the model.) Distribute the inflow based on proportion of storage belonging to each account holder.

Alla_CCM_refill *= 0.0462*Alla_acct_refill*

Alla_Cartv_refill *= 0.0224*Alla_acct_refill*

If there is more inflow than needed for one account, the other user account and the Corps share it (proportional to their pool %). Storage proportions:

USACE = 0.9314
USACE + Cartv = 0.9538
USACE + CCM = 0.9778

*if 0.0462*Alla_acct_refill > (Alla_CCM_acctFULL - Alla_CCM_acct_prev) :*
Alla_CCM_refill *= (Alla_CCM_acctFULL - Alla_CCM_acct_prev)*
Alla_Cartv_refill *= 0.0224*(Alla_acct_refill + (0.0462*Alla_acct_refill - Alla_CCM_refill)/0.9538)*

*if 0.0224*Alla_acct_refill > (Alla_Cartv_acctFULL - Alla_Cartv_acct_prev) :*
Alla_Cartv_refill *= (Alla_Cartv_acctFULL - Alla_Cartv_acct_prev)*
Alla_CCM_refill *= 0.0462*(Alla_acct_refill + (0.0224*Alla_acct_refill - Alla_Cartv_refill)/0.9778)*

Prevent accounts from going negative. If the refill value is negative due to a large evaporation and small inflow, the user accounts will not be allowed to drop below zero. The Corps pool will absorb the difference. (It is unlikely that these conditions would ever exist.)

Alla_CCM_acct *= max(0, Alla_CCM_acct_prev + Alla_CCM_refill)*
Alla_Cartv_acct *= max(0,Alla_Cartv_acct_prev + Alla_Cartv_refill)*

Prevent accounts from overtopping FULL.

Alla_CCM_acct *= min(Alla_CCM_acctFULL, Alla_CCM_acct)*
Alla_Cartv_acct *= min(Alla_Cartv_acctFULL, Alla_Cartv_acct)*

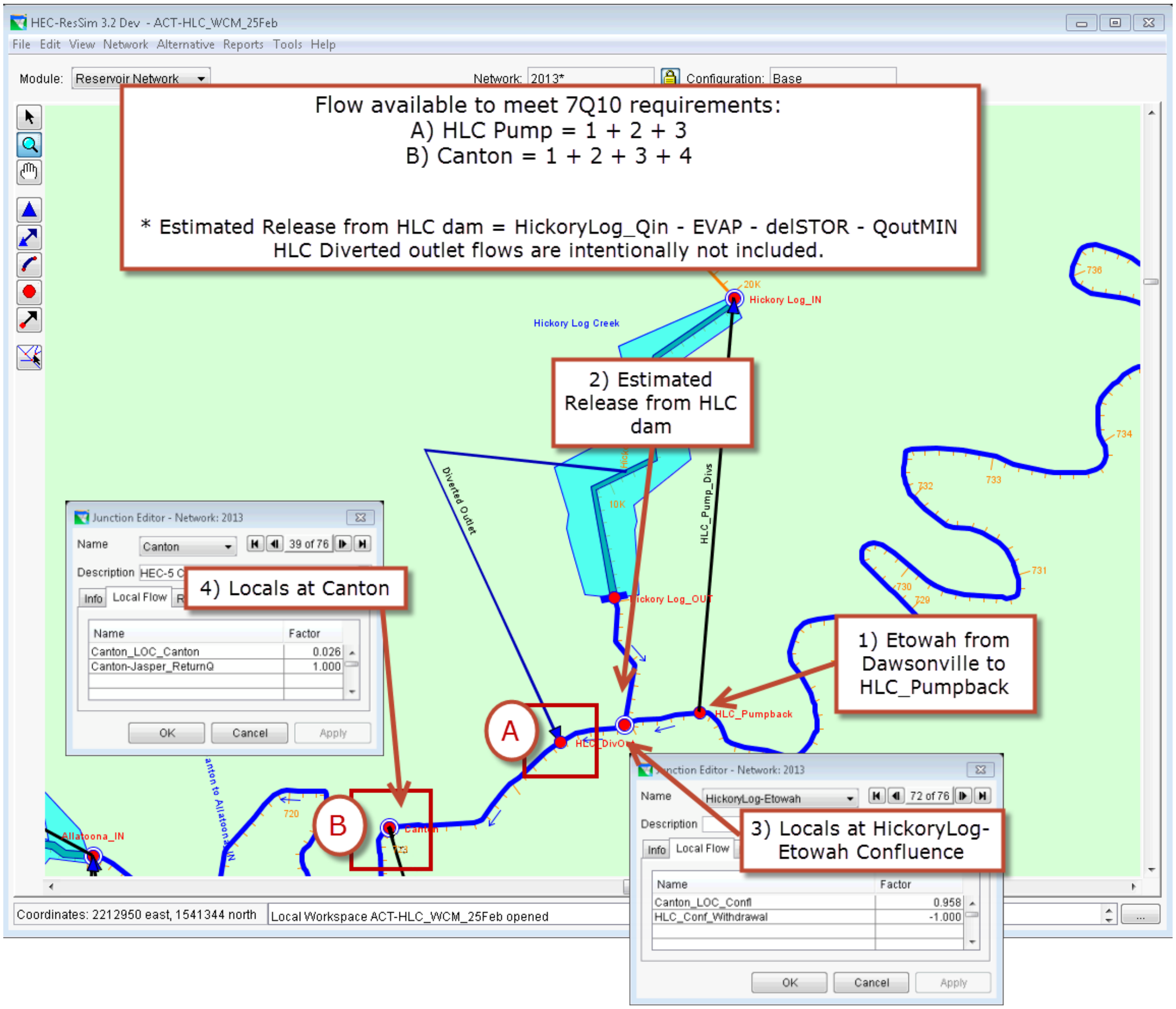
If Allatoona is at the summer full level of 840 feet, all accounts are reset to full.
if Alla_elev_prev >= 840 :
Alla_CCM_acct *= Alla_CCM_acctFULL*
Alla_Cartv_acct *= Alla_Cartv_acctFULL*

d. **Store Allatoona account values for previous timestep**

```
Alla_CCM_acct_SV = network.getStateVariable("Allatoona_CCM_acct")
Alla_CCM_acct_SV.setValue(prevRTS, Alla_CCM_acct)
Alla_Cartv_acct_SV = network.getStateVariable("Allatoona_Cartersville_acct")
Alla_Cartv_acct_SV.setValue(prevRTS, Alla_Cartv_acct)
```

3. **ETOWAH FLOW - Determine the flow coming into the HLC Pump location and Canton, which are required to pass the minimum of natural flow or 7Q10**

An estimate of the current flow in the Etowah River at the HLC Pump and at Canton can be determined. This will allow for the determination of how much flow is available to be taken from the Etowah at Canton to meet Canton and CCM demands, and how much can be pumped out of the Etowah for the purpose of filling HLC. Each location is required to pass the lesser of natural flow or 7Q10 flow.



a. **Get known components of Etowah flow in the HLC area.**

HLCFillvol_cur - volume needed to fill HLCR

Yesterday's HLCR storage will determine if any of today's inflow will be needed to fill.

> ***HLCFillvol_cur*** = *HLCTotVol - HLC_stor_prev*

QHLC_out_REQ- *minimum required release from HLCR*

HLC must release the lesser of inflow or the instream 7Q10 of 3.5 cfs.

> ***QHLC_out_REQ*** = *min(3.5,QHLC_in_cur)*

QHLC_out_est **-** Estimated current release from HLCR

The initial estimated outflow from HLCR is the local inflow – evaporation – Δ storage – minimum out, where

Δstorage = Full volume – prev volume

Estimated outflow is then the maximum of the initial estimated outflow and the minimum required outflow:

QHLC_out_est = *max[(QHLC_in_cur - QHLC_evap_cur - HLCFillvol_cur/cfs2AF), (QHLC_out_REQ)]*

QEtowahfromDawsonv_cur – current Etowah flow from Dawsonville to confluence
QHLCConfWD_cur – current withdrawal from confluence
QJasperRQ_cur – current Jasper return flow at confluence
QHLCConfLOC_cur – current local inflow at confluence inflow (0.958xCantonLOC)
QCantonLOC_Canton_cur – current local inflow at Canton inflow (0.026xCantonLOC)

b. Estimate flow that will be available to pump from the Etowah while passing the 7Q10.

Etowah Qin @ Pump is what is coming from the Etowah at Dawsonville + what is being released from HLC + local and diversion at the confluence. Although the Pump is being *modeled* upstream of the HLC-Etowah confluence, the pump is actually downstream. So we are looking at the flows at the diverted outlet junction.

QEtowah2PumpIN_cur = *QEtowahfromDawsonv_cur + QHLC_out_est + QHLCConfLOC_cur - QHLCConfWD_cur*

Canton is required to pass the lesser of inflow & 300 cfs (7Q10)

QHLCpumpIN_passbyREQ = *min(300, QEtowah2PumpIN_cur)*

So what is available to the pump is what is left over after the required amount is passed.

QHLCpumpIN_AVAIL = *QEtowah2PumpIN_cur - QHLCpumpIN_passbyREQ*

c. Estimate flow that will be available to withdraw at Canton while passing the 7Q10.

Etowah inflow at Canton is what is coming from the Etowah at Dawsonville + what is being released from HLC + local inflows, return flows, and diversions. Any flows released from HLC's accounts will not be counted, because they will be taken directly out at Canton.

QEtowah2CantonIN_cur *= QEtowahfromDawsonv_cur + QHLC_out_est + QHLCConfLOC_cur - QHLCConfWD_cur + QCantonLOC_Canton_cur + QJasperRQ_cur*

Canton is required to pass the lesser of inflow & 250 cfs (7Q10)
QCanton_passbyREQ *= min(250, QEtowah2CantonIN_cur)*

So what is available to withdraw at Canton is what is left over after the required amount is passed.
QEtowah2CantonIN_AVAIL *= QEtowah2CantonIN_cur - QCanton_passbyREQ*

4. CITY OF CANTON - withdrawal from the Etowah @ Canton

Calculate how much the City of Canton will take from the Etowah. Withdrawal occurs even if HLCR has no Canton acct.

The City of Canton is permitted to take up to 28.9 cfs, as long as the 7Q10 flow (250 cfs) is passed downstream, and it is permitted to take 8.4 cfs, regardless of what is passed downstream. Therefore, in order to withdraw in excess of 8.4 cfs, the flow leaving Canton must be no less than (250 - 8.4 cfs). Demand that cannot be met with what is left in the river will be drawn from the Canton HLCR account.

QEtowah_Canton- how much Canton can withdraw from the river not including HLCR's release.

QEtowah_Canton *= min(QCantondemand, QEtowah2CantonIN_AVAIL + 8.4)*
QHLC_Cantondemand *= max(0, QCantondemand - QEtowah_Canton)*

Initial calculation of flow for CCMWA from Etowah (not including release from HLC). CCMWA can meet some of its demand at Canton only if it builds an intake. Since no intake exists, all CCMWA withdrawal from the Etowah is zero for all alternatives.

QEtowah_CCM *= 0*

When some of the Etowah's flow is being taken out at Canton, this could impact how much is available to be pumped out upstream. Adjust the "pump Available" amount accordingly. Although the pump is upstream of Canton, and therefore theoretically would have the first claim on the water flowing in the Etowah, we are calculating the withdrawal at Canton before the amount pumped into HLCR, because it is more efficient for water users to take the water directly out of the Etowah at Canton than it is to pump the water into HLCR.

QHLCpumpIN_AVAIL *= min(QHLCpumpIN_AVAIL, QEtowah2CantonIN_AVAIL - QEtowah_Canton - QEtowah_CCM)*

QHLCpumpIN_AVAIL *= max(QHLCpumpIN_AVAIL, 0)*

Calculate how much CCMWA demand is left. Allatoona will try to meet that next. Since CCMWA cannot take any water from the Etowah or HLCR for any alternatives, this value is the full demand amount. (Recall that *QEtowah_CCM* is 0 for all study alternatives.)

QAlla_CCMdemand *= max(0,QCCMdemand - QEtowah_CCM)*

5. ALLATOONA RELEASES - Calculate withdrawals from Allatoona storage accounts

Calculate withdrawals from Allatoona storage accounts

a. Allatoona's release for CCMWA

Allatoona's release for CCMWA is the lesser of the demand or the flow the CCMWA account can provide.

QAlla_CCM *= min(QAlla_CCMdemand, Alla_CCM_acct/cfs2AF)*

No demand is made at HLCR in any alternative, although if it were, it would be the demand remaining after Allatoona's CCMWA account is empty.

QHLC_CCMdemand *= 0*

b. Allatoona's release for Cartersville

Allatoona's release for Cartersville is the lesser of the demand or the flow the Cartersville account can provide.

QAlla_Cartv *= min(QAlla_Cartvdemand, Alla_Cartv_acct/cfs2AF)*

6. HLCR RELEASES - Calculate withdrawals from HLCR storage accounts

a. **HLCR's release for City of Canton**

HLC release for Canton is the lesser of the account and the demand.

QHLC_Canton *= min(QHLC_Canton_demand, HLC_Canton_acct)*

The total Canton diversion is the sum of allowed withdrawal from the natural Etowah flow plus any releases from HLCR Canton account.

QCanton_CantonTot - Total flow diverted at Canton for the City of Canton

QCanton_CantonTot = *QEtowah_Canton + QHLC_Canton*

b. HLCR's release for CCMWA = 0

The total CCMWA diversion at Canton is ZERO for all alternatives. Otherwise, it would be the sum of the allowed withdrawal from the natural Etowah flow plus any releases from HLCR CCMWA account.

QHLC_CCM *= min(HLC_CCM_acct/cfs2AF, QHLC_CCMdemand)*

QCanton_CCMTot - Total flow diverted at Canton for the CCMWA (0)

QCanton_CCMTot *= QHLC_CCM + QEtowah_CCM*

c. Calculate total release from HLC's accounts

Limit the total release to 70MGD (108.3 cfs)

Assume Canton takes its demand first, then CCMWA can take its demand up to what is left in their account and limited by the (total release - QCanton)

QHLC_MAX = 108.3

QHLC_CCM_MAX *= QHLC_MAX - QHLC_Canton*

QHLC_CCM *= min(QHLC_CCM_MAX, QHLC_CCM)*

The final value being released for both HLC accounts:

QHLCacctOUT *= QHLC_CCM + QHLC_Canton*

7. HLCR PUMP - Calculate HLC Pump value

Now that all of the withdrawals have been calculated, determine how much to pump from the Etowah into HLCR.

If there is demand for water at HLCR, it is likely that water levels are too low to allow for HLC to pump. Regardless, if water is being withdrawn from the HLCR accounts, no pumping may occur in the same timestep.

<u>Pumping Objectives and Constraints</u>

- HLCpumpIN_MAX capacity= 60.33 cfs
- Pump to keep reservoir at 1060 feet
- Must leave the Etowah with 7Q10 of 300 cfs (if not enough flow, pump = 0)
- If any water is released for the storage accounts today, do not pump

The lesser of natural flow or the 7Q10 of 300cfs must be passed down the Etowah, and what flow exceeds 300 cfs is available to be pumped. The pump's actual location is below the junction of the Etowah and Hickory Log Creek.

QHLCpumpIN_AVAIL was calculated in step 4.

The maximum value that can be pumped:

QHLCpumpIN_MAX *= min(60.33, QHLCpumpIN_AVAIL)*

Next, determine HLC storage volume deficit, or the demand to the pump.

Pump demand is the HLC full volume – previous storage – current inflow + previous evaporation

QHLCpumpIN_demand *= max(0,(HLCTotVol - HLC_stor_prev)/cfs2AF - QHLC_in_cur + QHLC_evap_prev)*

Total pump-in is the demand or the max limit, whichever is smaller.
QHLCpumpIN *= min(QHLCpumpIN_MAX, QHLCpumpIN_demand)*

The pump will not be operated during the same (daily) timestep when water is being released from HLC accounts.
if QHLCacctOUT > 0 then QHLCpumpIN = 0

8. OVERDRAFT - Storage Account Overdraft at Allatoona

Track the account overdrafts (if allowed). If the alternative is one in which the accounts are allowed to be overdrawn, set the release values to the total demand.
if TheCurAlt in AltGroup_AllaUnlimited :
QAlla_CCM *= QAlla_CCMdemand*
QAlla_Cartv *= QAlla_Cartvdemand*

The overdrafts are negative numbers.
Alla_CCM_overdraw *= Alla_CCM_acct - QAlla_CCM*cfs2AF*
Alla_Cartv_overdraw *= Alla_Cartv_acct - QAlla_Cartv*cfs2AF*

9. RETURN FLOWS

CCM and Cartersville return flows are a fraction of their withdrawals.
Calculate CCM's return flow to Allatoona as 31% of total CCM withdrawals.
(Again, QHLC_CCM and QEtowah_CCM = 0.)
QAlla_CCM_Qreturn *= 0.31*(QAlla_CCM + QHLC_CCM + QEtowah_CCM)*

Calculate Cartersville's return flow to Cartersville as 64% of total Cartv withdrawals
QAlla_Cartv_Qreturn *= 0.64*QAlla_Cartv*

10. INTERIM STORAGE ACCOUNTING

Calculate interim storage in accounts, based on what is known at end of this time period (includes current releases, but not yet counting current inflows. Those are added at the beginning of the next time step.)
HLC_Cant_acct_int *= HLC_Cant_acct - QHLC_Canton*cfs2AF*
HLC_CCM_acct_int *= HLC_CCM_acct - QHLC_CCM*cfs2AF*
Alla_CCM_acct_int *= Alla_CCM_acct - QAlla_CCM*cfs2AF*
Alla_Cartv_acct_int *= Alla_Cartv_acct - QAlla_Cartv*cfs2AF*

11. STORE ALL COMPUTED VARIABLES

Store data to each slave state variable calculated by this state variable. Most of the slave states variables are needed to control one or more rules or diversions in the model. The time-series of values of all state variables will be written to the simulation.dss file at the end of the compute.

<u>Interim storage accounts</u>
Alla_CCM_accti_SV.setValue(currentRuntimestep, Alla_CCM_acct_int)
Alla_Cartv_accti_SV.setValue(currentRuntimestep, Alla_Cartv_acct_int)
HLC_CCM_accti_SV.setValue(currentRuntimestep, HLC_CCM_acct_int)
HLC_Cant_accti_SV.setValue(currentRuntimestep, HLC_Cant_acct_int)

<u>Total Canton withdrawal from the Etowah River at Canton</u>
QCanton_tot_SV = network.getStateVariable("Canton_Etowah_WD")
QCanton_tot_SV.setValue(currentRuntimestep, QCanton_CantonTot)

<u>Total CCM withdrawal from the Etowah River at Canton</u>
Set timeseries of withdrawals based on whether they are coming from Allatoona or the Etowah near Canton.
QEtowah_CCM_SV = network.getStateVariable("CCM_Etowah_WD")
ZeroFlow = 0 (set a constant)

If HLCR is an amenity flow reservoir, it does not make releases for any account holders. Therefore, there is no HLC releases, and no CCM withdrawal at Canton.

```
    if TheCurAlt in AltGroup_HLCAmenity :
        QEtowah_CCM_SV.setValue(currentRuntimestep, ZeroFlow)
```

Otherwise set the CCMWA withdrawal from the Etowah. (It is always zero for these alternatives.)

```
    else :
        QEtowah_CCM_SV.setValue(currentRuntimestep, QCanton_CCMTot)
```

<u>Allatoona account withdrawals</u>
QAlla_CCM_SV = network.getStateVariable("Allatoona_CCM_Q")
QAlla_CCM_SV.setValue(currentRuntimestep, QAlla_CCM)
QAlla_Cartv_SV = network.getStateVariable("Allatoona_Cartersville_Q")
QAlla_Cartv_SV.setValue(currentRuntimestep, QAlla_Cartv)

<u>Total CCM return flow at Allatoona_IN</u>
QAlla_CCM_return_SV = network.getStateVariable("Allatoona_CCM_Qreturn")
QAlla_CCM_return_SV.setValue(currentRuntimestep, QAlla_CCM_Qreturn)
QAlla_Cartv_return_SV = network.getStateVariable("Cartersville_Cartv_Qreturn")
QAlla_Cartv_return_SV.setValue(currentRuntimestep,QAlla_Cartv_Qreturn)

<u>HLC account withdrawals</u>
QHLC_CCM_SV = network.getStateVariable("HLC_CCM_Q")

QHLC_CCM_SV.setValue(currentRuntimestep, QHLC_CCM)
QHLC_Canton_SV = network.getStateVariable("HLC_Canton_Q")
QHLC_Canton_SV.setValue(currentRuntimestep, QHLC_Canton)

Total HLC account releases & pump in
HLC_PumpOUT_SV = network.getStateVariable("HLC_Acct_OUT")
HLC_PumpOUT_SV.setValue(currentRuntimestep, QHLCacctOUT)
HLCpumpIN_SV = network.getStateVariable("HLC_PumpIN")
HLCpumpIN_SV.setValue(currentRuntimestep, QHLCpumpIN)

placeholder_var = 0

For all alternatives, set this variable, which is a dummy variable - never actually used, except to calculate other variables.

currentVariable.setValue(currentRuntimestep, placeholder_var)

Appendix D

HEC-ResSim and HEC-5Q Simulation of Water Quality in the Alabama-Coosa-Tallapoosa River Basin

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FINAL REPORT

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

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1 INTRODUCTION

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

The water quality model was created to serve as a defensible screening tool to make relative comparisons of the impacts among various water management alternatives. The central focus of this effort was to enable the EIS team to evaluate the differences in water quality between alternatives over the algal growing season (spring, summer, fall). The decision to model 70 years of record allows insight regarding the frequency and duration of water quality situations resulting from water management operations. The 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 ACT system. The 2001–2008 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 was developed from database information compiled during this analysis.

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

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

The 1999 Comprehensive Study used HEC-5 to generate the flows that were input into HEC-5Q (HEC, 1999). These were used to model water quality of the streams in the ACT basin, using a daily time step. The current analysis uses ResSim to generate all flows. A plug-in 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 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 ACT model was extended to include modeling of the reservoirs themselves, was adjusted to approximate the 2001–2008 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 four proposed water management alternatives. This work was performed in close coordination with water quality and water management technical staff members from Mobile District, Tetra Tech, the Hydrologic Engineering Center (HEC), and Resource Management Associates (RMA).

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

1.1 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 qualitative assessment of the water quality model, performed for the period of 2001–2008, data are available for all reservoirs except Carters Reregulation Dam. 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 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 simulated periods. The extrapolation process used maximum and minimum air temperatures to select meteorological data from the historical record to derive meteorological forcing for each location for the analysis period. While the imposition of a generalized daily meteorological pattern can sometimes interfere with exactly reproducing historical observations, it allows a consistent approach and enables the model to reproduce general trends of the observed data. This process is described in greater detail in section 2.2.3. With this method, model results were intended to reproduce the general trends in observed data and focus on water quality responses from changes in water management operations rather than changes in the weather.

The daily timestep of the 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 70 years of record. 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 observed data represent the average over the euphotic zone, while the modeled data represent the surface layer. Rather than focus 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 Chla 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 tributary 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 represent non-tributary inflows and 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. Reservoir releases serve as the boundary condition for computing the initial water quality for the downstream stream reach, since reservoir residence times are significantly longer than the stream travel time. 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 ResSim/HEC-5Q model were developed from observed data in conjunction with BASINS model loadings that were developed during previous ACT modeling efforts (Tetra Tech, August 1998). The BASINS model computes flow and water quality (BOD, total nitrogen, and total phosphorus) as a function of precipitation, land use, antecedent conditions, and other factors. 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 to develop extrapolation functions that relate hydrograph dynamics and HEC-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 2001–2008 HEC-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 historic concentration values. Adjusting the model to replicate individual extreme values and particular times and locations can harm the ability of the model to provide reasonable estimates for the majority of time periods throughout the system. Therefore, the focus of this analysis was to achieve reasonable responses over the system for the entire analysis period, using a consistent set of model coefficients.

1.3 ALTERNATIVE OPERATING PLANS[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 each of four operating plans. These are referred to as:

1. No Action Alternative (also known as "Baseline")
2. Plan D
3. Plan F
4. Proposed Action Alternative (also known as "RPlan G")

1.3.1 NO ACTION ALTERNATIVE

The No Action Alternative represents current water control operations at each of the projects in the ACT Basin. These modeled flows, however, are not representative of observed flows, due to differences between simulated operations and real operations implemented in the field. A more detailed explanation is given in HEC (2011b). The No Action alternative includes targets to meet minimum in-stream flow requirements on the Alabama River at Claiborne. A minimum environmental target flow of 4,640 cfs was established at JBT Goal, below the confluence of the Coosa and Tallapoosa Rivers, upstream of Montgomery. When the flow meets or exceeds this level, the minimum flow at Claiborne is 6,600 cfs. If the flow drops below 4,640 cfs at JBT Goal, the minimum flow at Claiborne is 4,200 cfs.

1.3.2 PLAN D

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

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[1] The HEC-ResSim model was revised in 2014, which included adding Hickory Log Creek Reservoir and revising operating plans and flows. The HEC-5Q model was updated to incorporate these changes. The results presented in Chapter 4 were produced using the revised HEC-5Q model, using the revised ResSim flows. Modeled and observed water quality data were compared, and it was determined that the model changes did not have a large impact on water quality and that the HEC-5Q model is performing as required. However, an extensive comparison of the modeled and observed data was not performed using the revised ResSim flows. The flows used to adjust the HEC-5Q model in 2009 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.

1.3.3 PLAN F

Plan F includes all of the stipulations as stated in Plan G. One additional component is that the Allatoona operations are also changed according to the Phased Drawdown guide curve. This alternative also uses the Revised Drought Plan with the USFWS enhancement.

1.3.4 PROPOSED ACTION ALTERNATIVE

The Proposed Action Alternative is the same as Plan F, except that it uses the reduction in hydropower from September to October for Allatoona operations.

1.4 HYDROLOGIC CONDITIONS

To evaluate the effects of the four operating plans on the water quality of the ACT watershed, three types of hydrologic conditions were selected for analysis. The year 2002 was selected to represent normal hydrologic conditions, 2003 was selected to represent flood ("wet") conditions, and 2007 was selected to represent drought ("dry") conditions. These selections were based on an analysis of 2001–2008 flow data recorded on the Coosa River at the Alabama-Georgia state line, the Tallapoosa River at JBT Goal, and at ARP. The year 2002 corresponded to the median flow levels, while 2003 and 2007 corresponded to the highest and lowest flow levels, respectively, during the 2001–2008 model period. In addition, the 2001–2008 model period was summarized, plotting "composite" longitudinal river profiles of each water quality parameter. These analysis periods are shown in Table 1.1.

Table 1.1 Annual hydrologic conditions evaluated in this analysis, and the year(s) selected from the model results to represent these conditions.

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

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

1.5 PROJECT OBJECTIVES

The purpose of this analysis was to evaluate the impacts of proposed alternative water management plans on long-term, system-wide, stream and reservoir water quality of the

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

1.6 Report Organization

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

2 MODEL DESCRIPTION

HEC-5Q was developed so that temperature and selected conservative and non-conservative constituents could be readily included as a consideration in system planning and management. Using computed reservoir 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 ACT analysis, the following parameters were modeled.

- Temperature
- Point source tracer
- Dissolved oxygen
- Ammonia (NH_3) - Nitrogen
- Nitrate (NO_3) – Nitrogen
- Phosphate (PO_4) – Phosphorus
- Phytoplankton – Chlorophyll *a*[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]

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[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 0.01 and 0.08 for phosphorus (P) and nitrogen (N) respectively or CHLA:P and CHLA:N of 1 and 8 respectively. These values are in line with CE-QUAL-R1 (WES, 1986) guidelines.

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

Temperature

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

Point Source Tracer

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

Ammonia - Nitrogen

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

Nitrate - Nitrogen

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[3] The Total Suspended Solids (TSS) levels recorded at major discharge locations 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.

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. Sources of phosphorus include phytoplankton respiration, TSS and DOM decay. Phosphates tend to sorb to suspended solids and are subject to loss by settling. This phosphorus can then be rereleased from the bottom sediment. This anaerobic process is represented by the phosphorus flux rate.

Phytoplankton – Chlorophyll *a*

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

Dissolved Oxygen

Exchange of dissolved oxygen (DO) at the water surface is a function of the surface exchange (reaeration) rate that is determined by wind speed in reservoirs and hydraulic characteristics in streams. Phytoplankton photosynthesis is a source of DO. Sinks for DO include BOD and ammonia decay, phytoplankton respiration and benthic uptake. Oxygen consumption associated with the decay of DOM and 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 an oxygen demand (BOD) during decay and transformation to their chemical components. Thus they contribute to dissolved nitrogen and phosphorus. The dissolved material is subdivided into point and non-point origin to add flexibility in assigning decay rates. It is also a measure of point source influence that considers decay and source quality.

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 MODEL REPRESENTATION OF THE PHYSICAL SYSTEM

Reservoirs and rivers comprising the ACT 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 HEC-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 geometry (outlets, etc.) were taken from the 1998 HEC-5 model.

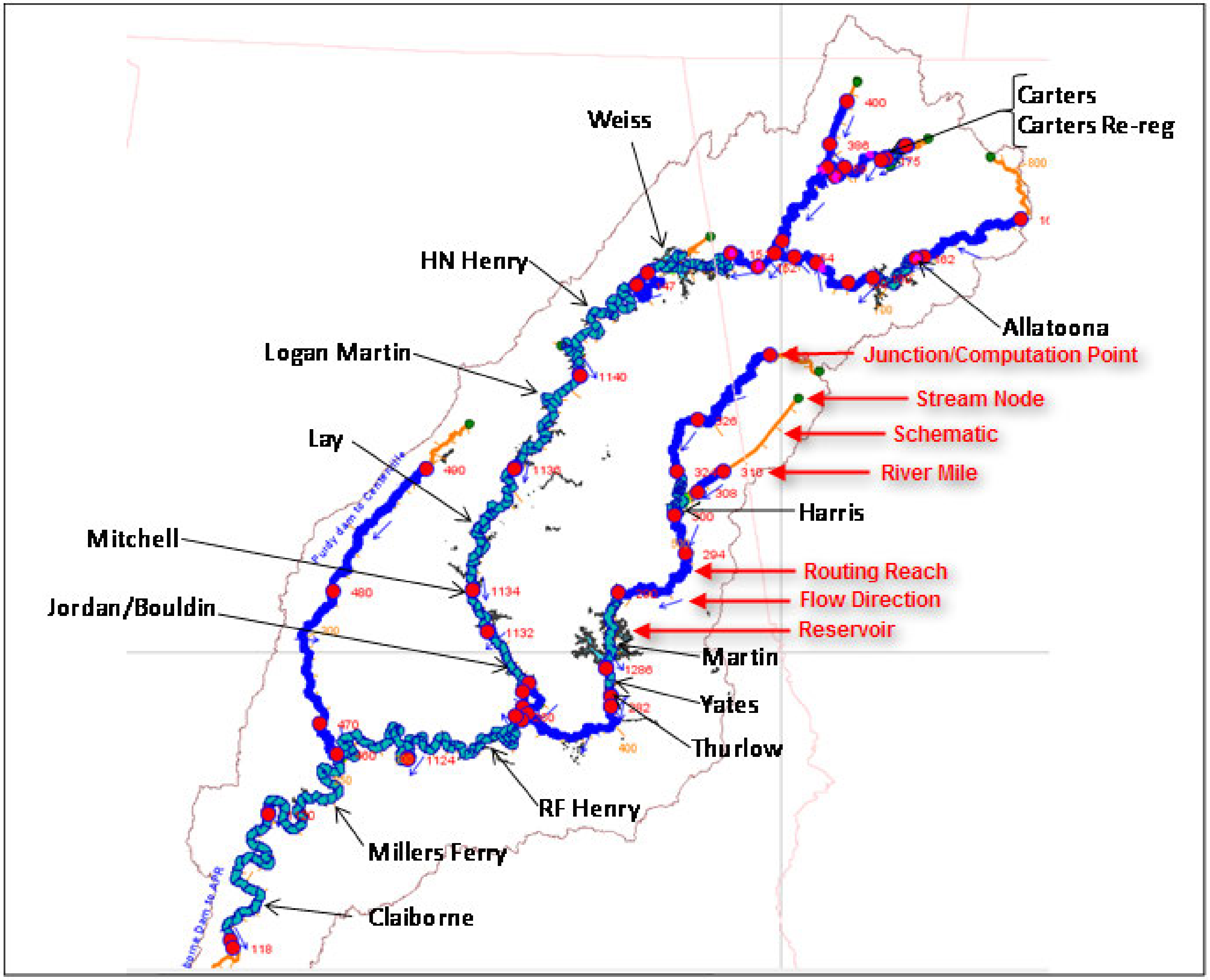

Figure 2.1 HEC-5 and HEC-5Q Model Schematic of ACT Basin showing reservoirs. The red numbers are control points of the HEC-5Q model, not river miles.

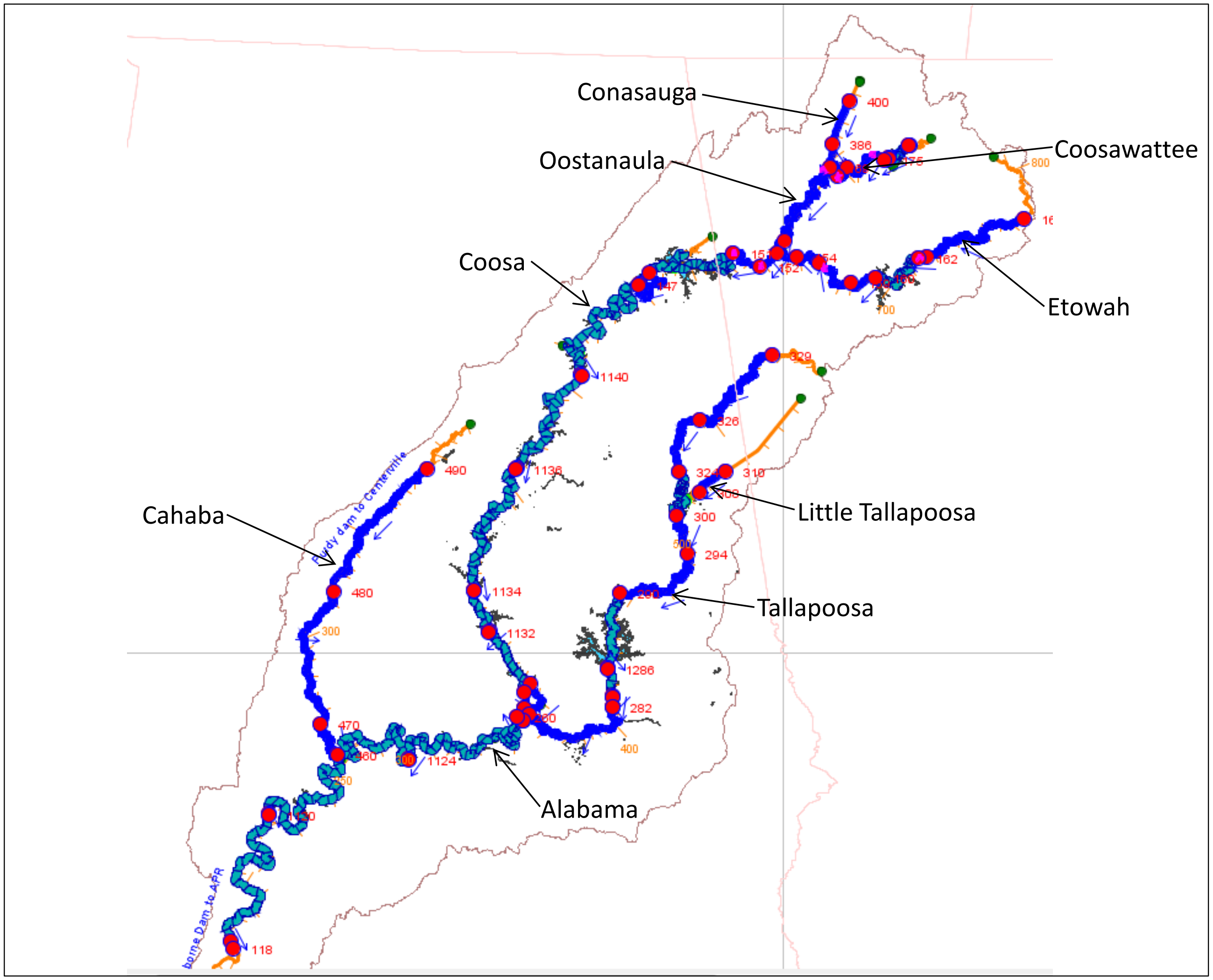

Figure 2.2 HEC-5 and HEC-5Q Model Schematic of ACT Basin showing rivers. See Figure 2-1 for definition of model elements.

2.1.1 MODEL REPRESENTATION OF RESERVOIRS

For water quality simulations, each reservoir was geometrically discretized and represented as either a vertically segmented, longitudinally segmented, or a vertically layered and longitudinally segmented water body. A description of the different types of reservoir representation follows. A list of all reservoirs, the geometric representation, inflows and tributaries is presented as an appendix to this report. The equations used by HEC-5Q for each configuration are listed in HEC (1986).

2.1.1.1 Vertically Segmented Reservoirs

Vertically stratified reservoirs are represented conceptually by a series of one-dimensional horizontal slices or layered volume elements, each characterized by an area, thickness, and volume. In the aggregate the assemblage of layered volume elements is a geometrically discretized representation of the prototype reservoir. Within each horizontal layer of a vertically segmented 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 segmented configuration.

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

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

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

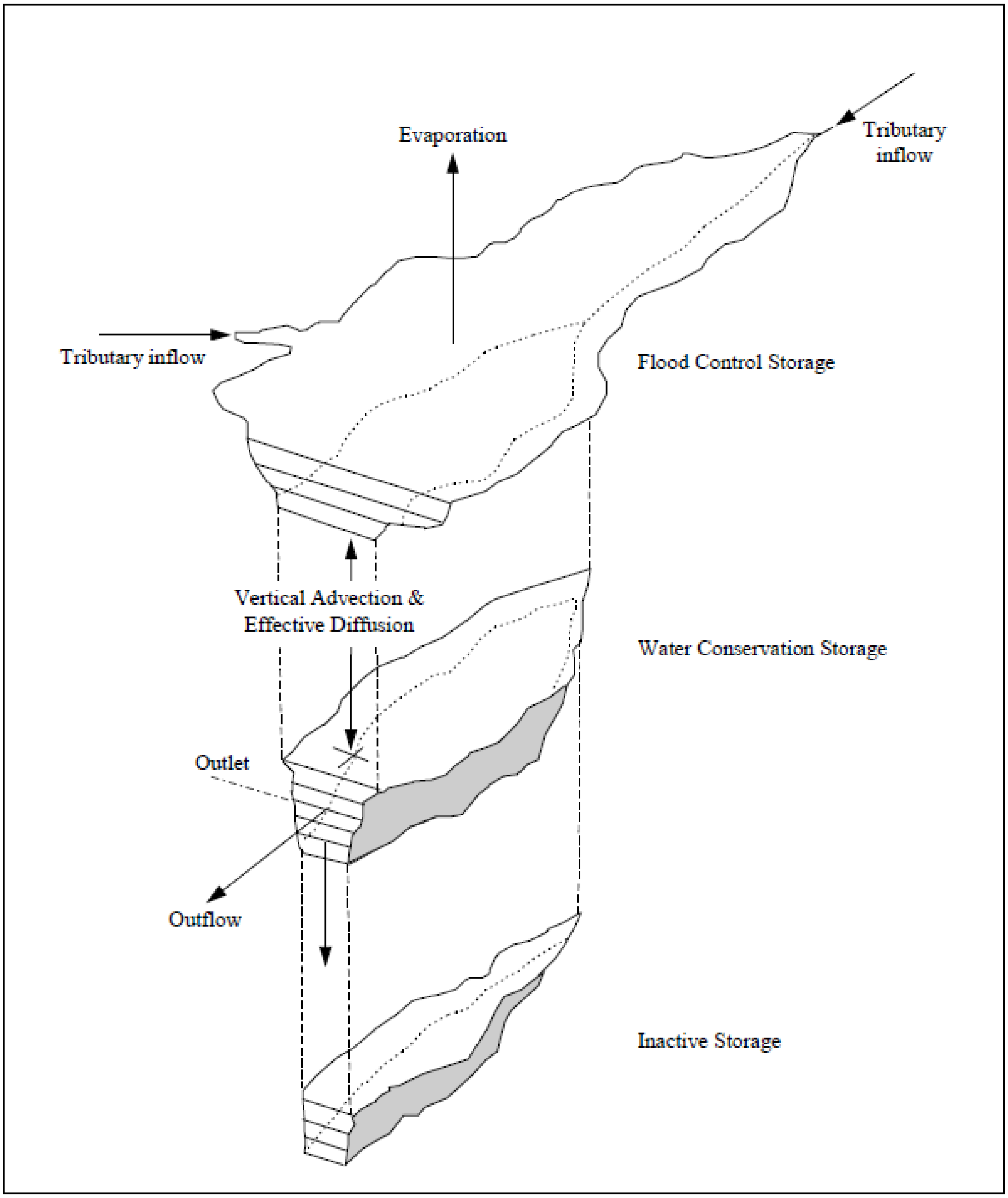

Figure 2.3 Schematic representation of a vertically segmented reservoir (HEC, 1986).

2.1.1.2 Longitudinally Segmented Reservoirs

Longitudinally segmented reservoirs are represented conceptually as a linear network of a specified number of segments or volume elements. Length and the relationship between width and elevation characterize the geometry of each reservoir segment. The surface areas, volumes and cross sections are computed from the width relationship.

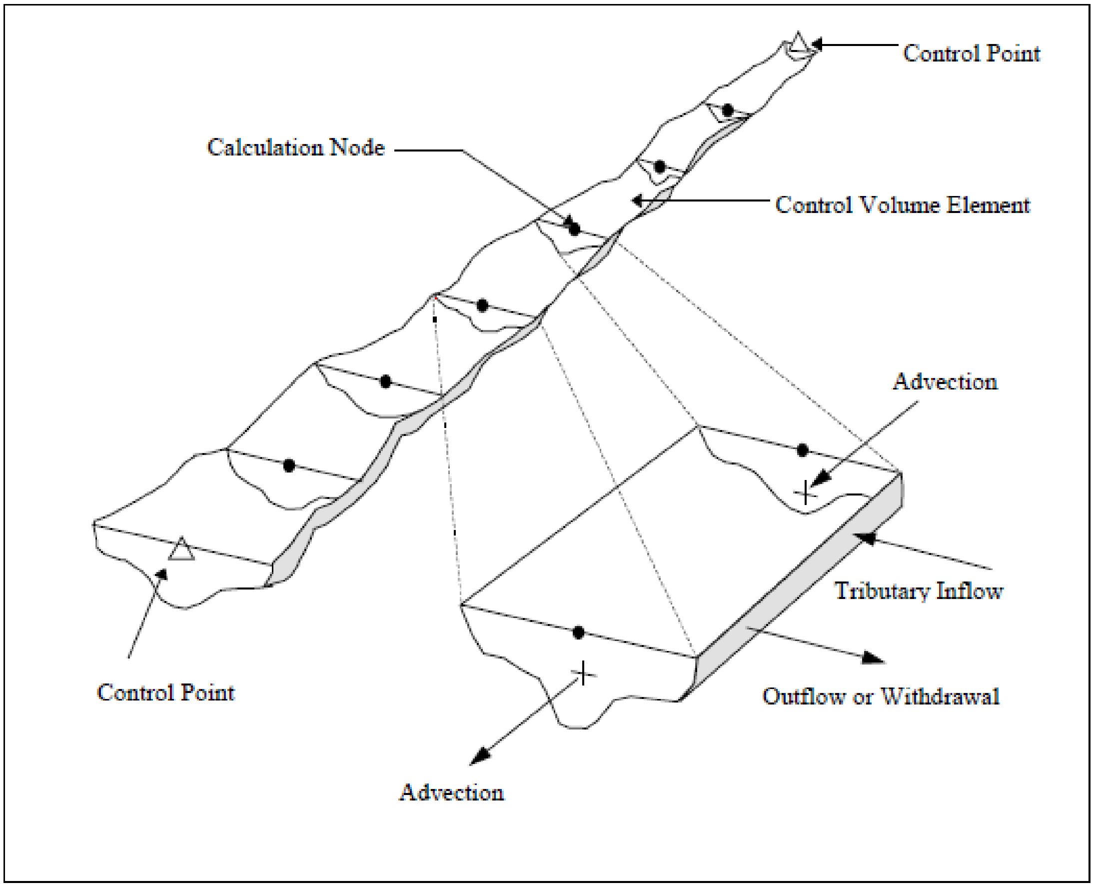

Figure 2.4 Schematic representation of a longitudinally stratified reservoir (HEC, 1986).

2.1.1.3 Vertically and Longitudinally Segmented Reservoirs

Longitudinally segmented reservoirs may be subdivided into vertical elements with each element assumed fully mixed in the vertical and lateral directions. Branching of reservoirs is allowed. For reservoirs represented as layered and longitudinally segmented, all cross-sections contain the same number of layers and each layer is assigned the same fraction of the reservoir cross-sectional area. The model performs a backwater computation to define the water surface profile as a function of the hydraulic gradient based on flow and Manning's equation.

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

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

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

Vertical flow distributions at dams are based on weir or orifice withdrawal. The velocity distribution within the water column is calculated as a function of the water density and depth using the WES weir withdrawal or orifice withdrawal allocation method (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).

Table 2.1 summarizes the discretization of all reservoirs in the ACT model, listing the number of segments and layers in each longitudinally segmented reservoir and the layer thickness of each vertically segmented reservoir.

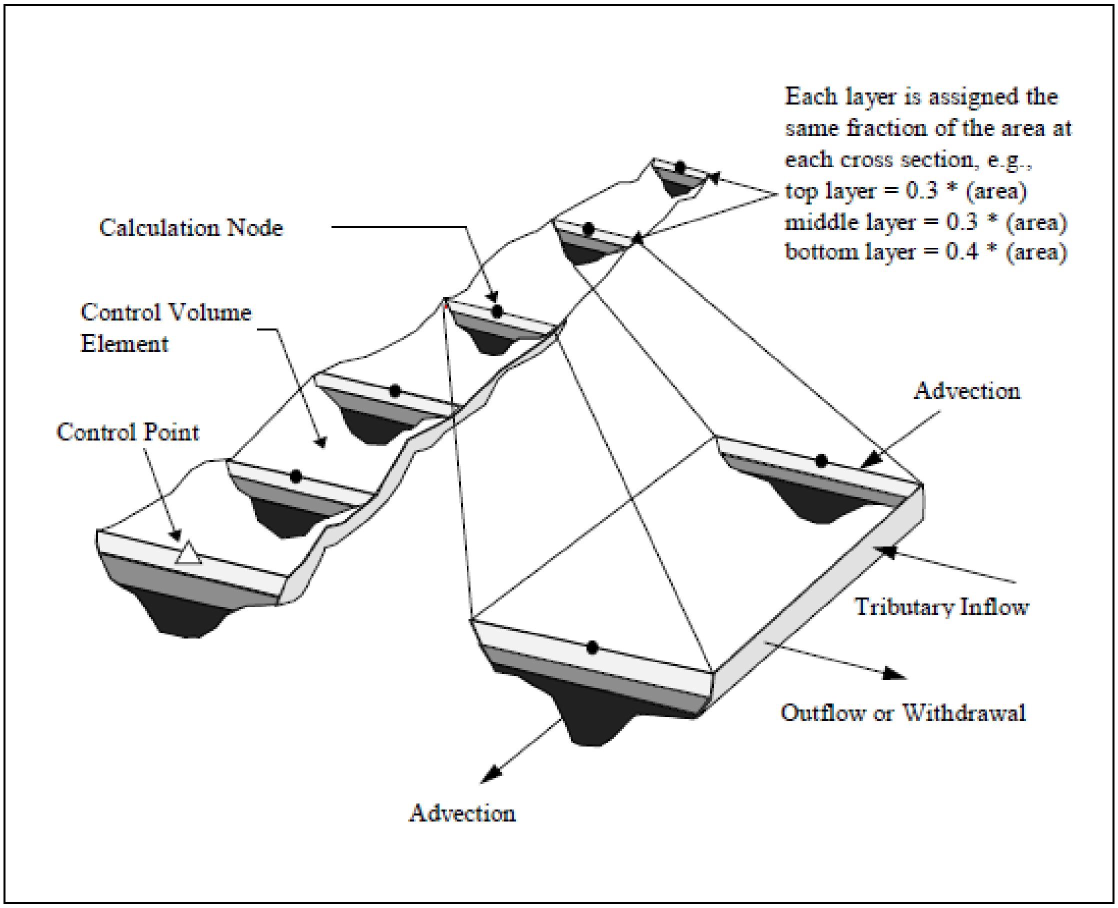

Figure 2.5 Schematic representation of a layered and longitudinally segmented reservoir (HEC, 1986).

Table 2.1 Summary of reservoir discretization.

River **\ Reservoir**	**Vertically Layered**	**Horizontally Segmented**	**Vertically Layered and Horizontally Segmented**	**Layer Thickness (feet)**	**Number of Layers**	**Number of Segments**
Etowah River						
Hickory Log Creek	x			3		
Allatoona	x			3		
Coosawattee River						
Carters	x			3		
Carters Re-reg		x			1	6
Coosa River						
Weiss			x		8	28
HN Henry			x		5	27
Logan Martin			x		5	21
Lay			x		5	23
Mitchell			x		5	7
Jordan			x		5	7
Bouldin			x		5	3
Tallapoosa River						
Harris	x			3		
Martin	x			3		
Yates			x		4	4
Thurlow			x		4	2
Alabama River						
RF Henry			x		5	30
Millers Ferry			x		5	40
Claiborne			x		5	19

2.1.2 MODEL REPRESENTATION OF STREAMS

In HEC-5Q, a reach of a river or stream is represented conceptually as a linear network of segments or layered volume elements. Each element is characterized by its length, depth, width, and cross-sectional area. The depth is defined as a function of flow, and the cross-section areas and widths are subsequently defined as a function of the 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 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. A list of all stream reaches and point and non-point source inflows and water quality is provided in the appendix in Table A-7.1 and Table A-7.2, respectively.

2.2 WATER QUALITY BOUNDARY CONDITIONS AND INPUT DATA

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

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

Negative inflows are a problem, however, from a water quality perspective in that the inflow quality must be defined while the negative inflow removes ambient water quality. As an example, if a -100 cfs is followed by a +100 cfs to represent an inflow of near zero, an artificial tributary load is introduced on the +100 cfs day. To mitigate this affect, the water quality load is computed from an inflow rate that is constrained as positive. An example of 7-day average (with negative flows) and constrained Weiss reservoir inflows is provided in Figure 2.6, with a detail view of 2001 in Figure 2.7. In some instances, the constrained inflow is developed by aggregating two or more sets of ResSim incremental inflows. The rate of decrease is further limited to 67% of the previous day’s flow. Residual negative inflows are allocated to future positive inflow. Aggregation is done when adjacent control points have erratic local flows or when one of the local flows has extensive negative inflows. An example of this approach is shown in Figure 2.8 where the inflow to HN Henry has extensive negative inflow periods. The inflows to HN Henry and Logan Martin are combined and then constrained to the 67% decrease. The scaled flows are then allocated to individual tributaries proportional to tributary inflow as computed by BASINS.

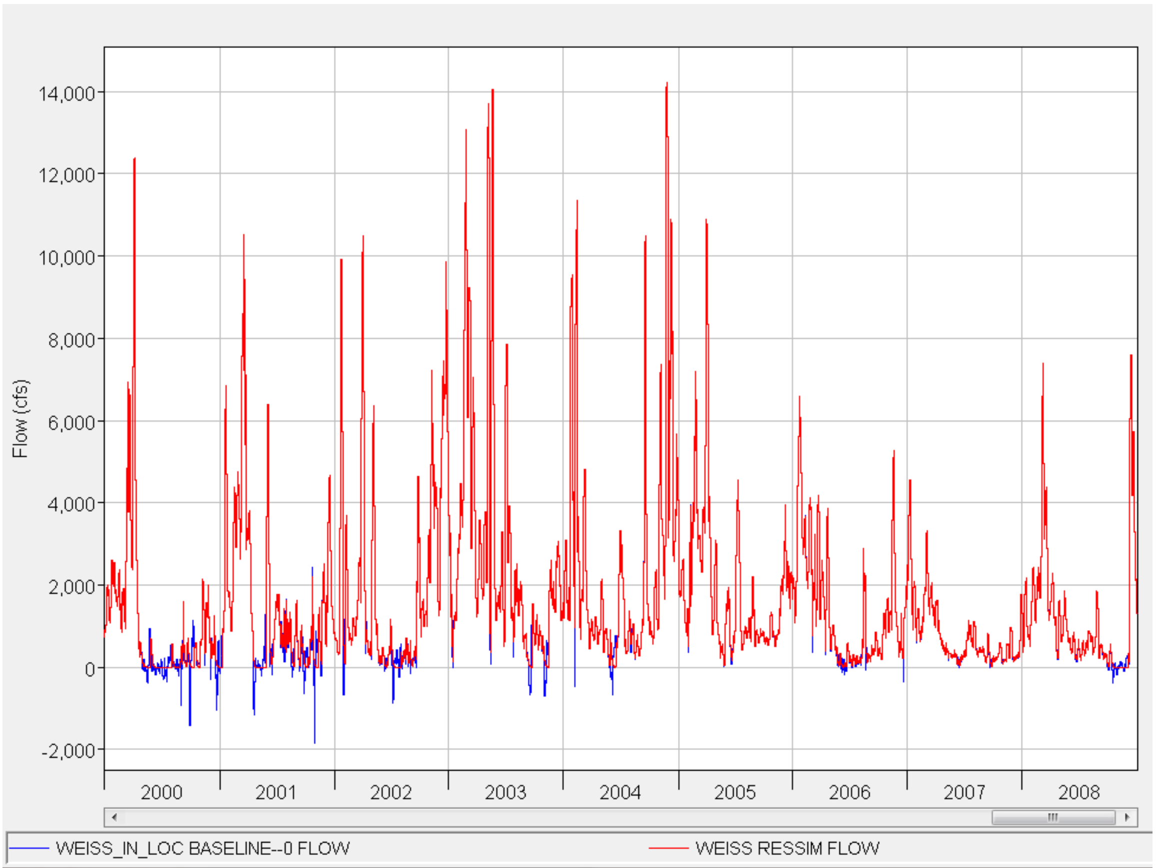

Figure 2.6 Comparison of 7-day average and constrained Weiss reservoir inflows.

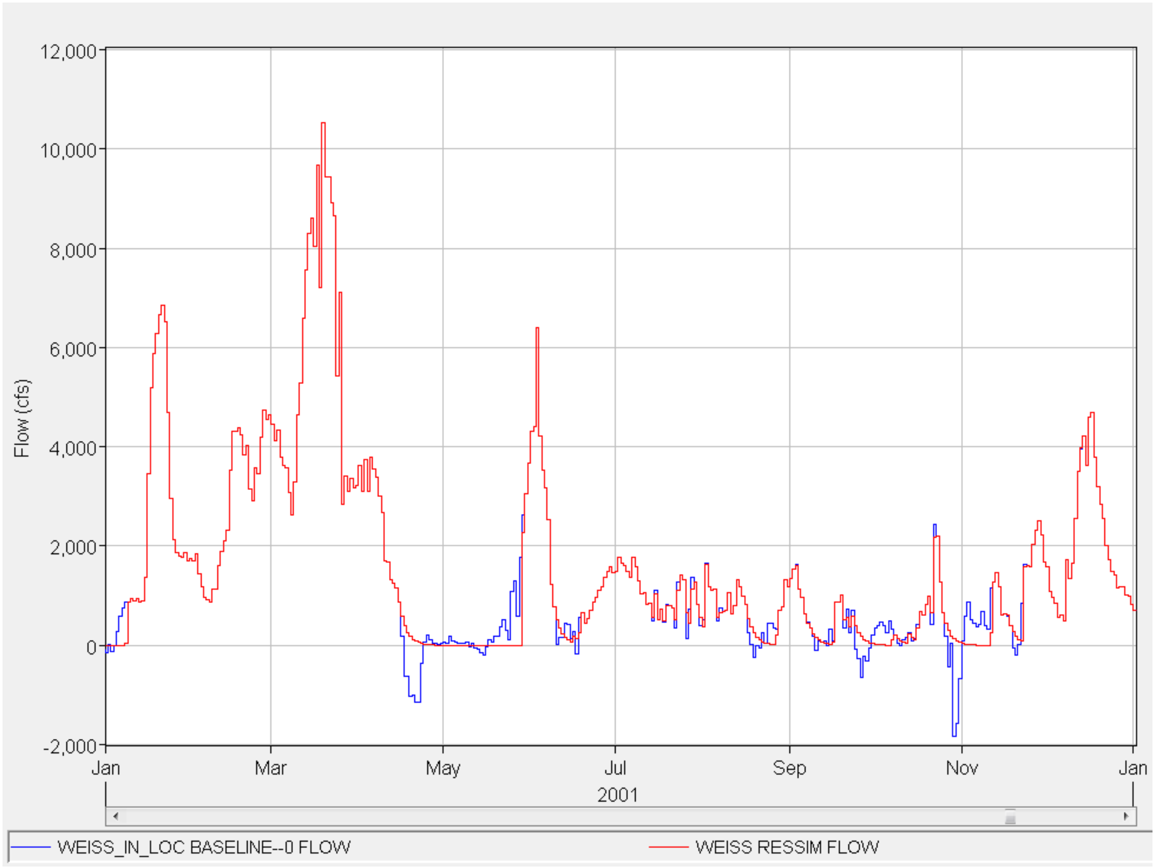

Figure 2.7 Comparison of 7-day average and constrained Weiss reservoir inflows (detail view of 2001).

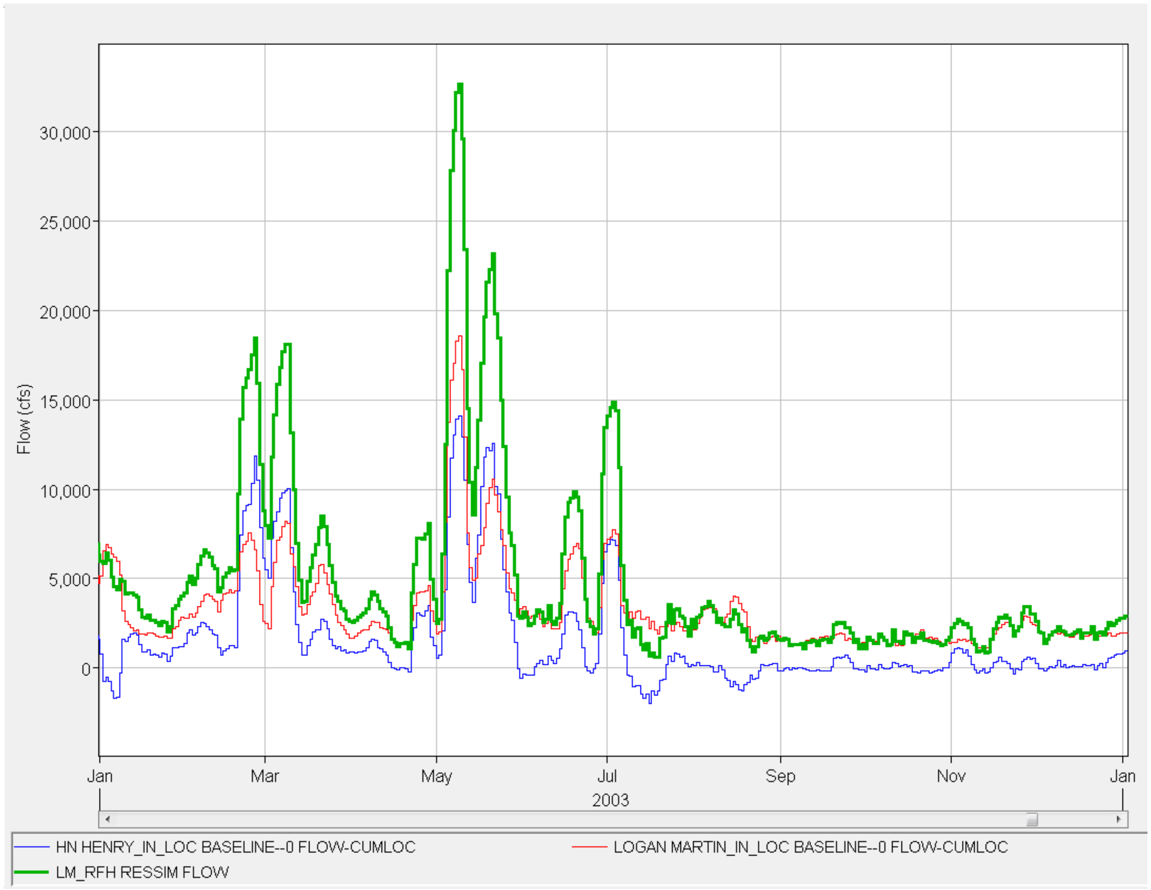

Figure 2.8 Inflows to HN Henry reservoir (blue) and Logan Martin reservoir (red) and combined and constrained HN Henry and Logan Martin ResSim flows (green).

2.2.1 NON-POINT SOURCE FLOW AND WATER QUALITY DATA

The non-point source water quality inputs to the ResSim/HEC-5Q model were developed from observed data in conjunction with BASINS model loadings that were developed during previous ACT modeling efforts (Tetra Tech, August 1998). The BASINS model computes flow and water quality (BOD, total nitrogen, and total phosphorus) as a function of precipitation, land use, antecedent conditions, and other factors. 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 analyzed to develop extrapolation functions that relate hydrograph dynamics and HEC-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 2001–2008 HEC-ResSim flows to generate the non-point-source loadings for input to HEC-5Q. Output for 200 BASINS watersheds of the ACT was available. These watersheds were consolidated to define 102 non-point source inflows for the current HEC-5Q modeling effort. The watersheds/stream names and corresponding stream / inflow locations are listed in the appendix (Table A-7.1).

The HEC-5Q model of the ACT was designed to utilize flows computed by ResSim for the 1939–2008 period of record. The tributary flows and water quality computed by BASINS for the 1984–1989 period served as a basis for estimating the response of water quality parameters to tributary stream flow dynamics and for extrapolating a comparable record for the 1939–2008 ResSim simulation period.

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

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

1. C = Concentration
2. C_o = Minimum concentration
3. K_1 = Scaling factor
4. Q_t = Flow for current day
5. 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.

Water quality field data for eight tributaries to the upper ACT Basin Rivers were compared with the BASINS-based water quality for the 2001–2008 period. The fraction of total nitrogen allocated to nitrate and ammonia was based on these observations.

Tributaries to the upper ACT:

1. Mountaintown Creek (15) [4]
2. Armuchee Creek (25)
3. Shoal Creek (6)
4. Little River (8)
5. Raccoon Creek (11)
6. Euharlee Creek (12)
7. Beech Creek (27)
8. Chattooga River (30)

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

1. BOD5U: 5-Day uninhibited BOD
2. DO: Dissolved Oxygen
3. NH3: Ammonia -nitrogen
4. NO2NO3: Nitrite + Nitrate-nitrogen
5. TOTALP: Total Phosphorus
6. SOLIDTSS: Suspended Solids
7. TEMP: Temperature
8. 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 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 Total Phosphorus and TSS are examples of

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

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

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 in Table A-7.1.

Table 2.2 Summary of available observed data for non-point source 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. (C)	Chlorophyll a (ug/L)
Mountaintown Creek at State Road 282 (US Hwy 76) near Ellijay, Ga.								
Samples	94	147	79	91	89	65	147	18
Avg	1.50	10.14	0.033	0.110	0.052	16.00	14.44	2.63
Min	0.10	7.64	0.010	0.040	0.012	1.00	2.40	0.80
Max	2.85	14.32	0.100	0.260	0.720	506.00	25.99	9.70
Median	2.00	9.88	0.030	0.101	0.020	6.00	15.08	2.10
Avg/Median	1.33	0.98	0.919	0.921	0.381	0.38	1.05	0.80
Armuchee Creek at Old Dalton Road near Rome, Ga.								
Samples	43	62	35	35	35	37	62	15
Avg	1.18	8.18	0.035	0.253	0.031	15.47	19.81	3.41
Min	0.00	6.06	0.010	0.050	0.020	1.00	4.80	1.00
Max	7.38	24.57	0.120	0.980	0.185	130.00	27.10	21.10
Median	0.83	7.56	0.030	0.240	0.020	11.50	21.86	1.90
Avg/Median	0.70	0.92	0.853	0.947	0.645	0.74	1.10	0.56
Shoal Creek at State Road 108 (Fincher Rd.) near Waleska, Ga.								
Samples	91	156	76	88	87	59	156	18
Avg	1.41	9.37	0.036	0.154	0.043	13.91	14.79	2.52
Min	0.10	5.67	0.010	0.020	0.015	1.00	2.02	0.70
Max	3.50	13.60	0.100	0.320	0.700	362.00	25.54	5.60
Median	1.45	9.21	0.030	0.170	0.020	5.00	15.10	2.20
Avg/Median	1.03	0.98	0.823	1.105	0.462	0.36	1.02	0.87
Little River at Georgia Highway 5 near Woodstock, Ga.								
Samples	91	156	76	88	86	91	156	18
Avg	1.65	8.88	0.113	0.843	0.080	25.83	15.73	3.59
Min	0.10	5.50	0.020	0.100	0.020	1.00	1.90	1.30
Max	6.30	13.20	0.530	6.800	0.660	240.00	25.90	11.90
Median	1.85	8.70	0.076	0.430	0.060	14.00	16.40	2.80
Avg/Median	1.12	0.98	0.672	0.510	0.750	0.54	1.04	0.78
Raccoon Creek at State Road 113 near Stilesboro, Ga.								
Samples	12	45	12	12	12	12	45	1
Avg	0.53	7.92	0.025	0.415	0.026	14.50	18.49	2.00
Min	0.20	5.40	0.010	0.160	0.020	1.00	4.10	2.00
Max	1.20	12.10	0.030	0.540	0.080	100.00	25.93	2.00
Median	0.40	7.54	0.030	0.450	0.020	7.00	19.52	2.00
Avg/Median	0.75	0.95	1.200	1.084	0.774	0.48	1.06	1.00
Euharlee Creek at County Road 32 near Stilesboro, Ga.								
Samples	42	35	36	36	36	37	35	14
Avg	1.09	8.14	0.038	0.690	0.116	24.38	18.28	2.41
Min	0.30	6.70	0.010	0.236	0.020	3.00	8.10	0.70
Max	2.85	10.30	0.160	1.440	0.410	112.00	24.14	11.30
Median	0.98	7.90	0.030	0.660	0.100	15.50	19.72	1.50
Avg/Median	0.90	0.97	0.794	0.957	0.859	0.64	1.08	0.62
Beech Creek at Mays Bridge Road SW near Rome, Ga.								
Samples	64	68	48	56	57	58	68	12
Avg	1.48	5.44	0.043	0.150	0.037	9.85	18.47	3.36
Min	0.00	2.14	0.018	0.020	0.019	1.00	7.80	1.10
Max	5.14	10.20	0.110	0.303	0.120	36.00	25.13	6.90
Median	1.29	5.20	0.032	0.150	0.028	9.50	19.62	2.50
Avg/Median	0.87	0.96	0.746	1.003	0.756	0.97	1.06	0.74

	BOD5U (mg/L)	OXYGEN (mg/L)	NH3-N (mg/L)	NO2+NO3-N (mg/L)	Total P (mg/L)	TSS (mg/L)	Temp. (C)	Chlorophyll a (ug/L)
Chattooga River at Holland-Chattoogaville Road (FAS1363) near Lyerly,								
Samples	90	156	76	90	88	91	157	24
Avg	1.78	8.60	0.065	0.421	0.266	16.77	17.23	3.49
Min	0.36	4.40	0.020	0.050	0.020	2.50	3.90	0.70
Max	3.91	15.85	0.370	1.160	0.950	94.00	29.59	11.10
Median	2.00	8.34	0.050	0.410	0.210	12.50	18.00	2.60
Avg/Median	1.13	0.97	0.775	0.974	0.790	0.75	1.05	0.75
Sample Weighted (Average of all tributaries)								
Samples	527	825	438	496	490	450	826	120
Avg	0.02	0.08	0.001	0.006	0.001	0.30	0.17	0.20
Min	0.00	0.05	0.000	0.001	0.000	0.03	0.04	0.07
Max	0.06	0.14	0.003	0.024	0.008	3.51	0.25	0.66
Median	0.02	0.08	0.001	0.005	0.001	0.18	0.18	0.15
Avg/Median	0.01	0.01	0.015	0.015	0.011	0.01	0.01	0.05

Table 2.3 Summary of average non-point source inflow and water quality for tributaries.

Location	Flow (cfs)	Temp (C)	NO3-N (mg/L)	PO4-P (mg/L)	Chlorophyll *a* (ug/L)	NH3-N (mg/L)	DO (mg/L)	Diss. Org. (mg/L)	Org. Solids (mg/L)
upstream Etowah R.	98.0	17.6	0.189	0.017	0.000	0.018	8.44	2.01	1.18
Amicaloa Cr.	96.0	17.6	0.200	0.017	0.000	0.019	8.43	2.02	1.27
Settingdown Cr.	173.7	17.6	0.232	0.018	0.000	0.022	8.43	2.02	1.27
Long Swamp Cr.	263.7	17.6	0.227	0.018	0.000	0.021	8.43	2.02	1.25
Mountain Cr.	372.7	17.6	0.236	0.019	0.000	0.022	8.43	2.03	1.32
Shoal Cr.	30.2	17.6	0.202	0.018	0.000	0.019	8.38	2.04	1.35
Noonday & Allatonna Cr.	147.0	17.6	0.283	0.025	0.000	0.025	8.38	2.23	1.80
Little R.	231.0	17.6	0.282	0.026	0.000	0.025	8.38	2.23	1.80
Pumpkinvine Cr.	107.4	17.6	0.330	0.017	0.000	0.019	8.43	2.02	1.28
Pettit Cr.	188.4	17.6	0.440	0.019	0.000	0.024	8.43	2.03	1.36
Raccoon Cr.	226.1	17.6	0.435	0.019	0.000	0.023	8.43	2.03	1.37
Euharlee Cr.	366.5	17.6	0.438	0.018	0.000	0.023	8.43	2.02	1.32
Two Run Cr.	77.0	17.6	0.437	0.018	0.000	0.023	8.43	2.01	1.24
Dikes Cr.	133.7	17.6	0.446	0.018	0.000	0.024	8.43	2.01	1.23
Coosawattee R.	616.2	17.6	0.182	0.016	0.000	0.018	8.43	2.01	1.23
Talking Rock Cr.	195.9	17.6	0.250	0.021	0.000	0.023	8.43	2.06	1.48
Salacoa Cr.	296.3	17.6	0.257	0.052	0.000	0.024	8.43	2.06	1.34
Conasauga R	255.6	17.6	0.258	0.024	0.000	0.024	8.43	2.04	1.28
Coahulla R.	265.8	17.6	0.346	0.037	0.000	0.030	8.43	2.20	1.61
Holly Cr.	468.5	17.6	0.319	0.035	0.000	0.028	8.43	2.24	1.68
Polecat Cr.	47.4	17.6	0.248	0.020	0.000	0.023	8.43	2.10	1.43
Oostanaula Tribs.	97.1	17.6	0.275	0.020	0.000	0.025	8.43	2.09	1.40
Oothkalooga Cr.	70.7	17.6	0.302	0.021	0.000	0.027	8.43	2.09	1.59
Johns Cr.	66.3	17.6	0.278	0.019	0.000	0.025	8.43	2.04	1.43
Armuchee Cr.	205.2	17.6	0.254	0.018	0.000	0.023	8.43	2.03	1.34
Silver Cr.	221.5	17.6	0.440	0.019	0.000	0.024	8.43	2.03	1.38
Coosa R. Tribs	16.0	17.6	0.274	0.020	0.000	0.025	8.43	2.11	1.59
Big Cedar Cr.	178.6	17.6	0.253	0.017	0.000	0.023	8.43	2.07	1.35
Spring Cr.	267.9	17.6	0.257	0.017	0.000	0.023	8.43	2.07	1.36
Chattooga R.	520.2	17.6	0.247	0.017	0.000	0.023	8.43	2.06	1.33
Weiss Lake	702.3	17.6	0.241	0.017	0.000	0.022	8.43	2.05	1.29
Terrapin Cr.	177.8	17.6	0.242	0.016	0.000	0.022	8.43	2.01	1.33
Big Willis Cr.	350.0	17.6	0.243	0.016	0.000	0.022	8.43	2.01	1.36
Big Canoe Cr.	516.3	17.6	0.237	0.015	0.000	0.022	8.43	2.00	1.31
Beaver Cr.	554.7	17.6	0.235	0.015	0.000	0.022	8.43	2.00	1.30
Ohatchee Cr.	174.5	17.6	0.183	0.015	0.000	0.018	8.43	2.00	1.17
Cane Cr.	251.4	17.6	0.182	0.015	0.000	0.018	8.43	2.00	1.19
Broken Arrow Cr.	366.4	17.6	0.175	0.015	0.000	0.017	8.43	2.00	1.17
Choccolocco Cr.	895.5	17.6	0.181	0.015	0.000	0.018	8.43	2.00	1.19
Kelley Cr.	85.7	17.6	0.225	0.017	0.000	0.021	8.43	2.06	1.31
Talladega Cr.	204.9	17.6	0.236	0.017	0.000	0.022	8.43	2.07	1.38
Upper Yellowleaf Cr.	284.3	17.6	0.230	0.017	0.000	0.021	8.43	2.07	1.34
Peckerwood Cr.	331.4	17.6	0.235	0.017	0.000	0.022	8.43	2.07	1.35
Waxahatchee Cr.	414.3	17.6	0.229	0.017	0.000	0.021	8.43	2.07	1.36
Lower Yellowleaf Cr.	59.1	17.6	0.170	0.016	0.000	0.017	8.43	2.03	1.19
Walnut Cr.	509.3	17.6	0.172	0.016	0.000	0.017	8.43	2.04	1.21
Chestnut Cr.	154.9	17.6	0.186	0.015	0.000	0.018	8.43	2.02	1.13
Weoka Cr.	398.4	17.6	0.176	0.015	0.000	0.018	8.43	2.02	1.12
Tallapoosa R.	162.6	17.6	0.245	0.019	0.000	0.023	8.43	2.03	1.39
Little Cr.	38.9	17.6	0.262	0.020	0.000	0.024	8.43	2.04	1.41
Muscadine Cr.	71.5	17.6	0.248	0.019	0.000	0.023	8.43	2.02	1.35
Kelley + Norman Cr.	97.6	17.6	0.255	0.020	0.000	0.023	8.43	2.03	1.38

Location	Flow (cfs)	Temp (C)	NO3-N (mg/L)	PO4-P (mg/L)	Chlorophyll *a* (ug/L)	NH3-N (mg/L)	DO (mg/L)	DOM (mg/L)	TSS (mg/L)
Silas Cr.	138.3	17.6	0.262	0.020	0.000	0.024	8.43	2.03	1.38
Cane Cr.	56.5	17.6	0.187	0.017	0.000	0.018	8.43	2.02	1.31
Dyne Cr.	102.6	17.6	0.198	0.017	0.000	0.019	8.43	2.01	1.29
Ketchepedrakee Cr.	151.1	17.6	0.194	0.016	0.000	0.019	8.43	2.01	1.25
Little Tallapoosa R.	244.7	17.6	0.330	0.024	0.000	0.029	8.43	2.07	1.52
Cohobadiah Cr.	83.6	17.6	0.287	0.019	0.000	0.026	8.43	2.00	1.20
Tallapoosa R. Tribs	157.6	17.6	0.245	0.018	0.000	0.023	8.43	2.01	1.24
Crooked Cr.	83.5	17.6	0.225	0.016	0.000	0.021	8.43	2.02	1.26
Cornhouse Cr.	178.9	17.6	0.218	0.016	0.000	0.021	8.43	2.02	1.23
High Pine Cr.	50.3	17.6	0.206	0.016	0.000	0.020	8.43	2.03	1.33
Chikasanoxee Cr.	146.7	17.6	0.201	0.016	0.000	0.019	8.43	2.02	1.24
Chatahospee Cr.	275.1	17.6	0.210	0.016	0.000	0.020	8.43	2.02	1.23
Hillabee Cr.	565.5	17.6	0.202	0.016	0.000	0.019	8.43	2.02	1.24
Martin Lake Tribs	367.1	17.8	0.206	0.016	0.000	0.020	8.34	2.02	1.30
Channahatchee Cr.	31.4	17.6	0.234	0.022	0.000	0.022	8.43	2.23	1.56
Tallapoosa R. Tribs	3.7	17.6	0.344	0.025	0.000	0.030	8.43	2.32	1.70
Upahee Cr.	29.3	17.6	0.321	0.033	0.000	0.028	8.43	2.47	1.91
Calebee Cr.	48.0	17.6	0.335	0.034	0.000	0.029	8.43	2.45	1.88
Cubahatchee Cr.	56.8	17.6	0.327	0.033	0.000	0.029	8.43	2.44	1.87
Line Cr.	86.1	17.6	0.349	0.033	0.000	0.030	8.43	2.38	1.79
Chubbehatchee Cr.	93.3	17.6	0.343	0.033	0.000	0.030	8.43	2.36	1.76
Tallapoosa R. Tribs	104.5	17.6	0.361	0.035	0.000	0.031	8.43	2.38	1.79
Coosa R. Tribs	9.9	17.6	0.473	0.048	0.000	0.040	8.43	2.36	1.76
Autauga Cr.	530.1	17.6	0.354	0.025	0.000	0.031	8.43	2.26	1.72
Pintalla Cr.	798.2	17.6	0.350	0.024	0.000	0.030	8.43	2.19	1.59
Swift Cr.	991.5	17.6	0.338	0.023	0.000	0.030	8.43	2.15	1.52
Purdy Lake Tribs	23.5	17.6	0.238	0.021	0.000	0.022	8.43	2.14	1.47
Cahaba R.	65.7	17.6	0.220	0.023	0.000	0.021	8.43	2.14	1.46
Little Shades Cr.	101.4	17.6	0.282	0.031	0.000	0.025	8.43	2.33	1.78
Buck Cr.	155.0	17.6	0.275	0.029	0.000	0.025	8.43	2.28	1.70
Pineywood Cr.	231.8	17.6	0.272	0.029	0.000	0.025	8.43	2.28	1.70
Little Cahaba R.	391.1	17.6	0.292	0.029	0.000	0.026	8.43	2.23	1.63
Shultz Cr.	438.2	17.6	0.284	0.028	0.000	0.026	8.43	2.21	1.59
Affohee+Hayson+Blue Cr.	110.1	17.6	0.209	0.015	0.000	0.020	8.43	2.01	1.27
Old Town + Wallace Cr.	193.4	17.6	0.210	0.016	0.000	0.020	8.43	2.01	1.29
Waters Cr.	246.7	17.6	0.214	0.016	0.000	0.020	8.43	2.01	1.29
Oakmulgee Cr.	414.4	17.6	0.213	0.015	0.000	0.020	8.43	2.01	1.27
Cahaba R. Tribs	25.2	17.6	0.437	0.026	0.000	0.037	8.43	2.01	1.23
Big Swamp Cr.	115.9	17.6	0.390	0.034	0.000	0.033	8.43	2.18	1.54
Mulberry Cr.	327.3	17.6	0.343	0.030	0.000	0.030	8.43	2.13	1.44
Beach Cr.	375.6	17.6	0.344	0.030	0.000	0.030	8.43	2.15	1.49
Cedar Cr.	575.7	17.6	0.332	0.030	0.000	0.029	8.43	2.17	1.52
Bogue Chitto Cr.	685.6	17.6	0.339	0.029	0.000	0.030	8.43	2.16	1.50
Chilatchee Cr.	849.1	17.6	0.328	0.029	0.000	0.029	8.43	2.16	1.52
Beaver Cr.	48.6	17.6	0.251	0.025	0.000	0.023	8.43	2.32	1.80
Pursley Cr.	63.6	17.6	0.252	0.025	0.000	0.023	8.43	2.35	1.85
Bear Cr.	78.9	17.6	0.250	0.025	0.000	0.023	8.43	2.35	1.84
Tallahatchee Cr.	94.9	17.6	0.253	0.025	0.000	0.023	8.43	2.35	1.85
Cane Cr.	113.9	17.6	0.249	0.025	0.000	0.023	8.43	2.33	1.82

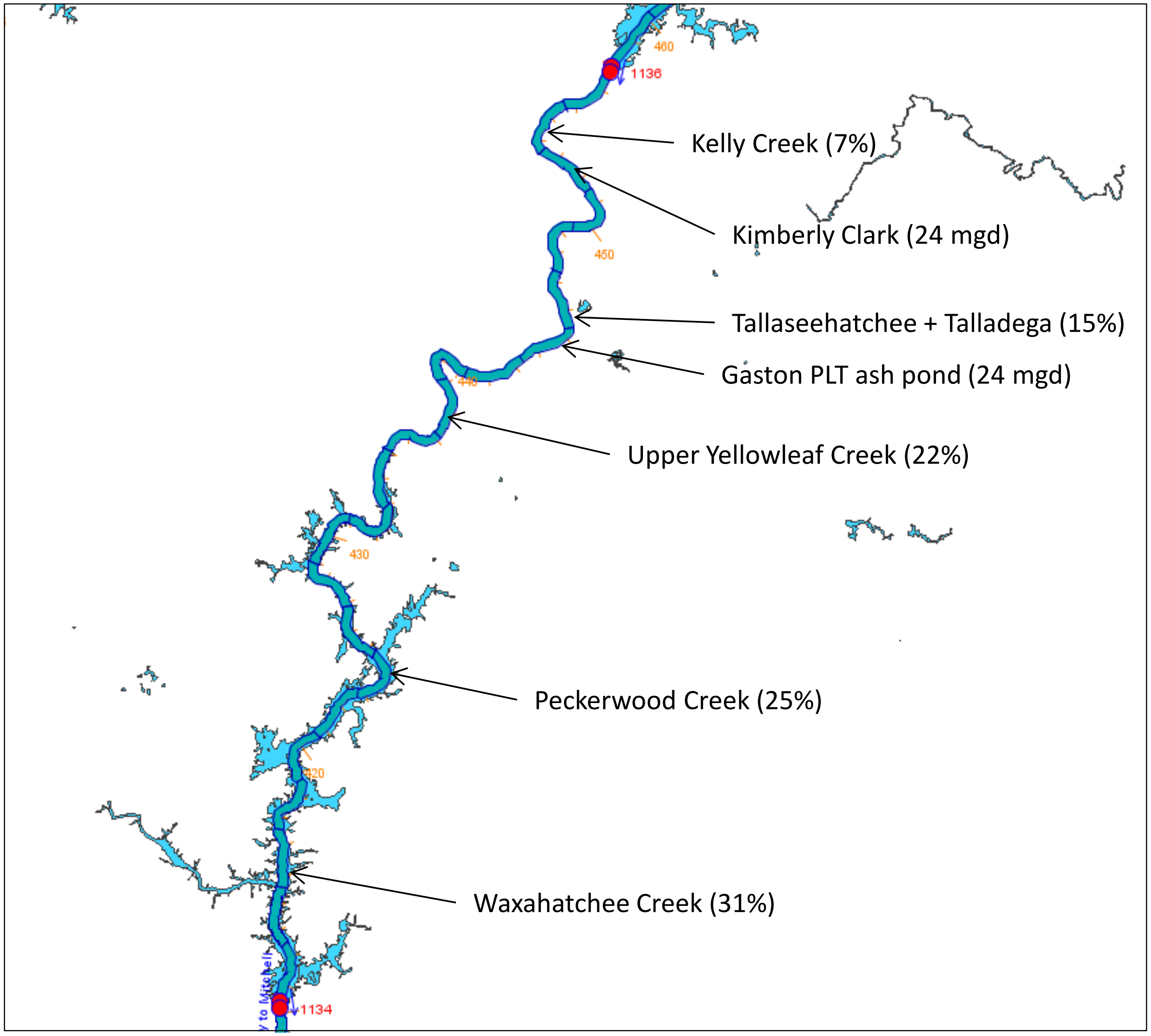

Figure 2.9 HEC-5 and HEC-5Q Model Schematic of Lay Reservoir with inflows. Non-point source flow allocation percentages and point source discharge rates are indicated.

2.2.2 POINT SOURCE FLOW AND WATER QUALITY DATA

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

The seasonal discharge rates and quality were based on point source discharge data provided by Tetra Tech for the 2001–2008 period. Monthly average flow and quality characteristics were defined as the average of all the available measurements without regard to the time of month.

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

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

Average point source inputs are summarized in Table 2.4. Full tables of maximum, minimum and average values can be found in the appendix in Table A-7.2.

Table 2.4 Summary of average point source inflow and quality for municipal and industrial discharges.

Location	Flow (cfs)	Temp (C)	NO3-N (mg/L)	PO4-P (mg/L)	Chlorophyll *a* (ug/L)	NH3-N (mg/L)	DO (mg/L)	Diss. Org (mg/L)	Org. Solids (mg/L)
Cartersville WPCP	13.0	21.6	10.000	3.720	0.000	1.336	3.92	17.16	9.55
Calhoun WPCP	11.5	21.6	10.000	3.720	0.000	0.566	4.66	26.36	16.58
City of Chatsworth	2.2	21.6	10.000	3.720	0.000	0.312	6.37	7.20	4.27
Cobb County Noonday Cree	15.1	21.6	10.000	0.264	0.000	0.155	6.43	3.75	1.39
Canton WPCP	2.4	21.6	10.000	4.605	0.000	2.426	4.37	16.25	11.13
Cherokee County Rose Cre	5.9	21.6	10.000	0.175	0.000	0.381	5.75	6.25	2.07
Cobb County Northwest WP	10.7	21.6	10.000	0.102	0.000	0.106	6.52	2.50	1.06
Inland Paperboard	35.1	21.6	1.000	0.300	0.000	4.000	3.90	41.33	94.05
Etowah River mile 675 NO3-N Source	0.1855	-	750 lb/day	-	-	-	-	-	-
Georgia Power Company	1.5	21.6	0.600	0.100	0.000	0.300	0.12	7.50	3.00
Rome WPCP	16.9	21.6	10.000	2.085	0.000	0.439	4.69	14.35	7.03
Rome - Coosa WPCP	1.3	21.6	10.000	1.524	0.000	0.204	5.45	2.68	3.51
Gadsden East WWTP	4.9	21.6	2.945	2.220	0.000	8.863	3.90	41.42	17.76
Gadsden West WWTP	8.3	21.6	4.303	1.942	0.000	6.921	4.01	21.70	10.62
Attalla Lagoon	3.3	21.6	0.686	1.048	0.000	3.657	3.59	53.71	43.38
Tyson Foods	1.6	21.6	10.000	6.500	0.000	1.000	6.24	22.63	11.31
Goodyear Tire and Rubber	12.8	24.4	1.000	0.300	0.000	4.000	3.73	35.00	13.77
Pell City Dye Creek WWTP	2.5	21.6	4.758	1.500	0.000	0.159	8.22	16.53	2.74
Kimberley-Clark Corporat	37.1	21.6	1.000	0.300	0.000	4.000	3.90	50.06	25.07
APCO Gaston PLT ash pond	38.5	21.6	0.220	0.060	0.000	0.050	6.24	9.00	3.60
Tallassee Lagoon	1.0	21.6	10.000	2.374	0.000	1.834	3.90	26.95	22.57
Tuskegee South WWTP (Cal	1.6	21.6	10.000	0.700	0.000	1.074	6.47	20.00	9.32
Tuskegee North WWTP	2.2	21.6	10.000	0.700	0.000	1.551	5.46	5.84	5.74
Alexander City Coley Cre	12.4	21.6	8.449	1.051	0.000	0.314	7.11	5.48	4.83
Wetumka City of Water Wo	3.2	21.6	10.000	2.700	0.000	0.250	6.24	6.25	6.22
International Paper Comp	44.5	21.6	1.000	0.300	0.000	4.000	0.86	88.42	45.69
International Paper	41.5	21.6	1.000	0.300	0.000	4.000	0.86	83.34	62.00
General Electric WWTP	4.1	21.6	0.100	0.300	0.000	0.100	5.85	17.45	10.65
Prattville Pine Creek	3.2	21.6	10.000	0.800	0.000	6.000	5.85	12.75	12.10
Montgomery Econchate	26.3	20.3	2.500	1.000	0.000	7.399	3.44	56.25	16.50
Montgomery Towassa	3.9	20.3	2.500	1.000	0.000	7.399	3.44	56.25	16.50
Catoma Creek WWTPg	25.4	21.6	10.000	0.700	0.000	0.200	5.19	6.40	2.89
Macmillan Bloedel Packin	27.8	21.6	1.000	1.200	0.000	1.400	2.34	104.79	62.13
Alabama River Pulp Compa	35.8	20.3	1.000	0.300	0.000	4.000	0.86	148.26	77.00
Selma Valley Creek WWTP	5.6	21.6	10.000	0.700	0.000	5.386	3.90	59.23	16.52
Leeds	1.7	22.0	14.250	5.000	0.000	1.000	5.93	37.50	6.70
Birminghan Area discharges	3.7	20.3	12.000	5.000	0.000	3.000	5.16	22.50	8.40
Jefferson Co. + Hoover RC	7.3	20.3	13.897	5.000	0.000	1.106	6.15	8.27	3.85
Pelham	1.5	19.0	14.000	5.000	0.000	1.000	6.34	30.00	11.20
* 0.1855 cfs at 750 mg/L = 750 pounds/day									

2.2.3 WATER QUALITY MONITORING

Water quality in the ACT Basin is monitored by a number of federal, state, and local agencies as well as by industries for compliance with standards. Table 2.5 summarizes water quality conditions along the main-stem rivers in the ACT Basin using data collected by States 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 ACT Basin.

Table 2.5 Summary of monitoring data collected by Alabama and Georgia from 2001 through 2008 in main-stem rivers of the ACT Basin.

	BOD_5U (mg/L)	Oxygen (mg/L)	NH_3-N (mg/L)	NO_3-N (mg/L)	PO_4-P (mg/L)	TSS (mg/L)	Temp. (C)	Chlorophyll *a* (µg/L)
Coosawattee River at Carters								
No. of Samples	61	53	47	47	49	55	53	10
Avg	1.54	8.94	0.04	0.14	0.03	8.06	20	7.56
Min	0.4	7.09	0.02	0.05	0.02	3	5.8	3.6
Max	5.14	12.8	0.15	0.25	0.09	19	24.77	16.4
Median	1.3	8.61	0.03	0.13	0.02	7.5	21.75	4.1
Period of Record	Jan 2001-Oct 2006							Jun – Oct 2005
Coosawattee River at Calhoun								
No. of Samples	69	92	62	63	64	63	94	15
Avg	1.57	8.7	0.04	0.26	0.04	19.66	17.94	4.88
Min	0.5	5.42	0.01	0.13	0.02	4	4.9	2.6
Max	5.37	12.6	0.22	0.43	0.15	66	25.47	11.5
Median	1.52	8.2	0.03	0.26	0.03	15	19.92	4.2
Period of Record	Jan 2001 - Oct 2006							Jun 2005 – Oct 2006
Etowah River at Lake Allatoona								
No. of Samples	0	56	56	56	49	56	56	56
Avg	NA	8.44	0.15	0.27	0.04	5.49	37.96	11.63
Min	NA	6.75	0.03	0.03	0.04	3	16.65	4.51
Max	NA	10.7	6.02	1.08	0.23	14.12	88.44	22.98
Median	NA	8.36	0.03	0.25	0.04	5	27.69	11.09
Period of Record	Apr 2000 – Oct 2007							
Etowah River at Euharlee								
No. of Samples	101	162	86	99	97	96	162	31
Avg	1.58	9.08	0.07	0.54	0.09	23.17	16.72	6.94
Min	0.34	5.9	0.01	0.11	0.02	1	4.9	0.6
Max	3.59	13.77	0.23	1.18	0.55	480	28	115
Median	2	8.87	0.05	0.5	0.06	7	16.7	2.1
Period of Record	Jan 2000 – Aug 2008							Jun 2005 – Oct 2006

Table 2.5, Continued

	BOD_5U (mg/L)	Oxygen (mg/L)	NH_3-N (mg/L)	NO_3-N (mg/L)	PO_4-P (mg/L)	TSS (mg/L)	Temp. (C)	Chlorophyll *a* (μg/L)
Etowah River at Canton								
No. of Samples	91	156	76	89	87	59	156	24
Avg	1.4	9.2	0.05	0.26	0.05	34.96	15.74	4.4
Min	0.1	5.8	0.01	0.05	0.02	1	2.46	1.3
Max	3.92	13.5	0.28	0.88	0.72	675	27.17	17.9
Median	1.4	8.95	0.03	0.25	0.02	8	15.6	2.2
Period of Record	Jan 2000 – Jun 2008					Jan 2000 – Dec 2007	Jan 2000 – Jun 2008	Feb - Dec 2006
Oostanaula River at Resaca								
No. of Samples	69	100	62	63	63	62	102	15
Avg	1.64	8.28	0.04	0.3	0.08	24.94	18.32	8.01
Min	0.2	4.62	0.01	0.04	0.02	2	3.9	1.9
Max	5.31	12.75	0.12	0.6	0.26	95	26.69	37
Median	1.66	7.76	0.03	0.29	0.07	21.5	19.9	4.7
Period of Record	Jan 2001 – Oct 2006							Jun – Oct 2005
Coosa River near Rome								
No. of Samples	0	595	0	0	0	0	3292	545
Avg	NA	8.94	NA	NA	NA	NA	17.37	6.04
Min	NA	5.4	NA	NA	NA	NA	4	1.48
Max	NA	12.4	NA	NA	NA	NA	29	31.8
Median	NA	8.7	NA	NA	NA	NA	18	4.28
Period of Record	NA	Mar 2005 – Dec 2006	NA	NA	NA	NA	Jan 2000 – Nov 2009	Mar 2005 – Sep 2006
Coosa River at State Line								
No. of Samples	130	3106	110	122	123	123	3352	678
Avg	2	8.82	0.04	0.4	0.1	17.68	19.82	7.04
Min	0.57	3.8	0.01	0.05	0.02	3	6	1.71
Max	9	15.3	0.18	0.61	0.5	229.09	34	36.2
Median	2	8.7	0.03	0.41	0.1	14	20	4.85
Period of Record	Jan 2000 – Aug 2008							Jun 2005 – Sep 2006
Coosa River at Weiss								
No. of Samples	0	118	118	118	118	0	118	118
Avg	NA	8.31	0.03	0.24	0.09	NA	23.67	19.67
Min	NA	4.04	0.02	0	0	NA	8.63	0.1
Max	NA	12.17	0.15	0.63	0.29	NA	33.42	51.4
Median	NA	8.3	0.02	0.22	0.08	NA	24.41	19.8
Period of Record	Apr 2002 – Nov 2008							Apr 2002 – Nov 2008
Coosa River at H.N. Henry								
No. of Samples	0	27	27	27	27	0	27	27
Avg	NA	8.07	0.02	0.06	0.06	NA	27.12	27.15
Min	NA	4.13	0.02	0	0	NA	20.43	2.14
Max	NA	12.93	0.07	0.66	0.14	NA	32.4	40.58
Median	NA	7.66	0.02	0.01	0.06	NA	27.99	26.7
Period of Record	Aug 2002 – Oct 2008							

Table 2.5, Continued

	BOD_5U (mg/L)	Oxygen (mg/L)	NH_3-N (mg/L)	NO_3-N (mg/L)	PO_4-P (mg/L)	TSS (mg/L)	Temp. (C)	Chlorophyll *a* (µg/L)
Coosa River at Logan Martin								
No. of Samples	0	38	39	39	39	0	38	39
Avg	NA	8.33	0.02	0.04	0.06	NA	27.09	20.22
Min	NA	5.26	0.02	0	0	NA	17.85	0.8
Max	NA	12.39	0.06	0.18	0.09	NA	32.56	34.89
Median	NA	8.04	0.02	0.01	0.06	NA	28.06	19.76
Period of Record	Aug 2002 – Sep 2005							
Coosa River at Lay								
No. of Samples	0	51	51	51	51	0	51	51
Avg	NA	8.46	0.03	0.09	0.05	NA	28.08	18.48
Min	NA	5.12	0.01	0	0	NA	17.84	0.36
Max	NA	12.96	0.17	0.6	0.1	NA	33.4	35.78
Median	NA	8.26	0.02	0.02	0.05	NA	28.8	17.89
Period of Record	Aug 2002 – Oct 2008							
Coosa River at Mitchell								
No. of Samples	0	53	53	53	53	0	53	53
Avg	NA	8.7	0.02	0.05	0.05	NA	27.2	18.01
Min	NA	4.56	0.02	0	0	NA	20.02	0.71
Max	NA	12.22	0.07	0.25	0.09	NA	33.66	60.18
Median	NA	8.78	0.02	0.02	0.06	NA	27.73	16.55
Period of Record	Aug 2002 – Oct 2008							
Coosa River at Jordan								
No. of Samples	0	30	30	30	30	0	30	30
Avg	NA	8.66	0.02	0.05	0.04	NA	27.21	14.32
Min	NA	3.55	0.02	0	0	NA	19.45	2.67
Max	NA	13.47	0.13	0.24	0.08	NA	32.37	24.03
Median	NA	8.65	0.02	0.02	0.04	NA	27.99	14.15
Period of Record	Aug 2002 – Oct 2008							
Tallapoosa River at Harris Lake								
No. of Samples	0	101	101	101	101	0	101	101
Avg	NA	8.54	0.03	0.07	0.04	NA	25.87	12.12
Min	NA	4.14	0.02	0	0	NA	19.29	2.14
Max	NA	12.06	0.26	0.31	0.09	NA	31.53	67.8
Median	NA	8.42	0.02	0.05	0.03	NA	26.2	8.9
Period of Record	Apr 2002 – Oct 2008							
Tallapoosa River at Lake Martin								
No. of Samples	0	129	129	129	129	0	129	129
Avg	NA	8.18	0.02	0.05	0.04	NA	26.68	4.48
Min	NA	6.28	0.02	0	0	NA	18.92	0.53
Max	NA	10.72	0.14	0.35	0.1	NA	32.55	13.62
Median	NA	8.12	0.02	0.03	0.03	NA	26.99	3.47
Period of Record	Apr 2002 – Oct 2008							

Table 2.5, Continued

	BOD_5U (mg/L)	Oxygen (mg/L)	NH_3-N (mg/L)	NO_3-N (mg/L)	PO_4-P (mg/L)	TSS (mg/L)	Temp. (C)	Chlorophyll *a* (µg/L)
Tallapoosa River at Yates								
No. of Samples	0	23	23	23	23	0	23	23
Avg	NA	8.32	0.04	0.13	0.03	NA	24.28	4.94
Min	NA	6.44	0.02	0.01	0.01	NA	17.94	1
Max	NA	10.26	0.19	0.21	0.07	NA	30.69	18.69
Median	NA	8.24	0.02	0.12	0.03	NA	24.15	3.74
Period of Record	Apr 2002 – Oct 2008							
Tallapoosa River at Thurlow								
No. of Samples	0	23	23	22	23	0	23	23
Avg	NA	8.18	0.03	0.14	0.03	NA	22.76	2.82
Min	NA	6.6	0.02	0	0	NA	18	0.8
Max	NA	11.27	0.15	0.22	0.06	NA	29.3	5.97
Median	NA	7.98	0.02	0.14	0.02	NA	22.86	2.4
Period of Record	Apr 2002 – Oct 2008							
Alabama River at R.F. Henry								
No. of Samples	0	50	50	50	50	0	50	50
Avg	NA	8.53	0.02	0.13	0.04	NA	27.15	16.09
Min	NA	5.4	0.02	0	0	NA	18.76	3.56
Max	NA	11.77	0.16	0.33	0.08	NA	33.4	33.11
Median	NA	8.51	0.02	0.11	0.04	NA	28.53	15.49
Period of Record	Aug 2002 – Oct 2008							

2.2.4 HISTORICAL METEOROLOGICAL DATA AND TRIBUTARY WATER TEMPERATURES

Meteorological data were developed for a five year period (1984–1989) during a previous effort using 3-hour observations of wind speed, cloud cover, air temperature and dew point (or wet bulb) temperature, etc. These data were provided for Class A National Weather Service (NWS) stations throughout the ACT watershed. Daily average equilibrium temperature, heat exchange rate, wind speed and solar radiation were computed for nine data zones for model input. These daily values were downscaled to 6-hour values using typical diurnal variations because diurnal variations are often important and daily time steps (used in previous ACT applications) cannot capture these variations. Therefore, a six hour time step data set was developed that included 6-hour meteorology data (heat exchange parameters) and revised model coefficients.

Normally, 6-hour heat exchange inputs are generated from short interval air temperature, relative humidity, wind speed and solar radiation. However, because sufficient 1-hour data are unavailable, the 24-hour average heat exchange parameters were downscaled based on typical diurnal variations. Figure 2.10 is an example of the typical and downscaled equilibrium temperature. The exchange rate was downscaled such that the 24-hour and 6-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 1939–2008 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 2001–2008 study period was based on 2000–2008 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 2 calendar days before or after the NWS calendar date could be selected. Thus up to 7 days from each of the 5 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 five meteorological zones in the ACT 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 ACT basin

Met Zone	River	Latitude of Met data application	Met station data source (specified by location)
1	Alabama River	up to Latitude 32.2°	Average of Mobile and Montgomery, AL
2	Alabama, Cahaba, Coosa and Tallapoosa Rivers	Latitude 32.2° - 33°	Montgomery, AL
3	Coosa, Cahaba and Tallapoosa Rivers	Latitude 33° to 34°	Birmingham, AL
4	Coosa River above H. Neely Henry Dam	Latitude 33.8° - 34.3°	Average of Huntsville and Birmingham, AL
5	ACT streams above Rome	North of Latitude 34°	Average of Chattanooga, TN and Atlanta, GA

*note that the overlap of longitudes is due to the southern extent of the Etowah River

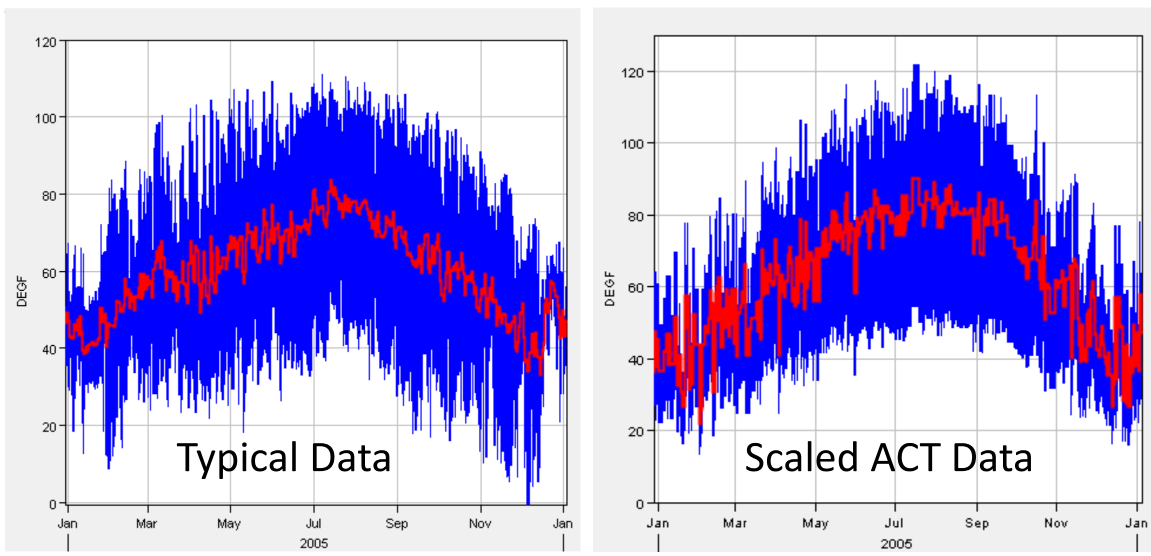


Figure 2.10 Typical and downscaled 6-hour equilibrium temperature (red line is the 24-hour data).

2.2.5 Climate Change

Various climate change studies for the southeast US indicate that a one degree Celsius increase in the average air temperature is likely within the 100-year planning horizon. To translate an average one degree Celsius (1.8 degree Fahrenheit) air temperature increase into a model meteorological data input, a similar extrapolation procedure was utilized. The maximum / minimum air temperature record for the 2000-2008 period was increased by one degree Celsius (1.8 Fahrenheit), and then a record from the 1984-1988 period was selected to represent the climate change meteorological conditions. 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. As a standard check on the meteorological data processing, the temperature of a 5-foot deep pool of water is routinely computed. The pool temperature can also provide a visual comparison of the historical and climate change conditions. Figure 2.11 shows the effect on water (pool) temperature for the Atlanta based meteorological data zone. This effect is typical of the increased air temperature in the extrapolation process. The average computed pool water temperature increase over the 2001–2008 period for the five ACT model meteorological data zones is listed in Table 2.7.

A formal climate change model analysis of water quality was not performed. Formal climate change modeling was not required to address the requirements of this study. Instead, the HEC-5Q model sensitivity to changing flows and air temperature were investigated as a sensitivity analysis. Simple adjustments were made to the historical ResSim flows and input into the HEC-5Q model to investigate its response to the changed flows. Then the sensitivity of the HEC-5Q model to air temperature was investigated by adding a simple offset of 1 degree C to the historical air temperatures. This did not consider factors such as changes in hydrology, 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. However, this approach can obscure the impact of individual changes. Therefore, the decision was made to make a simple adjustment to air temperature, as had been done for the flows and investigate the model sensitivity to flows and air temperature independently.

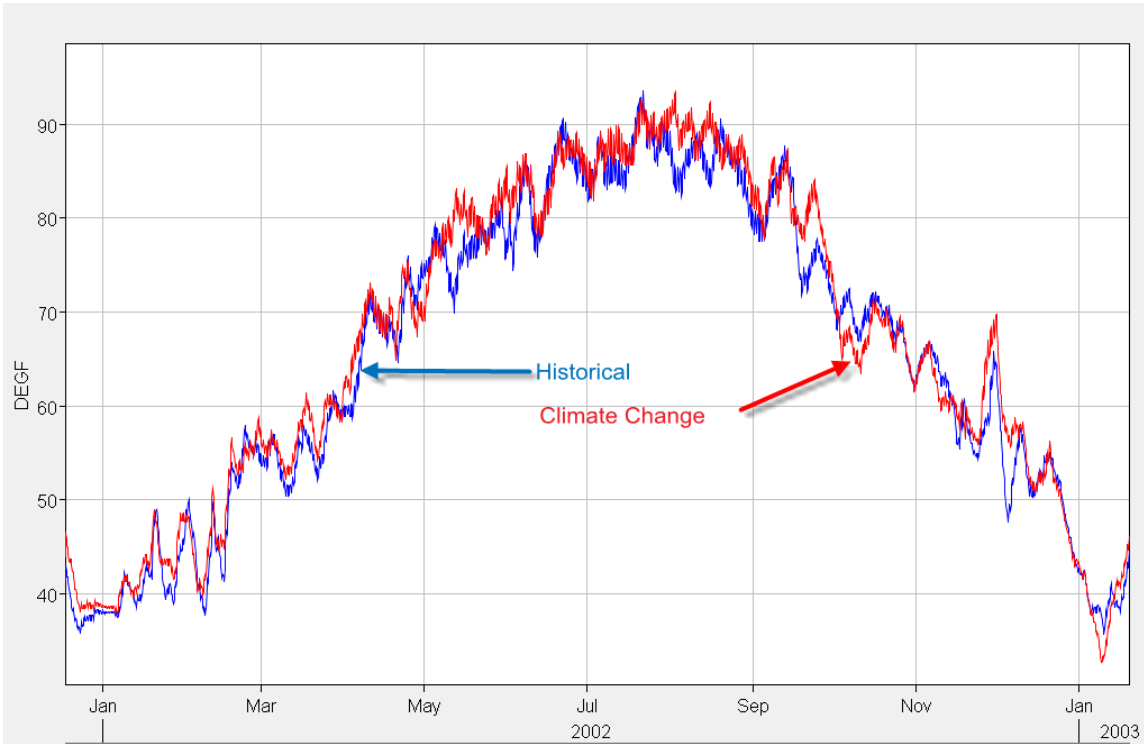


Figure 2.11 Computed temperature of a 5-foot deep pool of water for historical and climate change conditions for the Atlanta-based data zone.

Table 2.7 Average pool temperature for historical and climate change meteorology for the five ACT meteorological data zones.

River	Historical Temperature (°F)	Climate Change (°F)	Increment (°F)
Alabama River	71.40	72.27	0.87
Alabama, Cahaba, Coosa and Tallapoosa Rivers	72.08	72.93	0.84
Coosa, Cahaba and Tallapoosa Rivers	68.78	69.54	0.76
Upper Coosa River	67.16	68.00	0.84
Above Weiss Reservoir	66.36	67.35	0.98

3 DEMONSTRATION OF MODEL PERFORMANCE

Extensive comparison of modeled and observed time series (streams) and profiles (reservoirs) was performed on the HEC-5Q ACT model. Since HEC-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 2.2 was assumed. Constituents chosen for presentation of model demonstration results include temperature, dissolved oxygen, nitrate (NO3), ammonia (NH3), phosphate (PO4) and Chlorophyll *a*. Nutrient and Chlorophyll *a* data are typically available at monthly intervals during the spring, summer and fall months (growing season) and represent conditions in the photic zone.

3.1 RESERVOIRS

Model performance demonstration results for reservoirs are shown in Figure 3.1 through Figure 3.20. Computed and observed temperature and dissolved oxygen profiles are provided for Carters, Allatoona, Weiss, Lay, R.F. Henry, Harris, Martin and Yates reservoirs. Representative profiles are provided in each reservoir for either 2004 or 2005.

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

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

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

Observations in Carters reservoir (Figure 3.1 and Figure 3.2) are available near the surface (to a depth of 75’ +/-). Therefore we cannot evaluate the model performance in the lower 250’. Computed temperatures during April through June 2004 are in reasonable agreement with observed data, although tending to under predict right at the water surface. The computed thermocline seems to drop more rapidly than observed, resulting in poor agreement with observed data during July and August; however by September the agreement is excellent. The DO plots seem to indicate that the model is producing similar levels of DO near the surface, and a similar trend over time, however the model may progress more quickly. Without measurements of Carters Rereg discharge, it is difficult to assess the model’s capability to represent the pumpback/discharge operation.

At Allatoona, in Figure 3.3, surface temperatures are well represented during most months plotted for 2004. The thermocline is somewhat lower than observed during April through June. Bottom temperatures are under predicted for all months; however results are otherwise quite good for July through September. Computed dissolved oxygen, shown in Figure 3.4, is in good agreement with observed data during April through August. In September, the model shows that anoxic conditions at depth are beginning to improve, whereas the observed data still show very low DO values, indicating a difference in timing of lake overturn and the influence of oxygenated inflows.

Temperature profiles for Weiss Reservoir are shown in Figure 3.5 for 2005. Model results and observed data show minimal stratification and good agreement between the two. The model shows less difference between the dam and mid-lake locations than is seen among the observed data locations. DO profiles are shown in Figure 3.6. Computed DO is lower than observed in April. In May, computed surface DO is higher than observed, but in good agreement at depth. The model is in reasonable agreement with observed data during June and July, and slightly lower than observed at depth during August and September. Variation in model DO between the dam and mid-lake locations tends to be less than the variation among observed data at different locations. Surface variations seen in the observed data are often in response to the timing and location of algal blooms while the model tends to represent a more global response. The computed hypolimnion DO tends to be less than observed which may translate to lower discharge concentrations. The lower DO will accentuate differences in reservoir operational impacts and thus contribute to a more conservative assessment. These results are typical of those for the reservoirs of the upper Coosa River chain of reservoirs.

In Lay reservoir, computed temperatures are in good agreement with observed data during April through September, 2005 (Figure 3.7). The observed data show more variation by location than is seen between the computed dam and mid-lake temperatures. The cooler profile near the surface (above elevation 380’) shows the influence of a cooler water source other than the upstream main stem Coosa River that has a temperature of approximately 27°C. This profile is in a branch to the reservoir and no attempt was made to identify this source. Computed DO profiles in Figure 3.8 show generally good agreement with observed data and reproduce surface values throughout the plotted period. Computed DO near the bottom does not go quite as low as observed during April through June, and is slightly lower than observed during August. During August and September, computed DO values at depth are as much as 3 mg/L higher than observed, not approaching the anoxic conditions seen in the observed data. The computed and observed temperature profile for September shows virtually no stratification, allowing mixing of dissolved constituents. These results are typical of those for the reservoirs of the middle and lower Coosa River chain of reservoirs. The environment is eutrophic with high water temperatures. Therefore photosynthesis and respiration are occurring at high rates, which can also lead to strong diurnal variability. Since phytoplankton occurrence tends to be stratified within the water column, the profile of dissolved constituents can be stratified even when the reservoir is not thermally stratified.

Figure 3.9 shows 2005 temperature profiles in R. F. Henry reservoir. During April the model result is in good agreement with the limited observed data. During May through September, the model result tends to show slightly more stratification than observed, with lower temperatures in the hypolimnion. DO profiles in Figure 3.10 show again that the model tends to be more stratified than observed, with lower than observed values in the hypolimnion throughout the plotted period. These results are typical of those for the reservoirs of the Alabama River chain of reservoirs.

Temperature profiles in Harris reservoir show good agreement with observed data during 2004 (Figure 3.11). Surface temperatures and thermocline are generally well represented, however hypolimnion temperatures are lower than observed. The model does an excellent job of reproducing DO observations, as shown in Figure 3.12. The outlet centerline elevation of 775' would access near surface waters so it appears that there would be limited effects of the anoxic hypolimnion. However, in the absence of downstream ambient data, this cannot be confirmed.

Martin reservoir temperature profiles are plotted in Figure 3.13 for 2005. The model results show slightly more stratification than observed at times, and computed temperatures tend to be higher than observed. The DO profiles in Figure 3.14 show generally good agreement with observed data. There are, at times, large variations in observed DO by location. The model results in anoxic conditions earlier than two of the three observed data locations, but falls within a reasonable range using the vertically segmented reservoir.

Temperature profiles in Yates reservoir are plotted for 2005 in Figure 3.15. The model is in good agreement with observed data during April. Surface temperatures are higher than observed during May and temperatures are overall higher than observed during June through September. This is a result of the temperatures coming out of Martin reservoir and is consistent with the 2C +/- difference between the computed and observed temperature at elevation 430' in Lake Martin. The DO profiles in Figure 3.16 show good agreement with observed data in April. During May, June and September, computed surface DO is slightly higher than observed in the upper 20' of the reservoir. During June through September DO in the hypolimnion is lower than observed. These differences in DO are also consistent with the Lake Martin DO profiles (Figure 3-14).

3.2 STREAMS

Time series of computed and observed temperature, dissolved oxygen, nitrate, ammonia and phosphate are provided at locations (shown in Figure 3.17) in the upper ACT basin where observed data are available in Figures 3.18-47, Figure 3.54, and Figure 3.61. Model results are plotted at 6-hour intervals. Additionally, longitudinal profiles of computed and observed nutrients and Chlorophyll *a* (growing season values) are plotted along the Coosa River in Figures 3.48-53 and the Alabama Rivers in Figures 3.55-60. Note that the example profile plots in Chapter 4 include geographical references (Figure 4-13: Coosa River and Figure 4.28: Alabama River) that should be referred to aid in the interpretation of these plots,

The 5, 25, 50, 75 and 95% occurrence levels of the observed data were computed from near surface (growing zone) measurements at two locations in the reservoir.

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

Computed and observed temperatures in the Oostanaula River at Resaca are plotted in Figure 3.18. The model reproduces the seasonal trends and maximum and minimum values seen in the observed data. Figure 3.19 shows that the model reproduces the observed seasonal trends for DO. Winter time peaks tend to be slightly lower than observed. Nitrate, phosphate, and ammonia time series are shown in Figure 3.20 through Figure 3.22. The model results are within range of observed data for each nutrient. Noise in the model result is due to weekday/weekend variation in flows, which affects the dilution of the nutrient inputs. To achieve the dissolved oxygen results seen in Figure 3.19, a benthic demand (sediment oxygen demand, SOD) (3 g/m2/day) approximately three times the rate assigned to the other river's reach was specified. The intent of this demand was to represent the diffuse source of oxygen consuming material related to chicken production and processing.

Temperature time series in Coosawattee River at Calhoun are plotted in Figure 3.23. The model produces somewhat higher seasonal minimums than observed during 2001 and 2002, but the seasonal variations are otherwise well represented. The DO time series (Figure 3.24) show that the model tends to under-predict seasonal peak DO values, but otherwise reproduces the seasonal trends. Nitrate time series in Figure 3.25 show that seasonal minimums are lower than observed, but model results are otherwise within reasonable range of observed data. With the exception of two observed outliers, both the computed and observed ammonia nitrogen values are within a narrow range of 0.02 and 0.06 mg/L (Figure 3-26). Computed phosphate (Figure 3.27) tends to be higher than observed, with the model noise resulting from flow variations. The occasional major spikes (fall 2007) result for near zero flow in all of the Coosawattee River plots. These spikes were not considered a problem since our analysis of alternatives is limited to the 5% and 95% occurrence while the erroneous spikes represent <1% or >99% of the computed values.

In the Etowah River near Canton, computed temperatures (Figure 3.28) are higher than observed during the winter (very cold versus very, very cold), but are otherwise in good agreement with the observed data. Computed DO (Figure 3.29) is also in good agreement with observed data, although some of the seasonal highs and lows are missed. Nitrate (Figure 3.30) is generally in the range of observed data, but the lowest observed concentrations are not reproduced. Ammonia (Figure 3.31) is within the range of observed concentrations with the majority of both the computed and observed falling below 0.05 mg/L. Phosphate (Figure 3.32) tends to be higher than observed. Results at this location are primarily affected by the inflows rather than any adjustment of model parameters and serve as an indication of the accuracy and uncertainty associated with the specification of point and non-point source inflows discussed in Sections 0 and 2.2.2.

Computed temperatures in Etowah River near Euharlee are in good agreement with observed data, as shown in Figure 3.33. Computed DO (Figure 3.34) tends to have lower seasonal low values than observed, but otherwise matches observed data well. Computed nitrate, shown in Figure 3.35, is generally within range of observed data, although computed values during 2001-2008 are overall higher than observed. The spike in computed nitrate during 2005 (higher than the plot scale at 3.4 mg/L) is the result of near zero flows in the river. This location appears to be impacted by an upstream power plant. Although no observed data were available to quantify the impact of the power plant, observed values could not be reproduced by the model without the addition of 750 lb/day of nitrate to represent the load from the power plant. A comparison of computed values with and without this additional nitrate load is provided in Figure 3.36 to show that the load was required to bring average computed values closer to average observed data. The green curve in Figure 3.36 corresponds to the blue curve in Figure 3.35. Ammonia concentrations, shown in Figure 3.37, are well represented by the model.

Both the computed temperatures and DO in the Oostanaula River at the Rome water intake (Figure 3.38 and Figure 3.39) are well represented throughout the year. Nitrate (Figure 3.40) concentrations are in the range of observed data except for the low observed values during the summer of 2002 and 2007. Ammonia (Figure 3.41) is within the range of observed concentrations with the majority of both the computed and observed falling below 0.10 mg/L. Phosphate (Figure 3.42) is within the range of the observed data; however there is a tendency for more elevated observed concentrations.

Observed temperatures in Coosa River near Rome are reproduced by the model as shown in Figure 3.43.

In the Coosa River above State Line, computed temperatures reproduce the seasonal trends of the observed data (Figure 3.44). The DO results, plotted in Figure 3.45, do not show as much variation as observed. This monitoring station is located within the upstream end of Weiss Reservoir. The scatter seen in the observed data is likely a result of primary productivity that is more dynamic than predicted by the model. Additionally, the time of day of the measurement would impact DO concentration due to the active algal growth/respiration cycle. Computed nitrate and phosphate (Figure 3.46 and Figure 3.47) are in the range of observed data, although minimum nitrate values are not as low as observed.

A longitudinal profile of computed and observed temperature along the Coosa River by river mile is plotted in Figure 3.48. Solid lines are the 5%, 25%, 50%, 75% and 95% occurrence computed values during the 2001–2008 May through October growing seasons. The same percentile values are shown as blue squares for observed data. Maximum computed temperatures are a few degrees below observed, but otherwise the model is generally in reasonable agreement with observed data. At the upstream locations, computed 5% values are not as low as observed by as much as 5° C. These longitudinal occurrence profile results demonstrate the thermal uniformity of the surface waters of the Coosa lakes.

The Coosa River dissolved oxygen profile is shown in Figure 3.49 for the same May through October growing season. Minimum computed oxygen concentrations are in the observed range, while maximums are under predicted. Super saturation is not represented in the model, possibly due to too much reaeration or because of the time of day measurements are taken (during peak algal production).

A longitudinal profile of computed and observed nitrate along the Coosa River by river mile is plotted in Figure 3.50. Solid lines are the 5%, 25%, 50%, 75% and 95% occurrence computed values during the 2001–2008 April through November growing seasons. The same percentile values are shown as blue squares for observed data. At any location where only three squares are visible, the 5 and 25 percentile values are both 0.003 mg/L. The profile plot indicates that computed values are higher than observed. The 95% occurrence observed value tends to fall between the average and 75 percentile computed value. It is to be expected that the 95% computed concentration would be higher than observed since the computed includes the first and last weeks of April and November respectively. These periods are characterized by little biological activity and nutrient uptake. April and November measurements tend to be taken towards the end and beginning of the month respectively when biological activity is greater. Additionally, early and late season monitoring is omitted if conditions are not conducive to primary production, hence further reducing the biologic active period data.

The Coosa River ammonia nitrogen plot is shown in Figure 3.51 for the April through November growing season. Computed ammonia tends to be higher than observed. The spike at mile 628 is due to the total inorganic nitrogen (TIN) incorporated paper mill discharge. The ammonia default concentration of 4 mg/L was assigned, as a conservative estimate, to all paper / pulp mills. A sensitivity analysis was performed by setting these discharges lower to 1 mg/L ammonia. With this change, the 95% concentration is reduced from 0.24 to 0.15 and results in concentrations more in line with the observed.

The Coosa River phosphate profile is shown in Figure 3.52. Computed concentrations match reasonably well with observed data at the downstream locations. At the upstream locations the 95% occurrence values are higher than observed. The observed data show a general decrease in phosphate from upstream to downstream, and this is reproduced by the model.

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

A profile of Chlorophyll *a* in Coosa River is plotted in Figure 3.53. Model results are generally a good match with observed data. At the furthest upstream locations, the model result falls below the 95% occurrence values. The model tends to under predict spikes in algal production in the river below Rome. A time series of Chlorophyll *a* in the Coosa River and Weiss reservoir is plotted in Figure 3.54. Observed data are collected at two locations within the reservoir and computed time series are shown at the Weiss dam and at the mid-lake model location, downstream of the "Weiss at Stateline" monitoring station. The observed data from the two stations were combined and ranked so the percentages may have a preponderance of a particular station. The combining is in keeping with the model demonstration approach. The model reproduces the seasonal trends and the variation between the upstream and downstream reservoirs.

A longitudinal profile of computed and observed temperature along the Alabama River by river mile is plotted in Figure 3.55. Results are plotted for the 2001–2008 May through October growing seasons. Maximum computed temperatures are two to three degrees below observed and minimum temperatures are two to three degrees above observed.

The Alabama River dissolved oxygen profile is shown in Figure 3.56 for the same May through October growing season. Results vary by location. At the downstream end, maximum values are in agreement with observed but minimum values are higher than observed. The middle location is the reverse and the upstream location does not have as much variation as observed.

A longitudinal profile of nitrate nitrogen in the Alabama River is plotted in Figure 3.57. Computed values are higher than observed. The 95% occurrence observed value tends to fall between the average and 75% computed value. A profile of Ammonia nitrogen is plotted in Figure 3.58. Computed values are within the range of observed data. The pulp mill default ammonia concentration was set to 1 mg/L in the HEC-5Q model. As discussed previously, a sensitivity analysis with the pulp mill ammonia concentration set at 1 mg/L reduces the 95% concentration from 0.09 to 0.07.

The Alabama River phosphate profile is plotted in Figure 3.59. Observed data show fairly uniform phosphate concentrations from upstream to downstream. The 5%, 25% and 50% occurrence results are close to observed, while the 75% and 95% results are higher than observed. An observation bias occurs through each growing season, with more data collected during the middle of the growing season (summer) when the Chlorophyll *a* concentrations are higher and nutrient concentrations are correspondingly lower. This results in a data collection bias that affects comparisons of simulated and observed nitrogen and phosphorus concentrations.

A longitudinal profile of Chlorophyll *a* in the Alabama River is plotted in Figure 3.60. Computed values show a greater range than observed. A time series plot of computed and observed Chlorophyll *a* in Alabama River at Millers Ferry reservoir is plotted in Figure 3.61. Computed values at the Dam and mid-lake are very similar and match reasonably well with data observations. During some years, the modeled peaks are higher than observed. The general trend of slightly higher computed than observed Chlorophyll *a* is considered conservative since it accentuates the sensitivity to operational alternatives.

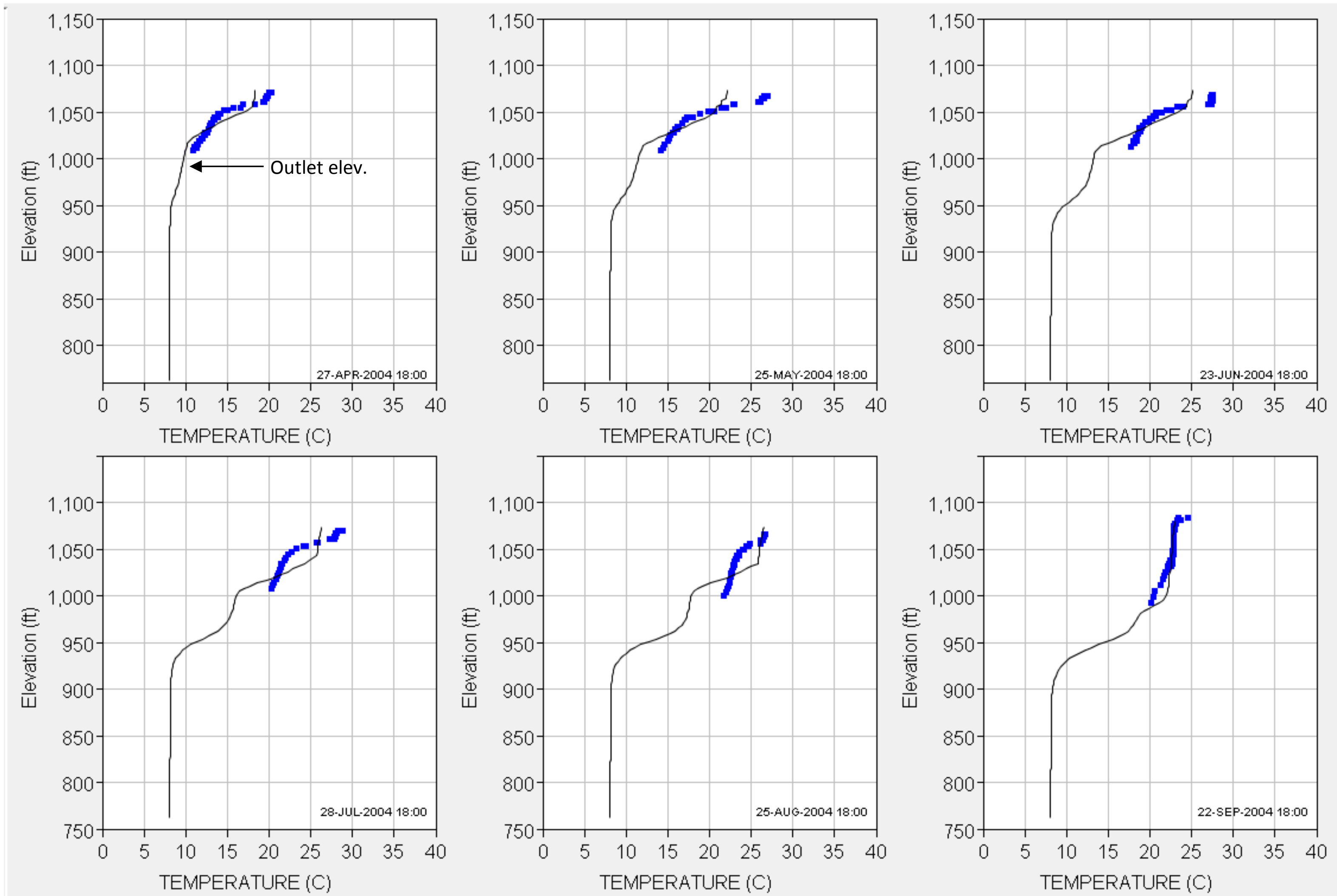


Figure 3.1 Typical computed and observed temperature profiles in Carters Reservoir for dates between April and September 2004. Multiple profile locations were measured on each day. Solid line = Computed; Blue dots = Observed.

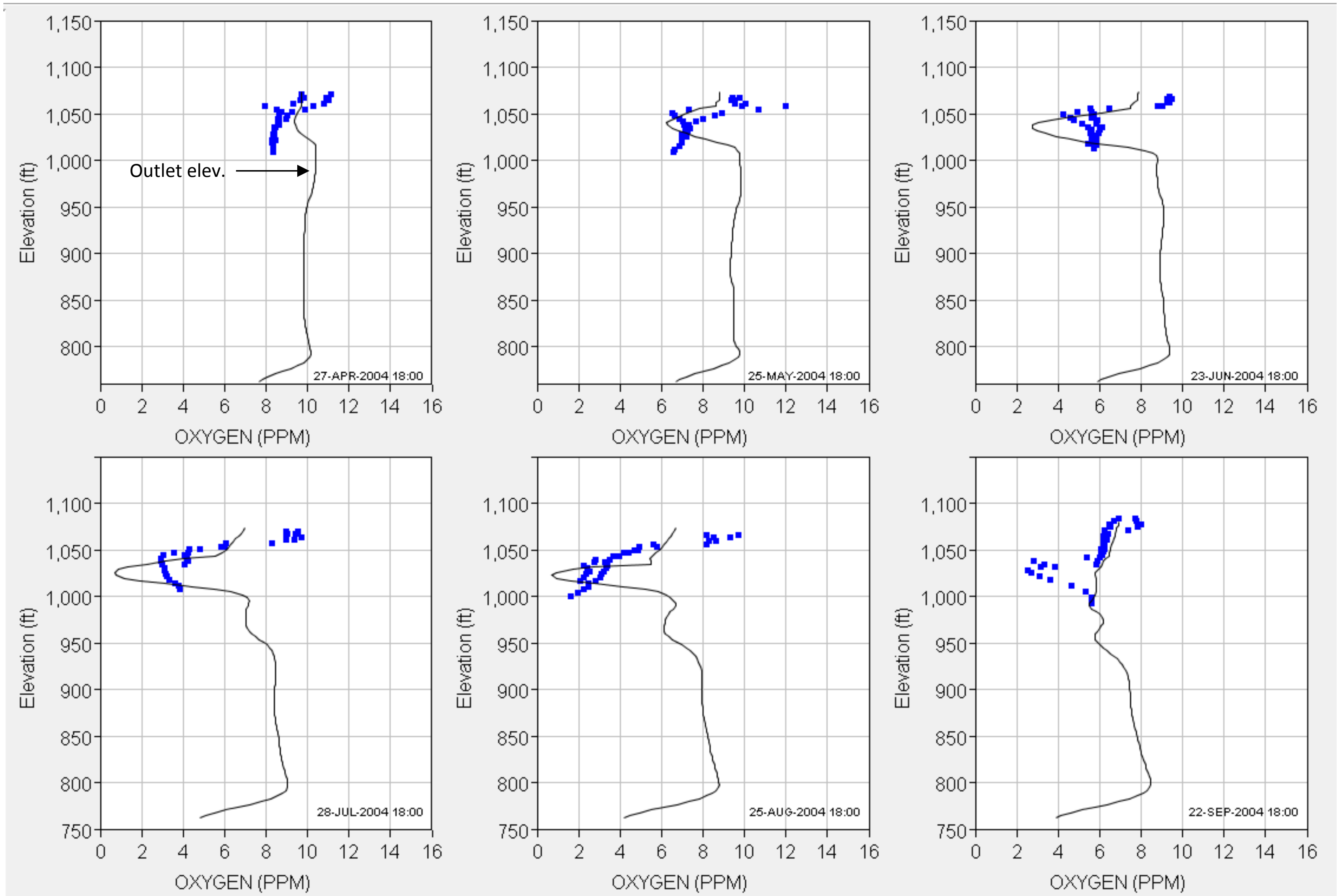


Figure 3.2 Typical computed and observed oxygen profiles (PPM = mg/L) in Carters Reservoir for dates between April and September 2004. Multiple profile locations were measured on each day. Solid line = Computed; Blue dots = Observed.

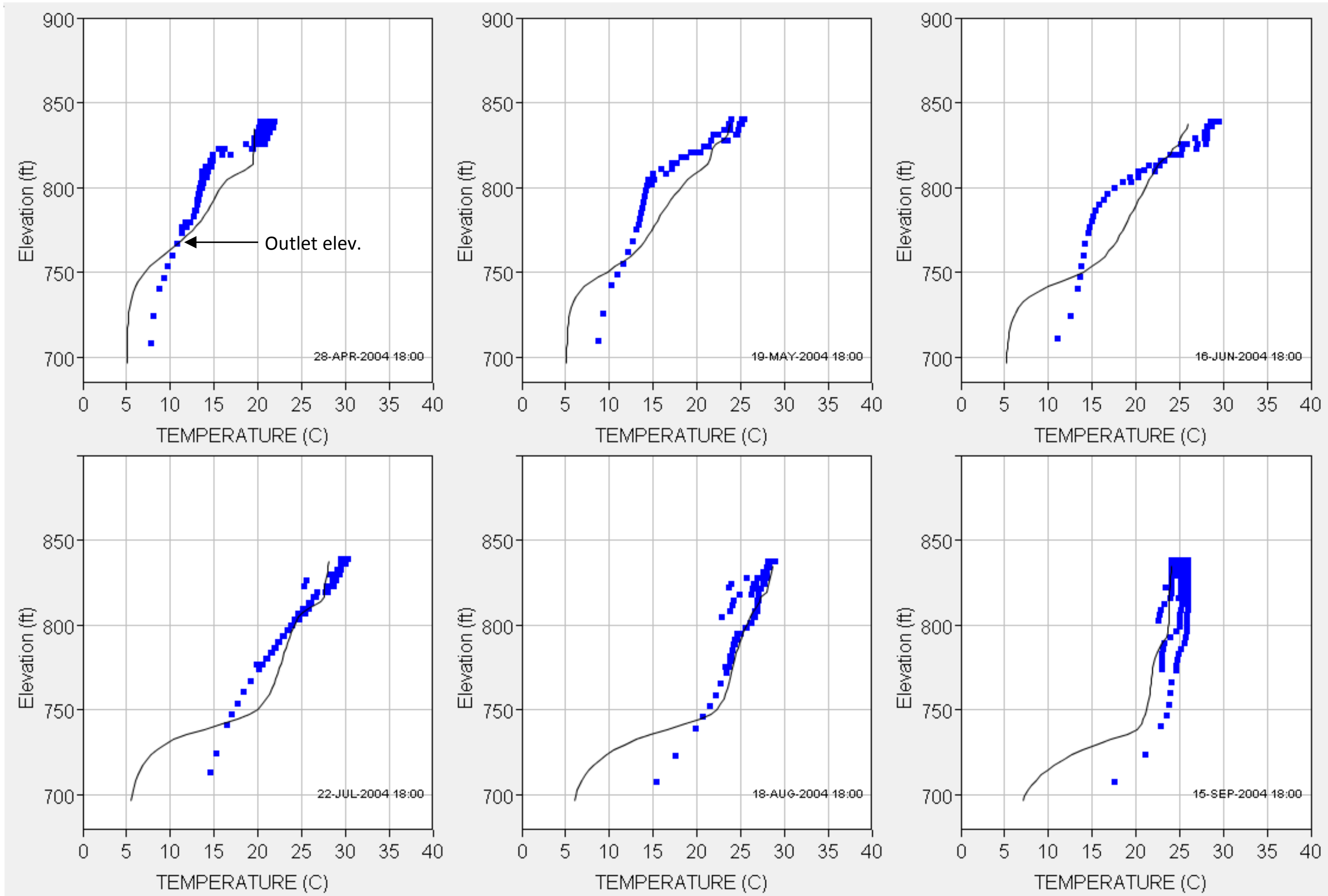


Figure 3.3 Typical computed and observed temperature profiles in Allatoona Reservoir for dates between April and September 2004. Multiple profile locations were measured on each day. Solid line = Computed; Blue dots = Observed.

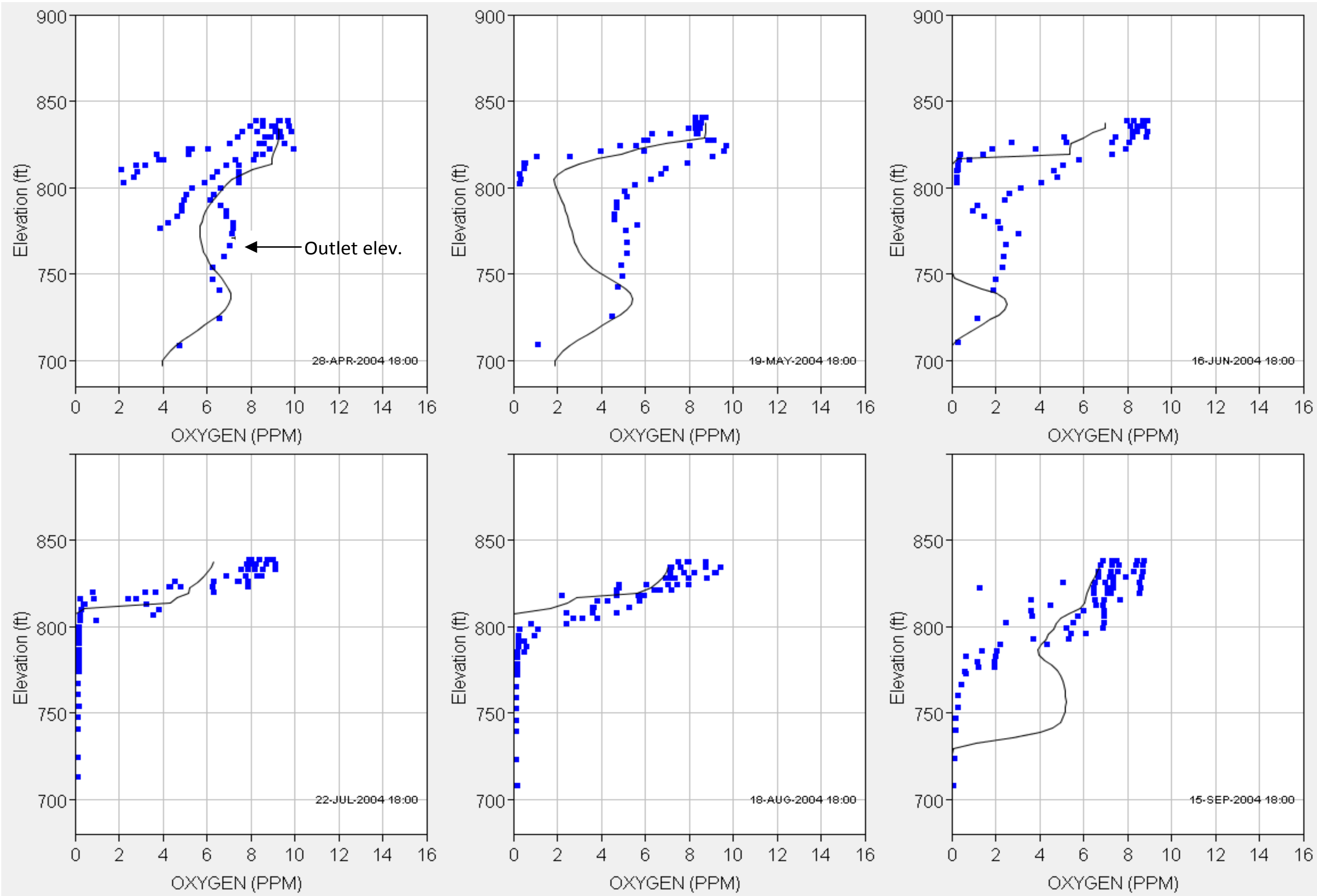


Figure 3.4 Typical computed and observed oxygen profiles (PPM = mg/L) in Allatoona Reservoir for dates between April and September 2004. Multiple profile locations were measured on each day. Solid line = Computed; Blue dots = Observed.

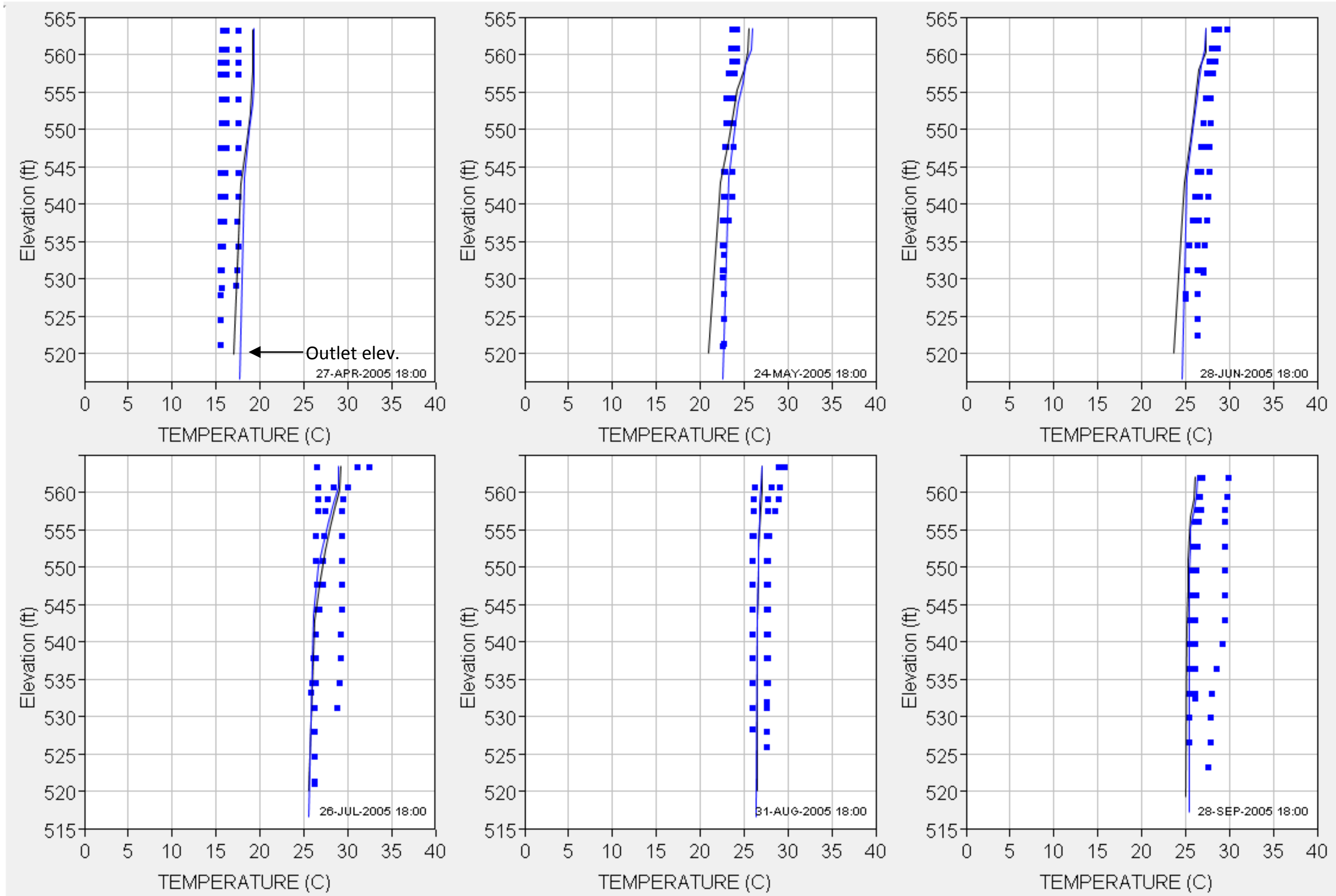


Figure 3.5 Typical computed and observed temperature profiles in Weiss Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day. Solid line = Computed; Blue dots = Observed.

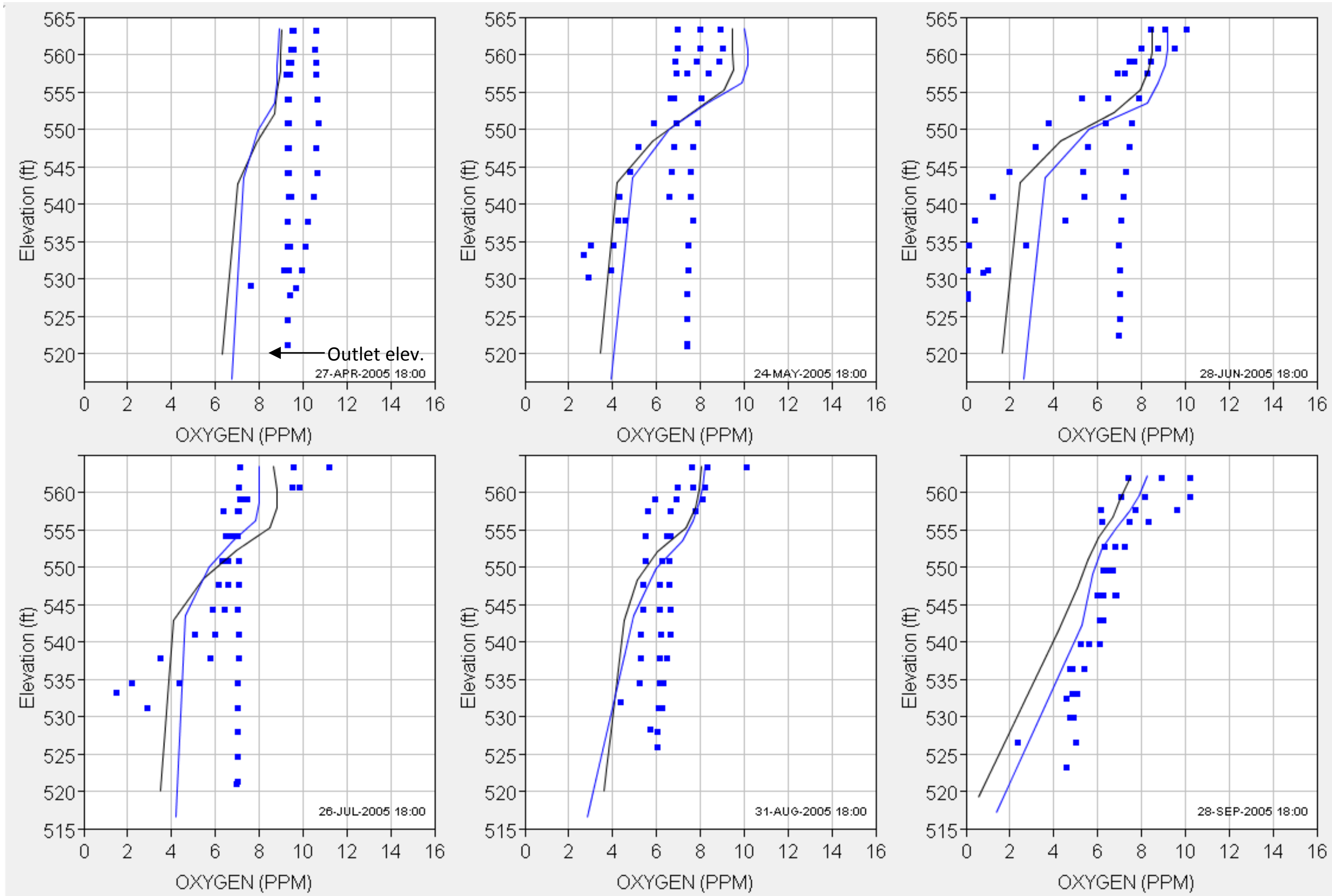


Figure 3.6 Typical computed and observed oxygen profiles (PPM = mg/L) in Weiss Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day. Solid line = Computed; Blue dots = Observed.

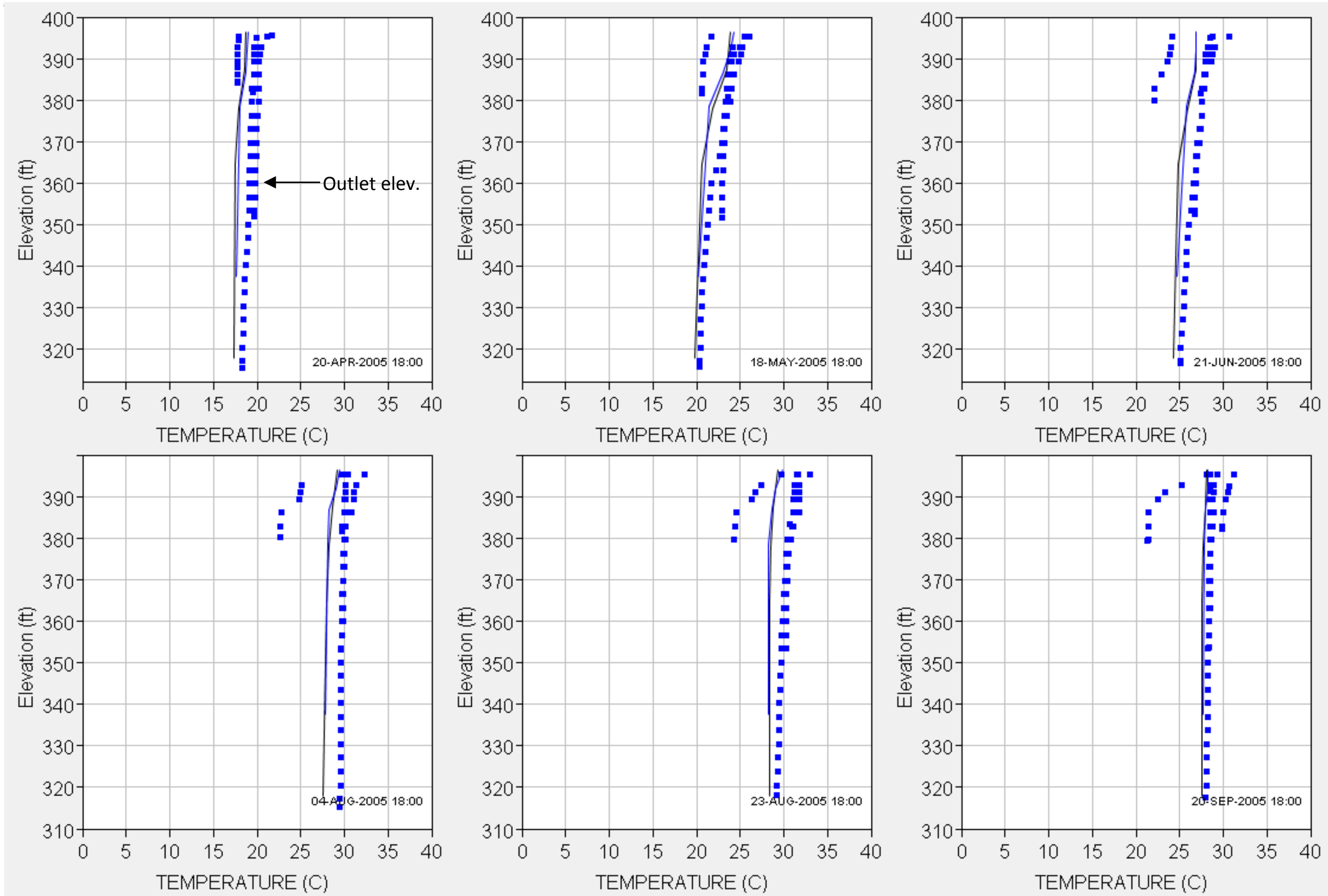


Figure 3.7 Typical computed and observed temperature profiles in Lay Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day. Solid line = Computed; Blue dots = Observed.

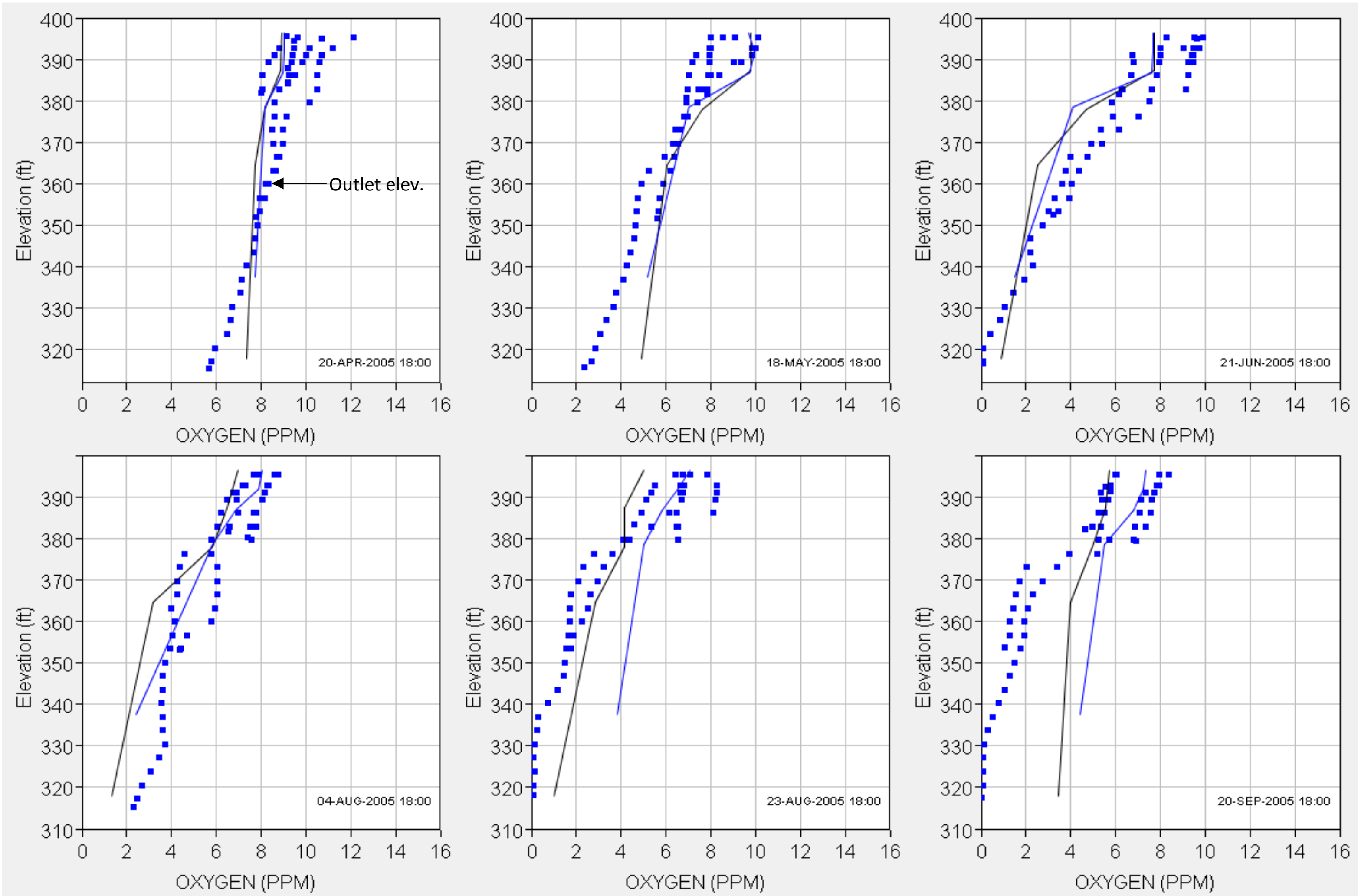


Figure 3.8 Typical computed and observed oxygen profiles (PPM = mg/L) in Lay Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day. Solid line = Computed; Blue dots = Observed.

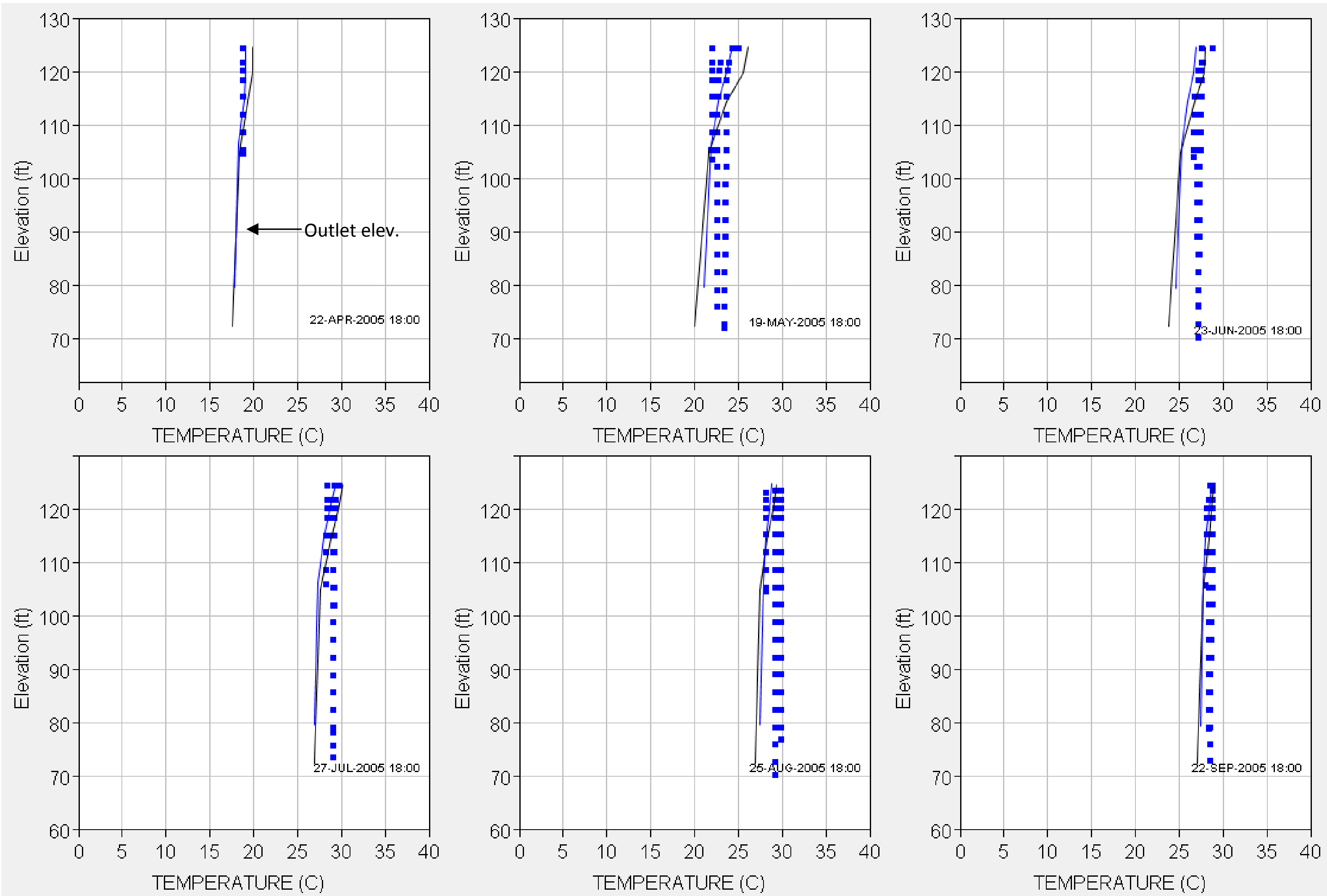


Figure 3.9 Typical computed and observed temperature profiles in R.F. Henry Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day. Solid line = Computed; Blue dots = Observed.

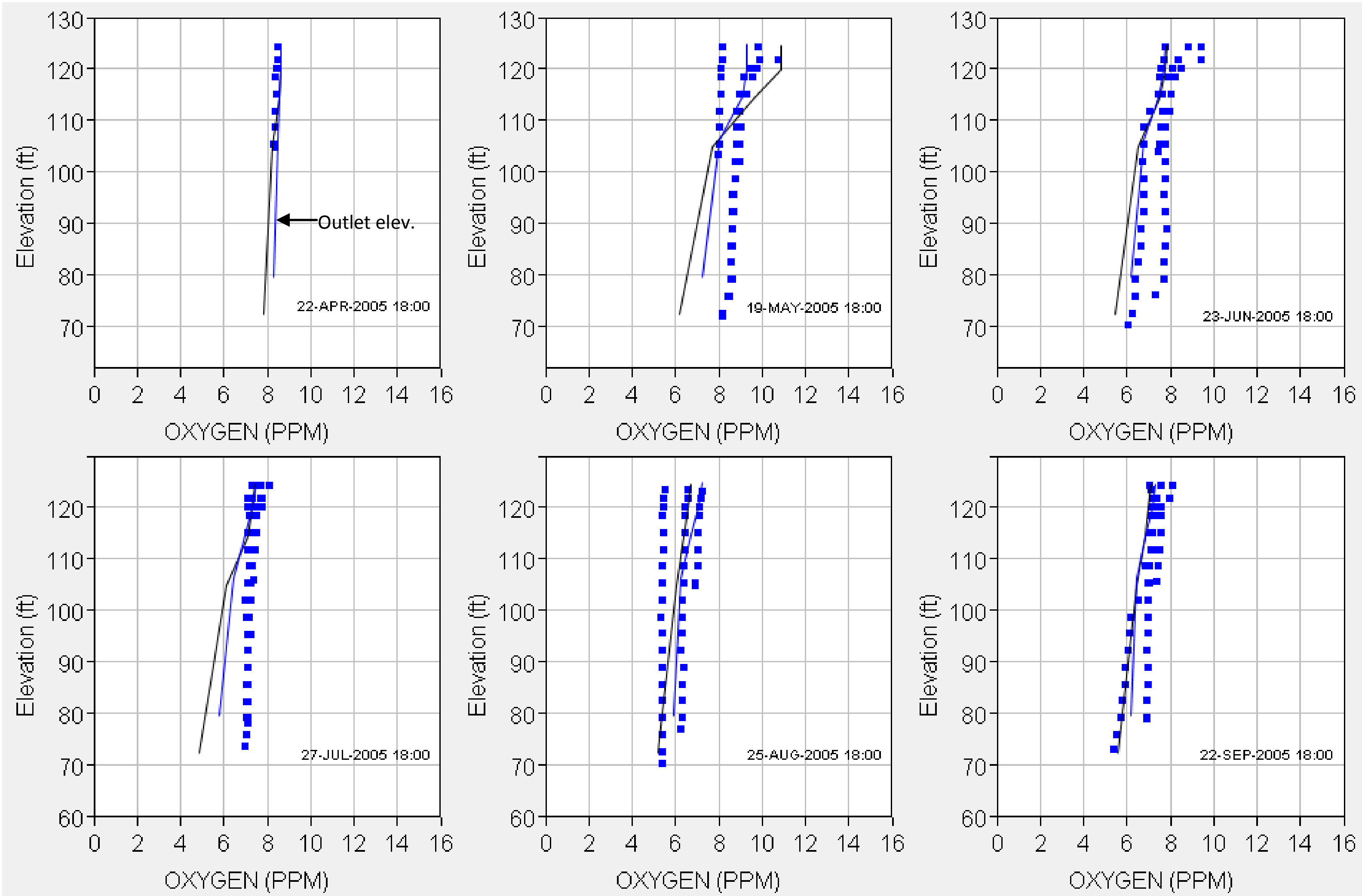


Figure 3.10 Typical computed and observed oxygen profiles (PPM = mg/L) in R.F. Henry Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day. Solid line = Computed; Blue dots = Observed.

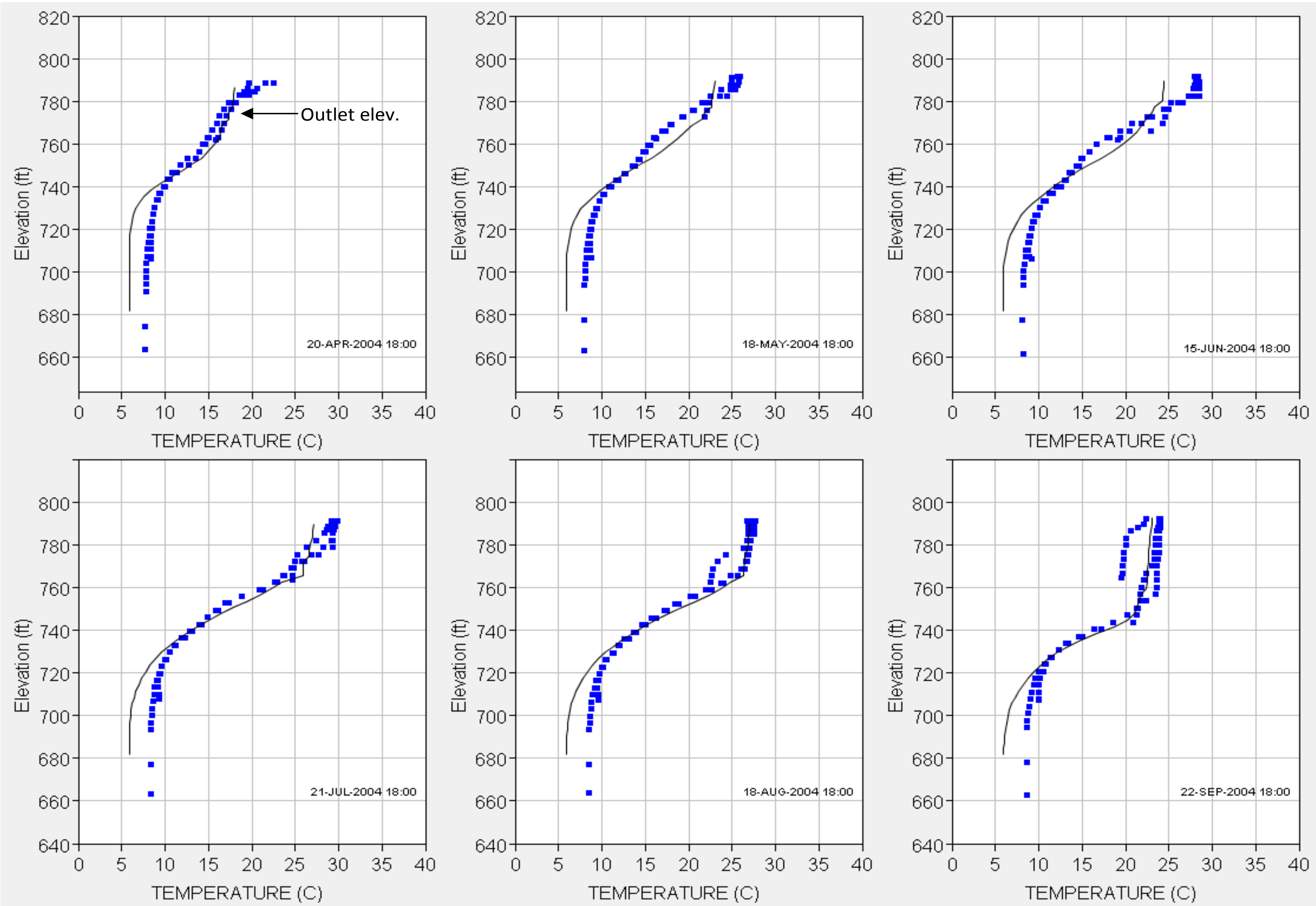


Figure 3.11 Typical computed and observed oxygen profiles in Harris Reservoir for dates between April and September 2004. Multiple profile locations were measured on each day. Solid line = Computed; Blue dots = Observed.

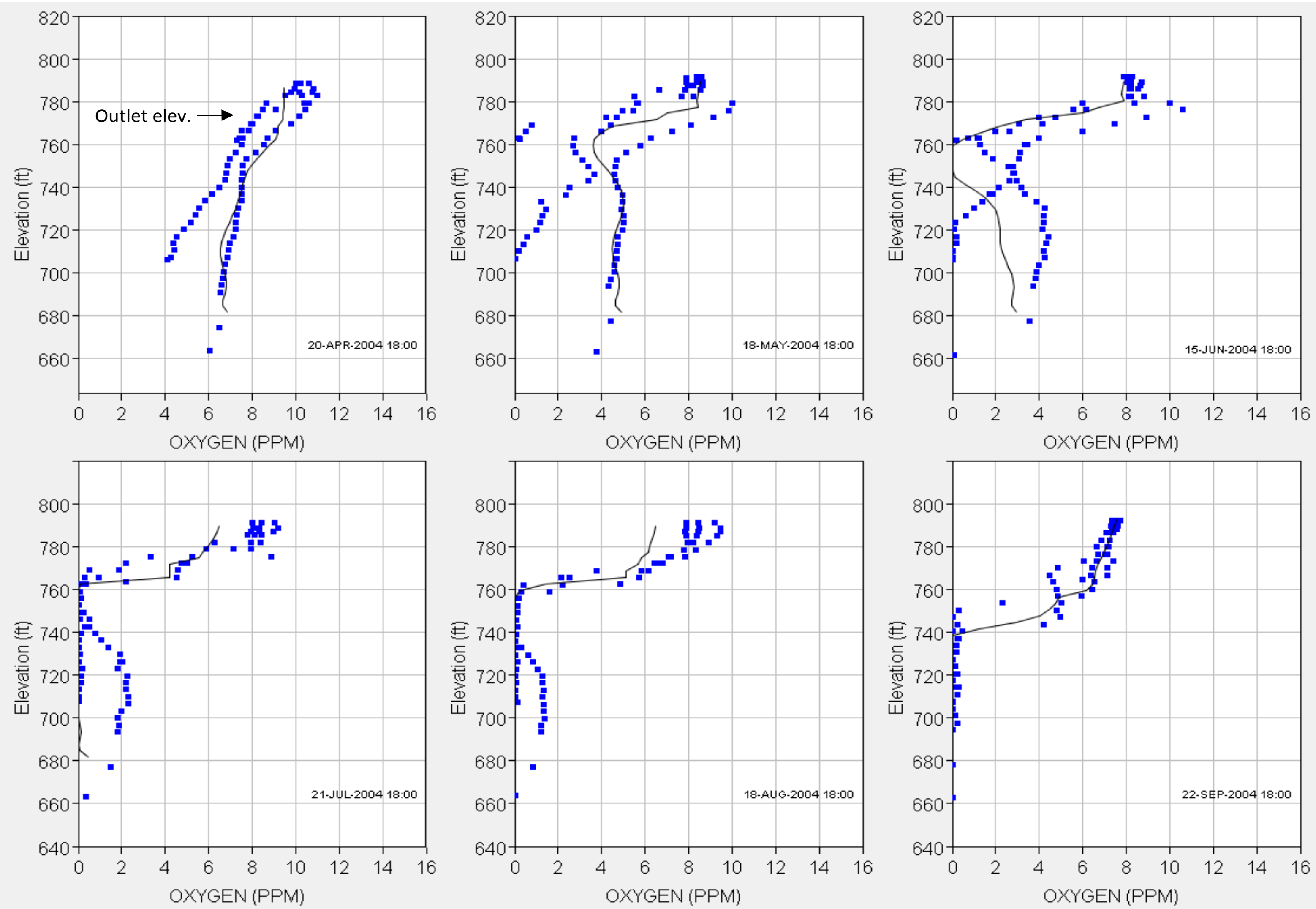


Figure 3.12 Typical computed and observed oxygen profiles (PPM = mg/L) in Harris Reservoir for dates between April and September 2004. Multiple profile locations were measured on each day. Solid line = Computed; Blue dots = Observed.

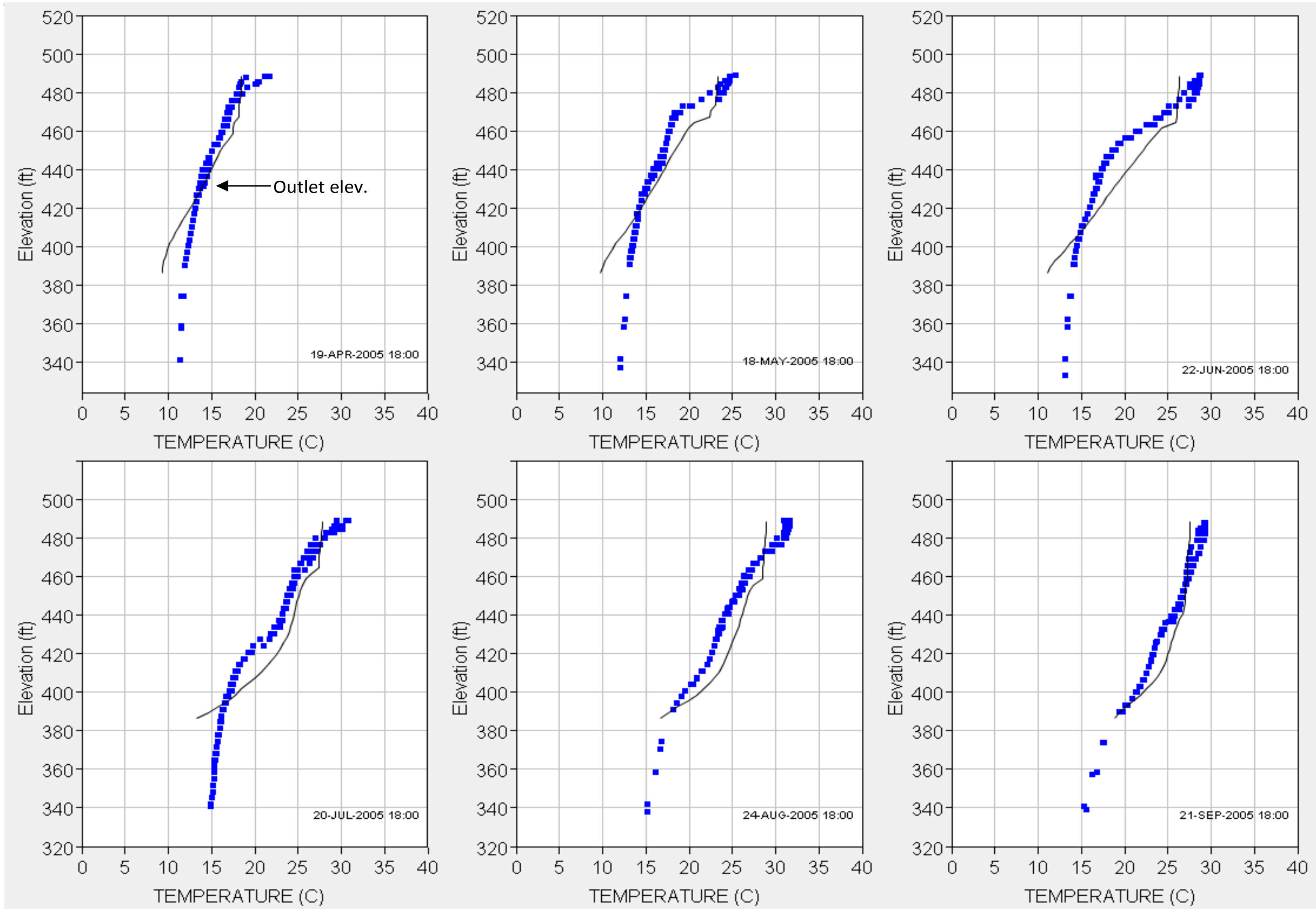


Figure 3.13 Typical computed and observed oxygen profiles in Martin Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day. Solid line = Computed; Blue dots = Observed.

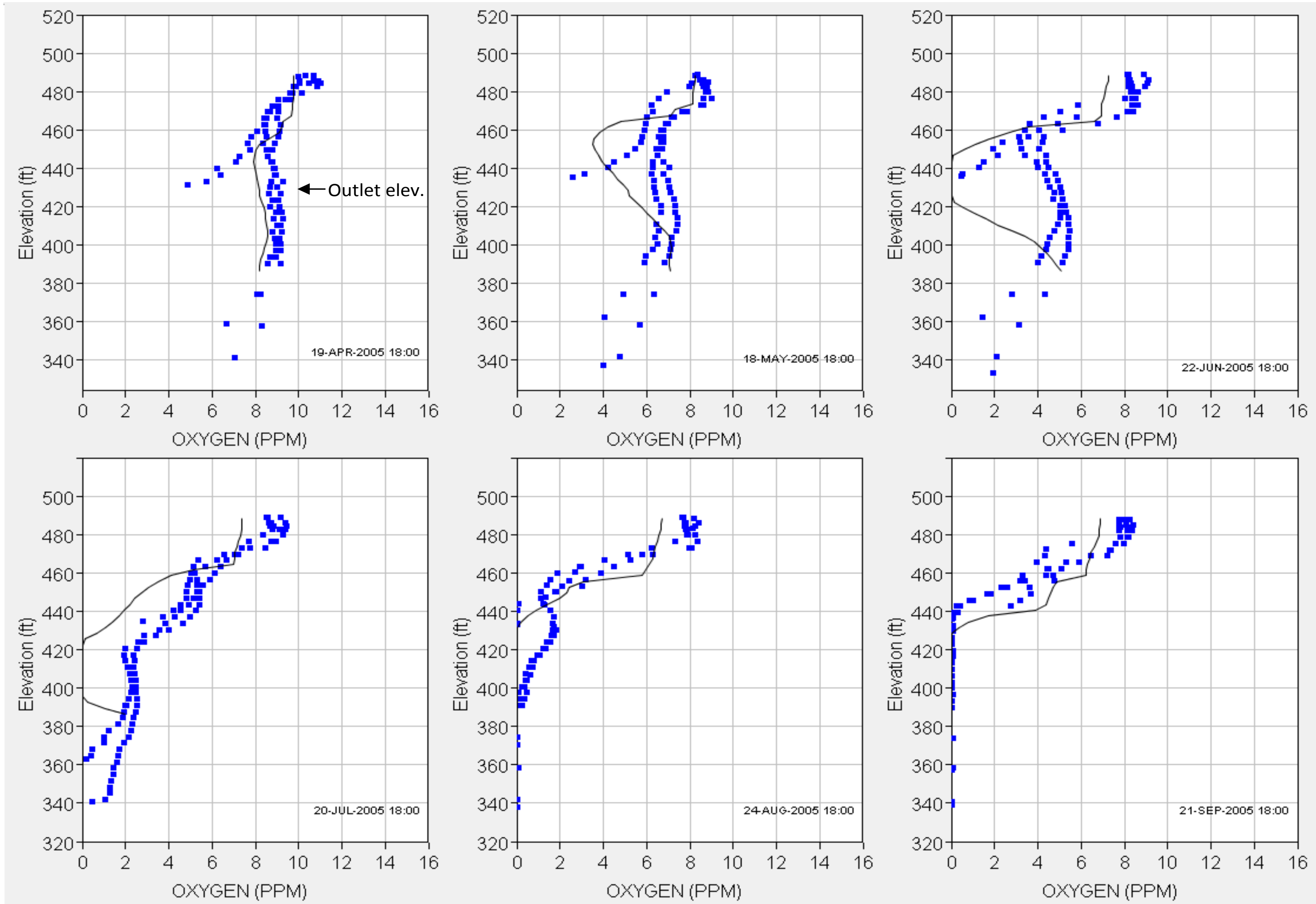


Figure 3.14 Typical computed and observed oxygen profiles (PPM = mg/L) in Martin Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day. Solid line = Computed; Blue dots = Observed.

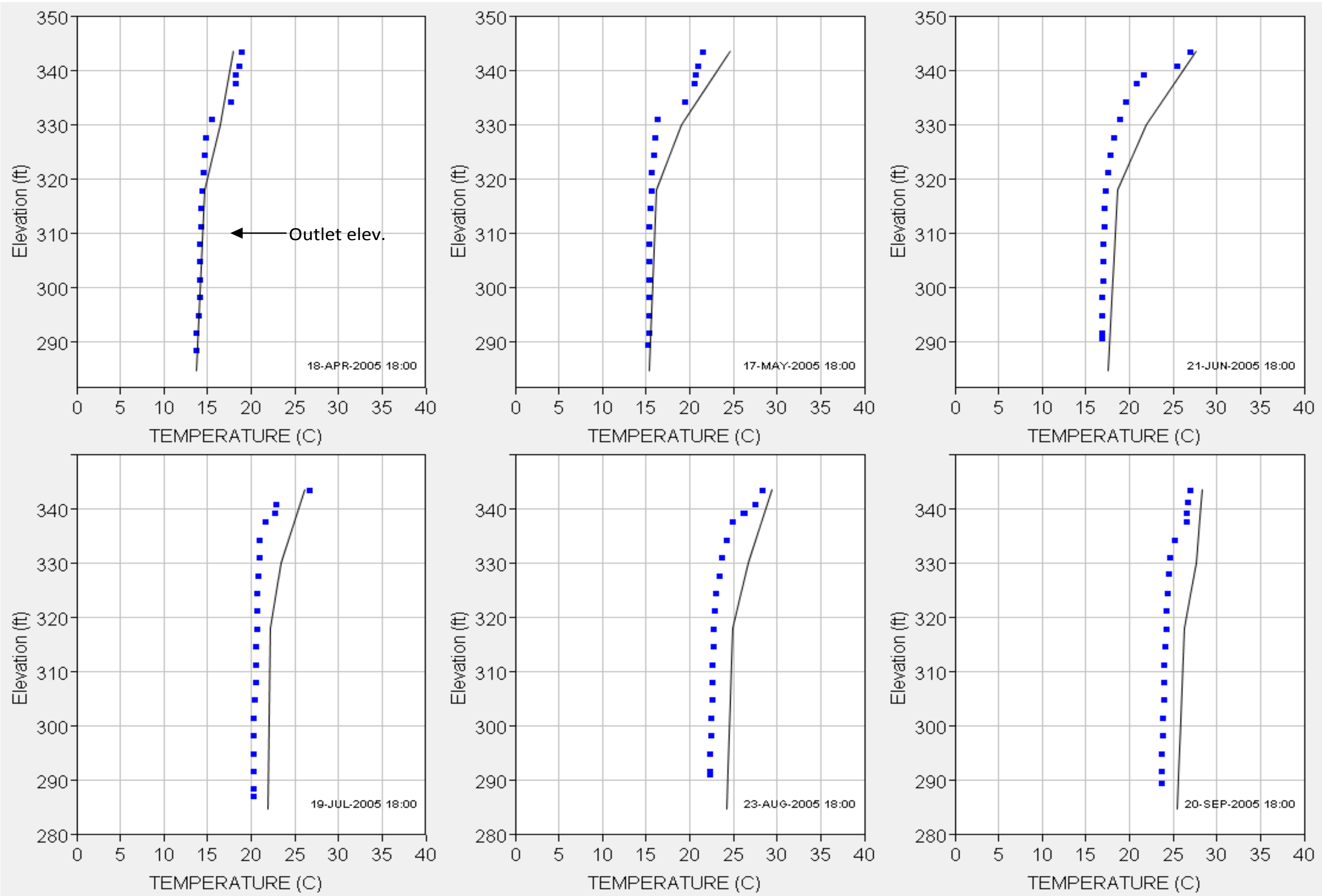


Figure 3.15 Typical computed and observed oxygen profiles in Yates Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day. Solid line = Computed; Blue dots = Observed.

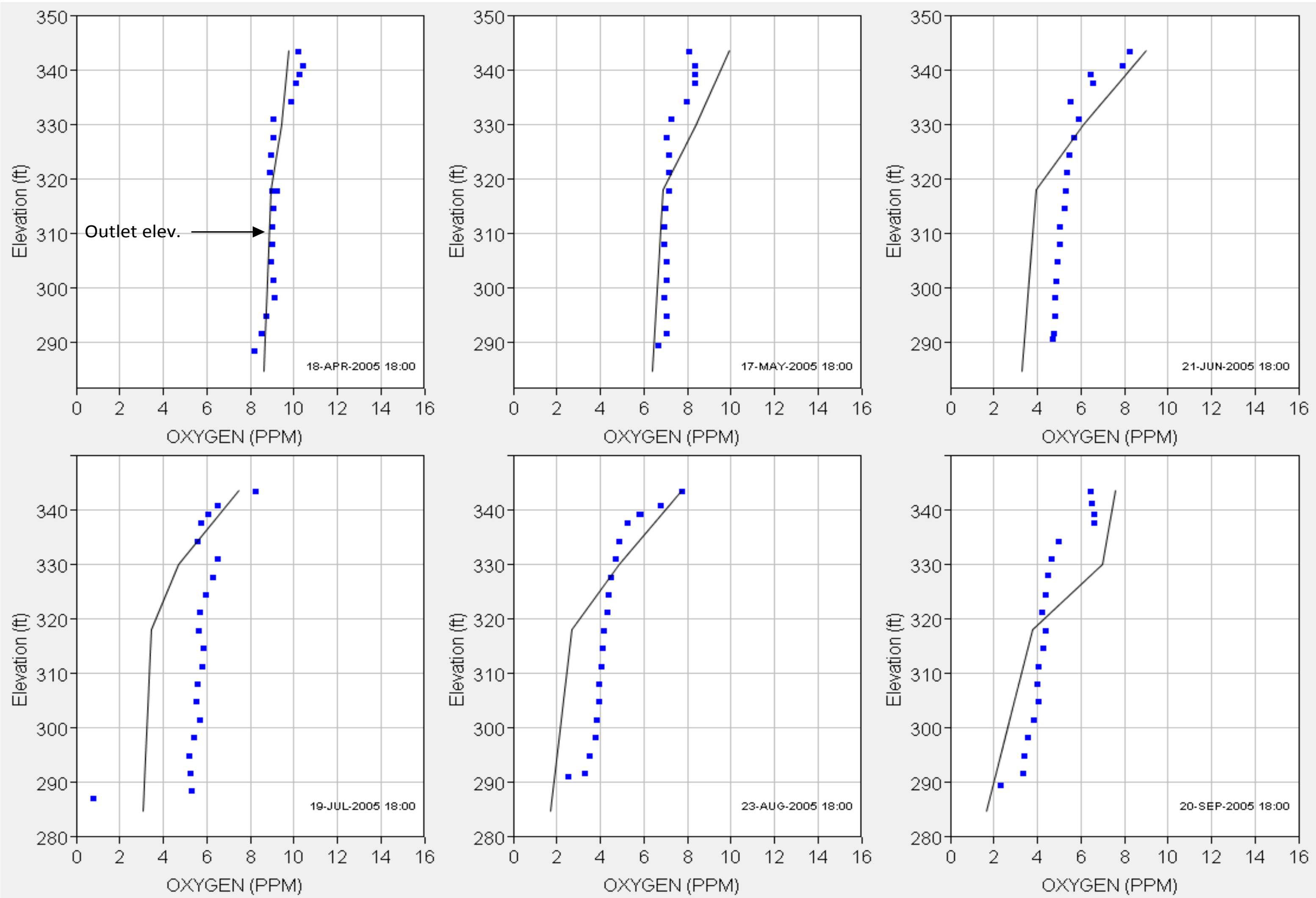


Figure 3.16 Typical computed and observed oxygen profiles (PPM = mg/L) in Yates Reservoir for dates between April and September 2005. Multiple profile locations were measured on each day. Solid line = Computed; Blue dots = Observed.

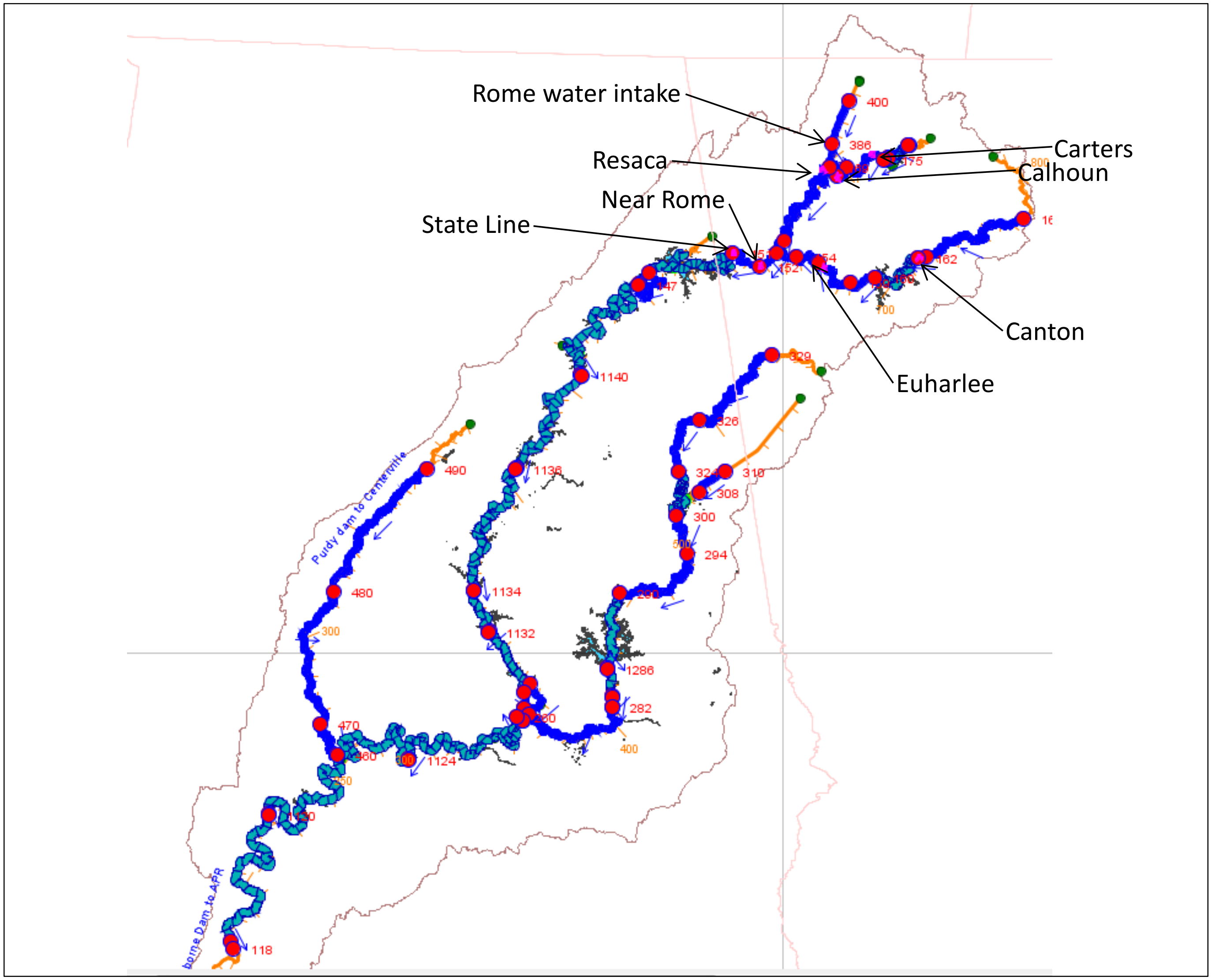


Figure 3.17 HEC-5 and HEC-5Q Model Schematic of ACT Basin showing time series plot locations.

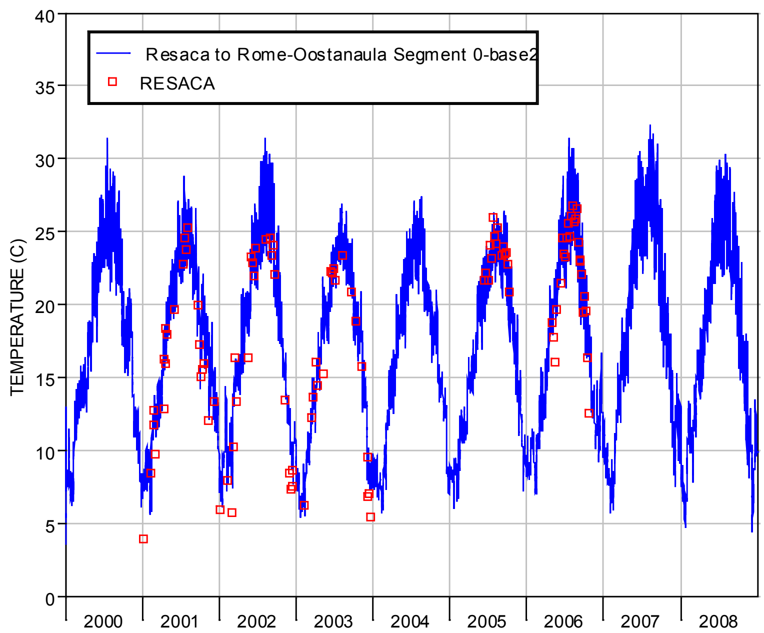


Figure 3.18 Time series of computed and observed temperature in Oostanaula River at Resaca.

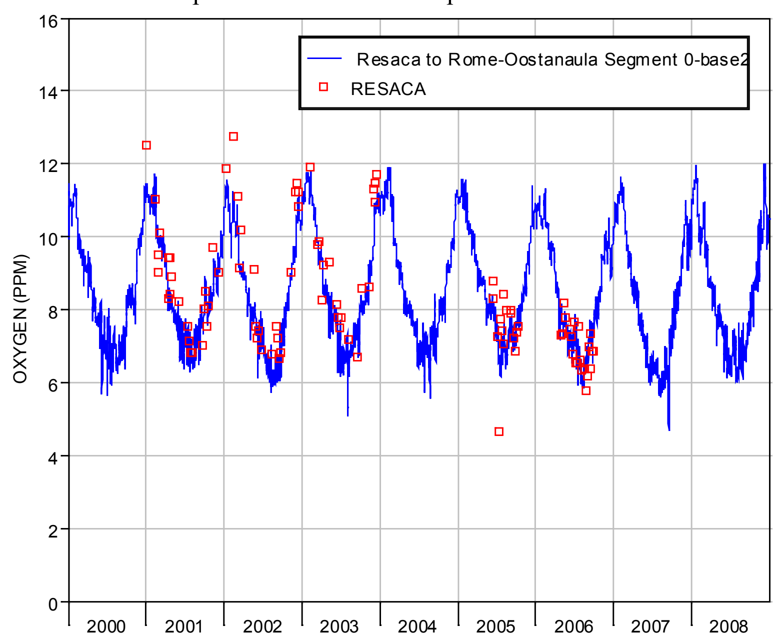


Figure 3.19 Time series of computed and observed oxygen in Oostanaula River at Resaca.

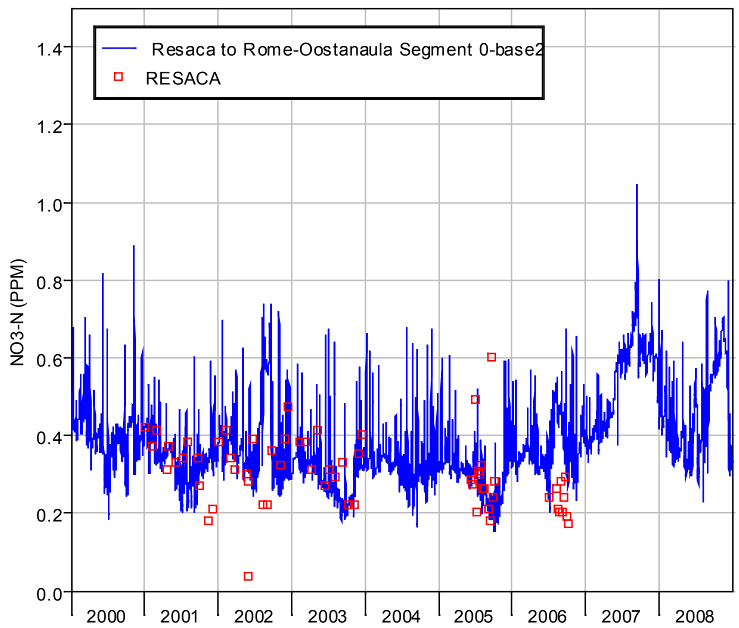


Figure 3.20 Time series of computed and observed nitrate in Oostanaula River at Resaca.

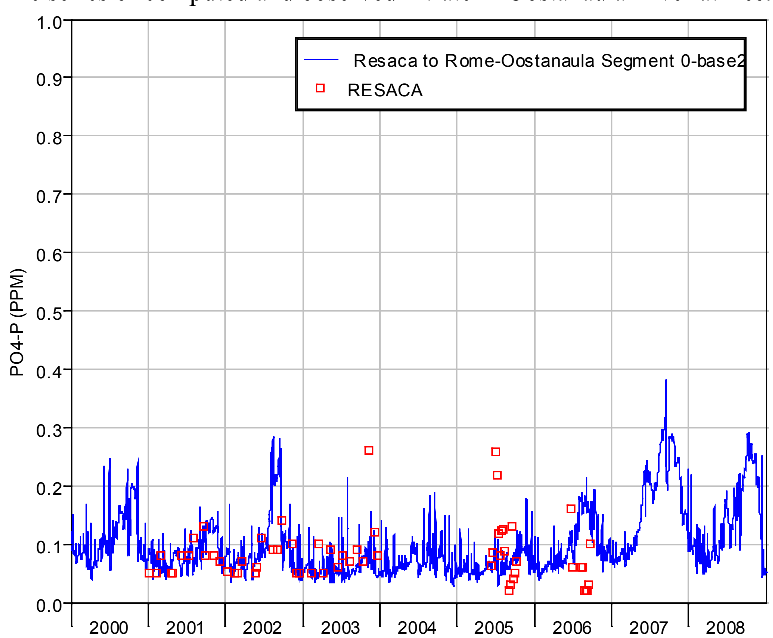


Figure 3.21 Time series of computed and observed phosphate in Oostanaula River at Resaca.

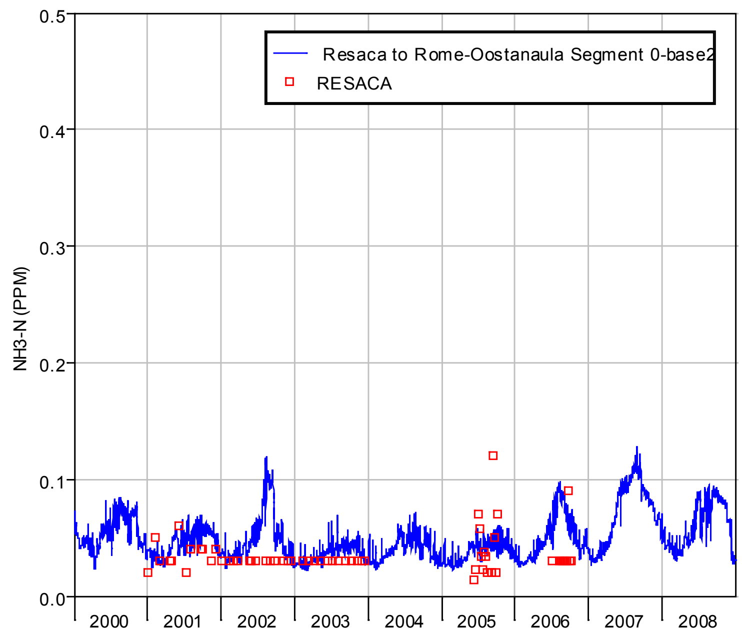


Figure 3.22 Time series of computed and observed ammonia in Oostanaula River at Resaca.

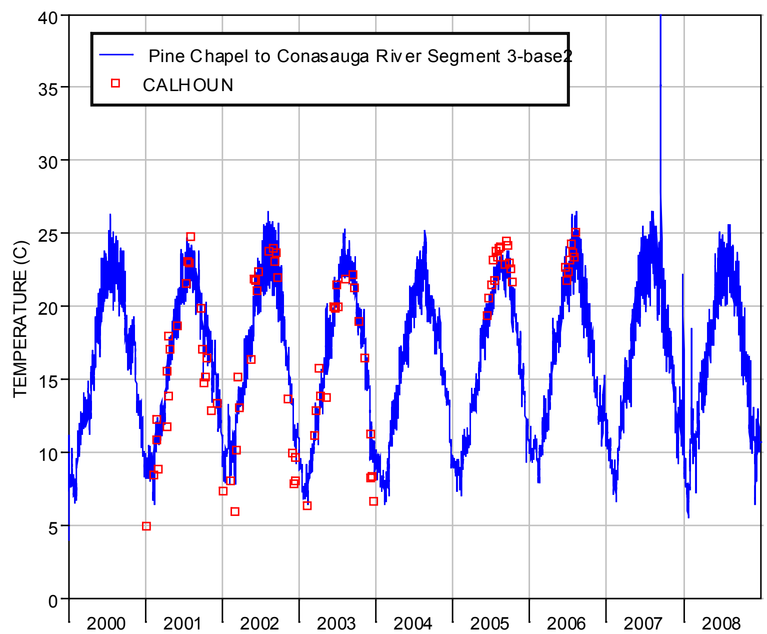


Figure 3.23 Time series of computed and temperature in Coosawattee River at Calhoun.

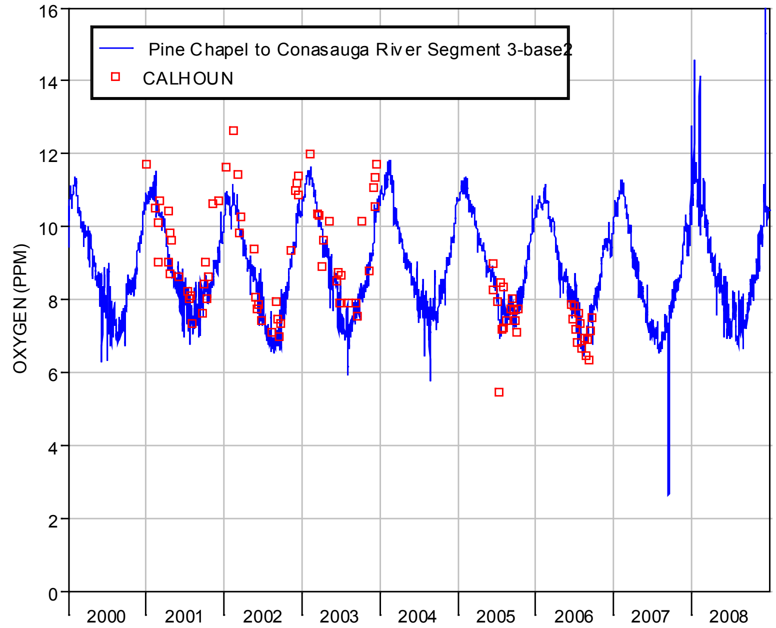


Figure 3.24 Time series of computed and observed oxygen in Coosawattee River at Calhoun.

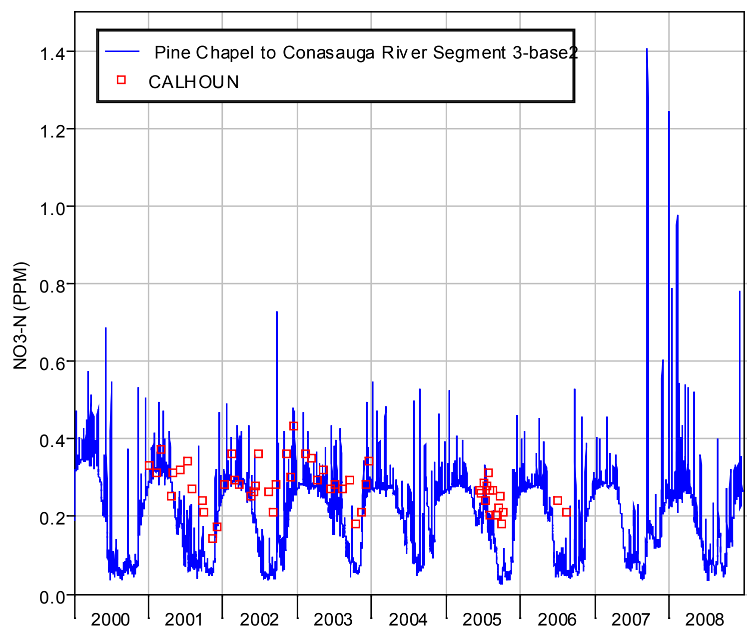


Figure 3.25 Time series of computed and observed nitrate in Coosawattee River at Calhoun.

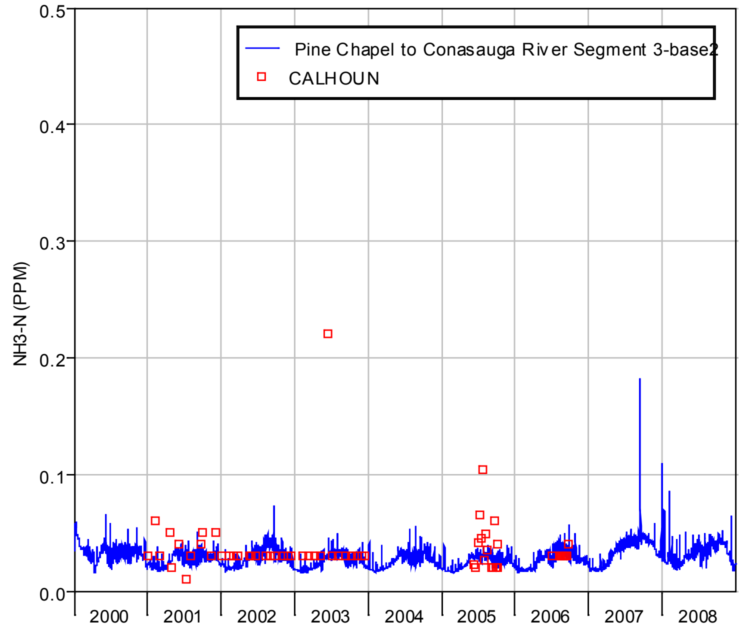


Figure 3.26 Time series of computed and observed ammonia in Coosawattee River at Calhoun.

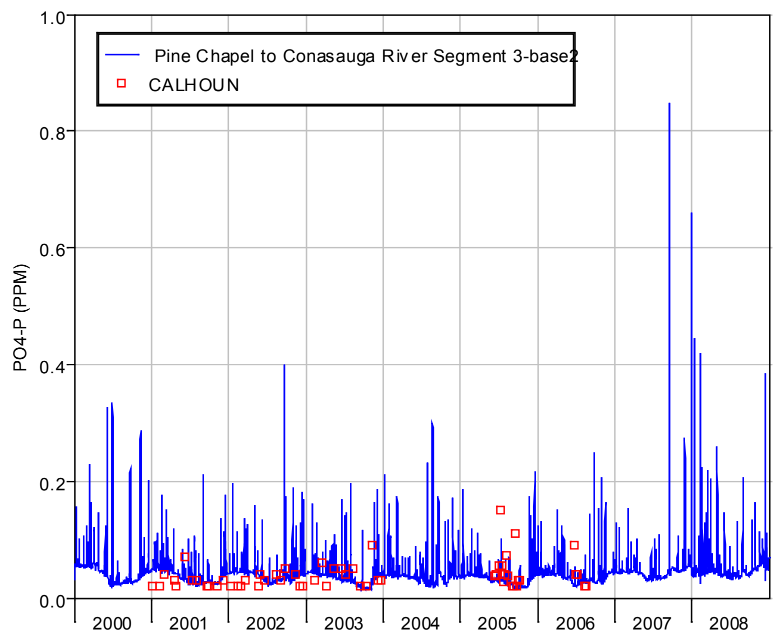


Figure 3.27 Time series of computed and observed phosphate in Coosawattee River at Calhoun.

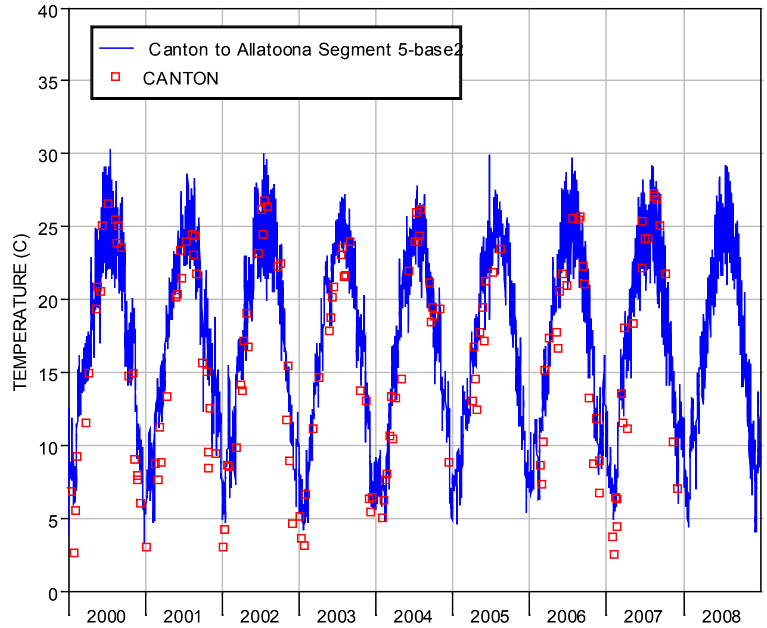


Figure 3.28 Time series of computed and observed temperature in Etowah River near Canton.

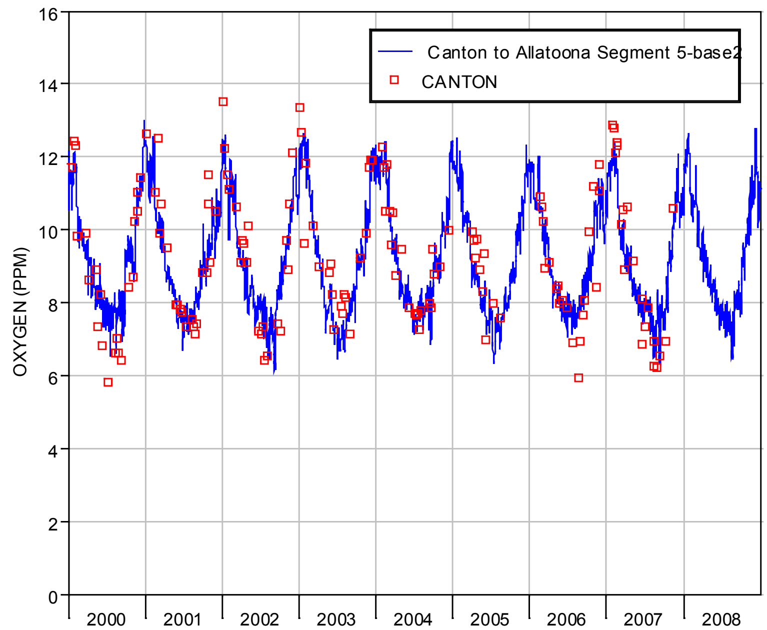


Figure 3.29 Time series of computed and observed oxygen in Etowah River near Canton.

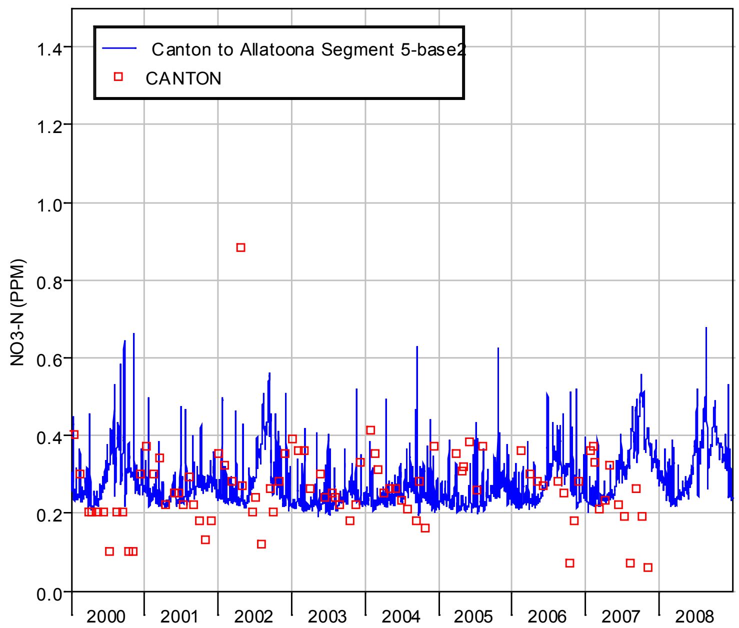


Figure 3.30 Time series of computed and observed nitrate in Etowah River near Canton.

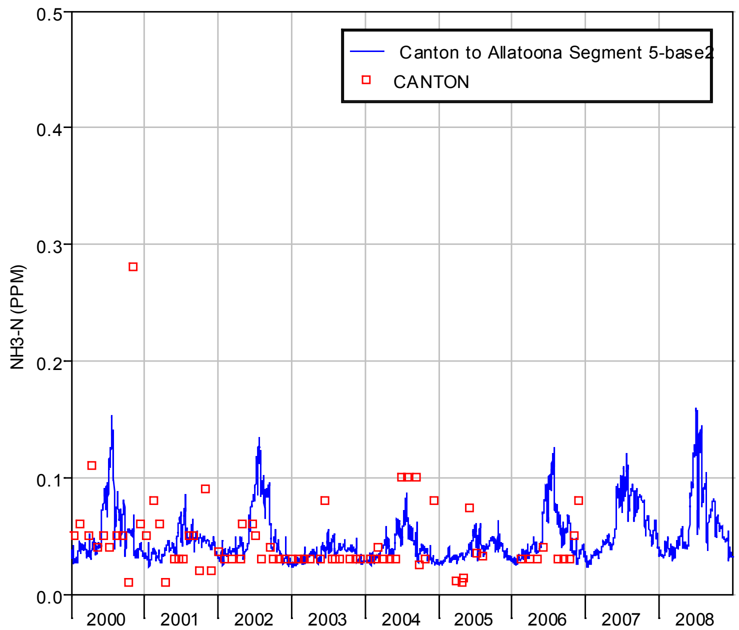


Figure 3.31 Time series of computed and observed ammonia in Etowah River near Canton.

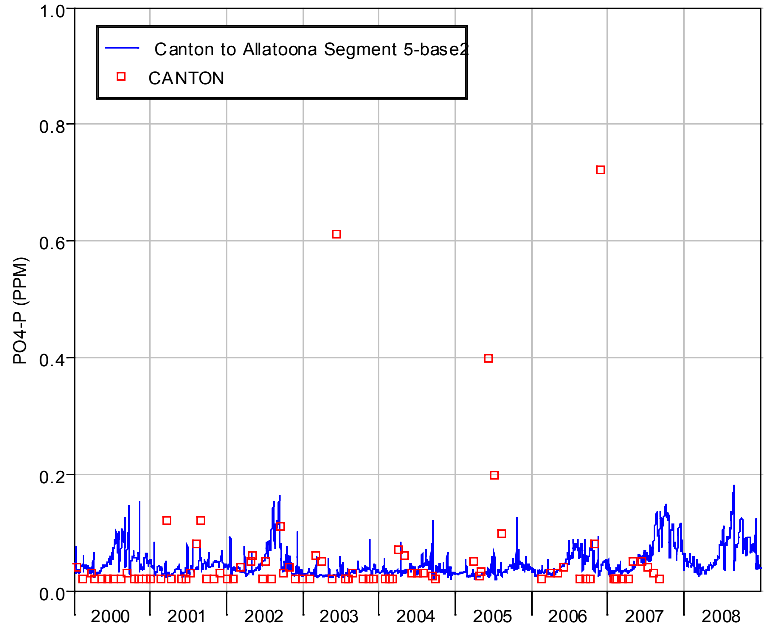


Figure 3.32 Time series of computed and observed phosphate in Etowah River near Canton.

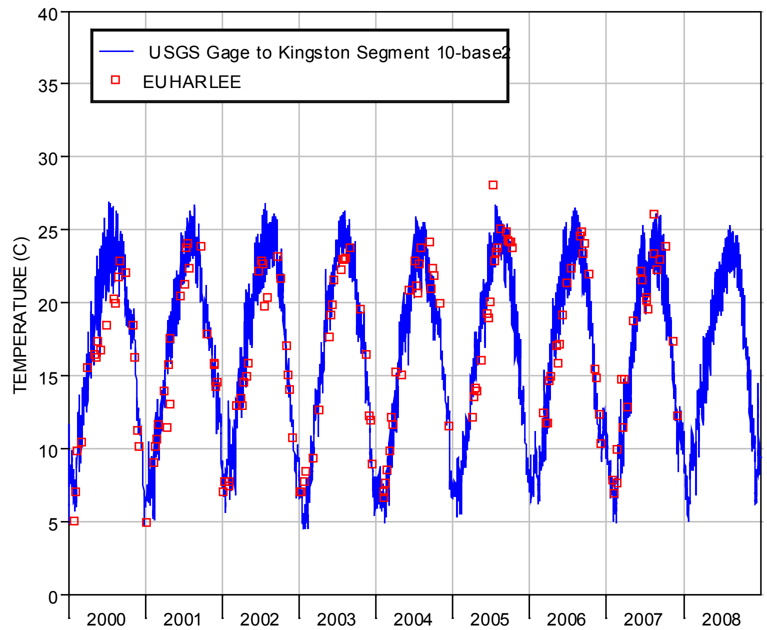


Figure 3.33 Time series of computed and observed temperature in Etowah River near Euharlee.

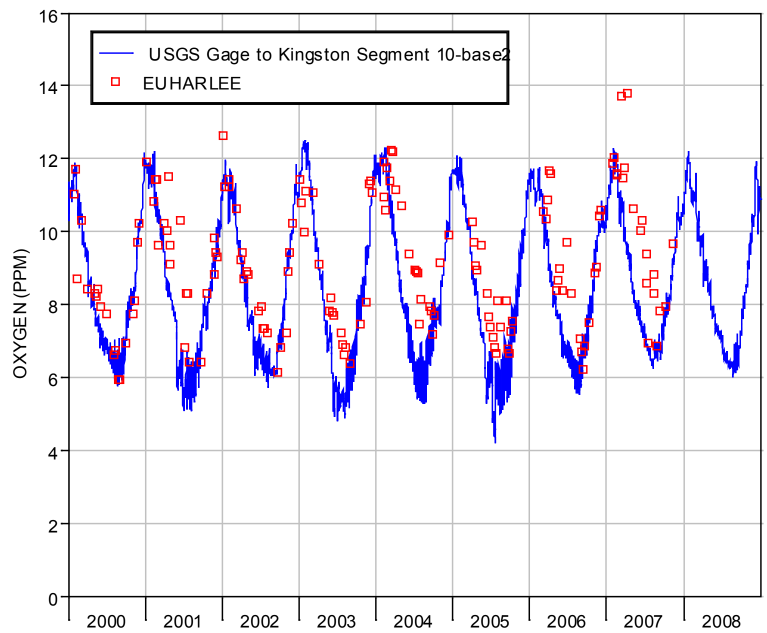


Figure 3.34 Time series of computed and observed oxygen in Etowah River near Euharlee.

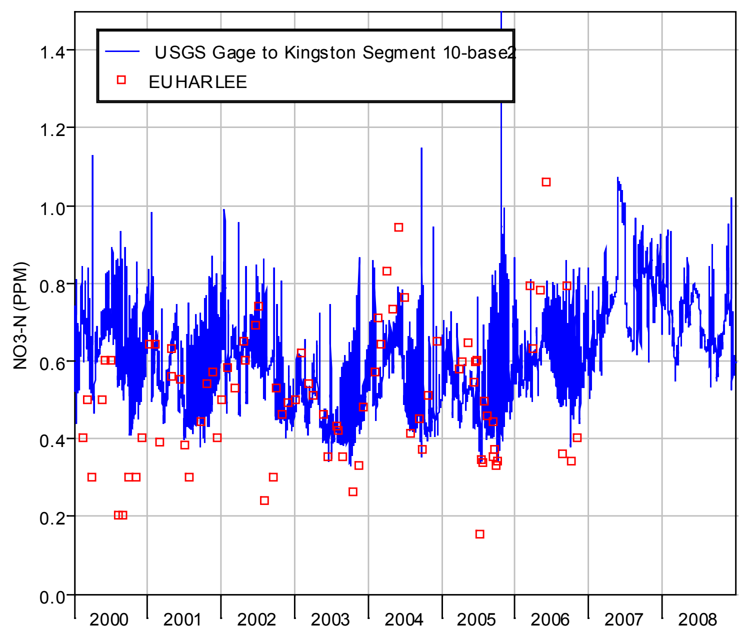


Figure 3.35 Time series of computed and observed nitrate in Etowah River near Euharlee. The simulated values in this figure were produced after a 750 lb/day NO3-N source was added to the HEC-5Q model to represent Georgia Power discharge.

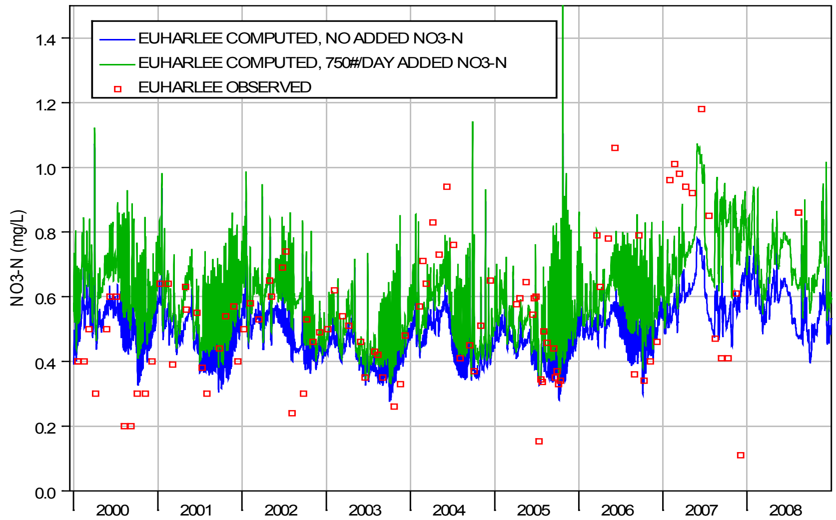


Figure 3.36 Time series of computed nitrate in Etowah River near Euharlee with and without 750 lb/day NO3-N added to represent Georgia Power discharge. Adding the 750 lb/day NO3-N source caused the simulated concentrations to reach the higher levels of the observed data.

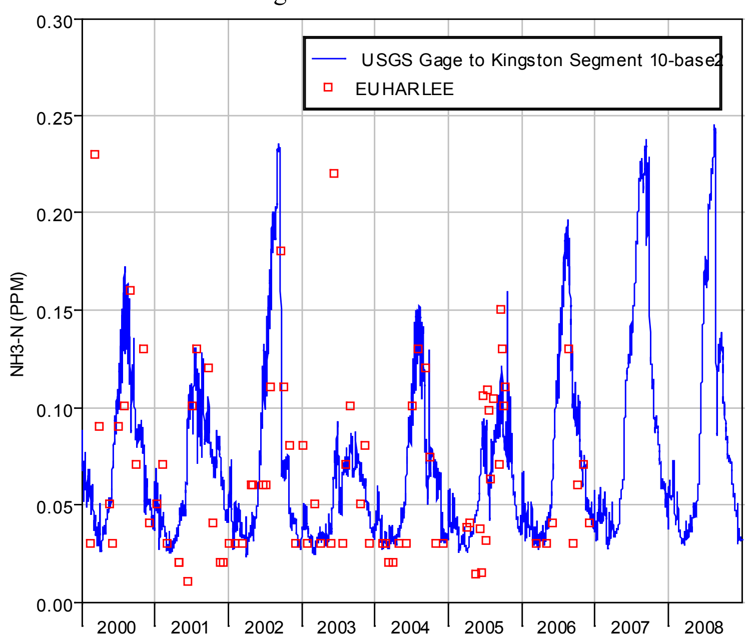


Figure 3.37 Time series of computed and observed ammonia in Etowah River near Euharlee.

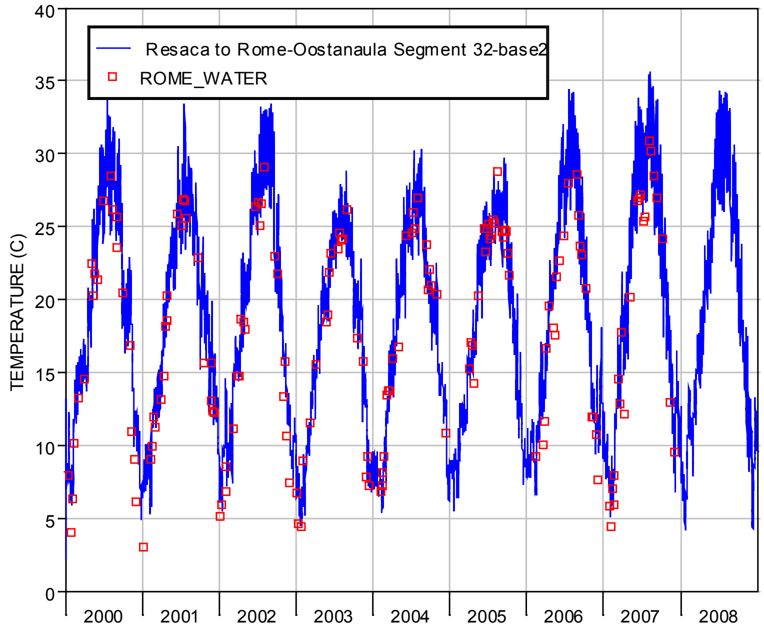


Figure 3.38 Time series of computed and observed temperature in Coosa River at Rome water intake.

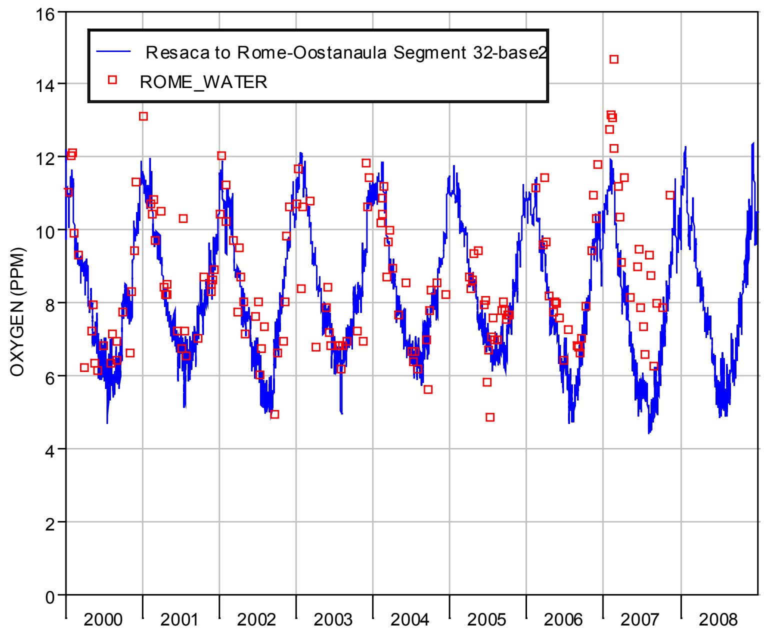


Figure 3.39 Time series of computed and observed oxygen in Coosa River at Rome water intake.

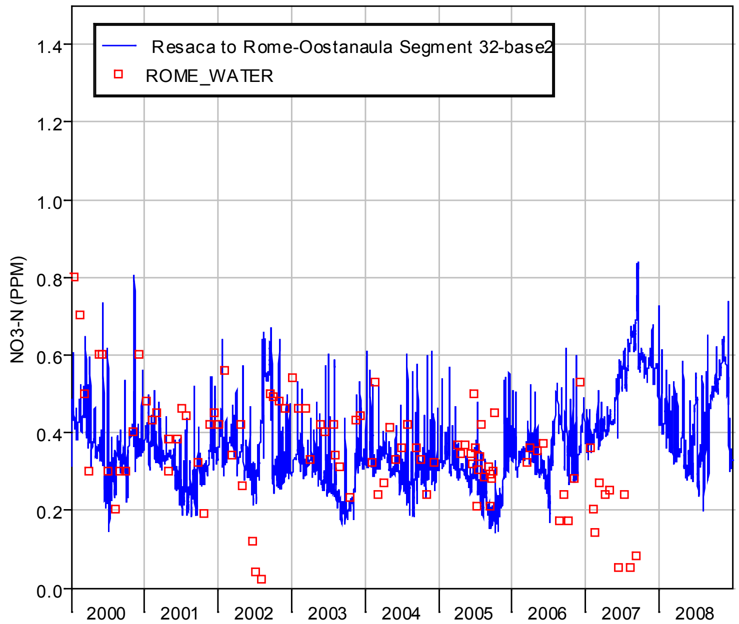


Figure 3.40 Time series of computed and observed nitrate in Coosa River at Rome water intake.

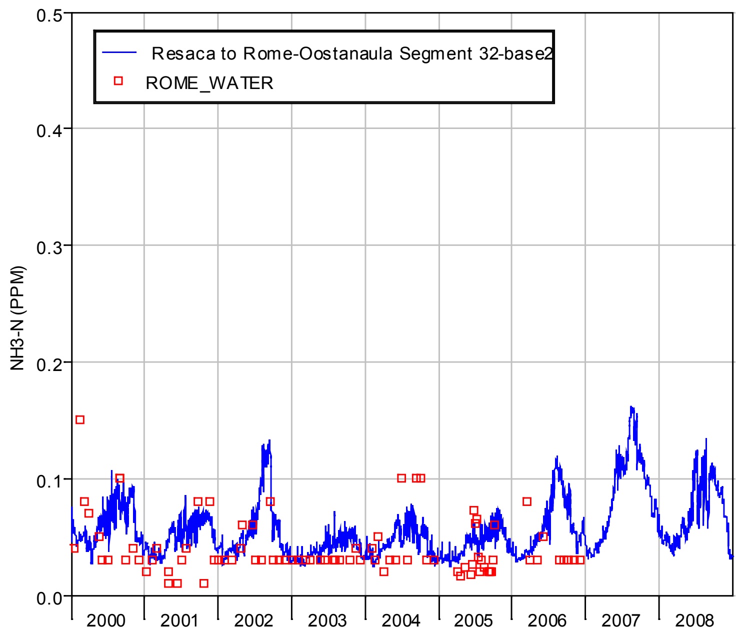


Figure 3.41 Time series of computed and observed ammonia in Coosa River at Rome water intake.

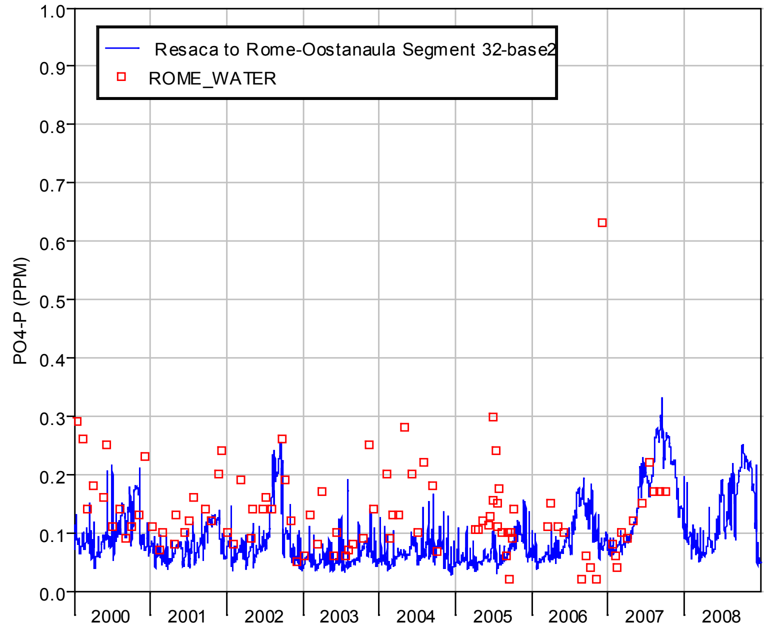


Figure 3.42 Time series of computed and observed phosphate in Coosa River at Rome water intake.

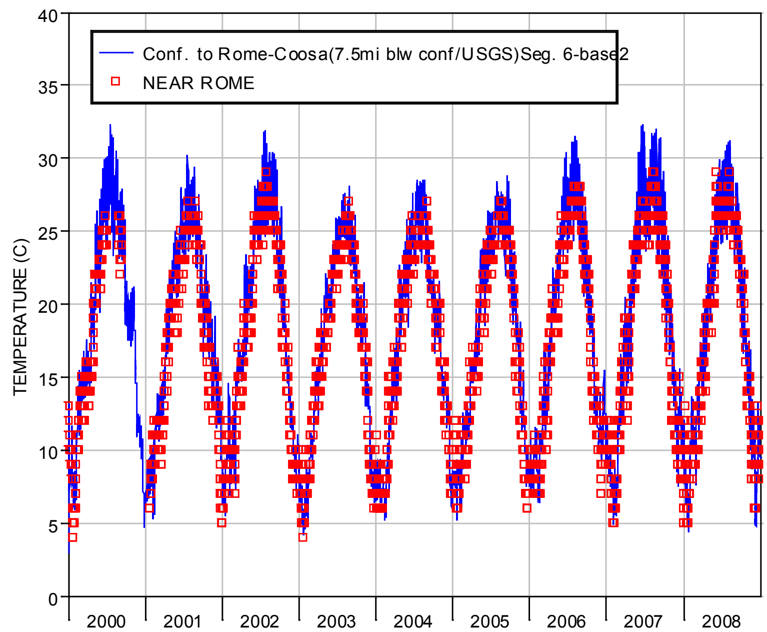


Figure 3.43 Time series of computed and observed temperature in Coosa River near Rome.

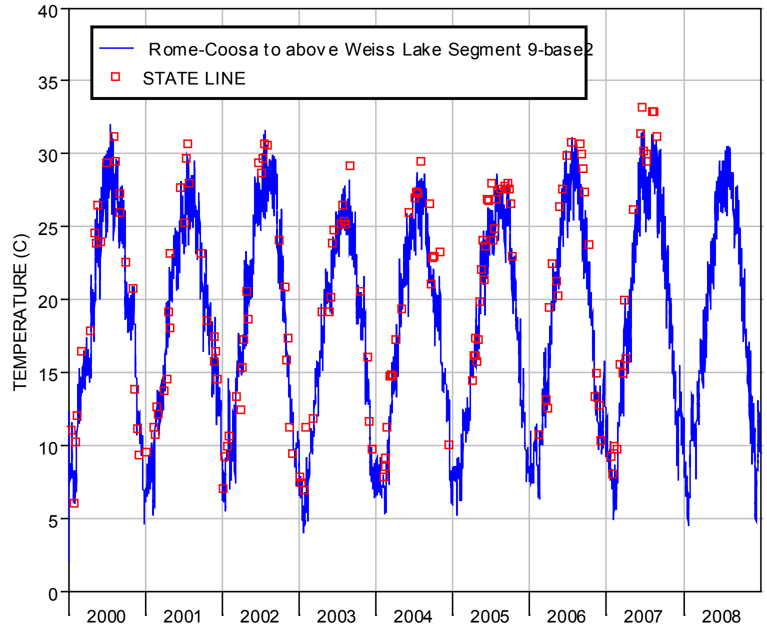


Figure 3.44 Time series of computed and observed temperature in Coosa River above State Line.

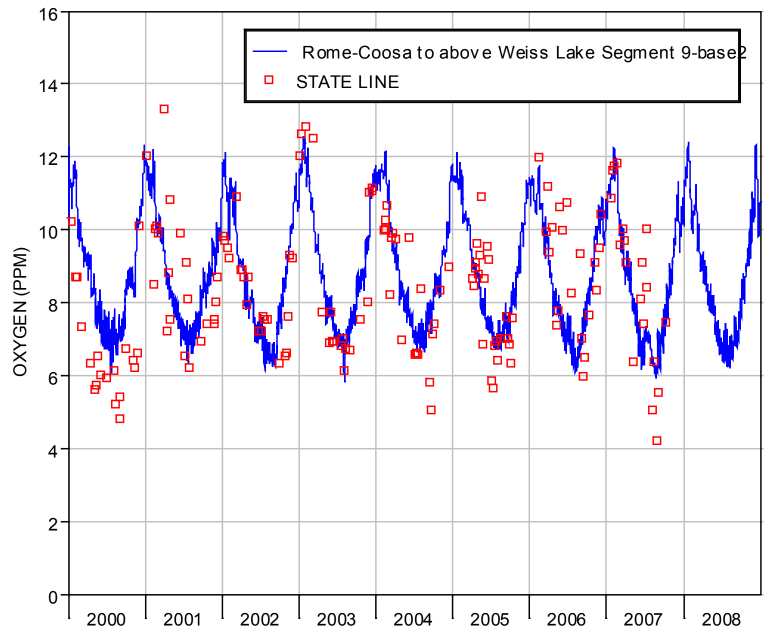


Figure 3.45 Time series of computed and observed oxygen in Coosa River above State Line.

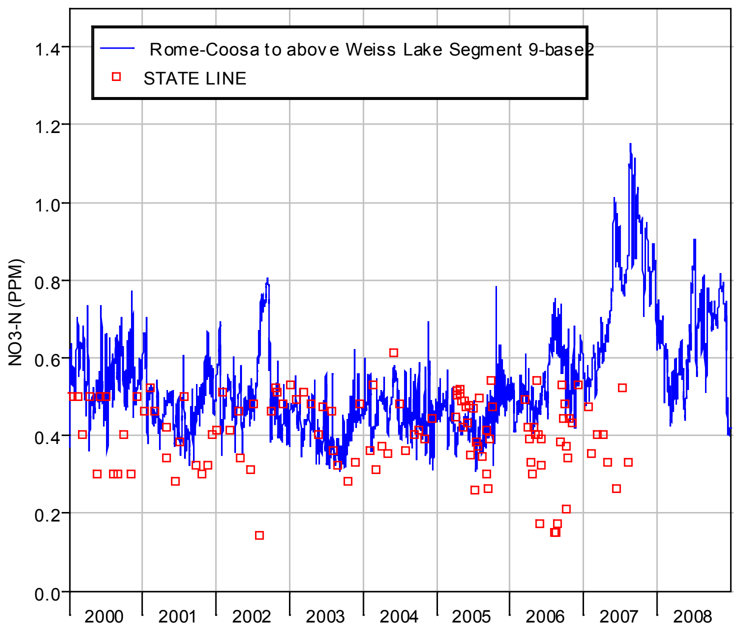


Figure 3.46 Time series of computed and observed nitrate in Coosa River above State Line.

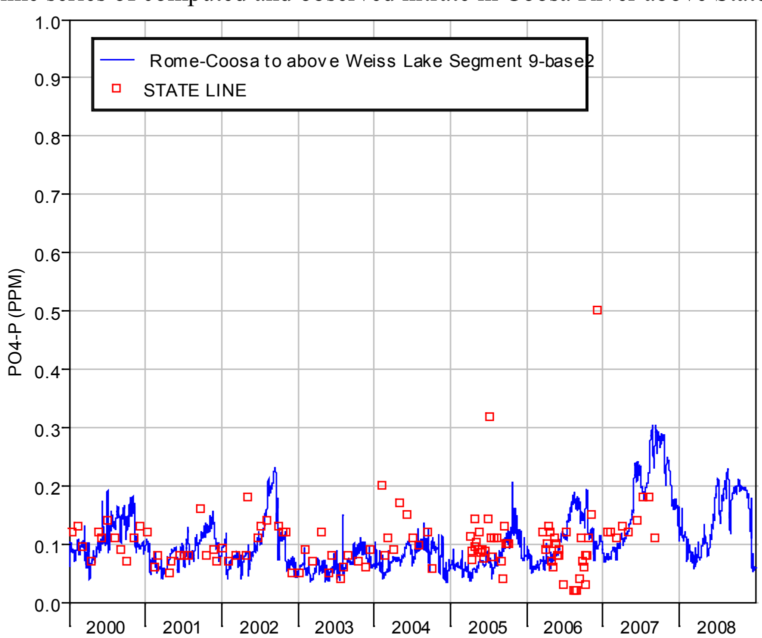


Figure 3.47 Time series of computed and observed phosphate in Coosa River above State Line.

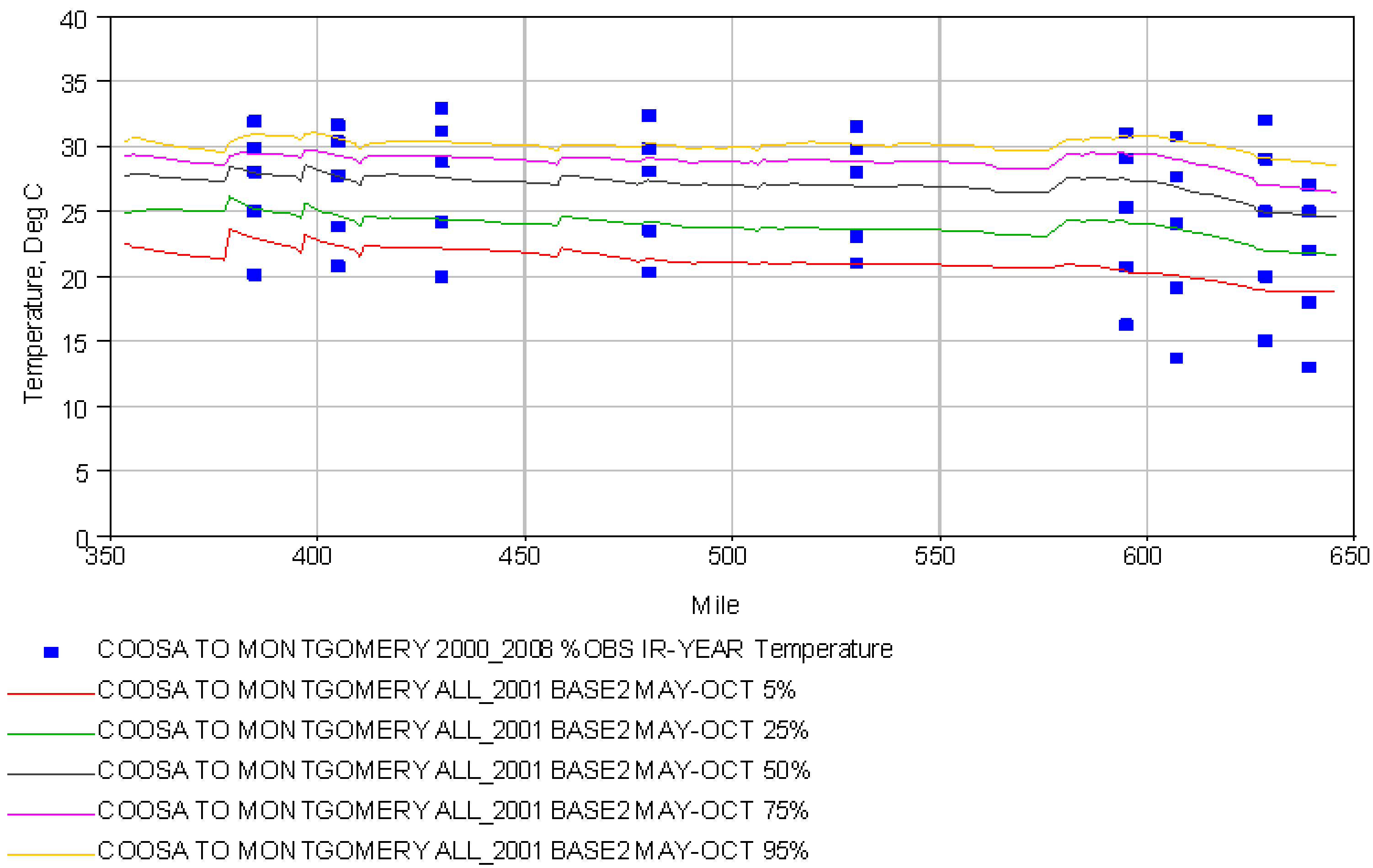


Figure 3.48 Longitudinal profile of observed and computed temperature in Coosa River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (May-October) values.

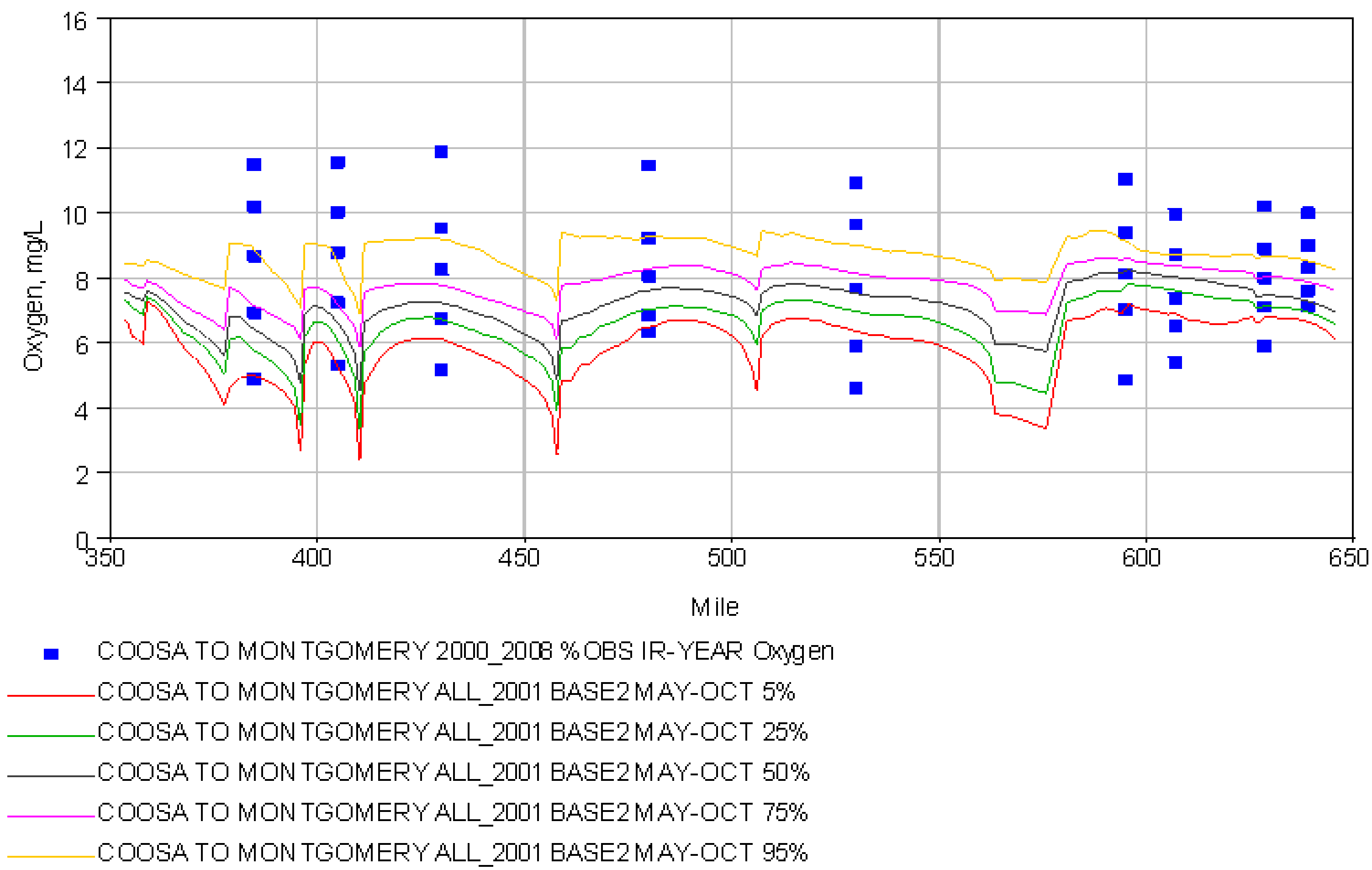


Figure 3.49 Longitudinal profile of observed and computed oxygen in Coosa River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (May-October) values.

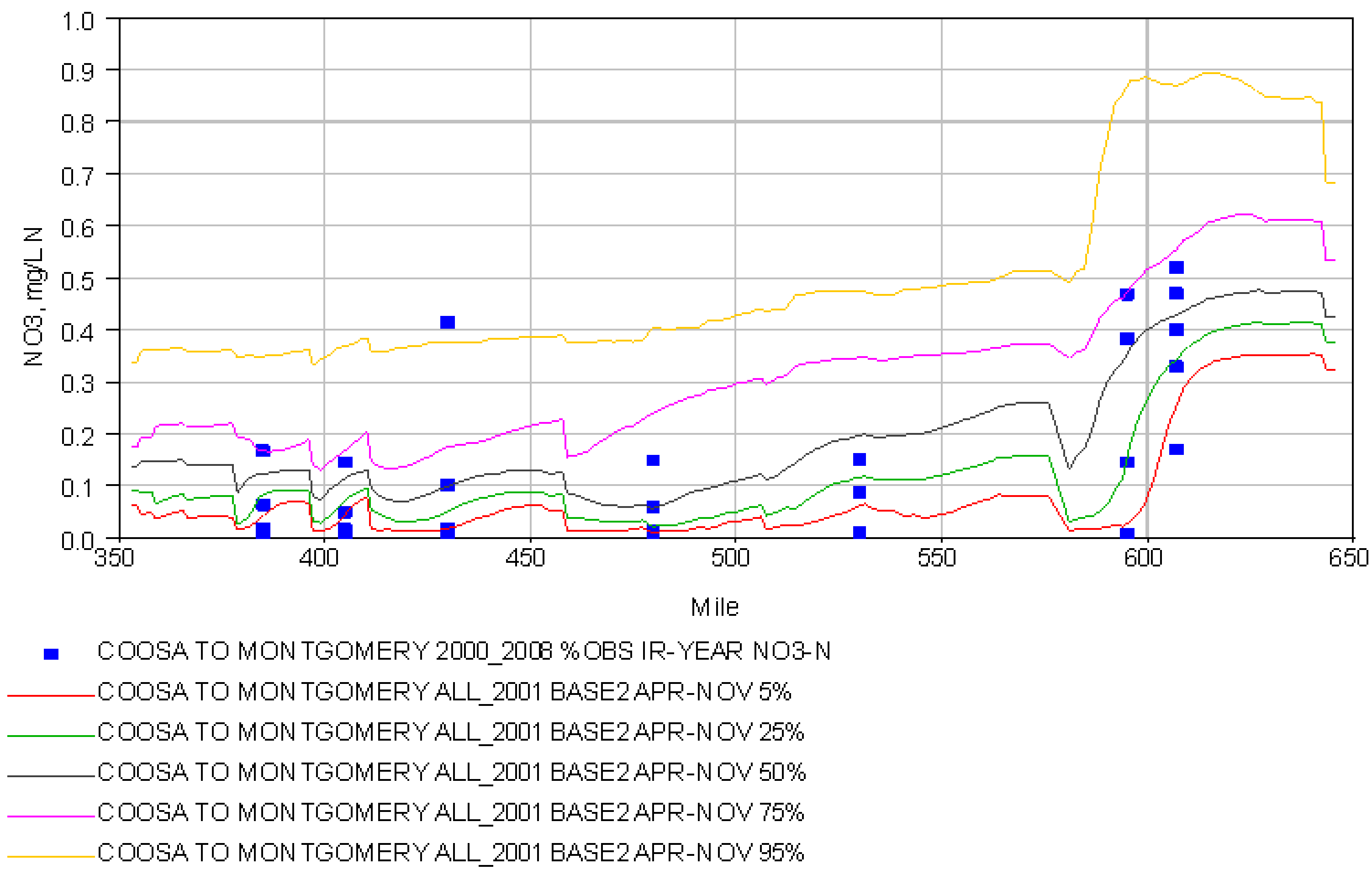


Figure 3.50 Longitudinal profile of observed and computed nitrate nitrogen in Coosa River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (April–November) values.

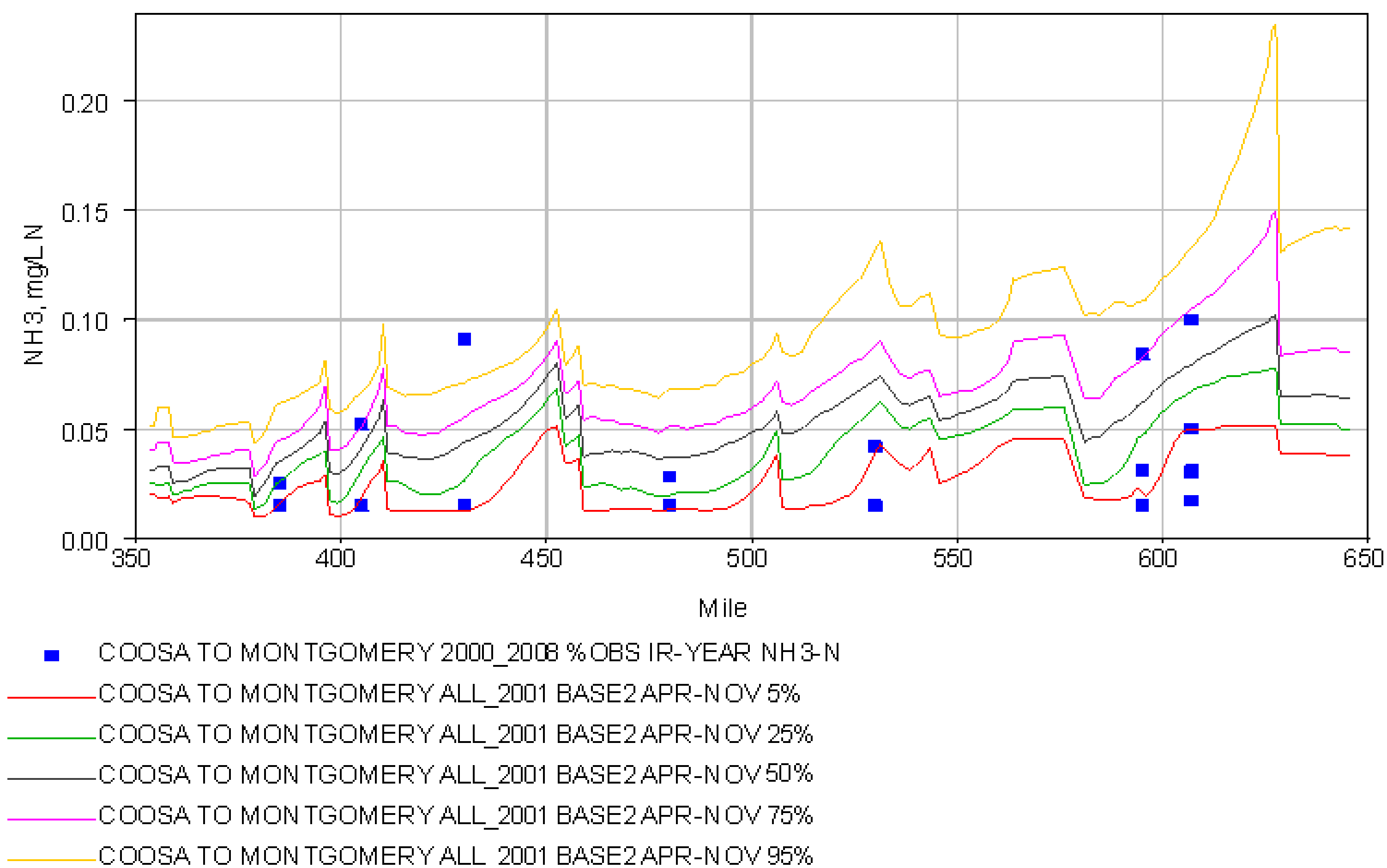


Figure 3.51 Longitudinal profile of observed and computed ammonia nitrogen in Coosa River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (April–November) values.

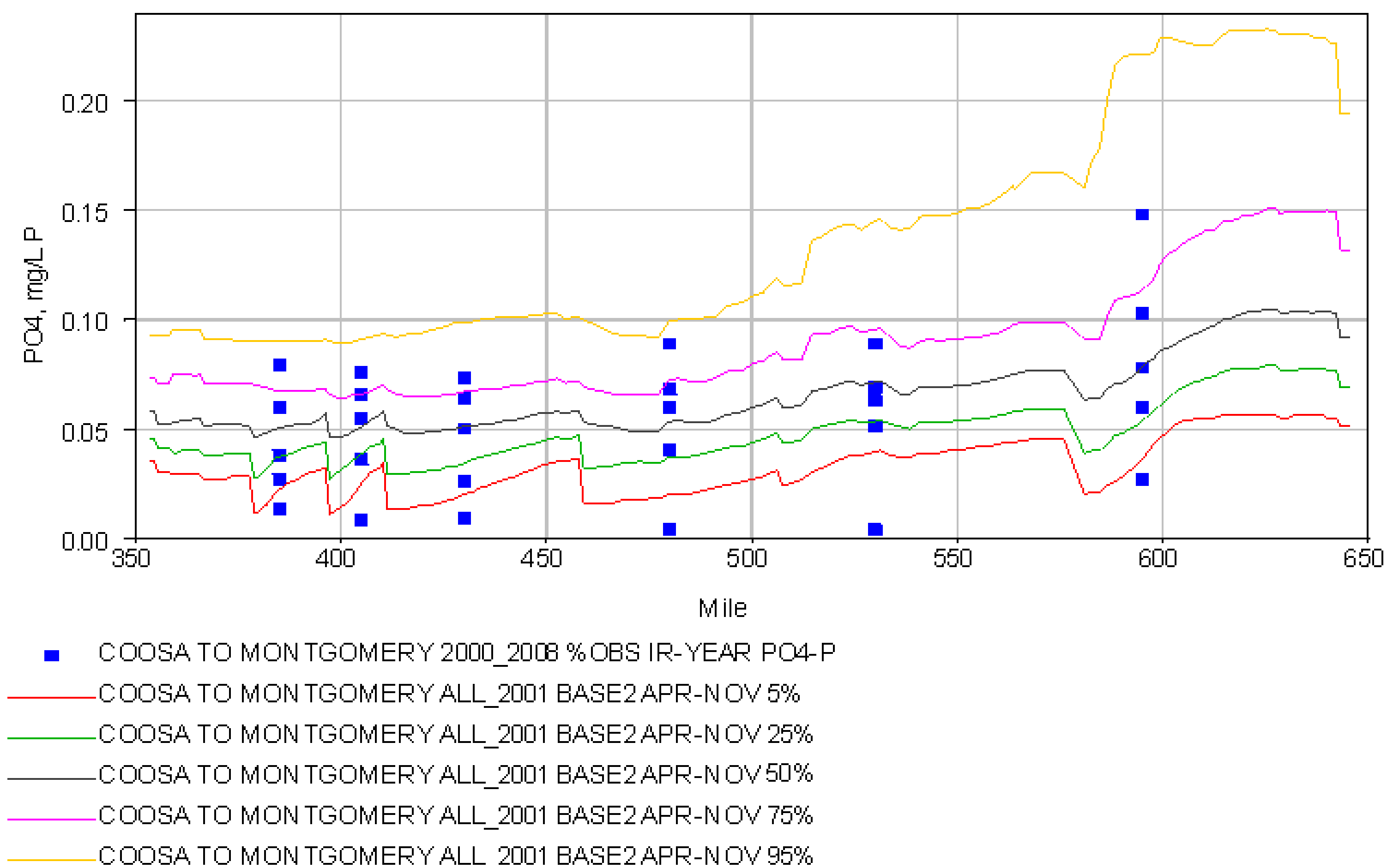


Figure 3.52 Longitudinal profile of observed and computed phosphate phosphorus in Coosa River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (April–November) values.

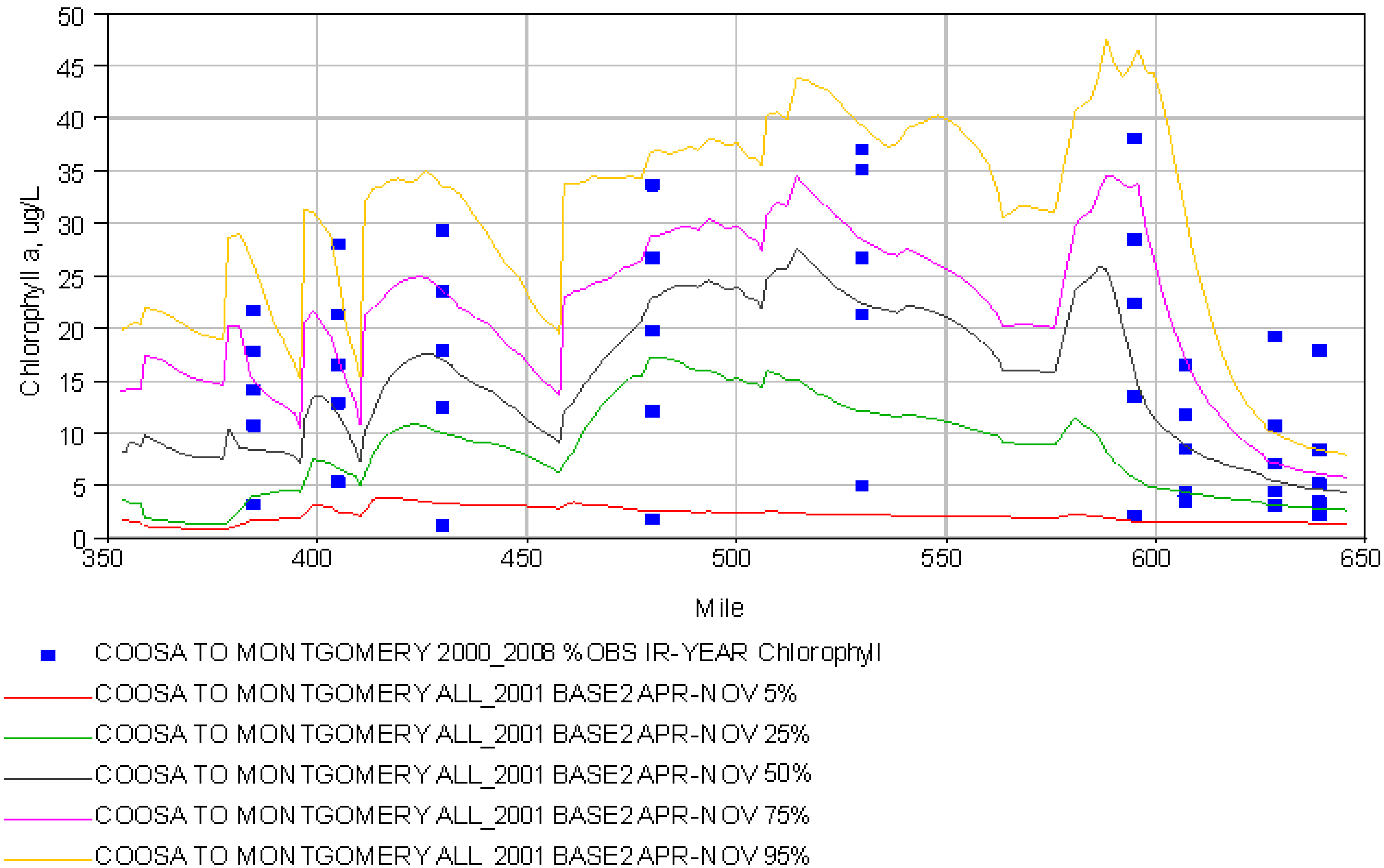


Figure 3.53 Longitudinal profile of observed and computed Chlorophyll *a* in Coosa River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (April–November) values.

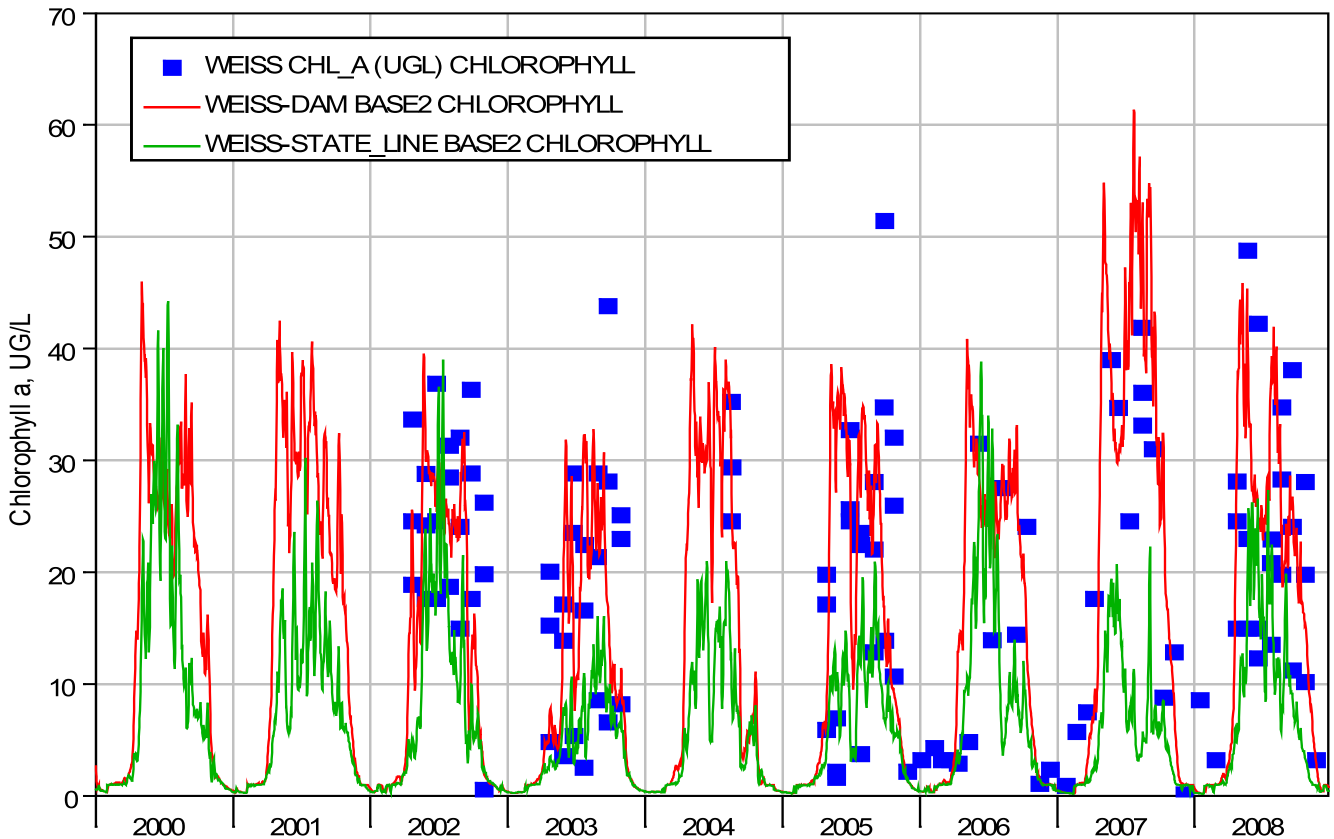


Figure 3.54 Observed and computed Chlorophyll *a* in Weiss reservoir.

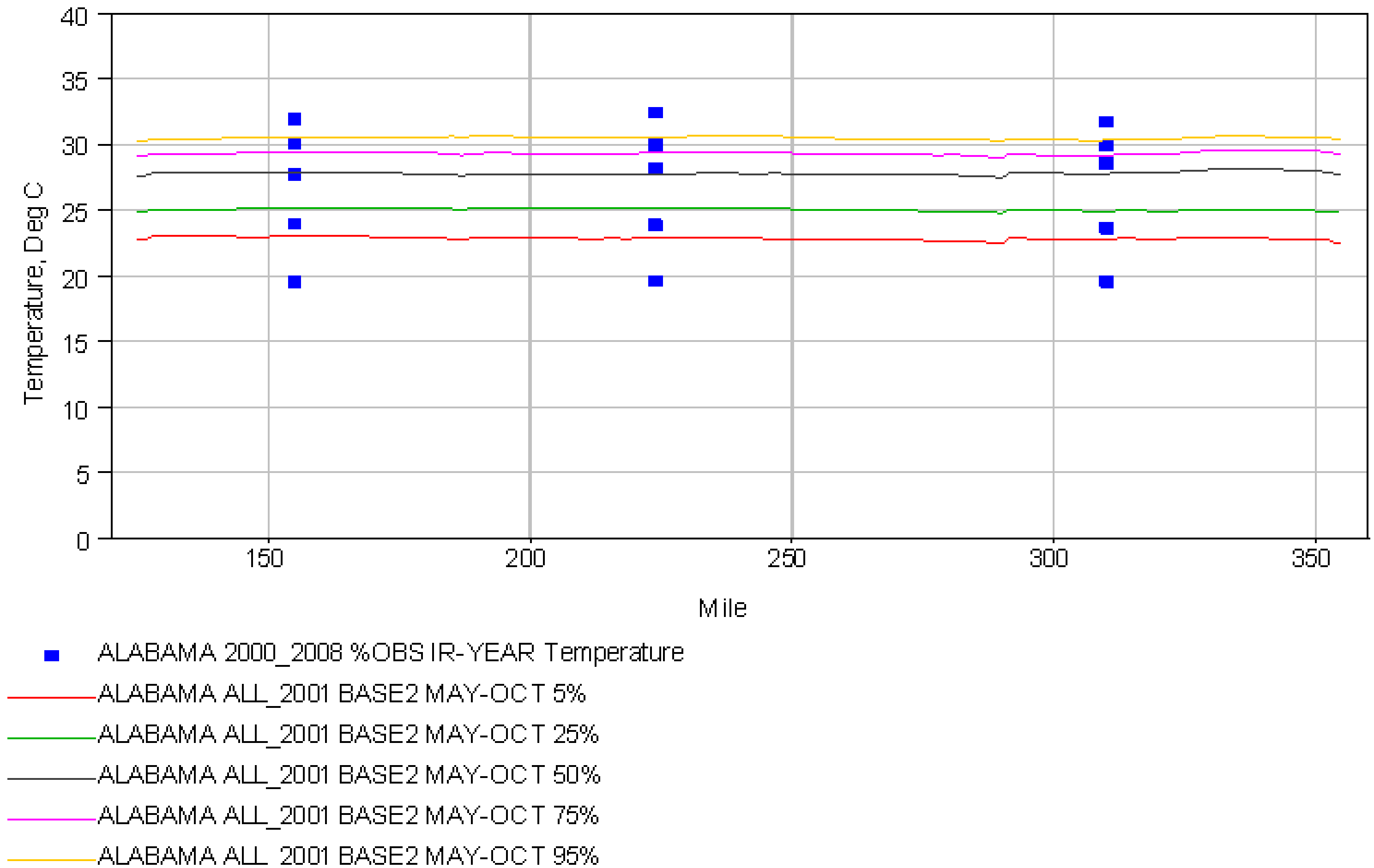


Figure 3.55 Longitudinal profile of observed and computed temperature in Alabama River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (May - October) values.

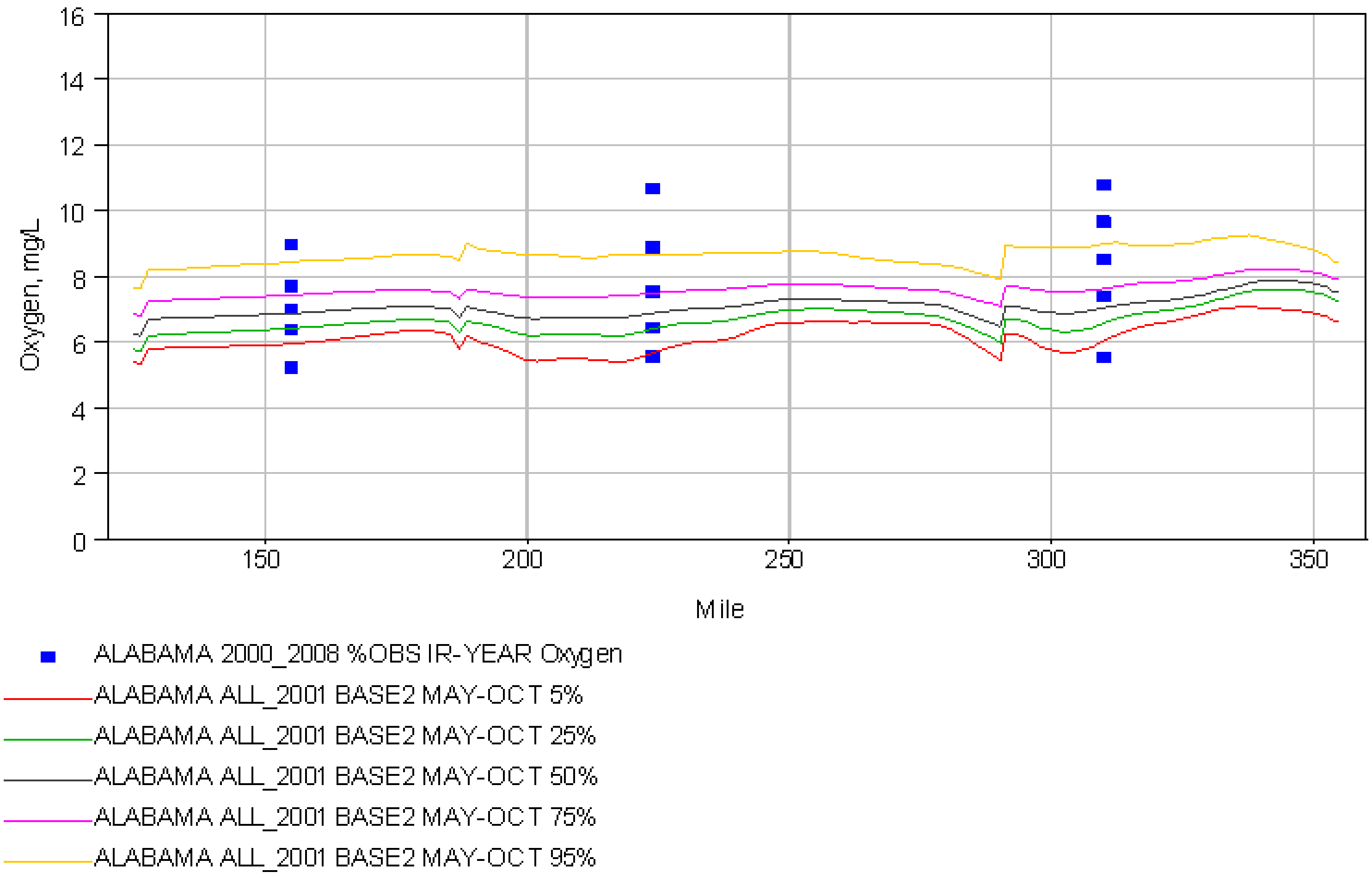


Figure 3.56 Longitudinal profile of observed and computed oxygen in Alabama River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (May - October) values.

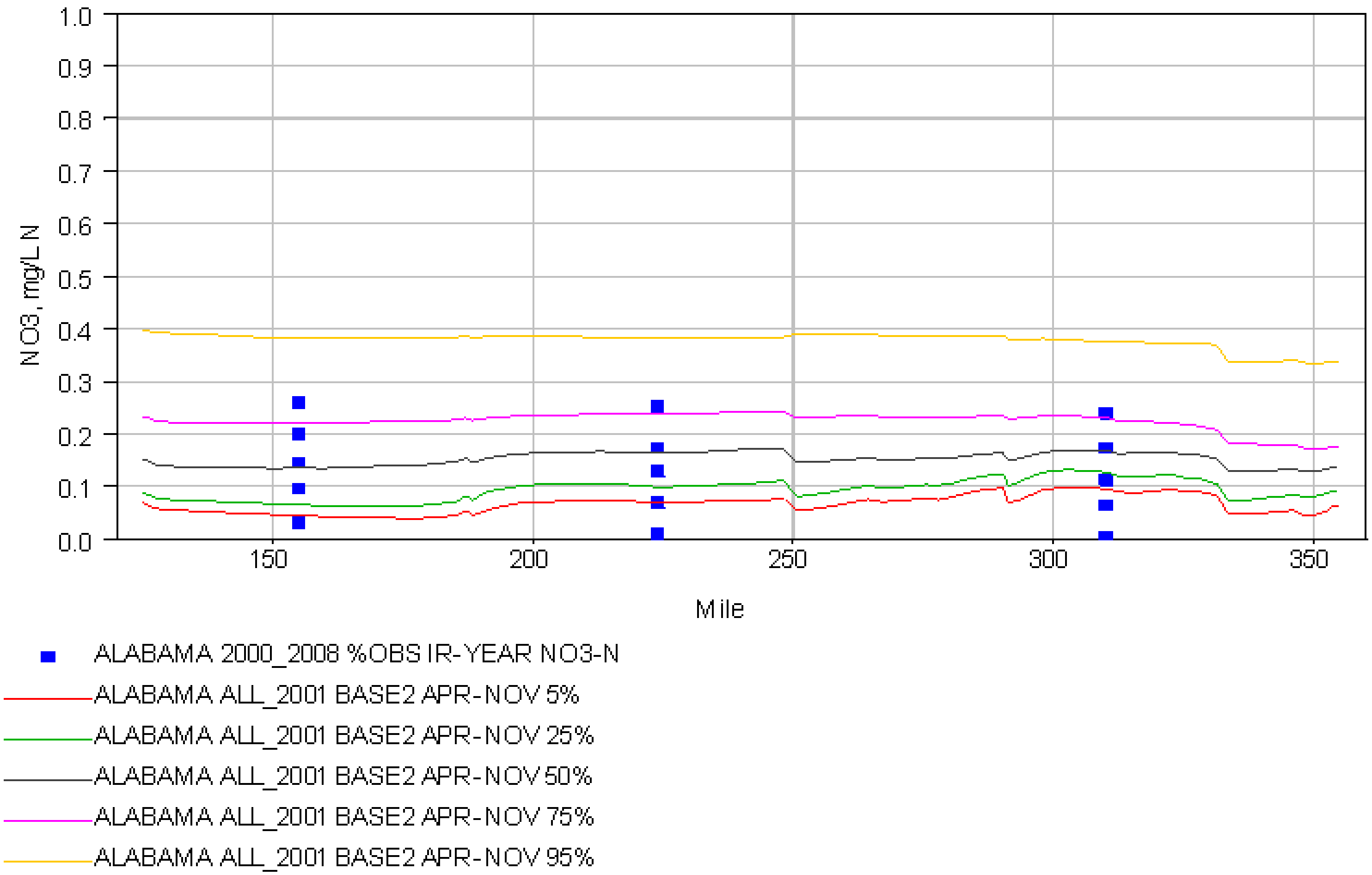


Figure 3.57 Longitudinal profile of observed and computed nitrate nitrogen in Alabama River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (April–November) values.

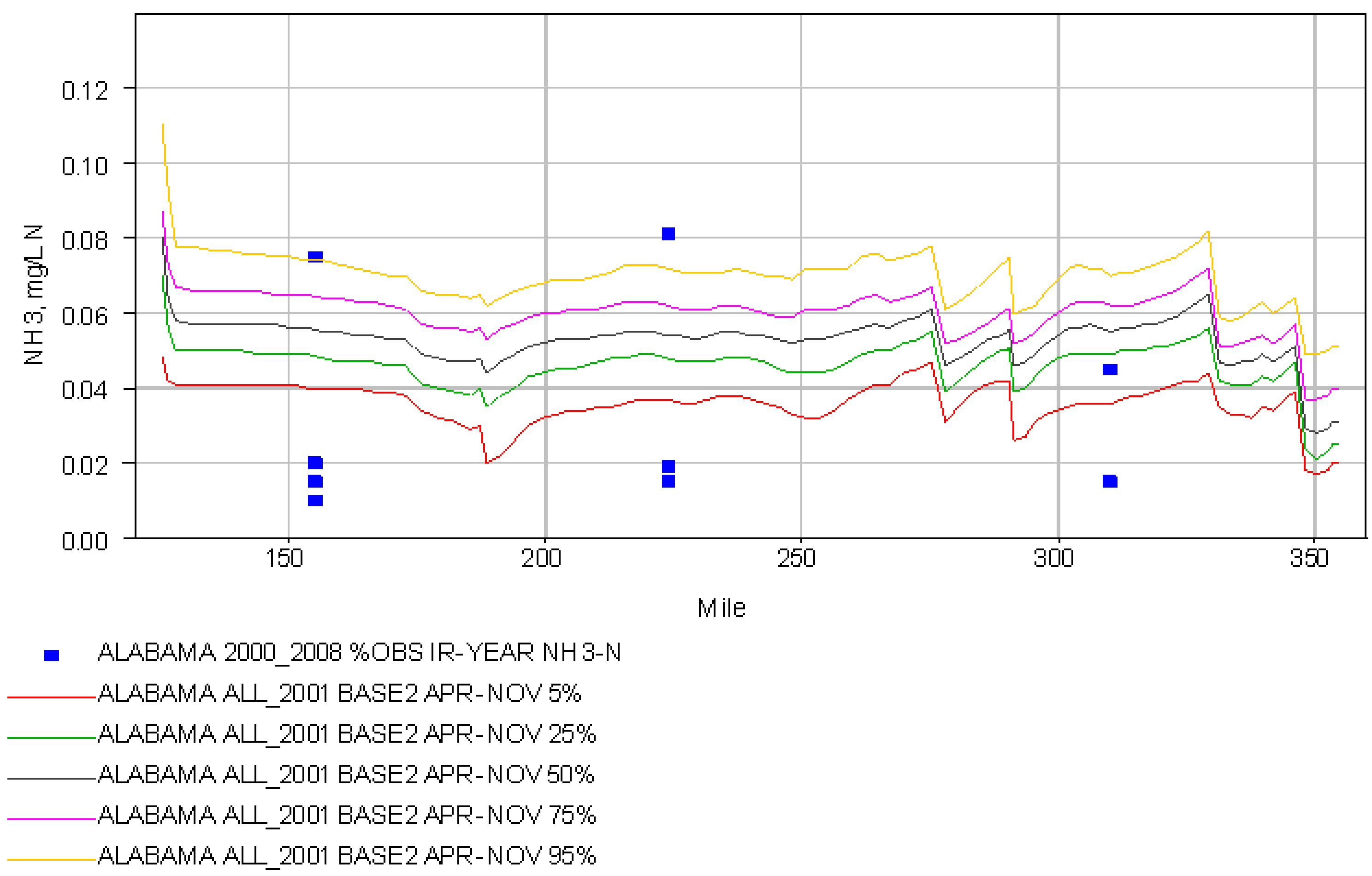


Figure 3.58 Longitudinal profile of observed and computed ammonia nitrogen in Alabama River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (April–November) values.

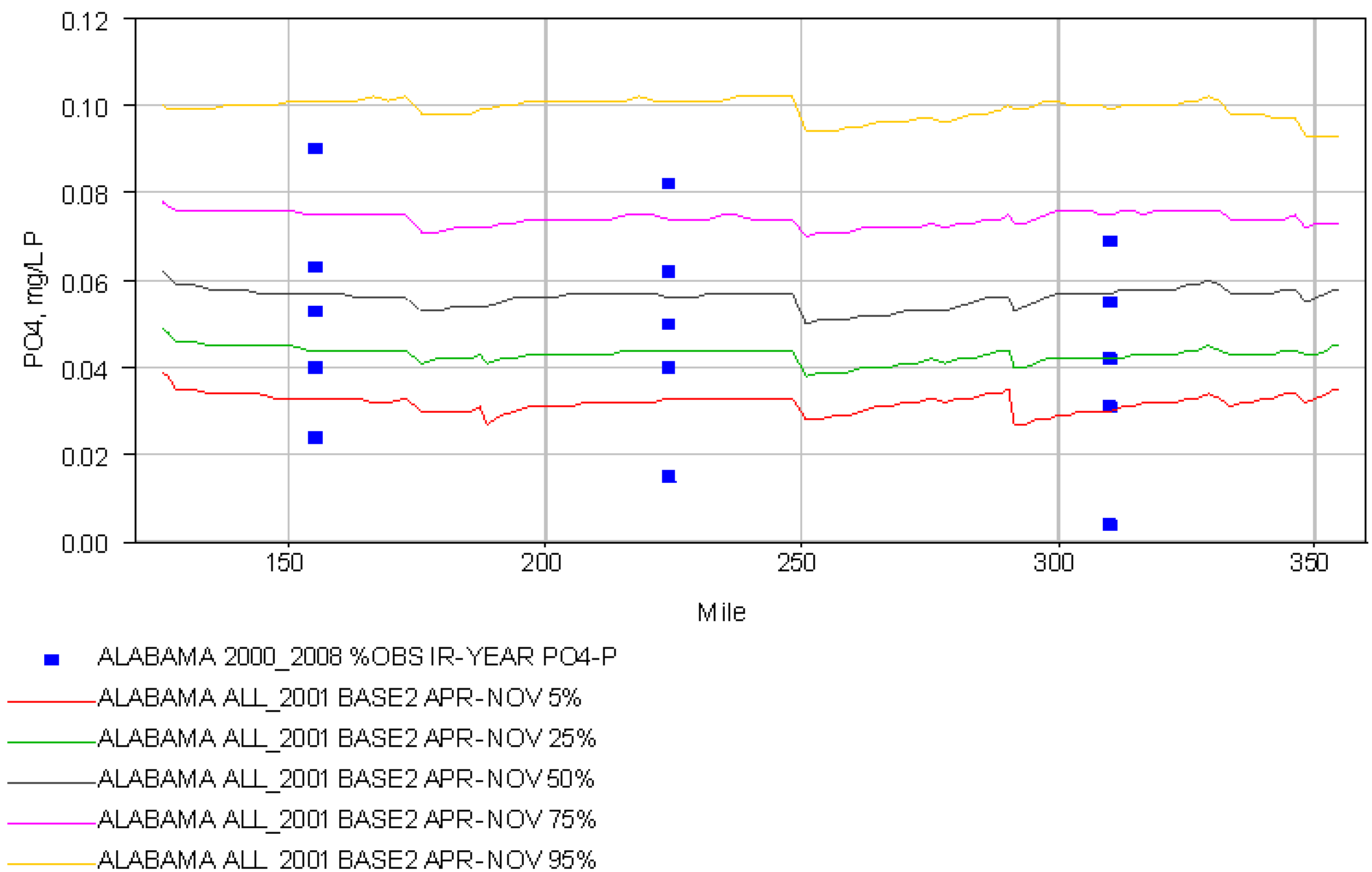


Figure 3.59 Longitudinal profile of observed and computed phosphate phosphorus in Alabama River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (April–November) values.

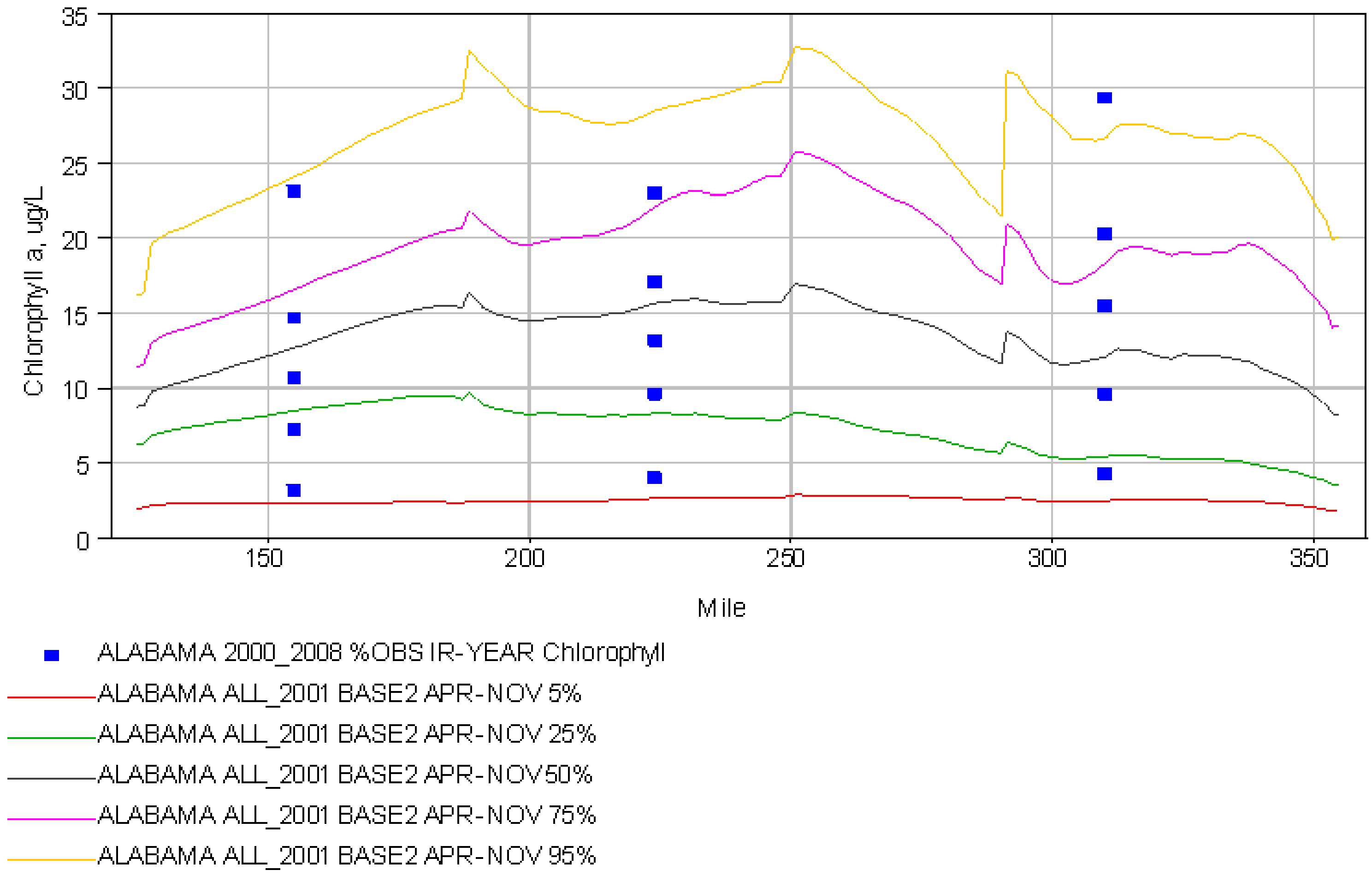


Figure 3.60 Longitudinal profile of observed and computed Chlorophyll *a* in Alabama River. All data are plotted as 5%, 25%, 50% (median), 75% and 95% occurrence of growing season (April–November) values.

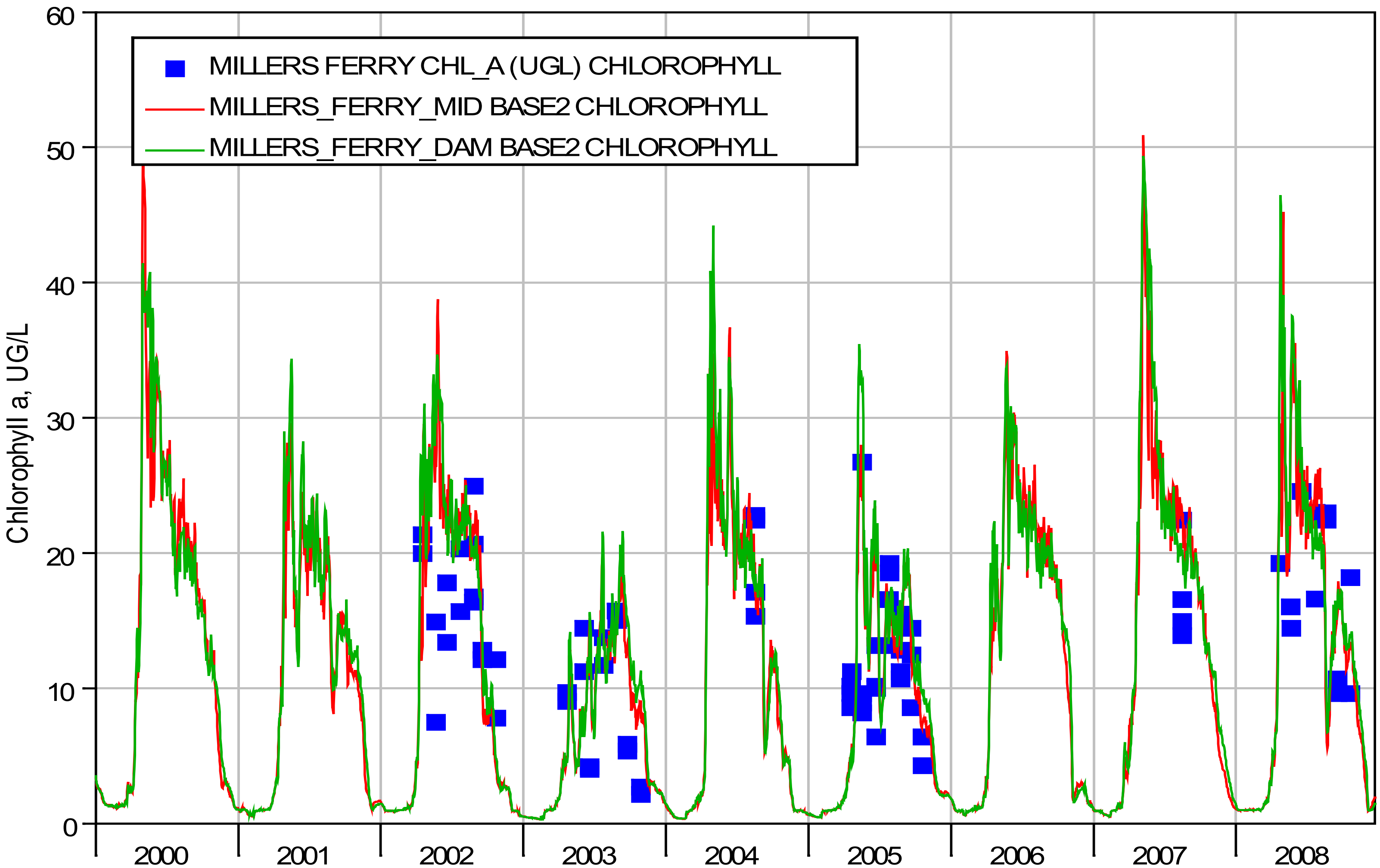


Figure 3.61 Observed and computed Chlorophyll *a* in Alabama River at Millers Ferry.

4 RESULTS

HEC-5Q was used to simulate water quality in the ACT basin for baseline and various alternative reservoir operation scenarios. These results consist of time series, cumulative occurrence profiles, and longitudinal river profiles of occurrence of each water quality parameter. The details of these results are outlined below, and only representative plots are shown. These plots and files were provided and used by the EIS PDT to analyze the water quality differences between alternatives. The DSS results were processed to produce tables in the main body of the EIS. These plots and DSS files are available upon request.. The model output in the DSS files may be viewed in tabular form or plotted using HEC-DSSVue.

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

Time series were output for several model locations along the Alabama, Coosa, Tallapoosa, Etowah, and Coosawattee Rivers. These locations are shown in Table 4.1. The time series were used to compute the cumulative occurrence of each water quality parameter shown in Table 4.2. Then occurrence was computed for several different annual, seasonal, and weekly periods and plotted by river mile to create longitudinal occurrence profiles for each parameter. The definition of each plot type and the various computation intervals applied to derive each set of plots are detailed in the following sections.

Table 4.1 Time Series Output Locations (Upstream to Downstream)

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

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

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

Table 4.2 Water quality parameters modeled by HEC-5Q

Water Quality Parameter
• Water Temperature
• Dissolved Oxygen (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 *

*The M&I percentage is either 100 (point sources) or 0 (non-point inflows). This is the tracer for computing the percentage component of M&I origin throughout the river system.

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 plots of simulation results over the 2001-2008 period were created for each location (Table 4.1) along the Alabama, Coosa, Tallapoosa, Etowah, and Coosawattee Rivers. Each of the water quality parameters shown in Table 4.2 was plotted. The full set of plots was provided to Mobile District via FTP transfer for analysis.

Representative plots of Chlorophyll *a*, dissolved oxygen, and temperature are shown in Figure 4.1–Figure 4.6 at two sample stations from both the Coosa and Alabama Rivers. The two sample stations for the Coosa River are Weiss – State Line and Jordan – Mid-lake. The two sample stations for the Alabama River are Above R.F. Henry and Claiborne – Mid-lake.

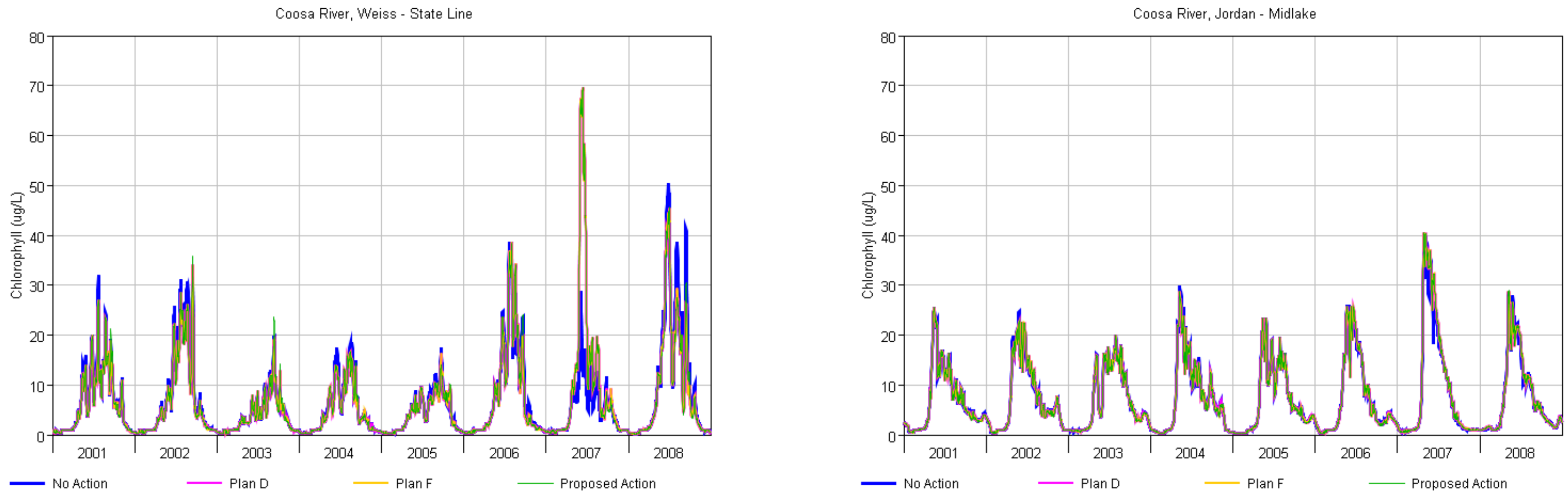


Figure 4.1 Time series of Chlorophyll *a*, computed for the Coosa River at two stations, Weiss – State Line and Jordan – Mid-lake, during the 2001–2008 modeling period.

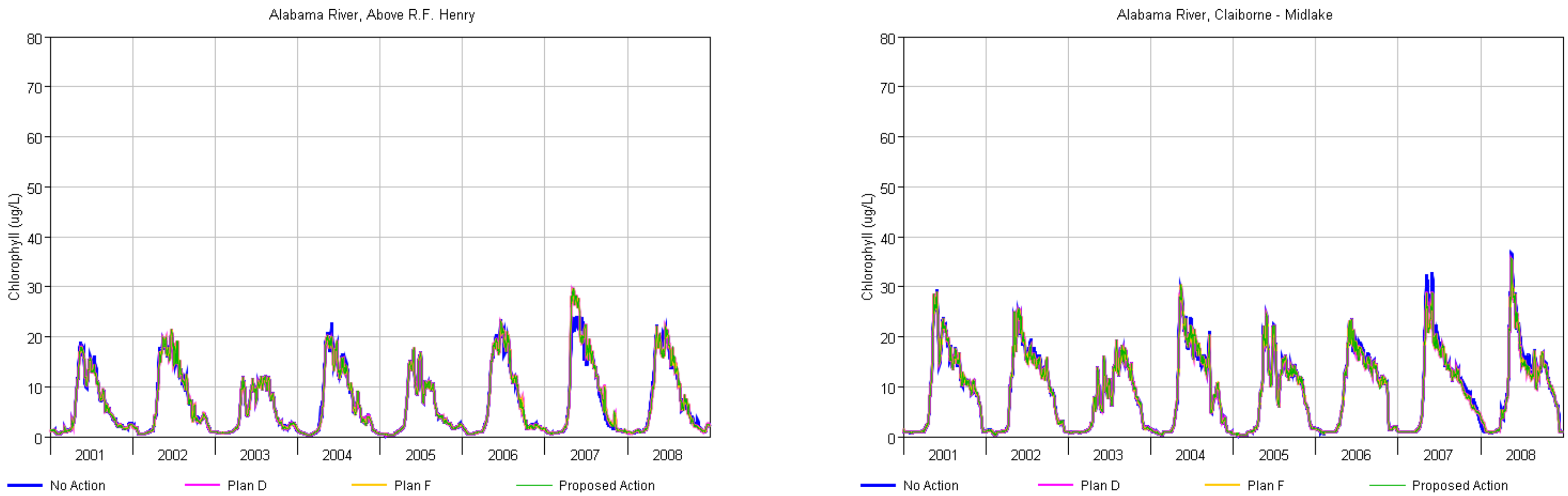


Figure 4.2 Time series of Chlorophyll *a*, computed for the Alabama River at two stations, Above R.F. Henry and Claiborne - Mid-lake, during the 2001–2008 modeling period.

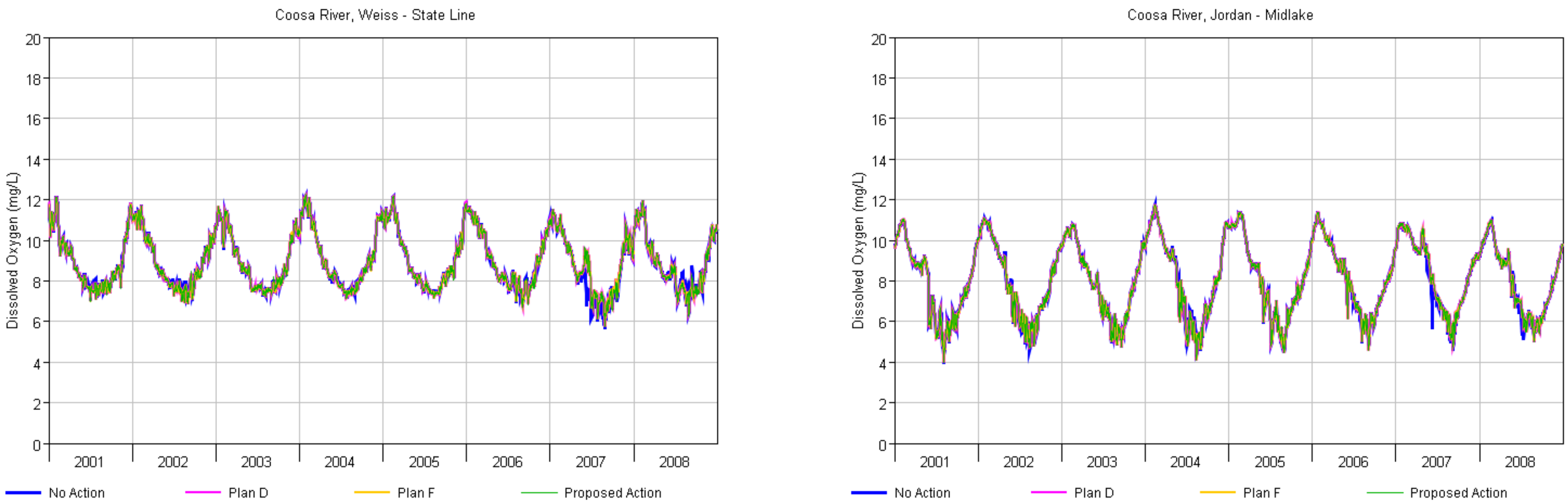
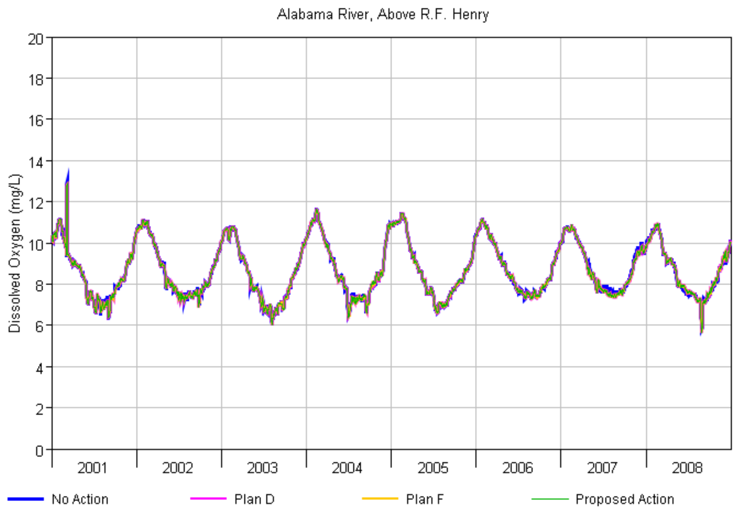


Figure 4.3 Time series of dissolved oxygen, computed for the Coosa River at two stations, Weiss – State Line and Jordan – Mid-lake, during the 2001–2008 modeling period.



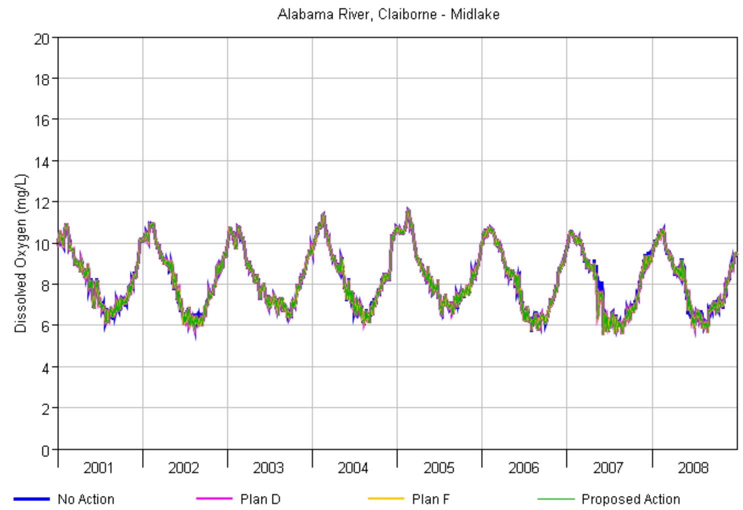
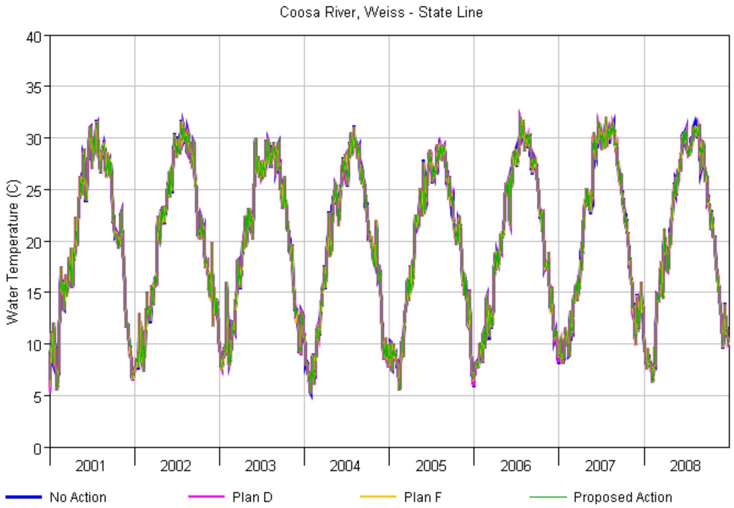


Figure 4.4 Time series of dissolved oxygen computed for the Alabama River at two stations, Above R.F. Henry and Claiborne - Mid-lake, during the 2001–2008 modeling period.



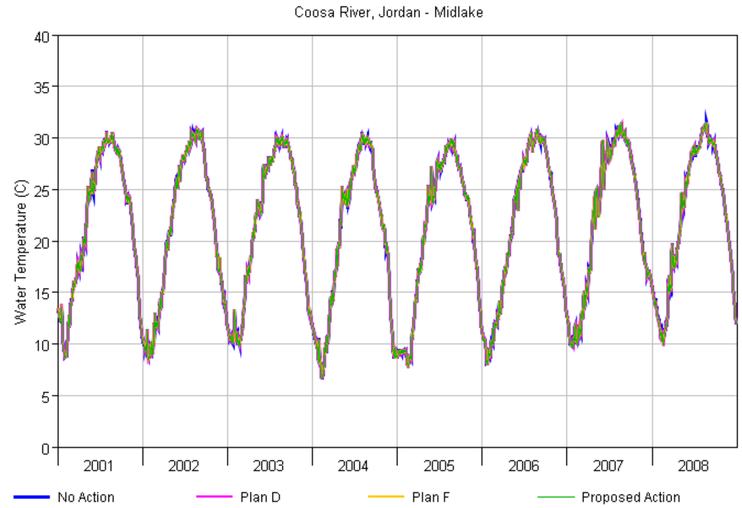


Figure 4.5 Time series of water temperature (°C), computed for the Coosa River at two stations, Weiss – State Line and Jordan – Mid-lake, during the 2001–2008 modeling period.

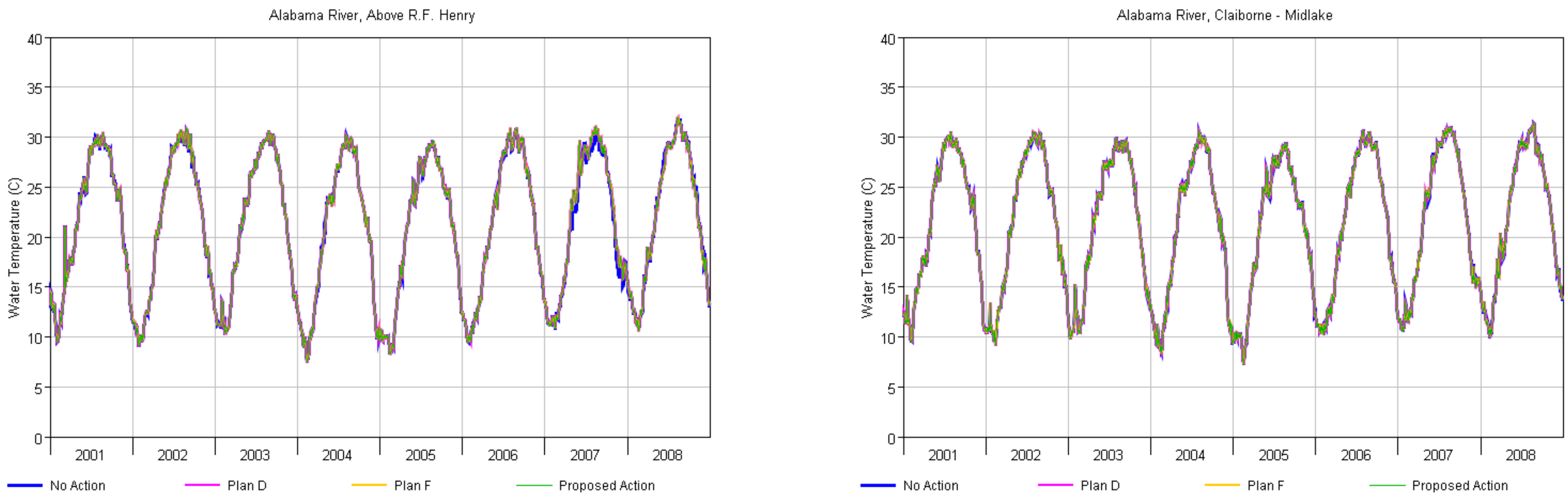


Figure 4.6 Time series of water temperature (^{o}C), computed for the Alabama River at two stations, Above R.F. Henry and Claiborne - Mid-lake, during the 2001–2008 modeling period.

4.2 CUMULATIVE OCCURRENCE

The Cumulative percentage of occurrence of each water quality parameter shown in Table 4.2 was computed for the 2001–2008 modeling period using the time series from each time series location shown in Table 4.1 along the Alabama, Coosa, Tallapoosa, Etowah, and Coosawattee Rivers. The cumulative occurrence plots show the percentage of time each parameter was lower than a certain concentration level. For example, if a dissolved oxygen plot shows a 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.

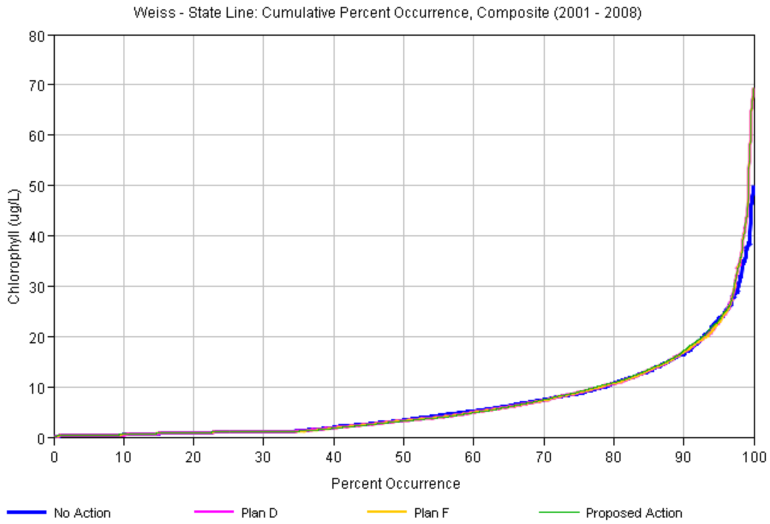
The dissolved oxygen plots indicate the DO standard specified by the USFWS. The USFWS DO standard for fish habitat in pristine water bodies is 6 mg/L, while the USFWS standard for the rest of the ACT system is 5 mg/L. The point where the cumulative occurrence curve intersects the top of the zone shows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

Representative plots of Chlorophyll *a*, dissolved oxygen, and temperature are shown in Figure 4.7 – Figure 4.12 at two sample stations from both the Coosa and Alabama Rivers. The two sample stations for the Coosa River are Weiss – State Line and Jordan – Mid-lake. The two sample stations for the Alabama River are Above R.F. Henry and Claiborne – Mid-lake.

All of the plots in Figure 4.7 – Figure 4.12 represent the cumulative occurrence over the 2001–2008 modeling period. Figure 4.7 – Figure 4.8 show the cumulative occurrence of Chlorophyll *a* at Weiss – State Line and Jordan – Mid-lake along the Coosa River and at Above R.F. Henry and Claiborne – Mid-lake along the Alabama River.

Figure 4.9 and Figure 4.10 show the cumulative occurrence for DO at Weiss – State Line and Jordan – Mid-lake along the Coosa River and at Above R.F. Henry and Claiborne – Mid-lake along the Alabama River. The zone where this standard would be violated is indicated on each figure. The DO plot of Jordan at Mid-lake shows that the USFWS DO standard is violated less than 2% of the time, according to HEC-5Q model predictions. The other plots show that HEC-5Q model predicts no violation of the DO standard.

Finally, Figure 4.11– Figure 4.12 show the cumulative occurrence for water temperature over the 2001–2008 modeling period.



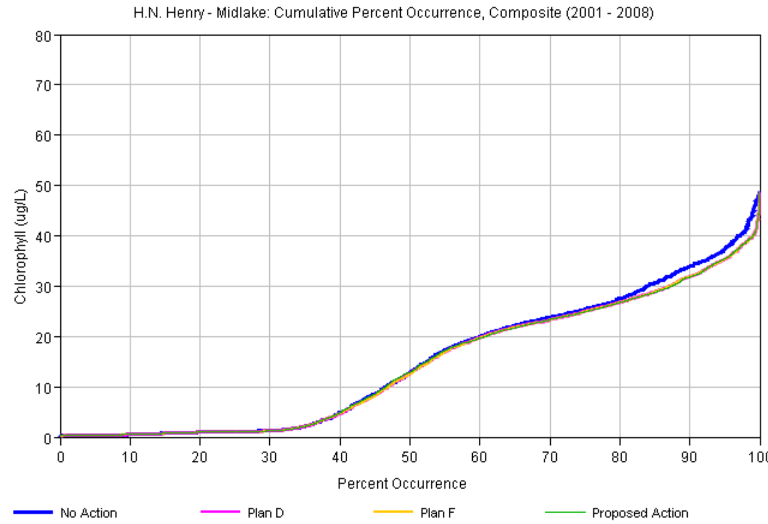


Figure 4.7 Cumulative occurrence of Chlorophyll *a*, computed for the Coosa River at two stations, Weiss – State Line and Jordan – Mid-lake, during the 2001–2008 modeling period.

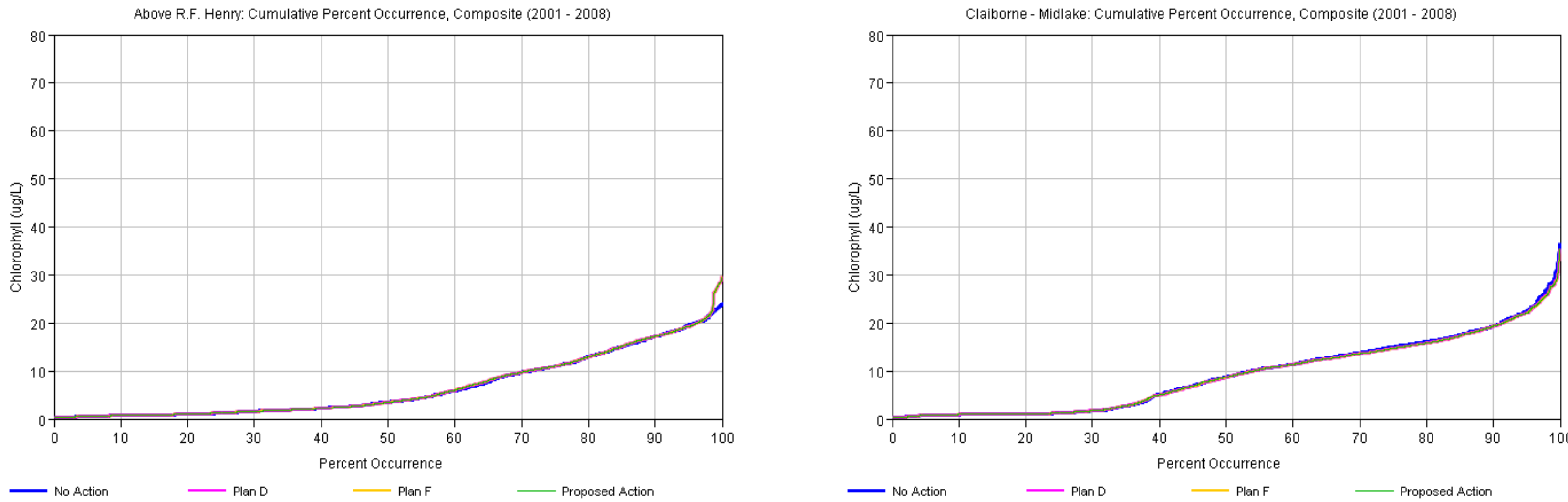
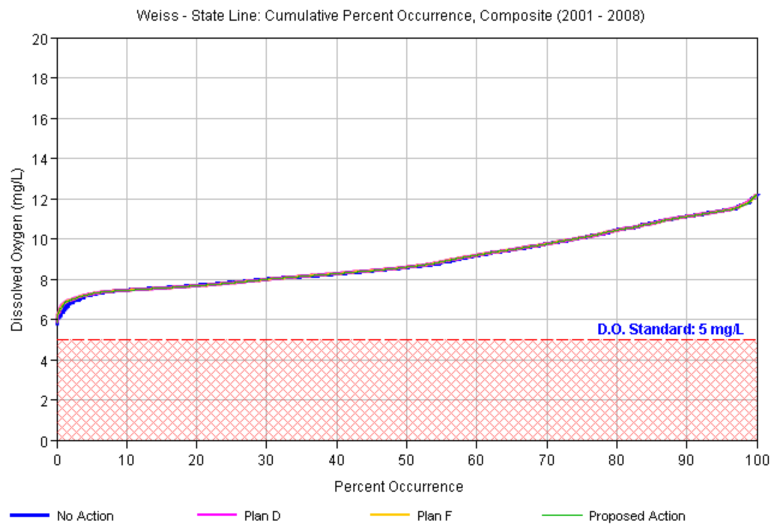


Figure 4.8 Cumulative occurrence of Chlorophyll *a*, computed for the Alabama River at two stations, Above R.F. Henry and Claiborne - Mid-lake, during the 2001–2008 modeling period.



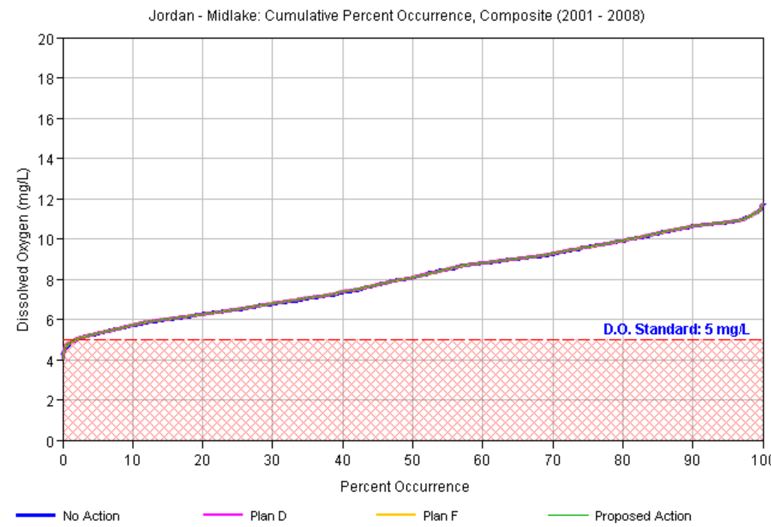
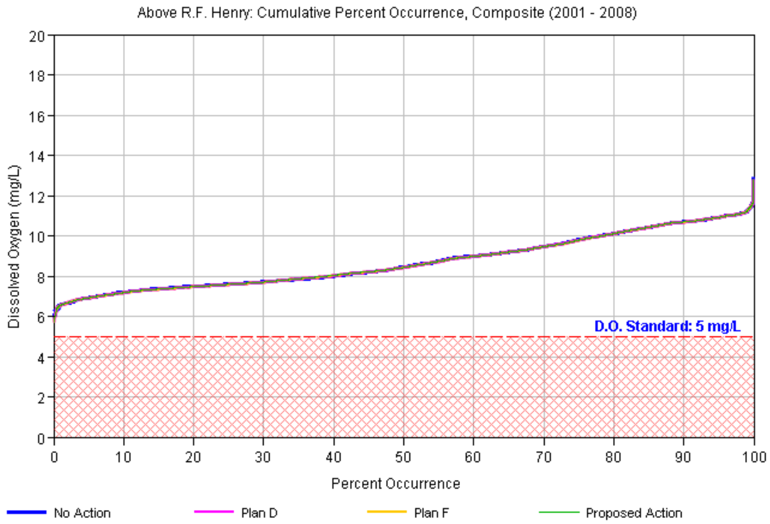


Figure 4.9 Cumulative occurrence of dissolved oxygen, computed for the Coosa River at two stations, Weiss – State Line and Jordan – Mid-lake, during the 2001–2008 modeling period. The USFWS standard of 5 mg/L is denoted by the red shaded zone.



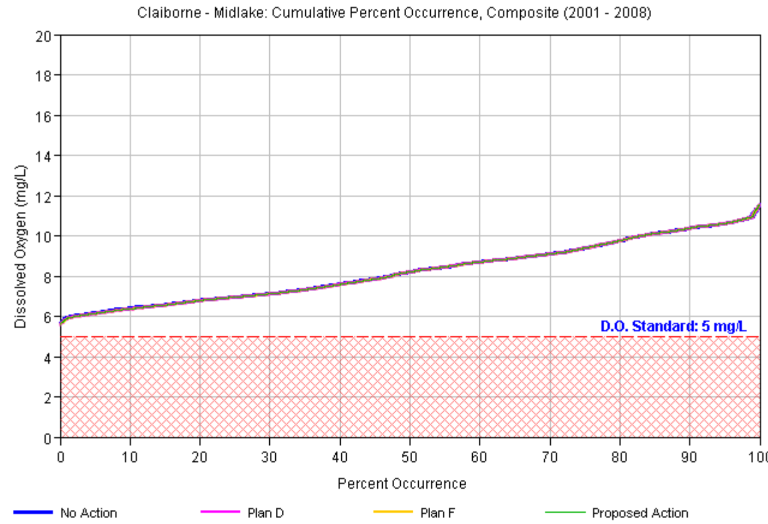


Figure 4.10 Cumulative occurrence of dissolved oxygen, computed for the Alabama River at two stations, Above R.F. Henry and Claiborne - Mid-lake, during the 2001–2008 modeling period. The USFWS standard of 5 mg/L is denoted by the red shaded zone.

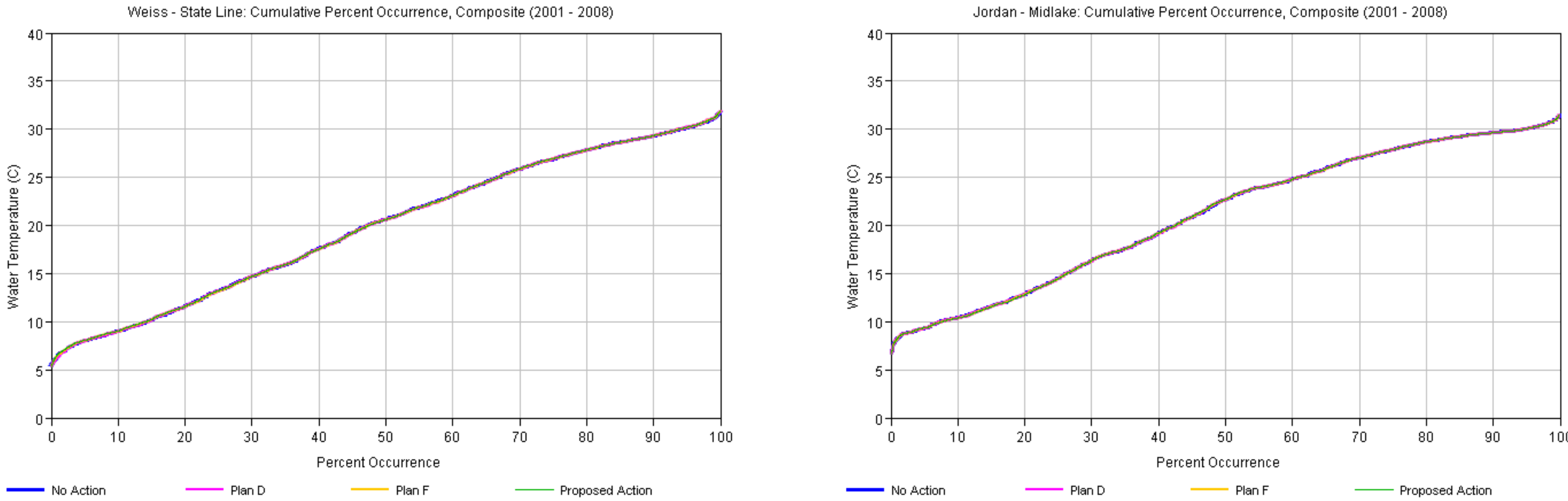
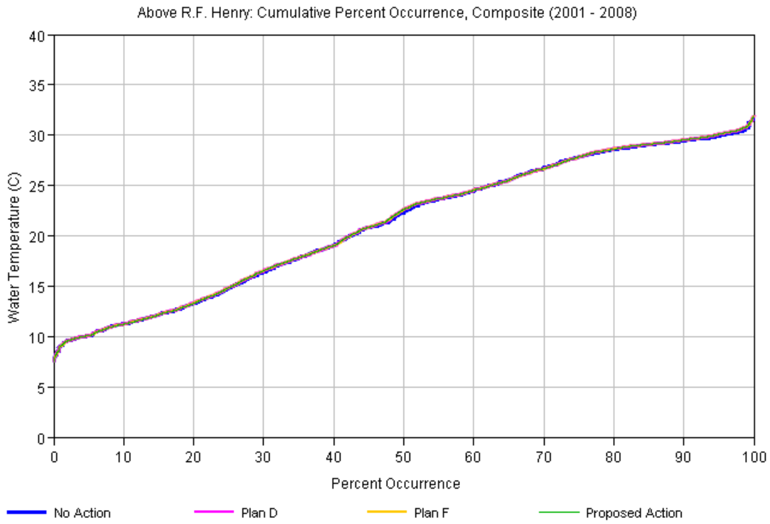


Figure 4.11 Cumulative occurrence of water temperature (^{o}C), computed for the Coosa River at two stations, Weiss – State Line and Jordan – Mid-lake, during the 2001–2008 modeling period.



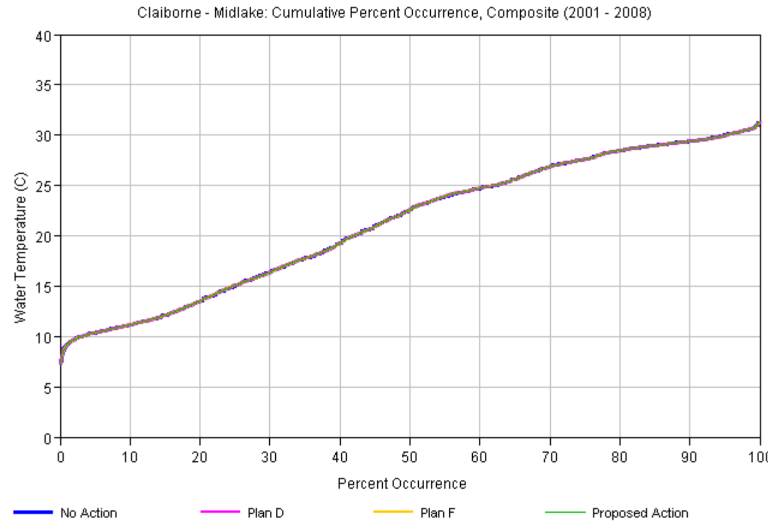


Figure 4.12 Cumulative occurrence of water temperature (^{o}C), computed for the Alabama River at two stations, Above R.F. Henry and Claiborne - Mid-lake, during the 2001–2008 modeling period.

4.3 River Profiles

Cumulative occurrence levels of each water quality parameter shown in Table 4.2 were computed for each river mile along the rivers of the ACT watershed 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 concentration in the ACT basin.

4.3.1 Computation

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

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

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

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

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

3. USFWS: May–October

Occurrence profiles were computed for each of these growing seasons.

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

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

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

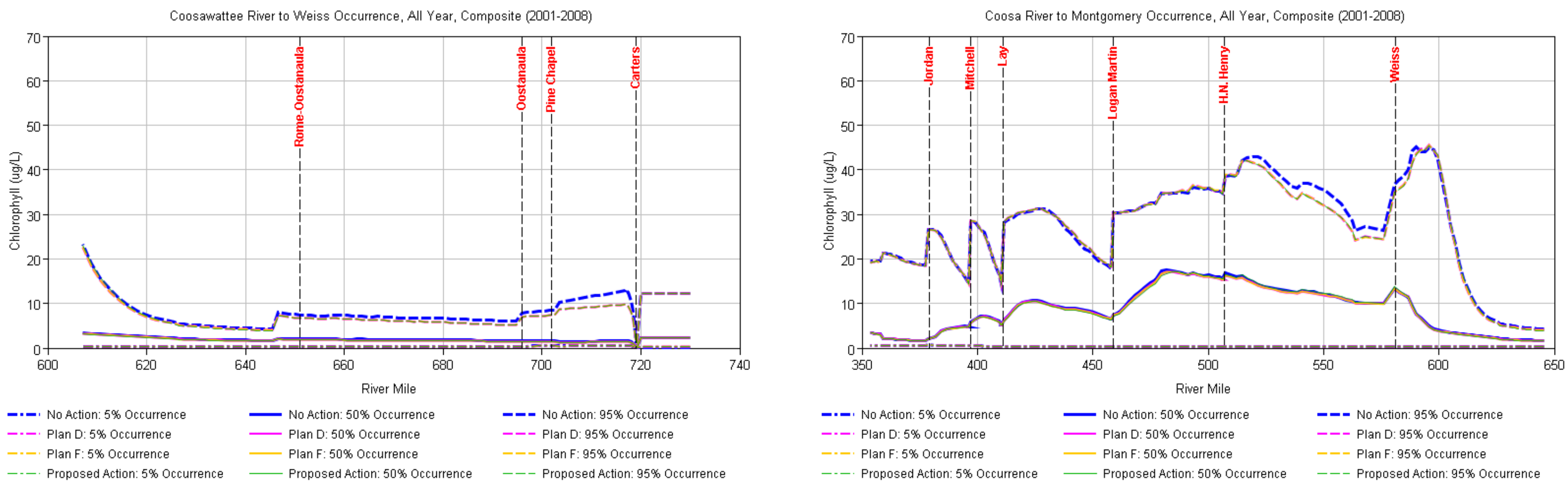


Figure 4.13 Longitudinal occurrence profiles of Chlorophyll *a*, computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001–2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

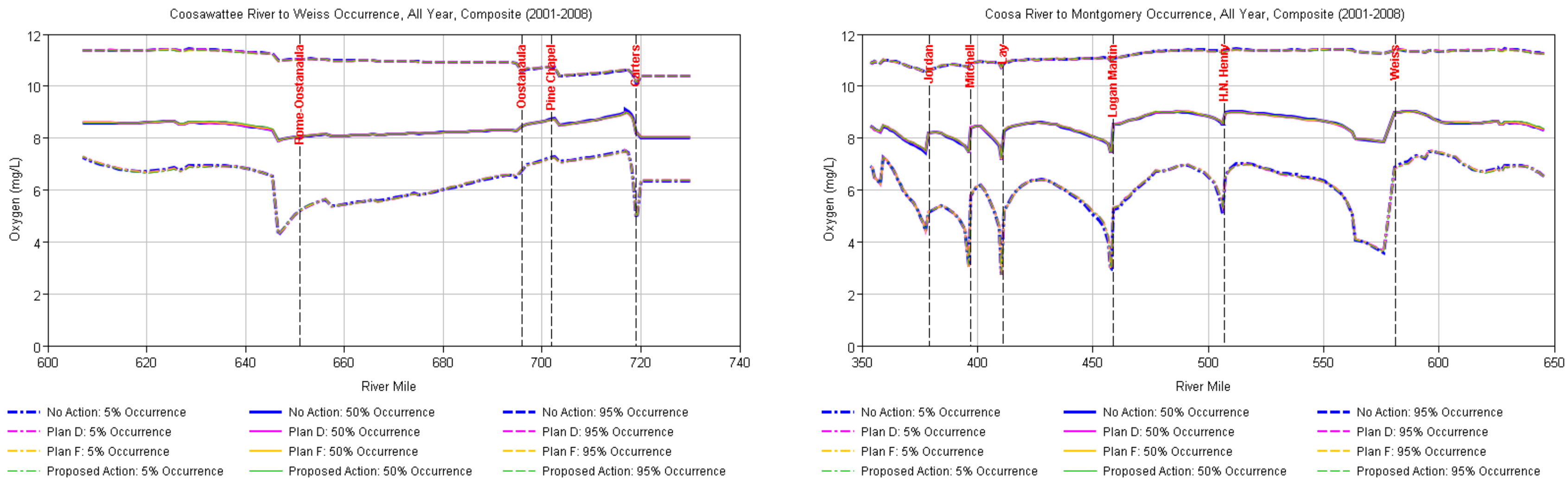


Figure 4.14 Longitudinal occurrence profiles of dissolved oxygen, computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001–2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

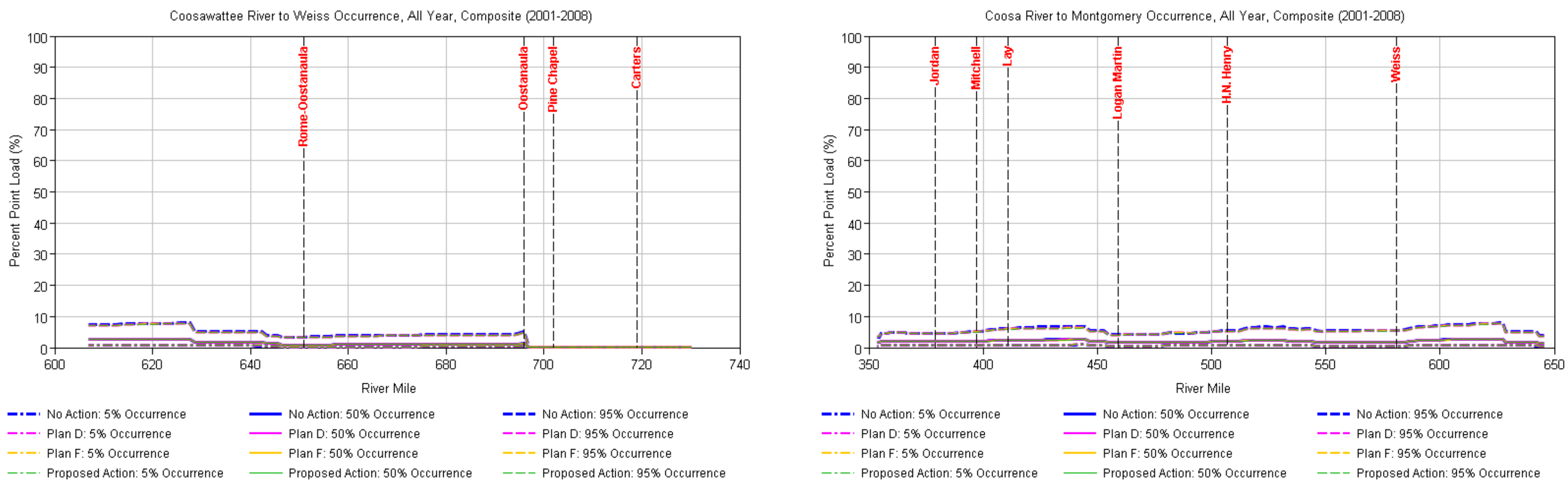


Figure 4.15 Longitudinal occurrence profiles of wastewater, computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001–2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

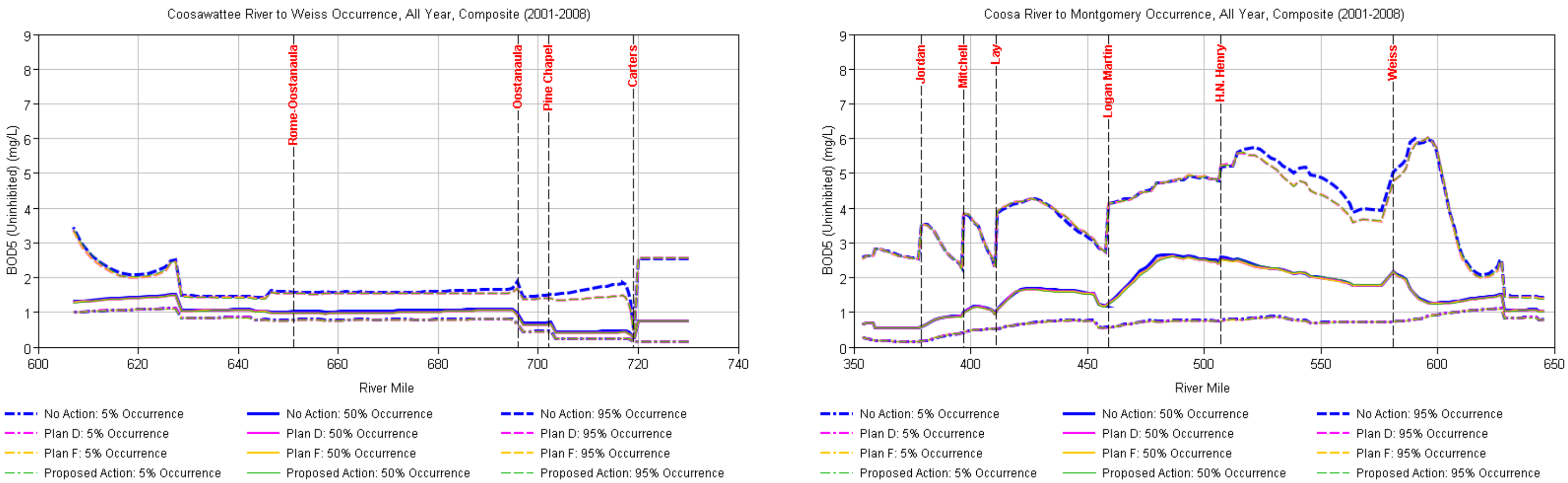


Figure 4.16 Longitudinal occurrence profiles of 5-Day uninhibited 5-day biochemical oxygen demand (BOD5U) computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001–2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

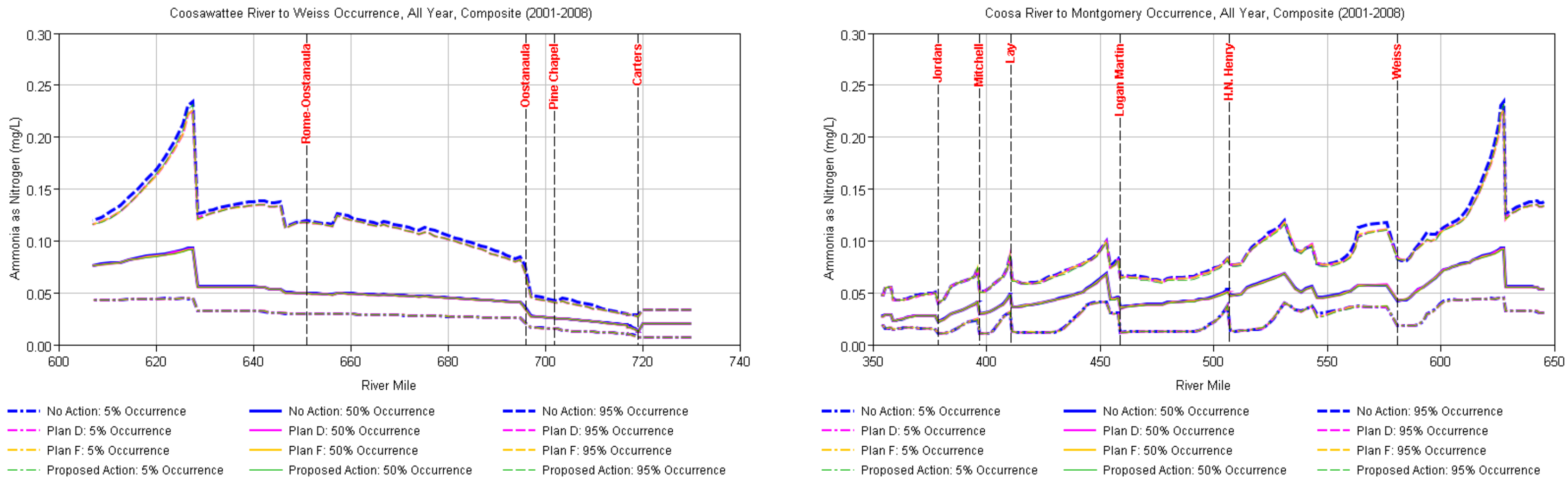


Figure 4.17 Longitudinal occurrence profiles of ammonia as nitrogen (NH3-N), computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001–2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

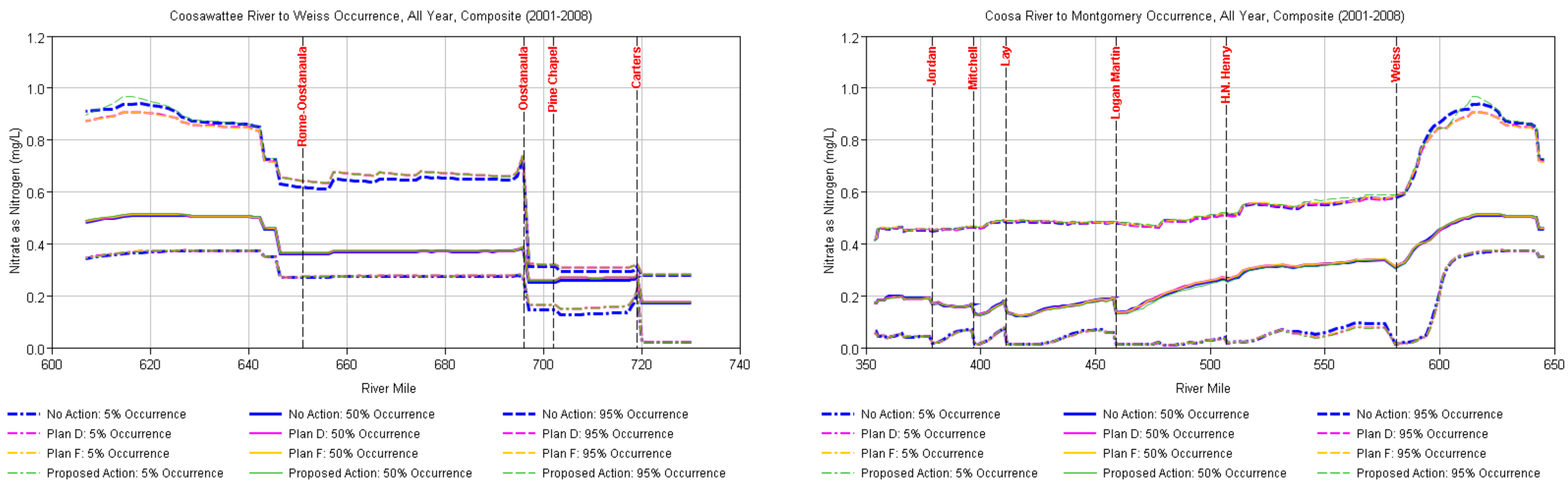


Figure 4.18 Longitudinal occurrence profiles of nitrate as nitrogen (NO3-N), computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001–2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

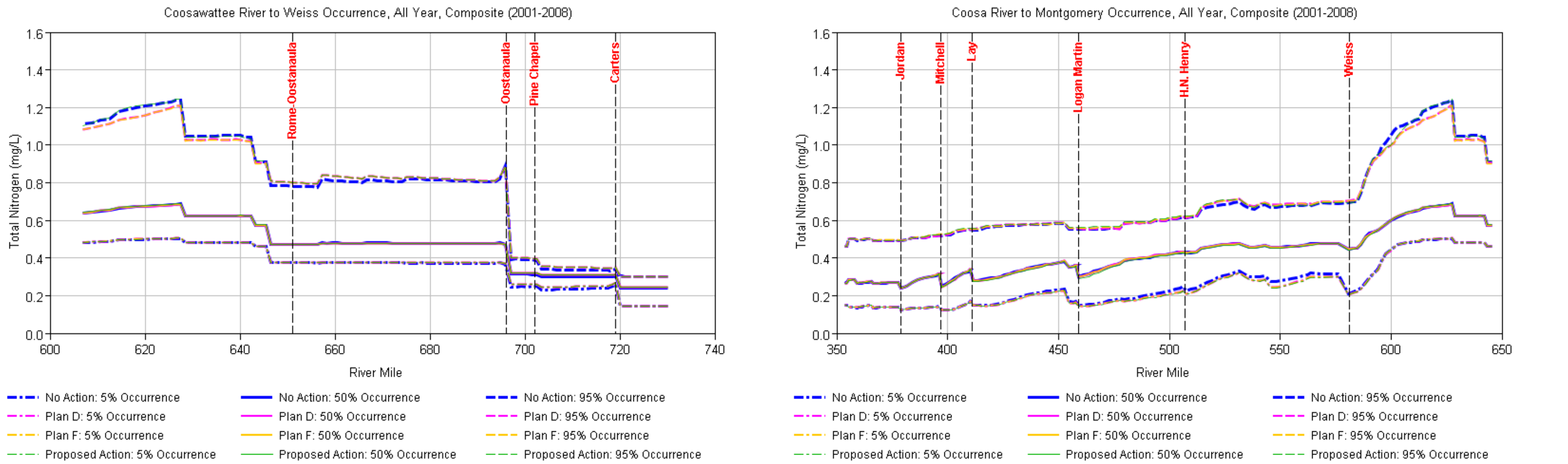


Figure 4.19 Longitudinal occurrence profiles of total nitrogen, computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001–2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

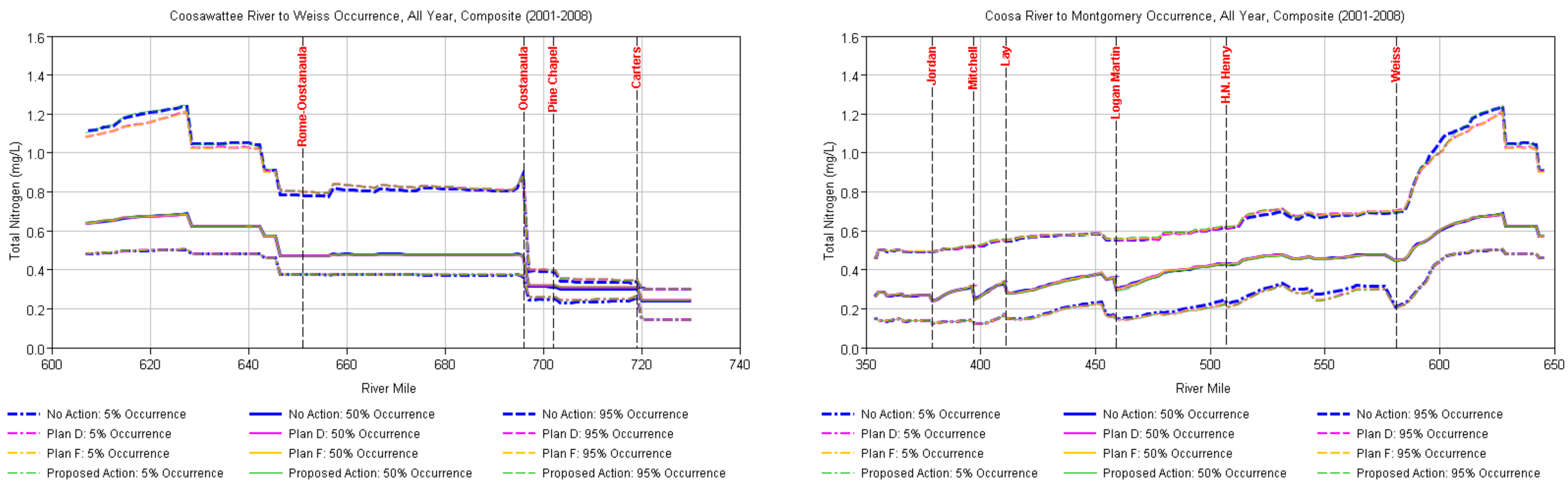


Figure 4.20 Longitudinal occurrence profiles of orthophosphate as phosphorus (PO4-P), computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001–2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

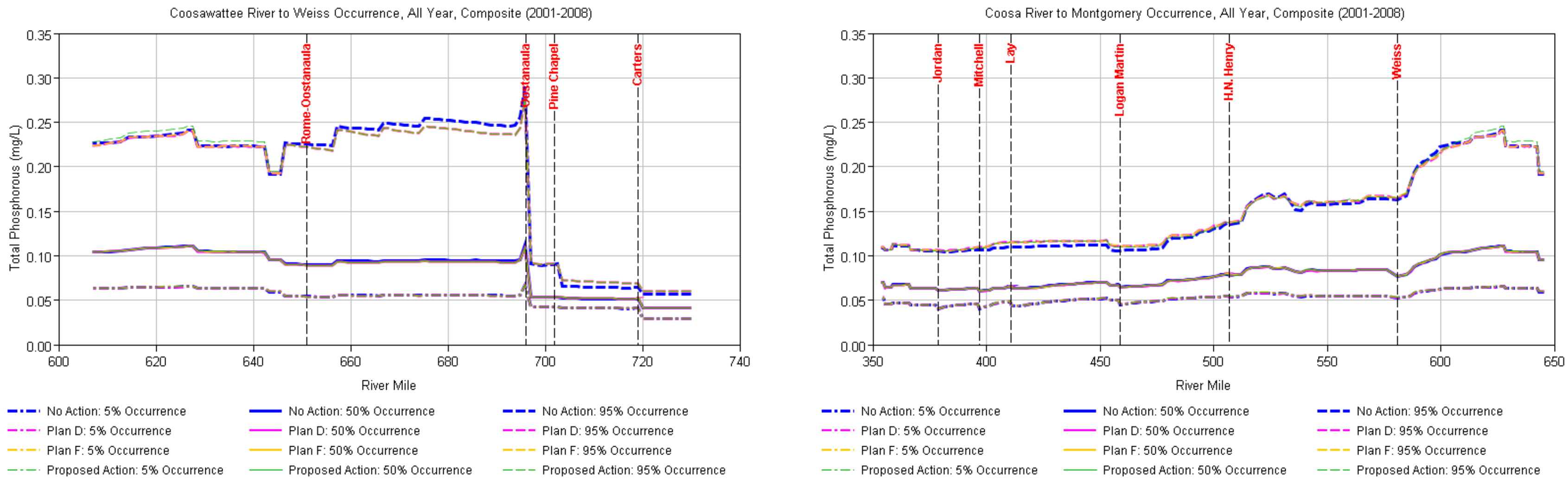


Figure 4.21 Longitudinal occurrence profiles of total phosphorus, computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001–2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

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

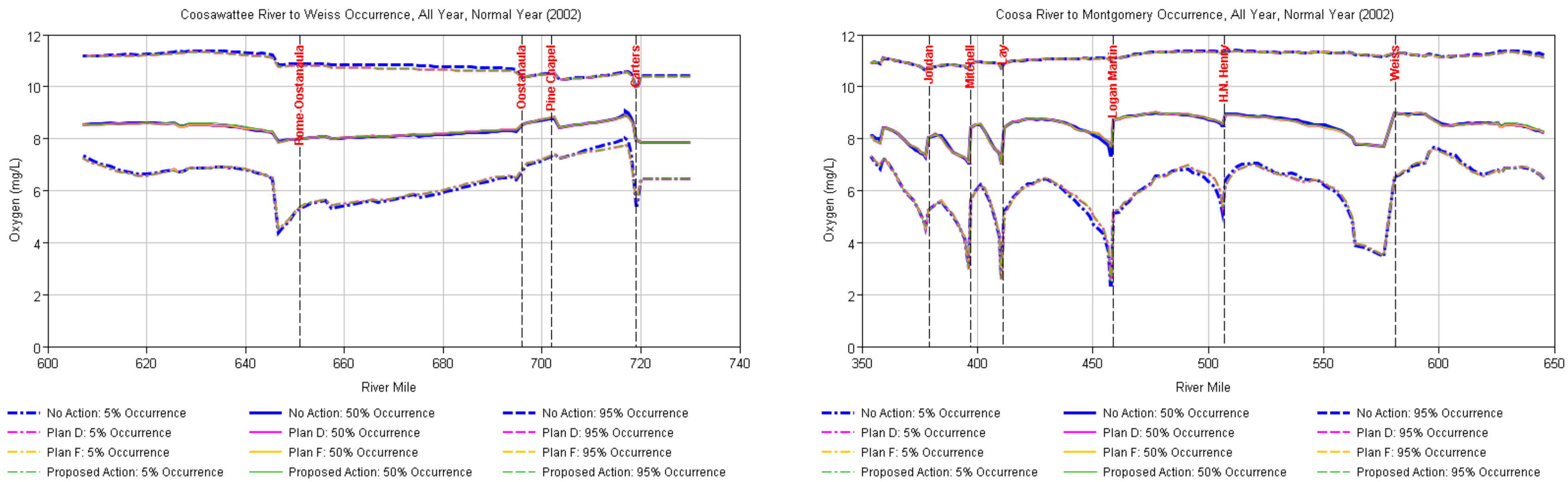


Figure 4.22 Longitudinal occurrence profiles of dissolved oxygen, computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during a "normal" year (2002). The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

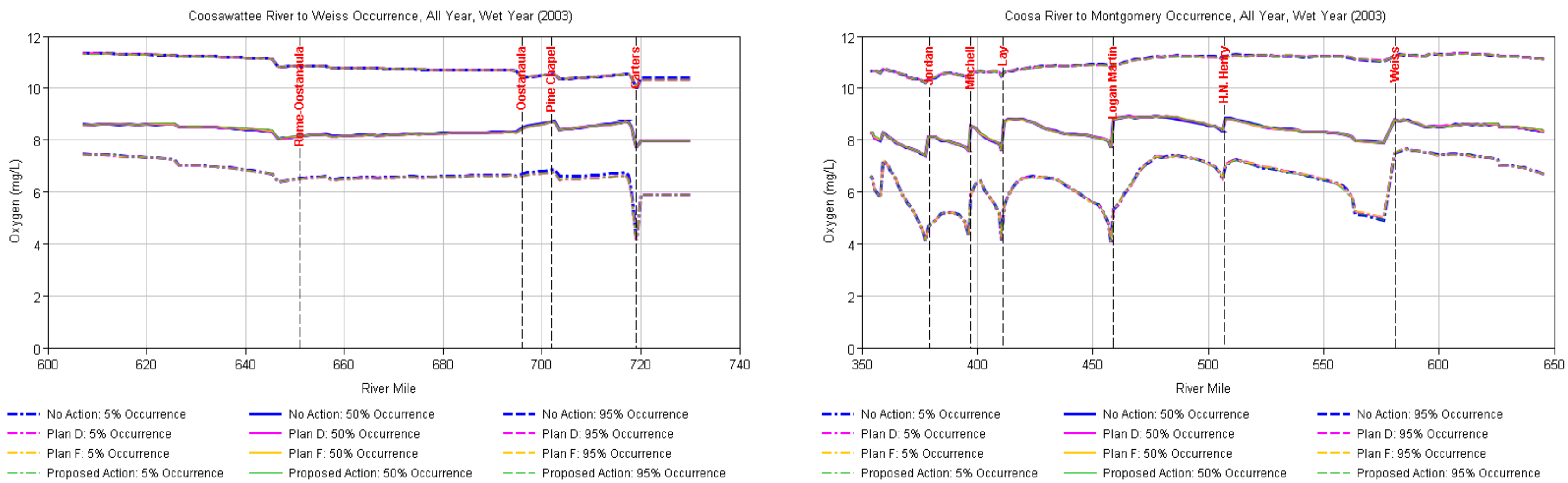


Figure 4.23 Longitudinal occurrence profiles of dissolved oxygen, computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during a "wet" year (2003). The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

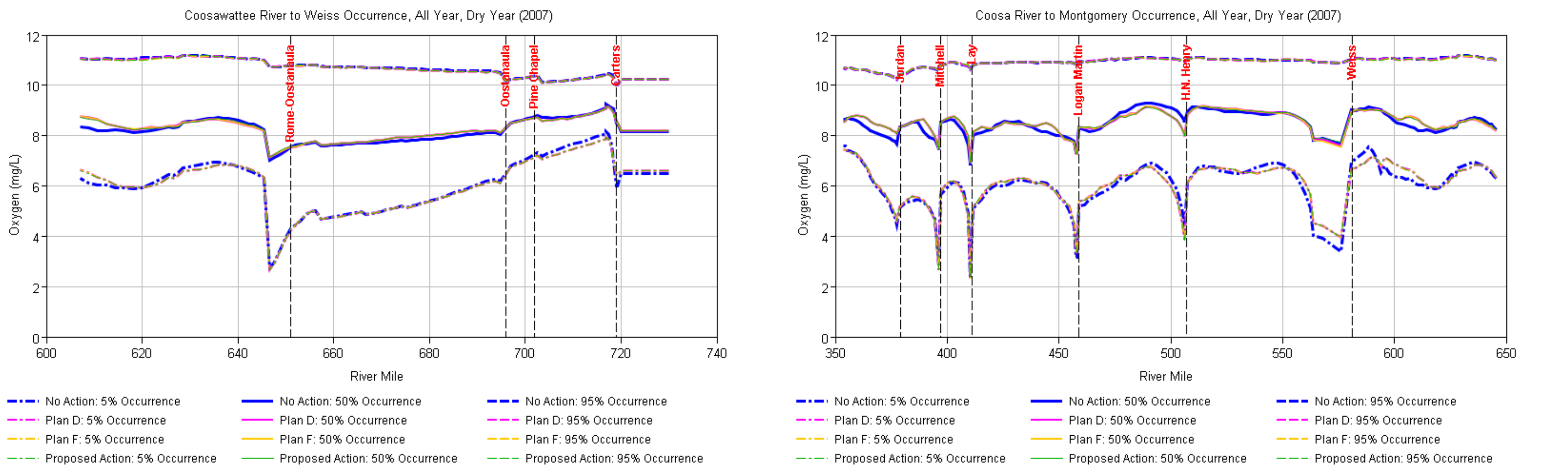


Figure 4.24 Longitudinal occurrence profiles of dissolved oxygen, computed along the Coosawattee to Weiss River and the Coosa to Montgomery River during a “dry” year (2007). The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

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

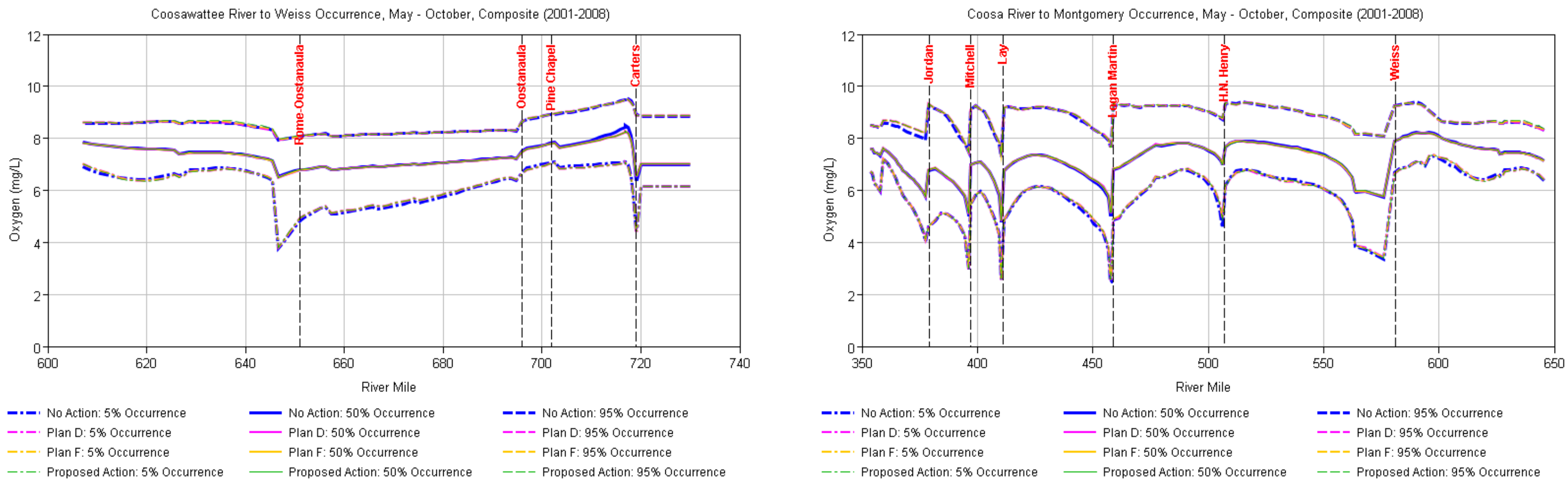
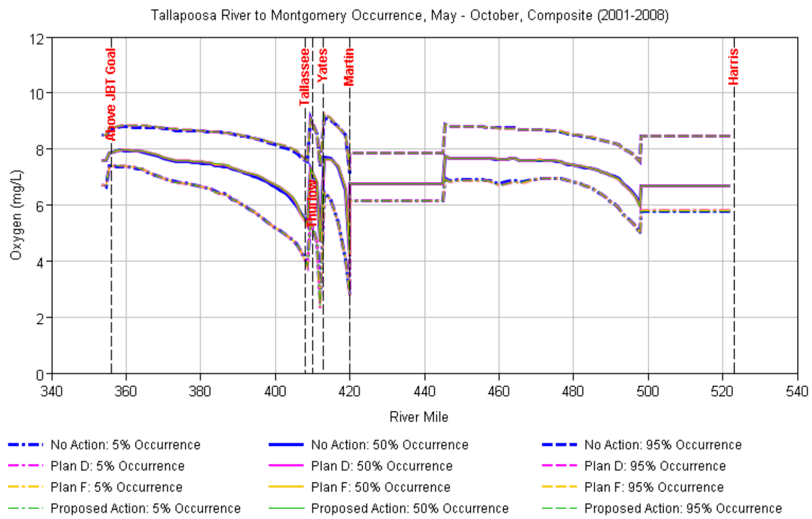


Figure 4.25 To address the standards of the U.S. Fish and Wildlife Service, dissolved oxygen was computed for the months of May-October along the Coosawattee to Weiss River and the Coosa to Montgomery River during the 2001–2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.



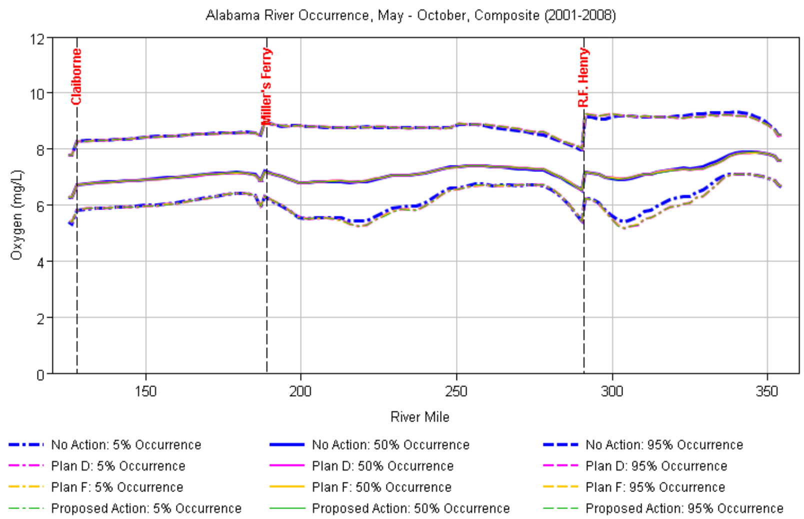


Figure 4.26 To address the standards of the U.S. Fish and Wildlife Service, dissolved oxygen was computed for the months of May-October along the Tallapoosa to Montgomery River and the Alabama River during the 2001–2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

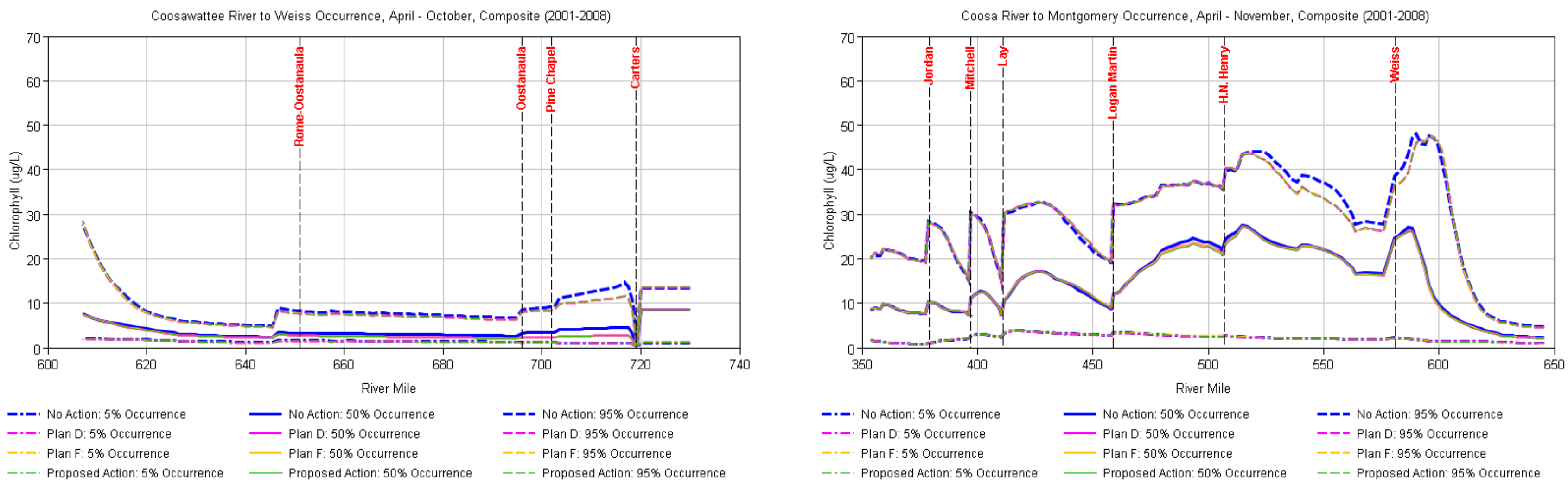


Figure 4.27 To address the standards of the states of Georgia and Alabama, Chlorophyll *a* was computed for the months of April-October along the Coosawattee to Weiss River according to Georgia's growing season, and chlorophyll was also computed for the months of April-November along the Coosa to Montgomery River according to Alabama's growing season. Both profiles were computed during the 2001–2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

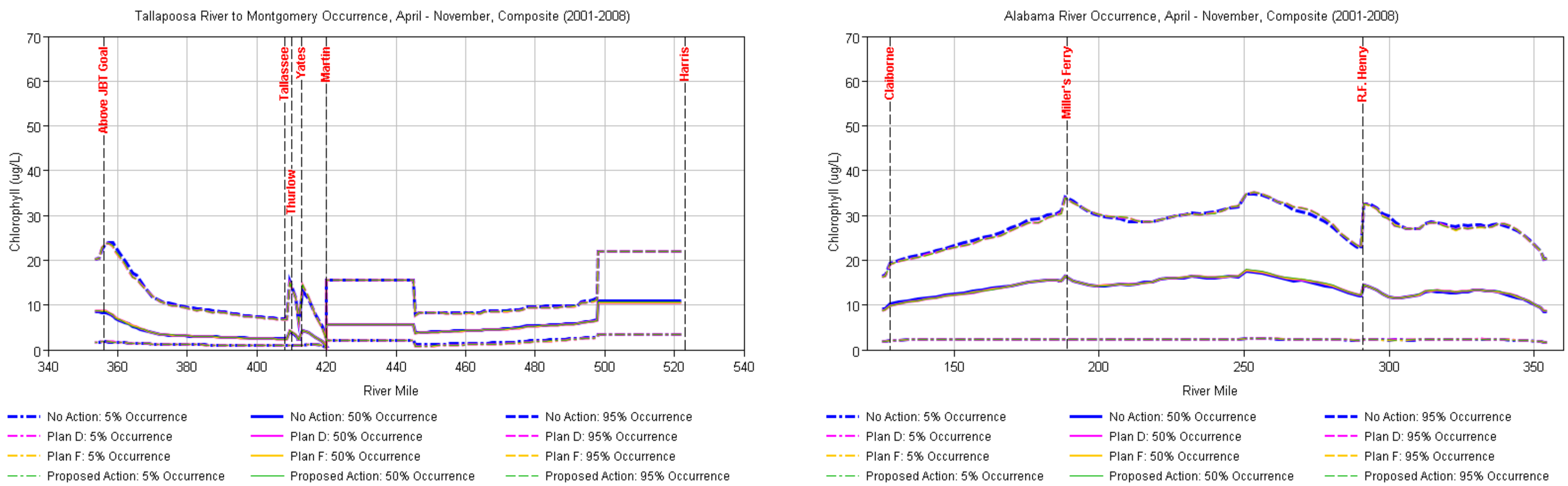


Figure 4.28 To address the standards of the state of Alabama, Chlorophyll *a* was computed for the months of April-November along the Tallapoosa to Montgomery River and the Alabama River during the 2001–2008 modeling period. The 95, 50, and 5 percent occurrence levels are shown for the no action and proposed action operating plans and for the two alternative plans, D and F.

5 CLIMATE, FLOW, AND LAND USE SENSITIVITY ANALYSIS

Water quality analyses were performed with the HEC-5Q model for three scenarios that examine the sensitivity of the ACT watershed to potential future changes in the ACT watershed. These scenarios are:

1. An across-the-board flow reduction of 15% (i.e., 85% of the historical flows)
2. Increased demands, projected for the year 2030
3. Increased air temperatures of 1 ^{o}C, due to climate change

The HEC-ResSim model produced new sets of flows for the first two scenarios, and these were input into the HEC-5Q model. The equilibrium water temperature in the HEC-5Q model was adjusted for the third scenario, in response to a 1 ^{o}C increase in air temperatures, as described in Section 2.2.4. Water quality was simulated for the Proposed Action plan under these conditions, and these results were compared to the Proposed Action plan under existing (non-sensitivity) 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 2001-2008 model period and each of the three hydrologic periods. Representative plots are shown below. These are independent scenarios with forcings of different relative magnitudes, i.e., a 1 ^{o}C temperature change should not be considered equivalent to a 15% reduction of flows. Furthermore, these scenarios were simulated independently as sensitivity analyses in order to assess the watershed's response to each condition. Therefore, the results of these analyses should not be compared with one another.

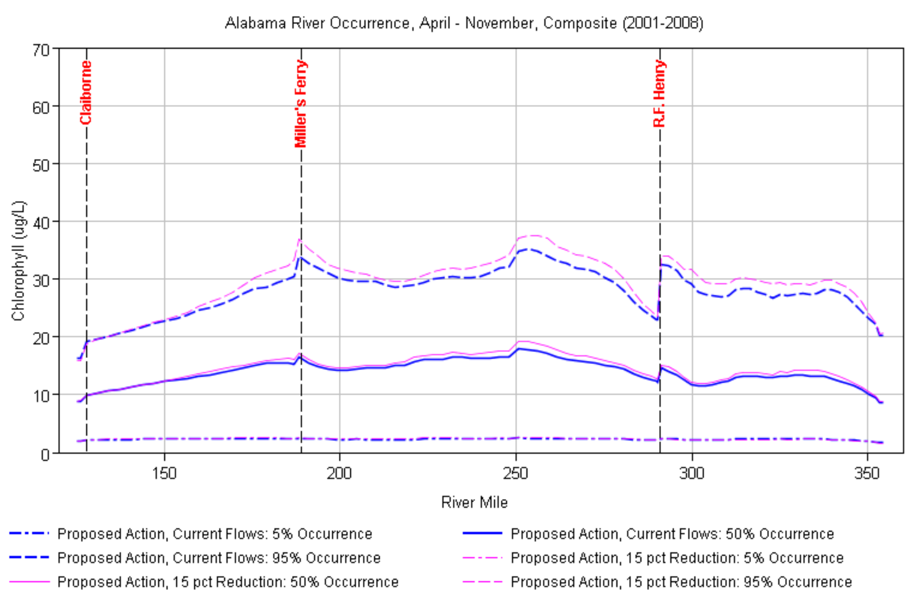


Figure 5.1 Longitudinal occurrence profiles of Chlorophyll *a* for the April-November growing season along the Alabama River during the 2001–2008 modeling period, comparing the response to existing flows and a 15% reduction in flows for the Proposed Action.

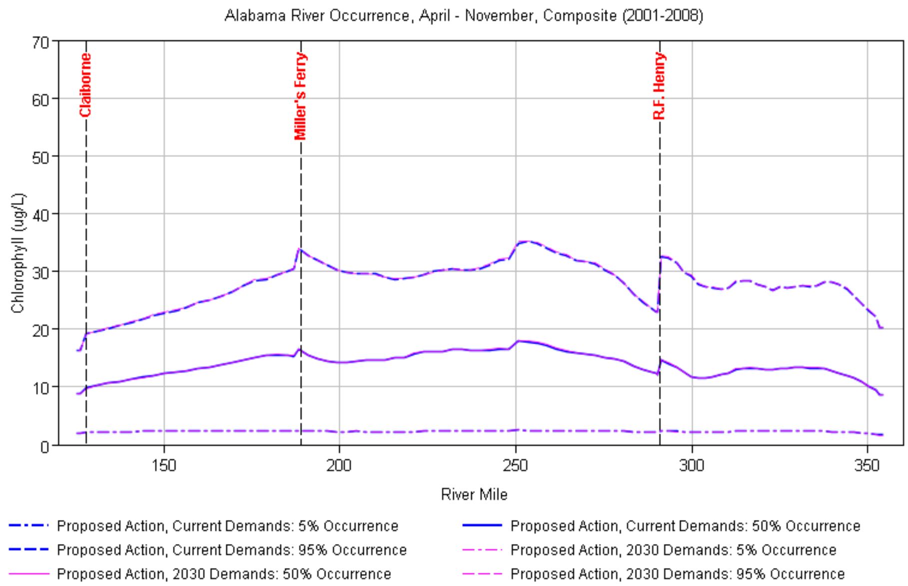


Figure 5.2 Longitudinal occurrence profiles of Chlorophyll *a* for the April-November growing season along the Alabama River during the 2001–2008 modeling period, comparing the response to existing and projected 2030 demands for the Proposed Action.

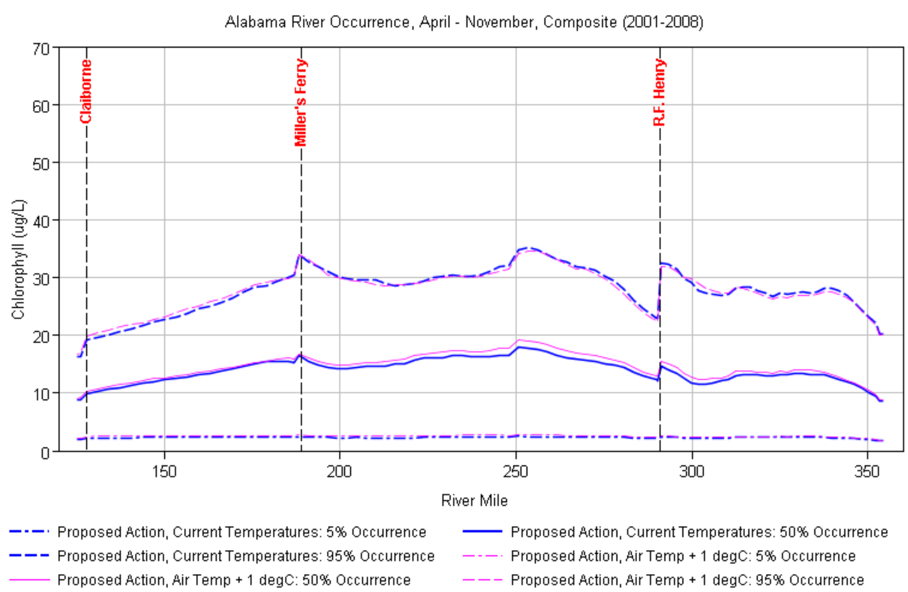


Figure 5.3 Longitudinal occurrence profiles of Chlorophyll *a* for the April-November growing season along the Alabama River during the 2001–2008 modeling period, comparing the response to existing temperatures and a 1 °C increase in air temperatures for the Proposed Actions.

6 REFERENCES

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7 APPENDIX A – TRIBUTARY FLOW AND WATER QUALITY INPUTS

Table A-7.1 Average, maximum and minimum tributary flow and water quality inputs.

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

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

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

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

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

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

Table A-7.2 Average, maximum and minimum flow and water quality inputs from municipal and industrial discharges.

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

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

8 APPENDIX B – MODEL SENSITIVITY ANALYSIS

A sensitivity analysis was performed on the HEC-5Q ACT model to quantify the relative impact of various model coefficients and sources on model predictions. The primary emphasis was the impacts on phytoplankton (chlorophyll *a*) since it has a major impact on dissolved oxygen, and high levels 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%. The values within the brackets are the typical baseline ranges.

1. Algal growth rate, 1/day (1.6 - 2.2)
2. Algal respiration rate, 1/day (0.25 - 0.3)
3. Algal settling velocity, m/day (0.15 - 0.5)
4. Benthic oxygen uptake/demand, mg/m2/day (500 - 1250)
5. Benthic nitrogen source rate, mg/ m2/day (5 - 12)
6. Benthic phosphorus source rate, mg/ m2/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 (NH3+NH4), mg/l (variable - BASINS based)
12. Point/municipal and industrial nitrogen (NH3+NH4), mg/l (variable - treatment plant specific)
13. Non-point/tributary stream phosphorus (PO4), mg/l (variable - BASINS based)
14. Point/municipal and industrial phosphorus (PO4), mg/l (variable - treatment plant specific)

Each sensitivity run affects multiple parameters throughout the ACT watershed. It is impossible to quantity the impacts at all locations and times; therefore the impacts are demonstrated as a longitudinal profile plot for the stream / reservoir system bounded by Lake Allatoona and Claiborne Lake. This reach is one of the seven profiles (Etowah to Claiborne) that are referenced in the body of the report. Typically, 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 algae growing season or equivalent mid-year month limit that varies by season (April - November or May - October) over the 2001–2008 simulation period. The average lines are bold for reference clarification.

Additionally, tables are available upon request that list the incremental changes relative to the baseline simulation The tables are in the form of an Excel spreadsheet with a separate sheet for each sensitivity run. The table is too large to include in the report. A printed table also precludes further analysis by the reader that is possible with a spreadsheet. A decrease (negative Sens-Base) indicates a reduction associated with the sensitivity run. The criterion for listing in the table is an incremental difference between the baseline and sensitivity run greater than |0.5%|. Each of the seven river segments, time periods and increments for the 5, 25, 50 (average), 75 and 95 percent occurrence levels is included. The table columns are as follows

1. River segment
2. Parameter
3. Units
4. Year period
5. Monthly time period, baseline label, sensitivity run label & increment label
6. Length weighted average concentration, 5% exceedance
7. Length weighted average concentration, 25% exceedance
8. Length weighted average concentration, 50% exceedance
9. Length weighted average concentration, 75% exceedance
10. Length weighted average concentration, 95% exceedance
11. Average percentage change
12. Results of the sensitivity runs are described below.

8.1 SENSITIVITY TO ALGAE GROWTH

As expected, a 25% higher growth rate results in larger algal concentrations, as shown in the chlorophyll profiles in Figure 8.1. The effect is the greatest in the upper reaches of Weiss Reservoir due to a higher growth rate and thus a quicker response. This effect is analogous to the higher levels computed for Alternative H that result from lower flow rates and slower moving water that allows more time for growth.

The increase in growth rate decreases the nutrient concentrations (Figure 8.2 and Figure 8.3) while dissolved oxygen (Figure 8.4) generally remains the same or higher in the reservoirs. Note that these plots reflect the near surface concentrations. Dissolved oxygen is slightly lower below the dams due to lower concentrations deeper in the water column, resulting from respiration of settled algae.

8.2 SENSITIVITY TO ALGAE RESPIRATION

As expected, a 25% higher Respiration rate results in smaller algal concentrations (Figure 8.5). The effect is fairly uniform (as a percentage) throughout the system. The increase in respiration rate increases the nutrient concentrations (Figure 8.6 and Figure 8.7). This is because nutrient uptake is less, due to the smaller algae concentrations. The nutrient byproducts of respiration are greater, due to the increased respiration rate. Dissolved oxygen concentrations are lower (Figure 8.8) because of uptake associated with respiration, and because the lower algae concentration results in less photosynthesis production.

The results of this analysis show impacts normally not associated with algae dynamics. BOD5U decreases because there is a smaller respiration component due to the lower algal concentration. The computation of BOD5U does not include the change in respiration rate assumed in the sensitivity run.

Even less intuitive is the change in percent of point sources. The small changes are due to small differences in reservoir dynamics that have an impact on the thermal structure caused by phytoplankton impacts on light attenuation. These small impacts to the thermal structure result in small changes in the phasing and location within the water column for the point-load-tagged water. These changes can be ignored.

Small changes in the growth and respiration can have a measurable effect on the magnitude and timing of algal dynamics. Computed algae levels are most dependent on these two model parameters, which are used as the primary model calibration variables.

8.3 SENSITIVITY TO ALGAE SETTLING

A higher algal settling rate results in lower algal concentrations (Figure 8.9). The effect is fairly uniform throughout the system. The response to settling is less than the response to changes in growth and respiration, but settling can have a measurable effect on the algal levels. The net impact on nutrients is relatively low and nearly undetectable in the profile plots. Changes in dissolved oxygen generally do not meet the 0.5% criteria for inclusion in the sensitivity analysis summary.

8.4 SENSITIVITY TO BENTHIC OXYGEN

Benthic oxygen demand reduces dissolved oxygen levels fairly uniformly throughout the system. The profile plots (Figure 8.10) show the near-surface concentrations that are affected the least. In stratified reservoirs, the impacts are greater in the hypolimnion. This model input is of particular importance during dissolved oxygen calibration of the deeper reservoirs such as Lake Allatoona and Lake Martin.

8.5 SENSITIVITY TO BENTHIC NITROGEN SOURCE RATE

The benthic source rate for nitrogen stimulates algal growth and increases total nitrogen. Both chlorophyll (Figure 8.11) and ammonia nitrogen (Figure 8.12) increase fairly uniformly as a percentage throughout the system. The relatively small increases in both parameters indicate that the benthic source is not the major nitrogen contributor at the rates assumed in the calibrated model.

8.6 SENSITIVITY TO BENTHIC PHOSPHORUS SOURCE RATE

The benthic source rate for phosphorus increases PO4-P (Figure 8.13) and total phosphorus but does not make an appreciable change in chlorophyll *a*, or in any other parameter. However, the percentage difference gradually increases as flow progresses downstream since the phosphorus source is additive without any appreciable increase in algal uptake. The relatively small increases in both phosphorus parameters indicate that the benthic source is not the major phosphorus contributor at the rates assumed in the calibrated model and does not stimulate algal growth. From the model perspective, the limiting nutrient for algal growth is nitrogen.

8.7 Sensitivity to Ammonia Decay

As expected, a higher ammonia decay rate hastens the transformation of ammonia to nitrate (ammonia nitrogen decreases (Figure 8.14) while nitrate increases (Figure 8.15)). There is little impact on other parameters, including chlorophyll *a*, since the algae preference for ammonia appears to have little impact. The percentage change in nitrate is less than that of ammonia due to the relative magnitude of the two parameters (about 4 to 1) but total nitrogen changes by less than 1% as seen in the summary table.

8.8 Sensitivity to Dissolved Organic Material Decay Rate

The dissolved organics decay rate has little impact on any parameter. The maximum change of any parameter is less than 5% as seen in the summary table.

8.9 Sensitivity to Non-point Source Dissolved Organic Material Concentration

The change in the dissolved organic 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 summary 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.

8.10 Sensitivity to Point Source Dissolved Organic Material Concentration

The change in the dissolved organic material (DOM) concentration of the point sources (treatment plants) does not have a major impact on any parameter. The maximum change of any parameter is less than 5% as seen in the summary table. Although the point source concentrations are greater than those of the non-point sources, the average non-point flows are considerably less.

8.11 Sensitivity to Non-Point Source Nitrogen

As expected, a 25% increase in non-point source nitrogen (both NH3 and NO3) concentration results in higher total nitrogen (Figure 8.16), chlorophyll (Figure 8.17) and near-surface dissolved oxygen (Figure 8.18). The higher phytoplankton population and subsequent settling results in slightly lower dissolved oxygen below several of the dams.

8.12 Sensitivity to Point Source Nitrogen

As with the 25% increase in the point source nitrogen (both NH3 and NO3), model results for total nitrogen (Figure 8.19), chlorophyll (Figure 8.20) and near surface dissolved oxygen (Figure 8.21) are higher. The higher phytoplankton levels and subsequent settling result in slightly lower dissolved oxygen below several of the dams. The relative impact of point sources is greater than that of non-point sources, as seen in the summary table and the plot comparing the two sensitivity conditions (Figure 8.22).

8.13 SENSITIVITY TO NON-POINT SOURCE PHOSPHORUS

As expected, a 25% increase in non-point source phosphorus results in higher total phosphorus (Figure 8.23). Since the model is nitrogen limited, there is little impact on chlorophyll and near-surface dissolved oxygen.

8.14 SENSITIVITY TO POINT SOURCE PHOSPHORUS

As expected, a 25% increase in point source phosphorus results in higher total phosphorus (Figure 8.24). Since the model is nitrogen limited, there is little impact on chlorophyll and near-surface dissolved oxygen. The relative impact of point sources is greater than that of non-point sources as seen in the summary table and the plot comparing the two sensitivity conditions (Figure 8.25).

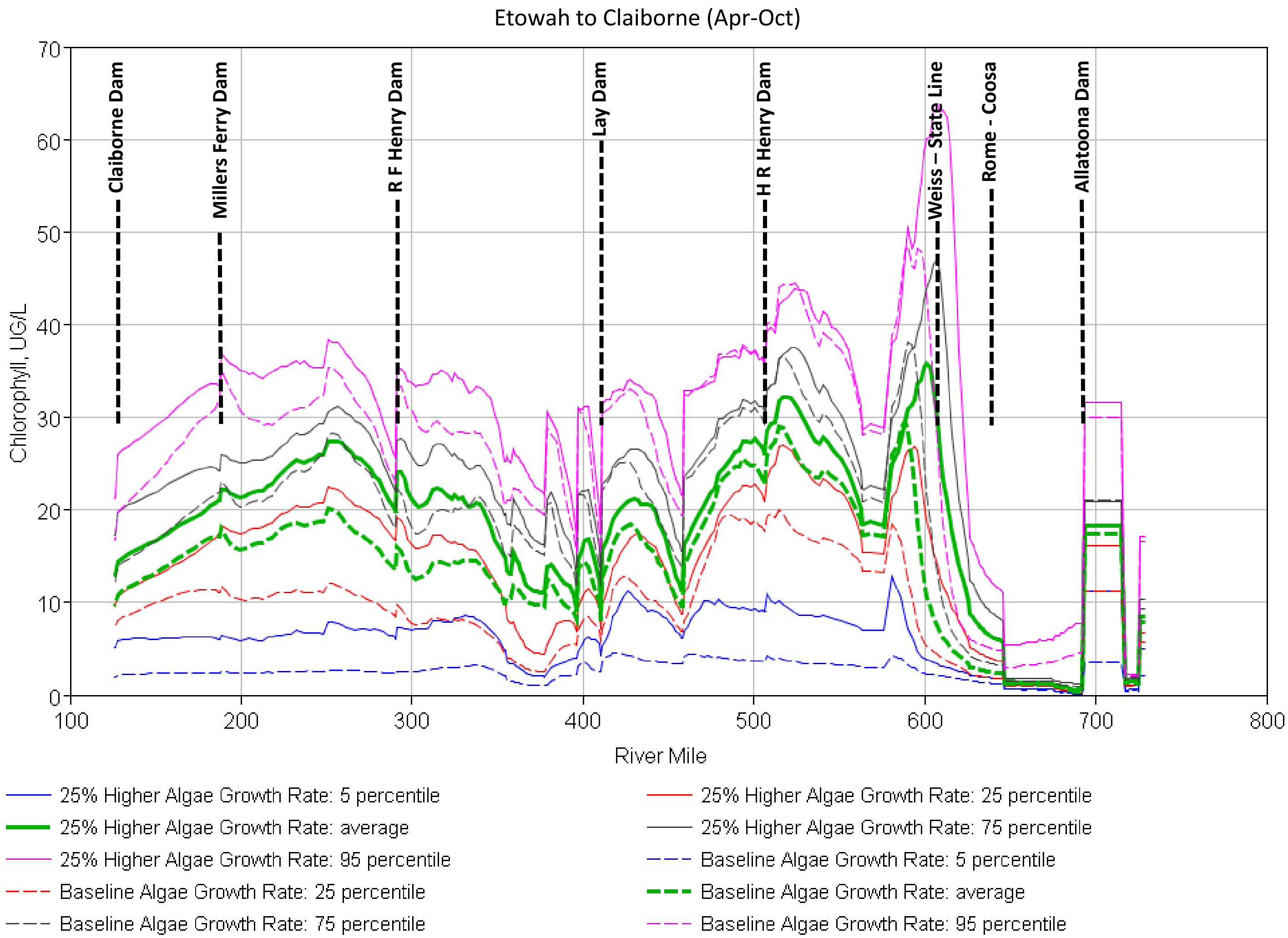

Figure 8.1 Longitudinal profiles of chlorophyll (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in algae growth rate.

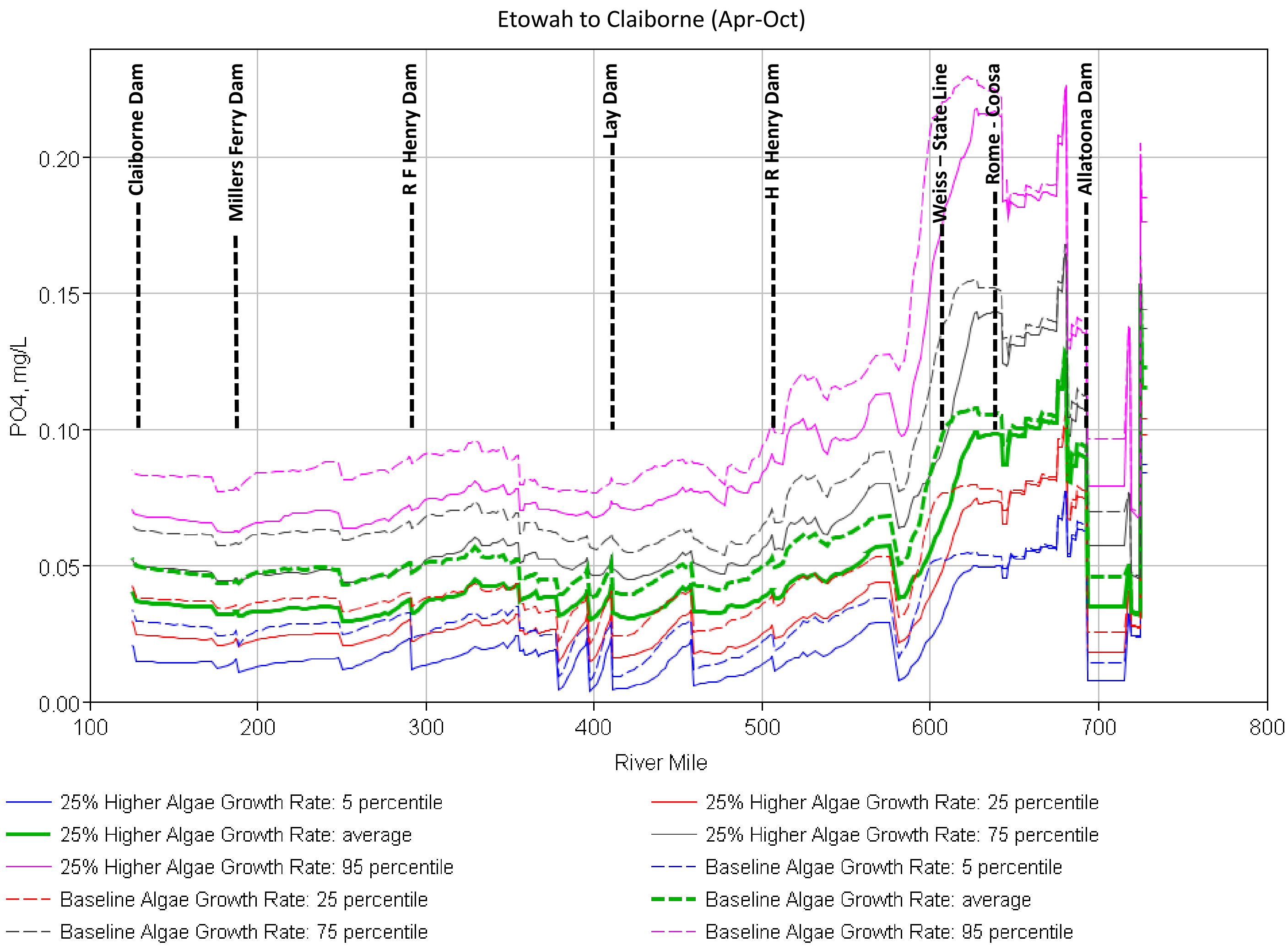

Figure 8.2 Longitudinal profiles of phosphate (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in algae growth rate.

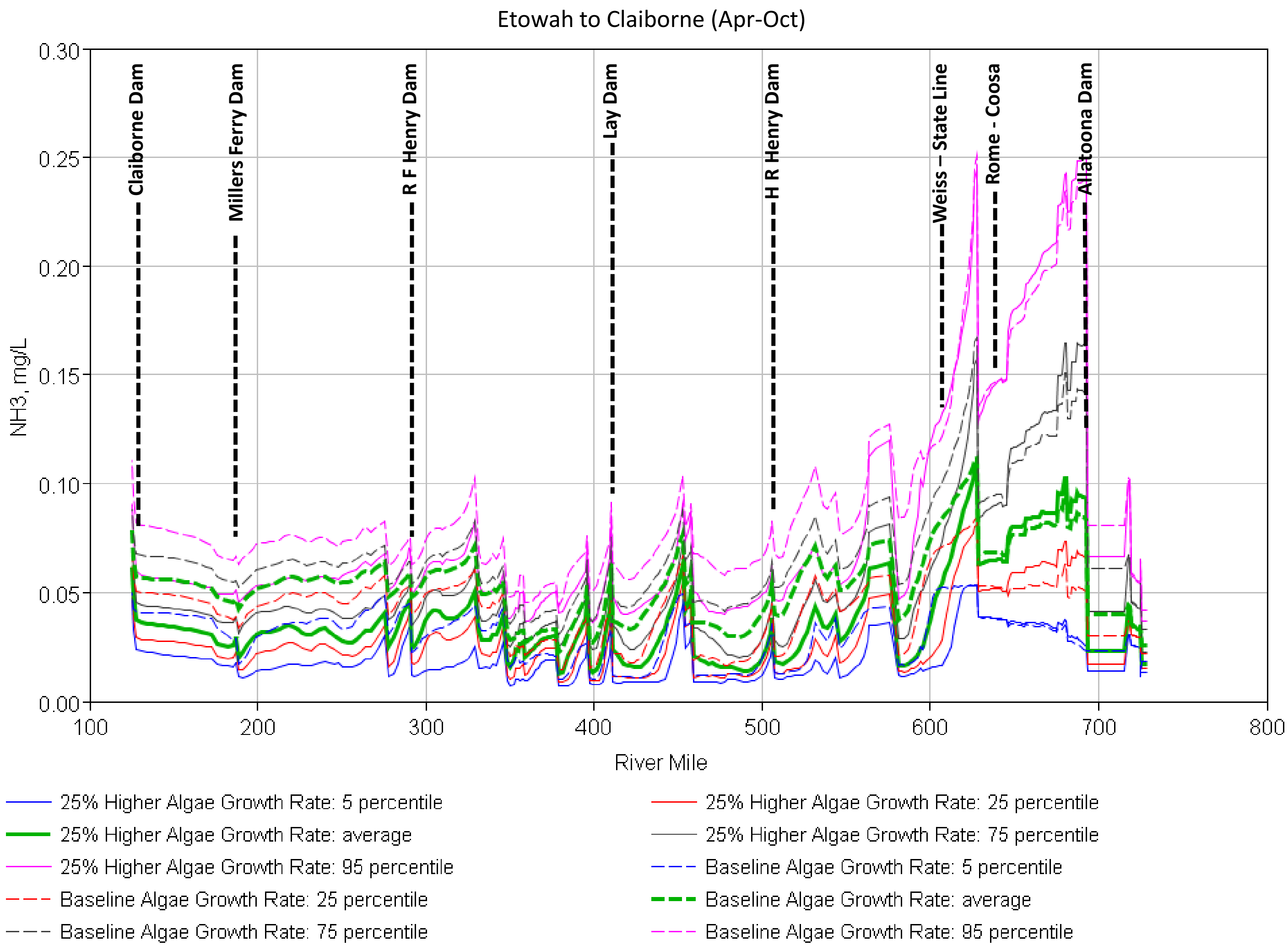

Figure 8.3 Longitudinal profiles of ammonia (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in algae growth rate.

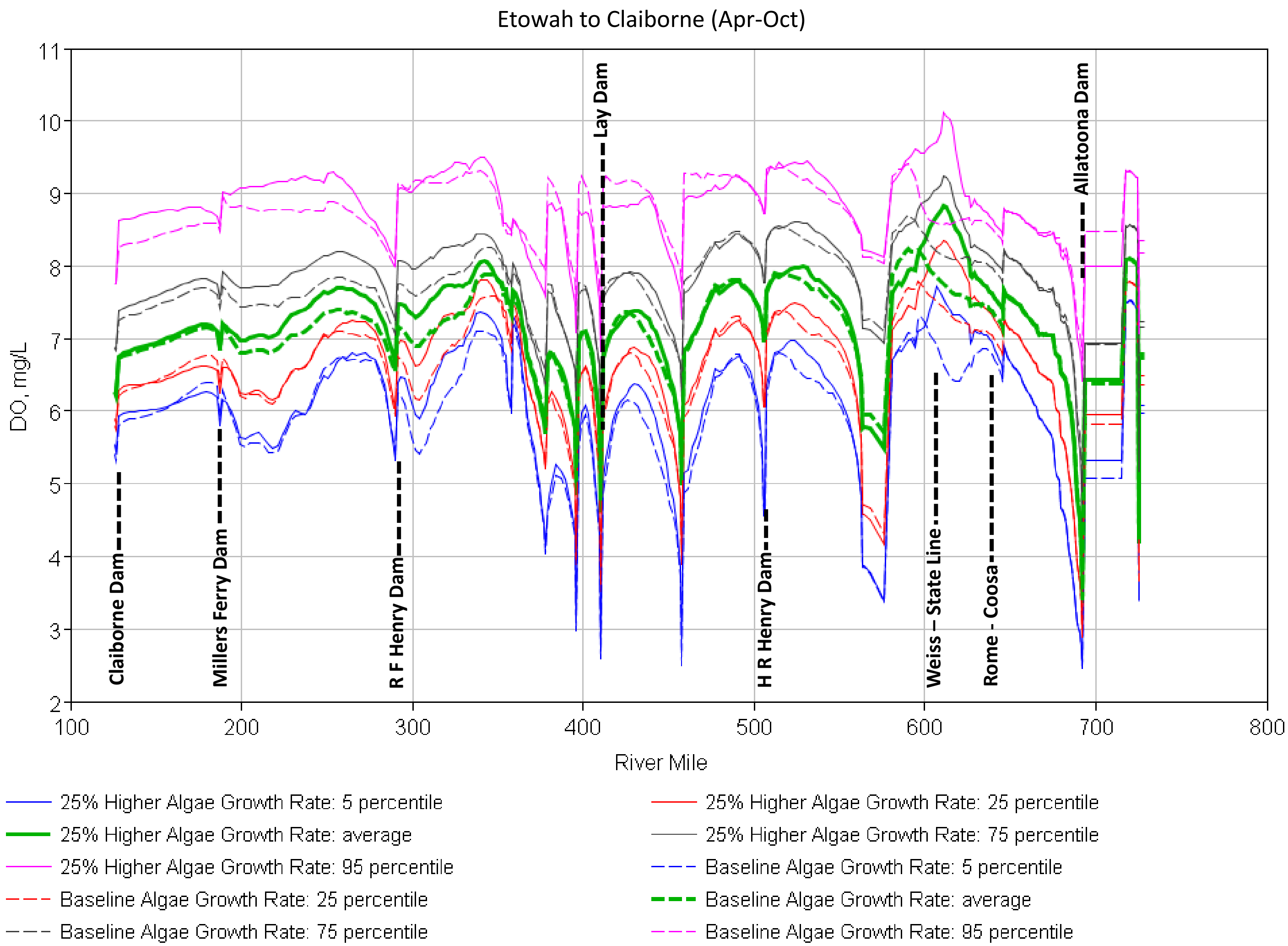

Figure 8.4 Longitudinal profiles of dissolved oxygen (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in algae growth rate.

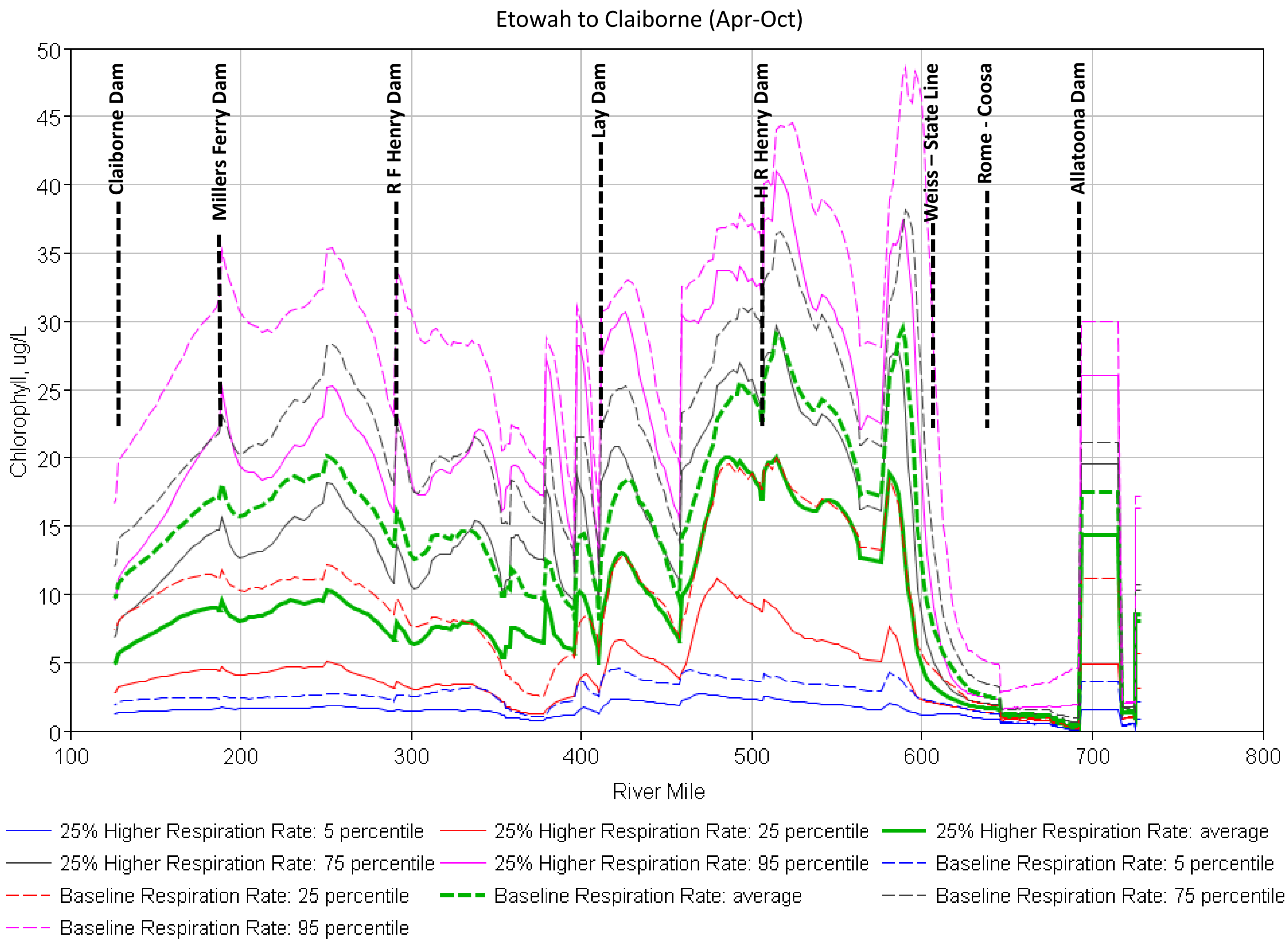

Figure 8.5 Longitudinal profiles of chlorophyll (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in algae respiration rate.

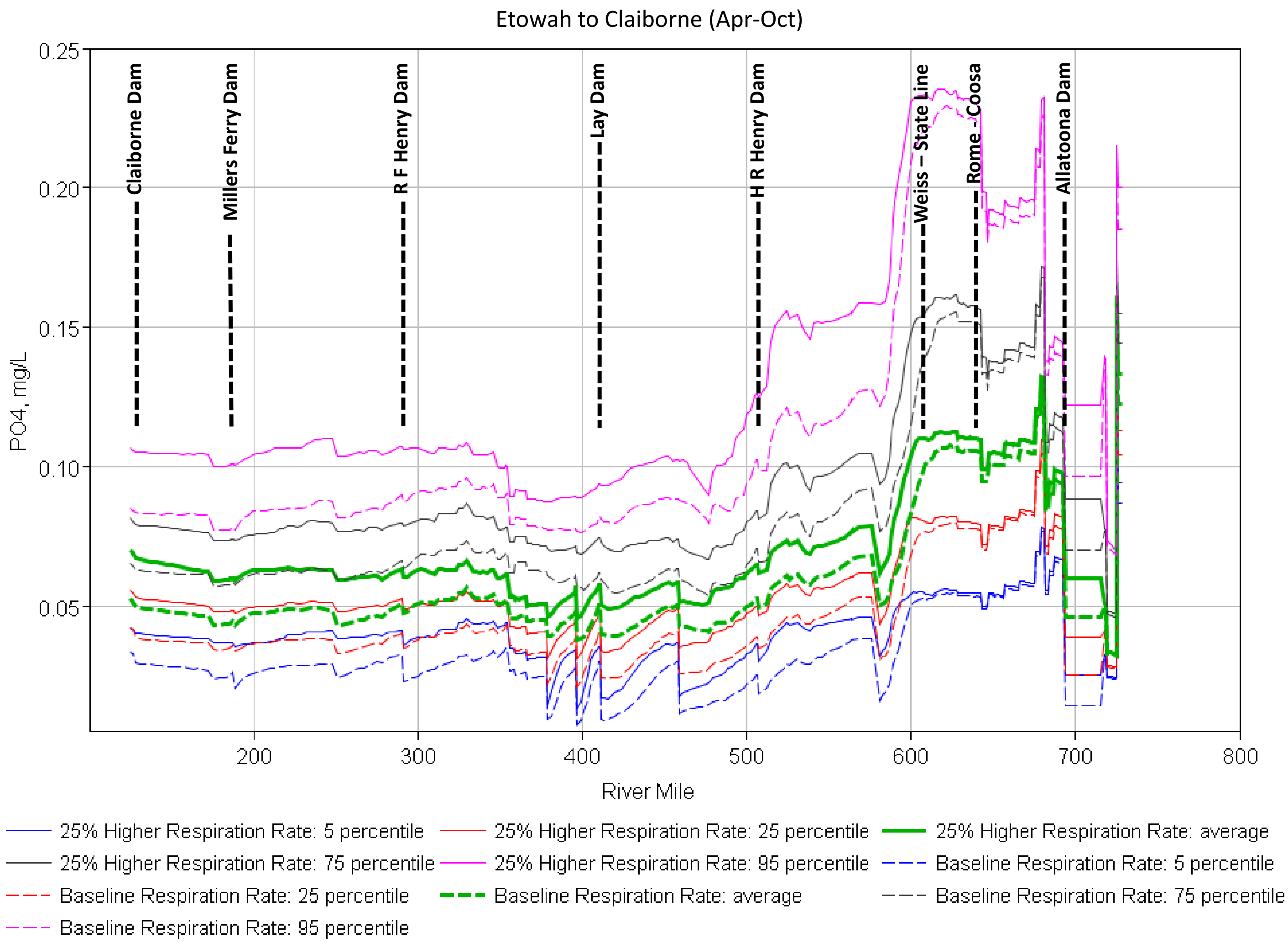

Figure 8.6 Longitudinal profiles of phosphate (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in algae respiration rate.

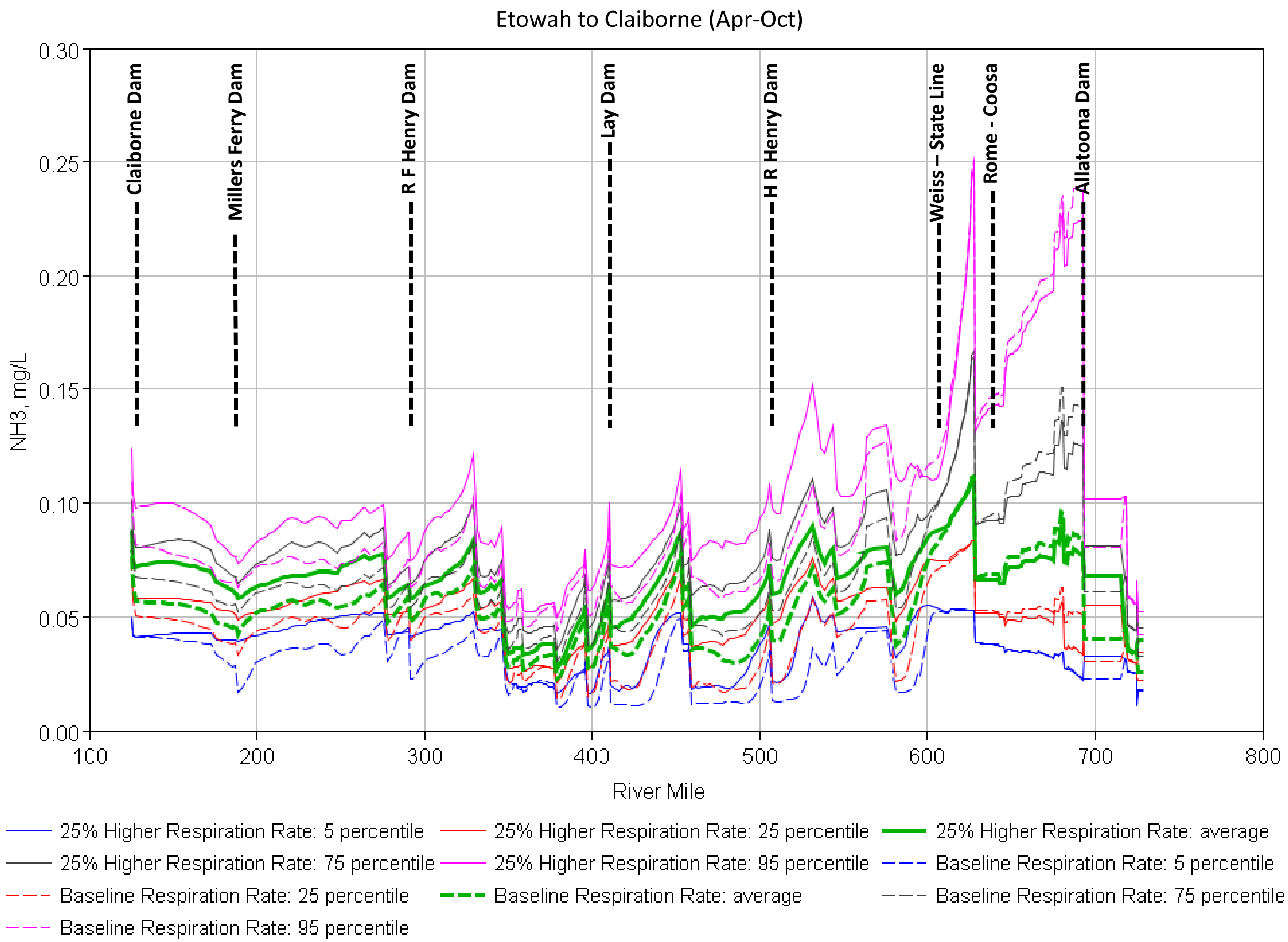

Figure 8.7 Longitudinal profiles of ammonia (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in algae respiration rate.

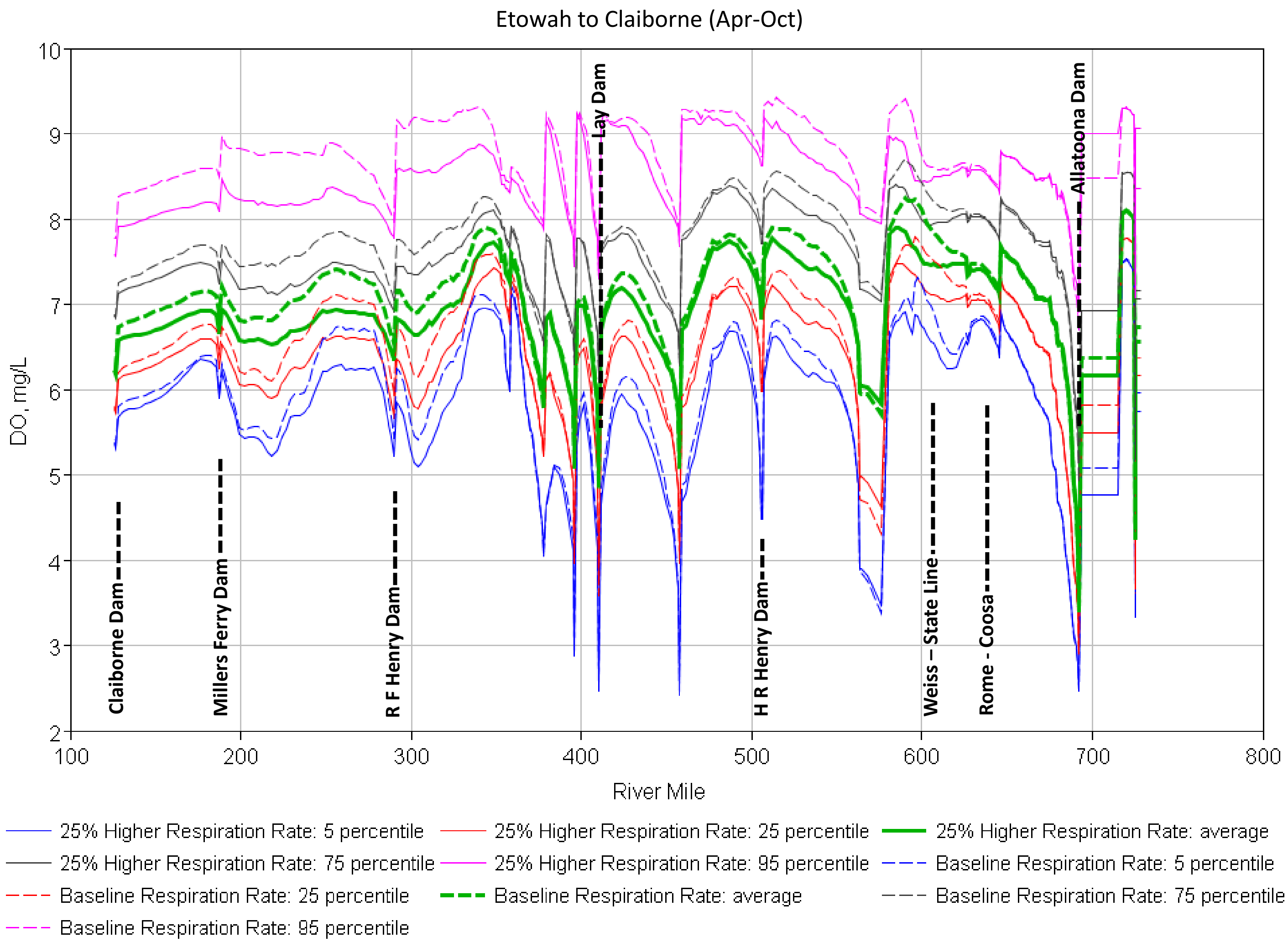

Figure 8.8 Longitudinal profiles of dissolved oxygen (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in algae respiration rate.

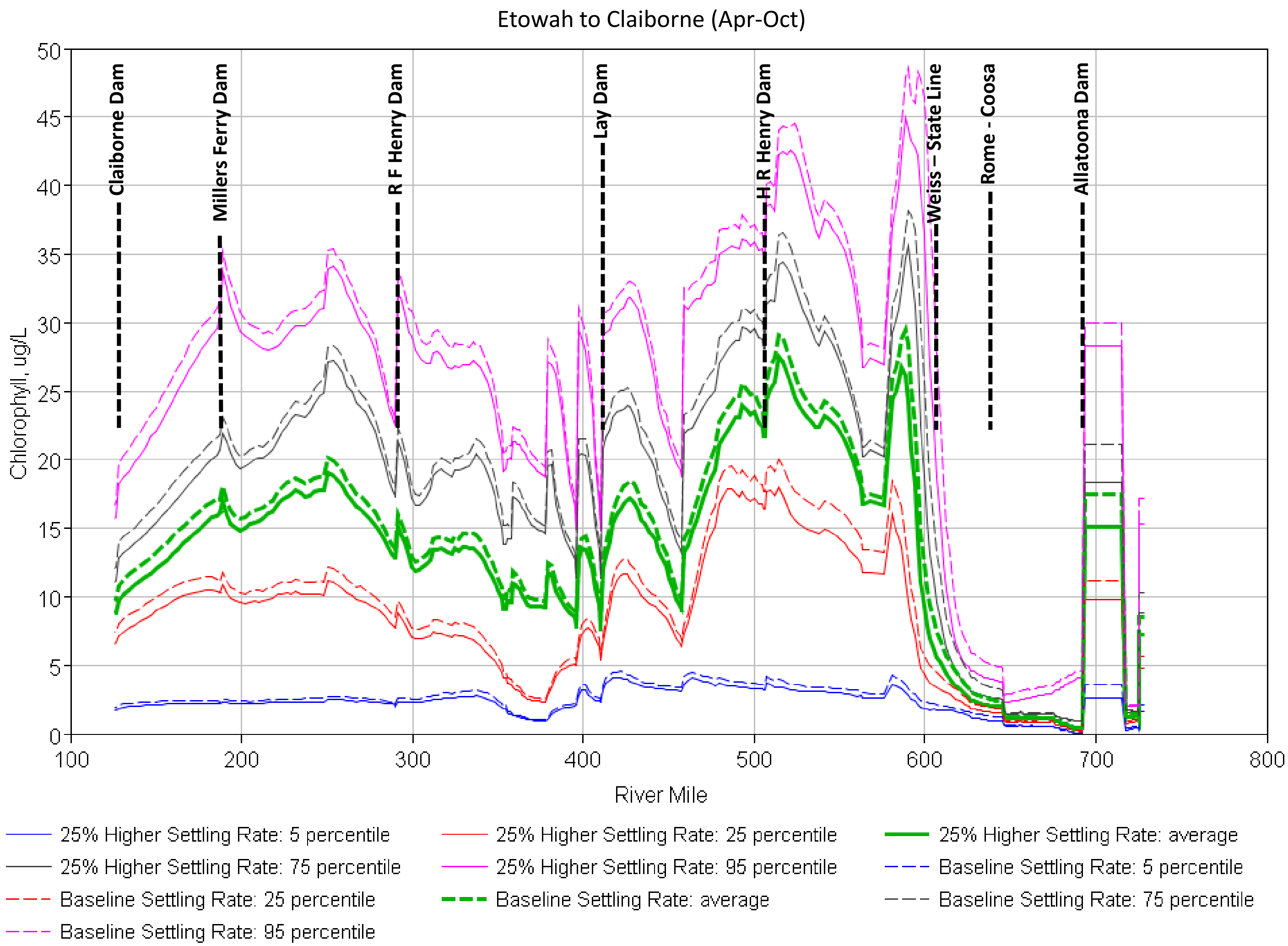

Figure 8.9 Longitudinal profiles of chlorophyll (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in algae settling rate.

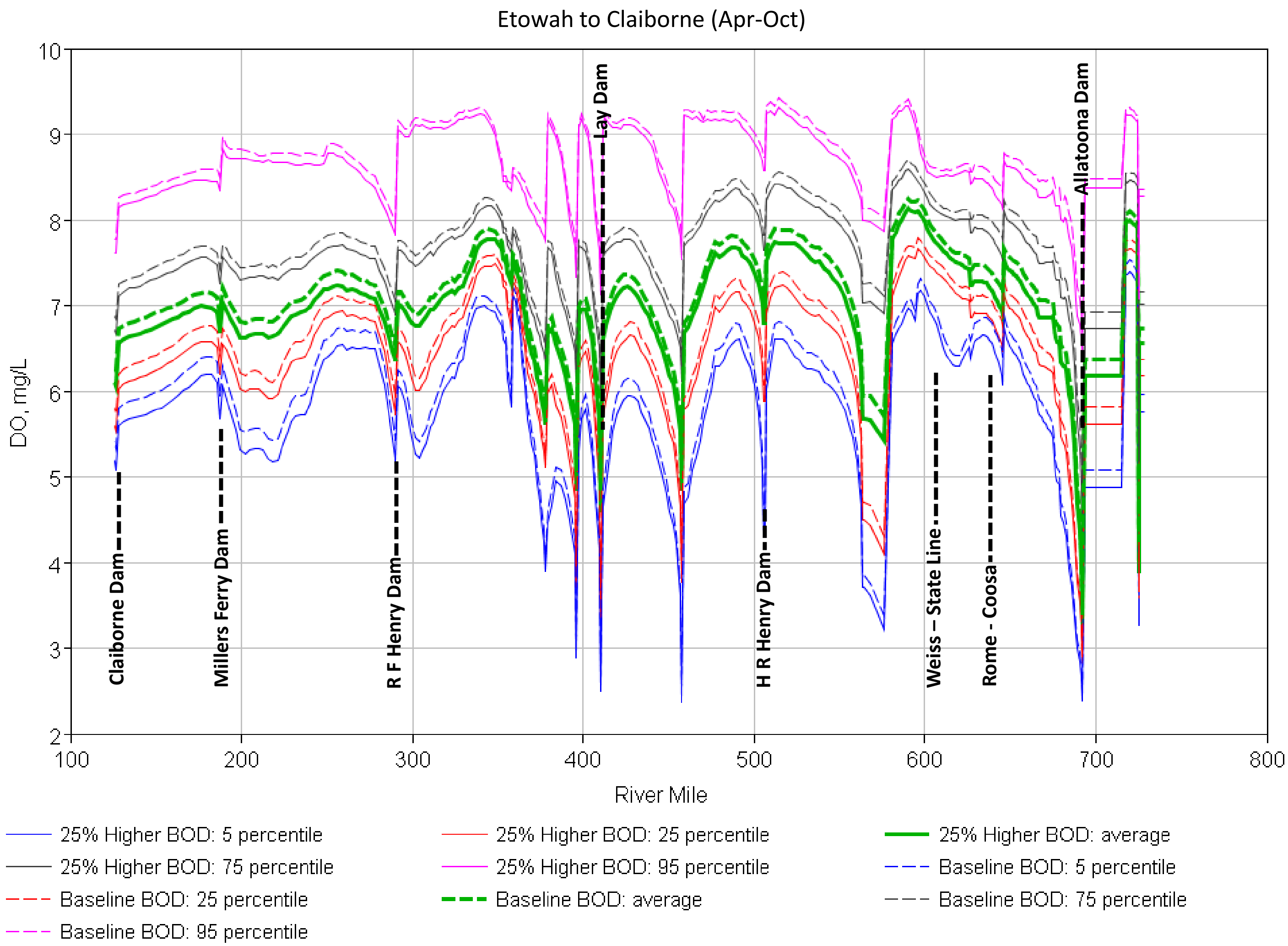

Figure 8.10 Longitudinal profiles of dissolved oxygen (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in BOD.

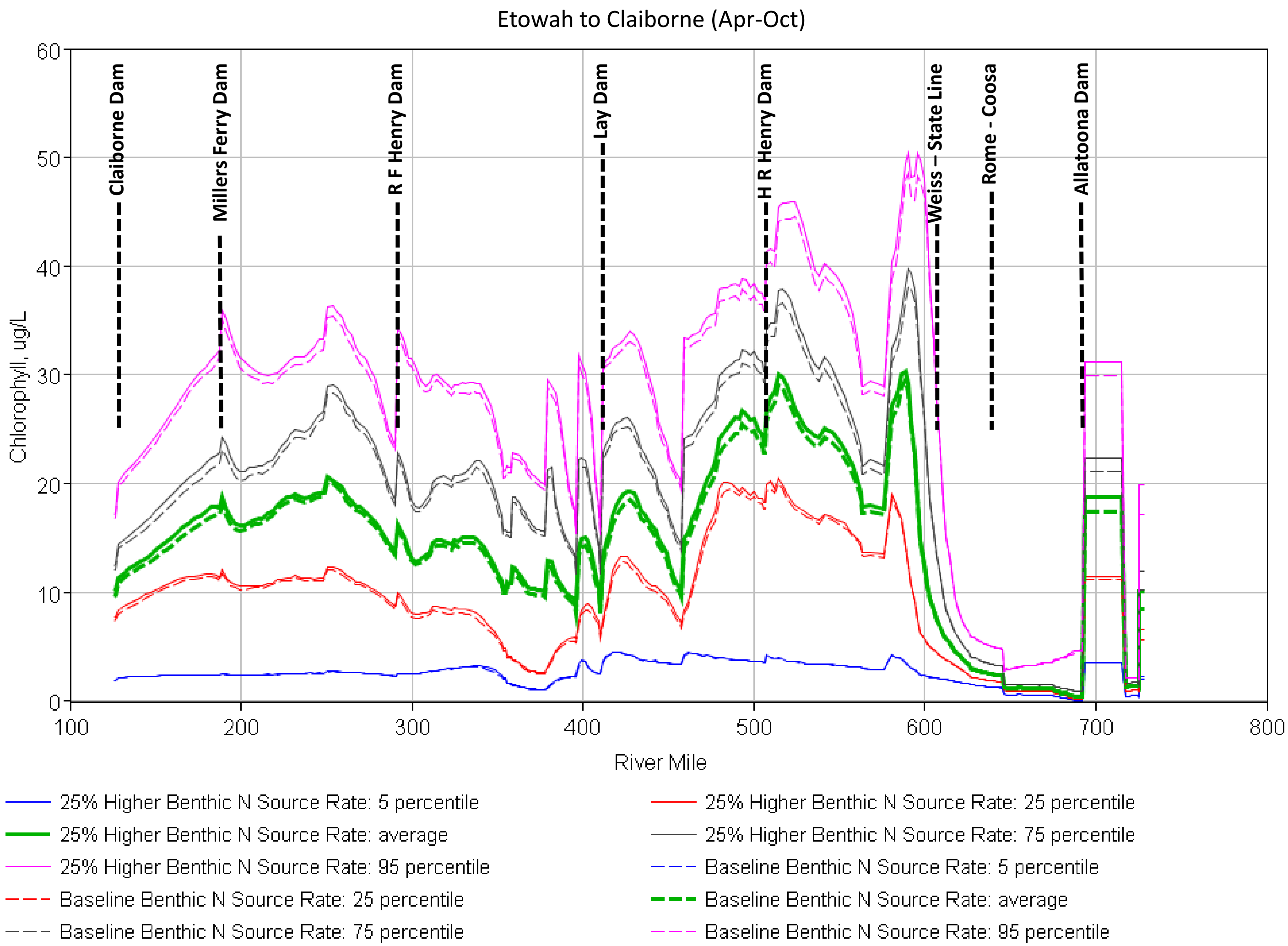

Figure 8.11 Longitudinal profiles of chlorophyll (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in benthic nitrogen source rate.

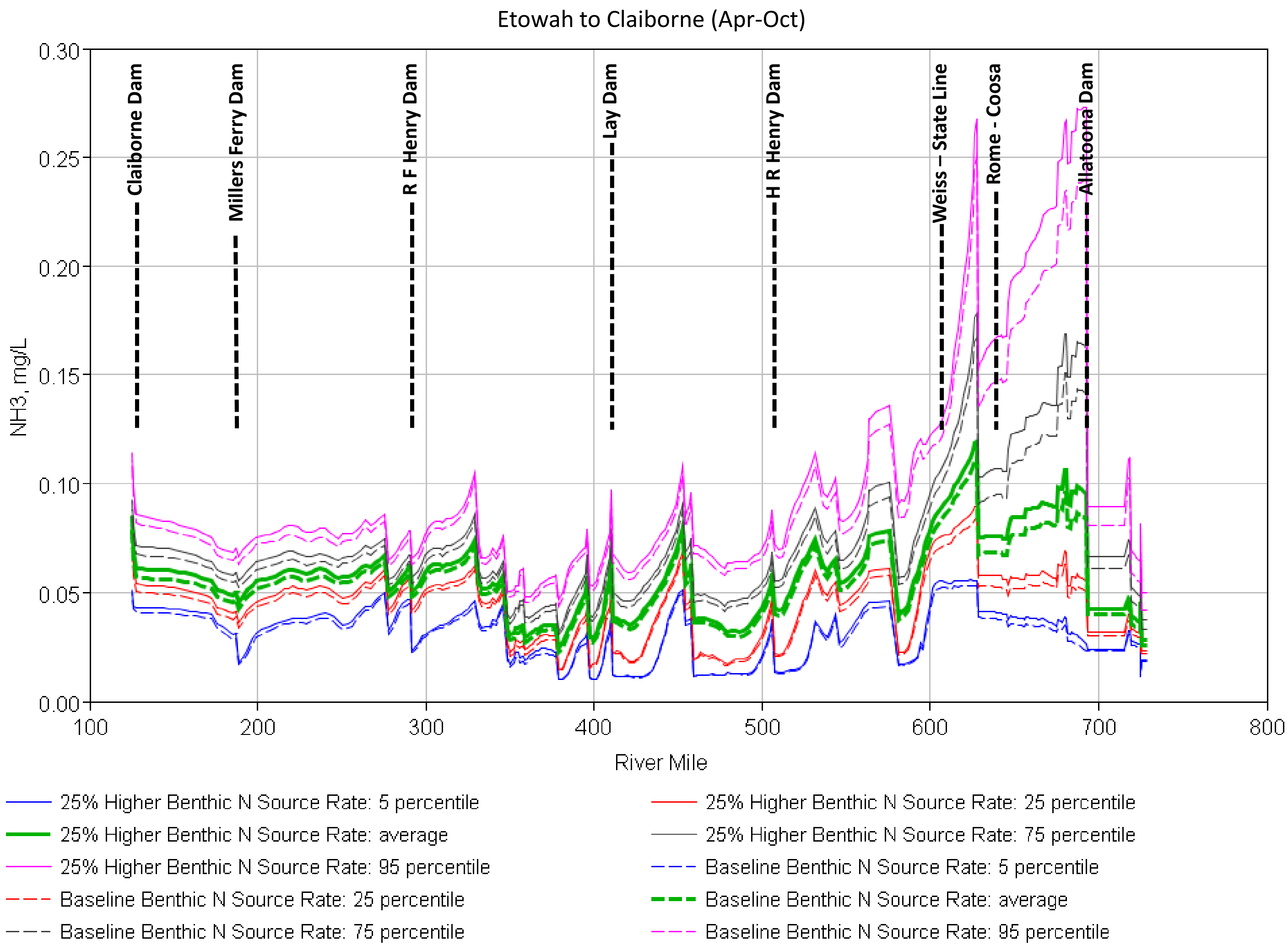

Figure 8.12 Longitudinal profiles of ammonia (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in benthic nitrogen source rate.

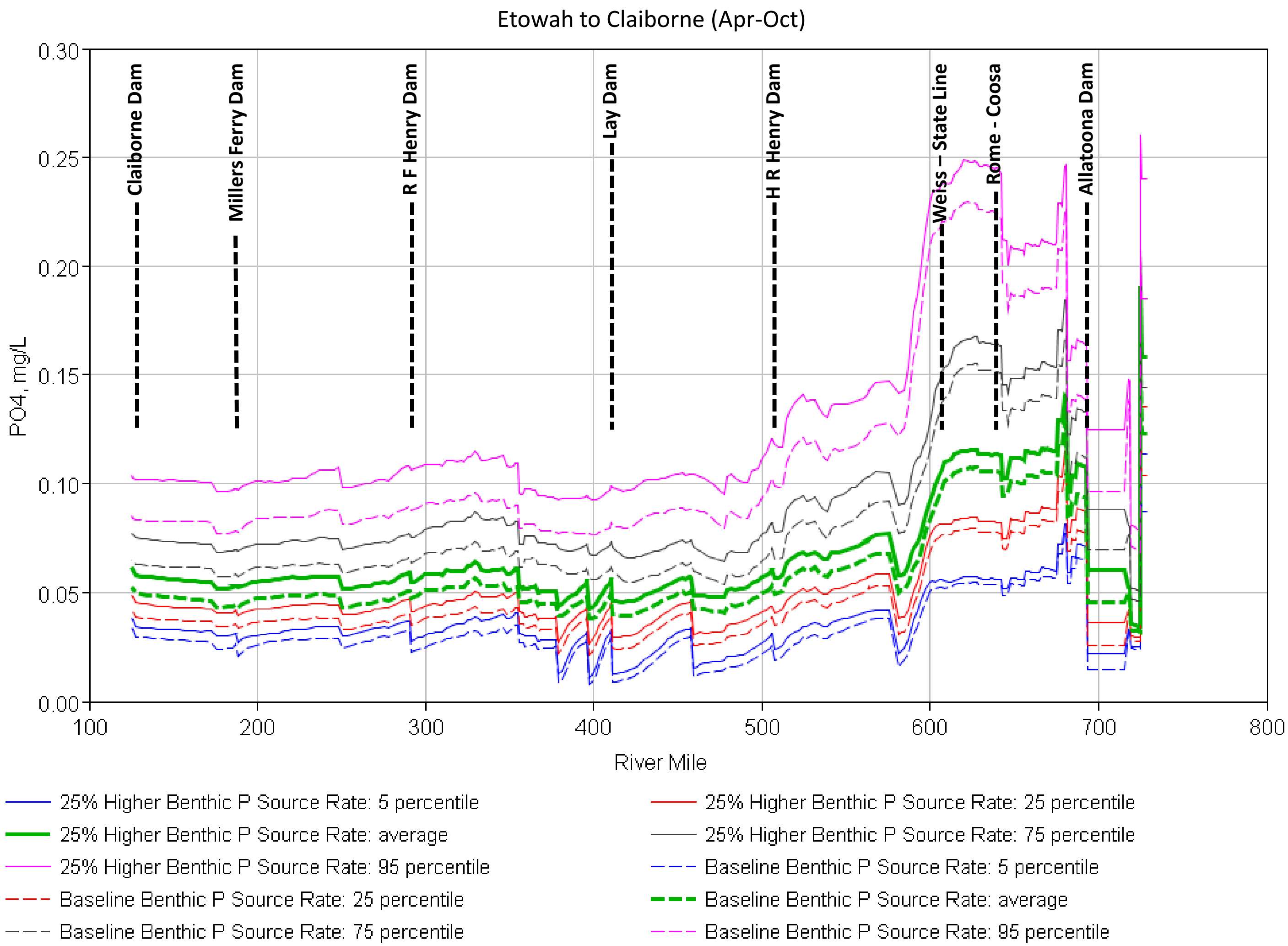

Figure 8.13 Longitudinal profiles of phosphate (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in benthic phosphorus source rate.

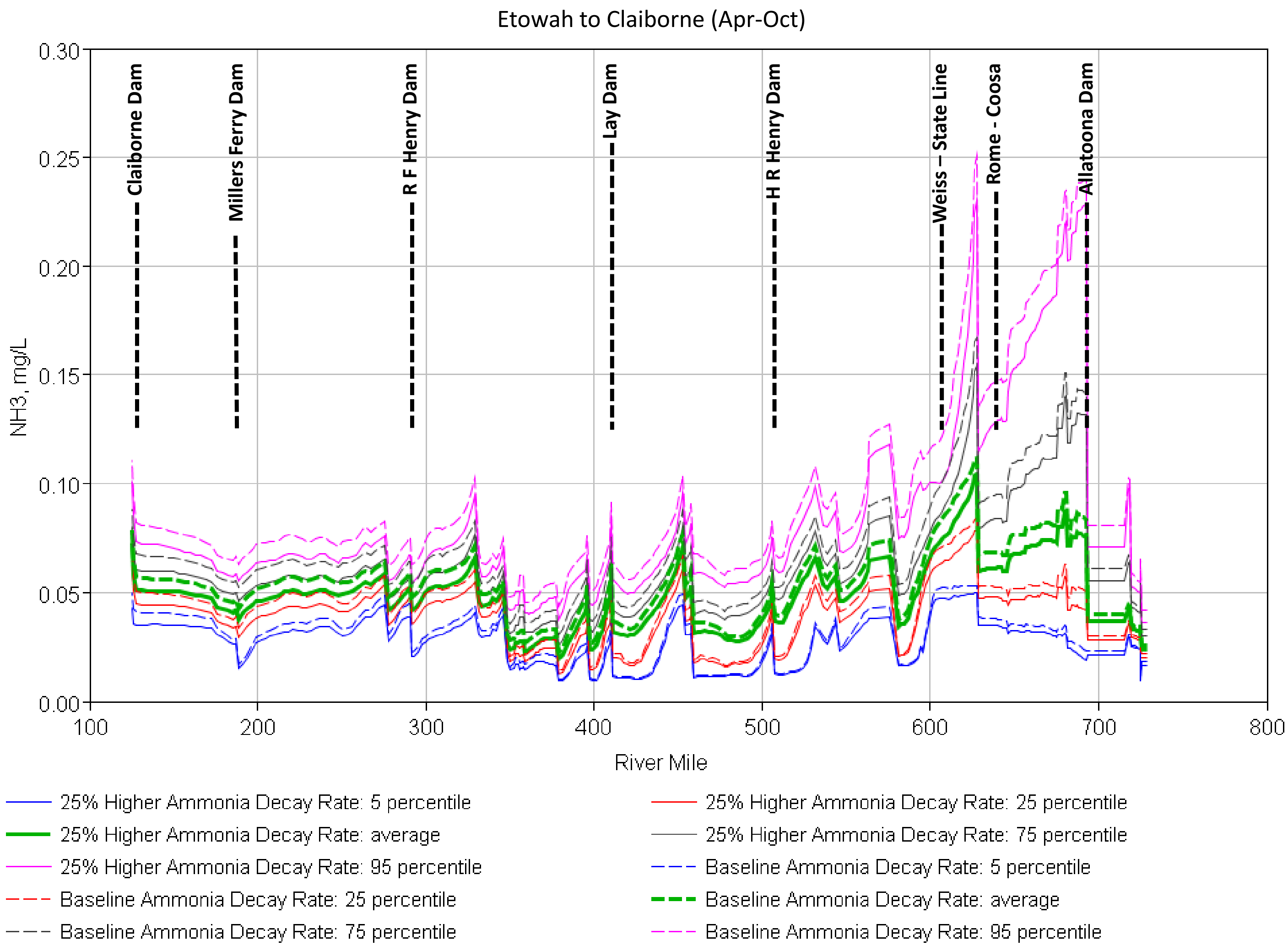

Figure 8.14 Longitudinal profiles of ammonia (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in ammonia decay rate.

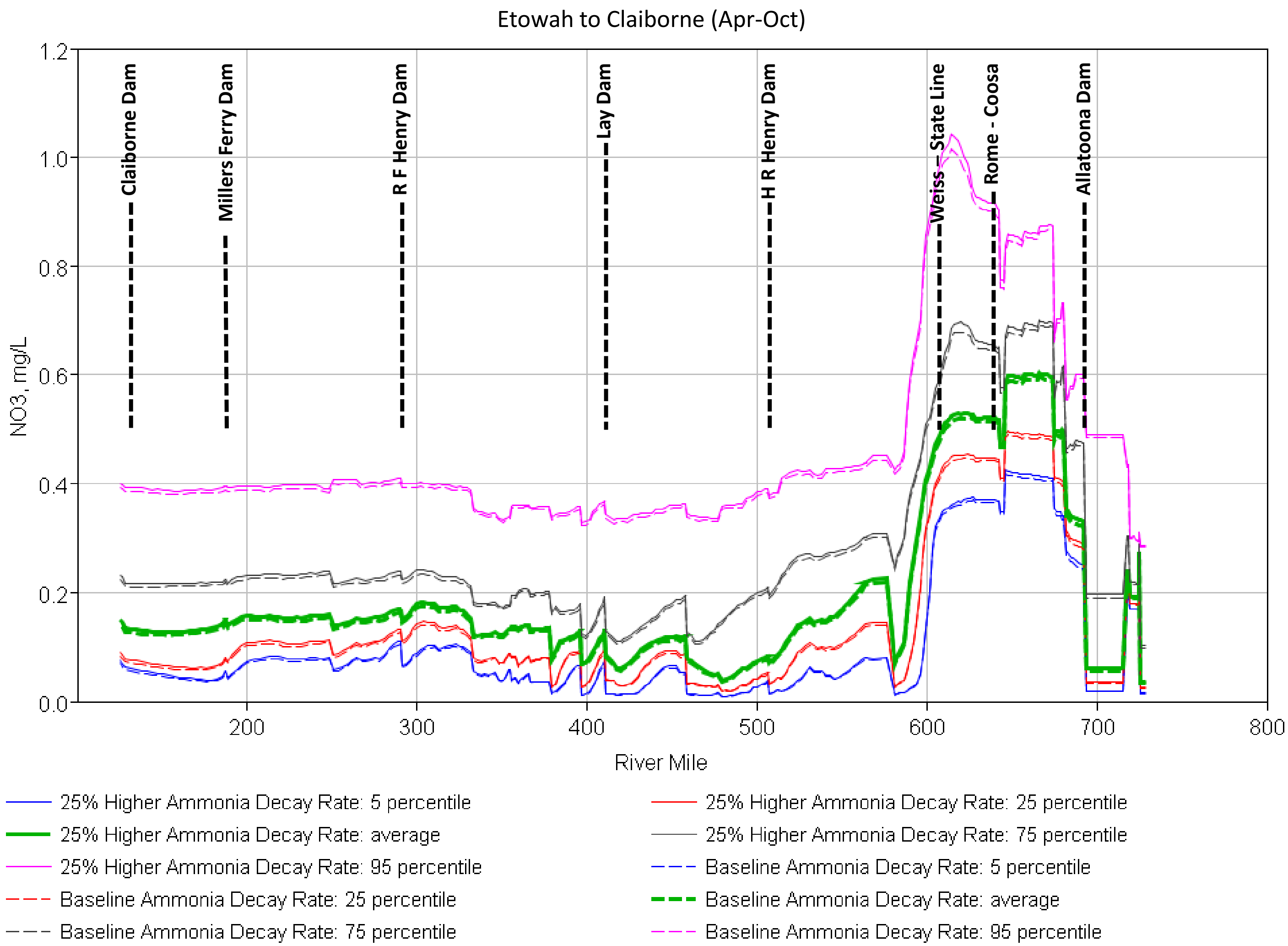

Figure 8.15 Longitudinal profiles of nitrate (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in ammonia decay rate.

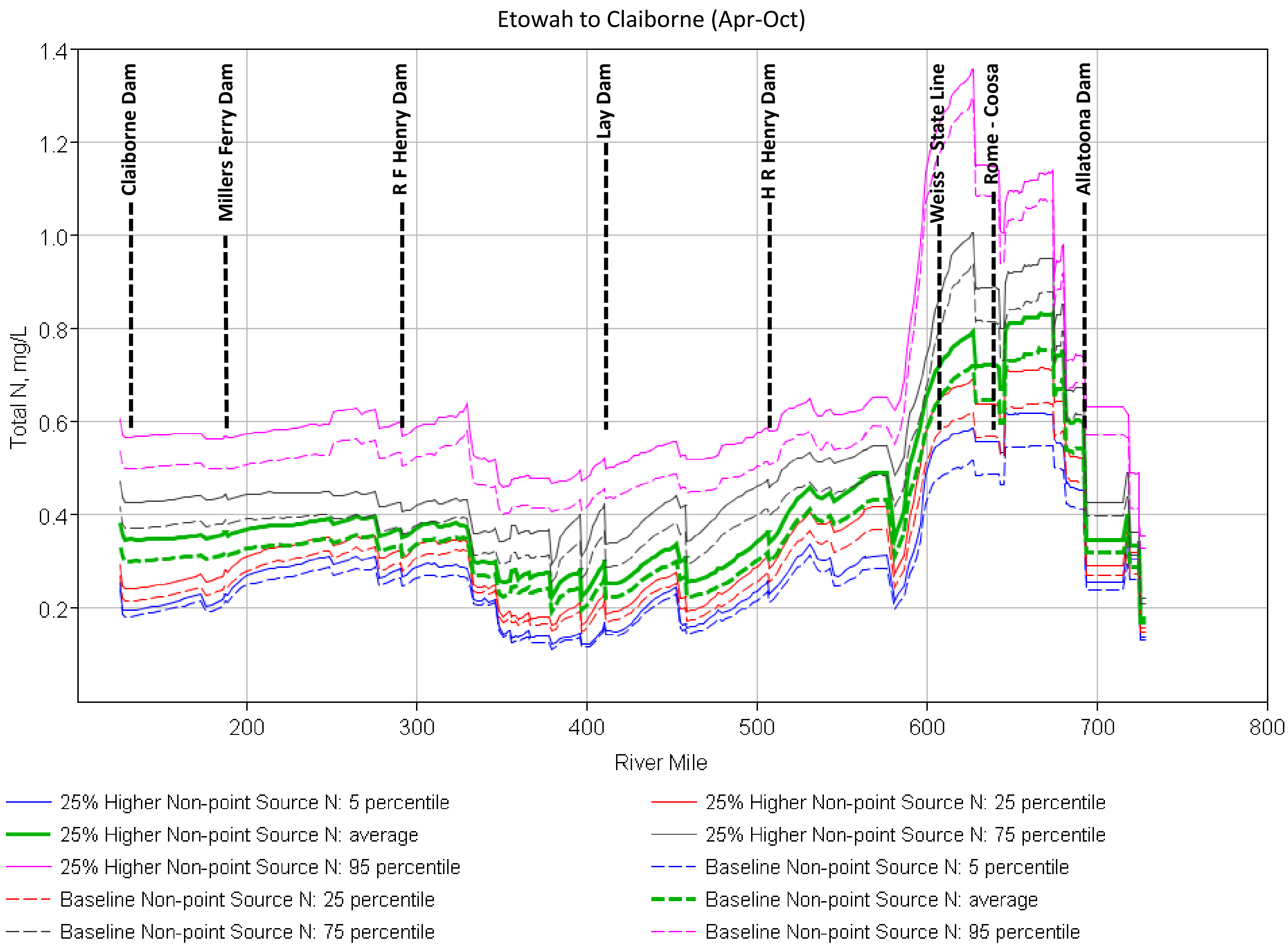

Figure 8.16 Longitudinal profiles of total nitrogen (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in non-point source nitrogen.

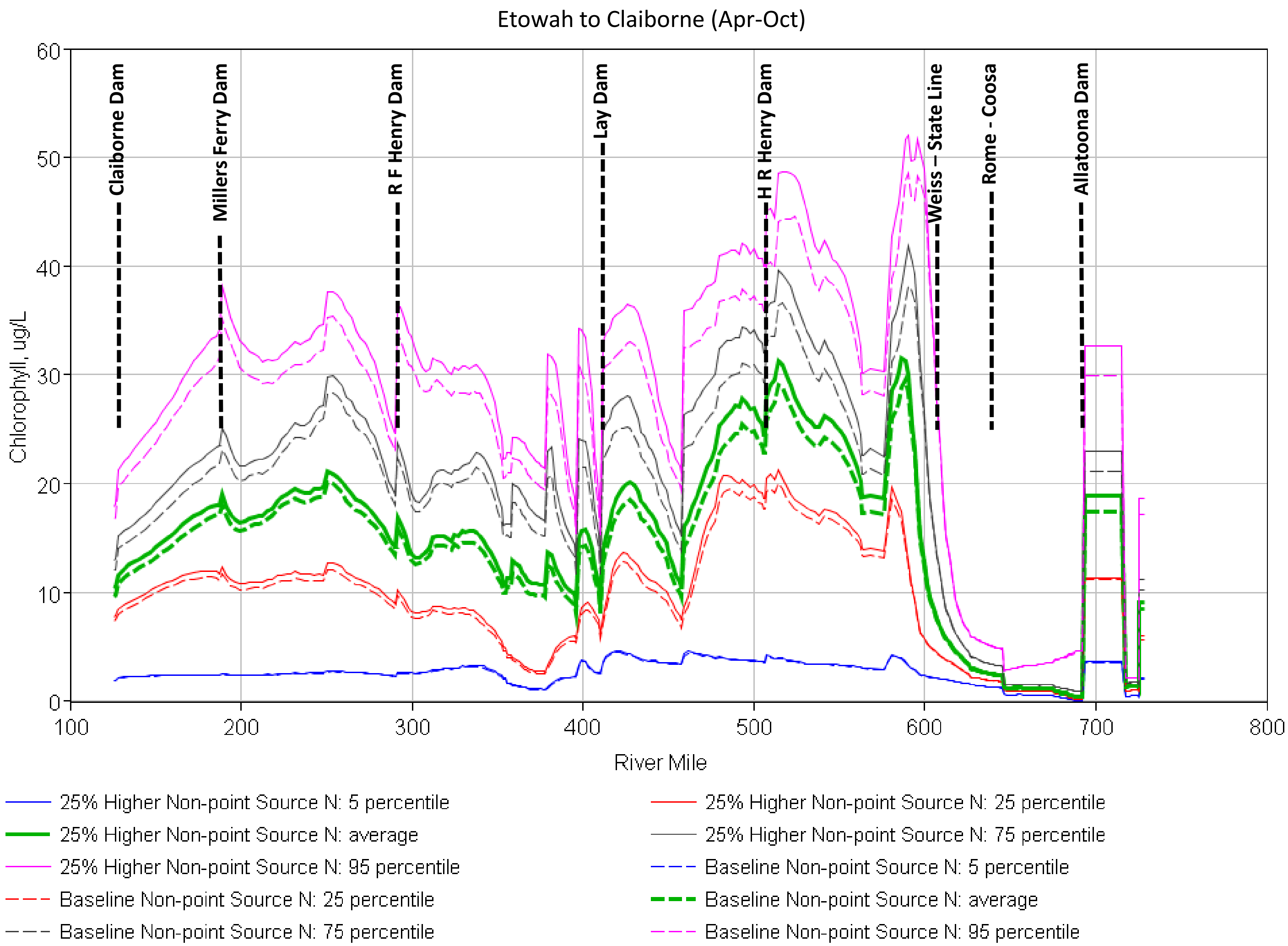

Figure 8.17 Longitudinal profiles of chlorophyll (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in non-point source nitrogen.

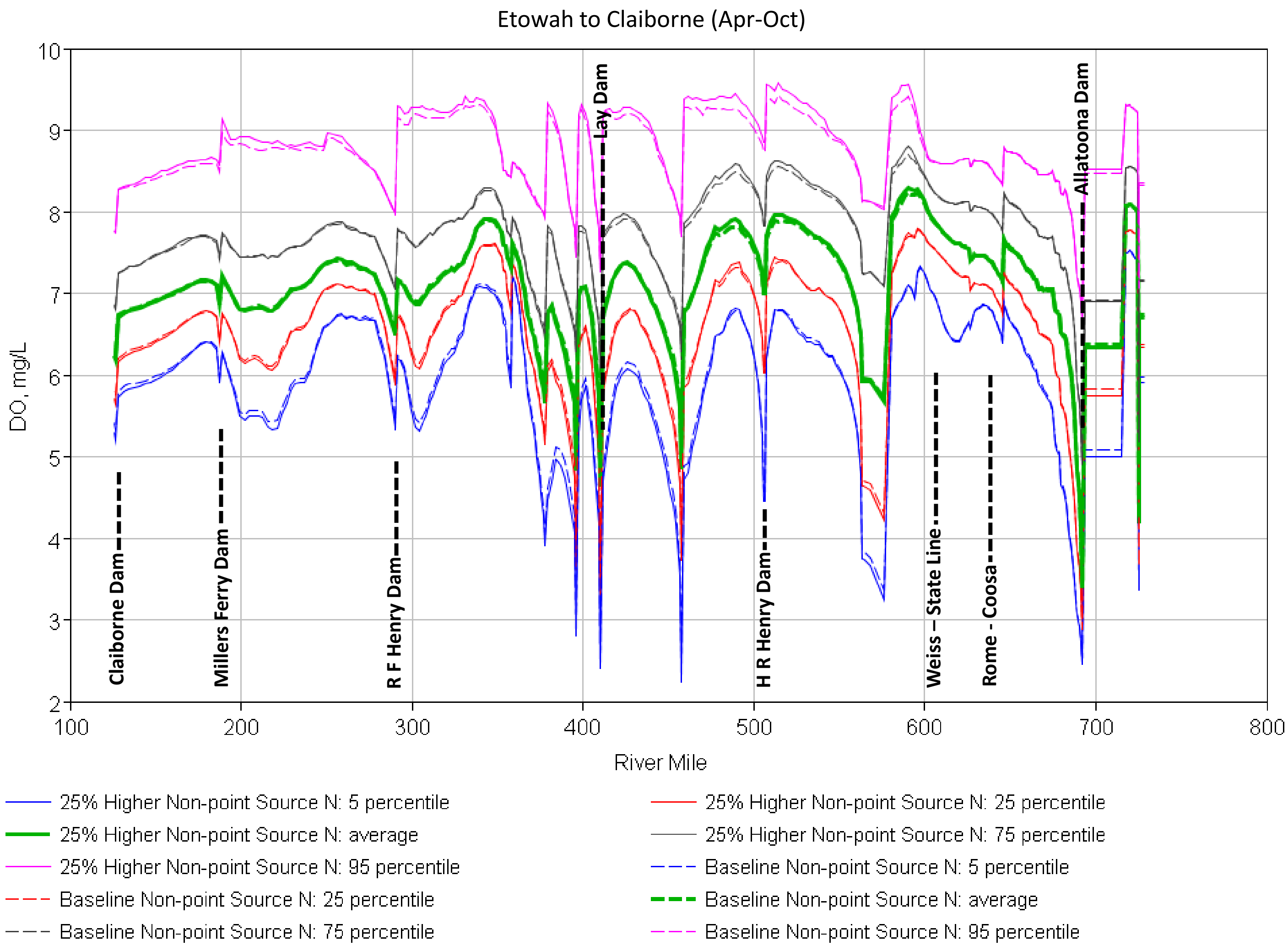

Figure 8.18 Longitudinal profiles of dissolved oxygen (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in non-point source nitrogen.

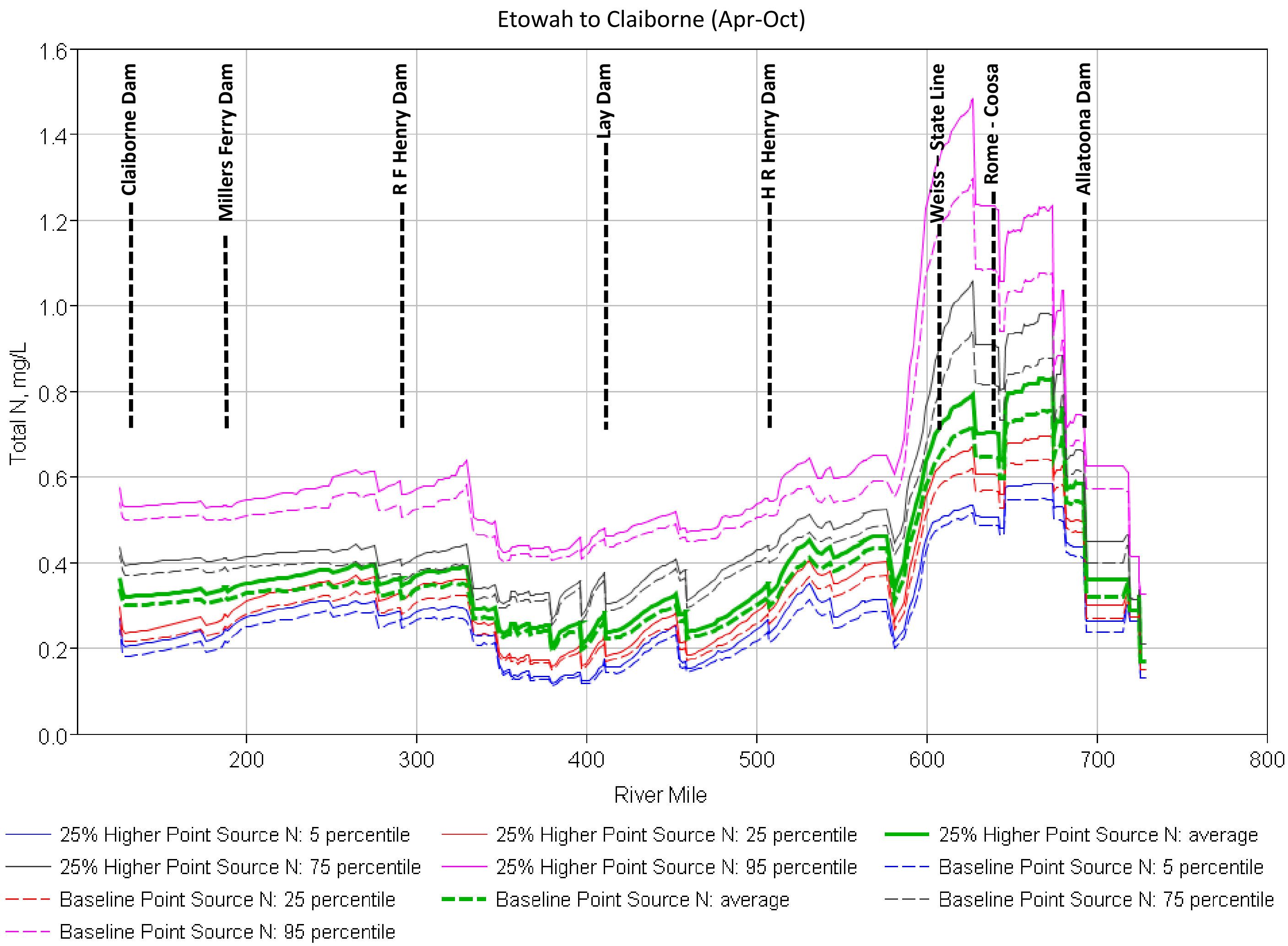

Figure 8.19 Longitudinal profiles of total nitrogen (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in non-point source nitrogen.

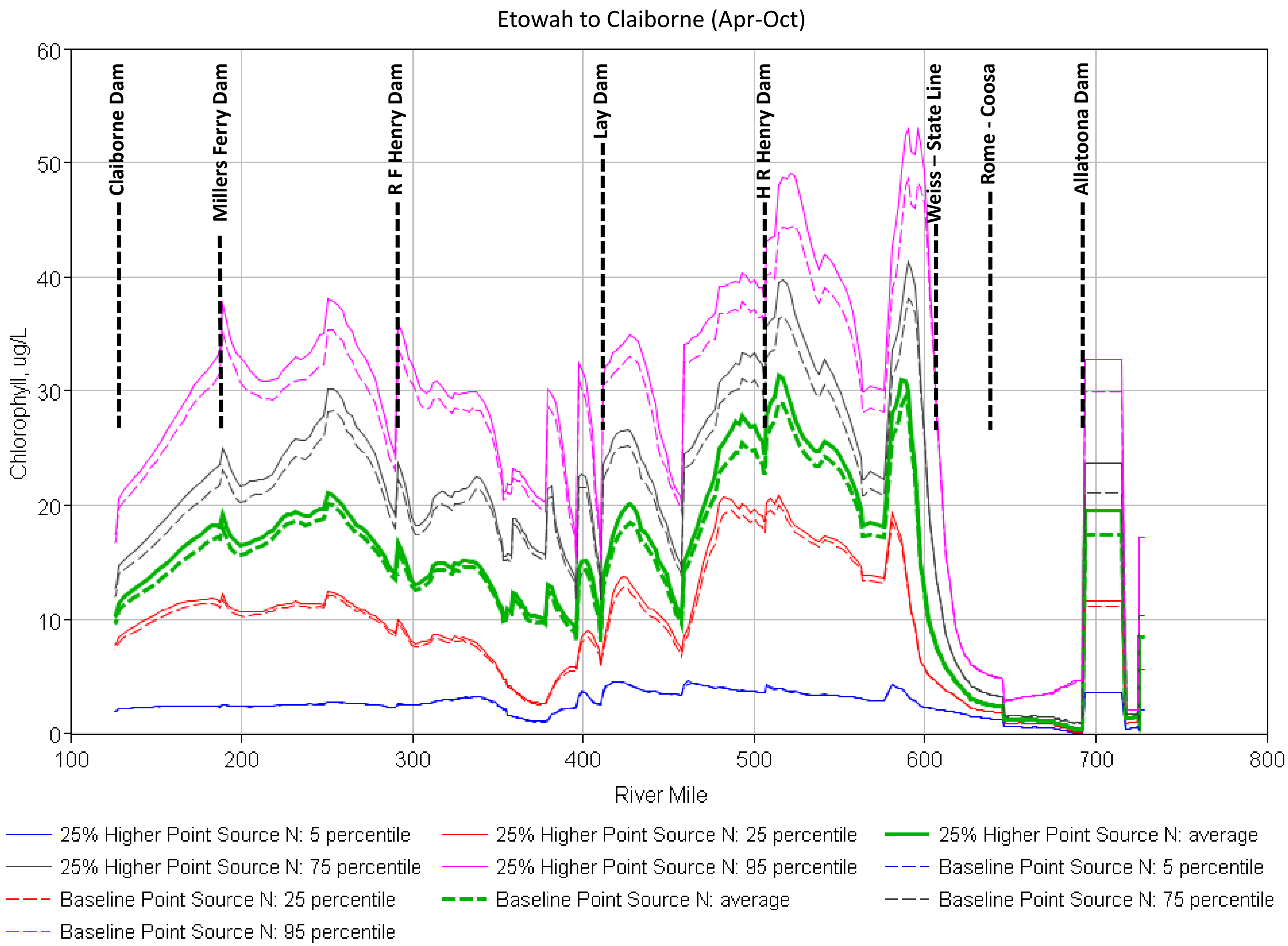

Figure 8.20 Longitudinal profiles of chlorophyll (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in non-point source nitrogen.

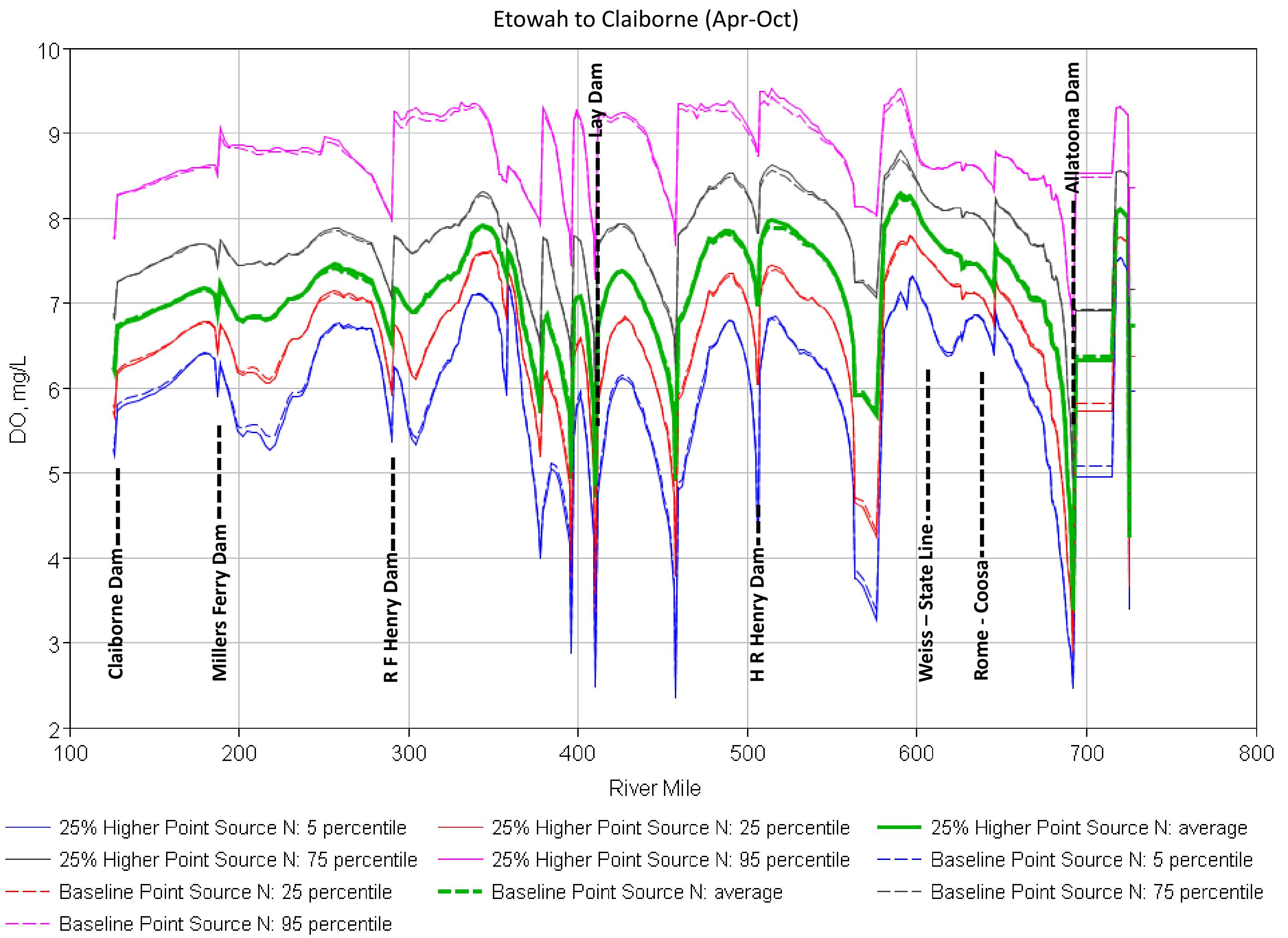

Figure 8.21 Longitudinal profiles of dissolved oxygen (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in point source nitrogen.

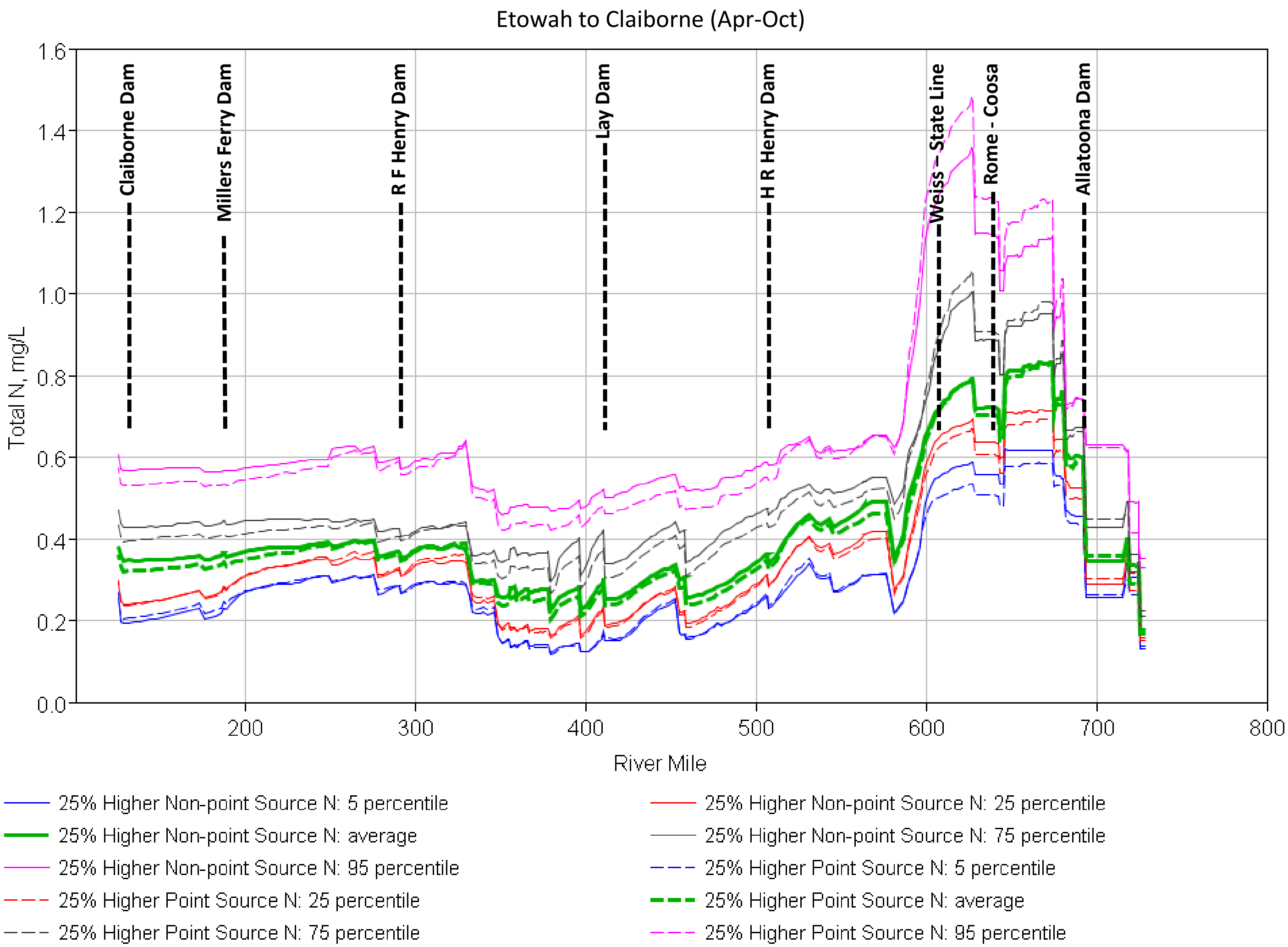

Figure 8.22 Longitudinal profiles of total nitrogen (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating the relative impact of a 25% increase in non-point source versus point source nitrogen.

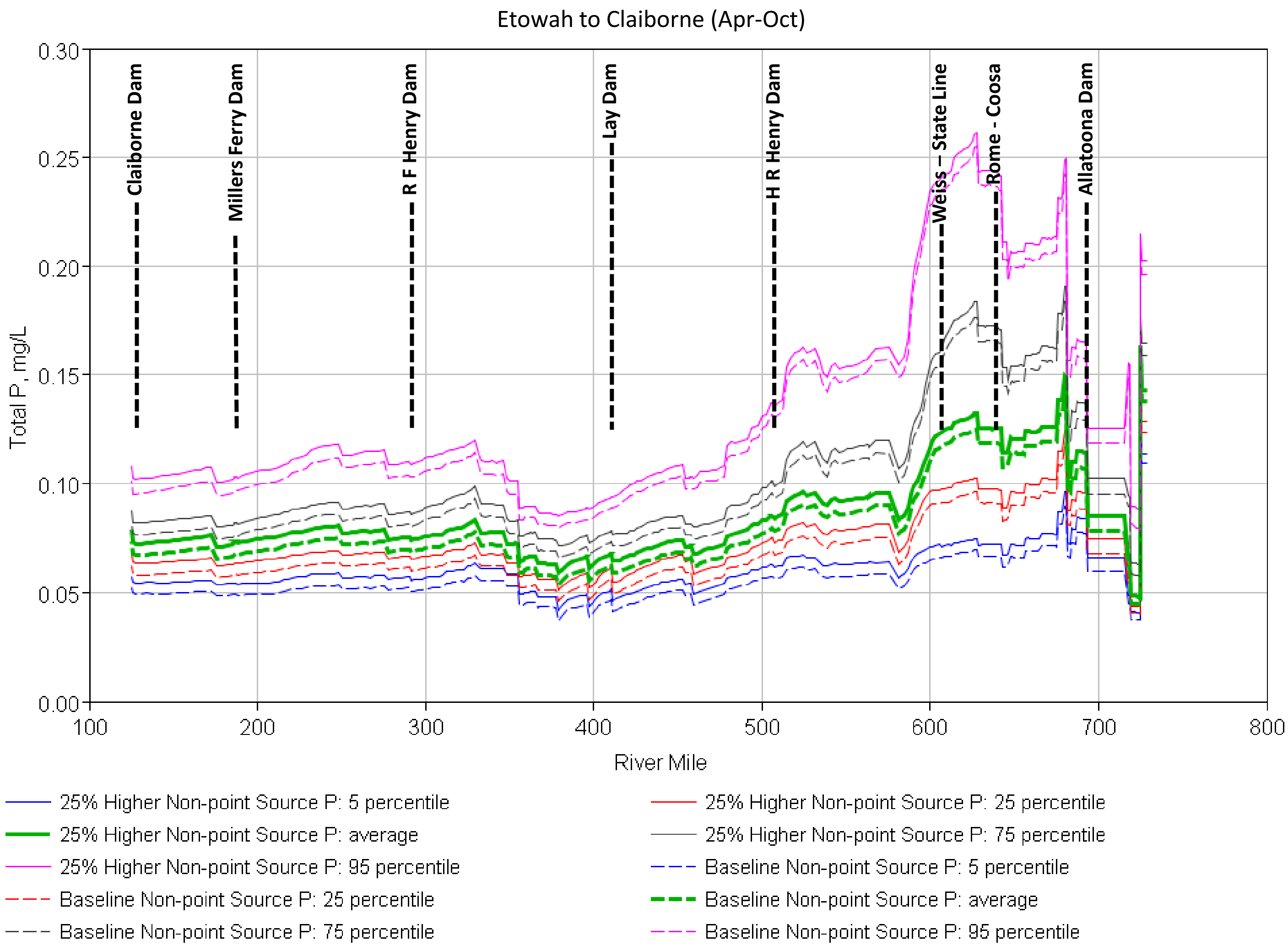

Figure 8.23 Longitudinal profiles of total phosphorus (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in non-point source phosphorus.

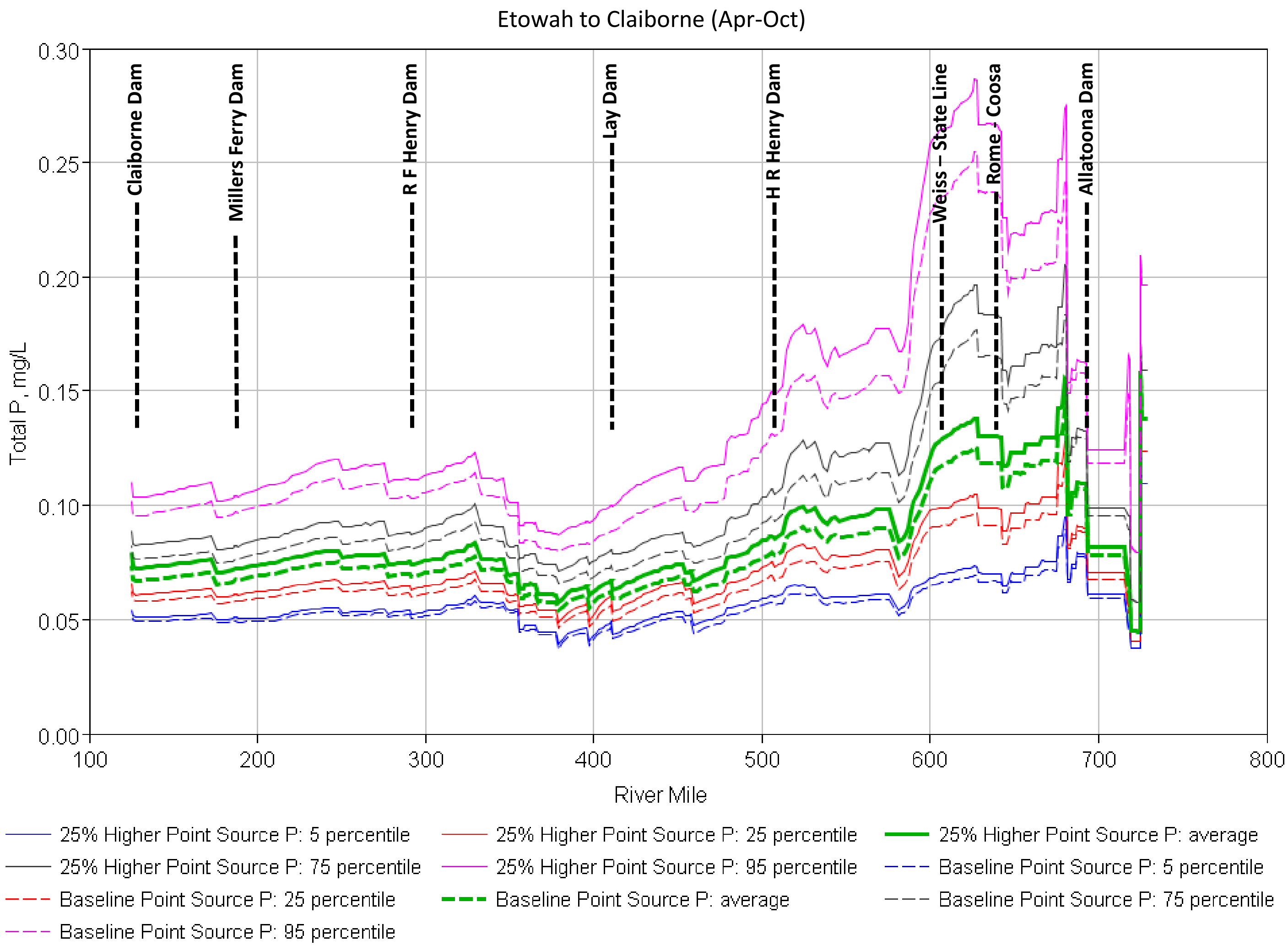

Figure 8.24 Longitudinal profiles of total phosphorus (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating sensitivity to a 25% increase in point source phosphorus.

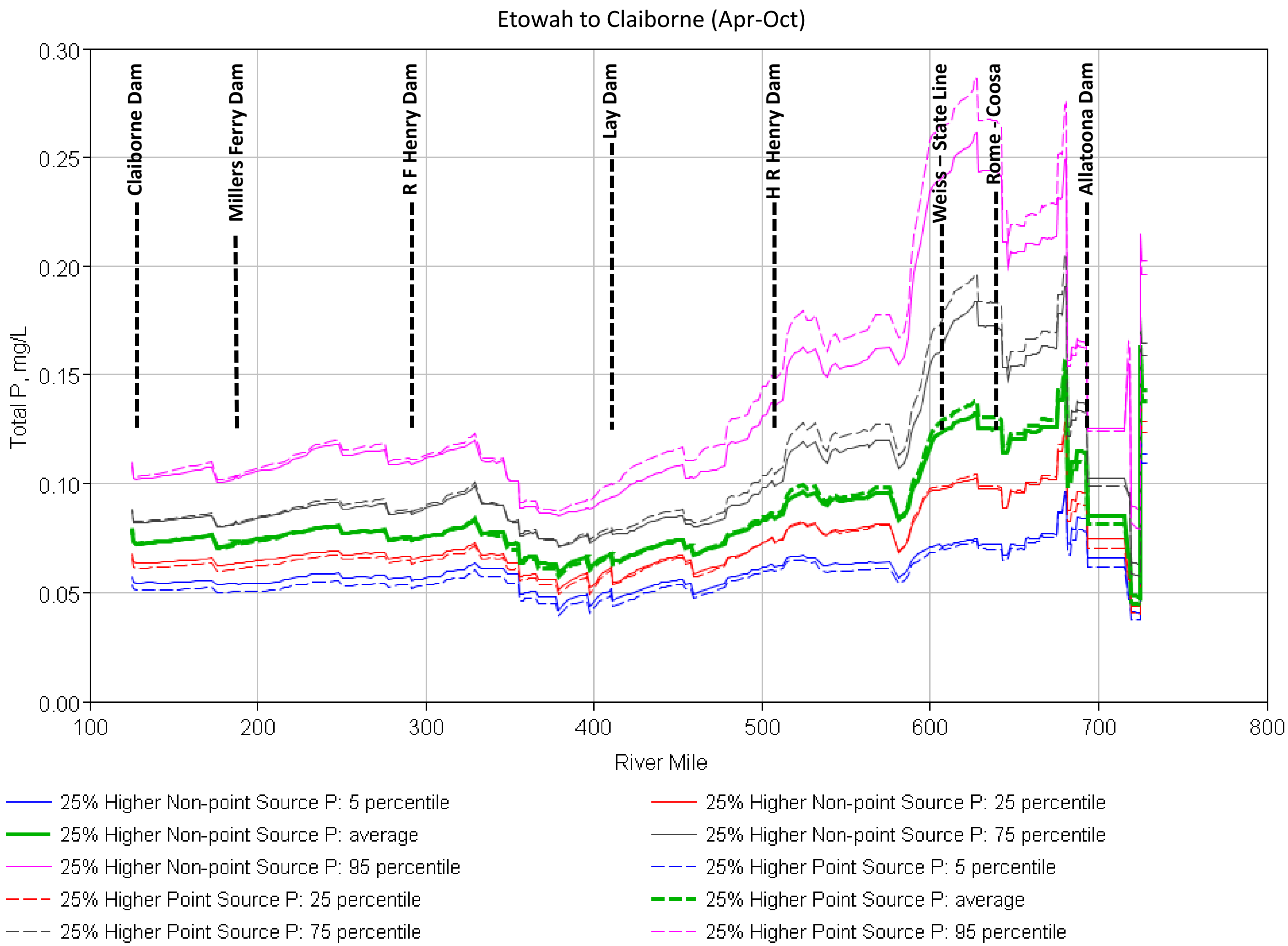

Figure 8.25 Longitudinal profiles of total phosphorus (average and 5, 25, 75 and 95 percentile) computed along Etowah to Claiborne during April – October illustrating the relative impact of a 25% increase in non-point source versus point source phosphorus.

Appendix E

ACT Hydropower Impact Analysis Draft

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ACT Hydropower Impact Analysis

Prepared by

The Hydropower Analysis Center

For

Mobile District USACE

June 2 2014

Table of contents

Introduction:

This chapter presents an analysis of the effects on hydropower benefits that are expected to result from proposed changes to system water control operations within the Alabama-Coosa-Tallapoosa (ACT) River Basin. The system hydropower benefits for energy and capacity were computed for the baseline condition, representing current water control operations, and for four alternative flow scenarios associated with the recommended ACT Water Control Plan described in previous chapters of this Environmental Impact Statement (EIS). The calculations of hydropower energy and capacity benefits are based on a fifty year simulation period using the HEC-ResSim model.

To understand how system operations can effect hydropower generation we will first consider the mathematics used to approximate the amount of power produced from a hydropower facility, the power equation (Eq. 1). This equation shows that power is directly proportional to three variables; the efficiency of the plant turbines, the amount of flow going through the turbines, and the head, the height of the water in the reservoir relative to its height after discharge.

$$P = e * g * Q * H \qquad \text{Eq. 1}$$

Where P=power (kw) , e=turbine efficiency , g = gravitational constant (m/s^2) , Q-flow (m^3/s), and H=head (m).

Reservoir operations can affect all three of these variables. Higher or lower operational reservoir elevations change the head. Maximum or minimum flow requirements used for flood risk management and environmental purpose can affect the flow. Although power is linear in both head and flow, this relationship quickly becomes non-linear with the inclusion of efficiency which is both a non-linear function of head and flow.

In general the hydropower benefits resulting from generation can be divided into two components: energy benefits and capacity benefits. A change in energy benefits is the result of a change in the amount of water that is available to pass through the turbines. The value of this benefit changes both daily and seasonally as a function of the systems electrical load. For example energy may be more valuable during the height of the summer heat while businesses and residents are attempting to cool their environments as opposed to the fall or winter when air conditioners maybe turned off. The capacity benefit is a measure of the amount of capacity that the project can reliably contribute towards meeting system peak power demands.

The value of the hydropower benefits calculated in this chapter is based upon the cost of utilizing the most likely alternative source for power. For example, if an operational strategy reduces hydropower storage or flow, the loss in energy benefits is equivalent to the cost of replacing the lost power with the most likely alternative source of power. In addition it may decrease the amount of capacity that the hydropower plant can contribute to the peak system load, making it necessary to replace this lost capacity with a thermal alternative.

This chapter contains the following: 1) an overview of the Bulk Power system for the ACT River Basin with an emphasis on hydropower 2) a descriptive analysis of the potential annual and seasonal changes in hydropower production due to water control management decisions, and 3) a description of the process of calculating the changes in the energy and capacity benefits of the ACT system resulting from the implementation of the recommended plan.

ACT Watershed Bulk Power System Overview:

The ACT watershed lies primarily in the Southeastern sub-region of the SERC (Southeastern Reliability Corporation). This corporation is responsible for improving the reliability related to the critical infrastructure of the bulk power system in the region. Since 1998, the Southeastern sub-region has undergone a significant increase in natural gas capacity. Natural gas currently nearly matches coal in percentage of total system capacity at around 35%. Nuclear and Hydroelectric energy make up the remaining bulk energy making up 15% and 10% of total system capacity respectively. (Figure 1)

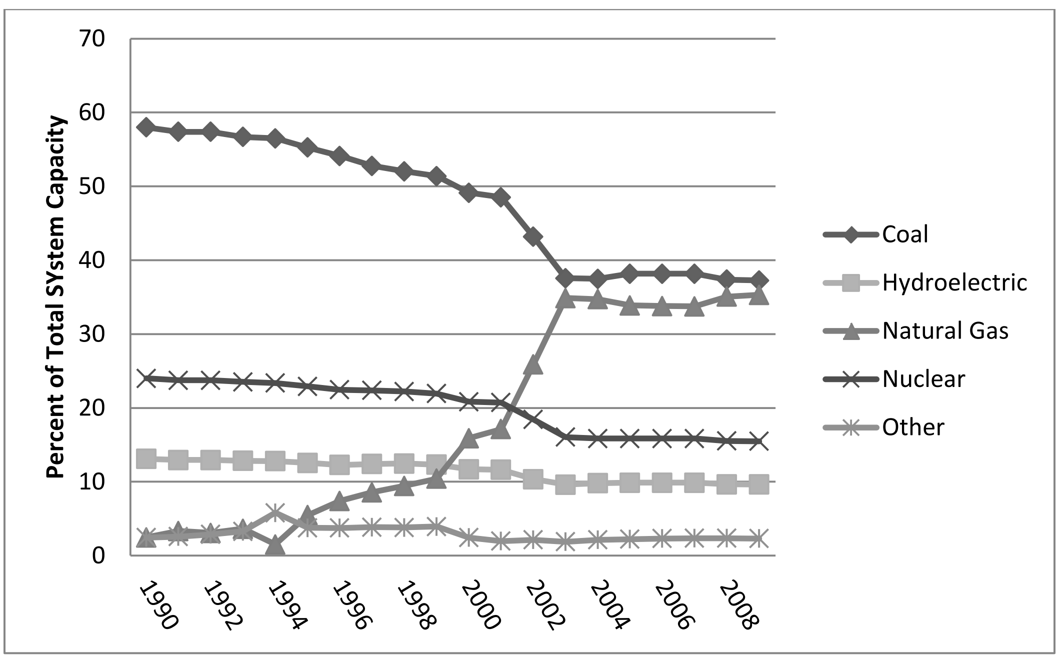

FIGURE 1.HISTORICAL TRENDS FOR THE PERCENT OF TOTAL SYSTEM CAPACITY FOR THE SOUTHEASTERN SUB-REGION OF SERC

Coal and nuclear power are predominately run as baseload plants, facilities that produce constant rates of generation to meet the systems continuous regional demands.

Natural gas and hydropower plants on the other hand are generally run as peaking plants, meeting the daily and seasonal peak loads throughout the system. This is important in conceptually understanding what

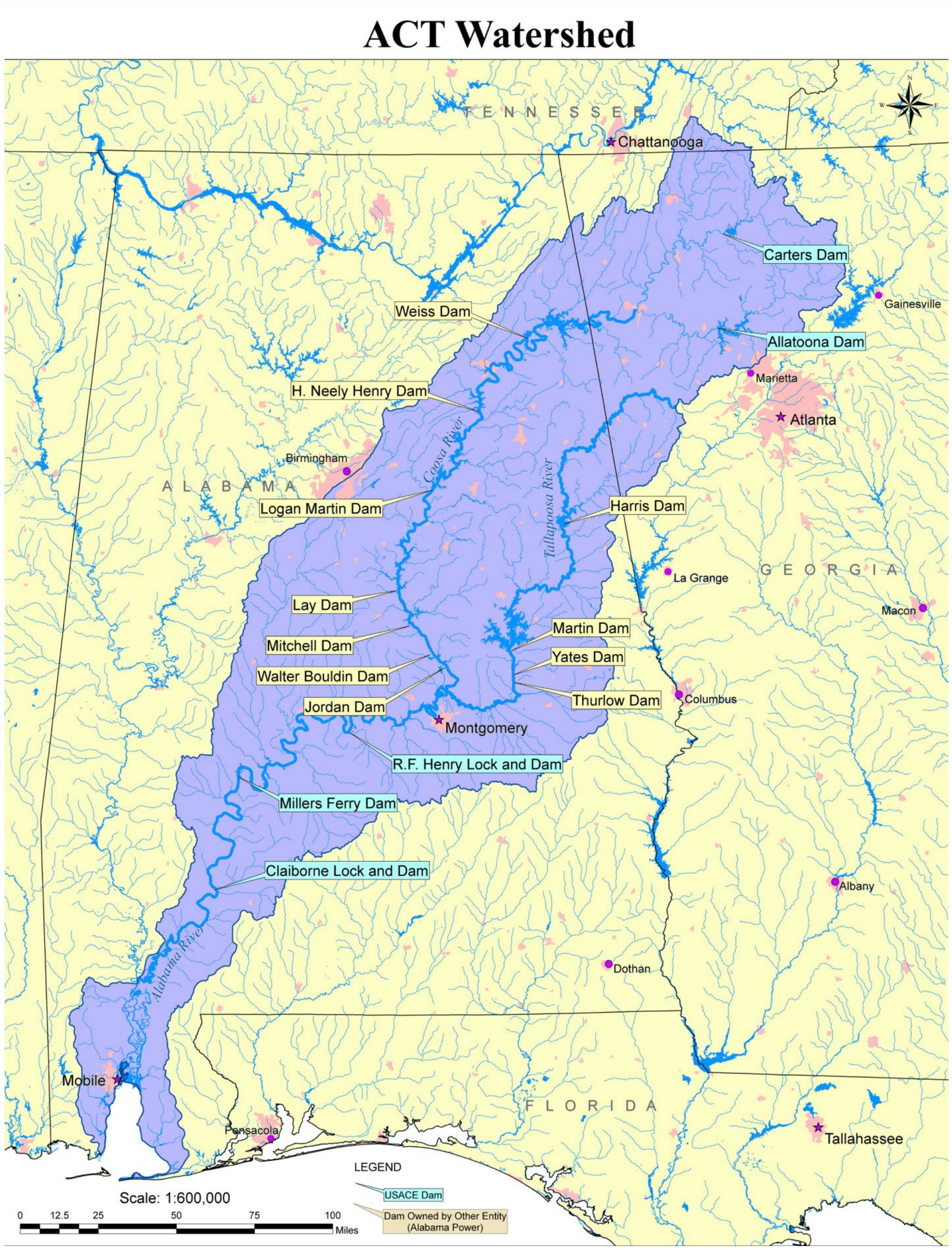

FIGURE 2 ACT WATERSHED HYDROPOWER SYSTEM MAP

alternative thermal plants might be used to replace hydropower if changes in operations dictated such a need. As an illustrative example consider the 2009 generation pattern reported by the EIA for the Southeastern sub-region (Figure 3). Increases (decreases) in percent of total generation for hydropower are matched by decreases (increases) in percent generation for natural gas. The same coupling of energy sources can be seen in the relationship between coal and nuclear power.

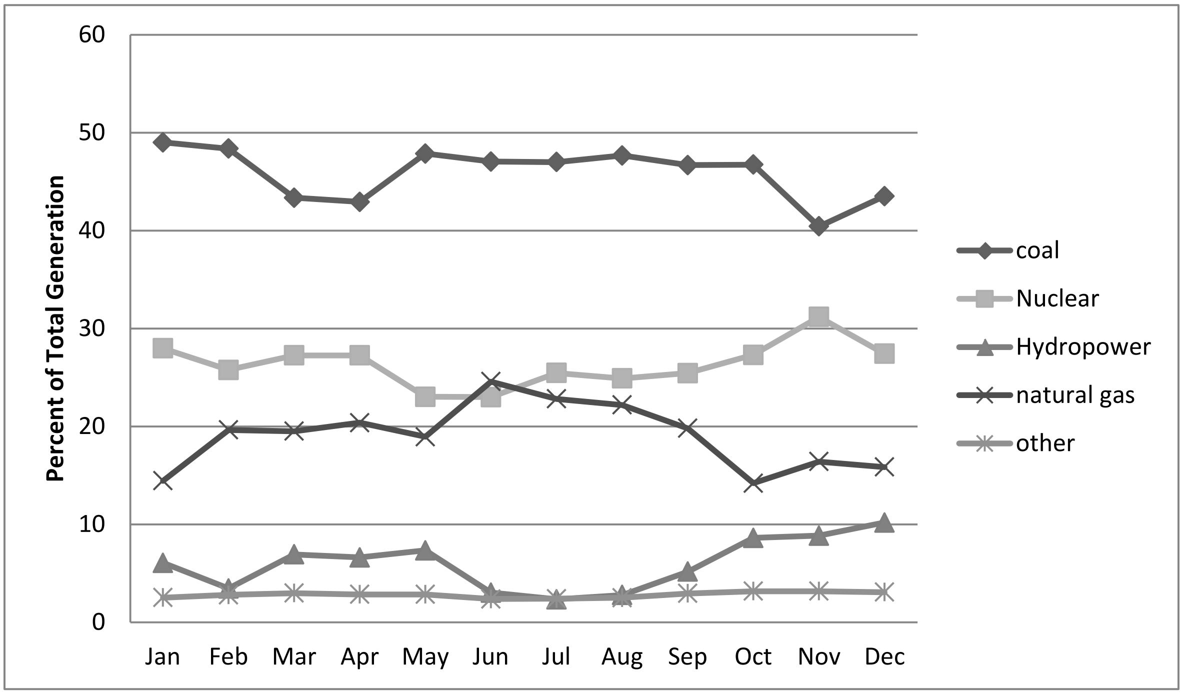

FIGURE 3 PERCENT OF TOTAL GENERATION BY FUEL TYPE FOR SOUTHEASTER SUB-REGION OF SERC

ACT Hydropower System:

The Corps of Engineers (Corps) operates four dams with hydropower capabilities in the ACT River Basin. The RF Henry Dam and Millers Ferry Lock and Dam are both located on the Alabama River around 200 miles upstream of Mobile Bay. These two dams work together with a combined generating capacity of 172 MW in supporting multiple purposes other than hydropower including navigation and waste assimilation. Allatoona Dam is located northwest of Atlanta on the Etowah River in Georgia. It is operated as a peaking plant with an installed generating capacity of 72 MW. The final plant, Carters Dam is located on the Coosawattee River in Georgia and is operated as a pump storage plant. This plant consists of two pools, Carters Lake and Carters Reregulation Pool. During peak loading hours, water is released from Carters Lake to the re-regulation pool generating energy. When demand is low, energy is purchased to pump water back into the Carters Lake from the re-regulation pool. This plant has a total generating capacity of 575 MW.

Ten non-Corps plants owned by Alabama Power Company are also considered in this analysis. As a whole, Alabama Power Company owns a total of 14 peaking power plants making up 6% of the company's power generation. The 1396 MW of installed generating capacity from these eleven plants are located on the Tallapoosa and Coosa Rivers.

TABLE 1 PLANT CHARACTERISTICS FOR ACT WATERSHED

Plant	Owner	No. of units	Installed Capacity (MW)
Weiss Dam	Alabama Power Company	3	81
H. Neely Henry	Alabama Power Company	3	70
Logan Martin	Alabama Power Company	3	135
Lay	Alabama Power Company	6	180
Mitchell	Alabama Power Company	4	166
Jordan	Alabama Power Company	4	100
Walter Boydn	Alabama Power Company	3	225
Harris	Alabama Power Company	2	132
Yates	Alabama Power Company	2	47
Thurlow	Alabama Power Company	3	78
Martins	Alabama Power Company		182
RF Henry	USACE	4	82
Millers Ferry	USACE	3	90
Allatoona	USACE	3	72
Carters	USACE	4	575
Total			2215

Hydropower Generation:

To determine the change in energy generation resulting from implementation of the recommended ACT Water Control Plan, an analysis was performed to determine the average annual energy generated in the baseline condition and for each of the alternative flow scenarios using the fifty-year ResSim Model simulation period. As shown in Figure 4 there is a less than a one percent decrease in average annual energy for each alternative when compared to the baseline condition. For the sensitivity alternatives illustrated in Figure 5 a large decrease in annual generation is experienced under Plan G85 alternative.

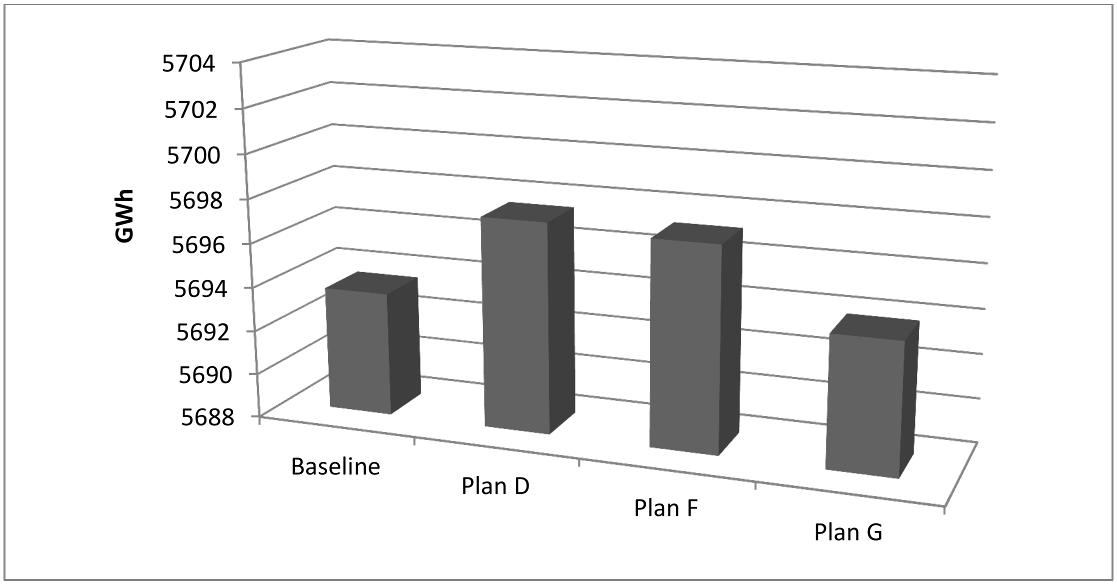

FIGURE 4 AVERAGE ANNUAL HYDROPOWER SYSTEM GENERATION BY ALTERNATIVES D, F, AND G

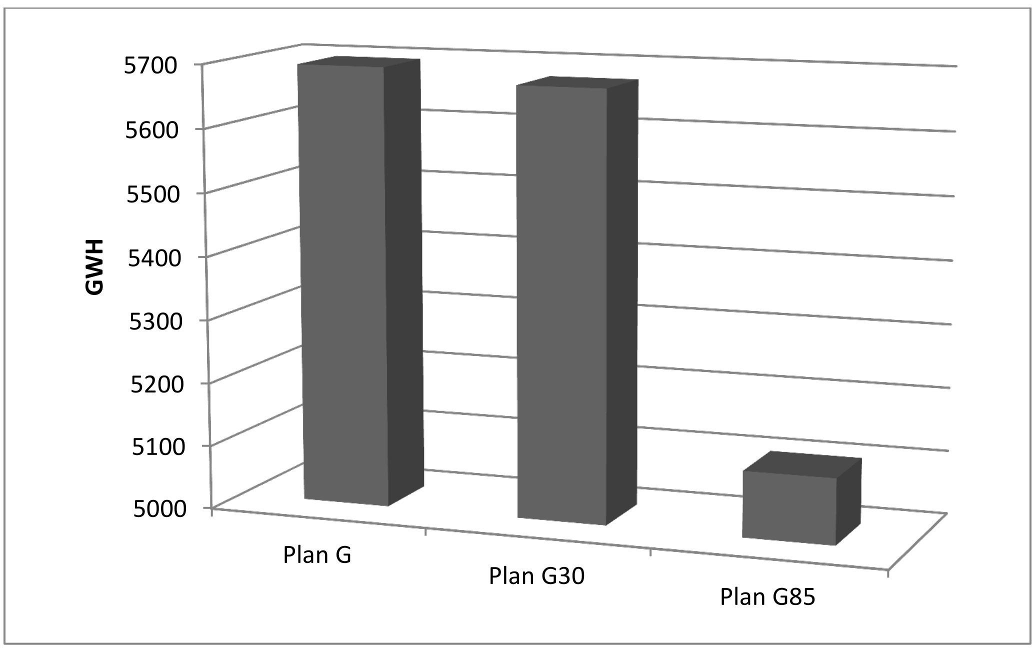

FIGURE 5 AVERAGE ANNUAL HYDROPOWER SYSTEM GENERATION FOR ALTERNATIVES G ,G30 AND G85

The value of the replacement energy has a seasonal trend following the demand and generating resource availability through the year. Therefore, in calculating annual benefits, it is necessary to look at how the generated energy is distributed on a monthly basis. Figure 6 shows both the average monthly energy generated and the percent difference between the baseline and the three alternative flow scenarios; Plan D, Plan F, Plan G. From January through August, the simulation shows a two percent or less increase in power generation for all four alternative flows scenarios compared to the baseline condition. The majority of the loss in generation for the alternatives occurs between September and November with a peak increase occurring in October, amounting to almost six percent. All alternative flow scenarios show an increase in generation in December.

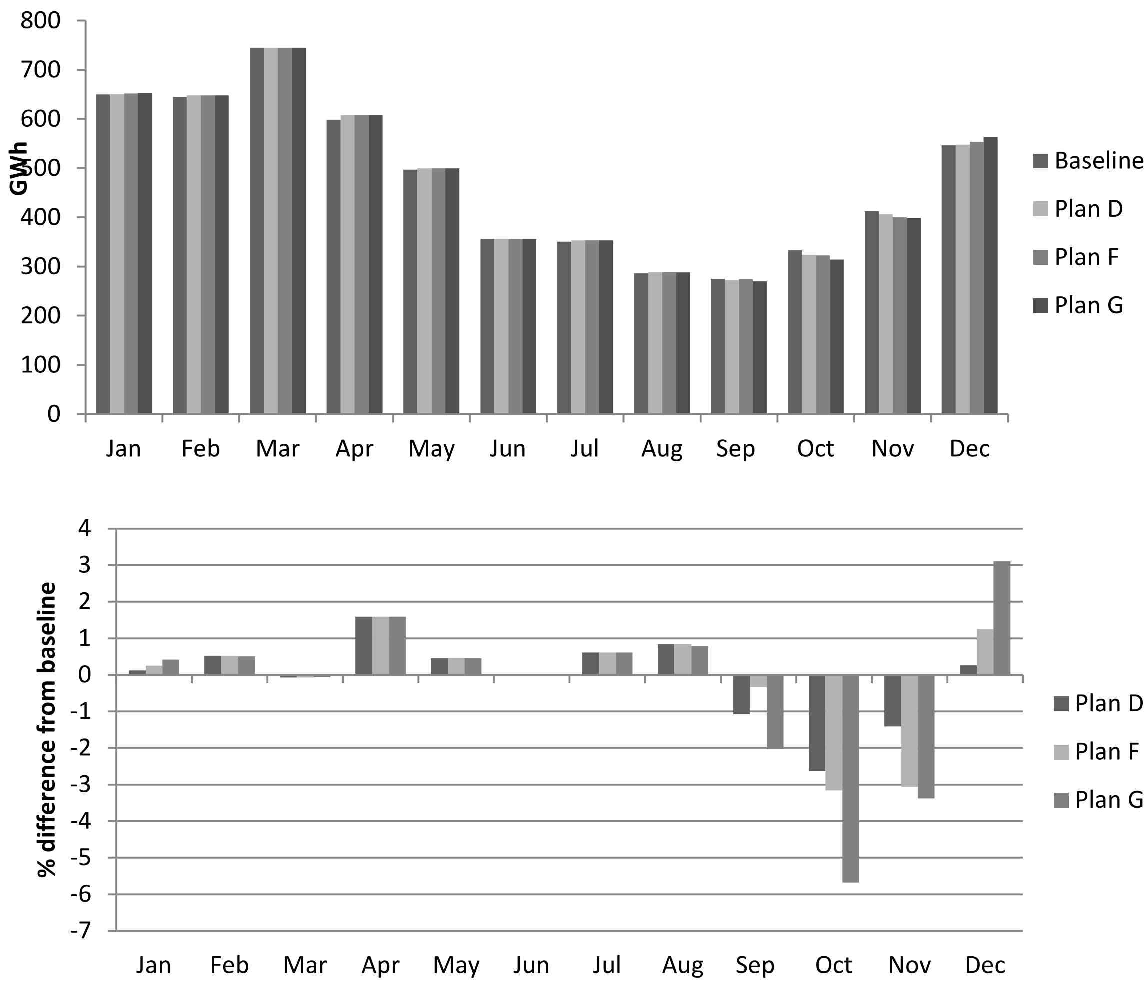

FIGURE 6 MONTHLY GENERATION, BASELINE AND ALTERNATIVES D, F, AND G

Figure 7 shows both the average monthly energy generated and the percent difference between the Plan G and the two sensitivity flow scenarios; Plan G30 and Plan G85. Losses ranging from 9% -12% are seen throughout the year for the Plan G85 alternative, with the greatest loss happening in October. The Plan G30 alternative more closely follows the baseline with losses ranging from 0%-1%. The greatest losses for this plan are seen in the months of September through October with a small recovery for the month of December.

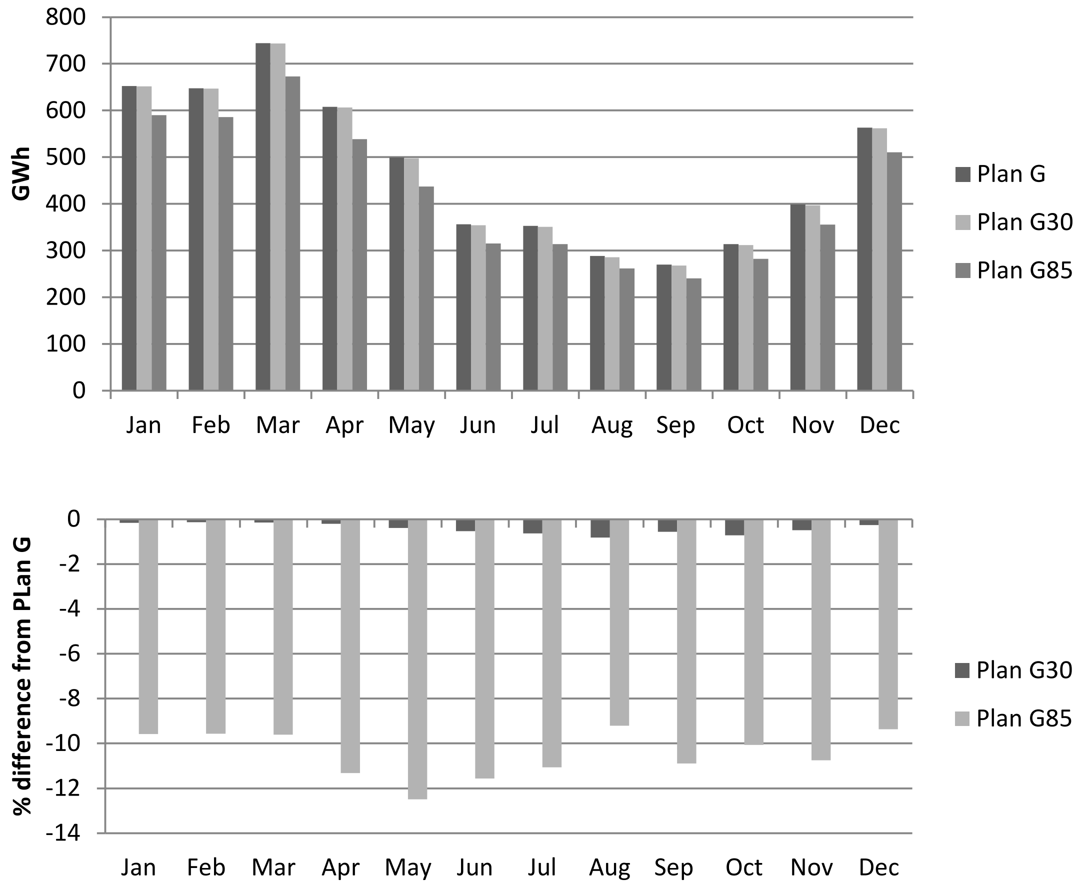

FIGURE 7 MONTHLY GENERATION, PLAN G AND ALTERNATIVES G30 AND G85

Energy Benefits:

Energy benefits are computed as the product of the energy loss in megawatt-hours and an energy unit value price ($/MWh). The energy price is based on the cost of energy from a combination of thermal generating plants that would replace the lost energy from the hydropower plant due to operational and/or structural changes.

Energy Price Computation:
This analysis uses a simulation over the period of record to estimate the effects of changes in water management on hydropower production. However, in order to evaluate the resulting changes in hydropower benefits over a 50-year period of analysis, forecasts of future energy prices are needed. These forecasted prices also need to reflect seasonal variation of both peak and off peak prices.

Energy Price Data Used:
To estimate regional future energy prices that reflect both seasonal and peak and off-peak variation two sources of data are required. The first data source is the EIA long term energy forecast, while the second data source is the system λ values reported in the Federal Energy Regulatory Commission (FERC) Form 714 reports.

EIA historical and long term forecast:
Future and historical energy values in this analysis are based on EIA forecasts from the supplemental tables of "Annual Energy Outlook" (AEO 2013). The EIA forecasts are developed with the Electricity Market Model (EMM) as part of the National Energy Modeling System (NEMS). The following description is from the model documentation report available on the EIA website:

> *The National Energy Modeling System (NEMS) was developed to provide 20-to-25 year forecasts and analyses of energy-related activities. The NEMS uses a central database to store and pass inputs and outputs between the various components. The NEMS Electricity Market Module (EMM) provides a major link in the NEMS framework (Figure 1). In each model year, the EMM receives electricity demand from the NEMS demand modules, fuel prices from the NEMS fuel supply modules, expectations from the NEMS system module, and macroeconomic parameters from the NEMS macroeconomic module. The EMM estimates the actions taken by electricity producers (electric utilities and nonutilities) to meet demand in the most economical manner. The EMM then outputs electricity prices to the demand modules, fuel consumption to the fuel supply modules, emissions to the integrating module, and capital requirements to the macroeconomic module. The model iterates until a solution is reached for each forecast year.*

In addition to providing average annual energy forecasts of electrical generation prices through 2040, AEO 2013 also includes regional forecasts corresponding to North American Electric Reliability Corporation (NERC) regional entity sub-regions. Federal ACF hydropower plants are located in the southeastern sub-region of the Southeastern Reliability Corporation (SERC/S). Discussions with SEPA confirmed that most of the electrical generation from ACF plants is marketed through SERC/S, and that EIA forecasts of thermal generation prices for the SERC/S region was appropriate for this analysis.

System Lambda:

Because EIA provides only a single average energy value for each future year through 2040, the EIA forecasts values are used to shape system λ values acquired from the Federal Energy Regulatory Commission (FERC) Form 714 reports. For utilities generating electricity from thermal plants, Form 714 requires reporting of hourly energy demand (load) and the hourly marginal cost (lambda) of generating one additional MW of electrical energy.

The following explanation of how lambda was calculated is from the FERC Form 714 report, Part II, Schedule 6, filed for 2010 by Southern Company:

> *The Southern Company system lambda is determined hourly and is based on the variable costs of the resources that serve the load obligations of the Operating Companies plus any sales to third parties. The variable costs of the resources include the components listed below, and may also reflect the cost of purchases. The economic dispatch formula used to dispatch Southern's generating resources on the basis of their variable cost components is as follows:*
>
> $$\lambda = [\{ (2aP + b) * (FC + EC) \} + VOM + FH] * TPF$$
>
> *Where:*
>
> λ = *System lambda*
>
> *a, b* = *Incremental heat rate coefficients*
>
> *P* = *Generation level*
>
> *FC* = *Marginal replacement fuel costs*
>
> *EC* = *Marginal replacement emission allowance costs*
>
> *VOM* = *Variable operations and maintenance expenses*
>
> *FH* = *In-plant fuel handling expenses*
>
> *TPF* = *Incremental transmission losses (penalty factors)*

Form 714 reports are available online for the five Southern Company utilities that generate thermal power in SERC/S for the years 2008 through 2012: Alabama Power, Georgia Power, Gulf Power, Mississippi Power, and Southern Power. The five Southern Company utilities represent about three quarters of the fossil fuel generating capacity in the SERC/S sub-region and about 92 percent of the fossil generation for which system lambda is reported to FERC.

While system lambda and load were also reported during this period by Southern Mississippi Electric Power Cooperative and Alabama Electric Cooperative, formatted data from these companies was not available for the entire period and therefore was not included in the calculations described below.

Methodology for energy price shaping:

To forecast the system λ using the EIA forecasted generation values the following ratio is assumed:

$$\frac{\lambda_{Future}}{\lambda_{Past}} = \frac{EIA\_Generation_{Future}}{EIA\_Generation_{Past}}$$

This can be rewritten as:

$$\lambda_{Future} = EIA\_Generation_{Future} * \frac{\lambda_{Past}}{EIA\_Generation_{Past}}$$

Future system λ values can then be computed by the product of the EIA generation forecast and a shaping ratio defined as:

$$ShapingRatio = \frac{\lambda_{Past}}{EIA\_Generation_{Past}}$$

To replicate the peak and off peak variation, daily system λ values are sorted from high to low and are averaged using the peak and off peak periods described in the Energy Benefits Calculation section below. Seasonal variability is taken into account by computing shaping ratios for each month. These shaping ratios are computed as averages among dates with like month and peak and off-peak classification using the equation:.

$$\text{ShapingRatio(Peak/offpeak designation, month)} = \text{Average}\left(\frac{\text{LMP}_{\text{Past}}\text{(Peak/offpeak designation, month)}}{\text{EIA\_Generation}_{\text{Past}}\text{(year)}}\right)$$

TABLE 2 PEAK AND OFF PEAK SHAPING FACTORS FOR SERC/S SUB-REGION USING SOUTHERN COMPANY SYSTEM Λ VALUES.

	peak	off peak
Jan	0.92	0.60
Feb	0.79	0.58
Mar	0.74	0.56
Apr	0.75	0.53
May	0.76	0.54
Jun	0.98	0.64
Jul	1.00	0.67
Aug	0.87	0.61
Sep	0.76	0.56
Oct	0.72	0.55
Nov	0.68	0.52
Dec	0.70	0.54

The proportions in Table 2 were then multiplied by the EIA forecast energy value for each year to obtain estimates of monthly on-peak and off-peak values. To develop the annualized prices for each calendar month, the present values of on-peak and off-peak prices for each month of the 50-year period of analysis were calculated using the federal discount rate of four percent. The resulting 50 present values were then summed and amortized over the 50-year period of analysis at the Federal discount rate. The resulting annualized prices are shown in Table 3.

TABLE 3 AVERAGE ANNUAL ON-PEAK AND OFF-PEAK ENERGY PRICES BY MONTH

Month	Peak	Off-Peak
Jan	$55.90	$36.44
Feb	$48.00	$35.39
Mar	$45.12	$34.27
Apr	$45.51	$32.34
May	$46.25	$33.06
Jun	$59.83	$38.98
Jul	$60.56	$40.60
Aug	$52.73	$36.79
Sep	$46.27	$33.94
Oct	$43.60	$33.47
Nov	$41.36	$31.89
Dec	$42.48	$32.52

Energy Benefit Calculations:
Although all plants in this system are defined as peaking plants the actual hydropower operations of the individual power plants can vary significantly. For example some plants may turn completely off and then back on again during peak demand periods, while others may have a minimum flow requirement that constantly generates a small amount of electricity with a maximum generation occurring during peak demand periods. Unfortunately, the detailed hourly generation information required from each plant to determine the daily peak and off peak percentage of total generation is not available. To calculate the energy benefits, the method assumes that plants will operate to maximize energy benefits; that is, to generate the maximum amount of energy during periods of peak demand.

The Southeastern Power Administration (SEPA) confirmed the seasonal variation of peak hours for the region. Eleven daily peaking hours were defined for the winter period from October 1 through March 31: 5:00 a.m. to 9:00 a.m. and 3:00 p.m. to 10:00 p.m., Monday through Friday Six daily peaking hours were defined for the summer period from April 1 through September 30: 1:00 p.m. to 7:00 p.m., Monday through Friday. The maximum daily amount of peak generation for each plant was then defined as the product of the number of daily peaking hours times the installed capacity of the plant.

Table 4 shows each plants average annual energy benefits under three alternative flow scenarios; Plan D, Plan F, Plan G. In general the majority of the plants showed no noteworthy differences between the baseline and the alternatives. In general the alternatives only showed a gain in average annual energy benefits in one plant, HN Henry. All of the other plants showed losses in average annual energy benefits with Martins having the largest loss of around $70 thousand. The total system energy benefits losses ranged from $80-$250 thousand.

TABLE 4 INDIVIDUAL PLANT AND TOTAL SYSTEM ENERGY BENEFITS FOR ALTERNATIVES D, F, AND G

plant	Baseline	Plan D	Plan F	Plan G
Harris	$8,454,000	$8,444,000	$8,444,000	$8,443,000
Walter	$34,823,000	$34,826,000	$34,821,000	$34,782,000
Thurlow	$11,530,000	$11,487,000	$11,488,000	$11,487,000
Weiss	$8,694,000	$8,688,000	$8,687,000	$8,669,000
HN Henry	$8,331,000	$8,551,000	$8,551,000	$8,543,000
Logan	$17,829,000	$17,798,000	$17,797,000	$17,785,000
Lay	$26,949,000	$26,909,000	$26,906,000	$26,886,000
Mitchell	$22,909,000	$22,883,000	$22,882,000	$22,875,000
Jordan	$11,550,000	$11,522,000	$11,526,000	$11,534,000
Allatoona	$5,081,000	$5,077,000	$5,094,000	$5,062,000

plant	Baseline	Plan D	Plan F	Plan G
Yates	$6,730,000	$6,704,000	$6,705,000	$6,704,000
RF Henry	$13,286,000	$13,258,000	$13,255,000	$13,235,000
Millers	$15,321,000	$15,279,000	$15,276,000	$15,251,000
Martins	$17,890,000	$17,818,000	$17,819,000	$17,817,000
Carters	$31,768,000	$31,785,000	$31,785,000	$31,785,000
Carters Pumping cost	-$18,840,000	-$18,810,000	-$18,810,000	-$18,810,000
Total	$222,304,000	$222,221,000	$222,226,000	$222,048,000

Table 5 shows each plants average annual energy benefits under the two sensitivity alternative flow scenarios; Plan G30 and Plan G85.Under the G85 alternative each plant showed significant losses when compared to the Plan G. Together the losses summed to annual value of over $23 million. The greates individual plant loss was seen for Walter, with an estimated loss of over $4 million. The alternative Plan G30 showed less significant differences with a total system loss of $850 thousand.

TABLE 5 INDIVIDUAL PLANT AND TOTAL SYSTEM ENERGY BENEFITS FOR ALTERNATIVES G30 AND G85

Plant	Plan G	Plan G30	Plan G85
Harris	$8,443,000	$8,428,000	$7,248,000
Walter	$34,782,000	$34,613,000	$30,512,000
Thurlow	$11,487,000	$11,461,000	$10,155,000
Weiss	$8,669,000	$8,620,000	$7,780,000
HN Henry	$8,543,000	$8,494,000	$7,606,000
Logan	$17,785,000	$17,710,000	$15,564,000
Lay	$26,886,000	$26,769,000	$24,221,000
Mitchell	$22,875,000	$22,786,000	$20,344,000
Jordan	$11,534,000	$11,523,000	$10,449,000
Allatoona	$5,062,000	$5,001,000	$4,187,000
Yates	$6,704,000	$6,689,000	$5,926,000
RF Henry	$13,235,000	$13,198,000	$12,664,000
Millers	$15,251,000	$15,208,000	$14,790,000
Martins	$17,817,000	$17,766,000	$15,410,000
Carters	$31,785,000	$31,781,000	$31,315,000
Carters Pumping cost	-$18,810,000	-$18,840,000	-$19,590,000
Total	$222,048,000	$221,205,000	$198,579,000

Carters Pumped Storage:

The Carters dam facility is operated as a pump storage plant. In this operational strategy water from Carters lake is released through turbines into a lower re-regulation reservoir during peak hours. On off-peak hours water is pumped from the lower reservoir back up into the upper Carter's lake. To calculate the energy benefit value for this operation the average annual energy cost required to pump the water back into Carters lake must be subtracted from the average annual energy benefit calculated above.

The equation (EQ 2) for estimating the power required to pump water from the re-regulation dam to the Carter Lake is structurally similar to the power equation (EQ 1) with power now inversely proportional to efficiency. In other words the more efficient the pump the less power it takes to pump the water to Carters lake.

$$P = \frac{g * Q * H}{e} \quad \text{(Eq 2)}$$

The RESSIM model outputs the average flow being pumped , the number of hours the pump is on , and elevations of both Carter Lake and the re-regulation lake to estimate head (H) on a daily time step. The only variable left is efficiency which like for generation is a non-linear function of both head and flow. For the sake of this estimate we will assume an efficiency of 75%.

In Table 6 we calculate the net annual average benefits for the Carters Dam facility for alternatives Plan D, Plan F, Plan G The baseline scenario is using approximately 1000 MWH more annually then the three alternatives. To approximate the monetary value of the MWH an estimated value of $30 per MwH is used, this represents an annualized value calculated using the historical cost received from SEPA.

TABLE 6 ESTIMATED PUMPING COST FOR CARTERS DAM FOR ALTERNATIVES D, F, AND G

	Baseline	Plan D	Plan F	Plan G
Average Annual Energy consumed by pump (MWH)	628000	627,000	627,000	627,000
Estimated Wholesale cost of energy ($/MWH)	$30.00	$30.00	$30.00	$30.00
estimated annual cost	$18,840,000	$18,810,000	$18,810,000	$18,810,000

In Table 7 we calculate the net annual average benefits for the Carters Dam facility for the two sensitivity alternatives; Plan G30 and Plan G85. The Plan G85 alternative uses approximately 26 thousand more Mwh when compared to Plan G, resulting in an increase of about $800 thousand. The Plan G30 alternative uses approximately 1000 Mwh more than the Plan G alternative.

TABLE 7 ESTIMATED PUMPING COST FOR CARTERS DAM FOR ALTERNATIVES G30 AND G85

	Plan G	Plan G30	Plan G85
Average Annual Energy consumed by pump (MWH)	627,000	628,000	653,000
Estimated Wholesale cost of energy ($/MWH)	$30.00	$30.00	$30.00
estimated annual cost	$18,810,000	$18,840,000	$19,590,000

Peak and Off peak Generation:
An interesting observation is that although Plans D, F, and G have a higher total annual system generation (Figure 4) they also have a lower system energy value. (Table 6) This is caused by slightly more generation occurring during off-peak time periods, predominantly weekends for certain months. Table 8 shows the percent of total generation that occurs during peak time periods for each scenario throughout the year.

TABLE 8 PERCENT OF TOTAL GENERATION OCCURRING PEAK TIME PERIODS

	Baseline	Plan D	Plan F	Plan G
Jan	53	52	52	52
Feb	50	50	50	50
Mar	48	48	48	48
Apr	39	38	38	38
May	47	47	47	47
Jun	60	60	60	60
Jul	61	60	60	60
Aug	71	69	69	69
Sep	70	69	69	69
Oct	73	73	73	73
Nov	66	66	67	66
Dec	59	58	58	58
total	55	55	55	55

Capacity Benefits:

Capacity benefits are defined as the product of the change in dependable capacity and a capacity unit value, which represents the capital cost of constructing replacement thermal capacity.

The dependable capacity of a hydropower project is a measure of the amount of capacity that the project can reliably contribute towards meeting system peak power demands. If a hydropower project always maintains approximately the same head, and there is always an adequate supply of stream flow so that there is enough generation for the full capacity to be usable in the system load, the full installed generator capacity can be considered dependable. In some cases even the overload capacity is dependable.

At storage projects, normal reservoir drawdown can result in a reduction of capacity due to a loss in head. At other times, diminished stream flows during low flow periods may result in insufficient generation to support the available capacity in the load. Dependable capacity accounts for these factors by giving a measure of the amount of capacity that can be provided with some degree of reliability during peak demand periods.

Dependable Capacity Calculation Procedure:

Dependable capacity can be computed in several ways. The method that is most appropriate for evaluating the dependable capacity of a hydropower plant in a predominantly thermal-based power system, like the ACT River Basin, is the average availability method. This method is described in Section 6-7g of EM 1110-2-1701, Hydropower, dated 31 December 1985. The occasional unavailability of a portion of a hydropower project's generating capacity due to hydrologic variations should be treated in the same manner as the occasional unavailability of all or part of a thermal plant's generating capacity due to forced outages.

In order to evaluate the average dependable capacity for a project, a long-term record of project operation must be used. Actual project operating records would be most desirable; however, certain factors may preclude the use of these records. The period of operation may not be long enough to give a statistically reliable value. Furthermore, operating changes may have occurred over the life of the project, which would make actual data somewhat inconsistent. In order to assure the greatest possible consistency in this calculation, the fifty-year ResSim simulation for the ACT River Basin was used.

The dependable capacity calculation procedure for the ACT River Basin projects began by approximating each project’s contribution (weekly hours operating on peak) in meeting the system capacity requirements demand for the regional critical year. This contribution estimate was determined by first calculating each project’s weekly average energy produced (MWh) for the peak demand months of mid-May through mid-September of 1981, the critical year from the ResSim baseline model run. This number was then divided by SEPA's defined marketable capacity (MW). This gave an estimate of weekly hours on peak for each project. Coordination with SEPA confirmed marketable capacity values for the Corps hydropower plants and the critical water year of 1981. Installed capacity was assumed for all non-Corps plants

Next, each project's weekly average energy (MWh) produced during the peak demand months was calculated for each simulated year. Dividing these values by each project's weekly average hours (H) on peak determined in the previous step, yielded an array of yearly dependable capacity values. The average across the array is each project's average dependable capacity.

This process is repeated for the baseline and the three alternative flow scenarios using the ResSim model runs. The total system difference between the three flow scenarios and the baseline condition is the gain or loss in dependable capacity caused by changes in system water control operations. These results are shown in Table 9. The results for the sensitivity alternatives are shown in Table 10.

TABLE 9 PLANT AND SYSTEM DEPENDABLE CAPACITY CALCULATIONS FOR ALTERNATIVES D, F, AND G

Capacity (MW)	Baseline	Plan D	Plan F	Plan G
Harris	127.72	126.23	126.23	126.26
Walter	210.29	210.58	210.57	210.38
Carters	576.59	576.79	576.79	576.79
Weiss	73	73.12	73.12	73.07
HN Henry	57.05	57.11	57.11	57.08
Logan	127.57	127.13	127.13	127.05
Lay	159.09	158.93	158.93	158.87
Mitchell	160.6	160.28	160.28	160.2
Jordan	108.09	107.24	107.25	107.22
Allatoona	76.87	76.87	76.86	76.51
Yates	45.29	44.35	44.35	44.39
RF Henry	77.33	76.96	76.96	76.96
Millers	88.36	88.07	88.07	88.07
Martins	181.48	177.97	177.97	178.12
Thurlow	77.76	76.49	76.49	76.55
Total	2147.08	2138.12	2138.12	2137.53

TABLE 10 PLANT AND SYSTEM DEPENDABLE CAPACITY CALCULATIONS FOR ALTERNATIVES G30 AND G85

Capacity (MW)	Plan G	Plan G30	Plan G85
Harris	126.26	126.23	120.05
Walter	210.38	209.52	201.67
Carters	576.79	576.78	575.91
Weiss	73.07	72.91	71.36
HN Henry	57.08	56.99	56.21
Logan	127.05	126.72	122.12
Lay	158.87	158.55	155.57
Mitchell	160.20	159.82	156.48
Jordan	107.22	107.16	104.69
Allatoona	76.51	76.26	73.15
Yates	44.39	44.46	43.98
RF Henry	76.96	76.89	75.94
Millers	88.07	88.00	87.10
Martins	178.12	178.59	176.99
Thurlow	76.55	76.66	75.98
Total	2137.53	2135.53	2097.21

Capacity Unit Value Calculation

Capacity unit values represent the capital cost and the fixed O&M cost of the most likely thermal generation alternative that would carry the same increment of load as the proposed hydropower project or modification. As discussed below in the screening curve analysis description, the cost effectiveness of the different thermal resources depends on how and when the resource is used. For example, coal fired plants may be used to replace a base loading hydropower plant while a gas fired turbine plant may be used to replace a peaking hydropower operation. A combined cycle plant would be used in an intermediate mode of load-following. In this section the process of determining the least costly, most likely combination of thermal generation resources, which comprise the thermal alternative to hydropower, is described. Also, the method calculating the capacity unit value is presented.

Typical Hourly System Generation

To establish the most likely thermal alternative, an analysis of how the hydropower system is currently operated is performed. The goal of this analysis is to show how much capacity can be defined as base load, how much can be defined as intermediate load, and how much can be defined as peaking. Typically the process of computing a capacity value is done on a plant by plant basis, however the necessary data, hourly generation for a typical year was only available for the four USACE plants. In this regard, a total system typical hourly generation exceedance curve is developed.

To produce the total system exceedance chart , two assumptions were made. First, the non-USACE plants acted similar in operation to the four USACE plants. . This assumption is reasonable since the non-Corps plants are similarly defined as peaking plants like the USACE facilities. Secondly a further assumption was made that the USACE hydropower plants' typical year occurred concurrently. With these assumptions the typical hourly generations for the USACE plants were combined and then divided by the Total nameplate capacity of all four USACE. This allows for an exceedance curve for percent of nameplate capacity. (Figure 8). This can then be made to represent the entire system by simply multiplying the y-axis in figure 7 by the total system capacity of ACT system.(Figure 9)

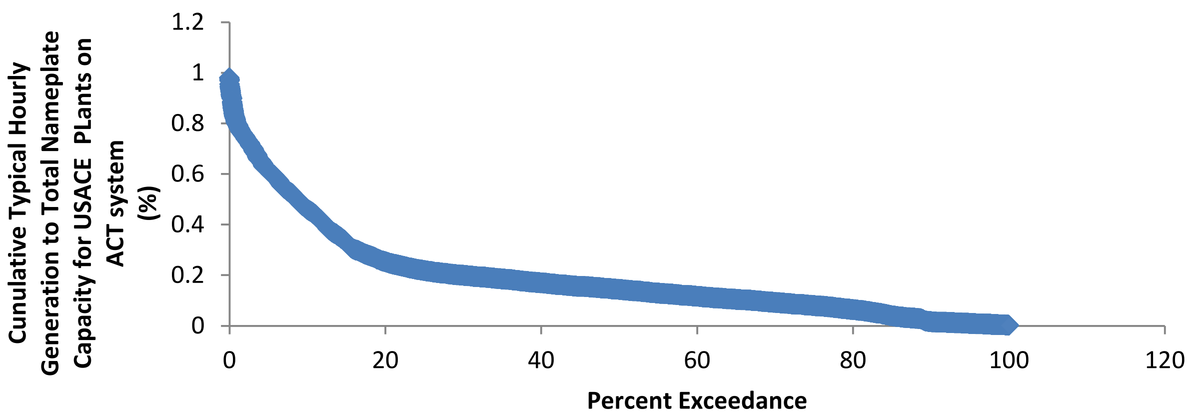

FIGURE 8 PERCENT OF NAMEPLATE CAPACITY EXCEEDANCE CHART FOR USACE PLANTS

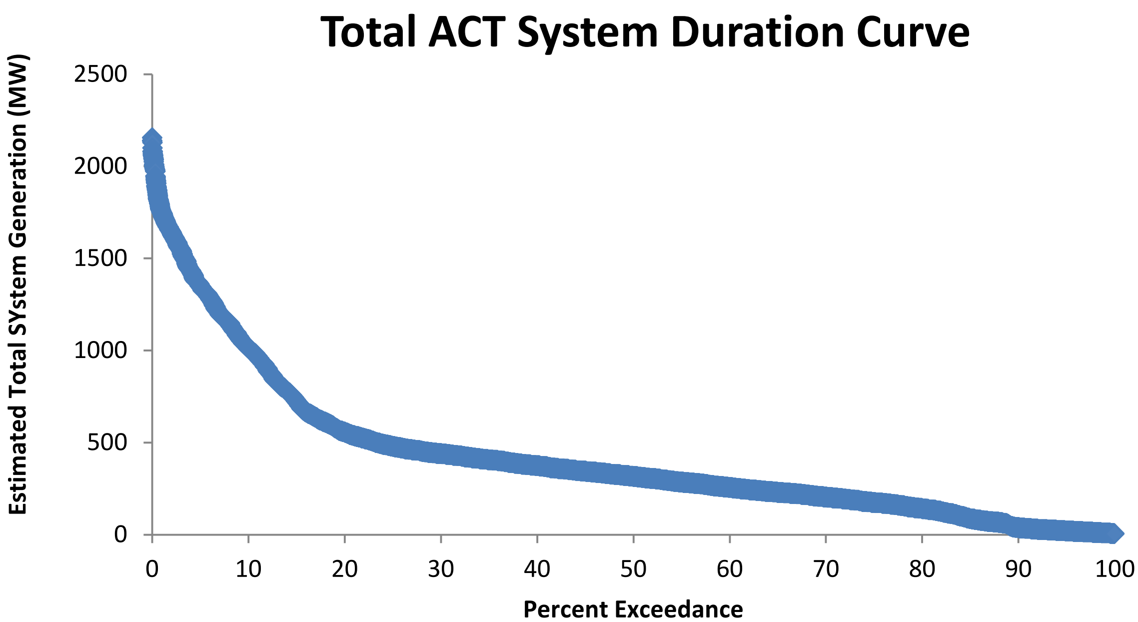

FIGURE 9 LOAD DURATION CURVE FOR ACT WATERSHED HYDROPOWER SYSTEM

Screening Curve Analysis

A screening curve is a plot of annual total plant costs for a thermal generating plant [fixed (capacity) cost plus variable (operating) cost] versus annual plant factor. When this is applied to multiple types of thermal generation resources, the screening curve provides an algebraic way to show which type of thermal generation is the least cost alternative for each plant factor range.

The screening curve assumes a linear function defined by the following equation:

$$AC = CV + (EV * 0.0876 * PF)$$

where: AC = annual thermal generating plant total cost ($/kW-year)

CV = thermal generating plant capacity cost ($/KkW-year)

EV = thermal generating plant operating cost ($/MWh)

Capacity unit values for coal-fired steam, gas-fired combined cycle and combustion turbine plants were computed using procedures developed by the Federal Energy Regulatory Commission (FERC). Capacity values were computed for the SEPA region based on a 3.5 percent interest rate and 2013 price levels. Adjusted capacity values are shown in Table 11.

The adjusted capacity values incorporate adjustments to account for differences in reliability and operating flexibility between hydropower and thermal generating power plants. See EM 1110-2-1701, Hydropower, Section 9-5c for further discussion of the capacity value FERC adjustments.

TABLE 11 ADJUSTED CAPACITY AND OPERATING COSTS FOR SEPA REGION

Thermal Generating Plant Type	Adjusted Capacity Cost $/KW-Year	Operating Cost $/MWh
Coal-Fired Steam	$271.16	$35.71
Combined Cycle	$165.54	$33.82
Combustion Turbine	$86.53	$52.67

Operating costs for coal-fired steam, gas-fired combined cycle and gas-fired combustion turbine plants were developed using information obtained from the publication *EIA Electric Power Monthly (DOE/EIA-0226)* and other sources. The information obtained included fuel costs, heat rates and variable O&M costs. The resulting values, based on 2013 price levels, are shown in Table 10. Since current Corps of Engineers policy does not allow the use of real fuel cost escalation, these values were assumed to apply over the entire period of analysis.

The plot for each thermal generation type was developed by computing the annual plant cost for various plant factors ranging from zero to 100 percent. The plots are shown in Figure 10.

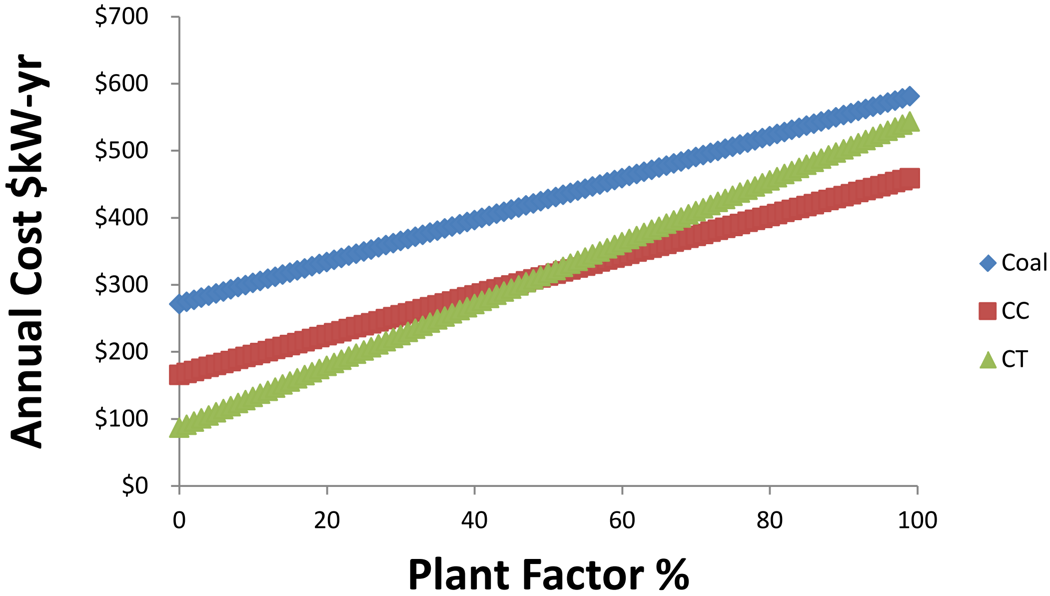

FIGURE 10 CURVE FOR VARIOUS THERMAL ALTERNATIVES IN THE SEPA REGION

Composite Unit Capacity Value

The process for calculating the composite unit capacity value for the ACT River Basin system is described by the following algorithm and is illustrated in Figure 11.

Composite Unit Capacity Algorithm:

The following is the algorithm used to compute composite unit capacity.

1. From the screening curve, determine the "breakpoints" (the plant factors at which the least cost plant type changes).

2. Find the points on the generation-duration curve where the percent of time generation is numerically identical to the plant factor breakpoints defined in the preceding step; these intersection points define the portion of the generation that would be carried by each thermal generation plant type.

3. Calculate percent of total generating capacity for each thermal alternative using the portions defined in step 2.

4. Calculate the composite unit capacity of the system as an average of each the thermal alternative's capacity cost weighted by their percent of total generating capacity defined in step 3.

The composite unit capacity values are computed for ACT river basin system is calculated in Table 12.

TABLE 12 COMPOSITE UNIT CAPACITY VALUE FOR ACT SYSTEM

	Estimated Replacement Generation	Percent of total generating capacity	Capacity Cost	Weighted Value		
Combustion Turbine	1874	0.85	$86.53	$73.77		
Combined -cycle	324	0.15	$166.54	$24.55		
Coal	0	0	271.16	$0.00		
				Total	$98.32	$/KW-yr

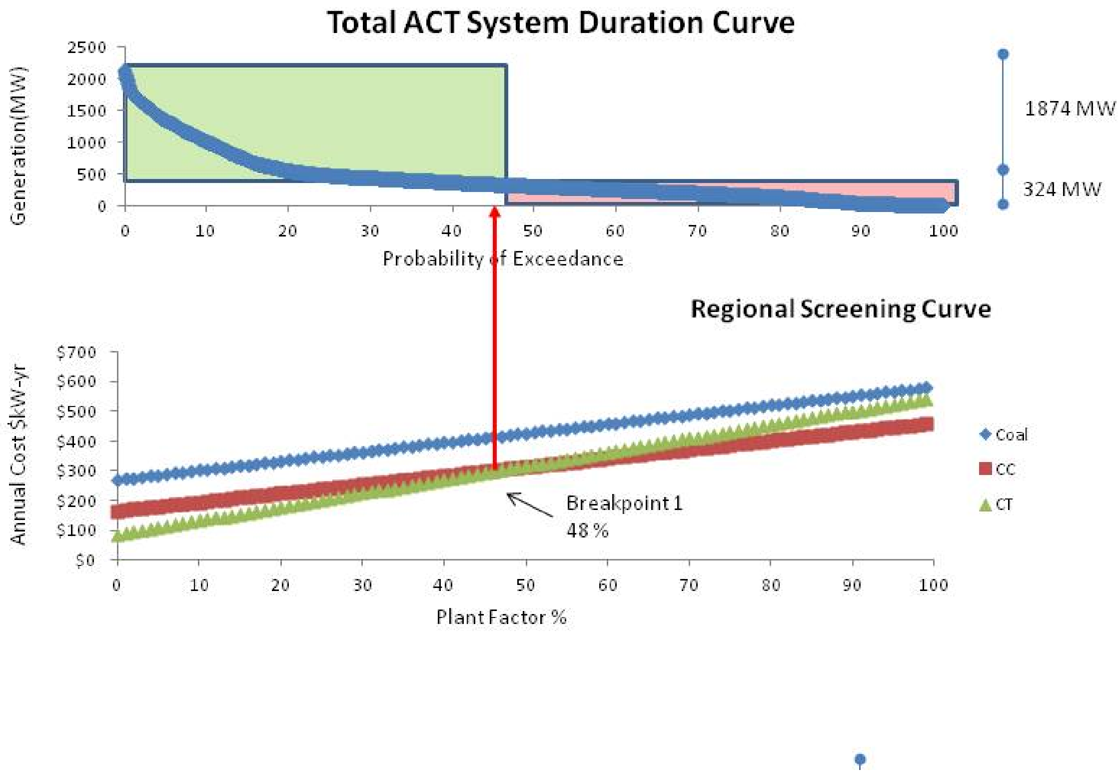

FIGURE 11 ILLUSTRATIVE EXAMPLE OF COMPOSITE UNIT CAPACITY VALUE FOR ACF RIVER BASIN HYDROPOWER SYSTEM

Summary-Hydropower Benefits

The following tables present a summary of the energy, capacity and total hydropower benefits of the two flow scenarios evaluated for the recommended ACT Water Control Plan compared to the baseline condition.

Energy Benefits:

TABLE 13 ENERGY BENEFITS FOR THE ACT RIVER BASIN HYDROPOWER SYSTEM UNDER ALTERNATIVES D, F, AND G

	Energy Value	Energy Benefit
BASELINE	$222,304,000	$0
Plan D	$222,221,000	($83,000)
Plan F	$222,226,000	($78,000)
Plan G	$222,048,000	($255,000)

TABLE 14 ENERGY BENEFITS FOR THE ACT RIVER BASIN HYDROPOWER SYSTEM UNDER ALTERNATIVES G30 AND G85

	Energy Value	Energy Benefit
Plan G	$222,048,000	$0
Plan G30	$221,205,000	($843,000)
Plan G85	$198,579,000	($23,469,000)

Capacity Benefits:

TABLE 15 CAPACITY BENEFITS FOR THE ACT RIVER BASIN HYDROPOWER SYSTEM UNDER ALTERNATIVES D, F, AND G

Plan	Capacity Value (MW)	Difference from Baseline (MW)	Capacity Value $MW-yr	Annual Capacity Benefit (rounded to nearest 1000)
BASELINE	2,147.08	0	$98,320	$0
Plan D	2,138.12	-8.96	$98,320	-$881,000
Plan F	2,138.12	-8.96	$98,320	-$881,000
Plan G	2,137.53	-9.55	$98,320	-$939,000

TABLE 16 CAPACITY BENEFITS FOR THE ACT RIVER BASIN HYDROPOWER SYSTEM UNDER ALTERNATIVES G30 AND G85

Plan	Capacity Value (MW)	Difference from Baseline (MW)	Capacity Value $MW-yr	Annual Capacity Benefit (rounded to nearest 1000)
BASELINE	2,147.55	0		
Plan G30	2,135.20	-12.35	$98,320	-$1,214,000
Plan G85	2097.32	-50.23	$98,320	-$4,938,000

Total Hydropower Benefits:

TABLE 17 TOTAL HYDROPOWER BENEFITS FOR ACT RIVER BASIN HYDROPOWER SYSTEM UNDER ALTERNATIVES D, F, AND G

Plan	Capacity Benefit	Energy Benefit	Total Benefits
BASELINE		$0.00	$0.00
Plan D	($881,000)	($83,000)	($964,000)
Plan F	($881,000)	($78,000)	($959,000)
Plan G	($939,000)	($255,219)	($1,194,219)

TABLE 18 TOTAL HYDROPOWER BENEFITS FOR ACT RIVER BASIN HYDROPOWER SYSTEM UNDER ALTERNATIVES G30 AND G85

Plan	Capacity Benefit	Energy Benefit	Total Benefits
Plan G		$0.00	$0.00
Plan G30	($197,000)	($843,000)	($1,040,000)
Plan G85	($3,964,000)	($23,469,000)	($27,433,000)

Appendix F

Record of Non-Applicability (RONA)

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RECORD OF NON-APPLICABILITY

In Accordance with the Clean Air Act—General Conformity Rule for the Master Water Control Manual Updates for the Alabama–Coosa–Tallapoosa River Basin

The U.S. Army Corps of Engineers proposes to update the *Master Water Control Manual* that outlines water management operations throughout the Alabama–Coosa–Tallapoosa River Basin (ACT Basin). Water control manuals outline the regulation schedules for each project and specifications for storage and releases from each reservoir. Water control manuals outline policies and data protocols for flood control operations and drought contingency operations. The updates to the water control manual are not expected to result in any reasonably foreseeable direct or indirect emissions. Such types of federal activities are specifically exempt from the general conformity regulations.

General Conformity under the Clean Air Act, section 176 has been evaluated according to the requirements of Title 40 of the *Code of Federal Regulations* Part 93, Subpart B. The requirements of that rule are not applicable to the proposed action or the alternatives because

> The proposed activities would result would result in no emissions increase [40 CFR 93.153(c)(2)], and/or the emissions are not reasonably foreseeable, such as electric power marketing activities that involve the acquisition, sale, and transmission of electric energy [40 CFR 93.153(c)(3)(ii)].

Supported documentation and emission estimates

( ) Are Attached
( ) Appear in the NEPA Documentation
(X) Other (Not Necessary)

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