Alabama-Coosa-Tallapoosa (ACT) Watershed

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

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 Study for the Alabama-Coosa-Tallapoosa (ACT) River Basin (Figure 1). The reservoir system model performs simulations of project operations for a baseline condition and alternative operations, and allows comparison of the relative differences among the results. 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, for twelve different operating scenarios. The twelve scenarios include the baseline condition and eleven alternative operating plans. Study teams evaluated these results in terms of economic, environmental, and operational improvements or disadvantages and used this information, along with results from a flood model and a water quality model, to select a recommended alternative operating plan.

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 Study 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.

The plan formulation process accounted for the bulk of the other activities. Ground rules for the study removed structure improvements or other physical changes from consideration, limiting the alternatives to differences in how to operate the federal projects. The team implemented and evaluated many individual changes to operations (i.e., "measures"). The measures underwent iterative refinements, both separately and in conjunction with other measures. The recommended plan consists of the most beneficial changes identified during this process.

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

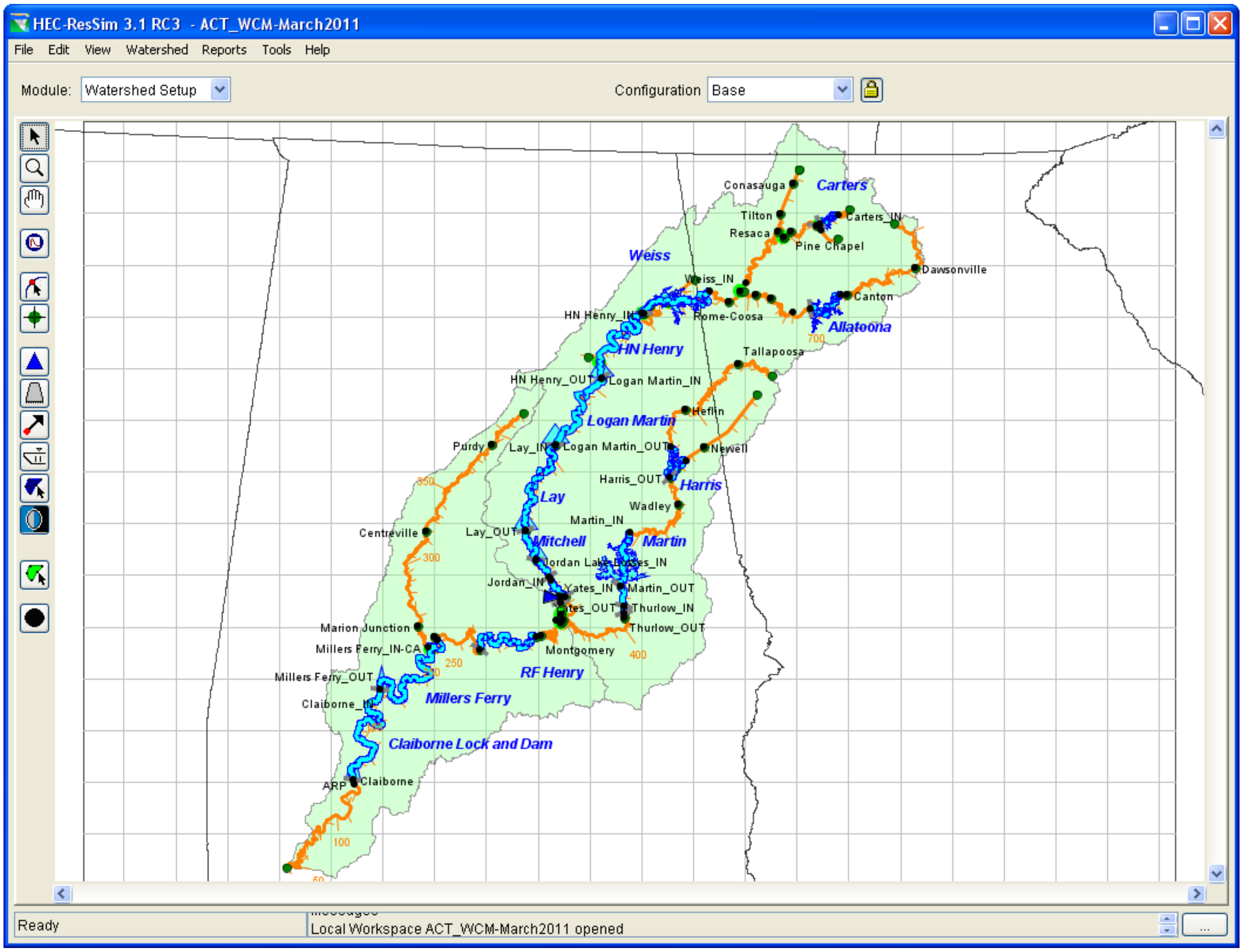
This analysis used HEC-ResSim Version 3.1 “Release Candidate 3, Build 42” (USACE, 2010a). The label “Release Candidate” means that the software is undergoing final testing before distribution as an official version. HEC-ResSim is the Next Generation GUI-based reservoir operations simulation software 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 Study 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 Study 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.



HEC-ResSim 3.1 RC3 - ACT_WCM-March2011

Module: Watershed Setup

Configuration: Base

Ready

Local Workspace ACT_WCM-March2011 opened

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 and other alternatives. The appendices contain more detailed information, including descriptions of differences between the baseline and other alternatives. 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).

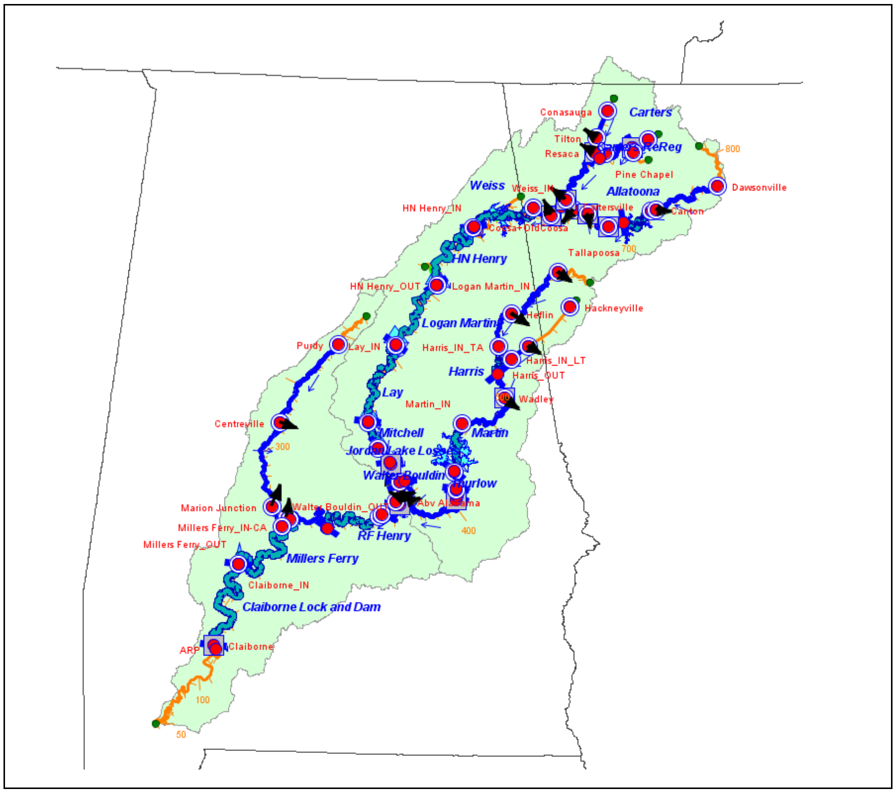


Figure 3. HEC-ResSim Network Module – 2009 Network (for ACT Baseline Modeling)

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.

Evaluation of flood control impacts required analysis on a shorter time step and using inflows beyond those observed for historical events. A special hourly model was developed to evaluate flood control measures by applying various synthetic flood hydrographs as inflows. This model focused on a sub-region of the watershed, including only the Army Corps reservoirs above Rome, GA (Carters, Carters ReReg and Allatoona). This topic is covered in Section G of this report.

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 20.0 to 81.80 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.

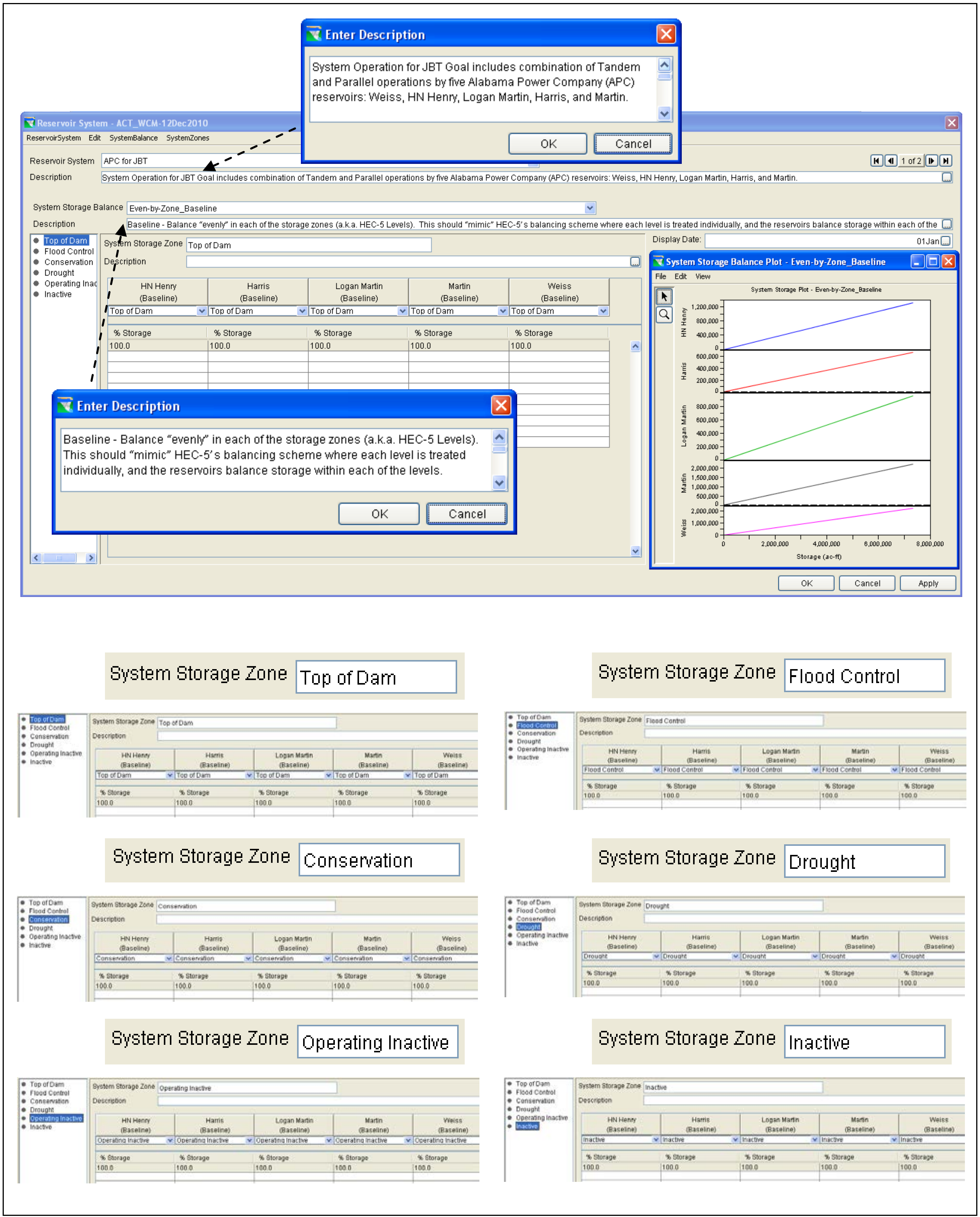
Claiborne consists of a concrete gravity-type dam with both a gated spillway section and a free overflow section, supplemented by earth dikes. It also contains a navigation lock and control station. The spillway has two sections. One section is a controlled broad crested weir with a crest elevation of 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).



Enter Description

System Operation for JBT Goal includes combination of Tandem and Parallel operations by five Alabama Power Company (APC) reservoirs: Weiss, HN Henry, Logan Martin, Harris, and Martin.

Reservoir System: APC for JBT

Description: System Operation for JBT Goal includes combination of Tandem and Parallel operations by five Alabama Power Company (APC) reservoirs: Weiss, HN Henry, Logan Martin, Harris, and Martin.

System Storage Balance: Even-by-Zone_Baseline

Description: Baseline - Balance "evenly" in each of the storage zones (a.k.a. HEC-5 Levels). This should "mimic" HEC-5's balancing scheme where each level is treated individually, and the reservoirs balance storage within each of the

Display Date: 01Jan

- Top of Dam
- Flood Control
- Conservation
- Drought
- Operating Inac
- Inactive

System Storage Zone: Top of Dam

Description:

HN Henry (Baseline)	Harris (Baseline)	Logan Martin (Baseline)	Martin (Baseline)	Weiss (Baseline)
Top of Dam	Top of Dam	Top of Dam	Top of Dam	Top of Dam
% Storage	% Storage	% Storage	% Storage	% Storage
100.0	100.0	100.0	100.0	100.0

Enter Description

Baseline - Balance "evenly" in each of the storage zones (a.k.a. HEC-5 Levels). This should "mimic" HEC-5's balancing scheme where each level is treated individually, and the reservoirs balance storage within each of the levels.

System Storage Zone: Top of Dam

HN Henry (Baseline)	Harris (Baseline)	Logan Martin (Baseline)	Martin (Baseline)	Weiss (Baseline)
Top of Dam	Top of Dam	Top of Dam	Top of Dam	Top of Dam
% Storage	% Storage	% Storage	% Storage	% Storage
100.0	100.0	100.0	100.0	100.0

System Storage Zone: Flood Control

HN Henry (Baseline)	Harris (Baseline)	Logan Martin (Baseline)	Martin (Baseline)	Weiss (Baseline)
Flood Control	Flood Control	Flood Control	Flood Control	Flood Control
% Storage	% Storage	% Storage	% Storage	% Storage
100.0	100.0	100.0	100.0	100.0

System Storage Zone: Conservation

HN Henry (Baseline)	Harris (Baseline)	Logan Martin (Baseline)	Martin (Baseline)	Weiss (Baseline)
Conservation	Conservation	Conservation	Conservation	Conservation
% Storage	% Storage	% Storage	% Storage	% Storage
100.0	100.0	100.0	100.0	100.0

System Storage Zone: Drought

HN Henry (Baseline)	Harris (Baseline)	Logan Martin (Baseline)	Martin (Baseline)	Weiss (Baseline)
Drought	Drought	Drought	Drought	Drought
% Storage	% Storage	% Storage	% Storage	% Storage
100.0	100.0	100.0	100.0	100.0

System Storage Zone: Operating Inactive

HN Henry (Baseline)	Harris (Baseline)	Logan Martin (Baseline)	Martin (Baseline)	Weiss (Baseline)
Operating Inactive	Operating Inactive	Operating Inactive	Operating Inactive	Operating Inactive
% Storage	% Storage	% Storage	% Storage	% Storage
100.0	100.0	100.0	100.0	100.0

System Storage Zone: Inactive

HN Henry (Baseline)	Harris (Baseline)	Logan Martin (Baseline)	Martin (Baseline)	Weiss (Baseline)
Inactive	Inactive	Inactive	Inactive	Inactive
% Storage	% Storage	% Storage	% Storage	% Storage
100.0	100.0	100.0	100.0	100.0

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

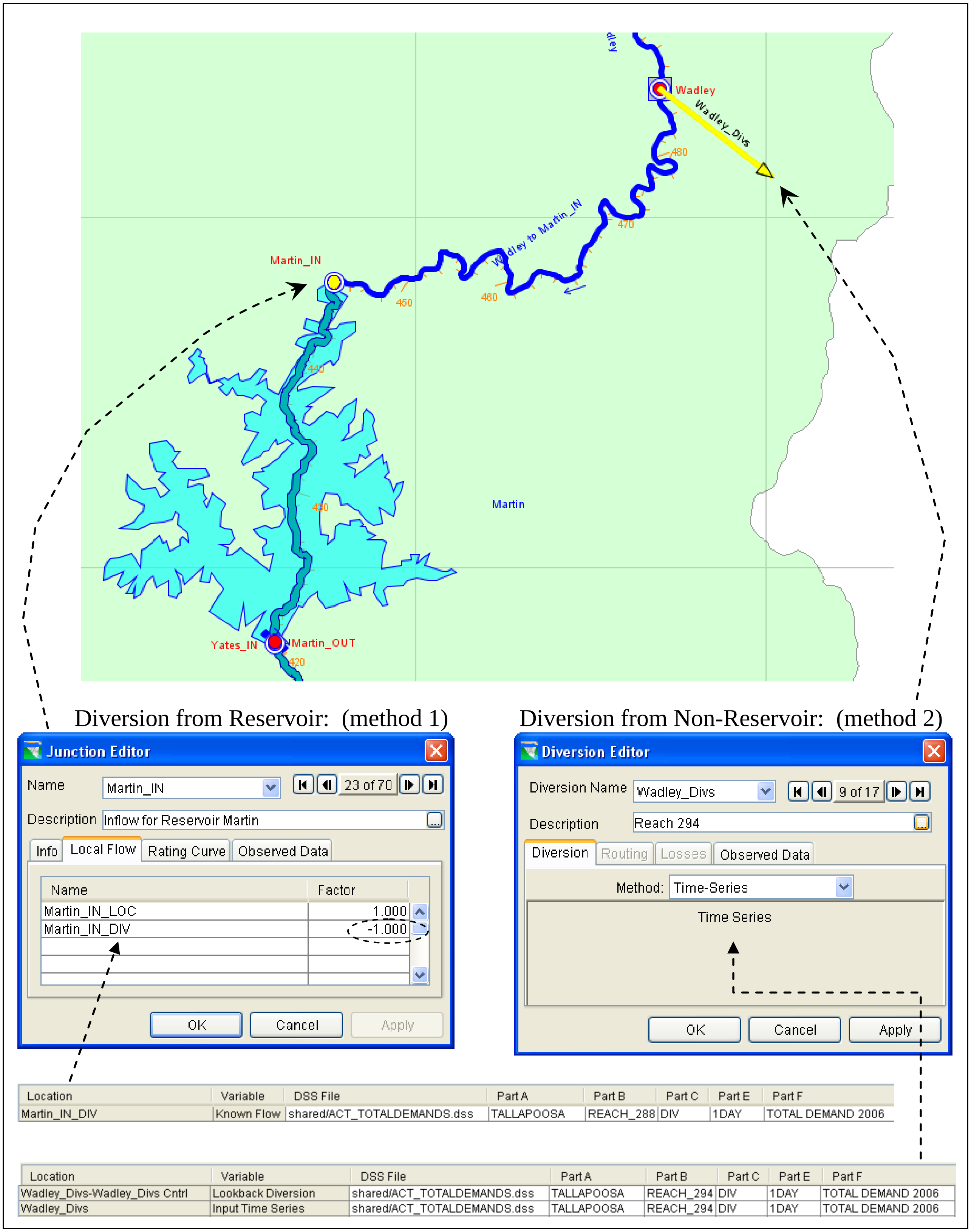
F. Water Supply/Diversions

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.



Diversion from Reservoir: (method 1)

Name: Martin_IN
23 of 70
Description: Inflow for Reservoir Martin

Name	Factor
Martin_IN_LOC	1.000
Martin_IN_DIV	-1.000

Diversion from Non-Reservoir: (method 2)

Diversion Name: Wadley_Divs
9 of 17
Description: Reach 294

Method: Time-Series

Time Series

Location	Variable	DSS File	Part A	Part B	Part C	Part E	Part F
Martin_IN_DIV	Known Flow	shared/ACT_TOTALDEMANDS.dss	TALLAPOOSA	REACH_288	DIV	1DAY	TOTAL DEMAND 2006

Location	Variable	DSS File	Part A	Part B	Part C	Part E	Part F
Wadley_Divs-Wadley_Divs Cntrl	Lookback Diversion	shared/ACT_TOTALDEMANDS.dss	TALLAPOOSA	REACH_294	DIV	1DAY	TOTAL DEMAND 2006
Wadley_Divs	Input Time Series	shared/ACT_TOTALDEMANDS.dss	TALLAPOOSA	REACH_294	DIV	1DAY	TOTAL DEMAND 2006

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

G. *Flood Modeling*

An hourly flood study model for the Upper ACT watershed was developed to evaluate any downstream flooding impact from proposed modifications to flood operations at Allatoona Reservoir. The flood model consists of a sub-region of the watershed, including Carters and Allatoona Reservoirs, and extending downstream to Rome, Georgia (Figure 6). Hypothetical unregulated hydrographs were developed at several frequencies and used to run the flood model to obtain monthly regulated frequency hydrographs at Etowah River at Kingston and the Coosa River at Rome. The regulated frequency curves for the Etowah River at Kingston and the Coosa River at Rome for the baseline and alternative conditions were generated and compared to evaluate the flooding impact from the modified flood operations at Allatoona Reservoir. For details of the flood modeling and results, refer to Appendix M.

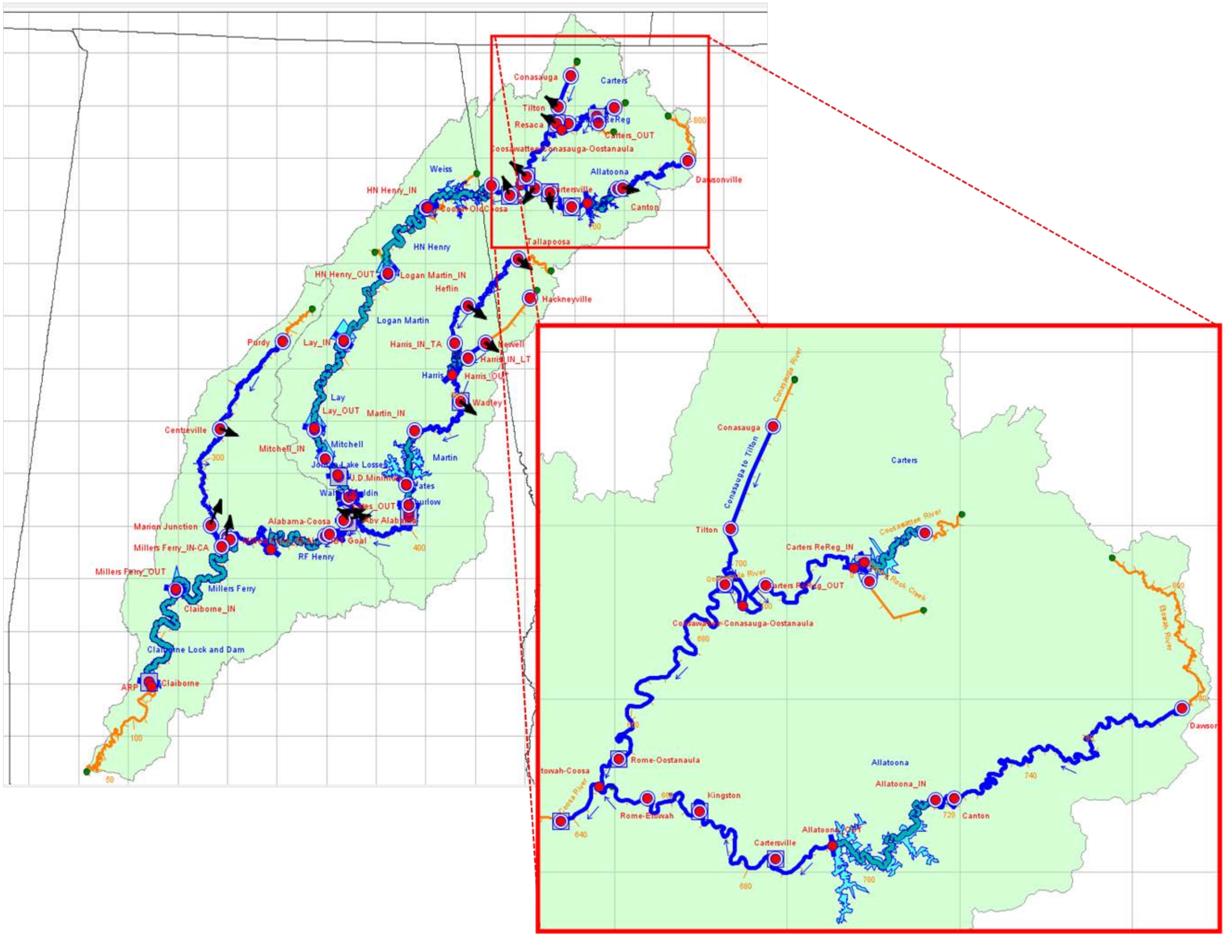


Figure 6. ResSim Network for ACT Flood Modeling (Upper Coosa above Rome, Georgia)

1. Boundary Conditions

The synthetic inflow hydrographs used for the hourly flood model were developed in a multi-stage process that began with the development of a relationship between daily and instantaneous peak flow at various locations. A flood frequency analysis was performed to compute instantaneous, 1-, 3-, 5-, and 45-day unimpaired peak flow frequency curves at Rome. The 1961, 1979, and 1990 events were selected to develop hourly unimpaired hydrographs, which were used to develop and calibrate an HEC-HMS (USACE, 2010b) model (Figure 7). The 1961, 1979, and 1990 unimpaired hourly hydrographs were scaled in an iterative manner and routed in the HEC-HMS model, such that the hydrographs at Rome from the HEC-HMS model match the computed instantaneous, 1-, 3-, 5-, and 45-day peak flow volumes within 10 percent. The resulting input hourly hydrographs are the synthetic inflow hydrographs for the 5-, 2-, 1-, 0.5-, and 0.2 percent-annual chance events.

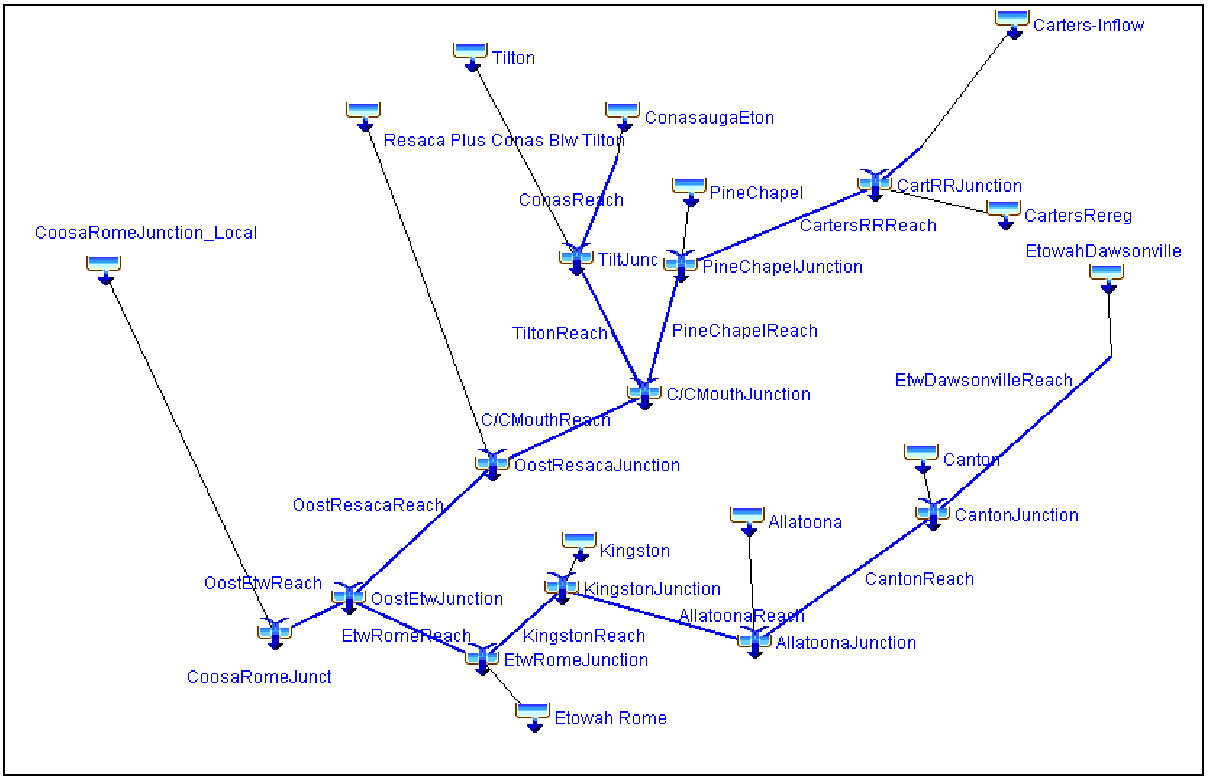


Figure 7. HEC-HMS Schematic for Generating Flood Hydrographs

The volumes for each frequency event determined according to this procedure were distributed throughout the storm duration according to observed events in 1961, 1979, and 1990, resulting in a series of similarly shaped but differently scaled inflow hydrographs similar to those shown in Figure 8. The final step was to temporally shift each hydrograph to center it on each of the 12 months of the calendar year, allowing simulation of storms centered during different seasons and amounts of available flood control space.

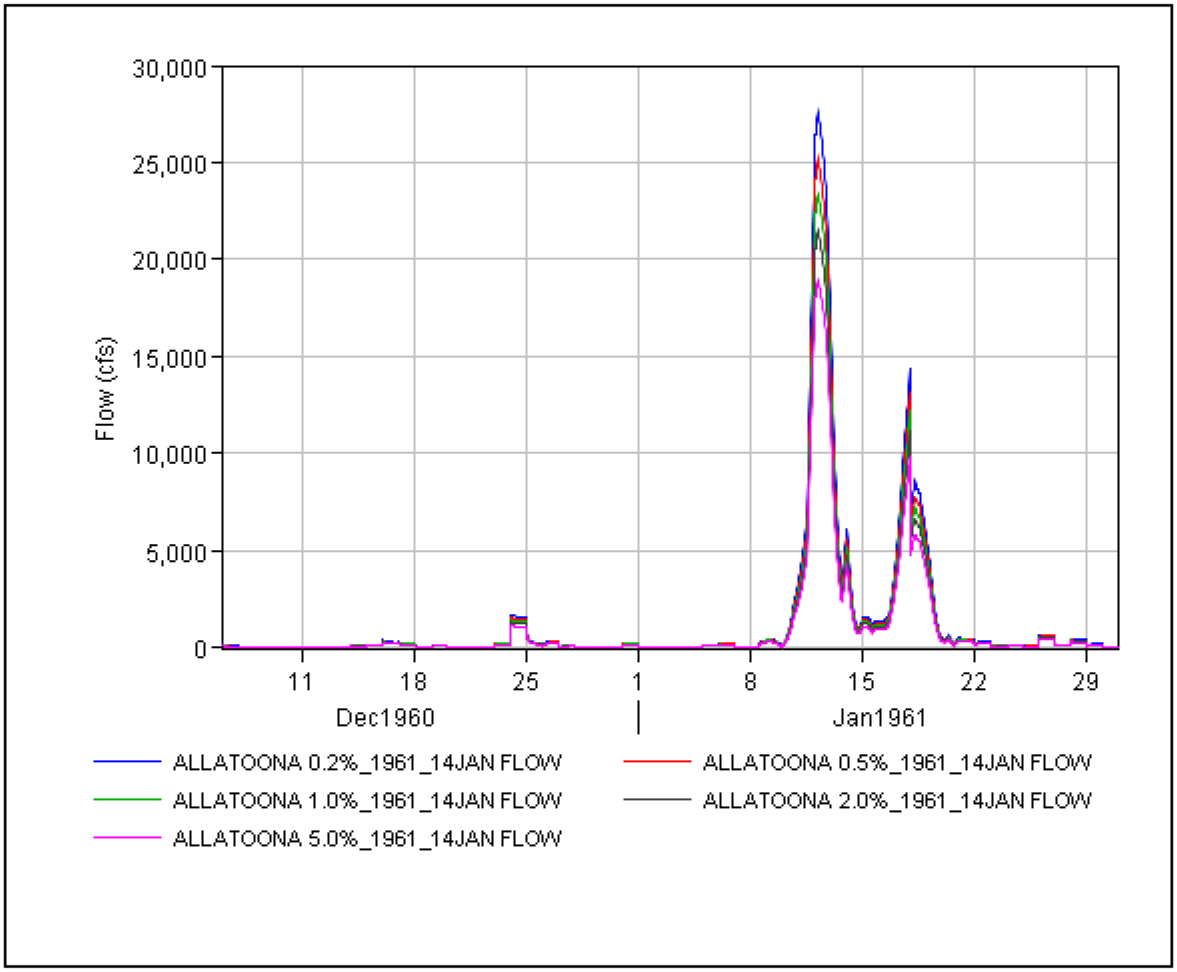


Figure 8. Synthetic Unimpaired Hourly Hydrographs at Kingston Based on 1961 Event

Appendix O provides a more detailed explanation of the processes used to develop the inflow hydrographs for HEC-ResSim flood modeling.

2. Model Adaptation from Daily to Hourly

The hourly ResSim flood model covers the system only in the Upper ACT, and was extracted from the master daily model. In addition to the different extents, a few physical and operational differences exist:

- Diversions were neglected, as they were determined to be too small to affect flood modeling.
- The flood model carries additional details regarding induced surcharge operations.
- The fish spawning rule from the daily model was left out of the flood model as it was determined to be an unnecessary complexity.

3. Verification and Analysis

A large storm event in September 2009 occurred during the ACT modeling effort, and offered a timely opportunity for verification of the reservoir flood operations. Mobile District and HEC developed incremental inflow hydrographs for the inflow junctions of the hourly ResSim model from analysis of observed flows from the event. The HEC-HMS model, previously calibrated for use in developing synthetic events, facilitated the hydrograph arithmetic by routing observed flows on the Etowah, Oostanaula, and Coosa Rivers from one gage to the next. The difference between the hydrograph at a gage and the one routed from upstream represents the incremental inflow between the observation points, which coincided with ResSim junctions.

The verification effort confirmed that the model's representation of flood operations corresponded well with the District's actual operations (Figure 9). During the September 2009 event, one of the two power plants at Allatoona Dam was offline. The ACT ResSim flood model was not developed to simulate the circumstance of a power plant being offline. This caused differences between observed and modeled results as discussed below.

With only one power plant available, the release capacity of Allatoona Dam (without operation of the spillway) varies within the range of approximately 3,500 to 4,000 cfs. When both power plants are available, the release capacity is in the range of 7,500 to 8,500 cfs. Because the flood model simulates the availability of both power plants, the simulated releases in the days leading up to the high reservoir inflows (approximately September 8 through September 18) are greater than the observed releases by about a factor of two. This caused the simulated pool elevation to become about two feet lower than the observed elevation. This difference in elevation carries through the remainder of the simulation period.

Allatoona Dam operates for downstream control at three locations: the Etowah River at Cartersville, the Etowah River at Kingston, and the Coosa River at Rome. During the simulation period, the simulated releases from Allatoona Dam are equal to the minimum release during the period from September 19 through September 22. During this time, the local inflows downstream of Allatoona Dam are high and the dam is operating for downstream control. Beginning late on September 22, the local inflows downstream decrease enough that releases can be made from Allatoona Dam without exceeding downstream flow limits. It is during this time period (from September 22 through the end of the simulation period) that two additional differences between the simulated and observed releases are seen.

1) Because of the availability of only one power plant during the September 2009 event, it was necessary to operate the spillway in order to mimic the availability of both power plants to facilitate the lowering of the the Allatoona pool. This causes slight variations in the releases during the September 23 through October 8 time period. The ResSim model assumes

the availability of both power plants and the spillway is not operated. This causes the uniform simulated release seen in the later days of the simulation period.

2) The ResSim model has "perfect foresight" when it comes to operating for downstream control. The model is therefore very effective at limiting releases so as not to exceed downstream flow limits and increasing releases to lower the pool elevation when local inflows downstream decrease. Real-time operations, inherently, do not have the luxury of this "perfect foresight." Therefore, some differences are expected between the timing of the observed and simulated releases during periods when local inflows downstream of the dam decrease to levels that allow for increased releases from the dam or when local inflows downstream increase to levels that call for restricted releases from the dam. This difference in timing between observed and simulated releases is seen during the period from September 23 through September 30. Essentially, the ResSim model is more effective at operating for downstream control than is possible in real-time operations.

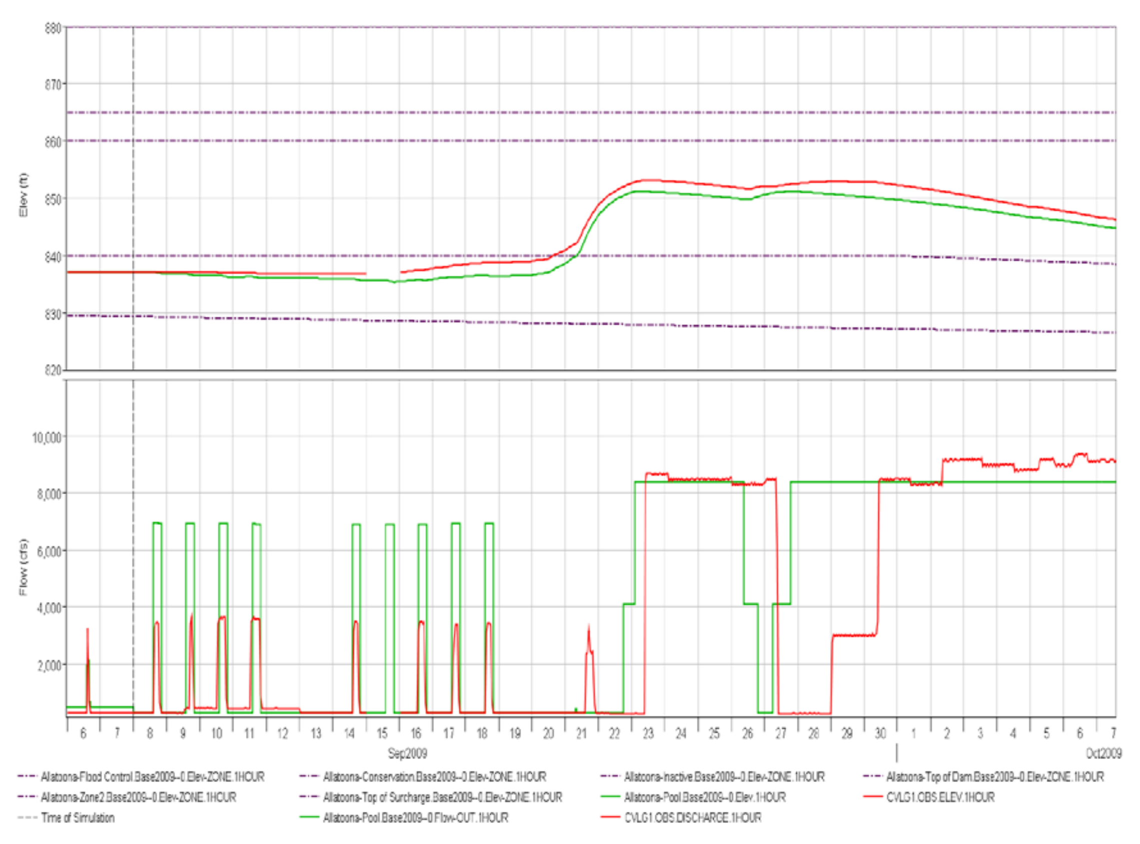


Figure 9. HEC-ResSim Results for September 2009 Event

4. Evaluation of Results

The flood frequency flow for the Etowah River at Kingston and the Coosa River at Rome depends on the storm inflow hydrographs and the month during which the storm hydrographs are applied. For each month, a regulated flood frequency curve was generated using the regulated hydrographs for various frequency events that were simulated in the flood HEC-ResSim model. These curves were combined to produce a "composite" regulated flood frequency curve at the Etowah River at Kingston and the Coosa River at Rome by considering the exceedance probabilities of flood events occurring in different months. This was developed for both the baseline and alternative conditions. The combined regulated flood frequency curves for the baseline and alternative conditions were compared to evaluate any impact on downstream flood conditions from the modifications to the flood operations at Allatoona Dam. Appendix M describes the calculation procedure and presents the results in detail.

III. Description of Alternatives

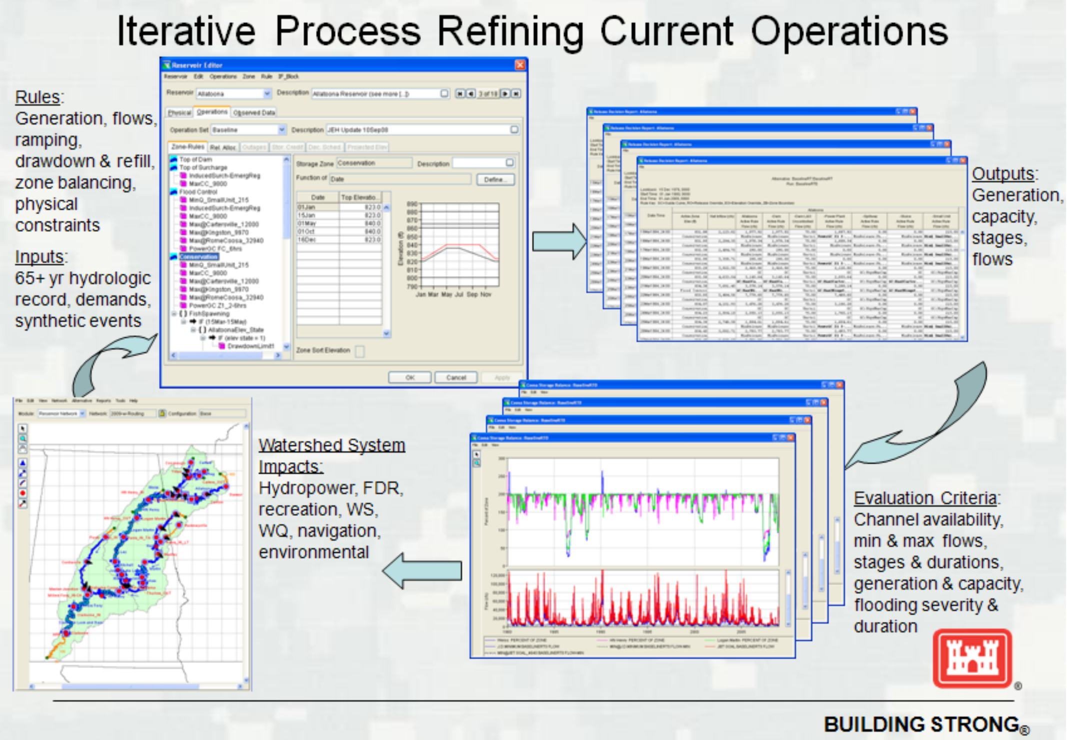
The ACT Water Control Manual Update Study follows the National Environmental Policy Act (NEPA), (EPA, 1969[2000]) process toward the ultimate goal of adopting a new set of water management guidelines for the Corps projects in the ACT system. This requires comparison of anticipated effects due to a proposed new plan against those of a “no action alternative,” (i.e., 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. Various alternative system operations were developed to formulate a recommended plan. The study considers no physical improvements to the projects. The alternatives differ solely in the water management operations defined for the projects and inter-related assumptions regarding diversions.

A. Process of Developing Alternatives

Based upon many years of operational experience and extensive stakeholder input during scoping, the Corps identified numerous operational measures for possible consideration in the updated ACT Master Water Control Manual (WCM). These measures included variations for revising reservoir drawdown and refill periods, reshaping reservoir action zones, revising hydropower objectives, revising drought procedures and environmental flows, and developing navigation-specific operations.

The Corps used an iterative process to identify the various measures that would be further developed, analyzed, and refined toward the goal of developing an updated ACT Basin Master WCM. Using ResSim, the Corps modeled the effects of changing individual and multiple operational measures (for instance, revising hydropower generation objectives per action zone or reshaping action zones) at individual reservoirs and across the entire ACT system. The software provided data outputs (hydropower generation, reservoir levels, river flows and stages, etc.) across the entire hydrologic period of record (1939 – 2008) which were then evaluated for performance in terms of project and watershed criteria (channel availability, generation and capacity, reservoir recreation impact levels, and other authorized purposes, intended benefits, and existing uses within the system). Once results were reviewed, the operational measures were adjusted and retested until satisfactory results were obtained. This iterative process is shown graphically below (Figure 10).



Iterative Process Refining Current Operations

Rules:
Generation, flows,
ramping,
drawdown & refill,
zone balancing,
physical
constraints

Inputs:
65+ yr hydrologic
record, demands,
synthetic events

Outputs:
Generation,
capacity,
stages,
flows

Evaluation Criteria:
Channel availability,
min & max flows,
stages & durations,
generation & capacity,
flooding severity &
duration

Watershed System
Impacts:
Hydropower, FDR,
recreation, WS,
WQ, navigation,
environmental

BUILDING STRONG®

Figure 10. Development of Alternative Operating Plans

The modeling team and PDT considered each measure individually and iteratively refined it, then evaluated its performance in combination with other measures. Results were shared among team members, incorporating feedback on measure effectiveness from operational, environmental, and economic specialists. Ultimately, the updated WCM will reflect the combination of measures that balances system operations, meeting the various types of objectives.

B. Measures / Components of Alternative

The modeling process began with formulating a model of “Baseline” conditions, which reflects current operations. Then several alternative operations were modeled (Plan Alternatives) and contrasted with each other and the Baseline condition in effort to select a Recommended Plan. Each Alternative combines one or more measures, which reflect deviations from the Baseline condition in order to meet specific objectives. The measures considered are adjustments that meet system needs related to water supply, navigation support, fish and wildlife interest, drought plans, action zones, hydropower demand, seasonal minimum flow, and guide curve drawdown. The Baseline condition (current operations) and each measure are described in the following section.

1. Current Operations

On the basis of the nature of the proposed action, the No Action/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.

2. Water Supply/Diversions

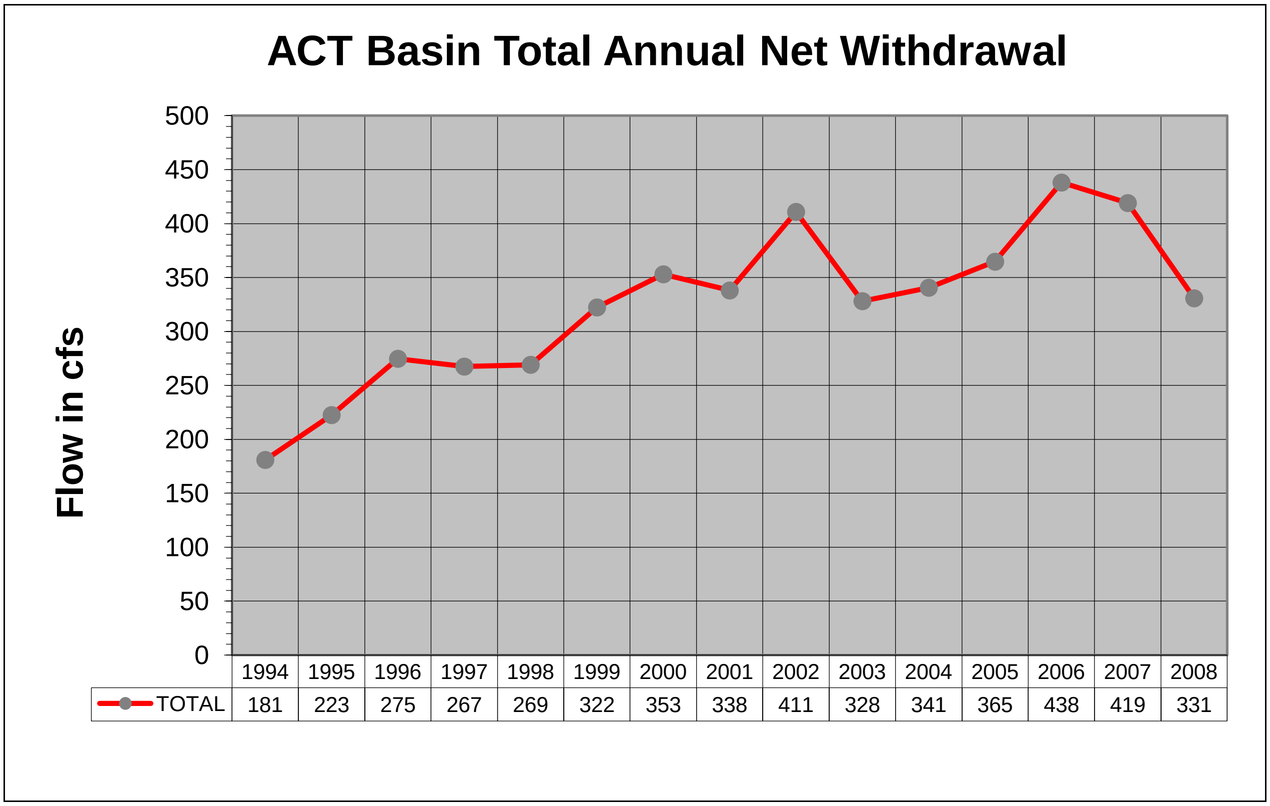
In developing its updated Water Control Manuals, the Corps considered the historic 2006 net water withdrawals through the ACT Basin and the existing water storage contracts for Allatoona and Carters (listed in Table 2).

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 alternative used the same 2006 net withdrawal values. This measure remained the same for each alternative.

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 11 and year 2006 is the largest value. Consequently, each alternative includes the maximum historic water use year data with monthly variability.



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
TOTAL	181	223	275	267	269	322	353	338	411	328	341	365	438	419	331

Figure 11. 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 12 plots the monthly distribution of the 2006 withdrawal for the entire ACT Basin. Figure 13 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

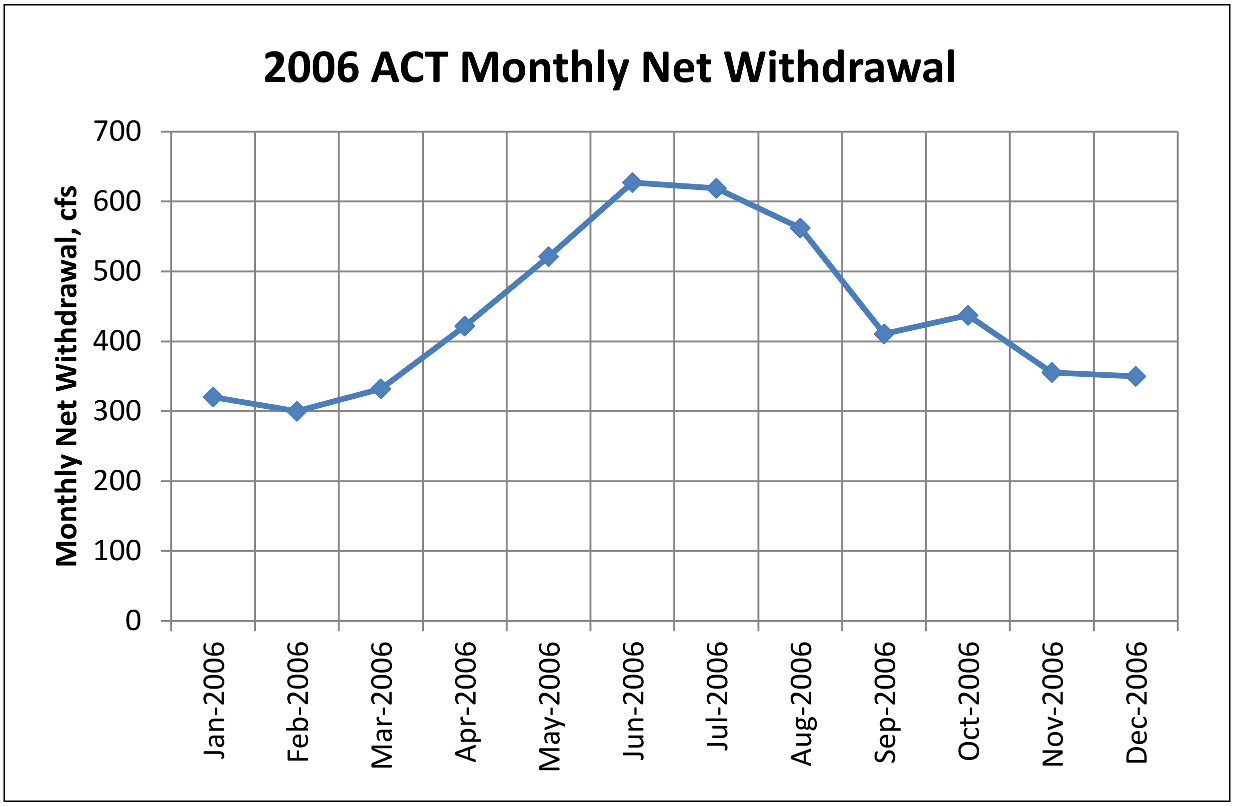


Figure 12. 2006 ACT Monthly Net Withdrawal

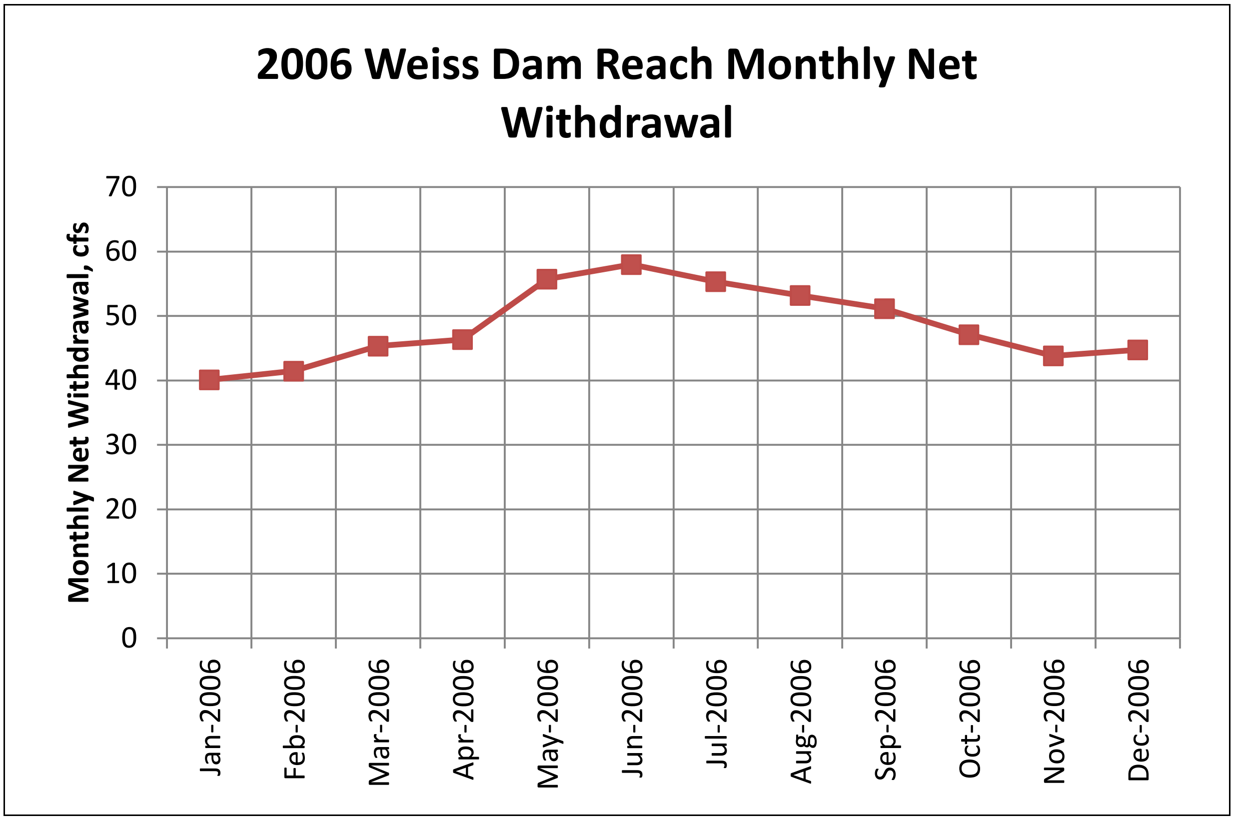


Figure 13. 2006 Weiss Dam Reach Monthly Net Withdrawal

3. Fish and Wildlife

Management measures considered for fish and wildlife operations were based on the following: recommendations provided by the USFWS in their Planning Aid Letter dated May 3, 2010; previous discussions with the USFWS; and, current Corps operations. The management measures considered by the Corps from the USFWS letter were the seasonally varying flows from Carters Reregulation Dam and changes in releases under the drought plan for the Tulatoma snail below Jordan Dam. The USFWS letter included recommendations for the development of alternatives and mitigation, hydrologic modeling, and methods used to evaluate the effects of Corps alternatives (USFWS, 2010). These recommendations were considered in updating the WCM.

The Corps would continue 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 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.

4. Navigation Support

The Corps considered several factors in developing options to support navigation on the ACT. First, it reviewed historic channel availability, flow depth patterns, and the relationship between basin inflows and storage usage in order to determine flows levels necessary to support navigation on the system. To accomplish this, the Corps also considered dredging impacts (timing and extent) during low and high flow periods. Since dredging typically occurs in the summer and fall months, less flow is required during these periods to provide the necessary channel depths. The Corps also examined storage relationships between Corps and APC projects, taking into account such factors as drainage areas, storage volumes, and historic contributions to flows. The following section describes examples of these analyses, from the initial development, to later, improved calculations.

The critical element to developing options that support navigation is the identification of flow values that will accommodate navigation on the system. Once these have been established, the next step is to develop rules to provide those flows. Figure 14, below, depicts the impact of dredging on flow requirements for different navigation channel depths during normal hydrologic conditions. A flow-depth template was developed based on reports of channel depths from navigation bulletins issued by the Mobile District (and associated flows) and Claiborne tailwater gage readings. The bulletins report the tailwater readings several times during the year and the coincident associated navigation depths. The tailwater gage/navigation depth relation was assumed to be reasonably stable unless changed by high water or dredging. Temporary rating curves were developed from daily values for recent years 2005 and 2007 for both the high water season (Dec – May) and the low water season (Jul – Nov). For each year the two rating curves were used to develop flows required prior to dredging and after dredging for various channel depths. The 2006 year was not used because there was no dredging that year. The results were averaged to show the flow requirement for the years 2005 and 2007. The template is shown in Figure 14.

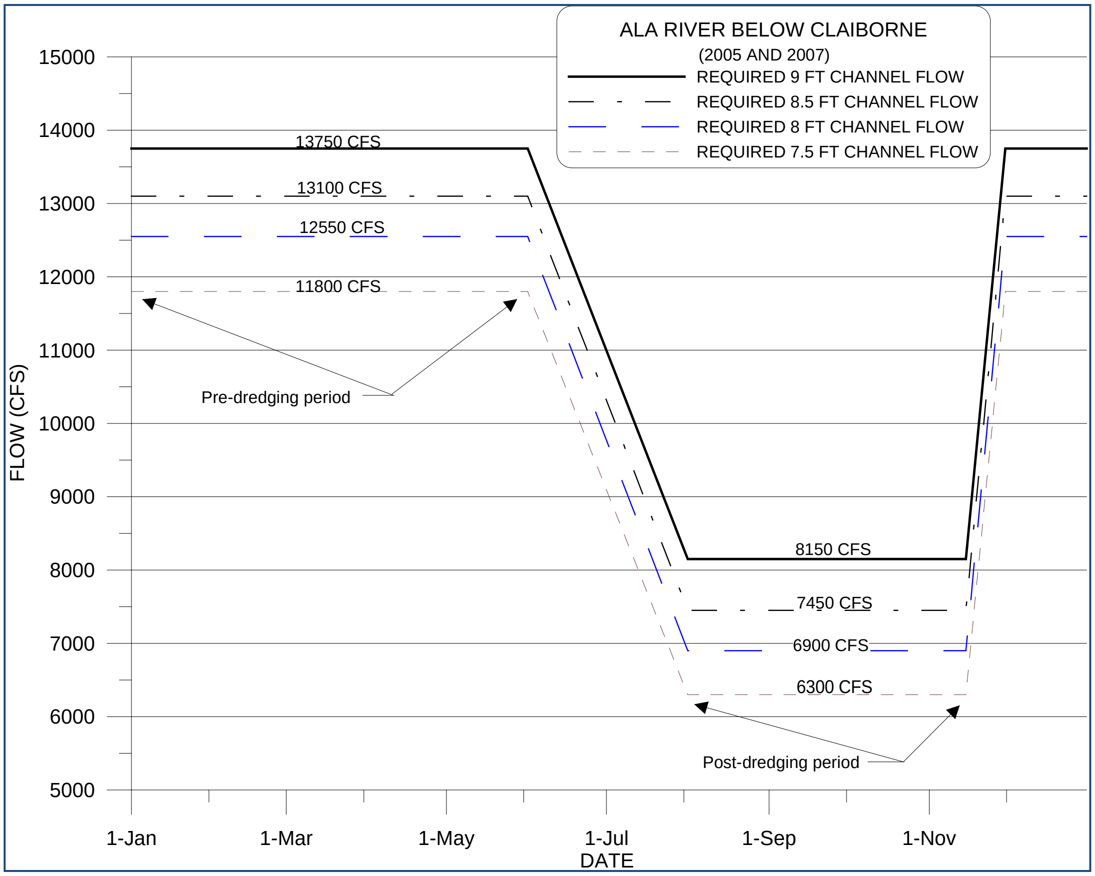


Figure 14. Flow-Depth Pattern with 2005-2007 Data

The template indicates that during the years 2005 and 2007, an average flow of 13,750 cfs was required during the high flow season prior to dredging to maintain a 9-ft channel and an average flow of 8150 cfs after dredging during the low flow season. The required flow in the high flow period is dependent on variables such as: shape and duration of prior flow hydrographs, extent of prior dredging, and extent of bank caving. During the low flow period, once the channel is restored to project conditions, the channel is reasonably stable if there is little flow to alter the depths. Such was the case in 2007, when the maximum flow after June was only 6200 cfs. However, because of this, low flow project depths are not available even for a 7.5-ft draft vessel.

Because of the extreme low flow during the 2005-2007 period, a similar template, developed for the 1992-1994 period, is also presented. Note that this template was developed with data from relatively wet years. The template is shown below (Figure 15).

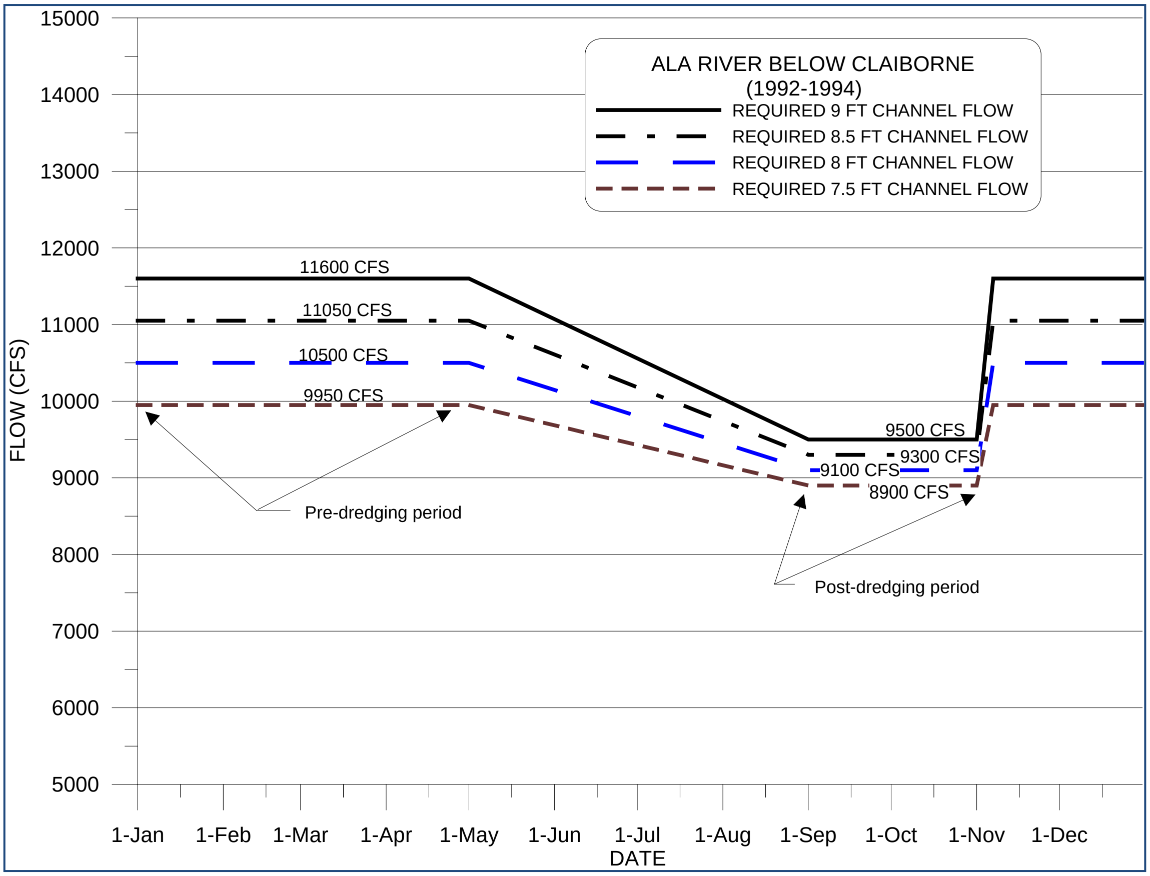


Figure 15. Flow-Depth Pattern from 1992-1994 Data

Figure 15 indicates that in order to achieve a 9-ft channel, a flow of 11600 cfs is required for the Jan – May pre-dredging period and a flow of 9500 cfs is required during the post-dredging season. The two flow-depth charts show the variance of flow required during different periods caused by the variance in the extent of the dredging program and flow patterns.

After careful consideration and discussions with the Corps navigation experts, the Navigation Template based on the 1992-1994 was selected as the navigation flow target for the Alabama River below Claiborne Lock and Dam (Table 4). Monthly flow targets for a 9-ft and 7.5-ft channel were incorporated into the alternatives to represent the system navigation demand. When a 9-ft channel cannot be met, the shallower 7.5-ft channel still allows for light loaded barges moving through the navigation system. This Navigation Flow Target measure remained the same for each alternative that included navigation.

Table 4. Monthly Navigation Flow Target in cfs for 9-ft and 7.5-ft Channel Depth

Month	9' Navigation Target	7.5' Claiborne Target
Jan	11600	9950
Feb	11600	9950
Mar	11600	9950
Apr	11600	9950
May	11100	9740
Jun	10600	9530
Jul	10100	9320
Aug	9600	9110
Sep	9100	8900
Oct	9100	8900
Nov	11600	9950
Dec	11600	9950

Historically, navigation has been supported by releases from storage in the ACT Basin. Another critical component of the navigation concept includes utilizing an amount of storage similar to the historic value, but in a more efficient manner. This can be accomplished by counting the natural flows towards the navigation target flow. By computing the anticipated volume of water stored during the wet period and released during dryer periods, the additional volume of water Mother Nature needs to provide to support navigation can be calculated. This is achieved by algebraically subtracting the storage usage from the navigation target. For example, for the month of November:

Required Flow to support Navigation = [Navigation Target] – [November storage usage]
Required Flow to support Navigation = [11,600 cfs] – [4,000 cfs] = 7,600 cfs.

Therefore, 7,600 cfs in total run-off above the Claiborne Lock and Dam is required to meet the 9 foot channel depth if an additional 4,000 cfs is released from storage. In real world conditions this natural run-off flow is subject to water use depletions and lake evaporative losses. Instead of this natural flow we use Basin Inflow in the calculation. Basin Inflow is natural flow adjusted to reflect the influences of reservoir evaporative losses, inter-basin water transfers, and consumptive water uses, such as municipal water supply and agricultural irrigation. The revised equation is listed below:

Required *Basin Inflow* to support Navigation = Navigation Target – November storage usage
where: *Basin Inflow* = Natural inflow – evaporation – diversions.

Therefore, 7,600 cfs is the total Basin Inflow above the Claiborne Lock and Dam required to meet the 9-ft channel depth if 4,000 cfs is released from storage. Figure 16 depicts historic storage usage by project on a monthly basis from 1982 to 2008.

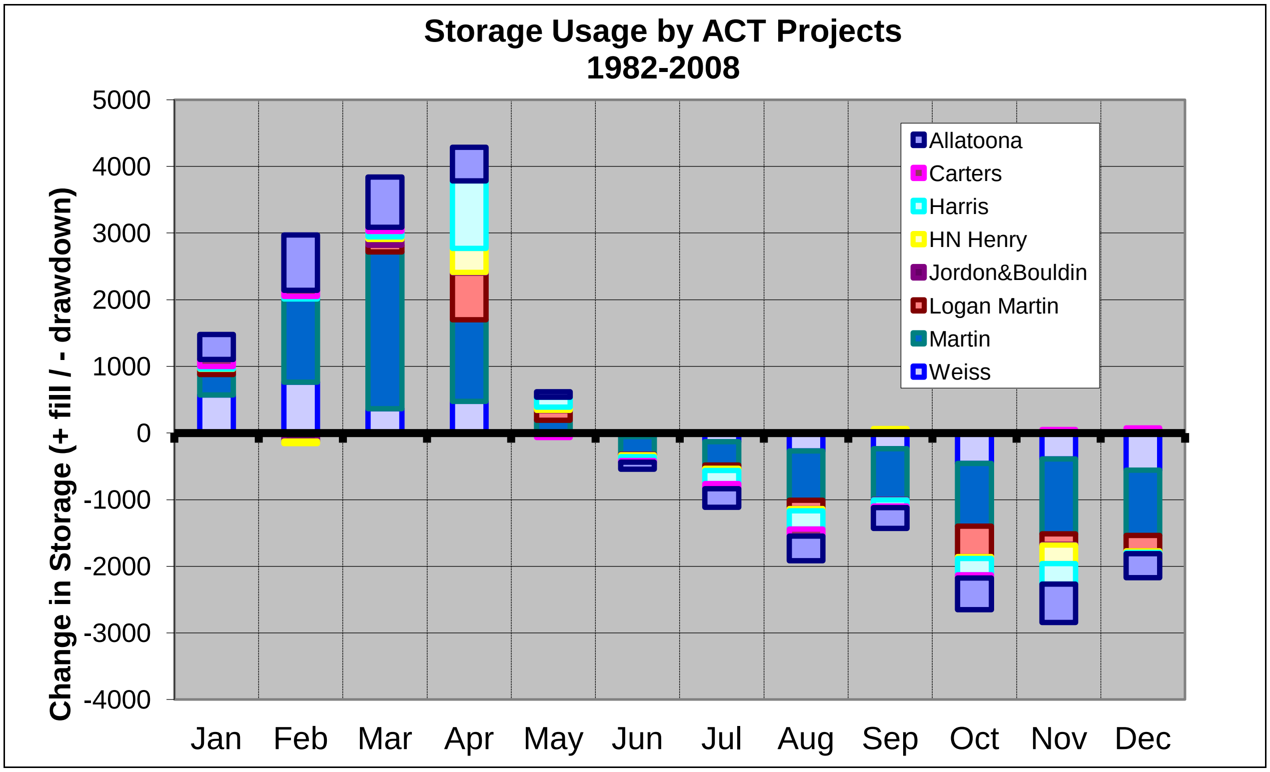
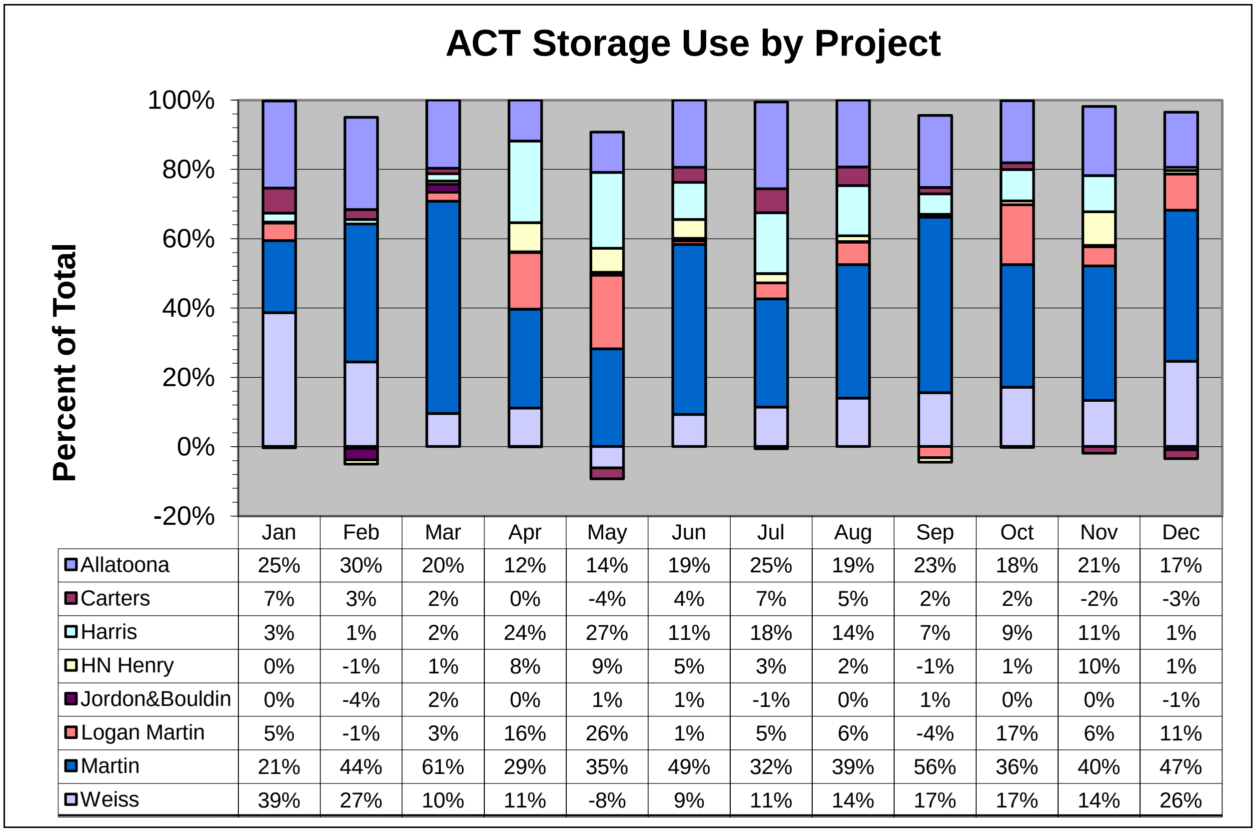


Figure 16. Average Monthly Storage Usage by ACT Projects, 1982-2008

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 17 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 18 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 17. ACT Storage Use by Project as Percent of Total

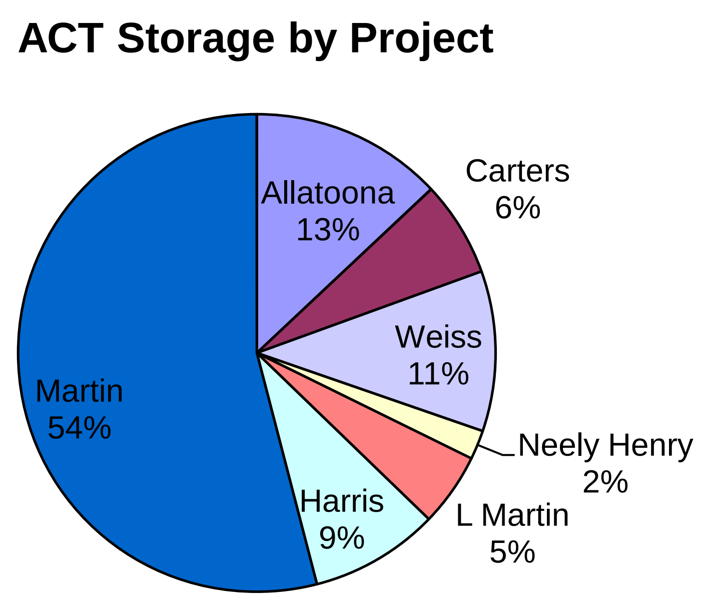


Figure 18. ACT Conservation Storage by Project as a Percent of Total Conservation Storage

Table 5 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 5 indicate the annual average project storage usage from 1982 to 2008 is similar to contribution of total storage.

Table 5. 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%

The Basin Inflow required to support navigation was modified to remove Allatoona and Carters storage usage. There are two reasons for the revision. First, navigation is not an authorized project purpose for Allatoona and Carters. Second, because they are subject to congressional action, federal projects are more likely to experience future changes in storage usage than are the APC projects. Linking the basin inflow to an expected storage usage from federal projects may require a reciprocating change in storage usage from Alabama Power projects. In other words, if the navigation target remains the same and there is a reduction in releases from the federal projects due to congressional action, then there could be an expected increase in storage usage from Alabama Power projects. As stated earlier a critical component of the navigation concept includes utilizing similar historic storage usage amount. This is now refined to utilize similar historic storage usage only at Alabama Power projects, and this revision would allow for alternatives that change the historic storage usage at Allatoona and Carters.

Figure 19 depicts historic storage usage by APC projects on a monthly basis from 1982 to 2008.

So, the Basin Inflow computation is updated below:
Monthly Required Basin Inflow to support Navigation
= Monthly Navigation Target – Monthly APC storage usage

This Basin Inflow now becomes the monthly flow levels necessary to support navigation on the system.

Figure 20 depicts channel reliability based on natural flows and APC historic use of storage.

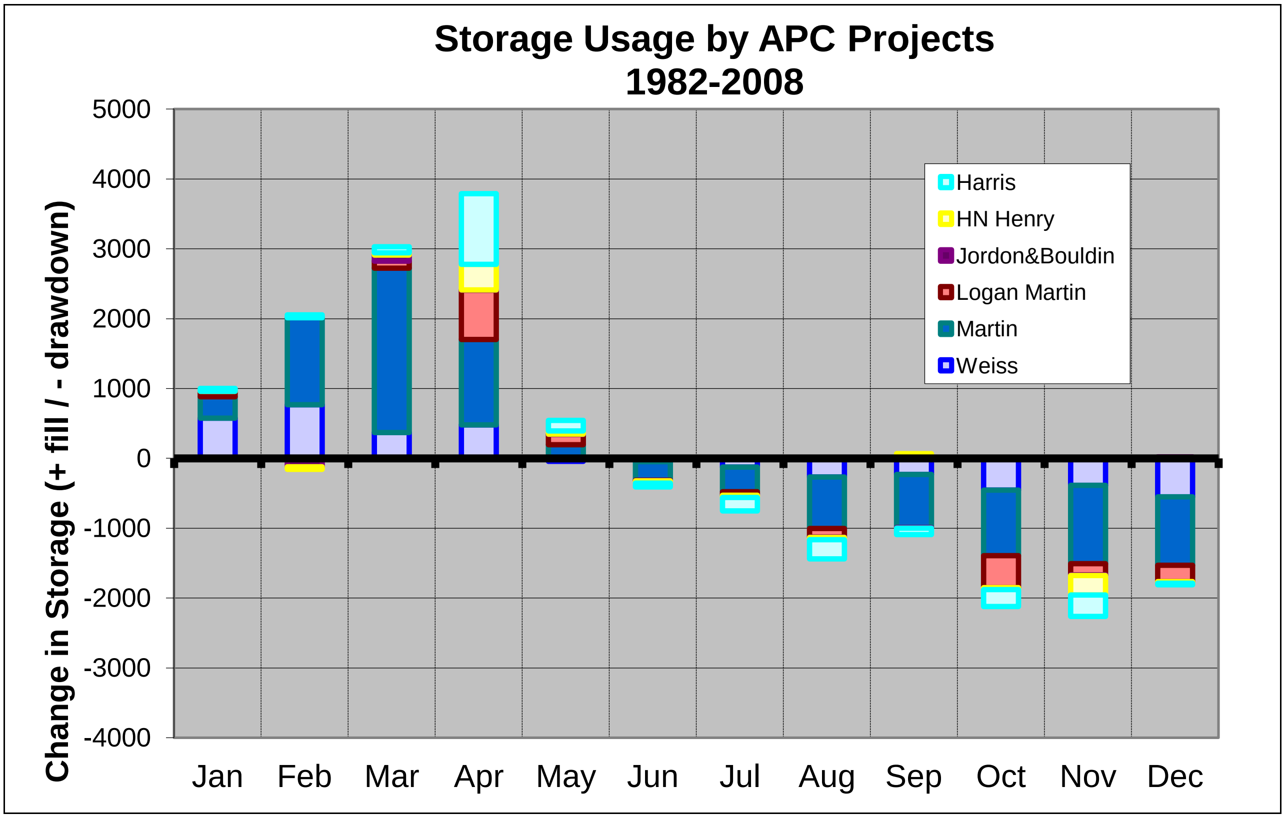


Figure 19. Average Monthly Storage Usage by Alabama Power Projects, 1982-2008

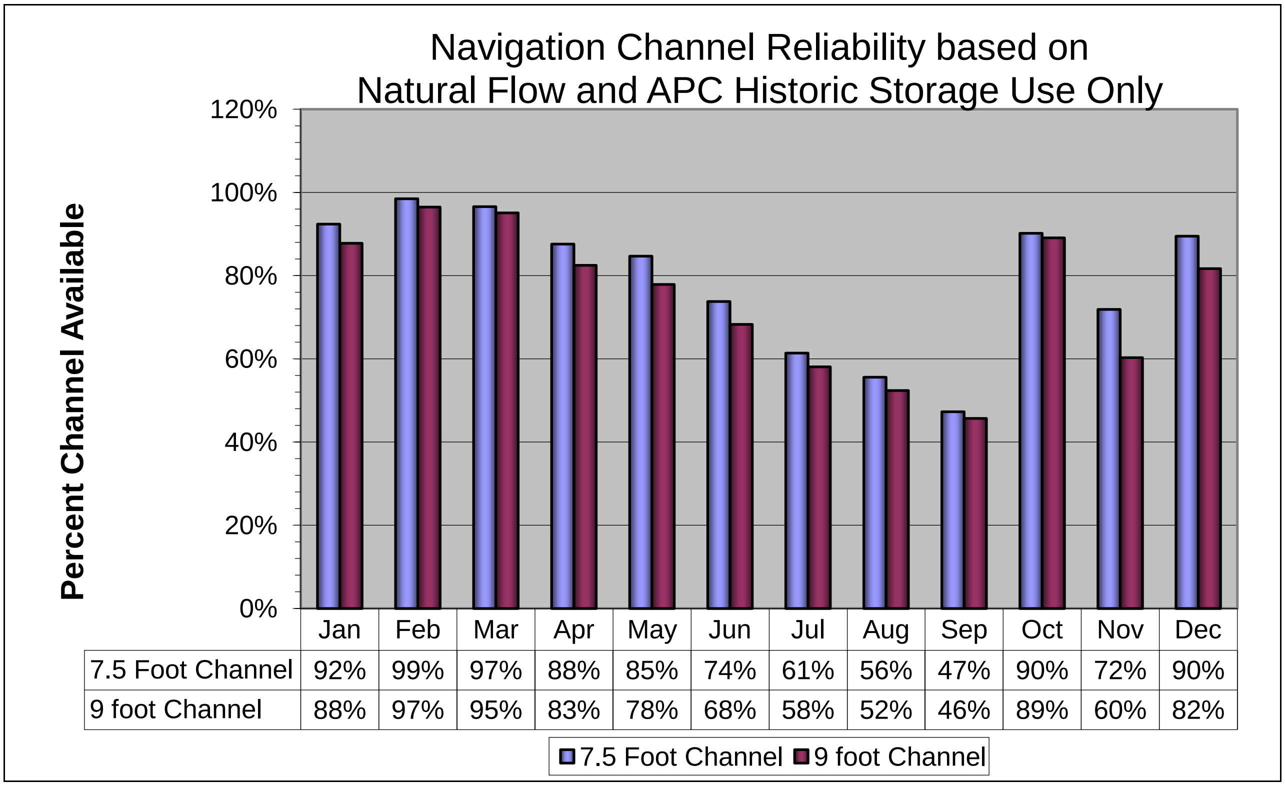


Figure 20. Navigation Channel Reliability based on Natural Flow and APC Historic Storage

With this backdrop, the Corps, in coordination with APC, developed a navigation operation based upon basin inflows and average storage usage by APC (e.g., navigation operations would not be predicated on use of additional storage) during normal hydrologic conditions. The Corps also examined the feasibility/impacts of varying channel depths (9.0-ft and 7.5-ft) during these conditions. Under this concept, the Corps and APC make releases for navigation when basin inflows meet or exceed seasonal targets for either the 9.0-ft or 7.5-ft channel templates. Triggers were also identified (e.g., when basin inflow are less than required natural flows) to change operational goals between the 9.0-ft and 7.5-ft channels. Similarly, basin inflow triggers were identified when releases for navigation will be suspended and only 7Q10 (4,640 cfs) releases will occur. During drought operations, releases to support navigation will be suspended until system recovery occurs as defined in the basin Drought Plan.

In order to determine the APC navigation flow requirements, navigation targets were prorated similarly to the proration of Claiborne Lock and Dam 7Q10 flow. Table 6 lists the monthly APC navigation flow targets to support a 9-ft and 7.5-ft channel.

Table 6. Prorated Claiborne Navigation Target at JBT Goal

Month	9’ Navigation Target	**9’ JBT Goal Target**	7.5’ Claiborne Target	**7.5’ JBT Goal Target**
Jan	11600	**9280**	9950	**7,960**
Feb	11600	**9280**	9950	**7,960**
Mar	11600	**9280**	9950	**7,960**
Apr	11600	**9280**	9950	**7,960**
May	11100	**8880**	9740	**7,792**
Jun	10600	**8480**	9530	**7,624**
Jul	10100	**8080**	9320	**7,456**
Aug	9600	**7680**	9110	**7,288**
Sep	9100	**7280**	8900	**7,120**
Oct	9100	**7280**	8900	**7,120**
Nov	11600	**9280**	9950	**7,960**
Dec	11600	**9280**	9950	**7,960**

The historic storage usage by APC projects on a monthly basis from 1982 to 2008 (Figure 19) is then used compute the required Basin Inflow above APC projects to support navigation. This now becomes the monthly flow levels or triggers that determine when APC must make releases to support navigation on the system. Table 7 lists, and Figure 21 plots, the required Basin Inflow for a 9-ft channel. Table 8 lists, and Figure 22 plots, the required Basin Inflow for a 7.5-ft channel.

Table 7. Basin Inflow above APC Projects Required to Meet 9-ft Navigation Channel

Month	APC Navigation Target	Monthly Historic Storage Usage	Required Basin Inflow
Jan	9,280	-994	**10,274**
Feb	9,280	-1894	**11,174**
Mar	9,280	-3028	**12,308**
Apr	9,280	-3786	**13,066**
May	8,880	-499	**9,379**
Jun	8,480	412	**8,068**
Jul	8,080	749	**7,331**
Aug	7,680	1441	**6,239**
Sep	7,280	1025	**6,255**
Oct	7,280	2118	**5,162**
Nov	9,280	2263	**7,017**
Dec	9,280	1789	**7,491**

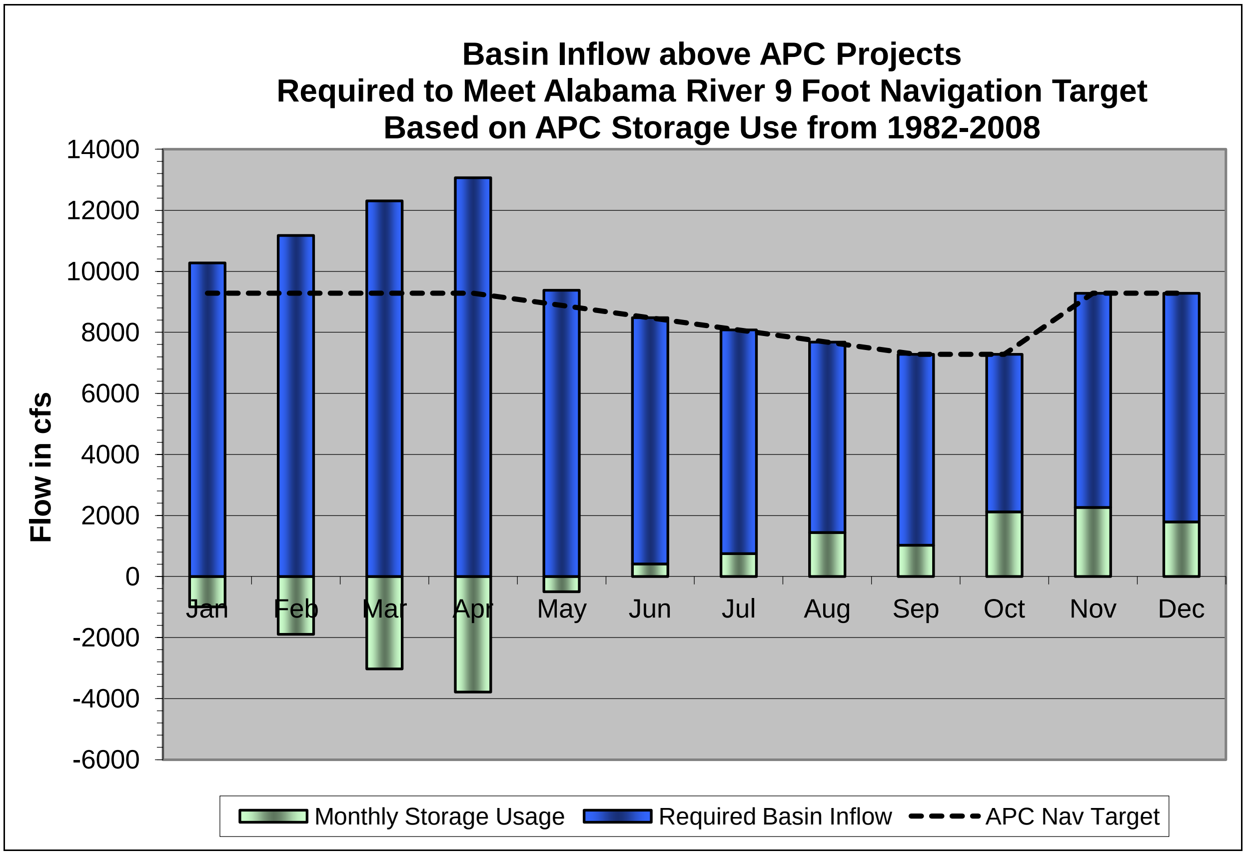


Figure 21. Basin Inflow above APC Projects Required to Meet 9-ft Navigation Channel

Table 8. Basin Inflow above APC Projects Required to Meet 7.5-ft Navigation Channel

Month	APC Navigation Target	Monthly Historic Storage Usage	Required Basin Inflow
Jan	7,960	-994	**8,954**
Feb	7,960	-1,894	**9,854**
Mar	7,960	-3,028	**10,988**
Apr	7,960	-3,786	**11,746**
May	7,792	-499	**8,291**
Jun	7,624	412	**7,212**
Jul	7,456	749	**6,707**
Aug	7,288	1,441	**5,847**
Sep	7,120	1,025	**6,095**
Oct	7,120	2,118	**5,002**
Nov	7,960	2,263	**5,697**
Dec	7,960	-994	**8,954**

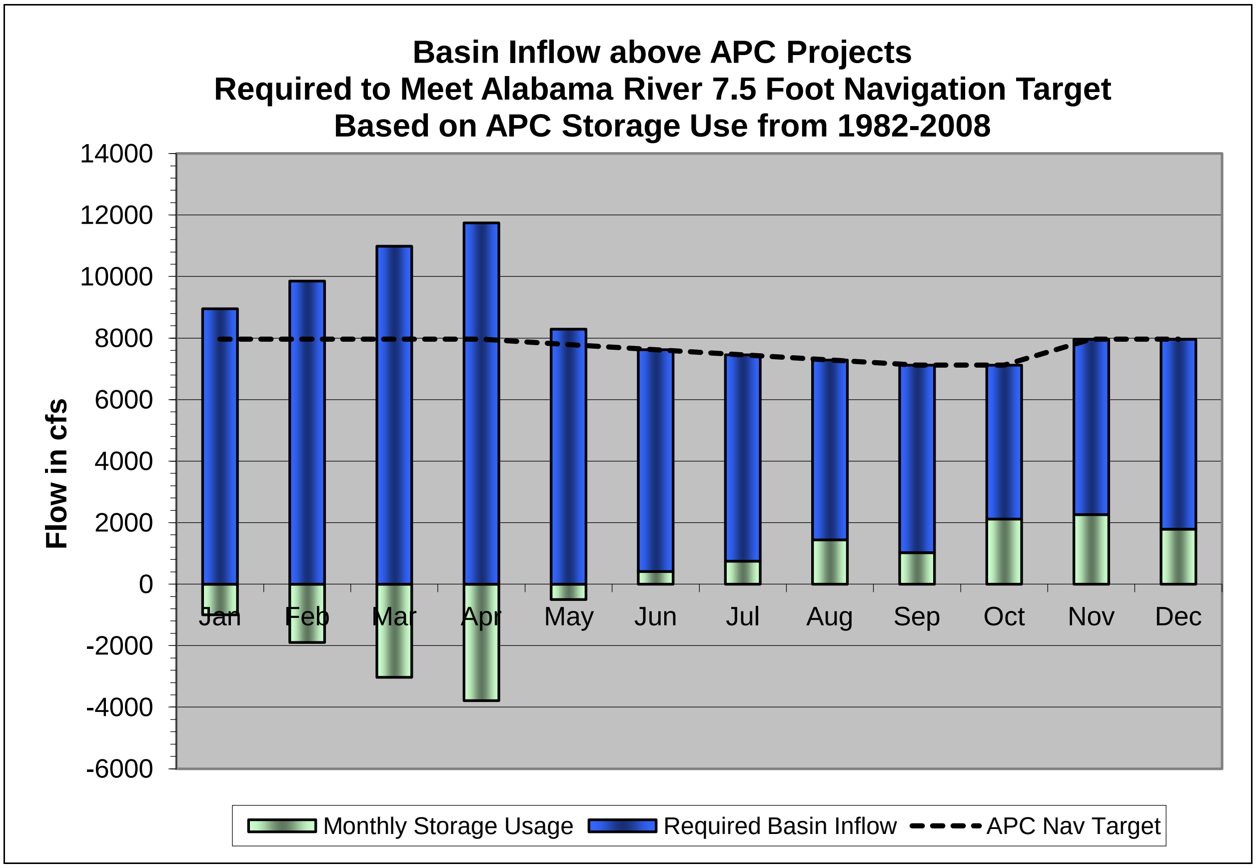


Figure 22. Basin Inflow above APC Projects Required to Meet 7.5-ft Navigation Channel

The Basin Inflow trigger for navigation operation is the sum of regulated local flows above each APC project. Figure 23 is a map indicating the local flow above the APC projects. For Weiss, the net inflow is used, which, unlike the Basin Inflow calculated for determining the Drought Intensity Level, includes regulated flows from Carters and Allatoona. These observed local flows include the effects of depletions and lake evaporative losses. The basic equation is:

$$\text{Basin Inflow}_{\text{Navigation}} = \text{Sum of Weiss Inflow} + \text{APC Unimpaired Local flows (below Weiss)}$$

The same calculation, as implemented in ResSim, using ResSim variables is as follows:

$$\text{Basin Inflow}_{\text{Navigation}} = \text{Jordan UNREG} + \text{Thurlow UNREG} - \text{Weiss UNREG} + \text{Weiss Net Inflow} - \text{APC lake evaporation (below Weiss)}$$

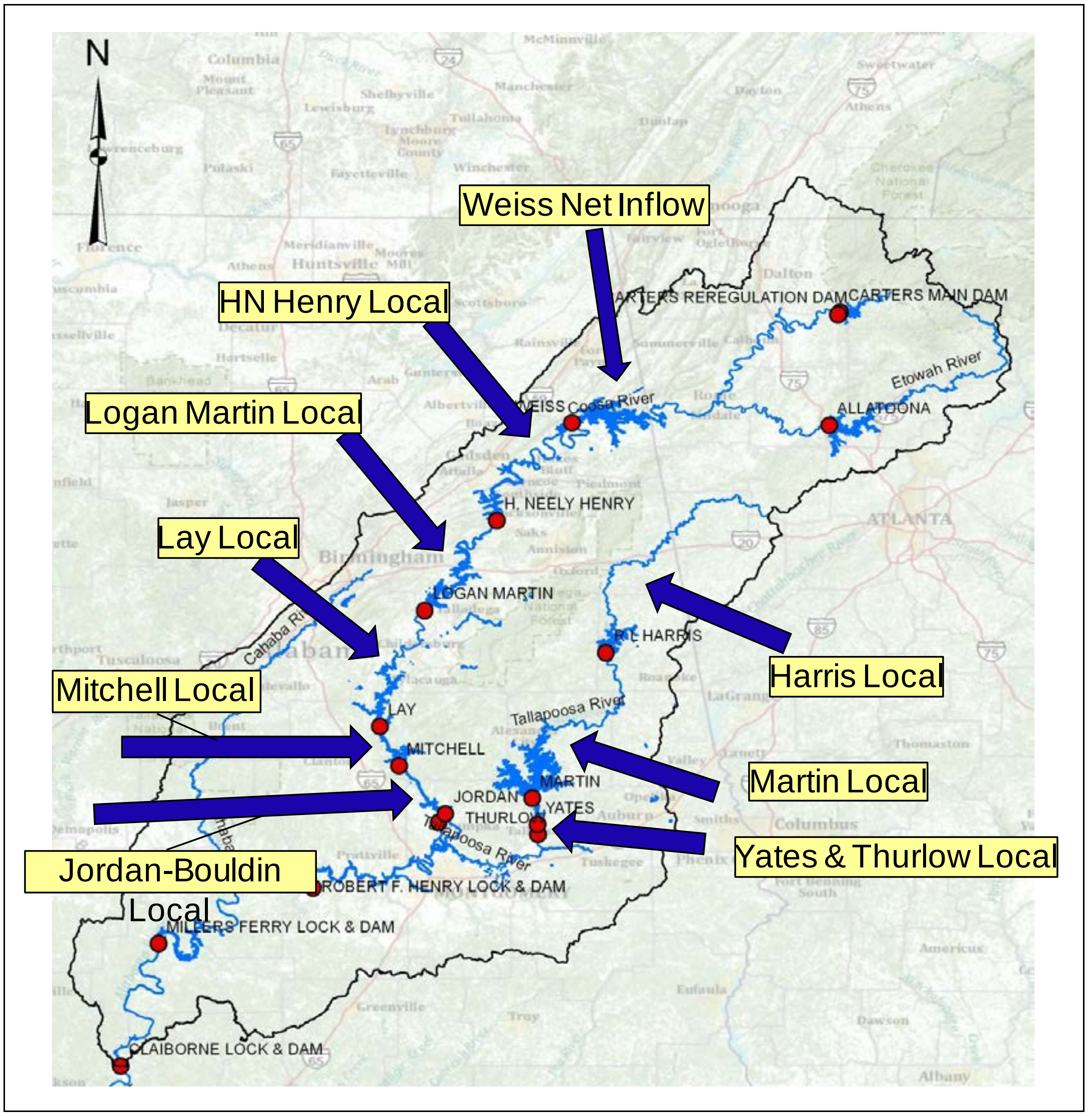


Figure 23. Local Flows above APC Projects

5. Carters Dam Measures

a. Seasonally Varying Flow

The Corps considered changing minimum flow releases from the Carters Reregulation (ReReg) dam, which were a constant 240 cfs, to a seasonally variable requirement. For example, see the Figure 24 plot of monthly flow values considered, which were based on a 2003 study of impacts of revised ReReg minimum flows. Coordination with US Fish and Wildlife Service (FWS) in 2003 indicated a USFWS desire that releases from the Carters Reregulation Dam be revised to mimic a more natural flow regime to benefit the aquatic ecosystem in the Coosawattee River downstream of the Carters Reregulation Dam.

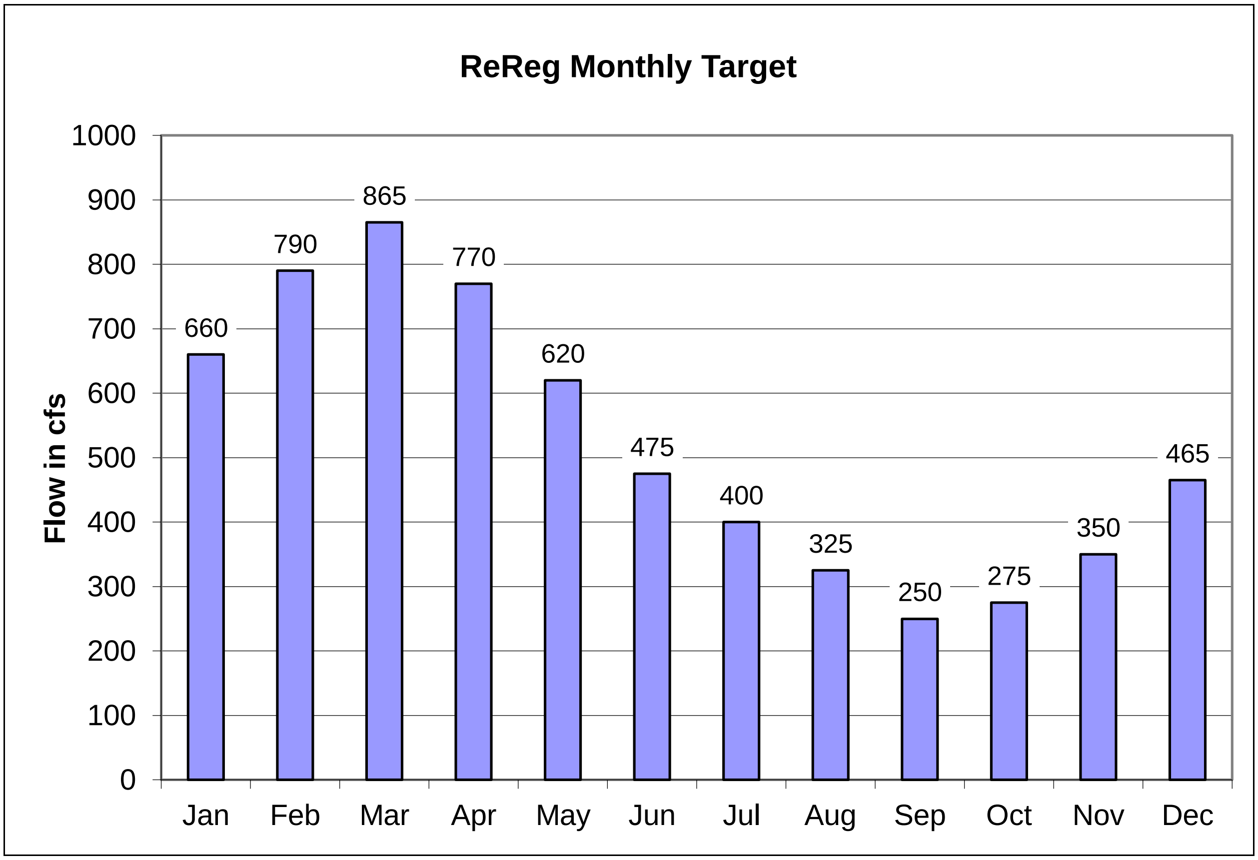


Figure 24. Carters Reregulation Dam Monthly Flow Target

b. Action Zones

The conservation pool of Carters was divided into two different zones - Zone 1 and below it, Zone 2. Once Zone 2 is entered, the seasonally-varying minimum flow is changed to the constant (and lesser) 7Q10 flow of 240 cfs. These zones are used to manage the lakes at the highest level possible for project purposes that benefit from high lake levels. The actions zones also provide guidance on meeting minimum hydropower needs at the project, as well as to determine the amount of storage available for water quality and environmental flows. The Zone1 / Zone 2 boundary represents a change in monthly minimum flow requirement from the Carters/Carters Reregulation Dam System. The seasonal varied flow is reduced to the constant 7Q10 flow. Zone 2 guide curve follows the pattern of the computed 20th percentile pool elevation (for period 1975-2010). Flow and stage that are less than the 20th percentile are typically classified as low flow or dry conditions for hydrological analysis. Refinements were made so that Zone1 would represent the need for flow augmentation. In other words, the volume of Zone 1 increased during periods of greatest demand in the fall (Sep-Oct) period. Zone 2 represents an operational response to drought conditions and guide curve shaped by historic low flow conditions at the lake. Zone1 guide curve is the original top of conservation guide curve with fixed dates to raise pool during spring and lower pool during fall.

c. Guide Curve Definition

The Corps considered formalizing the guide curve transitions that delineate winter and summer reservoir levels. The existing Carters manual describes a specific summer and winter level, but no exact date to transition from winter to summer or summer to winter. The transition date is selected based on many years of operational experience.

6. Allatoona Dam Measures

a. Action Zones

The 2007-2009 drought period revealed a need to further refine the reservoir operation to reduce the depletion of storage in drought period. Baseline operations include two action zones at Allatoona. The action zones are used to manage the lake levels at the highest level possible and provide guidance on meeting minimum project purposes as the storage is utilized.

Three variations of the actions zones at Allatoona Dam were developed. The first, called “Burkett,” adds two additional action zones, for a total of four (Figure 25). These action zones were derived by evaluating the historic demand for hydropower. There is a distinctive seasonal demand for the hydropower, with highest demand occurring June through August. The top of Zone 2 is revised to have a similar shape to the average pool elevation. This allows for greater generation when storage is above Zone 2 during above normal conditions. The storage in Zone 3 is used to provide reliable hydropower without depleting storage. Zone 4 represents a drought level zone where only minimum flow requirements are released.

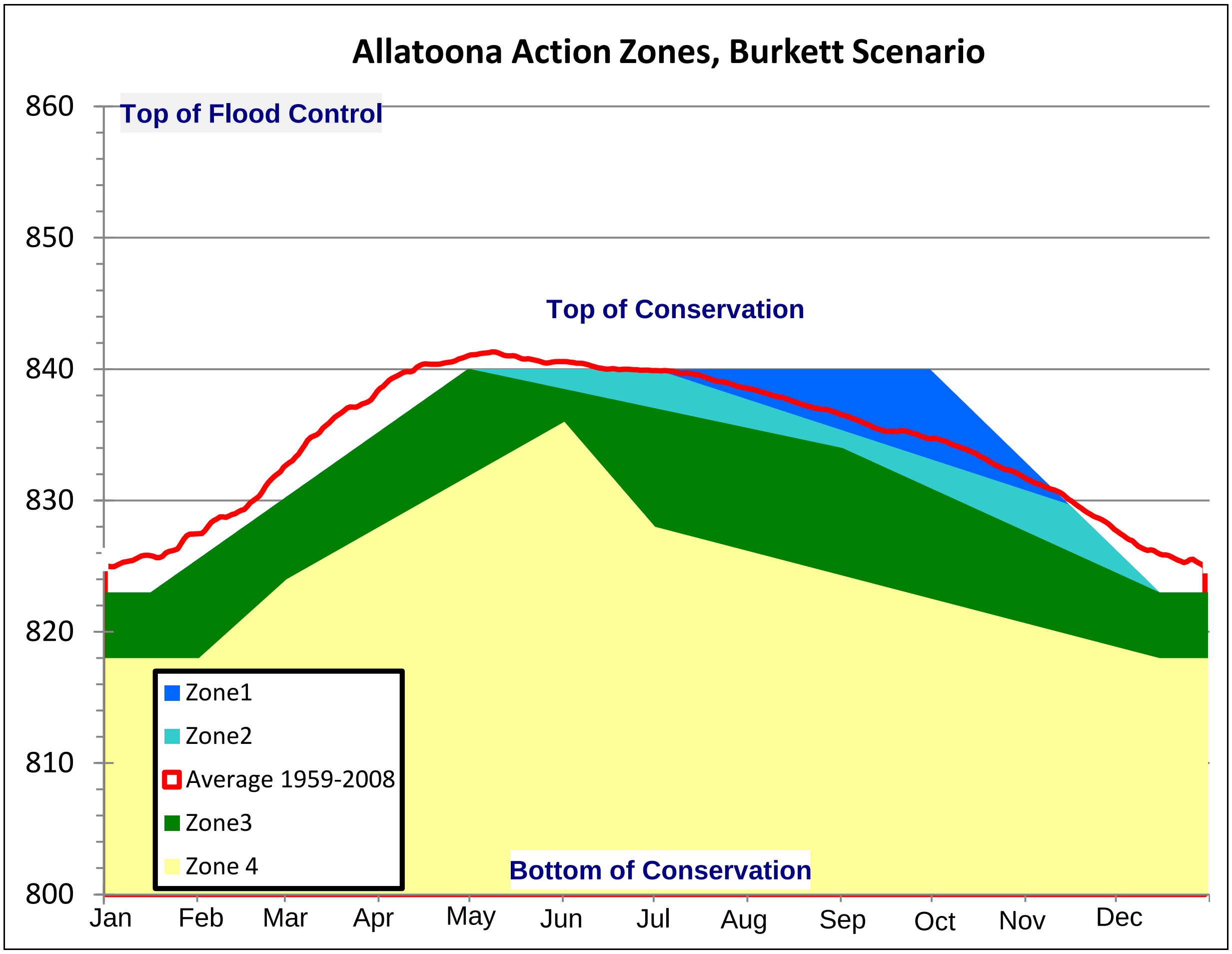


Figure 25. Burkett Allatoona Action Zone Scenario

An alternative operating scenario, "Drago A," adds only one additional action zone for a total of three (Figure 26). Action zones 1 and 2 are not changed. New Zone 3 is a drought level zone wherein only minimum flow requirements are released. The shape of Zone 3 is based on the reservoir operation during the recent 2007 drought period.

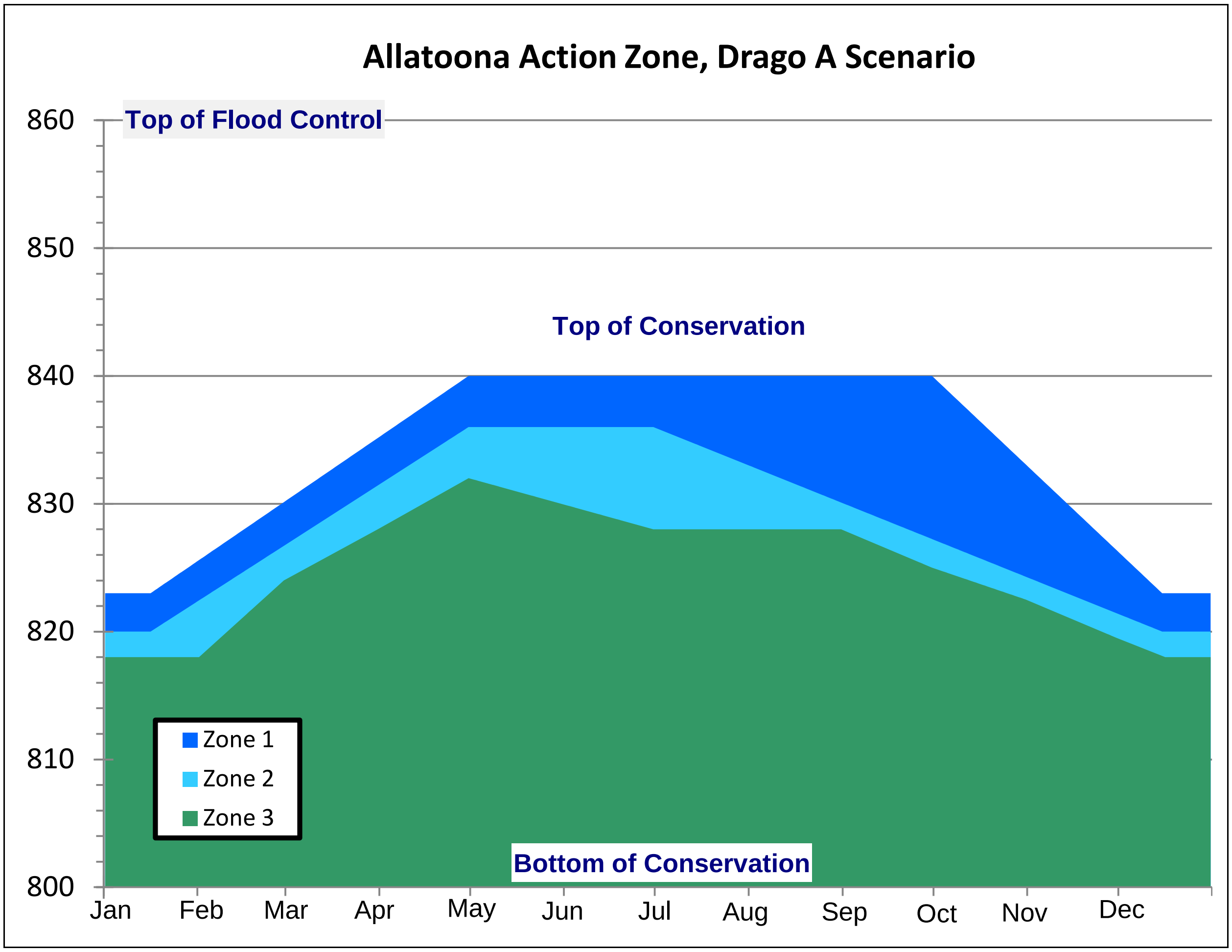


Figure 26. Drago A Allatoona Action Zone Scenario

A third operating scenario, “DragoB," is like DragoA in that it also adds one additional action zone for a total of three (Figure 27). Action Zones 1 and 2 are not changed. New Zone 3 is a drought level zone wherein only minimum flow requirements are released. The shape of Drago B’s Zone 3 is similar to Zone 2.

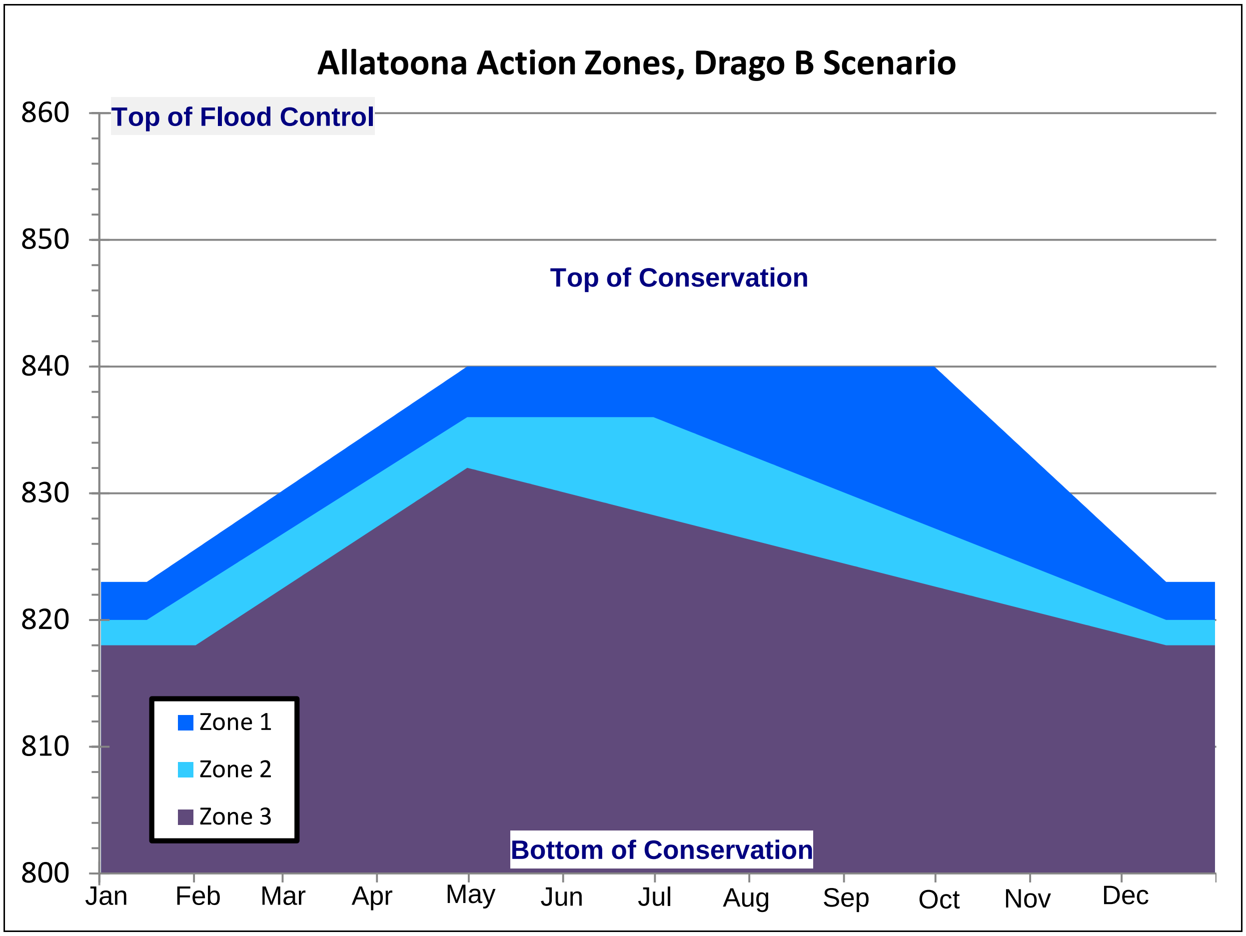


Figure 27. Drago B Allatoona Action Zone Scenario

b. Hydropower Requirement

The Corps also uses the action zones to provide guidance on meeting minimum hydropower needs at Allatoona. The minimum hydropower is represented by a range of peaking hours, depending on the hydrologic condition of the basin. Consistent with Corps conservative reservoir operation, the lower value of the hydropower range is used during low flow drought condition and recovery from droughts. When storage enters lowest zone, peaking hydropower operation is suspended and releases are made to meet the minimum 7Q10 flow release of 240 cfs. There are a total of four hydropower scenarios considered, three for the Burkett Action Zone scenarios and one for the Drago Action Zone scenarios (Table 9 through Table 12). The highest number of hours in each zone is used in the model to simulate the hydropower requirement. The range of hydropower peaking hours allows for flexibility in actual reservoir operation and is not captured in the modeling effort for the manual update.

Table 9. Burkett Hydropower Scenario

Zone	Hours	Minimum Q (cfs)
Zone 1	0-6	240
Zone 2	0-4	240
Zone 3	0-2	240
Zone 4	0	240

Table 10. Burkett B and Burkett C Hydropower Scenario

Zone	Hours	Minimum Q (cfs)
Zone 1	0-4	240
Zone 2	0-3	240
Zone 3	0-2	240
Zone 4	0	240

Table 11. Burkett D Hydropower Scenario[**]

Zone	Hours	Minimum Q (cfs)
Zone 1	0-4	240
Zone 2	0-3	240
Zone 3	0-2	240
Zone 4	0	240

[**] Reduced hydropower demand during Sep-Nov period

Table 12. DragoA and DragoB Hydropower Scenario

Zone	Hours	Minimum Q (cfs)
Zone 1	2-6	240
Zone 2	0-2	240
Zone 3	0	240

Fixed hydropower requirements were used in each zone. These requirements represent the most likely hydropower demand during normal conditions. Hydropower power reduction occurs primarily during predicted or actual prolonged low flow conditions. Allatoona is one of several hydropower projects in the ACT/ACF system that contributes to meeting the system demand. There are numerous factors that water managers consider when determining the available hydropower generation hours. These factors don't lend themselves to a model algorithm; as a result they were omitted. The fixed number of hydropower hours per zone is sufficient to capture typical reductions.

c. Guide Curve Fall Drawdown

Responding to comments from stakeholders, there was an attempt to modify the summer pool duration at Allatoona. This was accomplished by adjusting the timing of drawdown periods between summer and winter pool (guide curve fall shoulder).

One scenario included extending the summer level through October and drawing down to the winter level through January. Allatoona does not remain full for the entire summer period, May through September (as shown by historic average pool in Figure 28). Consequently, two early drawdown scenarios were considered; one, a continuous drawdown from September (after Labor Day) through December, and the other, a step-down that remains above the initial recreation impact level until mid November. Three different scenarios were modeled for the Allatoona drawdown (Figure 29):

1. Extended November drawdown
2. Early September drawdown
3. October stepped drawdown (Phased Drawdown).

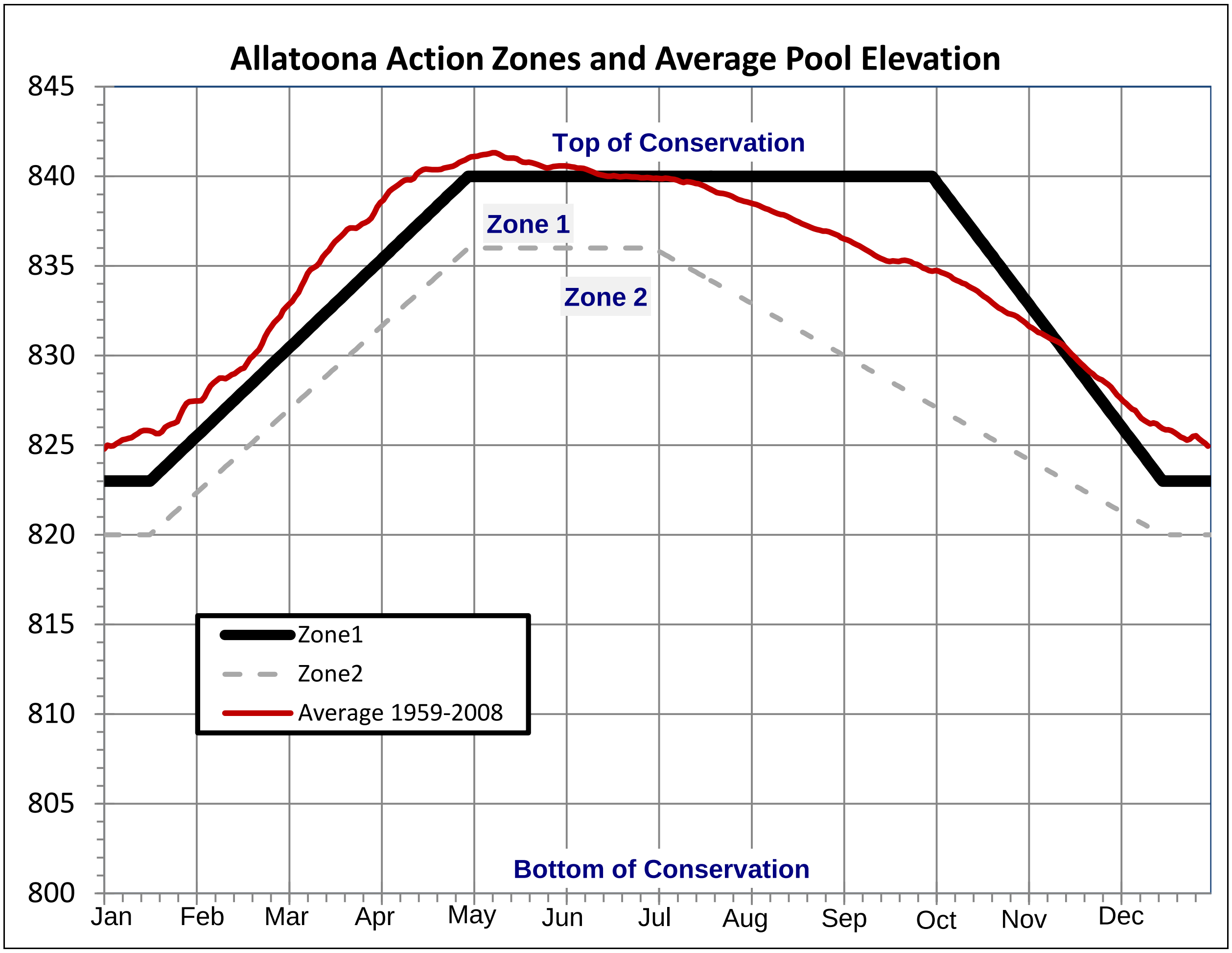


Figure 28. Allatoona Action Zones and Average Pool Elevation

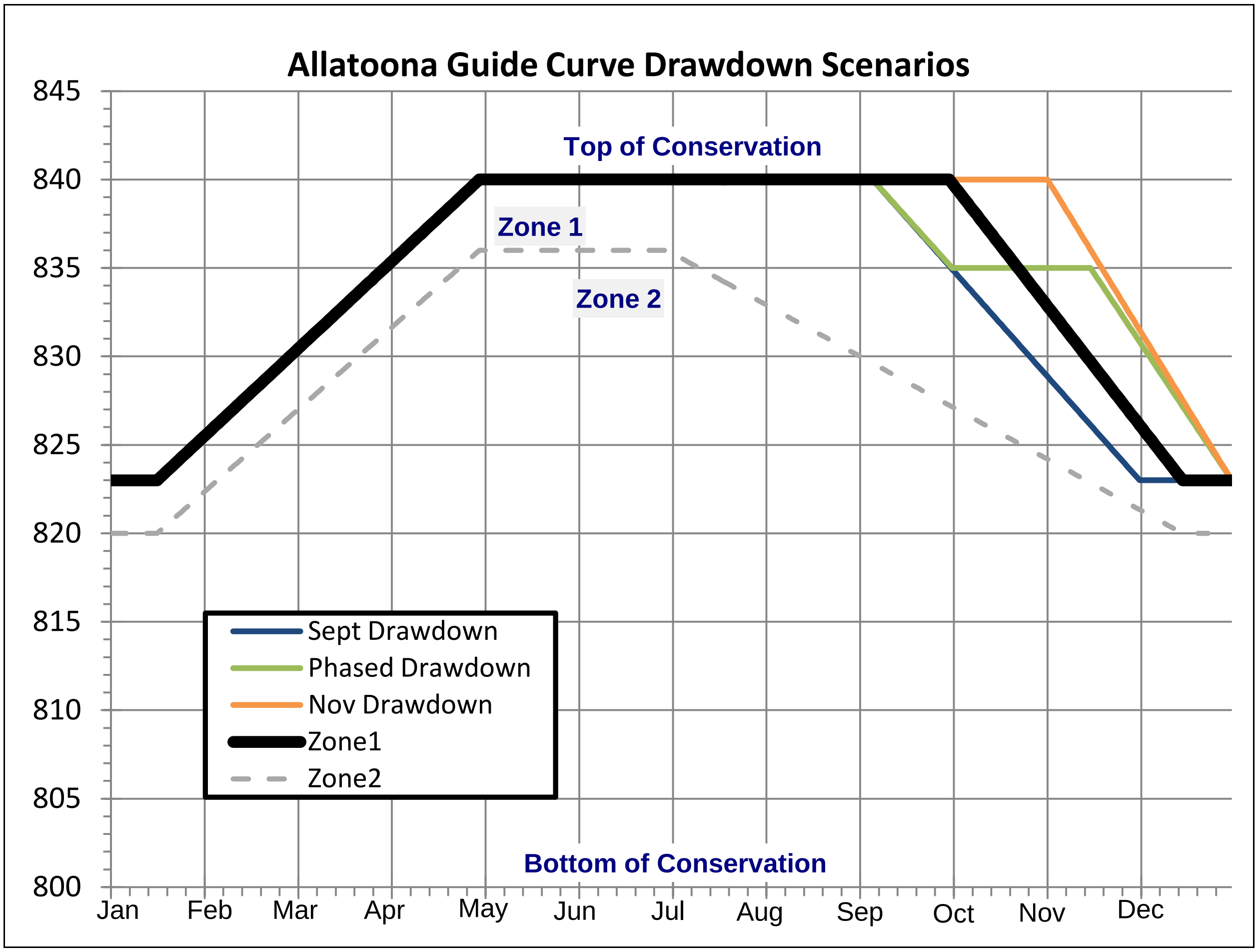


Figure 29. Allatoona Guide Curve Drawdown Scenarios

An hourly flood study model (as discussed in Appendix M) from the headwaters of Allatoona and Carters to Rome, Georgia was developed to evaluate any downstream flooding impact from proposed modifications to flood operations at Allatoona Dam.

The objectives of the flood modeling are as follows:

- Capture the current Flood Reduction operation of Carters and Allatoona,
- Simulate the current guide curve and three additional scenarios of the fall reservoir drawdown (Figure 29),
- Compare the resultant regulated frequency flow at Rome-Coosa and Kingston, and
- Identify improvements in the Carters and Allatoona flood operation.

The Step-Down, or Phased Drawdown, alternative was selected because of the benefit to flood protection, hydropower and recreation. Consequently, alternatives will be considered using the Phased Drawdown as the guide curve or Top of Zone 1. Figure 30 depicts the Burkett scenario with the Phased Drawdown.

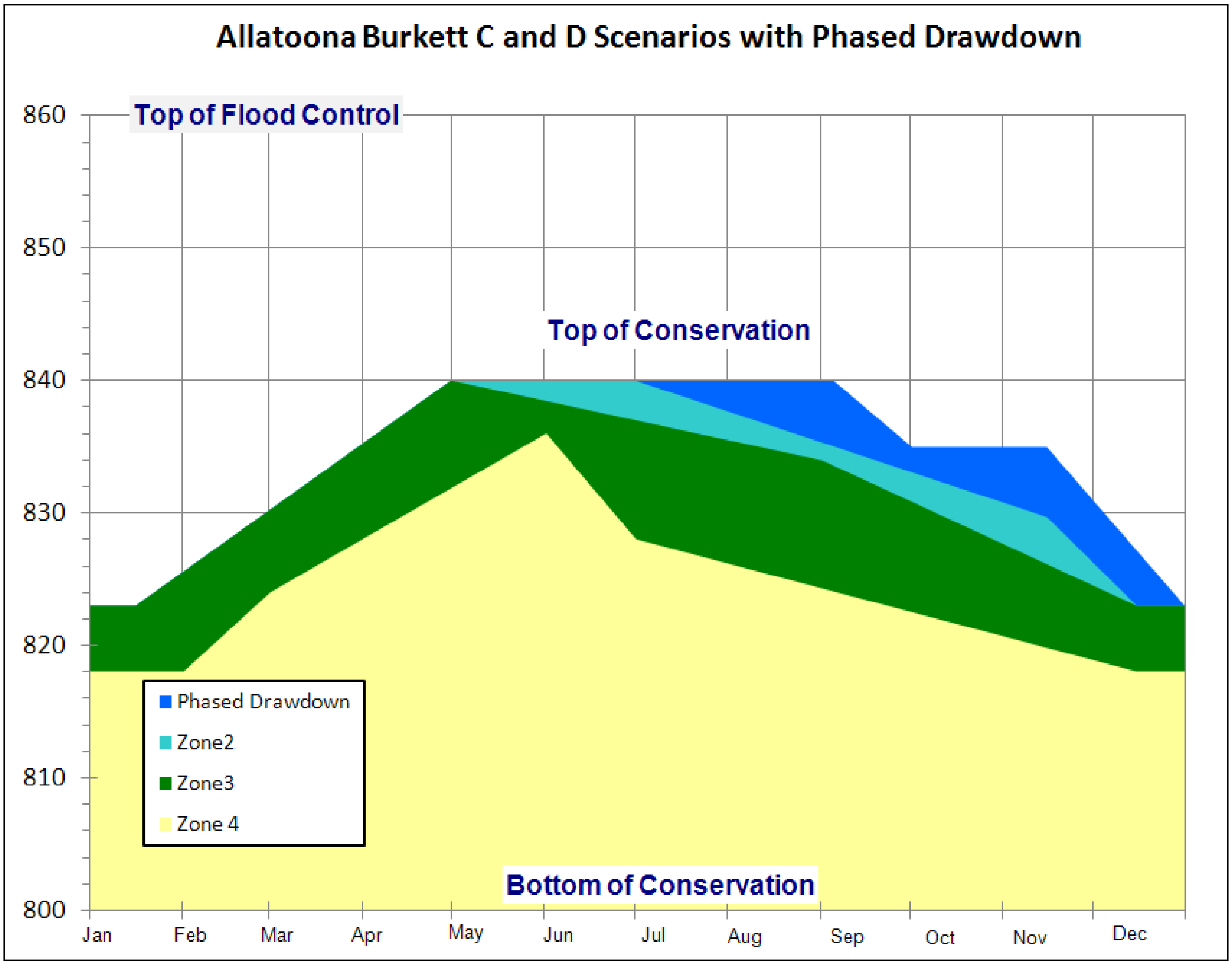


Figure 30. Allatoona Burkett Scenario with Phased Drawdown

7. Drought Plan

The ACT Basin experienced severe drought conditions during the 2007-2009 period. The Corps and APC do not currently have an agreed-upon methodology for defining drought conditions and corresponding reservoir operations. Therefore, while developing the navigation concept, the Corps, in coordination with APC, developed a drought plan to meet minimum flows from the Coosa and Tallapoosa Basins.

The Drought Level Response matrix is shown in Table 13. This matrix provides the operational guidelines for the Coosa, Tallapoosa, and Alabama Rivers, based on the Drought Intensity Level (DIL). The DIL is a drought indicator, ranging from zero to three, that is determined based on three different basin drought criteria. A DIL=0 indicates normal operations, while a DIL from 1 to 3 indicates some level of drought conditions. The DIL increases as the number of drought level criteria that have been triggered increases. The matrix defines monthly minimum flow requirements for the Coosa, Tallapoosa and into the Alabama River, as function of DIL and time of year. These flow requirements are modeled as daily averages.

Table 13. Alternative Drought Level Response Matrix

<table>
<tr><th colspan="14">Alternative Drought Level Response Matrix****</th></tr>
<tr><th></th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th colspan="2">Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td rowspan="4">Drought Intensity Level Triggers</td><td colspan="13">DL 0 - Normal Operations</td></tr>
<tr><td colspan="13">DL 1: Low Basin Inflows or Low Composite or Low State Line Flow</td></tr>
<tr><td colspan="13">DL 2: DL 1 criteria + (Low Basin Inflows or Low Composite or Low State Line Flow)</td></tr>
<tr><td colspan="13">DL 3: Low Basin Inflows + Low Composite + Low State Line Flow</td></tr>
<tr><td rowspan="4">Coosa River Flow*</td><td colspan="3">Normal Operation: 2000 cfs</td><td colspan="2">4000 (8000)</td><td colspan="2">4000 - 2000</td><td colspan="6">Normal Operation: 2000 cfs</td></tr>
<tr><td colspan="3">Jordan 2000 +/-cfs</td><td colspan="2">4000 +/- cfs</td><td colspan="2">6/15 Linear Ramp down</td><td colspan="3">Jordan 2000 +/-cfs</td><td colspan="3">Jordan 2000 +/-cfs</td></tr>
<tr><td colspan="3">Jordan 1800 +/-cfs</td><td colspan="2">2500 +/- cfs</td><td colspan="2">6/15 Linear Ramp down</td><td colspan="3">Jordan 2000 +/-cfs</td><td colspan="3">Jordan 1800 +/-cfs</td></tr>
<tr><td colspan="3">Jordan 1600 +/-cfs</td><td colspan="4">Jordan 1800 +/-cfs</td><td colspan="3">Jordan 2000 +/-cfs</td><td colspan="2">Jordan 1800 +/-cfs</td><td>Jordan 1600 +/-cfs</td></tr>
<tr><td rowspan="4">Tallapoosa River Flow**</td><td colspan="13">Normal Operations: 1200 cfs</td></tr>
<tr><td colspan="4">Greater of: 1/2 Yates Inflow or 2 x Heflin Gage(Thurlow releases > 350 cfs)</td><td colspan="6">1/2 Yates Inflow</td><td colspan="3">1/2 Yates Inflow</td></tr>
<tr><td colspan="4">Thurlow 350 cfs</td><td colspan="6">1/2 Yates Inflow</td><td colspan="3">Thurlow 350 cfs</td></tr>
<tr><td colspan="7">Maintain 400 cfs at Montgomery WTP (Thurlow release 350 cfs)</td><td colspan="3">Thurlow 350 cfs</td><td colspan="3">Maintain 400 cfs at Montgomery WTP (Thurlow release 350 cfs)</td></tr>
<tr><td rowspan="4">Alabama River Flow***</td><td colspan="13">Normal Operation: Navigation or 7Q10 flow</td></tr>
<tr><td colspan="4">4200 cfs (10% 7Q10 Cut) - Montgomery</td><td colspan="6">7Q10 - Montgomery (4640 cfs)</td><td colspan="3">Reduce: Full - 4200 cfs</td></tr>
<tr><td colspan="6">3700 cfs (20% 7Q10 Cut) - Montgomery</td><td colspan="4">4200 cfs (10% 7Q10 Cut) - Montgomery</td><td colspan="3">Reduce: 4200 cfs-> 3700 cfs Montgomery (1 week ramp)</td></tr>
<tr><td colspan="4">2000 cfs Montgomery</td><td colspan="3">3700 cfs Montgomery</td><td colspan="3">4200 cfs (10% 7Q10 Cut) - Montgomery</td><td colspan="3">Reduce: 4200 cfs -> 2000 cfs Montgomery (1month ramp)</td></tr>
<tr><td rowspan="4">Rule Curve Elevation</td><td colspan="13">Normal Operations: Elevations follow Rule Curves as prescribed in License (Measured in Feet)</td></tr>
<tr><td colspan="13">USACE Variances: As Needed; FERC Variance for Martin</td></tr>
<tr><td colspan="13">USACE Variances: As Needed; FERC Variance for Martin</td></tr>
<tr><td colspan="13">USACE Variances: As Needed; FERC Variance for Martin</td></tr>
</table>

*Jordan flows are based on a continuous +/- 5% of target flow.

**Thurlow flows are based on continuous +/- 5% of target flow: flows are reset on noon each Tuesday based on the prior day's daily average at Heflin or Yates.

***Alabama River flows are 7-Day Average Flow.

****Note these are based flows that will be exceeded when possible.

The drought triggers or indicators were selected to capture representative conditions throughout the basin. The combined occurrences of the drought triggers determine the DIL. There are four intensity levels determined using three drought intensity triggers in the ACT system.

Drought Intensity Levels (DIL):

- DL0 – no trigger, normal operation
- DL1 – (moderate drought) 1 of 3 triggers exceeded
- DL2 – (severe drought) 2 of 3 triggers exceeded
- DL3 – (exceptional drought) All 3 triggers exceeded

Drought Intensity Indicators (i.e., DIL Triggers):

a.) low Basin Inflow
b.) low Composite Storage
c.) low State Line Flow

If none of these indicators are triggered, the Drought Intensity Level (DIL) is set to zero. As each of these indicators are triggered, the DIL increases by one, meaning that the DIL will be between one and three if drought conditions are occurring, with three being the most severe DIL with all three indicators being triggered.

The DIL is computed on the 1st and 15th of each month. Once drought operation is triggered, the DIL trigger can only recover from drought condition at a rate of one level per period. For example as the system begins to recover from an exceptional drought with DIL=3, the DIL must be stepped incrementally back to zero to resume normal operations. In this case, even if the system triggers return to normal quickly, it will still take at least a month before normal operations may resume - conditions can only improve to DIL=2 for the next computation period, then DIL=1 for the next period, before finally returning to DIL=0.

For DIL=0, the matrix shows a Coosa River flow between 2,000 cfs and 4,000 cfs with peaking periods up to 8,000 cfs occurring. The required flow on the Tallapoosa River is a constant 1,200 cfs throughout the entire year. The navigation flows on the Alabama River are applied to the APC projects. The required navigation depth on the Alabama River is subject to the basin inflow.

For DIL=1, the Coosa River flow varies from 2,000 cfs to 4,000 cfs. On the Tallapoosa River, part of the year, the required flow is the greater of one-half of the inflow into Yates and twice the Heflin gage. For the remainder of the year, the required flow is one-half of Yates inflow. The required flows on the Alabama River are reduced from the amounts when DIL=0.

For DIL=2, the Coosa River flow varies from 1,800 cfs to 2,500 cfs. On the Tallapoosa River, the minimum is 350 cfs for part of the year and one-half of

Yates inflow for the remainder of the year. The requirement on the Alabama River is between 3,700 cfs and 4,200 cfs.

For DIL=3, the flows on the Coosa River range from 1,600 cfs to 2,000 cfs. A constant flow of 350 cfs on the Tallapoosa River is required. It is assumed an addition 50 cfs will occur between Thurlow Dam the City of Montgomery water supply intake. Required flows on the Alabama River range from 2,000 cfs to 4,200 cfs

In addition to the Drought Plan operations shown in the matrices, the DIL affects the navigation operations. When the DIL is equal to zero, APC projects are operated to meet navigation flow target or the 7Q10 flow as defined in the navigation measure section. Once DIL is greater than zero, drought operations will occur and navigation operations are suspended.

a. Low Basin Inflow Trigger

The Total Basin Inflow needed is sum of Total Filling Volume + 7Q10 flow (4,640 cfs). Table 14 lists the monthly Low Basin Inflow criteria. All numbers are in cfs-days. The Basin Inflow value is computed each daily time step and checked on the 1st and 15th of the month. If computed Basin Inflow is less than the value required, then the Low Basin Inflow Indicator is triggered.

Table 14. Low Basin Inflow Guide (in cfs-days)

Month	Coosa Filling Volume	Tallapoosa Filling Volume	Total Filling Volume	Navigation	Required Basin Inflow
Jan	629	0	629	4640	5269
Feb	647	1968	2615	4640	7255
Mar	603	2900	3503	4640	8143
Apr	1683	2585	4268	4640	8908
May	242	0	242	4640	4882
Jun			0	4640	4640
Jul			0	4640	4640
Aug			0	4640	4640
Sep	-602	-1304	-1906	4640	2734
Oct	-1331	-2073	-3404	4640	1236
Nov	-888	-2659	-3547	4640	1093
Dec	-810	-1053	-1863	4640	2777

The Basin Inflow is total flow above the APC projects including Allatoona and Carters. This is the sum of local flows, minus lake evaporation, minus diversions. Figure 31 is a map indicating the local inflows to the Coosa and Tallapoosa Basin projects. This Basin Inflow computation differs from the Navigation Basin Inflow, because it does not include inflows to Carters and Allatoona. The intent is to capture the hydrologic condition across the Coosa and Tallapoosa Basins. The basic equation is:

Basin Inflow Drought = APC Unimpaired Local flows

The same calculation, as implemented in ResSim, using ResSim variables is as follows:

$$\text{Basin Inflow}_{\text{Drought}} = \text{Jordan UNREG} + \text{Thurlow UNREG} - \text{Carters UNREG} - \text{Allatoona UNREG} - \text{APC lake evaporation}$$

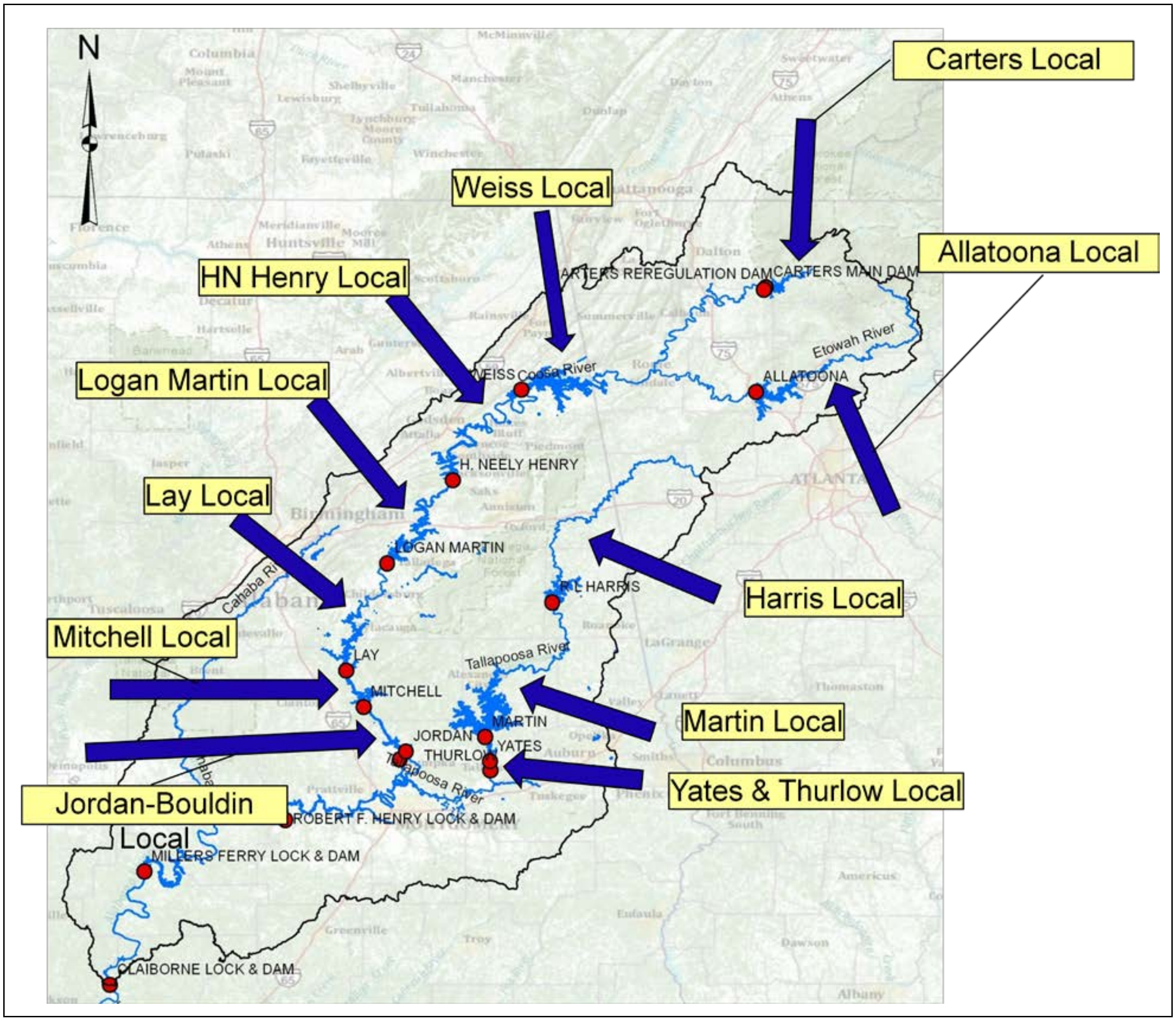


Figure 31. Local Flow above Coosa and Tallapoosa Basin Projects

b. State Line Flow Trigger

A Low State Line Flow trigger occurs when the Mayo's Bar USGS gage measures a flow below the monthly historical 7Q10 flow. The 7Q10 flow is defined as the lowest flow over a 7 day period that would occur once in 10 years. Table 15 list the Mayo’s Bar 7Q10 value for each month. The lowest 7-day average flow over the last 14 days is computed and checked at the 1st and 15th of the Month. If the lowest 7-day average value is less Mayo’s Bar 7Q10 value, then the State Line Flow Indicator is triggered. If the result is greater than or equal to the trigger value from Table 15, then the flow state is considered normal and the state line flow indicator is not triggered.

Table 15. State Line Flow Trigger

Month	Mayo's Bar (7Q10 in cfs)
Jan	2544
Feb	2982
Mar	3258
Apr	2911
May	2497
Jun	2153
Jul	1693
Aug	1601
Sep	1406
Oct	1325
Nov	1608
Dec	2043

Based on USGS Coosa River at Rome Gage (Mayo’s Bar, site 02397000) observed flow from 1949-2006.

c. Low Composite Storage

Low Composite Storage occurs when the APC projects' composite storage is less than or equal to the storage available within the drought contingency curves for the APC reservoirs. Composite storage is the sum of the amounts of storage available at the current elevation for each reservoir down to the drought contingency curve at each APC major storage project. The reservoirs considered for this trigger are Harris, HN Henry, Logan Martin, Martin, and Weiss. Figure 32 plots the APC composite zones. Figure 33 plots the APC low composite storage trigger.

If the actual active composite storage is less than or equal to the active composite drought zone storage, the Low Composite Storage state variable is then assigned a value of one, indicating that one level of drought severity has been triggered. This computation is performed on the 1st and 15th of each month, and is compared to the Low State Line flow trigger and basin inflow trigger.

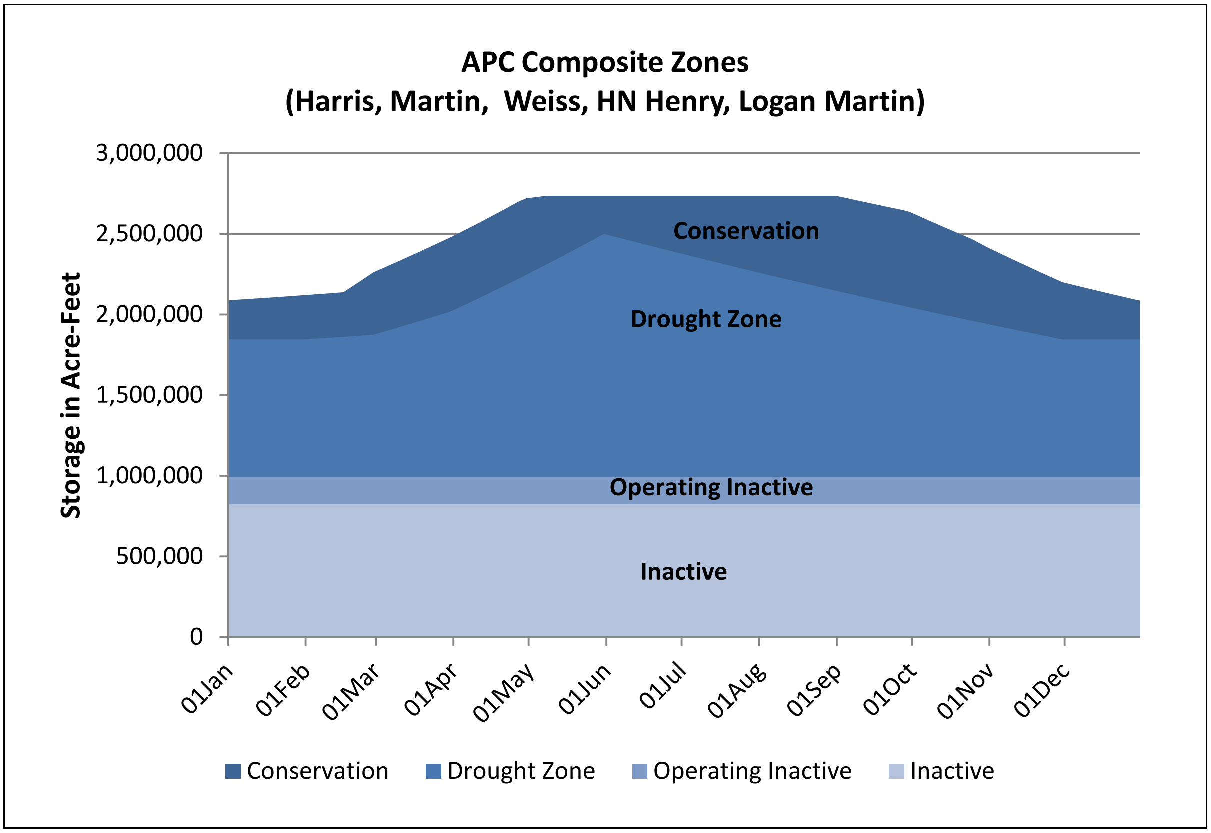


Figure 32. APC Composite Zones

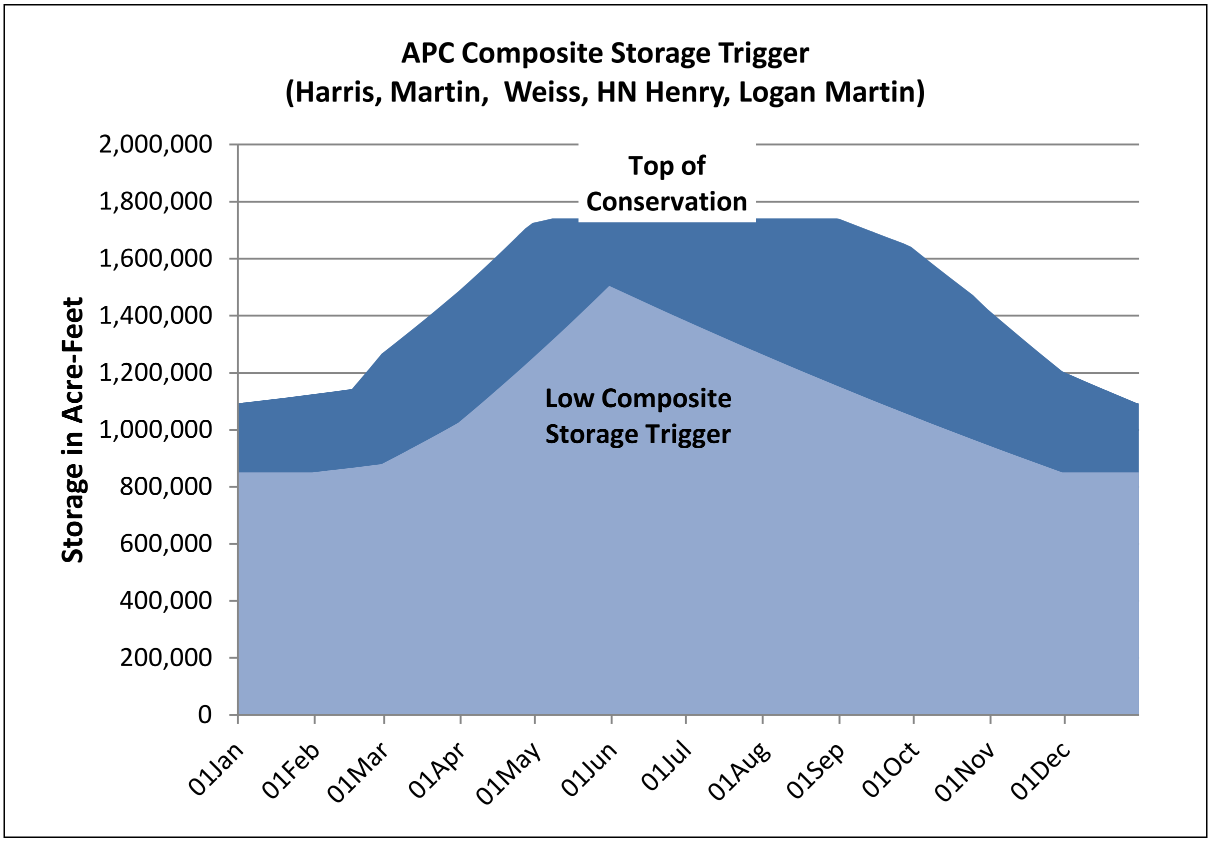


Figure 33. APC Low Composite Storage Trigger

There are three additional variations of the Drought Plan matrix that were considered in the alternative formulation and modeled in ResSim. The four different Drought Plan options modeled were:

- Original Drought Plan
- Revised Drought Plan
- Original Drought Plan with USFWS Enhancement
- Revised Drought Plan with USFWS Enhancement – aka Alternative Drought Plan

Table 16 shows the original Drought Plan matrix, which contained a typo in the 20% reduction of the 7Q10 flow (3900 cfs should be 3700 cfs). Table 17 shows the Revised Drought Plan matrix, which differs from the original plan by using the correct 20% 7Q10 flow reduction, and it includes the "actual revision" to the original drought plan related to the frequency and timing with which the DIL is calculated. The Original Drought Plan calculates the DIL once a month, but the Revised Drought Plan calculates the DIL twice per month. Table 18 shows the Original Drought Plan with a USFWS Enhancement that responds to a concern related to water temperatures below Jordan Dam. USFWS recommended increasing the minimum flow from the Jordan project from 1,600 to 1,800 cfs during the October-November period. To help offset the potential additional use of storage that may occur to meet the higher minimum flow, USFWS recommended lowering the spring Jordan minimum flow from 3,000 cfs to 2,500 cfs April through mid June. The final Drought Plan tested was the Revised (DIL calculated twice per month) Drought Plan with the USFWS Enhancement (previously shown in Table 13).

Table 16. Original Drought Plan Matrix

<table>
<tr><th colspan="13">Drought Level Response Matrix****</th></tr>
<tr><th></th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td rowspan="4">Drought Intensity Level Triggers</td><td colspan="12">DL 0 - Normal Operations</td></tr>
<tr><td colspan="12">DL 1: Low Basin Inflows or Low Composite or Low State Line Flow</td></tr>
<tr><td colspan="12">DL 2: DL 1 criteria + (Low Basin Inflows or Low Composite or Low State Line Flow)</td></tr>
<tr><td colspan="12">DL 3: Low Basin Inflows + Low Composite + Low State Line Flow</td></tr>
<tr><td rowspan="4">Coosa River Flow*</td><td colspan="3">Normal Operation: 2000 cfs</td><td colspan="2">4000 (8000)</td><td>4000 - 2000</td><td colspan="6">Normal Operation: 2000 cfs</td></tr>
<tr><td colspan="3">Jordan
2000 +/-cfs</td><td colspan="2">4000 +/- cfs</td><td>**6/15 Linear Ramp down**</td><td colspan="3">Jordan 2000 +/-cfs</td><td colspan="3">Jordan
2000 +/-cfs</td></tr>
<tr><td colspan="3">Jordan
1800 +/-cfs</td><td colspan="2">3000 +/- cfs</td><td>**6/15 Linear Ramp down**</td><td colspan="3">Jordan 2000 +/-cfs</td><td colspan="3">Jordan
1800 +/-cfs</td></tr>
<tr><td colspan="3">Jordan
1600 +/-cfs</td><td colspan="3">Jordan
1800 +/-cfs</td><td colspan="3">Jordan 2000 +/-cfs</td><td colspan="3">Jordan
1600 +/-cfs</td></tr>
<tr><td rowspan="4">Tallapoosa River Flow**</td><td colspan="12">Normal Operations: 1200 cfs</td></tr>
<tr><td colspan="4">Greater of: 1/2 Yates Inflow or
2 x Heflin Gage(Thurlow releases > 350 cfs)</td><td colspan="5">1/2 Yates Inflow</td><td colspan="3">1/2 Yates Inflow</td></tr>
<tr><td colspan="4">Thurlow 350 cfs</td><td colspan="5">1/2 Yates Inflow</td><td colspan="3">Thurlow 350 cfs</td></tr>
<tr><td colspan="6">Maintain 400 cfs at Montgomery WTP
(Thurlow release 350 cfs)</td><td colspan="3">Thurlow 350 cfs</td><td colspan="3">Maintain 400 cfs at Montgomery WTP
(Thurlow release 350 cfs)</td></tr>
<tr><td rowspan="4">Alabama River Flow***</td><td colspan="12">Normal Operation: Navigation or 7Q10 flow</td></tr>
<tr><td colspan="4">4200 cfs (10% 7Q10 Cut) - Montgomery</td><td colspan="5">7Q10 - Montgomery (4640 cfs)</td><td colspan="3">Reduce: Full - 4200 cfs</td></tr>
<tr><td colspan="4">3900 cfs (20% 7Q10 Cut) - Montgomery</td><td colspan="5">4200 cfs (10% 7Q10 Cut) - Montgomery</td><td colspan="3">Reduce: 4200 cfs-> 3900 cfs Montgomery</td></tr>
<tr><td colspan="4">2000 cfs
Montgomery</td><td colspan="2">3900 cfs
Montgomery</td><td colspan="3">4200 cfs (10% 7Q10 Cut) -
Montgomery</td><td colspan="3">Reduce: 4200 cfs -> 2000 cfs Montgomery
(ramp thru October)</td></tr>
<tr><td rowspan="4">Rule Curve Elevation</td><td colspan="12">Normal Operations: Elevations follow Rule Curves as prescribed in License (Measured in Feet)</td></tr>
<tr><td colspan="12">USACE Variances: As Needed; FERC Variance for Martin</td></tr>
<tr><td colspan="12">USACE Variances: As Needed; FERC Variance for Martin</td></tr>
<tr><td colspan="12">USACE Variances: As Needed; FERC Variance for Martin</td></tr>
</table>

*Jordan flows are based on a continuous +/- 5% of target flow.

**Thurlow flows are based on continuous +/- 5% of target flow: flows are reset on noon each Tuesday based on the prior day's daily average at Heflin or Yates.

***Alabama River flows are 7-Day Average Flow.

****Note these are based flows that will be exceeded when possible.

Table 17. Revised Drought Plan Matrix

<table>
<tr><th></th><th colspan="13">Revised Drought Level Response Matrix****</th></tr>
<tr><th></th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th colspan="2">Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td rowspan="4">Drought Intensity Level Triggers</td><td colspan="13">DL 0 - Normal Operations</td></tr>
<tr><td colspan="13">DL 1: Low Basin Inflows or Low Composite or Low State Line Flow</td></tr>
<tr><td colspan="13">DL 2: DL 1 criteria + (Low Basin Inflows or Low Composite or Low State Line Flow)</td></tr>
<tr><td colspan="13">DL 3: Low Basin Inflows + Low Composite + Low State Line Flow</td></tr>
<tr><td rowspan="4">Coosa River Flow*</td><td colspan="3">Normal Operation: 2000 cfs</td><td colspan="2">4000 (8000)</td><td colspan="2">4000 - 2000</td><td colspan="6">Normal Operation: 2000 cfs</td></tr>
<tr><td colspan="3">Jordan 2000 +/-cfs</td><td colspan="3">4000 +/- cfs</td><td>6/15 Linear Ramp down</td><td colspan="3">Jordan 2000 +/-cfs</td><td colspan="3">Jordan 2000 +/-cfs</td></tr>
<tr><td colspan="3">Jordan 1800 +/-cfs</td><td colspan="3">3000 +/- cfs</td><td>6/15 Linear Ramp down</td><td colspan="3">Jordan 2000 +/-cfs</td><td colspan="3">Jordan 1800 +/-cfs</td></tr>
<tr><td colspan="3">Jordan 1600 +/-cfs</td><td colspan="4">Jordan 1800 +/-cfs</td><td colspan="3">Jordan 2000 +/-cfs</td><td colspan="3">Jordan 1600 +/-cfs</td></tr>
<tr><td rowspan="4">Tallapoosa River Flow**</td><td colspan="13">Normal Operations: 1200 cfs</td></tr>
<tr><td colspan="4">Greater of: 1/2 Yates Inflow or 2 x Heflin Gage(Thurlow releases > 350 cfs)</td><td colspan="6">1/2 Yates Inflow</td><td colspan="3">1/2 Yates Inflow</td></tr>
<tr><td colspan="4">Thurlow 350 cfs</td><td colspan="6">1/2 Yates Inflow</td><td colspan="3">Thurlow 350 cfs</td></tr>
<tr><td colspan="7">Maintain 400 cfs at Montgomery WTP (Thurlow release 350 cfs)</td><td colspan="3">Thurlow 350 cfs</td><td colspan="3">Maintain 400 cfs at Montgomery WTP (Thurlow release 350 cfs)</td></tr>
<tr><td rowspan="4">Alabama River Flow***</td><td colspan="13">Normal Operation: Navigation or 7Q10 flow</td></tr>
<tr><td colspan="4">4200 cfs (10% 7Q10 Cut) - Montgomery</td><td colspan="6">7Q10 - Montgomery (4640 cfs)</td><td colspan="3">Reduce: Full - 4200 cfs</td></tr>
<tr><td colspan="4">3700 cfs (20% 7Q10 Cut) - Montgomery</td><td colspan="6">4200 cfs (10% 7Q10 Cut) - Montgomery</td><td colspan="3">Reduce: 4200 cfs-> 3700 cfs Montgomery</td></tr>
<tr><td colspan="4">2000 cfs Montgomery</td><td colspan="3">3700 cfs Montgomery</td><td colspan="3">4200 cfs (10% 7Q10 Cut) - Montgomery</td><td colspan="3">Reduce: 4200 cfs -> 2000 cfs Montgomery (ramp thru October)</td></tr>
<tr><td rowspan="4">Rule Curve Elevation</td><td colspan="13">Normal Operations: Elevations follow Rule Curves as prescribed in License (Measured in Feet)</td></tr>
<tr><td colspan="13">USACE Variances: As Needed; FERC Variance for Martin</td></tr>
<tr><td colspan="13">USACE Variances: As Needed; FERC Variance for Martin</td></tr>
<tr><td colspan="13">USACE Variances: As Needed; FERC Variance for Martin</td></tr>
</table>

*Jordan flows are based on a continuous +/- 5% of target flow.

**Thurlow flows are based on continuous +/- 5% of target flow: flows are reset on noon each Tuesday based on the prior day's daily average at Heflin or Yates.

***Alabama River flows are 7-Day Average Flow.

****Note these are based flows that will be exceeded when possible.

Table 18. Original Drought Plan Matrix with USFWS Enhancement

Drought Level Response Matrix, FWS Enhancement****

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Drought Intensity Level Triggers	DL 0 - Normal Operations											
	DL 1: Low Basin Inflows or Low Composite or Low State Line Flow											
	DL 2: DL 1 criteria + (Low Basin Inflows or Low Composite or Low State Line Flow)											
	DL 3: Low Basin Inflows + Low Composite + Low State Line Flow											
Coosa River Flow*	Normal Operation: 2000 cfs			4000 (8000)		4000 - 2000	Normal Operation: 2000 cfs					
	Jordan 2000 +/-cfs			4000 +/- cfs		6/15 Linear Ramp down	Jordan 2000 +/-cfs			Jordan 2000 +/-cfs		
	Jordan 1800 +/-cfs			**2500 +/- cfs**		6/15 Linear Ramp down	Jordan 2000 +/-cfs			Jordan 1800 +/-cfs		
	Jordan 1600 +/-cfs			Jordan 1800 +/-cfs			Jordan 2000 +/-cfs			**Jordan 1800 +/-cfs**		Jordan 1600 +/-cfs
Tallapoosa River Flow**	Normal Operations: 1200 cfs											
	Greater of: 1/2 Yates Inflow or 2 x Heflin Gage(Thurlow releases > 350 cfs)				1/2 Yates Inflow					1/2 Yates Inflow		
	Thurlow 350 cfs				1/2 Yates Inflow					Thurlow 350 cfs		
	Maintain 400 cfs at Montgomery WTP (Thurlow release 350 cfs)						Thurlow 350 cfs			Maintain 400 cfs at Montgomery WTP (Thurlow release 350 cfs)		
Alabama River Flow***	Normal Operation: Navigation or 7Q10 flow											
	4200 cfs (10% 7Q10 Cut) - Montgomery				7Q10 - Montgomery (4640 cfs)					Reduce: Full - 4200 cfs		
	3900 cfs (20% 7Q10 Cut) - Montgomery				4200 cfs (10% 7Q10 Cut) - Montgomery					Reduce: 4200 cfs-> 3900 cfs Montgomery		
	2000 cfs Montgomery				3900 cfs Montgomery		4200 cfs (10% 7Q10 Cut) - Montgomery			Reduce: 4200 cfs -> 2000 cfs Montgomery (ramp thru October)		
Rule Curve Elevation	Normal Operations: Elevations follow Rule Curves as prescribed in License (Measured in Feet)											
	USACE Variances: As Needed; FERC Variance for Martin											
	USACE Variances: As Needed; FERC Variance for Martin											
	USACE Variances: As Needed; FERC Variance for Martin											

*Jordan flows are based on a continuous +/- 5% of target flow.

**Thurlow flows are based on continuous +/- 5% of target flow: flows are reset on noon each Tuesday based on the prior day's daily average at Heflin or Yates.

***Alabama River flows are 7-Day Average Flow.

****Note these are based flows that will be exceeded when possible.

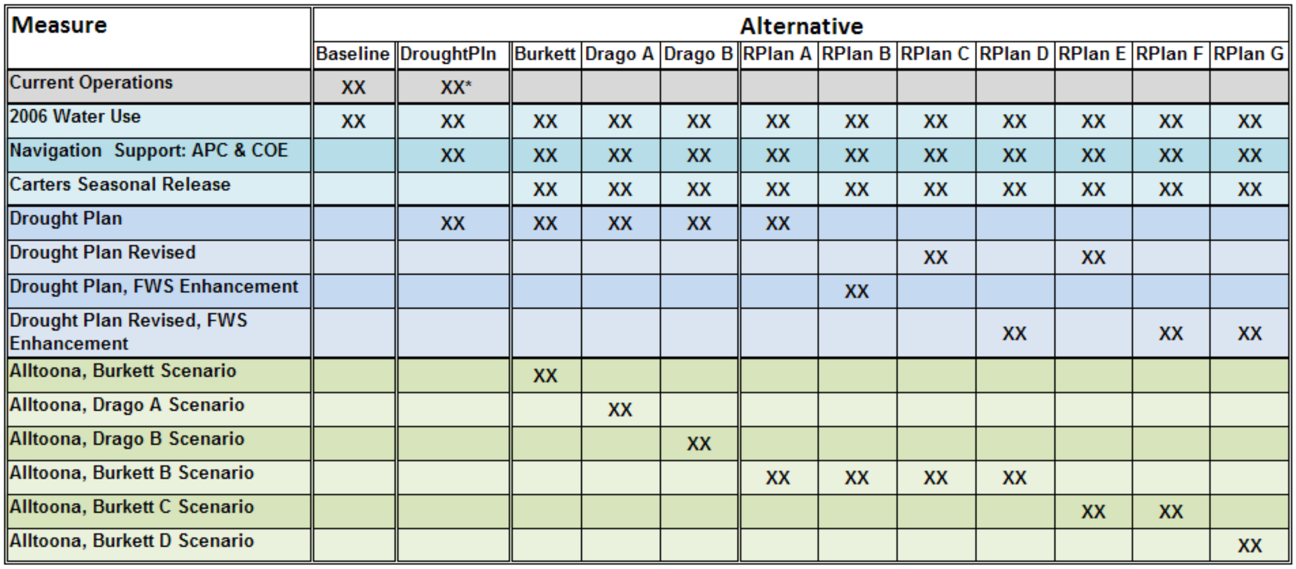
C. Study Alternatives/Operational Plans

Eleven alternatives were formulated during the Recommended Plan development for comparison with Baseline. The twelve alternatives are listed below. (While baseline operations are not considered a Plan alternative, the Baseline is considered an Alternative in ResSim terminology.)

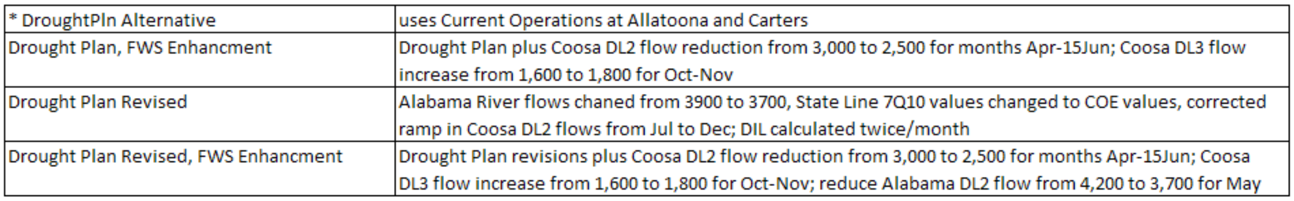
1.) Baseline
2.) DroughtPln
3.) Burkett
4.) DragoA
5.) DragoB
6.) RPlanA
7.) RPlanB
8.) RPlanC
9.) RPlanD
10.) RPlanE
11.) RPlanF
12.) RPlanG

Table 19 indicates the measures selected for each alternative.

Table 19. Alternative and Selected Measure



Measure	Alternative											
	Baseline	DroughtPln	Burkett	Drago A	Drago B	RPlan A	RPlan B	RPlan C	RPlan D	RPlan E	RPlan F	RPlan G
Current Operations	XX	XX*										
2006 Water Use	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Navigation Support: APC & COE		XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Carters Seasonal Release			XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Drought Plan		XX	XX	XX	XX	XX						
Drought Plan Revised								XX		XX		
Drought Plan, FWS Enhancement							XX					
Drought Plan Revised, FWS Enhancement									XX		XX	XX
Alltoona, Burkett Scenario			XX									
Alltoona, Drago A Scenario				XX								
Alltoona, Drago B Scenario					XX							
Alltoona, Burkett B Scenario						XX	XX	XX	XX			
Alltoona, Burkett C Scenario										XX	XX	
Alltoona, Burkett D Scenario												XX



* DroughtPln Alternative	uses Current Operations at Allatoona and Carters
Drought Plan, FWS Enhancment	Drought Plan plus Coosa DL2 flow reduction from 3,000 to 2,500 for months Apr-15Jun; Coosa DL3 flow increase from 1,600 to 1,800 for Oct-Nov
Drought Plan Revised	Alabama River flows chaned from 3900 to 3700, State Line 7Q10 values changed to COE values, corrected ramp in Coosa DL2 flows from Jul to Dec; DIL calculated twice/month
Drought Plan Revised, FWS Enhancment	Drought Plan revisions plus Coosa DL2 flow reduction from 3,000 to 2,500 for months Apr-15Jun; Coosa DL3 flow increase from 1,600 to 1,800 for Oct-Nov; reduce Alabama DL2 flow from 4,200 to 3,700 for May

1. Baseline

The Baseline Alternative represents current water control operations at each of the projects in the ACT Basin. The operations selected to represent the "Baseline" Alternative are listed below:

Baseline Measures:

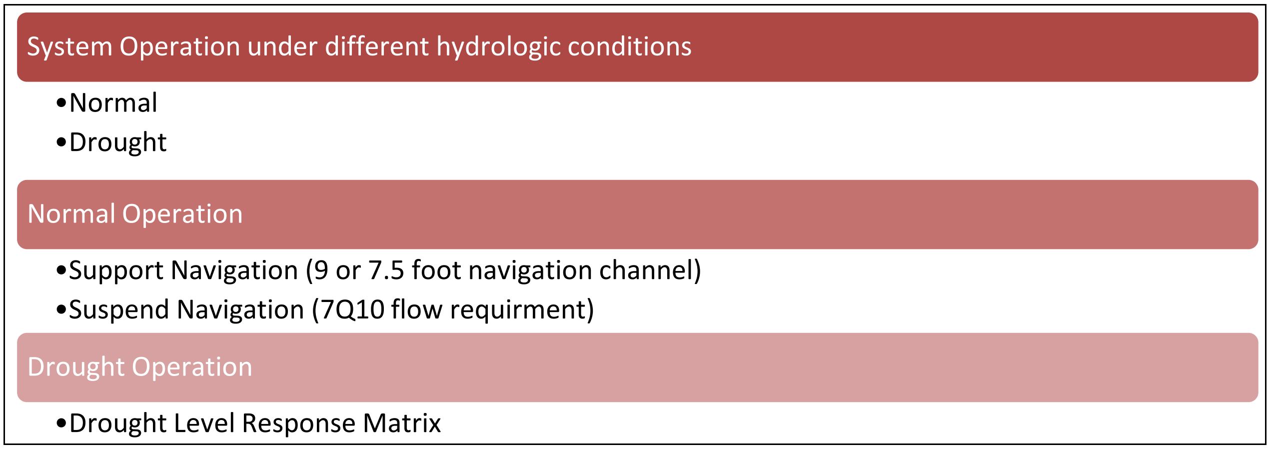
1. Current Operations
2. 2006 Water Use

2. Drought Plan

The Drought Plan alternative includes a navigation operation to support a 9-ft or 7.5-ft channel and drought operations (Figure 34). There is no change from the baseline (current) operations at Allatoona and Carters. The measures selected to represent the "DroughtPln" Alternative are listed below.

Drought Plan Measures:

1. Current Operations at Allatoona and Carters
2. 2006 Water Use (previously shown in Figure 12)
3. Navigation Support: APC projects and COE projects on the Alabama River
4. Drought Plan (previously shown in Table 16)



System Operation under different hydrologic conditions

- Normal
- Drought

Normal Operation

- Support Navigation (9 or 7.5 foot navigation channel)
- Suspend Navigation (7Q10 flow requirment)

Drought Operation

- Drought Level Response Matrix

Figure 34. System Operation Includes Navigation Concept and Drought Plan

3. Burkett

The Burkett Alternative includes a navigation operation to support a 9-ft or 7.5-ft channel and drought operations. Carters operations are changed with a seasonally varying minimum flow requirement, the addition of Zone 2, and a defined guide curve (Figure 35). Allatoona operations are changed with the addition of Zones 3 and 4 and the revised peaking hydropower demand that ranges from 0-6 hours (Figure 36). This alternative is the same as the Drought Plan alternative with the changes in operation at Allatoona and Carters. The measures selected to represent the “Burkett” Alternative are listed below.

Burkett Measures:

1. 2006 Water Use
2. Navigation Support: APC projects and COE projects on the Alabama River
3. Drought Plan (previously shown in Table 16)
4. Carters Seasonal Release
5. Allatoona, Burkett Scenario

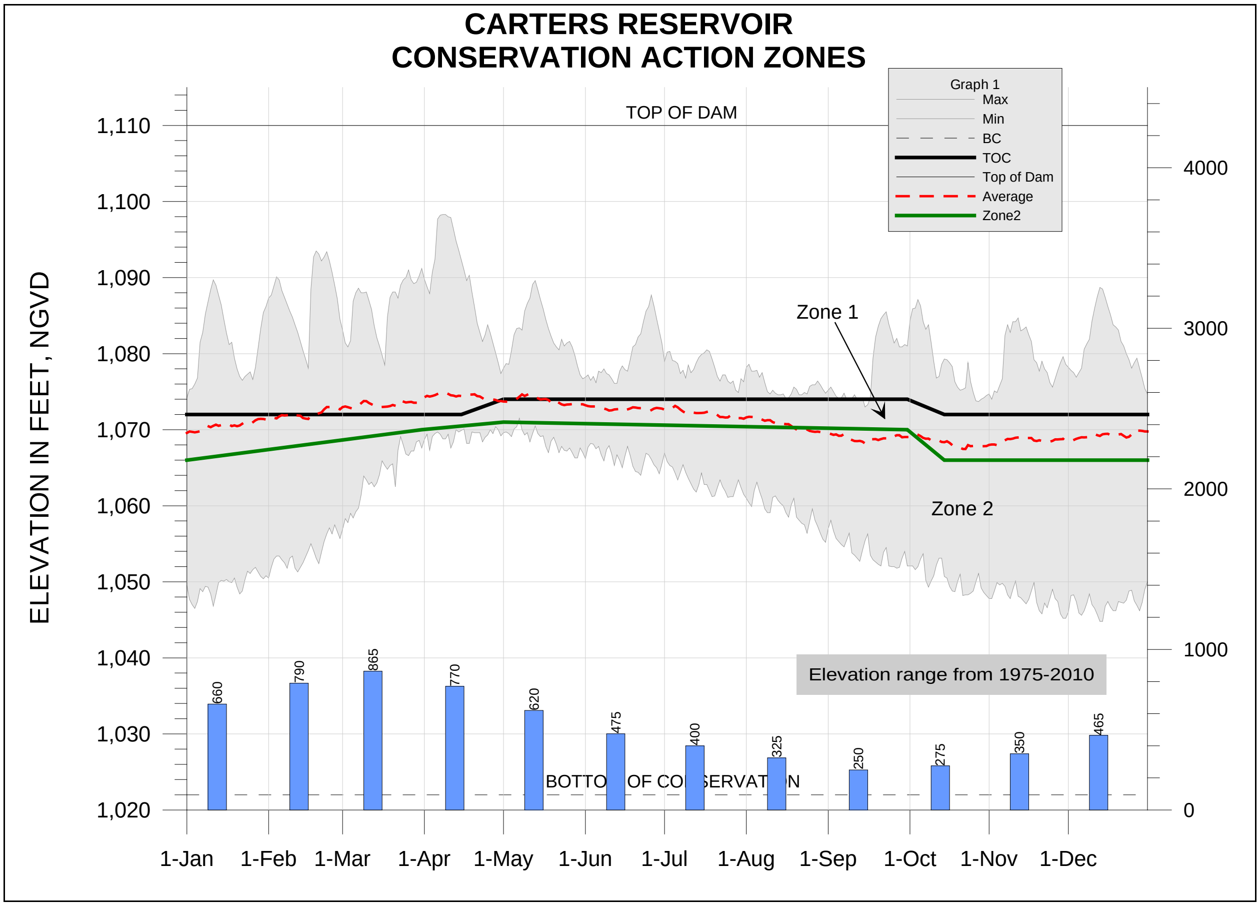
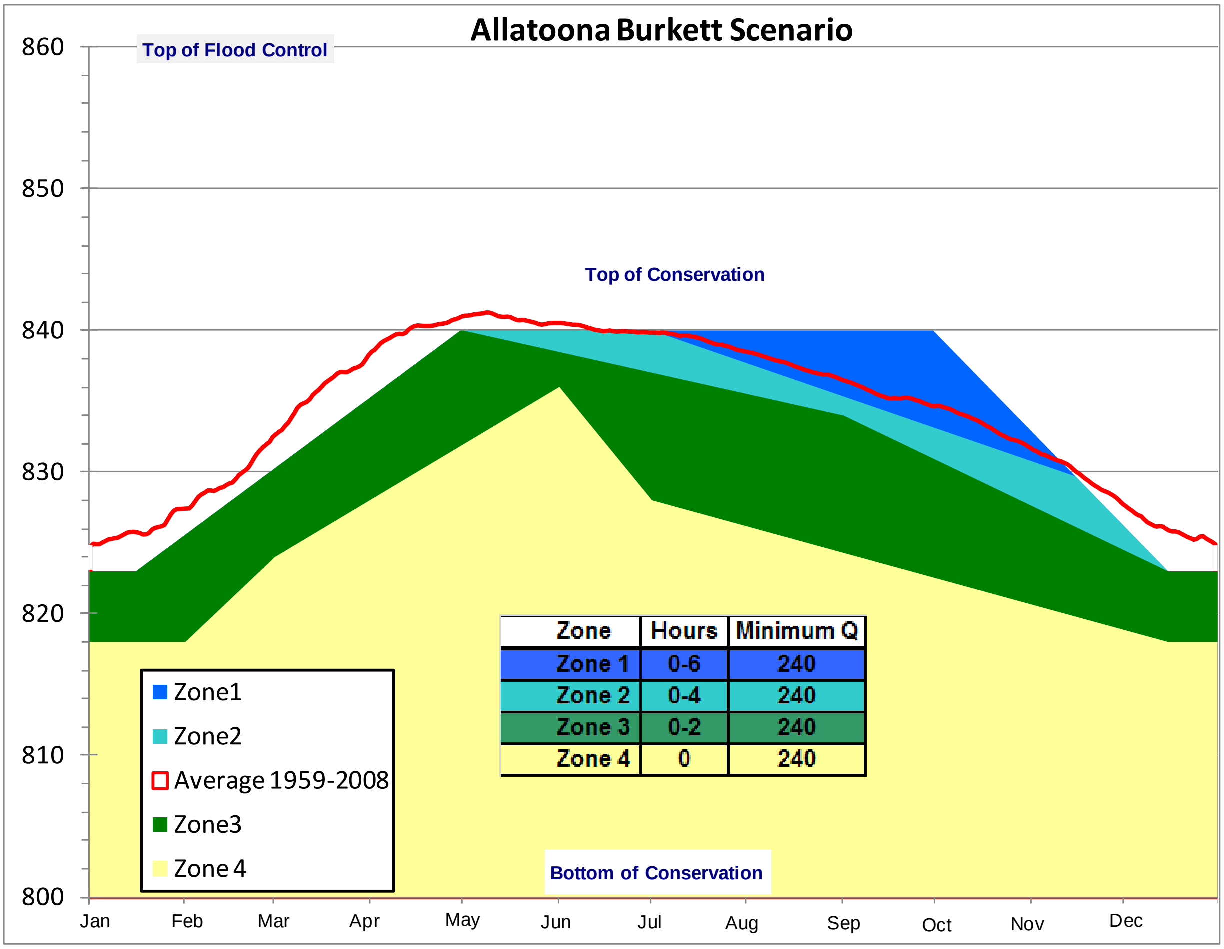


Figure 35. Carters Seasonal Release Scenario



Zone	Hours	Minimum Q
Zone 1	0-6	240
Zone 2	0-4	240
Zone 3	0-2	240
Zone 4	0	240

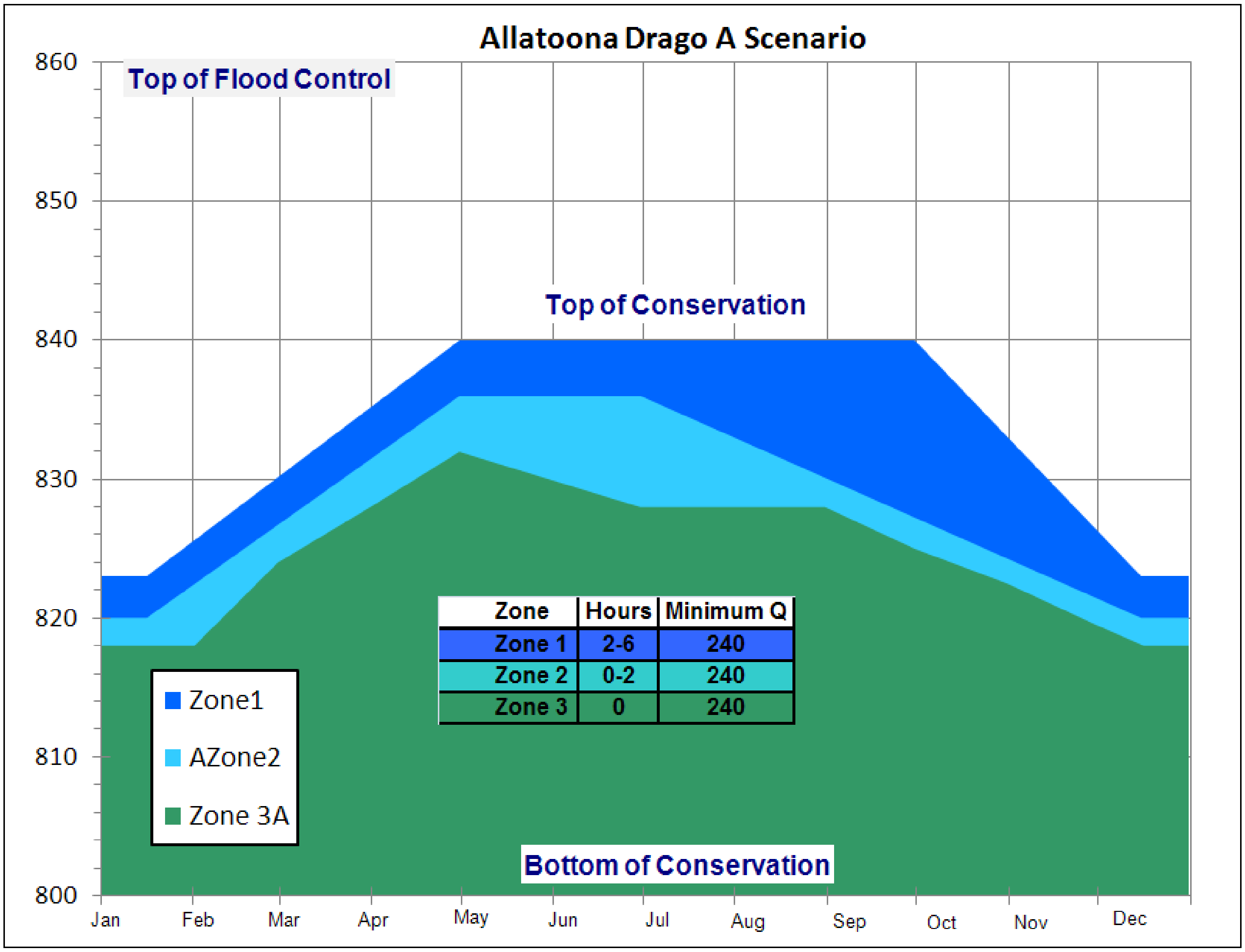
Figure 36. Allatoona Burkett Scenario

4. Drago A

The Drago A alternative includes a navigation operation to support a 9-ft or 7.5-ft channel and drought operations. Carters operations are changed with a seasonally varying minimum flow requirement, the addition of Zone 2, and a defined guide curve. Allatoona operations are changed with the addition of Zone 3 (version A) and the revised peaking hydropower demand that ranges from 0-6 hours (Figure 37). This alternative is the same as the Drought Plan alternative with the changes in operation at Allatoona and Carters. The measures selected to represent the "DragoA" Alternative are listed below.

Drago A Measures:

1. 2006 Water Use
2. Navigation Support: APC projects and COE projects on the Alabama River
3. Drought Plan (previously shown in Table 16)
4. Carters Seasonal Release
5. Allatoona, Drago A



Zone	Hours	Minimum Q
Zone 1	2-6	240
Zone 2	0-2	240
Zone 3	0	240

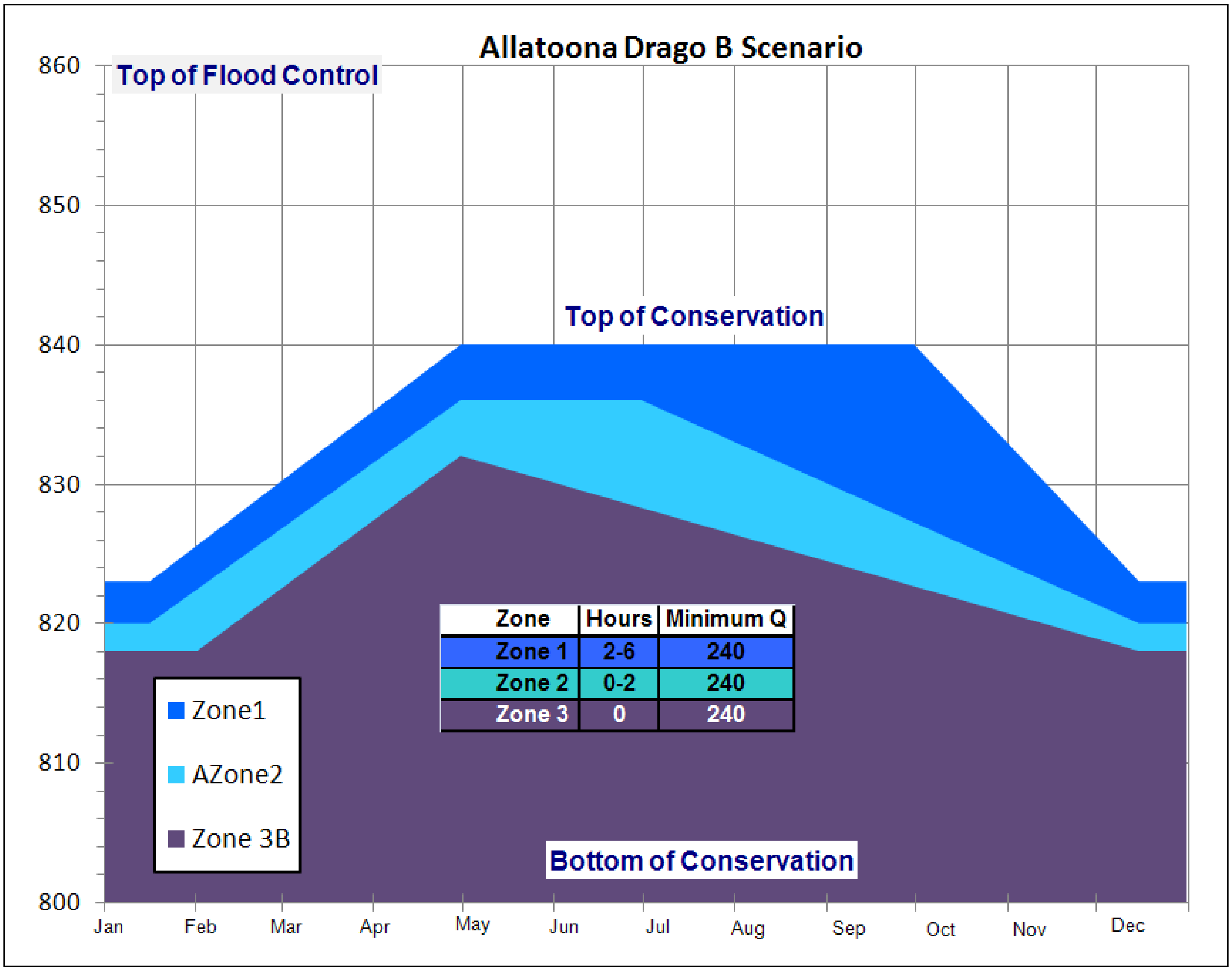
Figure 37. Allatoona Drago A Scenario

5. Drago B

The Drago B alternative includes a navigation operation to support a 9-ft or 7.5-ft channel and drought operations. Carters operations are changed with a seasonally varying minimum flow requirement, the addition of Zone 2, and a defined guide curve. Allatoona operations are changed with the addition of Zone 3 (version B) and the revised peaking hydropower demand that ranges from 0-6 hours (Figure 38). This alternative is the same as the Drought Plan alternative with the changes in operation at Allatoona and Carters. The measures selected to represent the “DragoB” Alternative are listed below.

Drago B Measures:

1. 2006 Water Use
2. Navigation Support: APC projects and COE projects on the Alabama River
3. Drought Plan (previously shown in Table 16)
4. Carters Seasonal Release
5. Allatoona, Drago B



Zone	Hours	Minimum Q
Zone 1	2-6	240
Zone 2	0-2	240
Zone 3	0	240

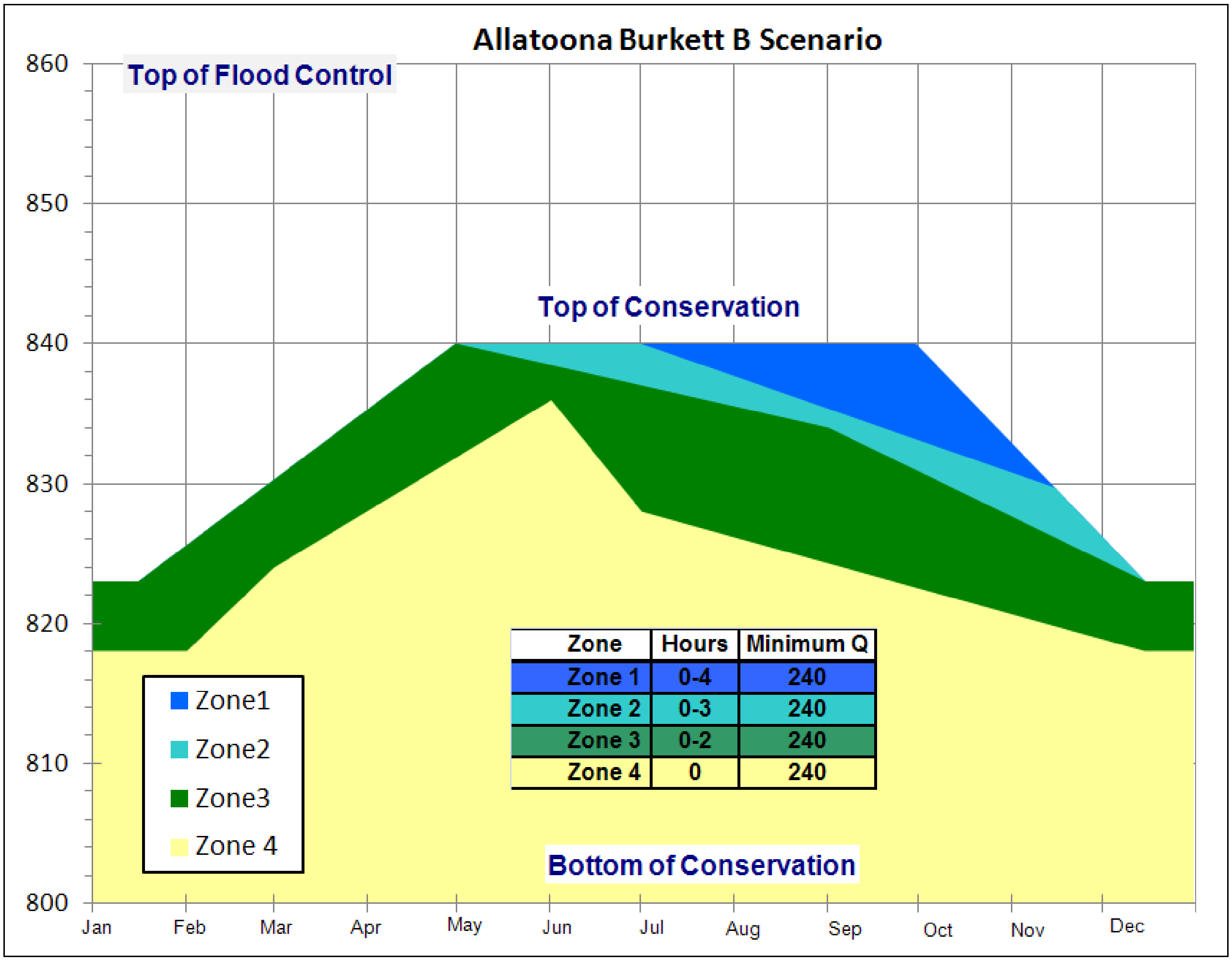
Figure 38. Allatoona Drago B Scenario

6. RPlan A

The RPlan A alternative includes a navigation operation to support a 9-ft or 7.5-ft channel and drought operations. Carters operations are changed with a seasonally varying minimum flow requirement, the addition of Zone 2, and a defined guide curve. Allatoona operations are changed with the addition of Zones 3 and 4 and the revised peaking hydropower demand that ranges from 0-4 hours (Figure 39). This alternative is the same as the Drought Plan alternative with the changes in operation at Allatoona and Carters. The measures selected to represent the "RPlanA" Alternative are listed below.

RPlan A Measures:

1. 2006 Water Use
2. Navigation Support: APC projects and COE projects on the Alabama River
3. Drought Plan (previously shown in Table 16)
4. Carters Seasonal Release
5. Allatoona, Burkett B



Zone	Hours	Minimum Q
Zone 1	0-4	240
Zone 2	0-3	240
Zone 3	0-2	240
Zone 4	0	240

Figure 39. Allatoona Burkett B Scenario

7. RPlan B

The RPlan B alternative includes a navigation operation to support a 9-ft or 7.5-ft channel and drought operations. Carters operations are changed with a seasonally varying minimum flow requirement, the addition of Zone 2, and a defined guide curve. Allatoona operations are changed with the addition of Zones 3 and 4 and the revised peaking hydropower demand that ranges from 0-4 hours. This alternative is the same as the RPlan A alternative, except that the Drought Plan includes the USFWS enhancement. The measures selected to represent the "RPlanB" Alternative are listed below.

RPlan B Measures:

1. 2006 Water Use
2. Navigation Support: APC projects and COE projects on the Alabama River
3. Drought Plan, FWS Enhancement (previously shown in Table 18)
4. Carters Seasonal Release
5. Allatoona, Burkett B

8. RPlan C

The RPlan C alternative includes a navigation operation to support a 9-ft or 7.5-ft channel and drought operations with the revised 20% reduction of 7Q10 flow (4,640 cfs) and DIL calculated semi-monthly. Carters operations are changed with a seasonally varying minimum flow requirement, the addition of Zone 2, and a defined guide curve. Allatoona operations are changed with the addition of Zones 3 and 4 and the revised peaking hydropower demand that ranges from 0-4 hours. This alternative is the same as the RPlan A alternative, except that it uses the Revised Drought Plan. The measures selected to represent the "RPlanC" Alternative are listed below.

RPlan C Measures:

1. 2006 Water Use
2. Navigation Support: APC projects and COE projects on the Alabama River
3. Drought Plan Revised (previously shown in Table 17)
4. Carters Seasonal Release
5. Allatoona, Burkett B

9. RPlan D

The RPlan D alternative includes a navigation operation to support a 9-ft or 7.5-ft channel and drought operations with the revised 20% reduction of 7Q10 flow (4,640 cfs), the DIL calculated semi-monthly, and the USFWS enhancement. Carters operations are changed with a seasonally varying minimum flow requirement, the addition of Zone 2, and a defined guide curve. Allatoona operations are changed with the addition of Zones 3 and 4 and the revised peaking hydropower demand that ranges from 0-4 hours. This alternative is the same as the RPlan A alternative, except that it uses the Revised Drought Plan with the USFWS enhancement. The measures selected to represent the "RPlanD" Alternative are listed below.

RPlan D Measures:

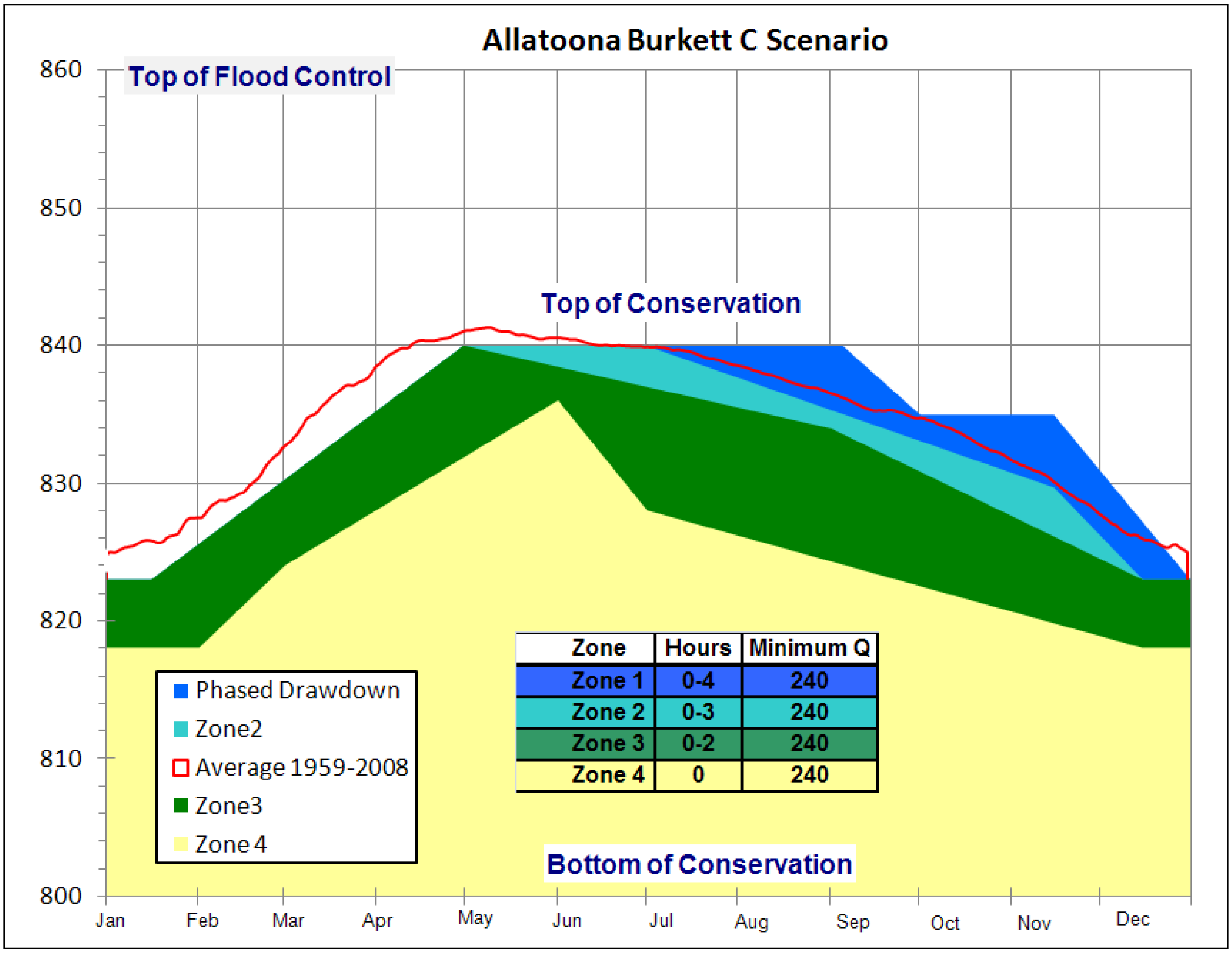
1. 2006 Water Use
2. Navigation Support: APC projects and COE projects on the Alabama River
3. Drought Plan Revised, FWS Enhancement (previously shown in Table 13)
4. Carters Seasonal Release
5. Allatoona, Burkett B

10. RPlan E

The RPlan E alternative includes a navigation operation to support a 9-ft or 7.5-ft channel and drought operations with the revised 20% reduction of 7Q10 flow (4,640 cfs) and the DIL calculated semi-monthly. Carters operations are changed with a seasonally varying minimum flow requirement, the addition of Zone 2, and a defined guide curve. Allatoona operations are changed with the addition of Zones 3 and 4 and the revised peaking hydropower demand that ranges from 0-4 hours and the Phased Drawdown guide curve (Figure 40). This alternative is the same as the RPlan C alternative, except that it uses the Allatoona Phased Drawdown guide curve. The measures selected to represent the "RPlanE" Alternative are listed below.

RPlan E Measures:

1. 2006 Water Use
2. Navigation Support: APC projects and COE projects on the Alabama River
3. Drought Plan Revised (previously shown in Table 17)
4. Carters Seasonal Release
5. Allatoona, Burkett C



Zone	Hours	Minimum Q
Zone 1	0-4	240
Zone 2	0-3	240
Zone 3	0-2	240
Zone 4	0	240

Figure 40. Allatoona Burkett C Scenario

11. RPlan F

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

RPlan F Measures:

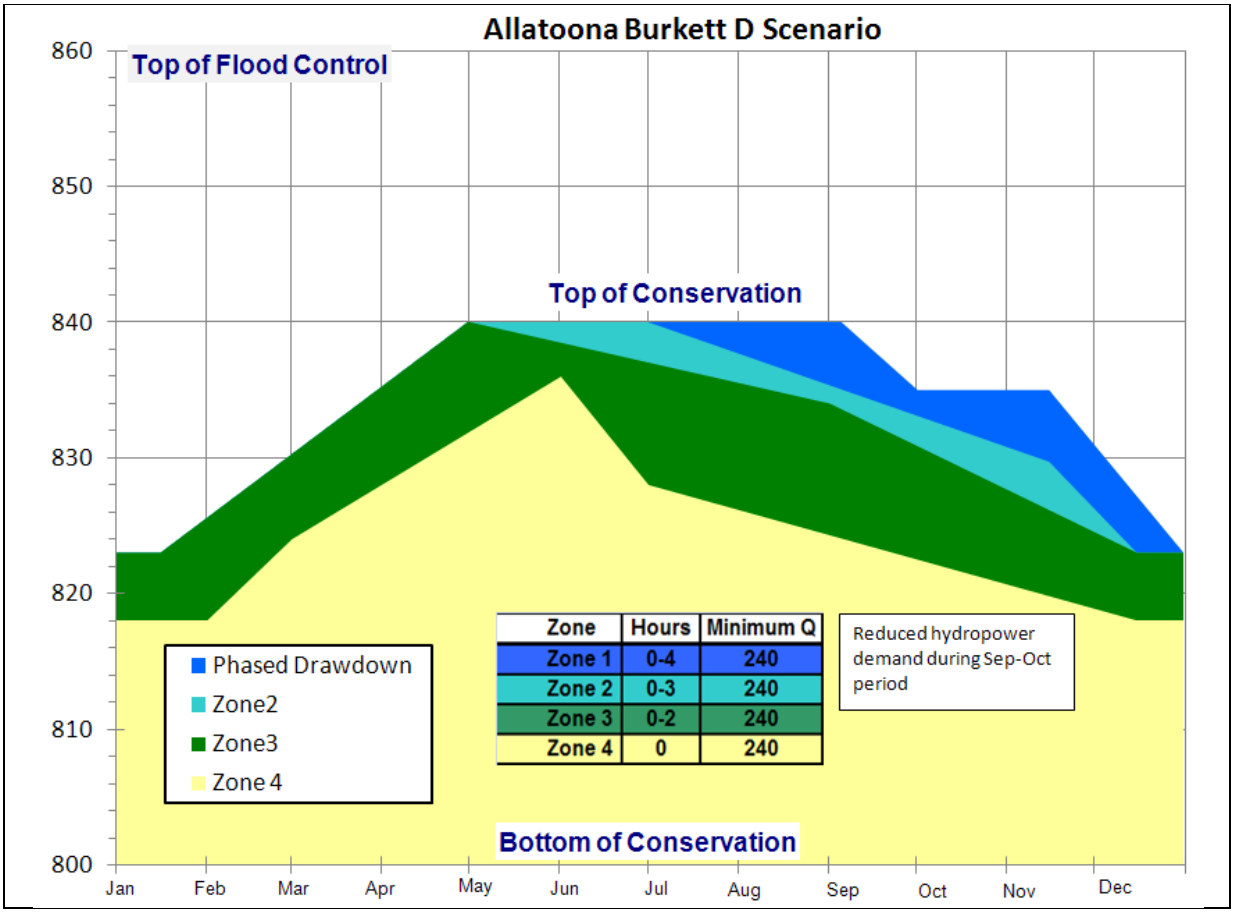
1. 2006 Water Use
2. Navigation Support: APC projects and COE projects on the Alabama River
3. Drought Plan Revised, FWS Enhancement (previously shown in Table 13)
4. Carters Seasonal Release
5. Allatoona, Burkett C

12. RPlan G

The RPlan G alternative includes a navigation operation to support a 9-ft or 7.5-ft channel and drought operations with the revised 20% reduction of 7Q10 flow (4,640 cfs), the DIL calculated semi-monthly, and the USFWS enhancement. Carters operations are changed with a seasonally varying minimum flow requirement, the addition of Zone 2, and a defined guide curve. Allatoona operations are changed with the addition of Zones 3 and 4 and the revised peaking hydropower demand that ranges from 0-4 hours, reduced during September-October period, and the Phased Drawdown guide curve (Figure 41). This alternative is the same as the RPlan F alternative, except that it uses the reduction in hydropower from September to October. The measures selected to represent the "RPlanG" Alternative are listed below.

RPlan G Measures:

1. 2006 Water Use
2. Navigation Support: APC projects and COE projects on the Alabama River
3. Drought Plan Revised, FWS Enhancement (previously shown in Table 13)
4. Carters Seasonal Release
5. Allatoona, Burkett D



Zone	Hours	Minimum Q
Zone 1	0-4	240
Zone 2	0-3	240
Zone 3	0-2	240
Zone 4	0	240

Reduced hydropower demand during Sep-Oct period

Figure 41. **Allatoona Burkett D Scenario**

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 42 shows the list of custom scripts used for plotting and building reports.

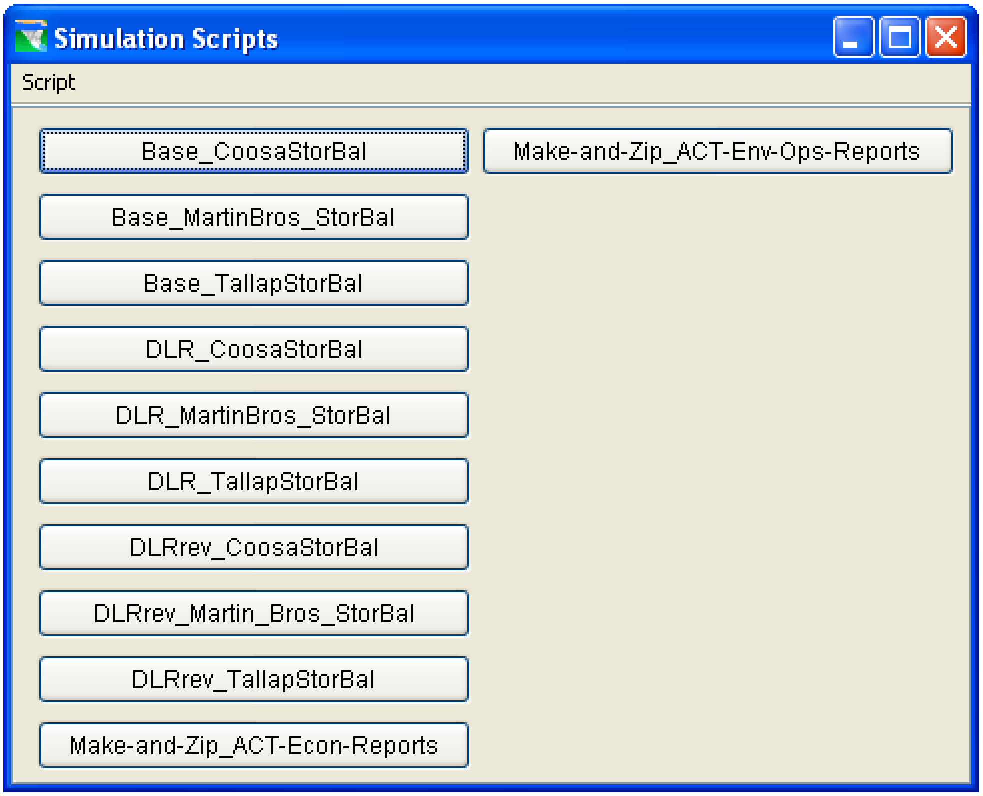


Figure 42. Simulation Scripts for Generating Plots and Reports

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 43). 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 44). The Tallapoosa Storage Balance script plots storage in Harris and Martin, as well as reservoir releases and flows at Tallassee and JBT Goal (Figure 45). 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%.

Separate scripts are used to review the results for the Baseline Alternative (scripts beginning with “Base_”: Base_CoosaStorBalance, Base_Martin_Bros_StorBal, and Base_TallapStorBal), all alternatives that use the basic Drought Operations (scripts beginning with “DLR_”), and all alternatives that use the Revised Drought Operations (scripts beginning with “DLRrev_”). The plots that were designed to be used with alternatives that use Drought Operations include a plot area for the Drought Intensity Level. This allows the user to easily view how operations are responding to the changing Drought Levels. Figure 46 shows an example of one of these plots, with the DIL at the top.

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.

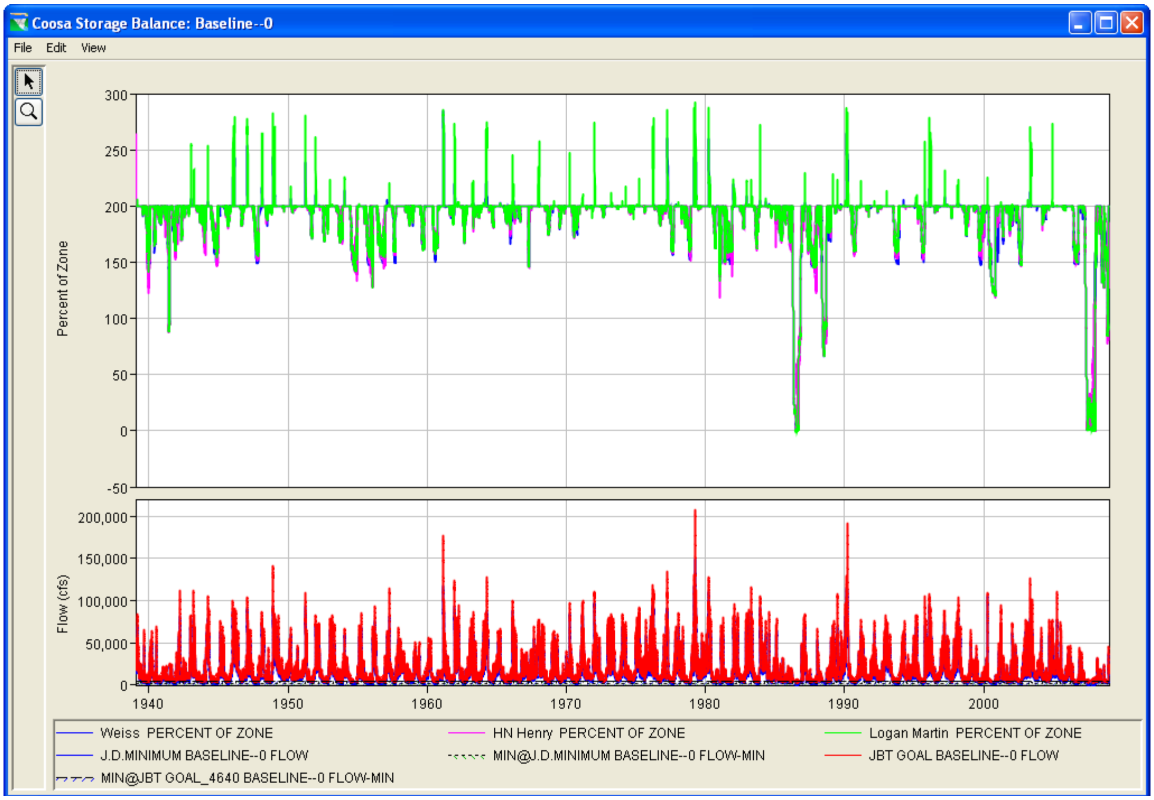


Figure 43. Coosa Storage Balance for Baseline Alternative

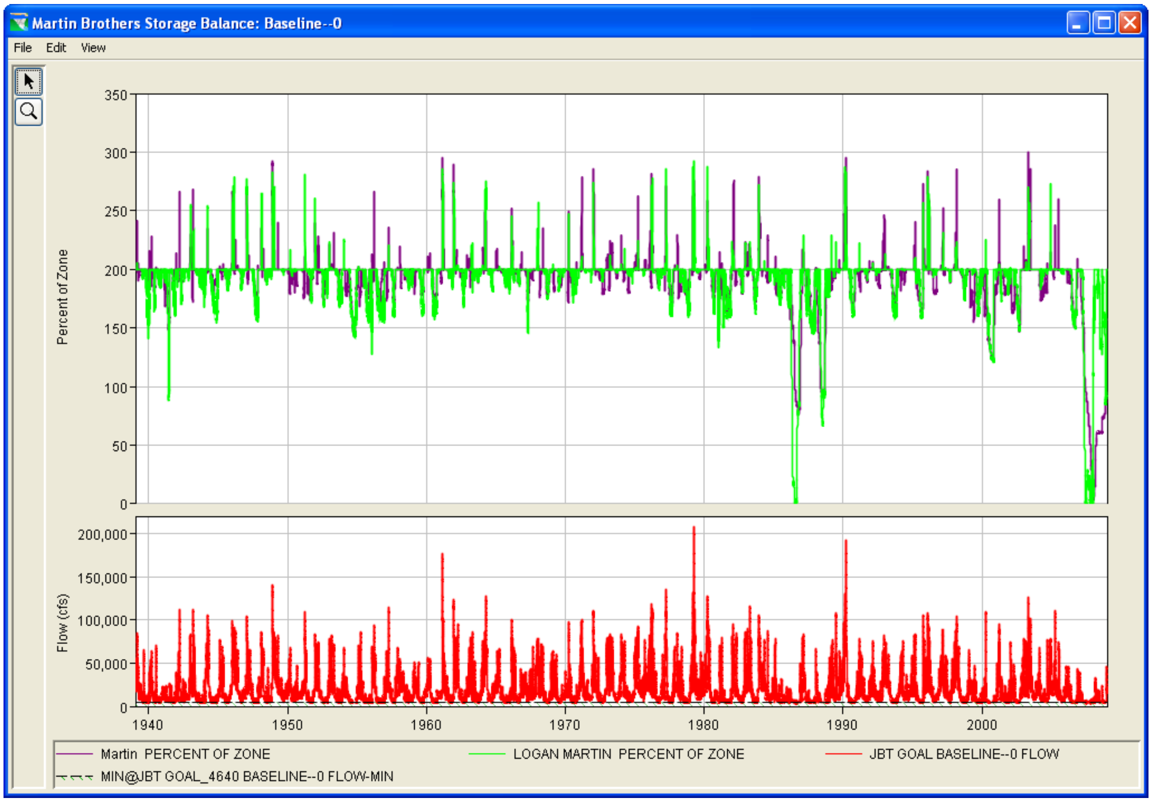


Figure 44. Martin Brothers Storage Balance for Baseline Alternative

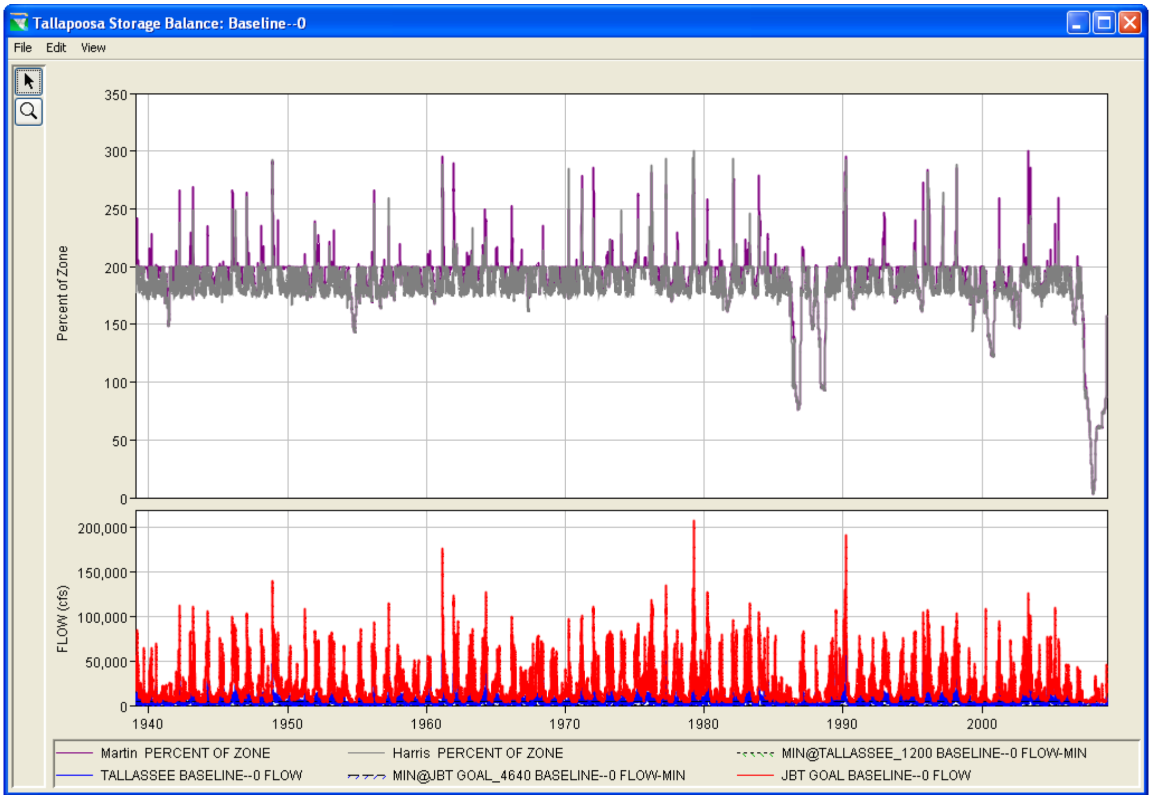


Figure 45. Tallapoosa Storage Balance for Baseline Alternative

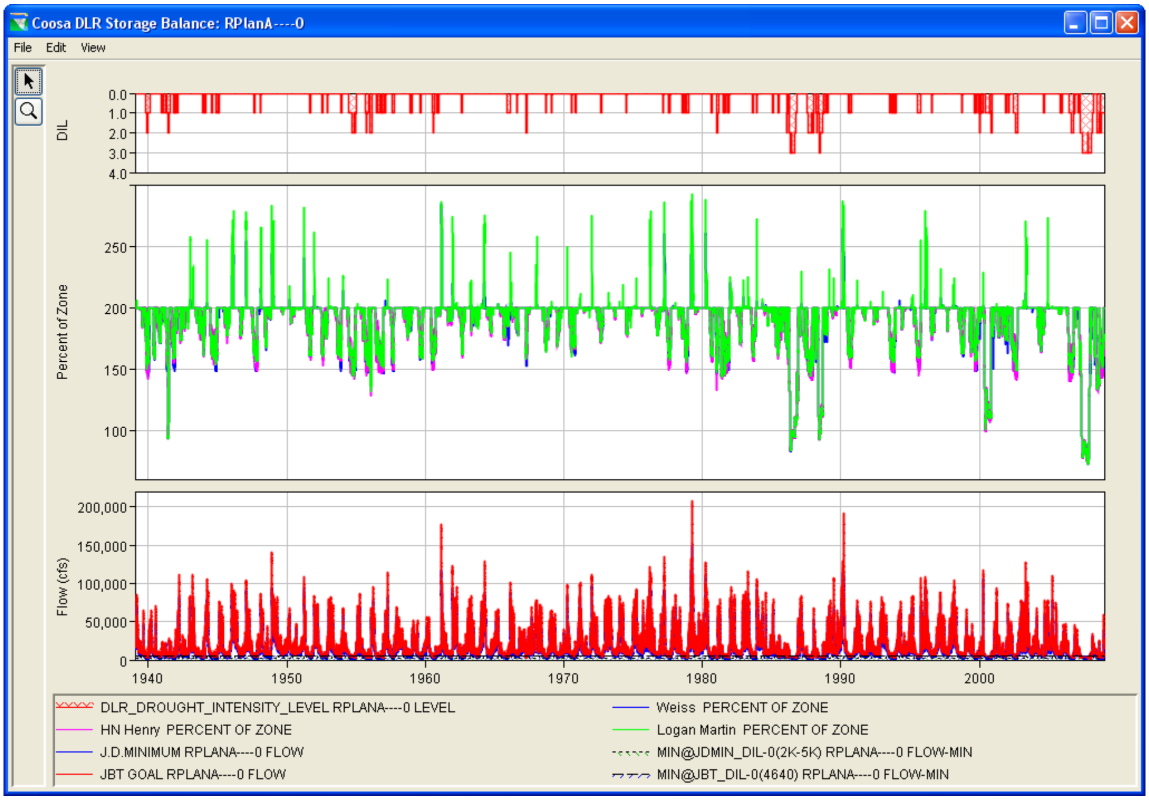


Figure 46. Coosa Storage Balance for RPlan A Alternative (with Drought Operations)

V. References

EPA, 1969[2000]. U. S. Environmental Protection Agency, *National Environment Policy Act of 1969,* (Public Law 91-190), [As Amended Through Dec. 31, 2000].

USACE, 1997. U.S. Army Corps of Engineers, Mobile District, *ACT/ACF Comprehensive Water Resource Study, Surface Water Availability Volume I: Unimpaired Flow*, July 1997.

USACE, 1998. U.S. Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center, *HEC-5, Simulation of Flood Control and Conservation Systems, Version 8.0*, October 1998.

USACE, 2001. U.S. Army Corps of Engineers, South Atlantic Division (CESAD), Division Regulation (DR) 1130-2-16, Project Operations, Lake Regulation and Coordination for Fish Management Purposes, March 2001.

USACE, 2004[2009]. U.S. Army Corps of Engineers, Mobile District, *Extended Unimpaired Flow Report January 1994 – December 2001 for ACT/ACF Basins*, April 2004 [updated in 2009].

USACE, 2005a. U.S. Army Corps of Engineers, Mobile District, *Draft: Project Operations, Reservoir Regulations and Coordination for Fish Management Purposes (Enclosure 11, CESAM SOP 1130-2-9)*, February 2005.

USACE, 2005b. U.S. Army Corps of Engineers, CECW-CP, Engineering Circular, *Planning Models Improvement Program: Model Calibration (EC 1105-2-407)*, 31 May 2005.

USACE, 2007. U.S. Army Corps of Engineers, CECW-CE, Engineering and Construction Bulletin, *Model Certification Issues for Engineering Software in Planning Studies (ECB No. 2007-6)*, 10 April 2007.

USACE, 2010a. U.S. Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center, *HEC-ResSim, Reservoir System Simulation, (Version 3.1, RC3, Build 42)*, July 2010.

USACE, 2010b. U.S. Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center, *HEC-HMS, Hydrologic Modeling System, Version 3.5*, August 2010.

USFWS, 2010. U.S. Fish and Wildlife Service (USFWS), Planning Aid Letter, May 3, 2010.

Alabama-Coosa-Tallapoosa (ACT) Watershed

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

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M	Flood Modeling above Rome, Georgia
N	Description of Alternatives
O	Development of Sub-daily Flows for Upper Coosa

March 2011 (DRAFT)

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Alabama-Coosa-Tallapoosa (ACT) Watershed

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

Appendix A – Carters and Carters Reregulation Reservoirs

March 2011 (DRAFT)

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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.

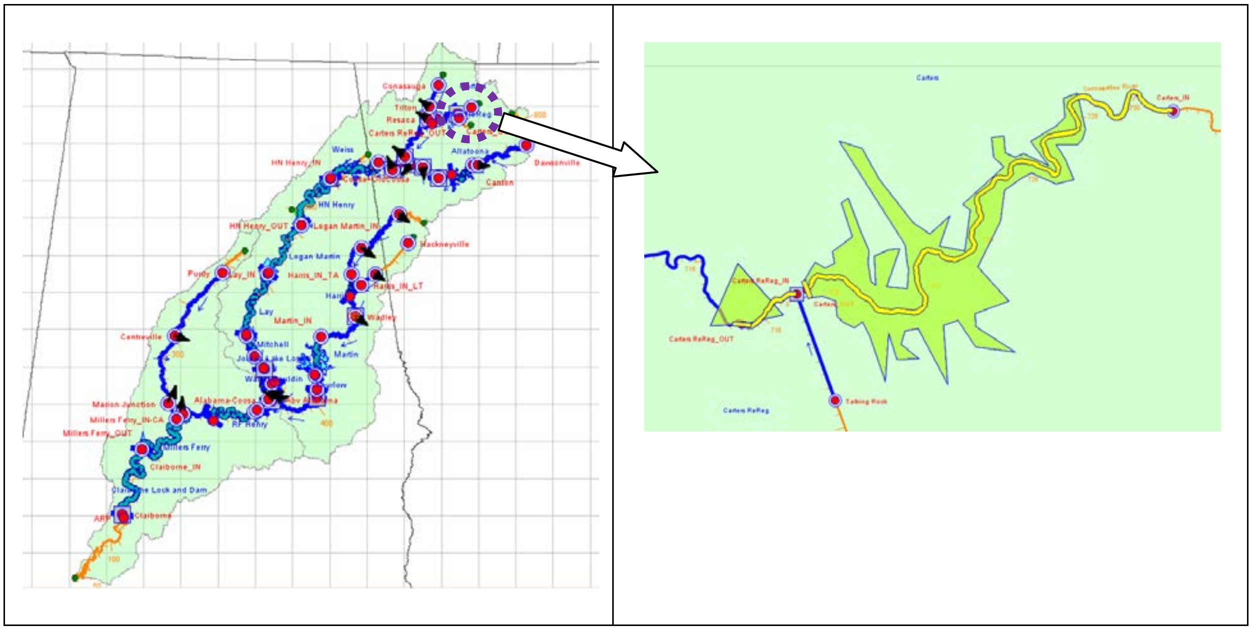


Figure A.01 HEC-ResSim Map Display Showing Location of Carters Reservoir and Carters ReReg

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

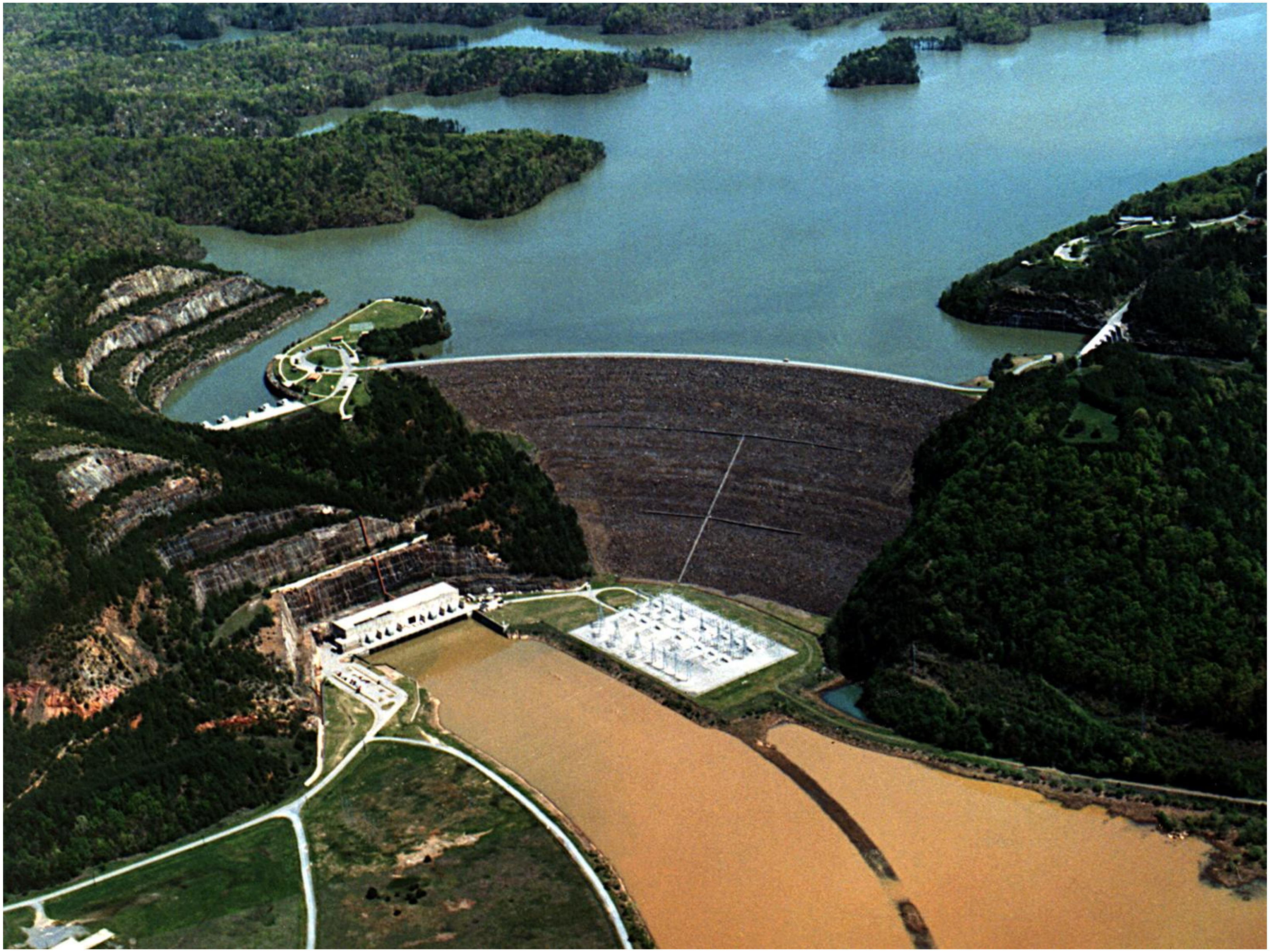
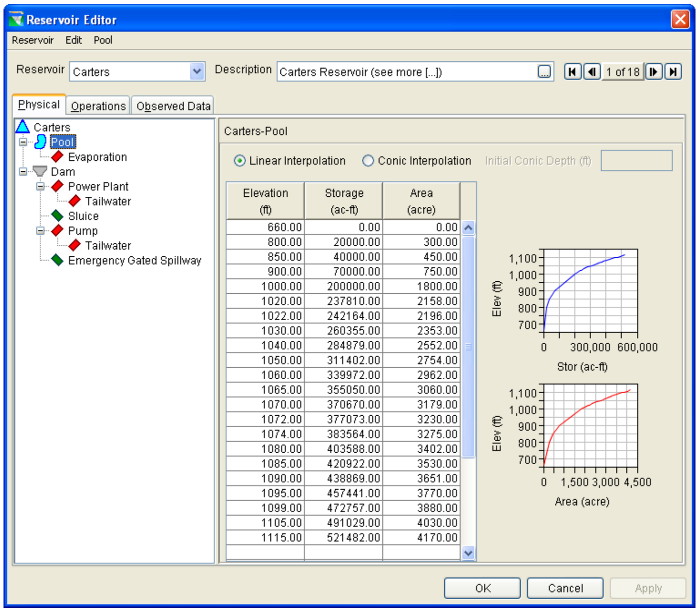


Figure A.02 Photo of Carters Main Dam

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



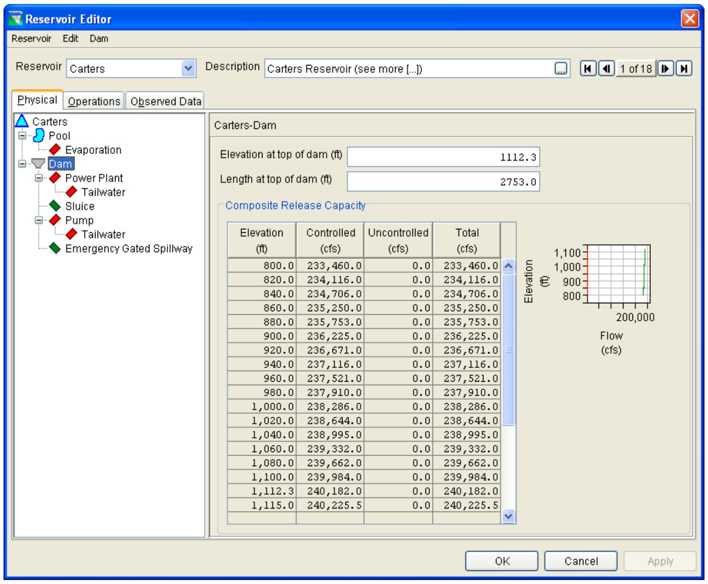
Reservoir: Carters
Description: Carters Reservoir (see more [...])

Carters-Pool

● Linear Interpolation ○ Conic Interpolation

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



Reservoir: Carters
Description: Carters Reservoir (see more [...])

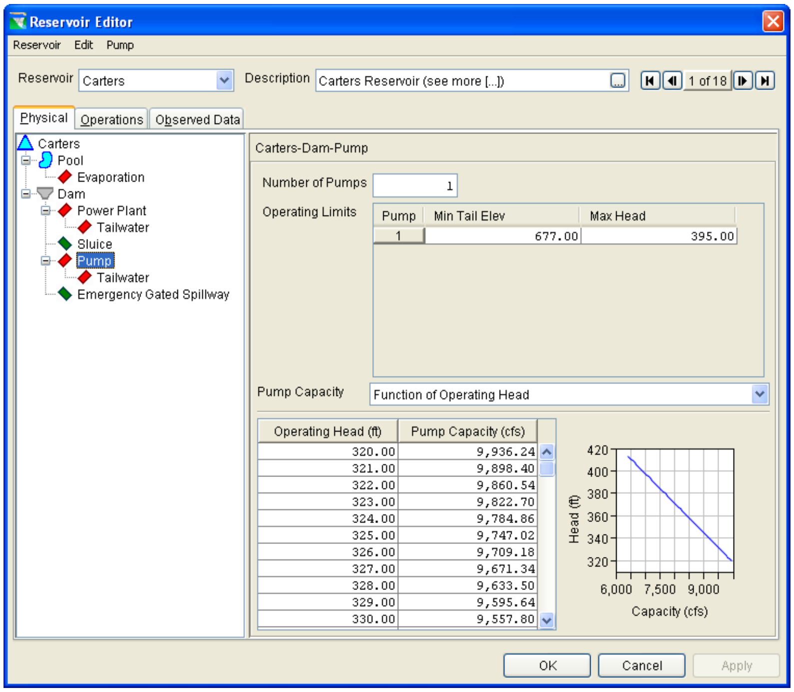
Carters-Dam

Elevation at top of dam (ft): 1112.3
Length at top of dam (ft): 2753.0

Composite Release Capacity

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



Reservoir: Carters

Description: Carters Reservoir (see more [...])

1 of 18

Carters-Dam-Pump

Number of Pumps: 1

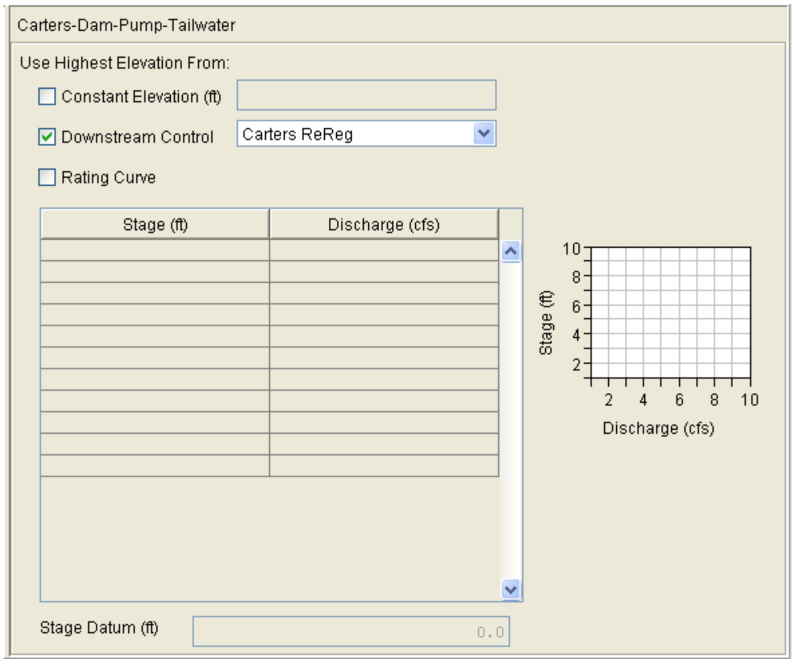
Operating Limits

Pump	Min Tail Elev	Max Head
1	677.00	395.00

Pump Capacity: Function of Operating Head

Operating Head (ft)	Pump Capacity (cfs)
320.00	9,936.24
321.00	9,898.40
322.00	9,860.54
323.00	9,822.70
324.00	9,784.86
325.00	9,747.02
326.00	9,709.18
327.00	9,671.34
328.00	9,633.50
329.00	9,595.64
330.00	9,557.80

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



Carters-Dam-Pump-Tailwater

Use Highest Elevation From:

☐ Constant Elevation (ft)

☑ Downstream Control: Carters ReReg

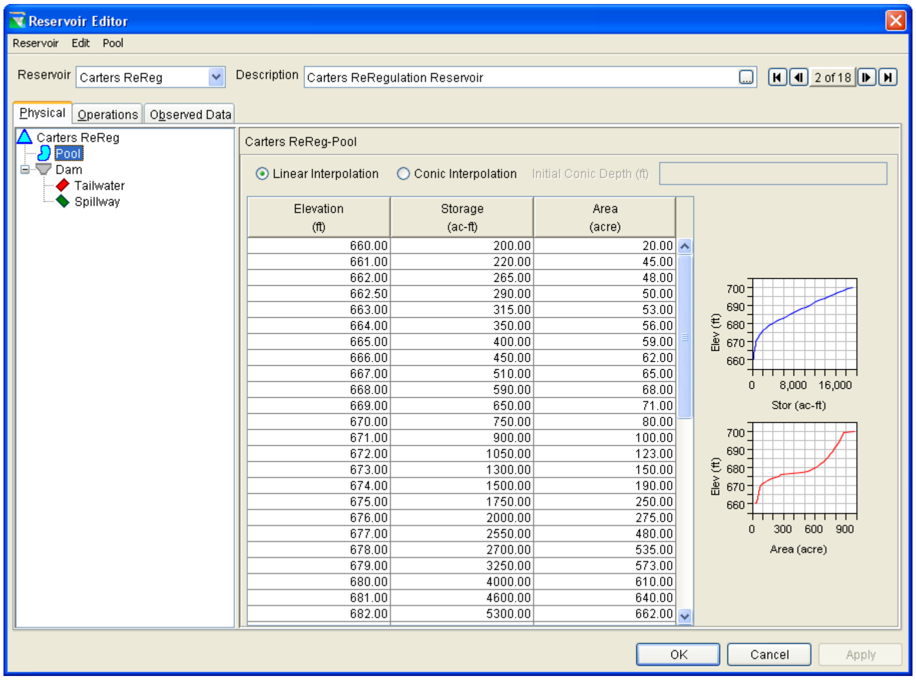
☐ Rating Curve

Stage (ft)	Discharge (cfs)

Stage Datum (ft): 0.0

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.



Reservoir: Carters ReReg

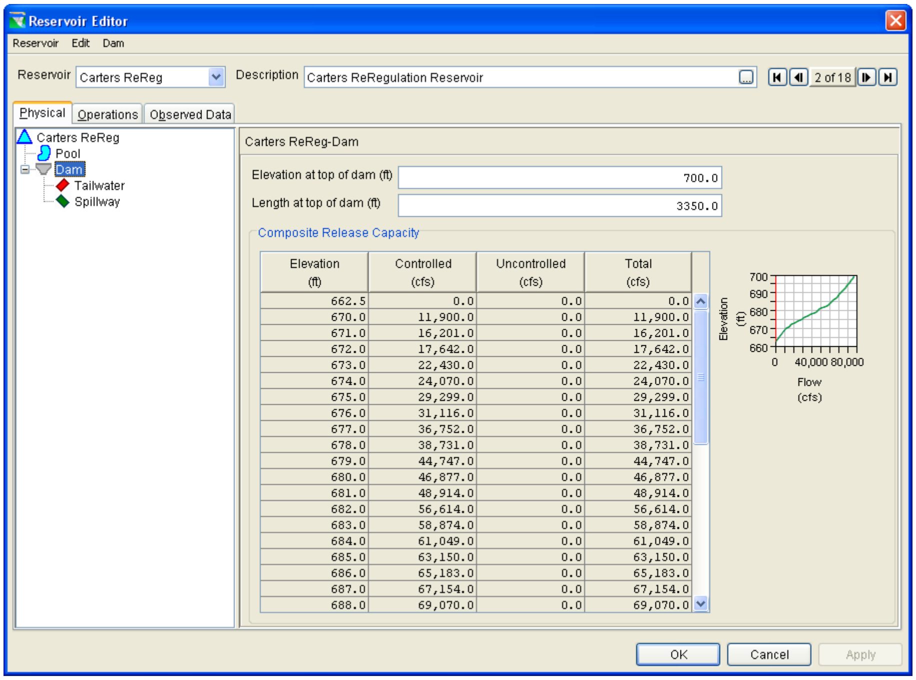
Description: Carters ReRegulation Reservoir

Carters ReReg-Pool

● Linear Interpolation ○ Conic Interpolation Initial Conic Depth (ft)

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



Reservoir: Carters ReReg

Description: Carters ReRegulation Reservoir

Carters ReReg-Dam

Elevation at top of dam (ft): 700.0

Length at top of dam (ft): 3350.0

Composite Release Capacity

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*

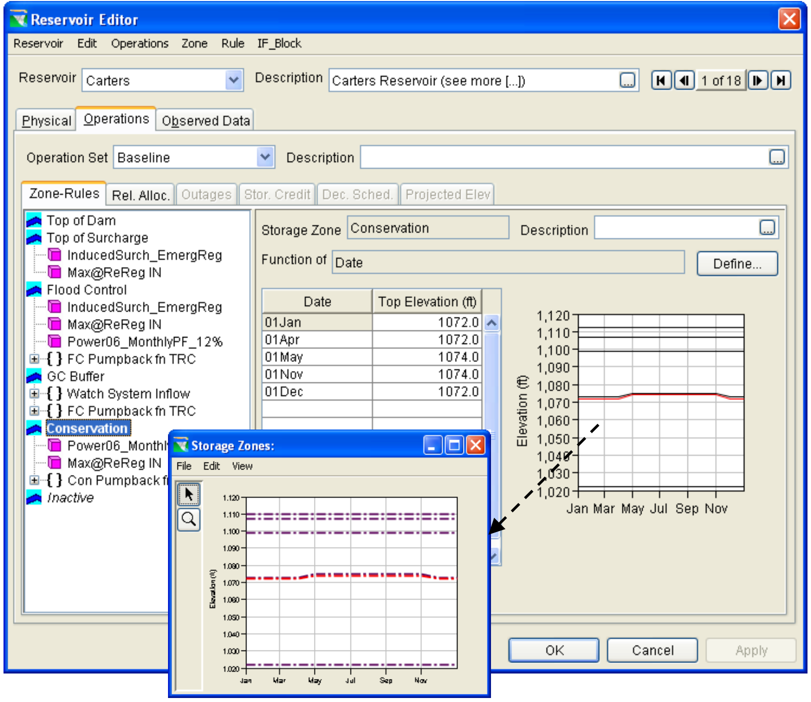
Table A.02 shows the definition of "Baseline" operational zones for Carters ReReg, which consist of zones of flood control and conservation. The conservation pool is divided into a couple of operational zones.

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)

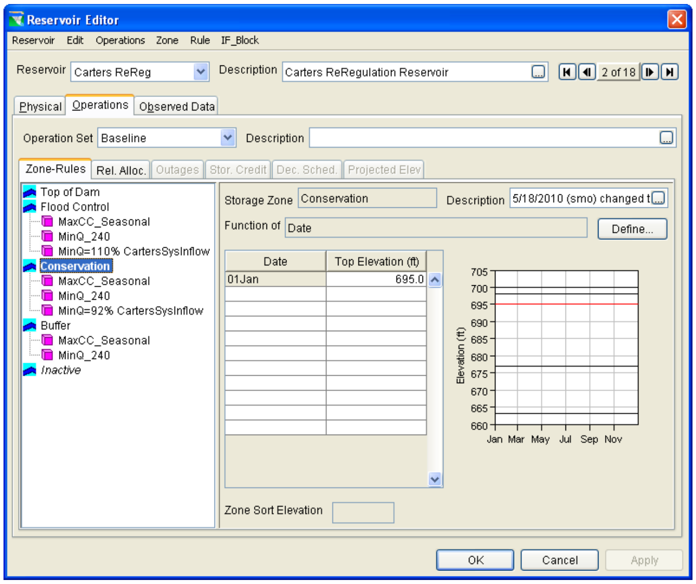


Reservoir: Carters
Description: Carters Reservoir (see more [...])
1 of 18
Operation Set: Baseline
Description:
Storage Zone: Conservation
Description:
Function of: Date

Date	Top Elevation (ft)
01Jan	1072.0
01Apr	1072.0
01May	1074.0
01Nov	1074.0
01Dec	1072.0

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.



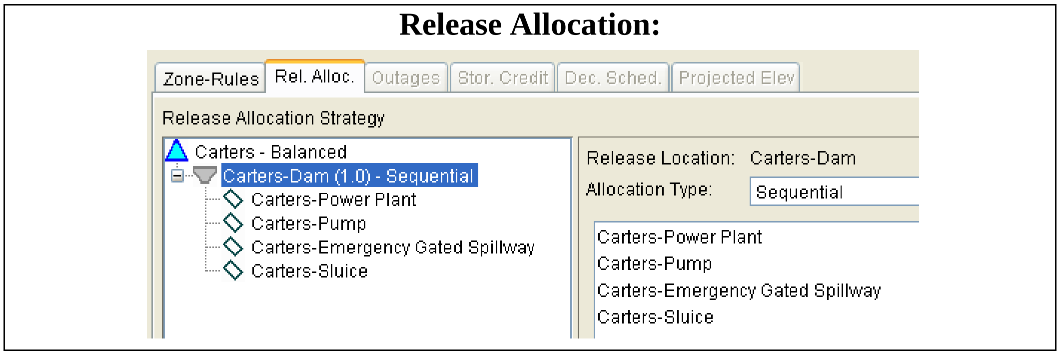
Reservoir: Carters ReReg
Description: Carters ReRegulation Reservoir
2 of 18
Operation Set: Baseline
Description:
Storage Zone: Conservation
Description: 5/18/2010 (smo) changed t
Function of: Date

Date	Top Elevation (ft)
01Jan	695.0

Zone Sort Elevation:

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:

Release Allocation Strategy

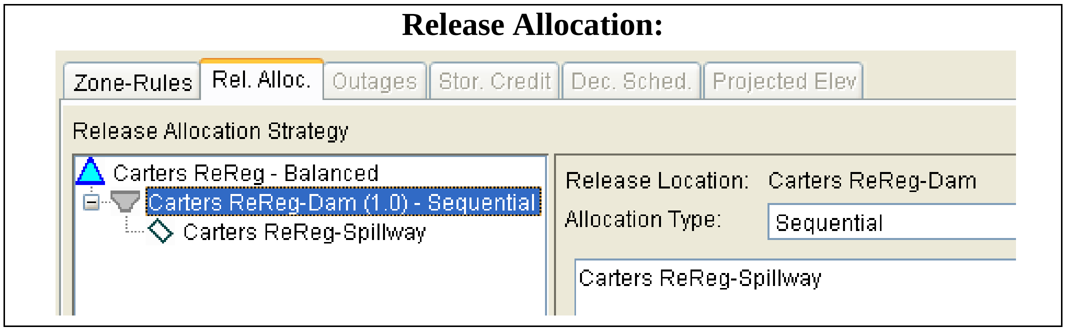
- Carters - Balanced
  - Carters-Dam (1.0) - Sequential
    - Carters-Power Plant
    - Carters-Pump
    - Carters-Emergency Gated Spillway
    - Carters-Sluice

Release Location: Carters-Dam
Allocation Type: Sequential

Carters-Power Plant
Carters-Pump
Carters-Emergency Gated Spillway
Carters-Sluice

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:

Release Allocation Strategy

- Carters ReReg - Balanced
  - Carters ReReg-Dam (1.0) - Sequential
    - Carters ReReg-Spillway

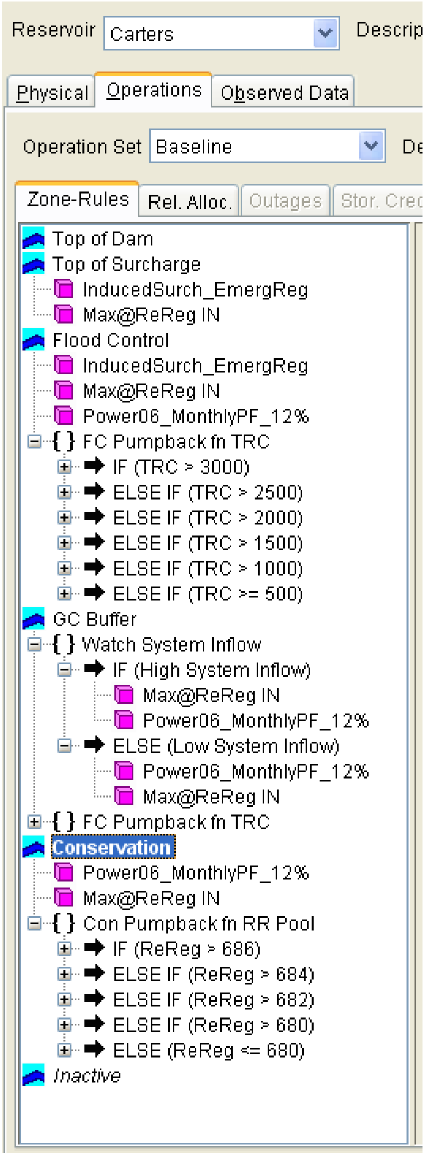
Release Location: Carters ReReg-Dam
Allocation Type: Sequential

Carters ReReg-Spillway

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.



Reservoir Carters

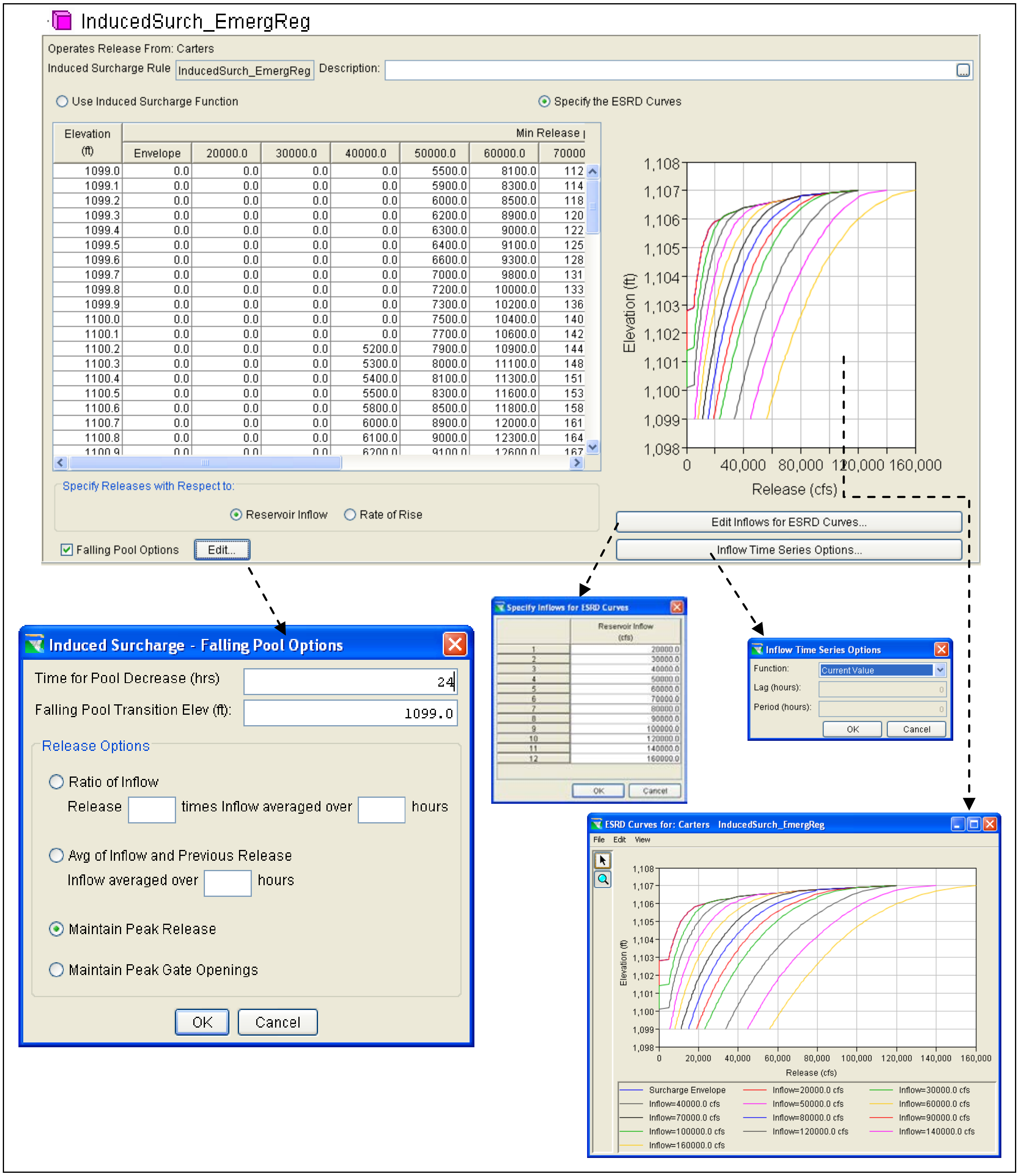
Operation Set Baseline

- Top of Dam
- Top of Surcharge
  - InducedSurch_EmergReg
  - Max@ReReg IN
- Flood Control
  - InducedSurch_EmergReg
  - Max@ReReg IN
  - Power06_MonthlyPF_12%
  - { } FC Pumpback fn TRC
    - ➡ IF (TRC > 3000)
    - ➡ ELSE IF (TRC > 2500)
    - ➡ ELSE IF (TRC > 2000)
    - ➡ ELSE IF (TRC > 1500)
    - ➡ ELSE IF (TRC > 1000)
    - ➡ ELSE IF (TRC >= 500)
- GC Buffer
  - { } Watch System Inflow
    - ➡ IF (High System Inflow)
      - Max@ReReg IN
      - Power06_MonthlyPF_12%
    - ➡ ELSE (Low System Inflow)
      - Power06_MonthlyPF_12%
      - Max@ReReg IN
  - { } FC Pumpback fn TRC
- Conservation
  - Power06_MonthlyPF_12%
  - Max@ReReg IN
  - { } Con Pumpback fn RR Pool
    - ➡ IF (ReReg > 686)
    - ➡ ELSE IF (ReReg > 684)
    - ➡ ELSE IF (ReReg > 682)
    - ➡ ELSE IF (ReReg > 680)
    - ➡ ELSE (ReReg <= 680)
- *Inactive*

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).



InducedSurch_EmergReg

Operates Release From: Carters

Induced Surcharge Rule: InducedSurch_EmergReg

Description:

○ Use Induced Surcharge Function ● Specify the ESRD Curves

Elevation (ft)	Min Release						
	Envelope	20000.0	30000.0	40000.0	50000.0	60000.0	70000
1099.0	0.0	0.0	0.0	0.0	5500.0	8100.0	112
1099.1	0.0	0.0	0.0	0.0	5900.0	8300.0	114
1099.2	0.0	0.0	0.0	0.0	6000.0	8500.0	118
1099.3	0.0	0.0	0.0	0.0	6200.0	8900.0	120
1099.4	0.0	0.0	0.0	0.0	6300.0	9000.0	122
1099.5	0.0	0.0	0.0	0.0	6400.0	9100.0	125
1099.6	0.0	0.0	0.0	0.0	6600.0	9300.0	128
1099.7	0.0	0.0	0.0	0.0	7000.0	9800.0	131
1099.8	0.0	0.0	0.0	0.0	7200.0	10000.0	133
1099.9	0.0	0.0	0.0	0.0	7300.0	10200.0	136
1100.0	0.0	0.0	0.0	0.0	7500.0	10400.0	140
1100.1	0.0	0.0	0.0	0.0	7700.0	10600.0	142
1100.2	0.0	0.0	0.0	5200.0	7900.0	10900.0	144
1100.3	0.0	0.0	0.0	5300.0	8000.0	11100.0	148
1100.4	0.0	0.0	0.0	5400.0	8100.0	11300.0	151
1100.5	0.0	0.0	0.0	5500.0	8300.0	11600.0	153
1100.6	0.0	0.0	0.0	5800.0	8500.0	11800.0	158
1100.7	0.0	0.0	0.0	6000.0	8900.0	12000.0	161
1100.8	0.0	0.0	0.0	6100.0	9000.0	12300.0	164
1100.9	0.0	0.0	0.0	6200.0	9100.0	12600.0	167

Specify Releases with Respect to: ● Reservoir Inflow ○ Rate of Rise

☑ Falling Pool Options

Induced Surcharge - Falling Pool Options

Time for Pool Decrease (hrs): 24

Falling Pool Transition Elev (ft): 1099.0

Release Options

○ Ratio of Inflow

Release ___ times Inflow averaged over ___ hours

○ Avg of Inflow and Previous Release

Inflow averaged over ___ hours

● Maintain Peak Release

○ Maintain Peak Gate Openings

Specify Inflows for ESRD Curves

	Reservoir Inflow (cfs)
1	20000.0
2	30000.0
3	40000.0
4	50000.0
5	60000.0
6	70000.0
7	80000.0
8	90000.0
9	100000.0
10	120000.0
11	140000.0
12	160000.0

Inflow Time Series Options

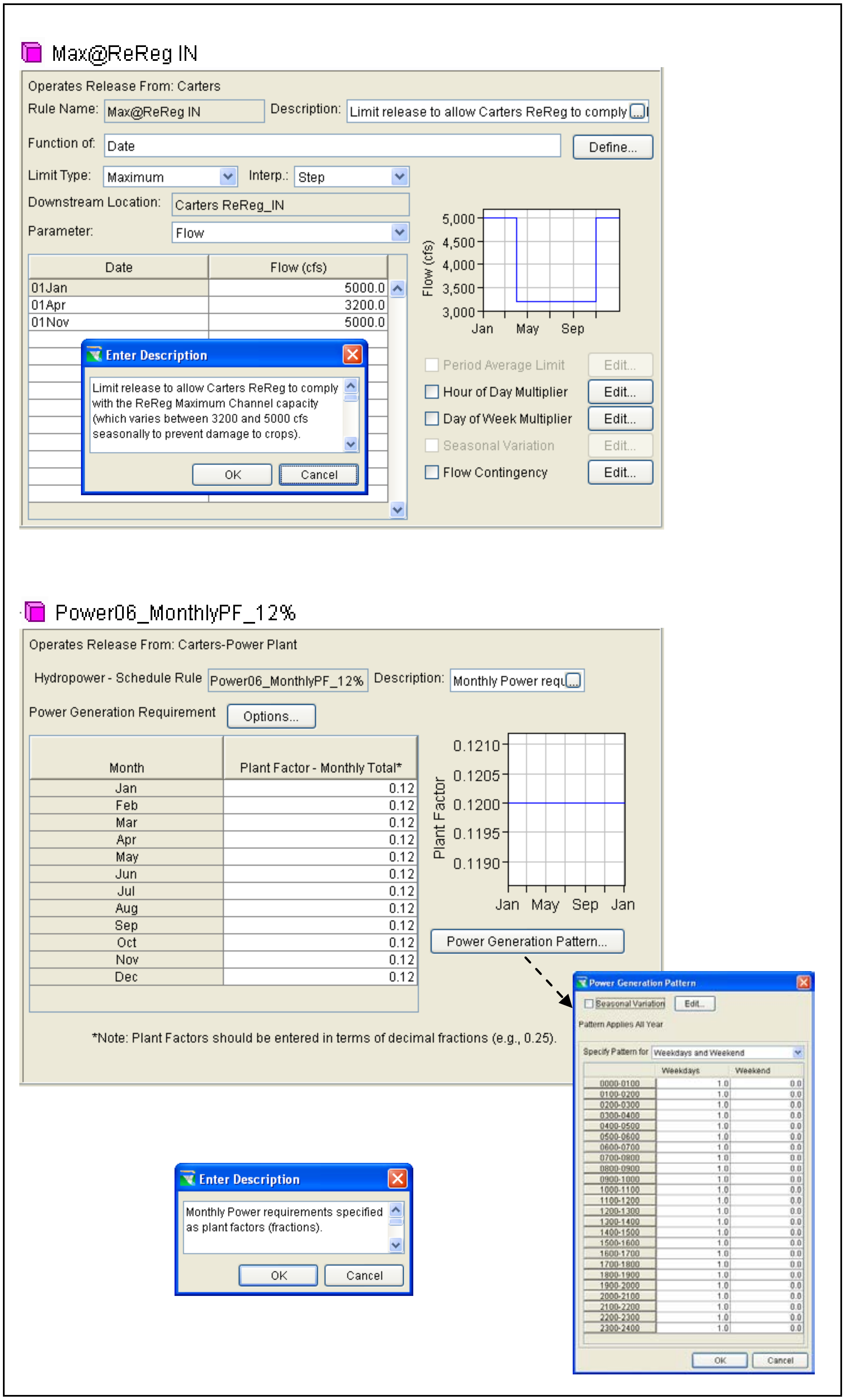
Function: Current Value

Lag (hours): 0

Period (hours): 0

ESRD Curves for: Carters InducedSurch_EmergReg

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



Max@ReReg IN

Operates Release From: Carters

Rule Name: Max@ReReg IN

Description: Limit release to allow Carters ReReg to comply

Function of: Date

Limit Type: Maximum

Interp.: Step

Downstream Location: Carters ReReg_IN

Parameter: Flow

Date	Flow (cfs)
01Jan	5000.0
01Apr	3200.0
01Nov	5000.0

Enter Description

Limit release to allow Carters ReReg to comply with the ReReg Maximum Channel capacity (which varies between 3200 and 5000 cfs seasonally to prevent damage to crops).

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Power06_MonthlyPF_12%

Operates Release From: Carters-Power Plant

Hydropower - Schedule Rule: Power06_MonthlyPF_12%

Description: Monthly Power requ

Power Generation Requirement

Month	Plant Factor - Monthly Total*
Jan	0.12
Feb	0.12
Mar	0.12
Apr	0.12
May	0.12
Jun	0.12
Jul	0.12
Aug	0.12
Sep	0.12
Oct	0.12
Nov	0.12
Dec	0.12

*Note: Plant Factors should be entered in terms of decimal fractions (e.g., 0.25).

Enter Description

Monthly Power requirements specified as plant factors (fractions).

Power Generation Pattern

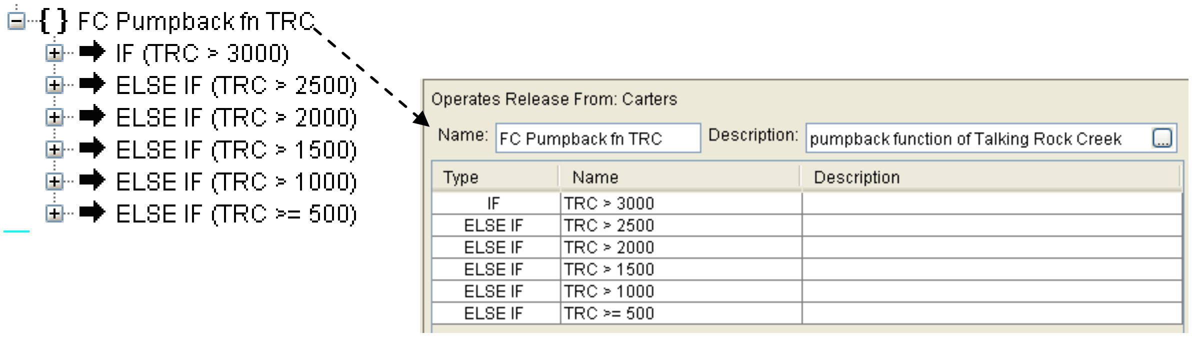
☐ Seasonal Variation

Pattern Applies All Year

Specify Pattern for: Weekdays and Weekend

	Weekdays	Weekend
0000-0100	1.0	0.0
0100-0200	1.0	0.0
0200-0300	1.0	0.0
0300-0400	1.0	0.0
0400-0500	1.0	0.0
0500-0600	1.0	0.0
0600-0700	1.0	0.0
0700-0800	1.0	0.0
0800-0900	1.0	0.0
0900-1000	1.0	0.0
1000-1100	1.0	0.0
1100-1200	1.0	0.0
1200-1300	1.0	0.0
1300-1400	1.0	0.0
1400-1500	1.0	0.0
1500-1600	1.0	0.0
1600-1700	1.0	0.0
1700-1800	1.0	0.0
1800-1900	1.0	0.0
1900-2000	1.0	0.0
2000-2100	1.0	0.0
2100-2200	1.0	0.0
2200-2300	1.0	0.0
2300-2400	1.0	0.0

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



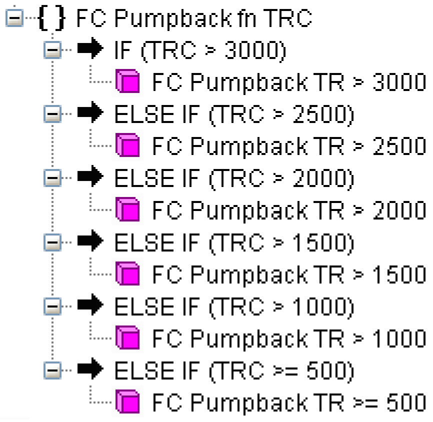
{ } FC Pumpback fn TRC
- IF (TRC > 3000)
- ELSE IF (TRC > 2500)
- ELSE IF (TRC > 2000)
- ELSE IF (TRC > 1500)
- ELSE IF (TRC > 1000)
- ELSE IF (TRC >= 500)

Operates Release From: Carters

Name: FC Pumpback fn TRC Description: pumpback function of Talking Rock Creek

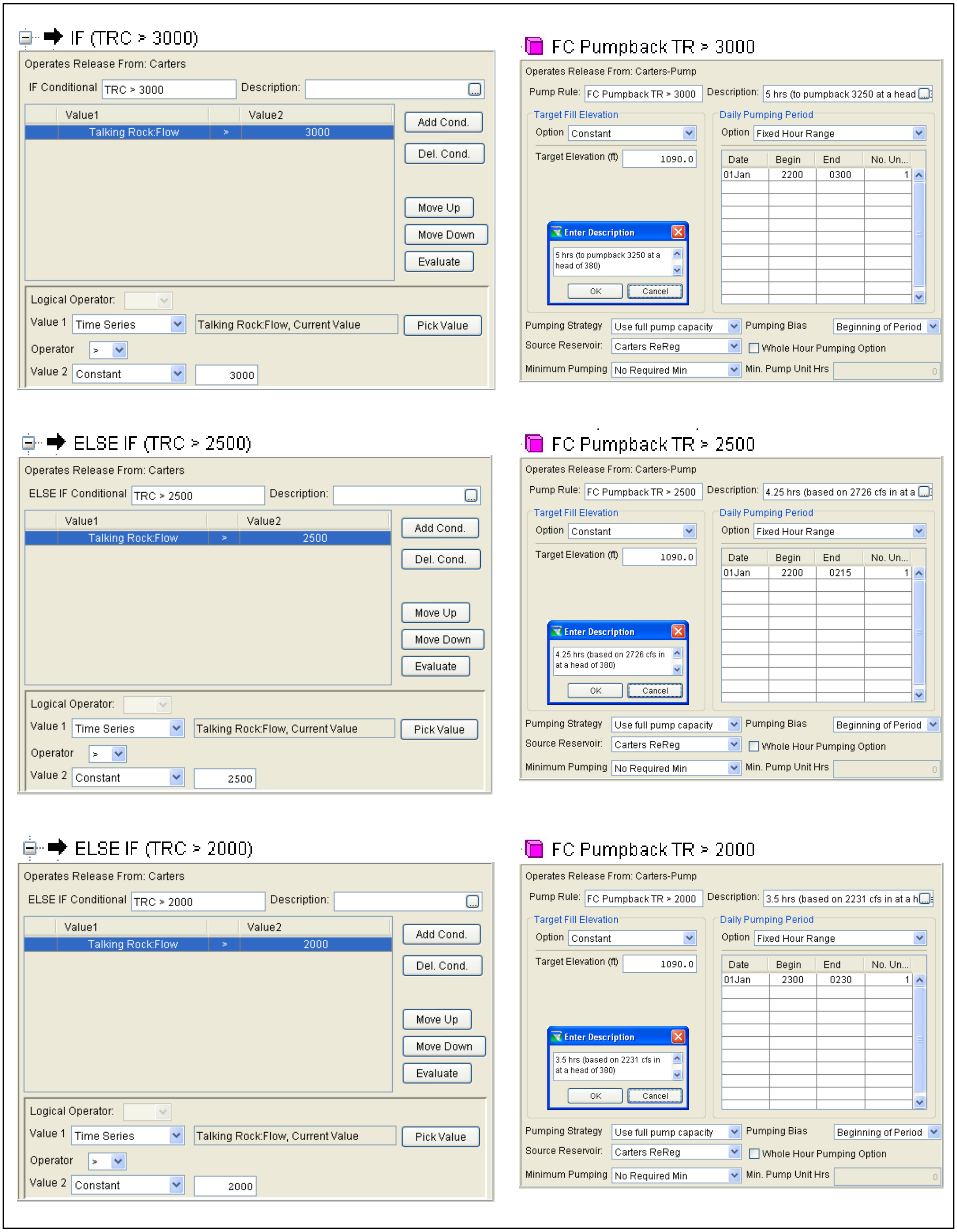
Type	Name	Description
IF	TRC > 3000	
ELSE IF	TRC > 2500	
ELSE IF	TRC > 2000	
ELSE IF	TRC > 1500	
ELSE IF	TRC > 1000	
ELSE IF	TRC >= 500	

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



{ } FC Pumpback fn TRC
- IF (TRC > 3000)
  - FC Pumpback TR > 3000
- ELSE IF (TRC > 2500)
  - FC Pumpback TR > 2500
- ELSE IF (TRC > 2000)
  - FC Pumpback TR > 2000
- ELSE IF (TRC > 1500)
  - FC Pumpback TR > 1500
- ELSE IF (TRC > 1000)
  - FC Pumpback TR > 1000
- ELSE IF (TRC >= 500)
  - FC Pumpback TR >= 500

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



IF (TRC > 3000)

Operates Release From: Carters

IF Conditional: TRC > 3000
Description:

Value1		Value2
Talking Rock:Flow	>	3000

Logical Operator:
Value 1: Time Series — Talking Rock:Flow, Current Value
Operator: >
Value 2: Constant — 3000

FC Pumpback TR > 3000

Operates Release From: Carters-Pump

Pump Rule: FC Pumpback TR > 3000
Description: 5 hrs (to pumpback 3250 at a head

Target Fill Elevation
Option: Constant
Target Elevation (ft): 1090.0

Enter Description: 5 hrs (to pumpback 3250 at a head of 380)

Daily Pumping Period
Option: Fixed Hour Range

Date	Begin	End	No. Un...
01Jan	2200	0300	1

Pumping Strategy: Use full pump capacity
Pumping Bias: Beginning of Period
Source Reservoir: Carters ReReg
☐ Whole Hour Pumping Option
Minimum Pumping: No Required Min
Min. Pump Unit Hrs: 0

ELSE IF (TRC > 2500)

Operates Release From: Carters

ELSE IF Conditional: TRC > 2500
Description:

Value1		Value2
Talking Rock:Flow	>	2500

Logical Operator:
Value 1: Time Series — Talking Rock:Flow, Current Value
Operator: >
Value 2: Constant — 2500

FC Pumpback TR > 2500

Operates Release From: Carters-Pump

Pump Rule: FC Pumpback TR > 2500
Description: 4.25 hrs (based on 2726 cfs in at a

Target Fill Elevation
Option: Constant
Target Elevation (ft): 1090.0

Enter Description: 4.25 hrs (based on 2726 cfs in at a head of 380)

Daily Pumping Period
Option: Fixed Hour Range

Date	Begin	End	No. Un...
01Jan	2200	0215	1

Pumping Strategy: Use full pump capacity
Pumping Bias: Beginning of Period
Source Reservoir: Carters ReReg
☐ Whole Hour Pumping Option
Minimum Pumping: No Required Min
Min. Pump Unit Hrs: 0

ELSE IF (TRC > 2000)

Operates Release From: Carters

ELSE IF Conditional: TRC > 2000
Description:

Value1		Value2
Talking Rock:Flow	>	2000

Logical Operator:
Value 1: Time Series — Talking Rock:Flow, Current Value
Operator: >
Value 2: Constant — 2000

FC Pumpback TR > 2000

Operates Release From: Carters-Pump

Pump Rule: FC Pumpback TR > 2000
Description: 3.5 hrs (based on 2231 cfs in at a h

Target Fill Elevation
Option: Constant
Target Elevation (ft): 1090.0

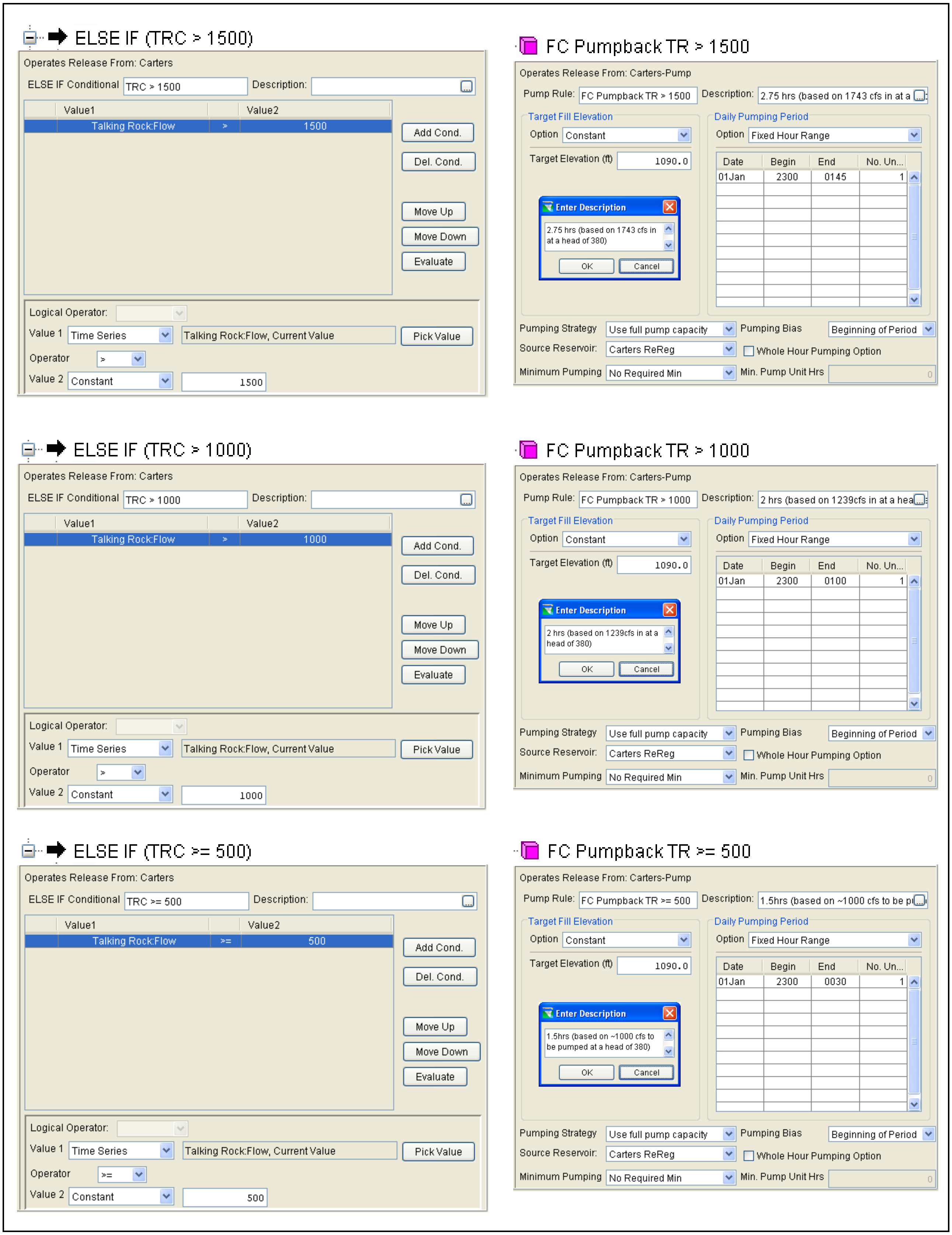
Enter Description: 3.5 hrs (based on 2231 cfs in at a head of 380)

Daily Pumping Period
Option: Fixed Hour Range

Date	Begin	End	No. Un...
01Jan	2300	0230	1

Pumping Strategy: Use full pump capacity
Pumping Bias: Beginning of Period
Source Reservoir: Carters ReReg
☐ Whole Hour Pumping Option
Minimum Pumping: No Required Min
Min. Pump Unit Hrs: 0

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



ELSE IF (TRC > 1500)

Operates Release From: Carters

ELSE IF Conditional: TRC > 1500
Description:

Value1		Value2
Talking Rock:Flow	>	1500

Logical Operator:
Value 1: Time Series — Talking Rock:Flow, Current Value
Operator: >
Value 2: Constant — 1500

FC Pumpback TR > 1500

Operates Release From: Carters-Pump

Pump Rule: FC Pumpback TR > 1500
Description: 2.75 hrs (based on 1743 cfs in at a

Target Fill Elevation
Option: Constant
Target Elevation (ft): 1090.0

Enter Description
2.75 hrs (based on 1743 cfs in at a head of 380)

Daily Pumping Period
Option: Fixed Hour Range

Date	Begin	End	No. Un...
01Jan	2300	0145	1

Pumping Strategy: Use full pump capacity
Pumping Bias: Beginning of Period
Source Reservoir: Carters ReReg
☐ Whole Hour Pumping Option
Minimum Pumping: No Required Min
Min. Pump Unit Hrs: 0

ELSE IF (TRC > 1000)

Operates Release From: Carters

ELSE IF Conditional: TRC > 1000
Description:

Value1		Value2
Talking Rock:Flow	>	1000

Logical Operator:
Value 1: Time Series — Talking Rock:Flow, Current Value
Operator: >
Value 2: Constant — 1000

FC Pumpback TR > 1000

Operates Release From: Carters-Pump

Pump Rule: FC Pumpback TR > 1000
Description: 2 hrs (based on 1239cfs in at a hea

Target Fill Elevation
Option: Constant
Target Elevation (ft): 1090.0

Enter Description
2 hrs (based on 1239cfs in at a head of 380)

Daily Pumping Period
Option: Fixed Hour Range

Date	Begin	End	No. Un...
01Jan	2300	0100	1

Pumping Strategy: Use full pump capacity
Pumping Bias: Beginning of Period
Source Reservoir: Carters ReReg
☐ Whole Hour Pumping Option
Minimum Pumping: No Required Min
Min. Pump Unit Hrs: 0

ELSE IF (TRC >= 500)

Operates Release From: Carters

ELSE IF Conditional: TRC >= 500
Description:

Value1		Value2
Talking Rock:Flow	>=	500

Logical Operator:
Value 1: Time Series — Talking Rock:Flow, Current Value
Operator: >=
Value 2: Constant — 500

FC Pumpback TR >= 500

Operates Release From: Carters-Pump

Pump Rule: FC Pumpback TR >= 500
Description: 1.5hrs (based on ~1000 cfs to be p

Target Fill Elevation
Option: Constant
Target Elevation (ft): 1090.0

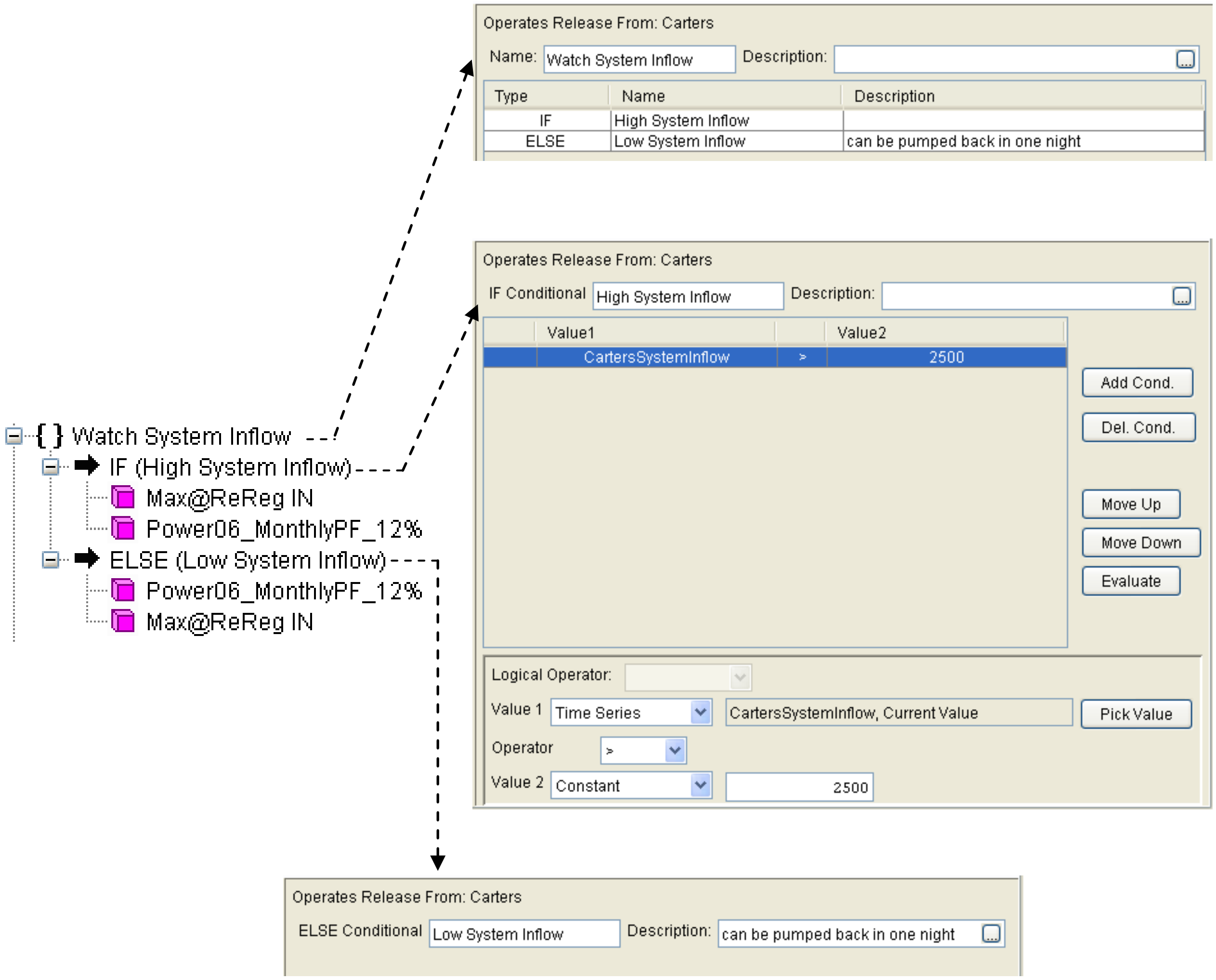
Enter Description
1.5hrs (based on ~1000 cfs to be pumped at a head of 380)

Daily Pumping Period
Option: Fixed Hour Range

Date	Begin	End	No. Un...
01Jan	2300	0030	1

Pumping Strategy: Use full pump capacity
Pumping Bias: Beginning of Period
Source Reservoir: Carters ReReg
☐ Whole Hour Pumping Option
Minimum Pumping: No Required Min
Min. Pump Unit Hrs: 0

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


- { } Watch System Inflow
  - IF (High System Inflow)
    - Max@ReReg IN
    - Power06_MonthlyPF_12%
  - ELSE (Low System Inflow)
    - Power06_MonthlyPF_12%
    - Max@ReReg IN

Operates Release From: Carters

Name: Watch System Inflow

Description:

Type	Name	Description
IF	High System Inflow	
ELSE	Low System Inflow	can be pumped back in one night

Operates Release From: Carters

IF Conditional: High System Inflow

Description:

	Value1		Value2
	CartersSystemInflow	>	2500

Logical Operator:

Value 1: Time Series — CartersSystemInflow, Current Value

Operator: >

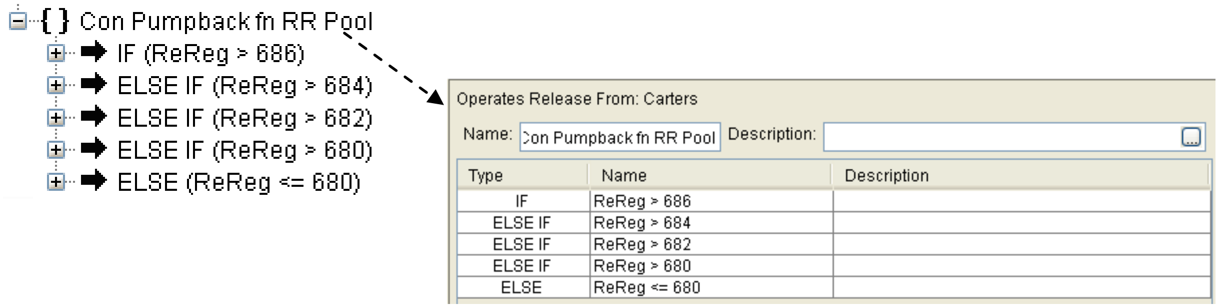
Value 2: Constant — 2500

Operates Release From: Carters

ELSE Conditional: Low System Inflow

Description: can be pumped back in one night

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



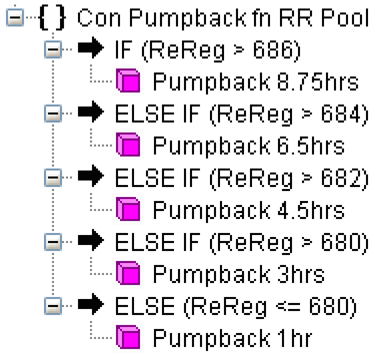
- { } Con Pumpback fn RR Pool
  - IF (ReReg > 686)
  - ELSE IF (ReReg > 684)
  - ELSE IF (ReReg > 682)
  - ELSE IF (ReReg > 680)
  - ELSE (ReReg <= 680)

Operates Release From: Carters

Name: Con Pumpback fn RR Pool Description:

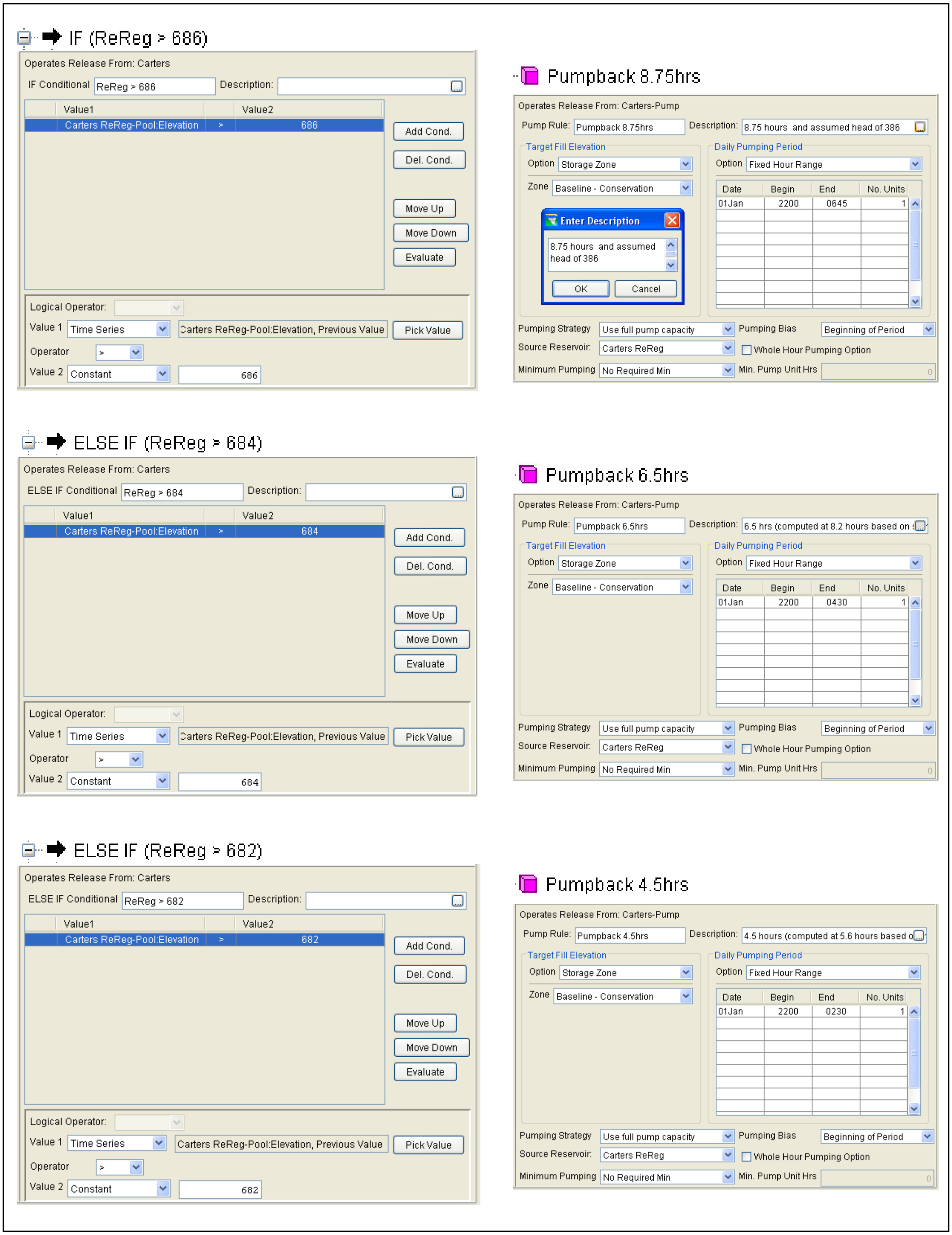
Type	Name	Description
IF	ReReg > 686	
ELSE IF	ReReg > 684	
ELSE IF	ReReg > 682	
ELSE IF	ReReg > 680	
ELSE	ReReg <= 680	

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



- { } Con Pumpback fn RR Pool
  - IF (ReReg > 686)
    - Pumpback 8.75hrs
  - ELSE IF (ReReg > 684)
    - Pumpback 6.5hrs
  - ELSE IF (ReReg > 682)
    - Pumpback 4.5hrs
  - ELSE IF (ReReg > 680)
    - Pumpback 3hrs
  - ELSE (ReReg <= 680)
    - Pumpback 1hr

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



IF (ReReg > 686)

Operates Release From: Carters

IF Conditional: ReReg > 686

Description:

Value1		Value2
Carters ReReg-Pool:Elevation	>	686

Logical Operator:

Value 1: Time Series — Carters ReReg-Pool:Elevation, Previous Value

Operator: >

Value 2: Constant — 686

Pumpback 8.75hrs

Operates Release From: Carters-Pump

Pump Rule: Pumpback 8.75hrs

Description: 8.75 hours and assumed head of 386

Target Fill Elevation

Option: Storage Zone

Zone: Baseline - Conservation

Enter Description

8.75 hours and assumed head of 386

Daily Pumping Period

Option: Fixed Hour Range

Date	Begin	End	No. Units
01Jan	2200	0645	1

Pumping Strategy: Use full pump capacity

Pumping Bias: Beginning of Period

Source Reservoir: Carters ReReg

☐ Whole Hour Pumping Option

Minimum Pumping: No Required Min

Min. Pump Unit Hrs: 0

ELSE IF (ReReg > 684)

Operates Release From: Carters

ELSE IF Conditional: ReReg > 684

Description:

Value1		Value2
Carters ReReg-Pool:Elevation	>	684

Logical Operator:

Value 1: Time Series — Carters ReReg-Pool:Elevation, Previous Value

Operator: >

Value 2: Constant — 684

Pumpback 6.5hrs

Operates Release From: Carters-Pump

Pump Rule: Pumpback 6.5hrs

Description: 6.5 hrs (computed at 8.2 hours based on

Target Fill Elevation

Option: Storage Zone

Zone: Baseline - Conservation

Daily Pumping Period

Option: Fixed Hour Range

Date	Begin	End	No. Units
01Jan	2200	0430	1

Pumping Strategy: Use full pump capacity

Pumping Bias: Beginning of Period

Source Reservoir: Carters ReReg

☐ Whole Hour Pumping Option

Minimum Pumping: No Required Min

Min. Pump Unit Hrs: 0

ELSE IF (ReReg > 682)

Operates Release From: Carters

ELSE IF Conditional: ReReg > 682

Description:

Value1		Value2
Carters ReReg-Pool:Elevation	>	682

Logical Operator:

Value 1: Time Series — Carters ReReg-Pool:Elevation, Previous Value

Operator: >

Value 2: Constant — 682

Pumpback 4.5hrs

Operates Release From: Carters-Pump

Pump Rule: Pumpback 4.5hrs

Description: 4.5 hours (computed at 5.6 hours based o

Target Fill Elevation

Option: Storage Zone

Zone: Baseline - Conservation

Daily Pumping Period

Option: Fixed Hour Range

Date	Begin	End	No. Units
01Jan	2200	0230	1

Pumping Strategy: Use full pump capacity

Pumping Bias: Beginning of Period

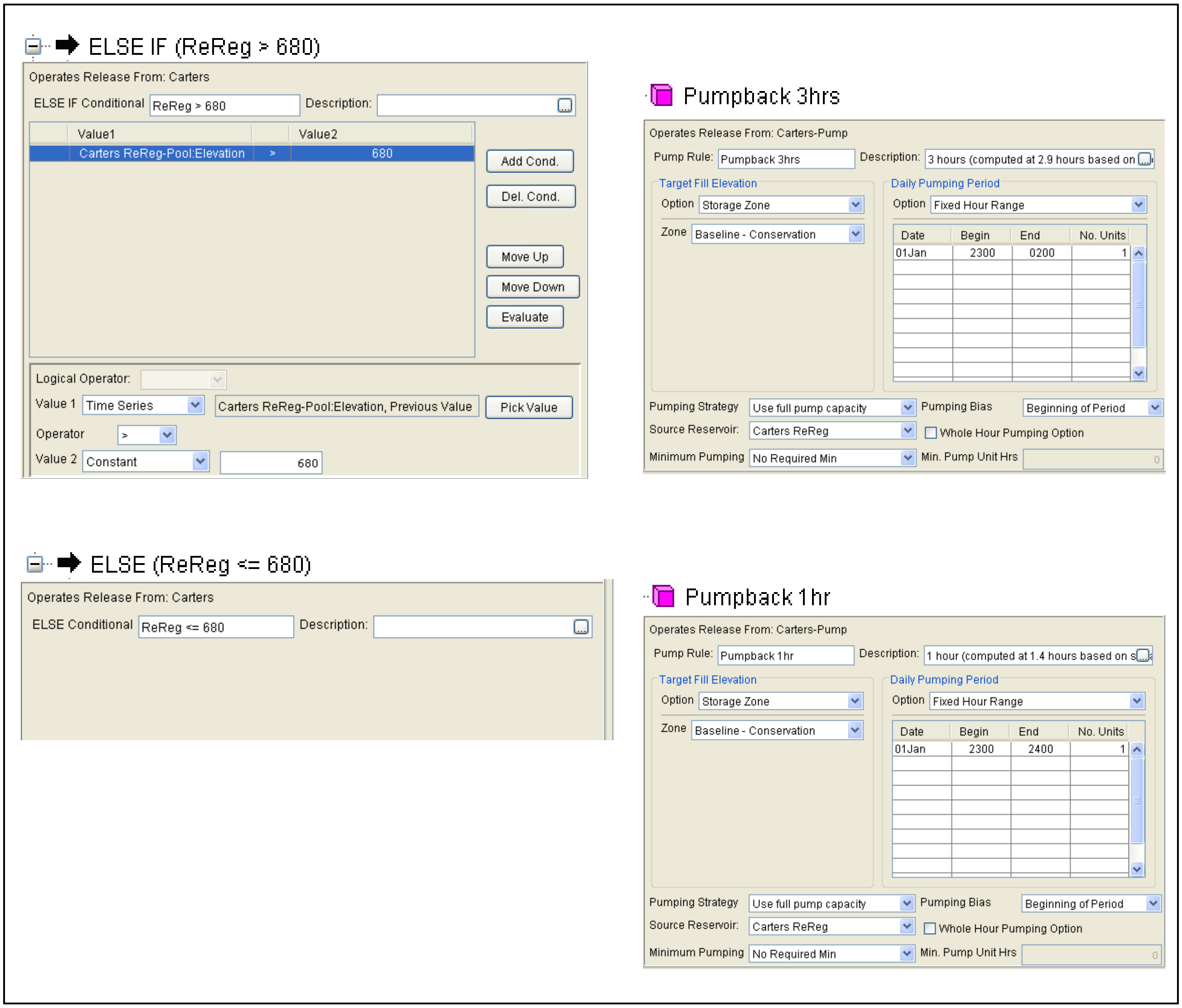
Source Reservoir: Carters ReReg

☐ Whole Hour Pumping Option

Minimum Pumping: No Required Min

Min. Pump Unit Hrs: 0

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



ELSE IF (ReReg > 680)

Operates Release From: Carters

ELSE IF Conditional: ReReg > 680

Description:

Value1		Value2
Carters ReReg-Pool:Elevation	>	680

Logical Operator:

Value 1: Time Series — Carters ReReg-Pool:Elevation, Previous Value

Operator: >

Value 2: Constant — 680

Pumpback 3hrs

Operates Release From: Carters-Pump

Pump Rule: Pumpback 3hrs

Description: 3 hours (computed at 2.9 hours based on

Target Fill Elevation

Option: Storage Zone

Zone: Baseline - Conservation

Daily Pumping Period

Option: Fixed Hour Range

Date	Begin	End	No. Units
01Jan	2300	0200	1

Pumping Strategy: Use full pump capacity

Pumping Bias: Beginning of Period

Source Reservoir: Carters ReReg

☐ Whole Hour Pumping Option

Minimum Pumping: No Required Min

Min. Pump Unit Hrs: 0

ELSE (ReReg <= 680)

Operates Release From: Carters

ELSE Conditional: ReReg <= 680

Description:

Pumpback 1hr

Operates Release From: Carters-Pump

Pump Rule: Pumpback 1hr

Description: 1 hour (computed at 1.4 hours based on s

Target Fill Elevation

Option: Storage Zone

Zone: Baseline - Conservation

Daily Pumping Period

Option: Fixed Hour Range

Date	Begin	End	No. Units
01Jan	2300	2400	1

Pumping Strategy: Use full pump capacity

Pumping Bias: Beginning of Period

Source Reservoir: Carters ReReg

☐ Whole Hour Pumping Option

Minimum Pumping: No Required Min

Min. Pump Unit Hrs: 0

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.

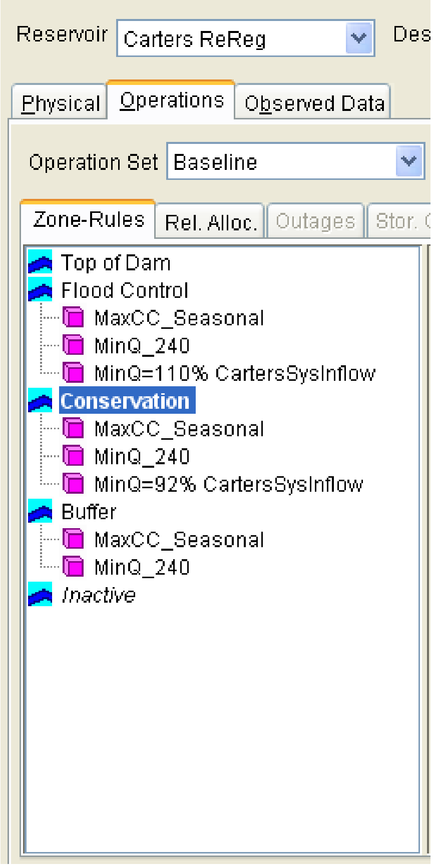
Table A.04 Relationship of Carters ReReg Pool Elevation to Conservation Pumpback Operation at Carters

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.



Reservoir: Carters ReReg

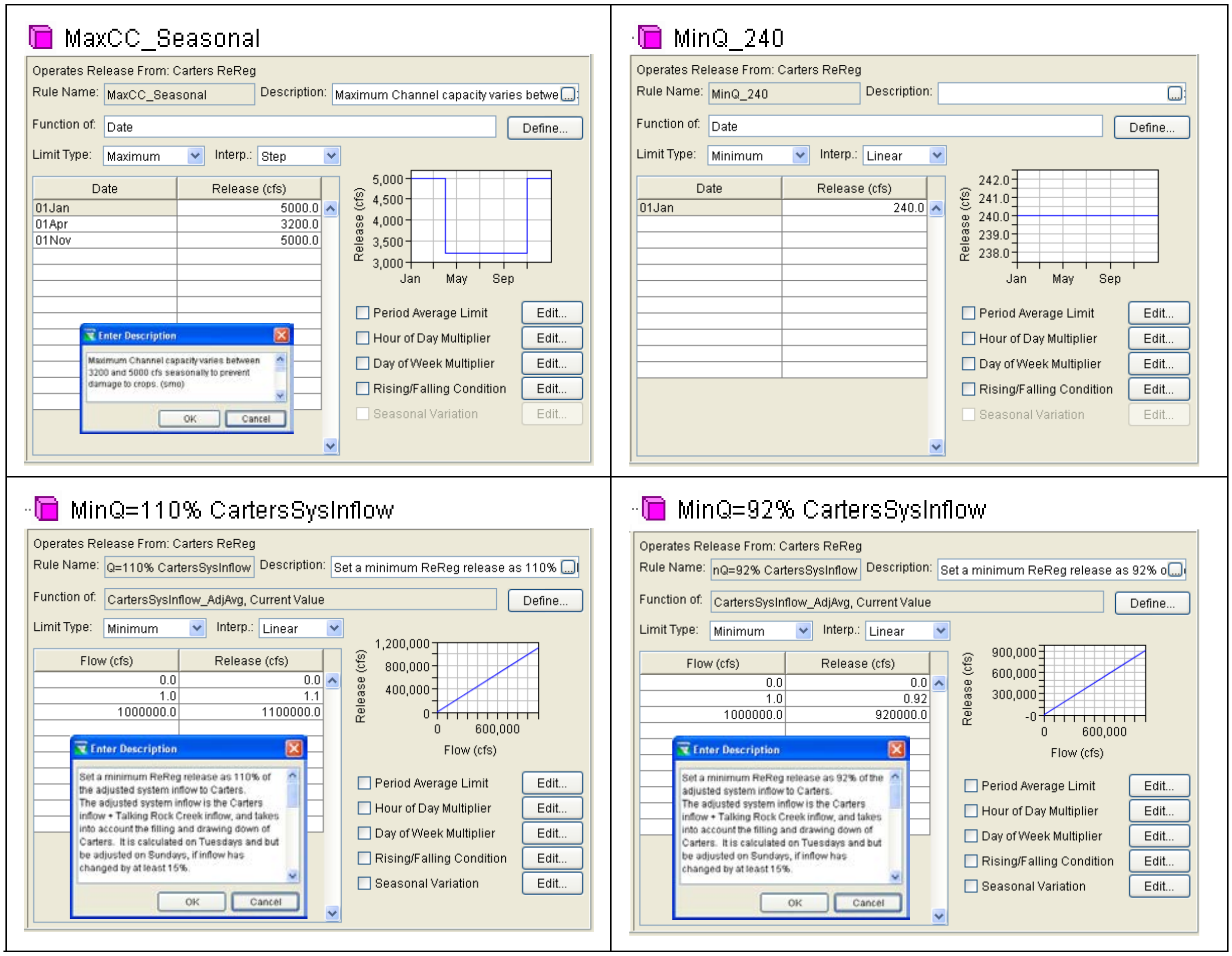
Operation Set: Baseline

- Top of Dam
- Flood Control
  - MaxCC_Seasonal
  - MinQ_240
  - MinQ=110% CartersSysInflow
- Conservation
  - MaxCC_Seasonal
  - MinQ_240
  - MinQ=92% CartersSysInflow
- Buffer
  - MaxCC_Seasonal
  - MinQ_240
- *Inactive*

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).



MaxCC_Seasonal

Operates Release From: Carters ReReg
Rule Name: MaxCC_Seasonal
Description: Maximum Channel capacity varies betwe
Function of: Date
Limit Type: Maximum
Interp.: Step

Date	Release (cfs)
01Jan	5000.0
01Apr	3200.0
01Nov	5000.0

Enter Description
Maximum Channel capacity varies between 3200 and 5000 cfs seasonally to prevent damage to crops. (smo)

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

MinQ_240

Operates Release From: Carters ReReg
Rule Name: MinQ_240
Description:
Function of: Date
Limit Type: Minimum
Interp.: Linear

Date	Release (cfs)
01Jan	240.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

MinQ=110% CartersSysInflow

Operates Release From: Carters ReReg
Rule Name: Q=110% CartersSysInflow
Description: Set a minimum ReReg release as 110%
Function of: CartersSysInflow_AdjAvg, Current Value
Limit Type: Minimum
Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	0.0
1.0	1.1
1000000.0	1100000.0

Enter Description
Set a minimum ReReg release as 110% 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 Tuesdays and but be adjusted on Sundays, if inflow has changed by at least 15%.

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

MinQ=92% CartersSysInflow

Operates Release From: Carters ReReg
Rule Name: nQ=92% CartersSysInflow
Description: Set a minimum ReReg release as 92% o
Function of: CartersSysInflow_AdjAvg, Current Value
Limit Type: Minimum
Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	0.0
1.0	0.92
1000000.0	920000.0

Enter Description
Set 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 Tuesdays and but be adjusted on Sundays, if inflow has changed by at least 15%.

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

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%.

IV. Alternative Operations

Twelve ResSim alternatives were developed to represent the Baseline operations and 11 Alternative operating plans.

A. Overview of Operation Sets

There were 2 operation sets used in the 12 alternatives for Carters and Carters ReReg. The alternatives and their operation sets for Carters and Carters ReReg are given in Table A.05. Table A.06 describes each operation set.

Table A.05 Alternatives and Operation Sets Used at Carters and Carters ReReg

Alternative	Operation Set
Baseline	Baseline
DroughtPln	Baseline
Burkett	Seasonal
DragoA	Seasonal
DragoB	Seasonal
RPlanA	Seasonal
RPlanB	Seasonal
RPlanC	Seasonal
RPlanD	Seasonal
RPlanE	Seasonal
RPlanF	Seasonal
RPlanG	Seasonal

Table A.06 Operation Sets Used at Carters and Carters ReReg

Operation Set	Description
Baseline	Current operation / no action
Seasonal	2 action zones with seasonal varying flow requirement from Carters ReReg Reservoir

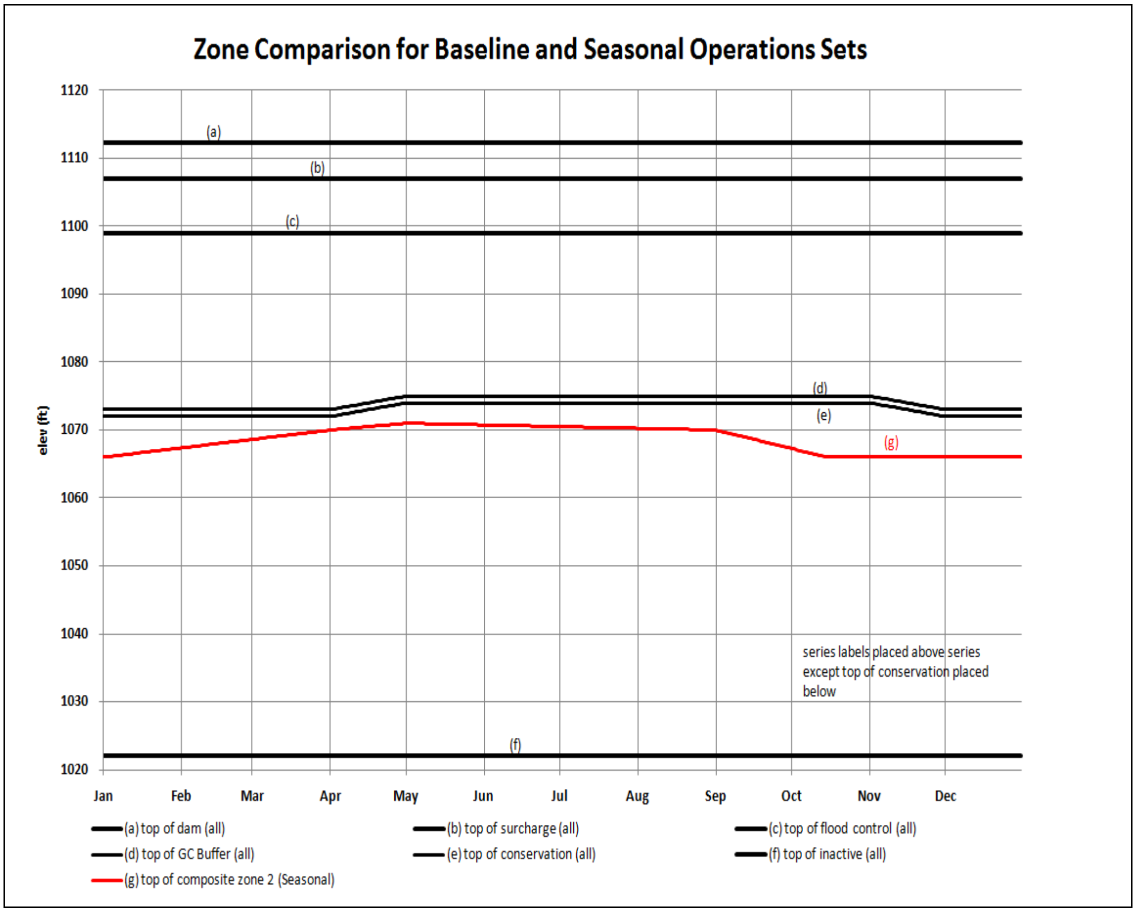
The “Baseline” operation set for Carters and Carters ReReg was used for the Baseline and DroughtPln alternatives. The “Seasonal” operation set for Carters and Carters ReReg was used for the remaining alternatives. The rule sets at Carters and Carters ReReg for the “Seasonal” operation sets are shown in Figure A.29 and Figure A.31. Explanations of the rules not found in the “Baseline” operation set are given following each figure. The screenshots for the additional rules at Carters are given in Figure A.30. The screenshots for the additional rules at Carters ReReg are given in Figure A.32 and Figure A.33.

B. “Seasonal” Operation Set -- Carters

At Carters, the “Seasonal” operation set had an additional sub-zone in the conservation pool titled CompositeZone2. The elevations for the “Baseline” zones did not change. The elevations for the zones used in the “Seasonal” operation set at Carters are shown in Table A.07. The zone comparison between the “Baseline” and “Seasonal” operation sets is shown in Figure A.28. An additional rule titled MinQ_Seas-TRC was added to Flood Control, GC Buffer, and Conservation at Carters. This rule sets the minimum release from Carters based on monthly minimum values of flow below Carters. Also at Carters in the “Seasonal” operation set, the rules in the zone titled CompositeZone2 are the same as those found in Conservation with one exception. The application of the MinQ_Seas-TRC rule is dependent on the composite storage value at Carters and Carters ReReg.

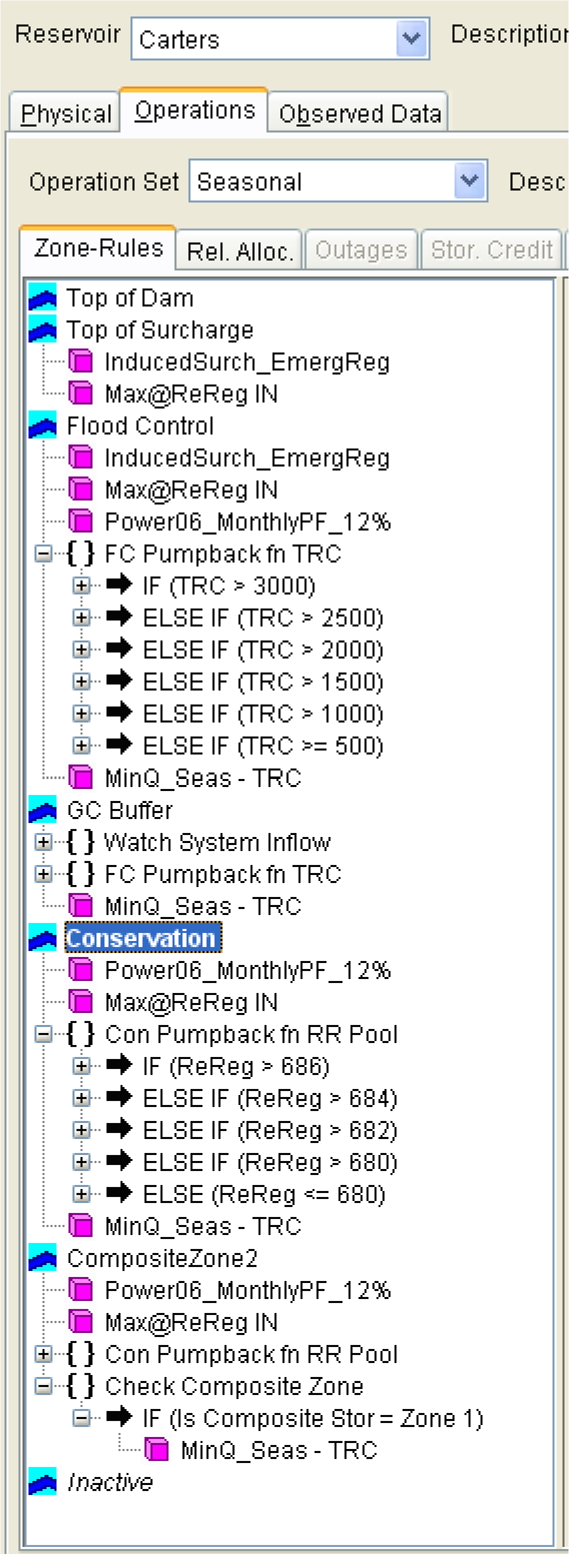
Table A.07 Zones and Elevations for Carters "Seasonal" Operation Set

Carters	**Seasonal** Top of **Zone Elevation** Values (feet)						
Seasons =	**1-Jan**	**1-Apr**	**1-May**	**01-Sep**	**15-Oct**	**1-Nov**	**1-Dec**
Zones:							
Top of Dam	1112.3	*1112.3*	*1112.3*	*1112.3*	*1112.3*	*1112.3*	*1112.3*
Top of Surcharge	1107	*1107*	*1107*	*1107*	*1107*	*1107*	*1107*
Flood Control	1099	*1099*	*1099*	*1099*	*1099*	*1099*	*1099*
GC Buffer	1073	1073	1075	1075	1075	1075	1073
Conservation	1072	1072	1074	1074	1074	1074	1072
CompositeZone2	1066	1070	1071	1070	1066	1066	1066
Inactive	1022	*1022*	*1022*	*1022*	*1022*	*1022*	*1022*



series labels placed above series except top of conservation placed below

Figure A.28 Zone Comparison for "Baseline" and "Seasonal" Operation Sets at Carters



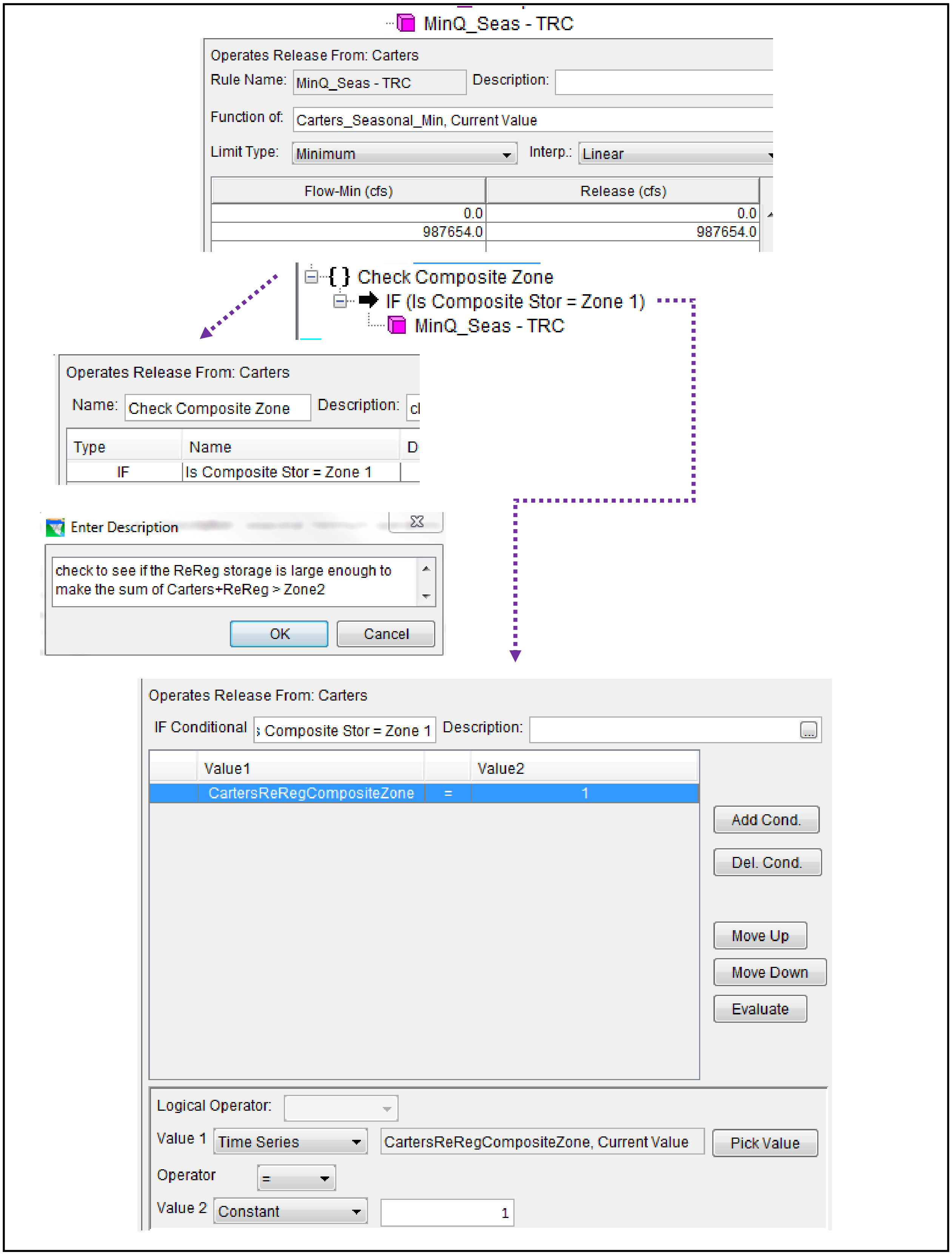
Reservoir Carters

Operation Set Seasonal

- Top of Dam
- Top of Surcharge
  - InducedSurch_EmergReg
  - Max@ReReg IN
- Flood Control
  - InducedSurch_EmergReg
  - Max@ReReg IN
  - Power06_MonthlyPF_12%
  - { } FC Pumpback fn TRC
    - IF (TRC > 3000)
    - ELSE IF (TRC > 2500)
    - ELSE IF (TRC > 2000)
    - ELSE IF (TRC > 1500)
    - ELSE IF (TRC > 1000)
    - ELSE IF (TRC >= 500)
  - MinQ_Seas - TRC
- GC Buffer
  - { } Watch System Inflow
  - { } FC Pumpback fn TRC
  - MinQ_Seas - TRC
- Conservation
  - Power06_MonthlyPF_12%
  - Max@ReReg IN
  - { } Con Pumpback fn RR Pool
    - IF (ReReg > 686)
    - ELSE IF (ReReg > 684)
    - ELSE IF (ReReg > 682)
    - ELSE IF (ReReg > 680)
    - ELSE (ReReg <= 680)
  - MinQ_Seas - TRC
- CompositeZone2
  - Power06_MonthlyPF_12%
  - Max@ReReg IN
  - { } Con Pumpback fn RR Pool
  - { } Check Composite Zone
    - IF (Is Composite Stor = Zone 1)
      - MinQ_Seas - TRC
- *Inactive*

Figure A.29 Rule Set for Carters "Seasonal" Operation Set

1. Rule Illustrations – Carters



MinQ_Seas - TRC

Operates Release From: Carters

Rule Name: MinQ_Seas - TRC
Description:

Function of: Carters_Seasonal_Min, Current Value

Limit Type: Minimum
Interp.: Linear

Flow-Min (cfs)	Release (cfs)
0.0	0.0
987654.0	987654.0

{ } Check Composite Zone
IF (Is Composite Stor = Zone 1)
MinQ_Seas - TRC

Operates Release From: Carters

Name: Check Composite Zone
Description: cl

Type	Name	D
IF	Is Composite Stor = Zone 1	

Enter Description

check to see if the ReReg storage is large enough to make the sum of Carters+ReReg > Zone2

Operates Release From: Carters

IF Conditional: ; Composite Stor = Zone 1
Description:

	Value1		Value2
	CartersReRegCompositeZone	=	1

Logical Operator:
Value 1: Time Series — CartersReRegCompositeZone, Current Value
Operator: =
Value 2: Constant — 1

Figure A.30 Additional Rules Used in "Seasonal" Operation Set at Carters

2. Rule Descriptions - Carters

a) MinQ_Seas – TRC

This rule (see Figure A.30) is applied at Carters in Flood Control, GC Buffer, and Conservation. It sets the minimum release from Carters using the current value of the state variable Carters_Seasonal_Min. The value of this state variable is set equal to the minimum release from Carters. The state variable is computed by subtracting the current value of the flow at Talking Rock and 240 cfs from a monthly constant. The monthly constants are shown in Table A.08.

Table A.08 Monthly Constant Used in Carters_Season_Min State Variable

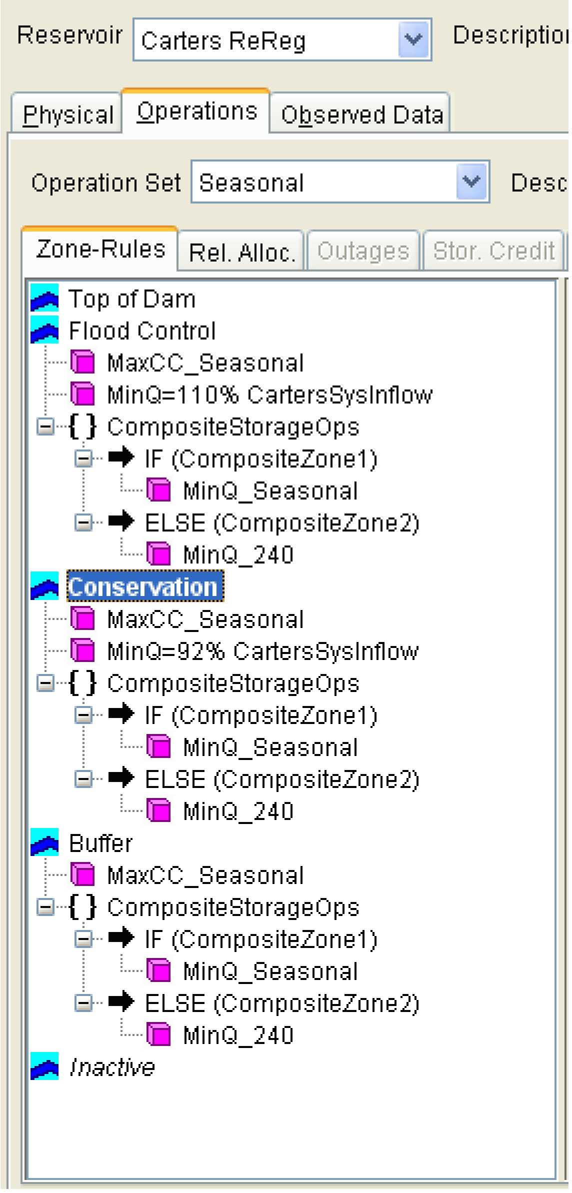
Month	Constant Used to Determine Minimum Flow from Carters
January	660
February	790
March	865
April	770
May	620
June	475
July	400
August	325
September	250
October	275
November	350
December	465

b) Check Composite Zone

This statement is used in CompositeZone2 at Carters to determine whether or not the MinQ_Seas – TRC rule described above will be used. The state variable CartersReRegCompositeZone is used. This state variable computes the composite storage at Carters and Carters ReReg. The composite storage value is then compared to the total storage at the top of CompositeZone2 at Carters. If the composite storage of Carters and Carters ReReg is greater than the total storage at the top of CompositeZone2, then the MinQ_Seas – TRC rule is used. If the composite storage is not greater, then the MinQ_Seas – TRC rule is not used.

C. “Seasonal” Operation Set – Carters ReReg

There was no change to the zones at Carters ReReg (i.e., zones are same as in the “Baseline” operation set). At Carters ReReg in the “Seasonal” operation set, the minimum release is determined by the composite storage value at Carters and Carters ReReg.



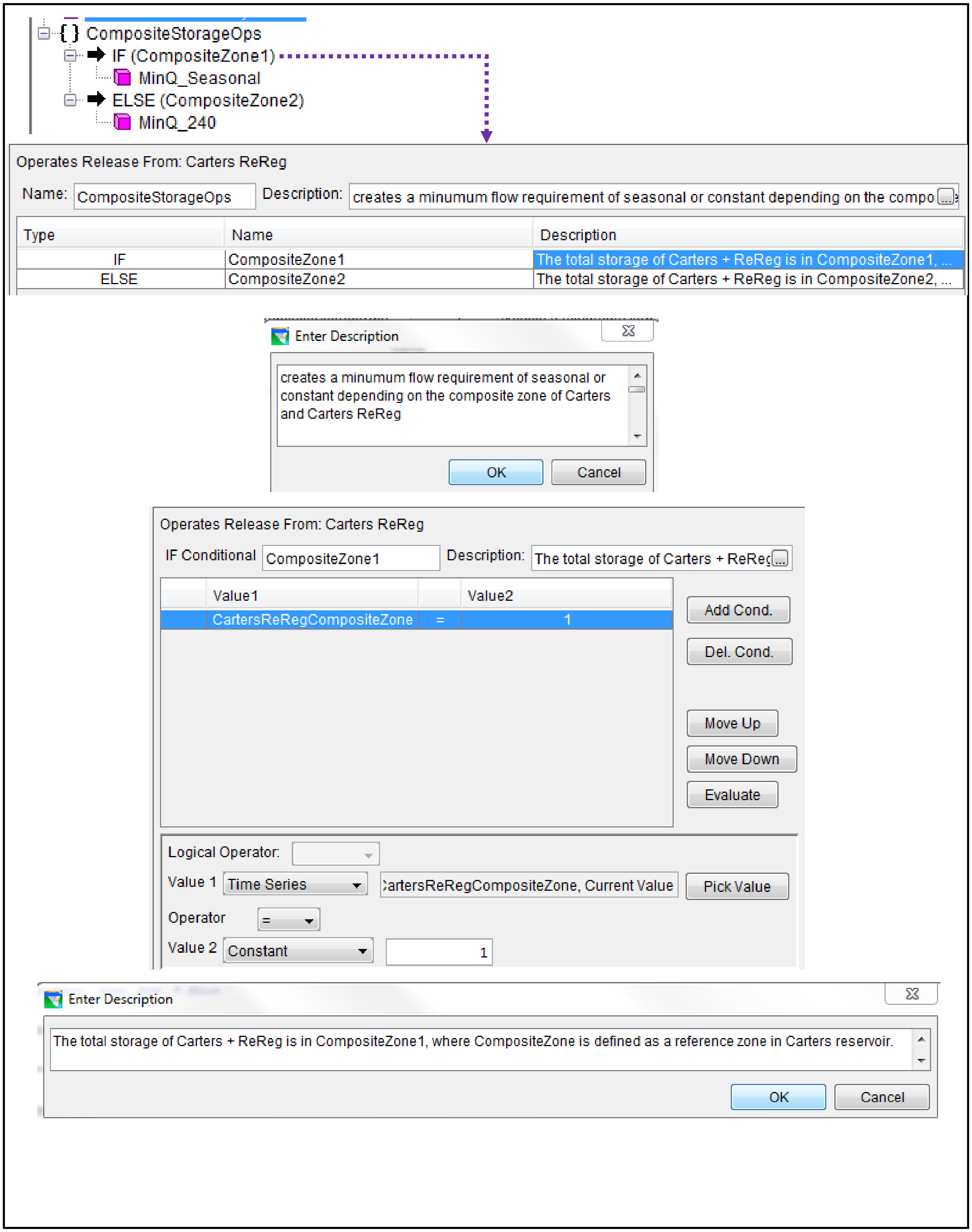
Reservoir: Carters ReReg

Operation Set: Seasonal

- Top of Dam
- Flood Control
  - MaxCC_Seasonal
  - MinQ=110% CartersSysInflow
  - { } CompositeStorageOps
    - ➡ IF (CompositeZone1)
      - MinQ_Seasonal
    - ➡ ELSE (CompositeZone2)
      - MinQ_240
- Conservation
  - MaxCC_Seasonal
  - MinQ=92% CartersSysInflow
  - { } CompositeStorageOps
    - ➡ IF (CompositeZone1)
      - MinQ_Seasonal
    - ➡ ELSE (CompositeZone2)
      - MinQ_240
- Buffer
  - MaxCC_Seasonal
  - { } CompositeStorageOps
    - ➡ IF (CompositeZone1)
      - MinQ_Seasonal
    - ➡ ELSE (CompositeZone2)
      - MinQ_240
- *Inactive*

**Figure A.31 Rule Set for Carters ReReg
“Seasonal” Operation Set**

1. Rule Illustrations – Carters ReReg



{ } CompositeStorageOps
IF (CompositeZone1)
MinQ_Seasonal
ELSE (CompositeZone2)
MinQ_240

Operates Release From: Carters ReReg

Name: CompositeStorageOps

Description: creates a minumum flow requirement of seasonal or constant depending on the compo

Type	Name	Description
IF	CompositeZone1	The total storage of Carters + ReReg is in CompositeZone1, ...
ELSE	CompositeZone2	The total storage of Carters + ReReg is in CompositeZone2, ...

Enter Description

creates a minumum flow requirement of seasonal or constant depending on the composite zone of Carters and Carters ReReg

Operates Release From: Carters ReReg

IF Conditional: CompositeZone1

Description: The total storage of Carters + ReReg

Value1		Value2
CartersReRegCompositeZone	=	1

Logical Operator:

Value 1: Time Series; :artersReRegCompositeZone, Current Value

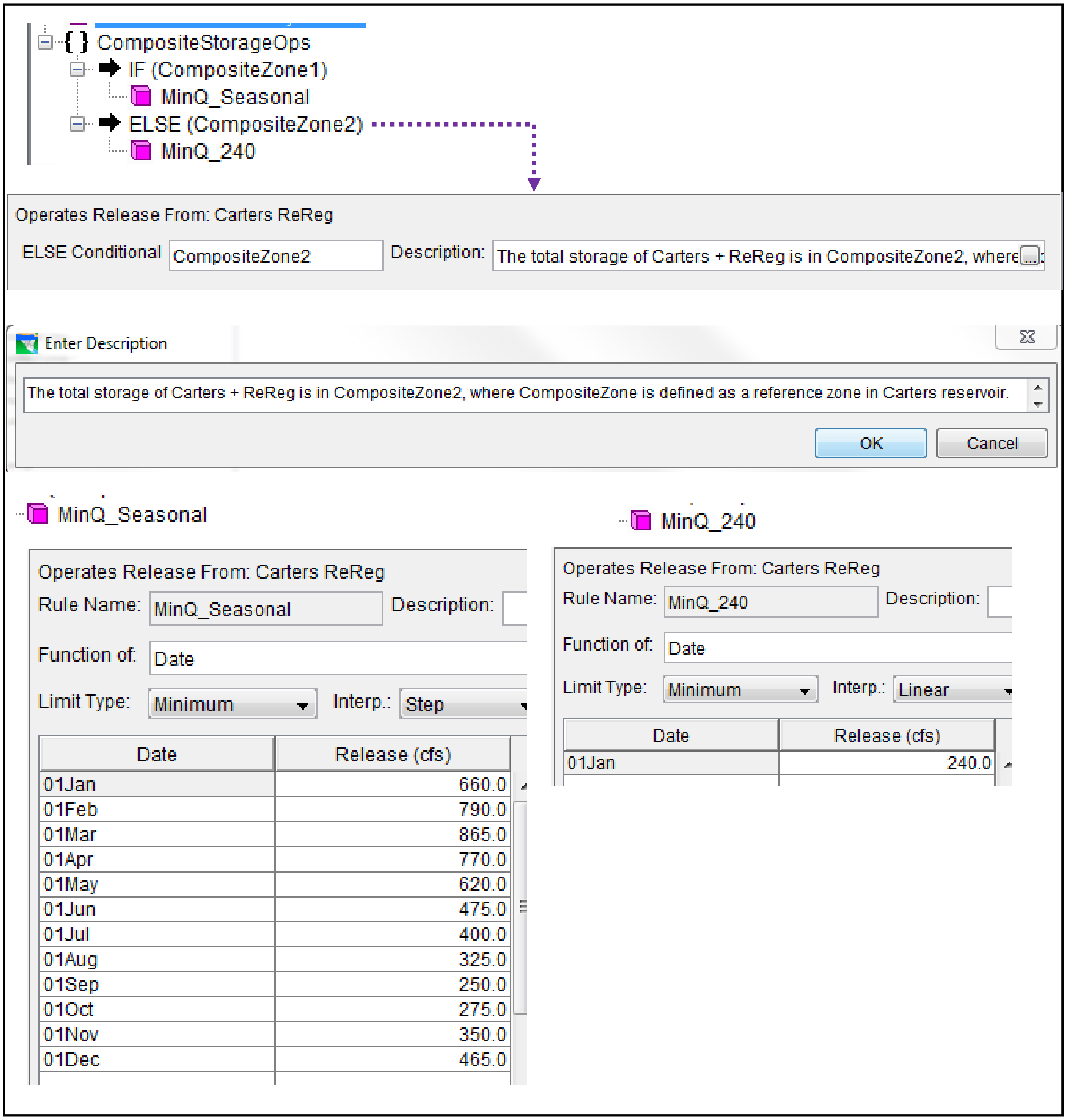
Operator: =

Value 2: Constant; 1

Enter Description

The total storage of Carters + ReReg is in CompositeZone1, where CompositeZone is defined as a reference zone in Carters reservoir.

Figure A.32 Additional Rules Used in "Seasonal" Operation Set at Carters ReReg *(Part 1 of 2)*



CompositeStorageOps
- IF (CompositeZone1)
  - MinQ_Seasonal
- ELSE (CompositeZone2)
  - MinQ_240

Operates Release From: Carters ReReg

ELSE Conditional: CompositeZone2

Description: The total storage of Carters + ReReg is in CompositeZone2, where

Enter Description

The total storage of Carters + ReReg is in CompositeZone2, where CompositeZone is defined as a reference zone in Carters reservoir.

MinQ_Seasonal

Operates Release From: Carters ReReg

Rule Name: MinQ_Seasonal

Description:

Function of: Date

Limit Type: Minimum

Interp.: Step

Date	Release (cfs)
01Jan	660.0
01Feb	790.0
01Mar	865.0
01Apr	770.0
01May	620.0
01Jun	475.0
01Jul	400.0
01Aug	325.0
01Sep	250.0
01Oct	275.0
01Nov	350.0
01Dec	465.0

MinQ_240

Operates Release From: Carters ReReg

Rule Name: MinQ_240

Description:

Function of: Date

Limit Type: Minimum

Interp.: Linear

Date	Release (cfs)
01Jan	240.0

Figure A.33 Additional Rules Used in "Seasonal" Operation Set at Carters ReReg *(Part 2 of 2)*

2. Rule Descriptions – Carters ReReg

a) CompositeStorageOps

This conditional statement (see Figure A.32) is used in Flood Control, Conservation, and Buffer zones at Carters ReReg. It uses the state variable, CartersReRegCompositeZone that was described previously for Carters. If the composite storage of Carters and Carters ReReg is greater than the total storage at the top of CompositeZone2 at Carters, then the MinQ_Seasonal rule sets the minimum release from Carters ReReg. If the composite storage is not greater, then the MinQ_240 rule (which sets the minimum release to 240 cfs, as shown in Figure A.33) is used for the minimum release.

b) MinQ_Seasonal

This rule (see Figure A.33) sets the minimum release between 250 cfs and 865 cfs depending on the time of year.

Alabama-Coosa-Tallapoosa (ACT) Watershed

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

Appendix B – Allatoona Reservoir

March 2011 (DRAFT)

Prepared for:
US Army Corps of Engineers
Mobile District
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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.

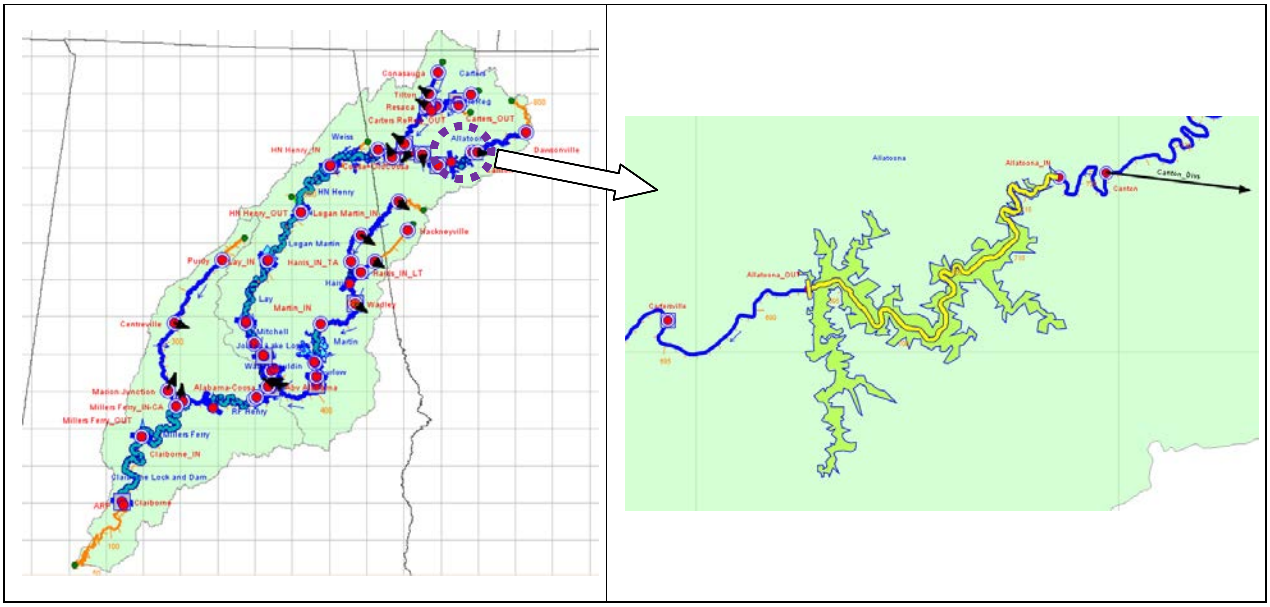


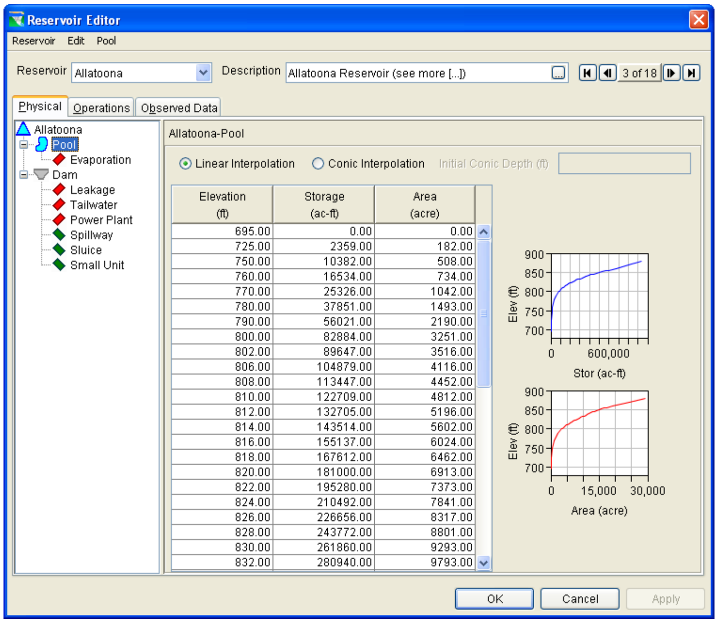
Figure B.01 HEC-ResSim Map Display Showing Location of Allatoona Reservoir

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.



Reservoir: Allatoona

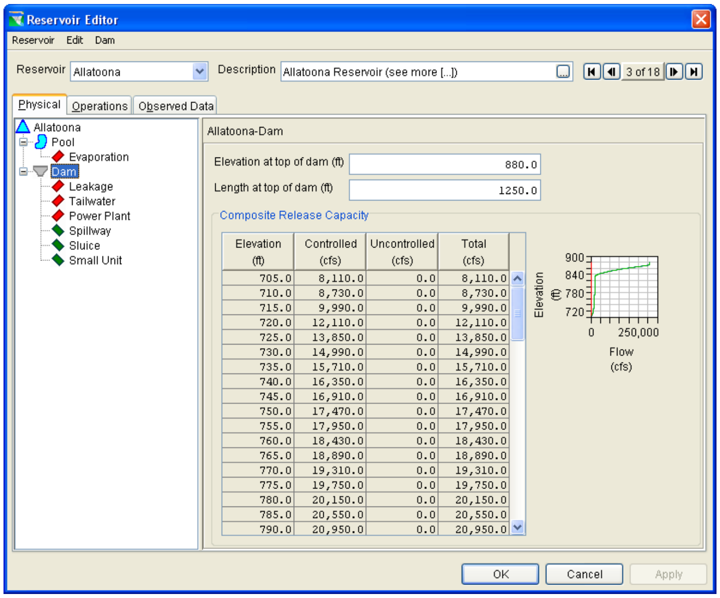
Description: Allatoona Reservoir (see more [...])

Allatoona-Pool

● Linear Interpolation ○ Conic Interpolation Initial Conic Depth (ft)

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



Reservoir: Allatoona

Description: Allatoona Reservoir (see more [...])

Allatoona-Dam

Elevation at top of dam (ft): 880.0

Length at top of dam (ft): 1250.0

Composite Release Capacity

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

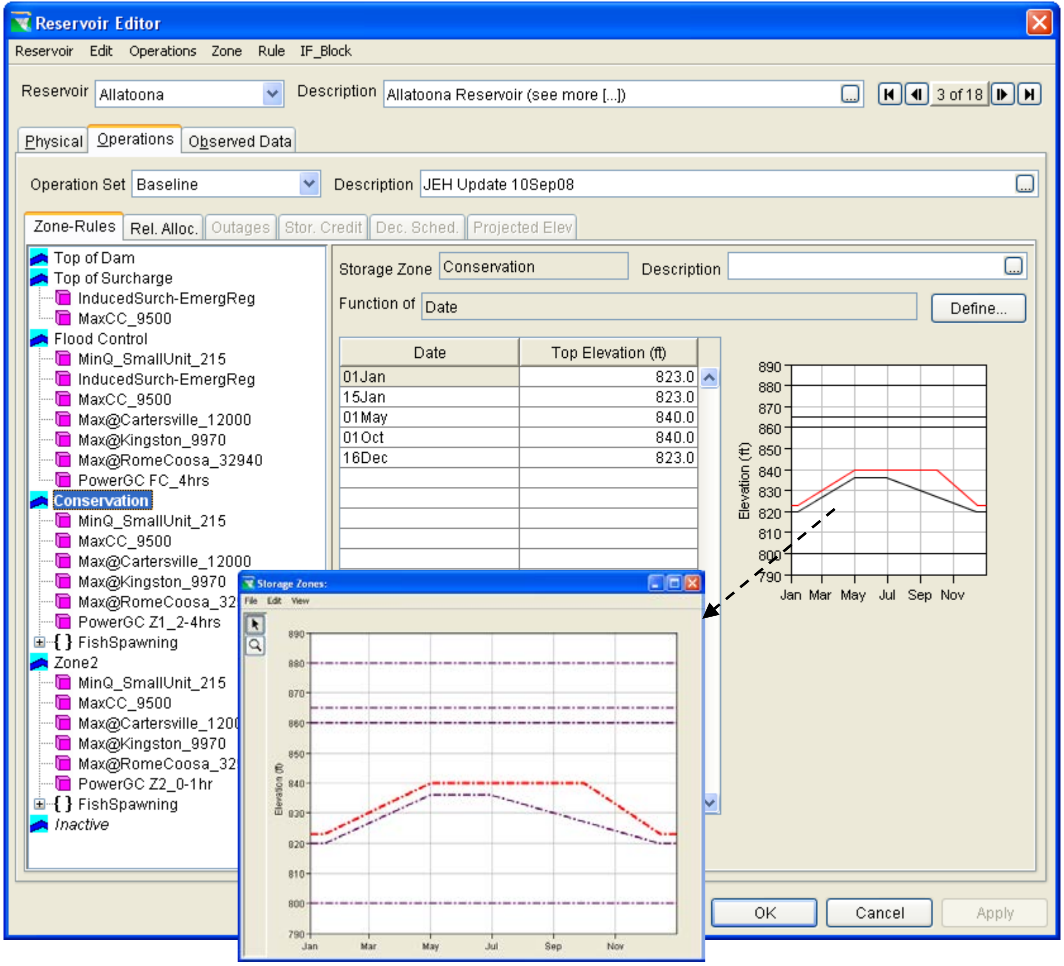
Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table B.01 shows the definition of Allatoona's "Baseline" operational zones, which consist of zones of flood control and conservation.

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)



Reservoir: Allatoona
Description: Allatoona Reservoir (see more [...])
3 of 18

Operation Set: Baseline
Description: JEH Update 10Sep08

- Top of Dam
- Top of Surcharge
  - InducedSurch-EmergReg
  - MaxCC_9500
- Flood Control
  - MinQ_SmallUnit_215
  - InducedSurch-EmergReg
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC FC_4hrs
- Conservation
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32
  - PowerGC Z1_2-4hrs
  - { } FishSpawning
- Zone2
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_120
  - Max@Kingston_9970
  - Max@RomeCoosa_32
  - PowerGC Z2_0-1hr
  - { } FishSpawning
- *Inactive*

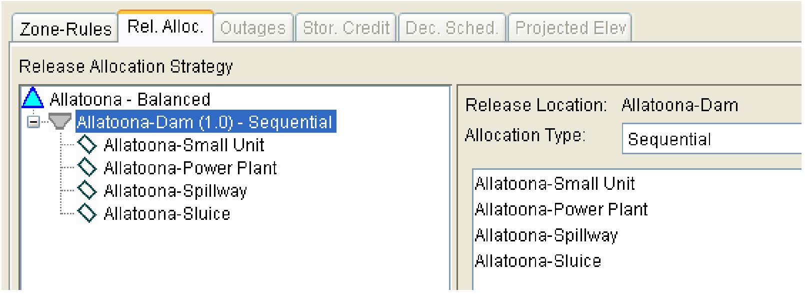
Storage Zone: Conservation
Description:
Function of: Date

Date	Top Elevation (ft)
01Jan	823.0
15Jan	823.0
01May	840.0
01Oct	840.0
16Dec	823.0

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:



Release Allocation Strategy

- Allatoona - Balanced
  - Allatoona-Dam (1.0) - Sequential
    - Allatoona-Small Unit
    - Allatoona-Power Plant
    - Allatoona-Spillway
    - Allatoona-Sluice

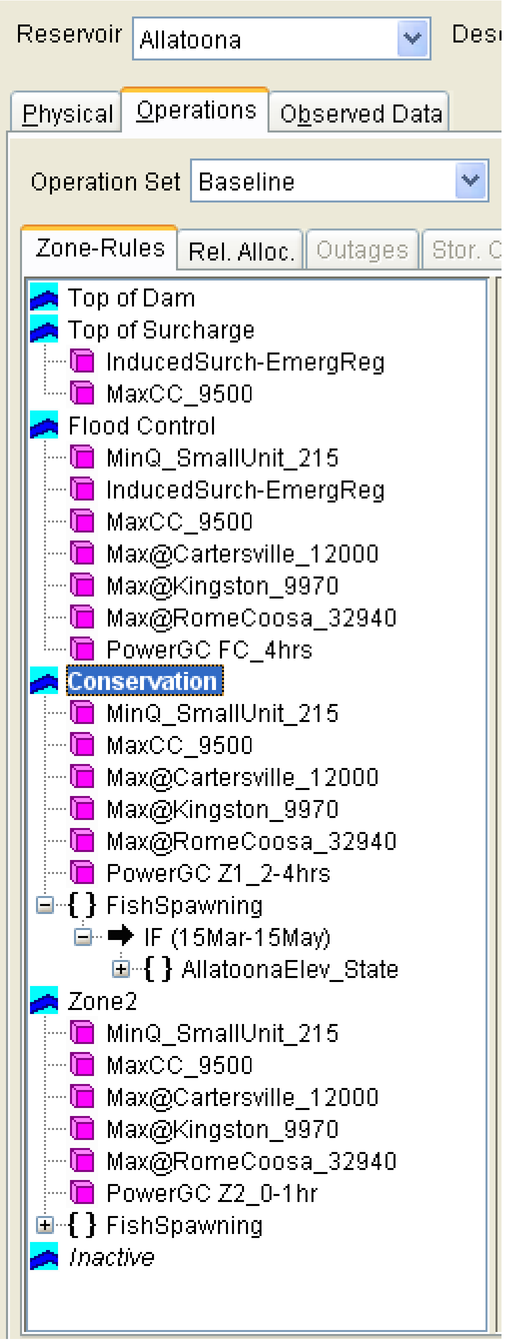
Release Location: Allatoona-Dam
Allocation Type: Sequential

Allatoona-Small Unit
Allatoona-Power Plant
Allatoona-Spillway
Allatoona-Sluice

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”.



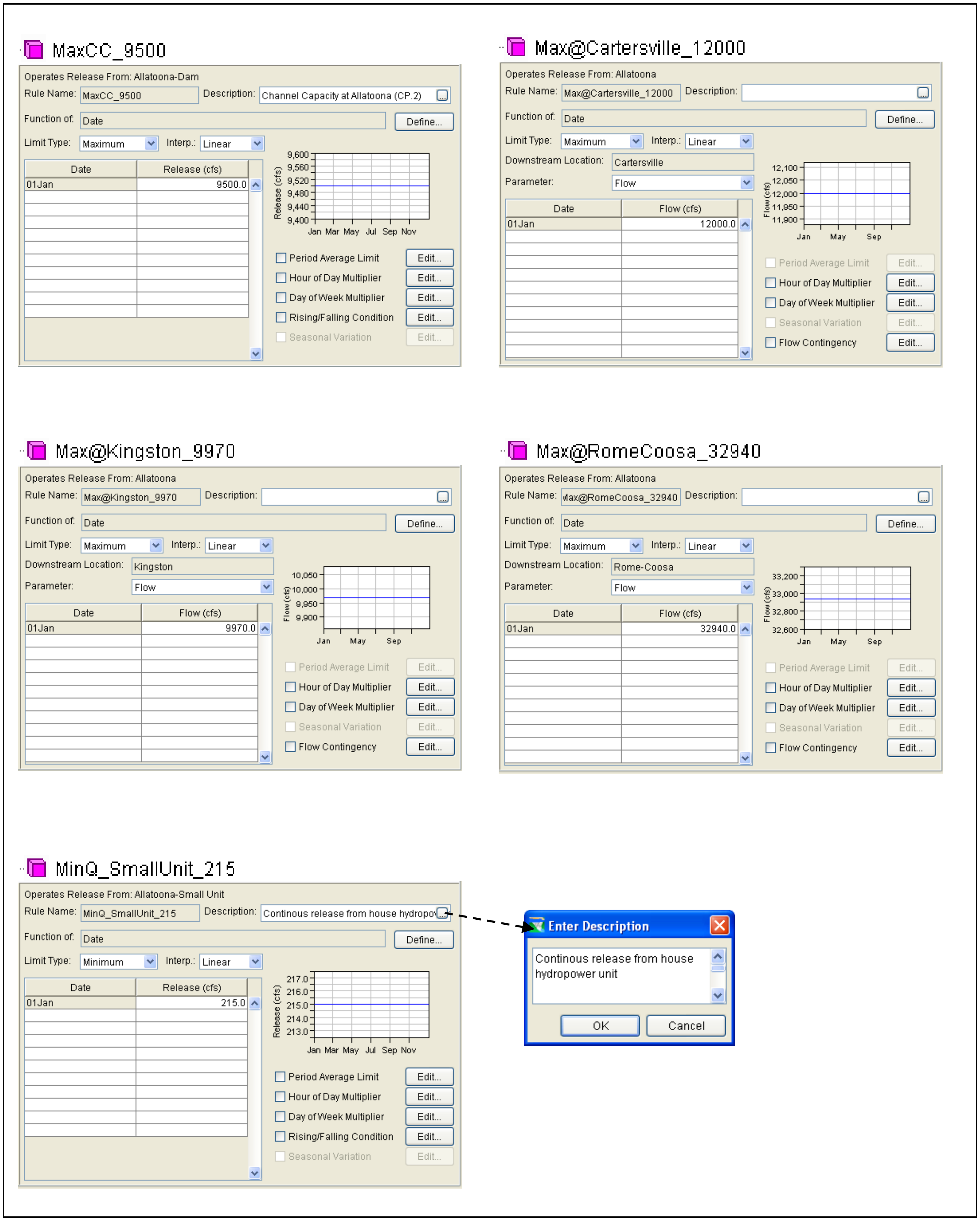
Reservoir: Allatoona

Operation Set: Baseline

- Top of Dam
- Top of Surcharge
  - InducedSurch-EmergReg
  - MaxCC_9500
- Flood Control
  - MinQ_SmallUnit_215
  - InducedSurch-EmergReg
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC FC_4hrs
- Conservation
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC Z1_2-4hrs
  - { } FishSpawning
    - IF (15Mar-15May)
      - { } AllatoonaElev_State
- Zone2
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC Z2_0-1hr
  - { } FishSpawning
- *Inactive*

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.



MaxCC_9500

Operates Release From: Allatoona-Dam

Rule Name: MaxCC_9500

Description: Channel Capacity at Allatoona (CP.2)

Function of: Date

Limit Type: Maximum

Interp.: Linear

Date	Release (cfs)
01Jan	9500.0

☐ Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☐ Rising/Falling Condition

☐ Seasonal Variation

Max@Cartersville_12000

Operates Release From: Allatoona

Rule Name: Max@Cartersville_12000

Description:

Function of: Date

Limit Type: Maximum

Interp.: Linear

Downstream Location: Cartersville

Parameter: Flow

Date	Flow (cfs)
01Jan	12000.0

☐ Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☐ Seasonal Variation

☐ Flow Contingency

Max@Kingston_9970

Operates Release From: Allatoona

Rule Name: Max@Kingston_9970

Description:

Function of: Date

Limit Type: Maximum

Interp.: Linear

Downstream Location: Kingston

Parameter: Flow

Date	Flow (cfs)
01Jan	9970.0

☐ Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☐ Seasonal Variation

☐ Flow Contingency

Max@RomeCoosa_32940

Operates Release From: Allatoona

Rule Name: Max@RomeCoosa_32940

Description:

Function of: Date

Limit Type: Maximum

Interp.: Linear

Downstream Location: Rome-Coosa

Parameter: Flow

Date	Flow (cfs)
01Jan	32940.0

☐ Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☐ Seasonal Variation

☐ Flow Contingency

MinQ_SmallUnit_215

Operates Release From: Allatoona-Small Unit

Rule Name: MinQ_SmallUnit_215

Description: Continous release from house hydropo

Function of: Date

Limit Type: Minimum

Interp.: Linear

Date	Release (cfs)
01Jan	215.0

☐ Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

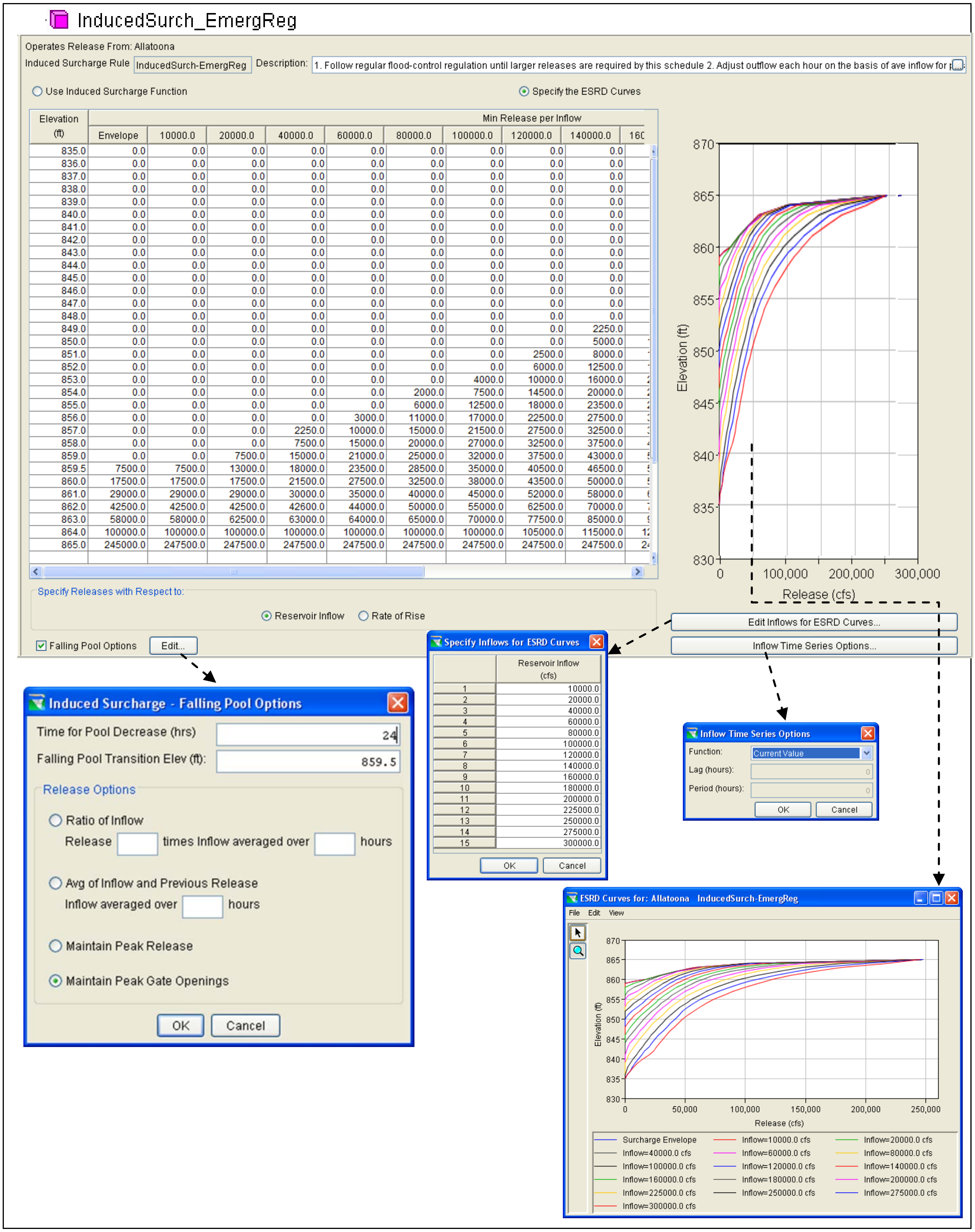
☐ Rising/Falling Condition

☐ Seasonal Variation

Enter Description

Continous release from house hydropower unit

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



InducedSurch_EmergReg

Operates Release From: Allatoona

Induced Surcharge Rule: InducedSurch-EmergReg

Description: 1. Follow regular flood-control regulation until larger releases are required by this schedule 2. Adjust outflow each hour on the basis of ave inflow for p

○ Use Induced Surcharge Function ● Specify the ESRD Curves

Elevation (ft)	Min Release per Inflow								
	Envelope	10000.0	20000.0	40000.0	60000.0	80000.0	100000.0	120000.0	140000.0
835.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
836.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
837.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
838.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
839.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
840.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
841.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
842.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
843.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
844.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
845.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
846.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
847.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
848.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
849.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2250.0
850.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5000.0
851.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2500.0	8000.0
852.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6000.0	12500.0
853.0	0.0	0.0	0.0	0.0	0.0	0.0	4000.0	10000.0	16000.0
854.0	0.0	0.0	0.0	0.0	0.0	2000.0	7500.0	14500.0	20000.0
855.0	0.0	0.0	0.0	0.0	0.0	6000.0	12500.0	18000.0	23500.0
856.0	0.0	0.0	0.0	0.0	3000.0	11000.0	17000.0	22500.0	27500.0
857.0	0.0	0.0	0.0	2250.0	10000.0	15000.0	21500.0	27500.0	32500.0
858.0	0.0	0.0	0.0	7500.0	15000.0	20000.0	27000.0	32500.0	37500.0
859.0	0.0	0.0	7500.0	15000.0	21000.0	25000.0	32000.0	37500.0	43000.0
859.5	7500.0	7500.0	13000.0	18000.0	23500.0	28500.0	35000.0	40500.0	46500.0
860.0	17500.0	17500.0	17500.0	21500.0	27500.0	32500.0	38000.0	43500.0	50000.0
861.0	29000.0	29000.0	29000.0	30000.0	35000.0	40000.0	45000.0	52000.0	58000.0
862.0	42500.0	42500.0	42500.0	42600.0	44000.0	50000.0	55000.0	62500.0	70000.0
863.0	58000.0	58000.0	62500.0	63000.0	64000.0	65000.0	70000.0	77500.0	85000.0
864.0	100000.0	100000.0	100000.0	100000.0	100000.0	100000.0	100000.0	105000.0	115000.0
865.0	245000.0	247500.0	247500.0	247500.0	247500.0	247500.0	247500.0	247500.0	247500.0

Specify Releases with Respect to: ● Reservoir Inflow ○ Rate of Rise

☑ Falling Pool Options

Induced Surcharge - Falling Pool Options

Time for Pool Decrease (hrs): 24

Falling Pool Transition Elev (ft): 859.5

Release Options

○ Ratio of Inflow
Release ___ times Inflow averaged over ___ hours

○ Avg of Inflow and Previous Release
Inflow averaged over ___ hours

○ Maintain Peak Release

● Maintain Peak Gate Openings

Specify Inflows for ESRD Curves

	Reservoir Inflow (cfs)
1	10000.0
2	20000.0
3	40000.0
4	60000.0
5	80000.0
6	100000.0
7	120000.0
8	140000.0
9	160000.0
10	180000.0
11	200000.0
12	225000.0
13	250000.0
14	275000.0
15	300000.0

Inflow Time Series Options

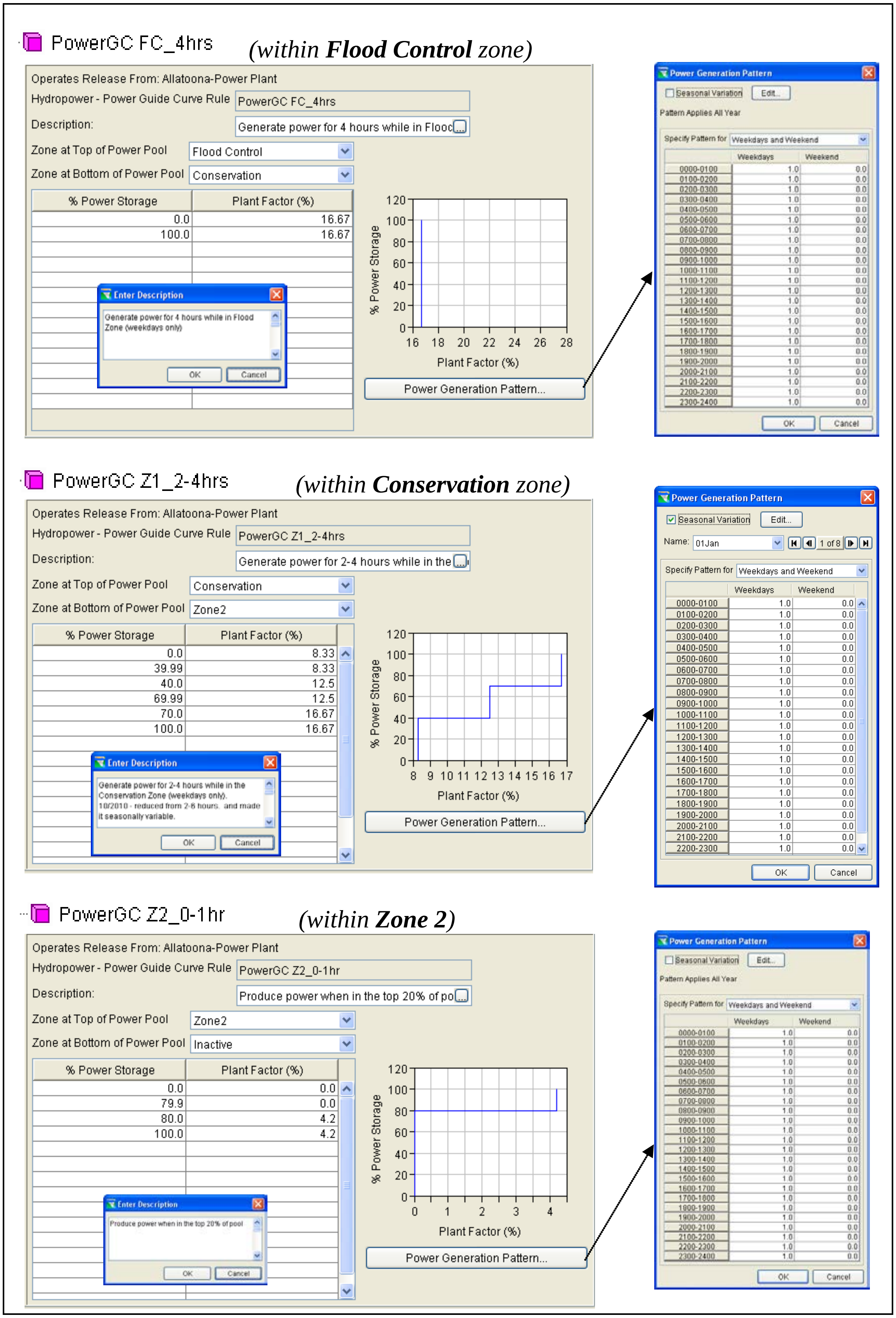
Function: Current Value

Lag (hours): 0

Period (hours): 0

ESRD Curves for: Allatoona InducedSurch-EmergReg

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



Operates Release From: Allatoona-Power Plant
Hydropower - Power Guide Curve Rule: PowerGC FC_4hrs
Description: Generate power for 4 hours while in Flooc
Zone at Top of Power Pool: Flood Control
Zone at Bottom of Power Pool: Conservation

% Power Storage	Plant Factor (%)
0.0	16.67
100.0	16.67

Enter Description
Generate power for 4 hours while in Flood Zone (weekdays only)

Power Generation Pattern
☐ Seasonal Variation
Pattern Applies All Year
Specify Pattern for: Weekdays and Weekend

	Weekdays	Weekend
0000-0100	1.0	0.0
0100-0200	1.0	0.0
0200-0300	1.0	0.0
0300-0400	1.0	0.0
0400-0500	1.0	0.0
0500-0600	1.0	0.0
0600-0700	1.0	0.0
0700-0800	1.0	0.0
0800-0900	1.0	0.0
0900-1000	1.0	0.0
1000-1100	1.0	0.0
1100-1200	1.0	0.0
1200-1300	1.0	0.0
1300-1400	1.0	0.0
1400-1500	1.0	0.0
1500-1600	1.0	0.0
1600-1700	1.0	0.0
1700-1800	1.0	0.0
1800-1900	1.0	0.0
1900-2000	1.0	0.0
2000-2100	1.0	0.0
2100-2200	1.0	0.0
2200-2300	1.0	0.0
2300-2400	1.0	0.0

Operates Release From: Allatoona-Power Plant
Hydropower - Power Guide Curve Rule: PowerGC Z1_2-4hrs
Description: Generate power for 2-4 hours while in the
Zone at Top of Power Pool: Conservation
Zone at Bottom of Power Pool: Zone2

% Power Storage	Plant Factor (%)
0.0	8.33
39.99	8.33
40.0	12.5
69.99	12.5
70.0	16.67
100.0	16.67

Enter Description
Generate power for 2-4 hours while in the Conservation Zone (weekdays only).
10/2010 - reduced from 2-6 hours. and made it seasonally variable.

Power Generation Pattern
☑ Seasonal Variation
Name: 01Jan (1 of 8)
Specify Pattern for: Weekdays and Weekend

	Weekdays	Weekend
0000-0100	1.0	0.0
0100-0200	1.0	0.0
0200-0300	1.0	0.0
0300-0400	1.0	0.0
0400-0500	1.0	0.0
0500-0600	1.0	0.0
0600-0700	1.0	0.0
0700-0800	1.0	0.0
0800-0900	1.0	0.0
0900-1000	1.0	0.0
1000-1100	1.0	0.0
1100-1200	1.0	0.0
1200-1300	1.0	0.0
1300-1400	1.0	0.0
1400-1500	1.0	0.0
1500-1600	1.0	0.0
1600-1700	1.0	0.0
1700-1800	1.0	0.0
1800-1900	1.0	0.0
1900-2000	1.0	0.0
2000-2100	1.0	0.0
2100-2200	1.0	0.0
2200-2300	1.0	0.0

Operates Release From: Allatoona-Power Plant
Hydropower - Power Guide Curve Rule: PowerGC Z2_0-1hr
Description: Produce power when in the top 20% of po
Zone at Top of Power Pool: Zone2
Zone at Bottom of Power Pool: Inactive

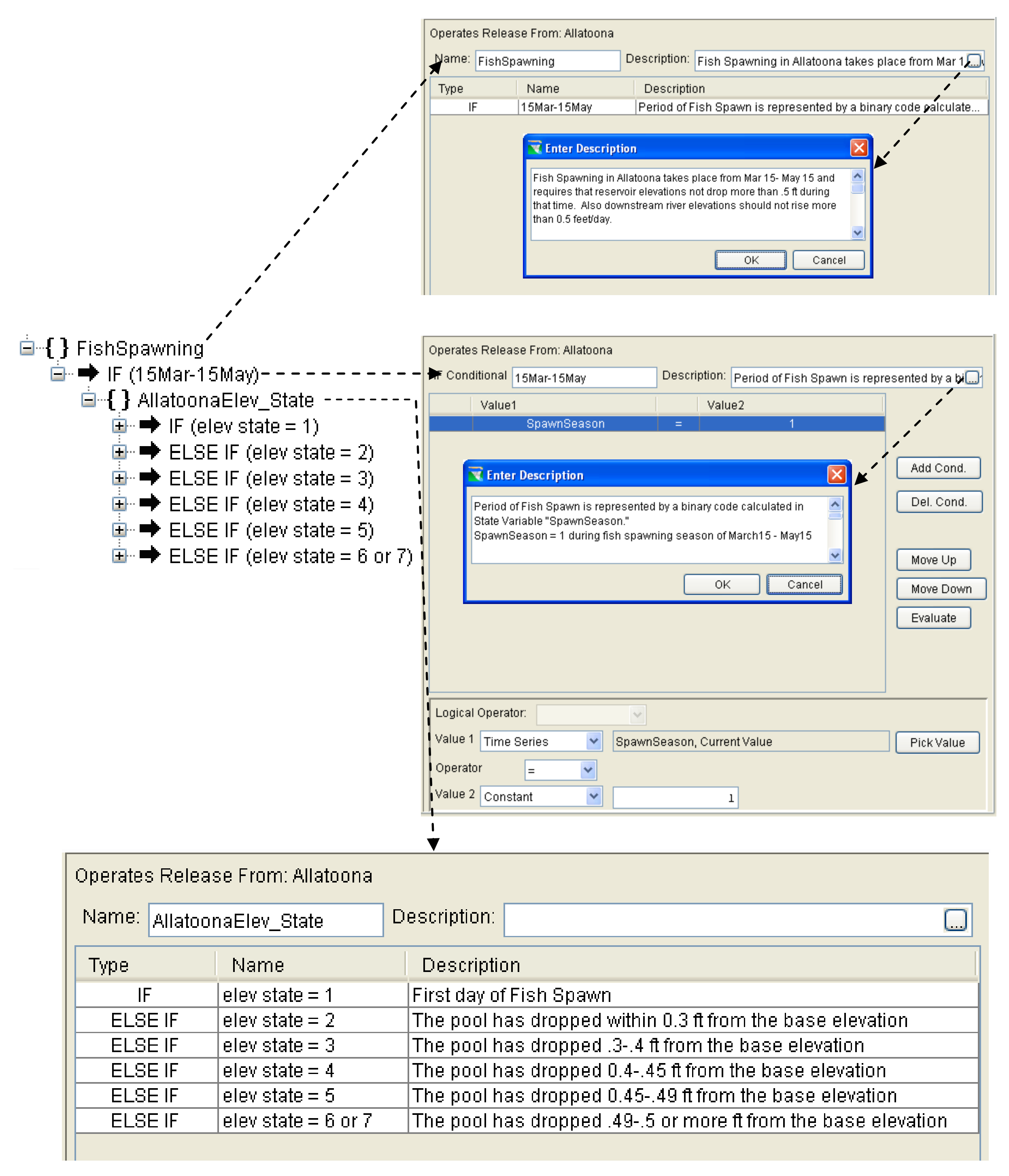
% Power Storage	Plant Factor (%)
0.0	0.0
79.9	0.0
80.0	4.2
100.0	4.2

Enter Description
Produce power when in the top 20% of pool

Power Generation Pattern
☐ Seasonal Variation
Pattern Applies All Year
Specify Pattern for: Weekdays and Weekend

	Weekdays	Weekend
0000-0100	1.0	0.0
0100-0200	1.0	0.0
0200-0300	1.0	0.0
0300-0400	1.0	0.0
0400-0500	1.0	0.0
0500-0600	1.0	0.0
0600-0700	1.0	0.0
0700-0800	1.0	0.0
0800-0900	1.0	0.0
0900-1000	1.0	0.0
1000-1100	1.0	0.0
1100-1200	1.0	0.0
1200-1300	1.0	0.0
1300-1400	1.0	0.0
1400-1500	1.0	0.0
1500-1600	1.0	0.0
1600-1700	1.0	0.0
1700-1800	1.0	0.0
1800-1900	1.0	0.0
1900-2000	1.0	0.0
2000-2100	1.0	0.0
2100-2200	1.0	0.0
2200-2300	1.0	0.0
2300-2400	1.0	0.0

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



{ } FishSpawning
- IF (15Mar-15May)
  - { } AllatoonaElev_State
    - IF (elev state = 1)
    - ELSE IF (elev state = 2)
    - ELSE IF (elev state = 3)
    - ELSE IF (elev state = 4)
    - ELSE IF (elev state = 5)
    - ELSE IF (elev state = 6 or 7)

Operates Release From: Allatoona

Name: FishSpawning
Description: Fish Spawning in Allatoona takes place from Mar 1

Type	Name	Description
IF	15Mar-15May	Period of Fish Spawn is represented by a binary code calculate...

Enter Description

Fish Spawning in Allatoona takes place from Mar 15- May 15 and requires that reservoir elevations not drop more than .5 ft during that time. Also downstream river elevations should not rise more than 0.5 feet/day.

Operates Release From: Allatoona

IF Conditional: 15Mar-15May
Description: Period of Fish Spawn is represented by a bi

	Value1		Value2
	SpawnSeason	=	1

Enter Description

Period of Fish Spawn is represented by a binary code calculated in State Variable "SpawnSeason."
SpawnSeason = 1 during fish spawning season of March15 - May15

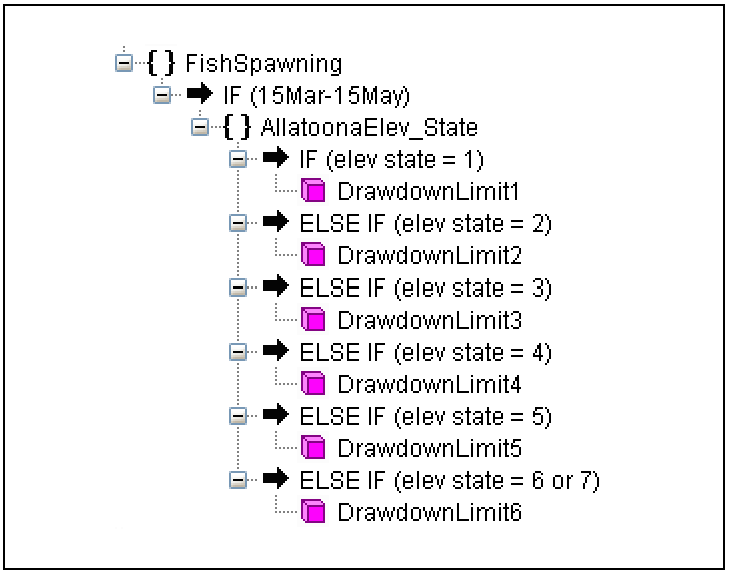
Logical Operator:
Value 1: Time Series — SpawnSeason, Current Value
Operator: =
Value 2: Constant — 1

Operates Release From: Allatoona

Name: AllatoonaElev_State
Description:

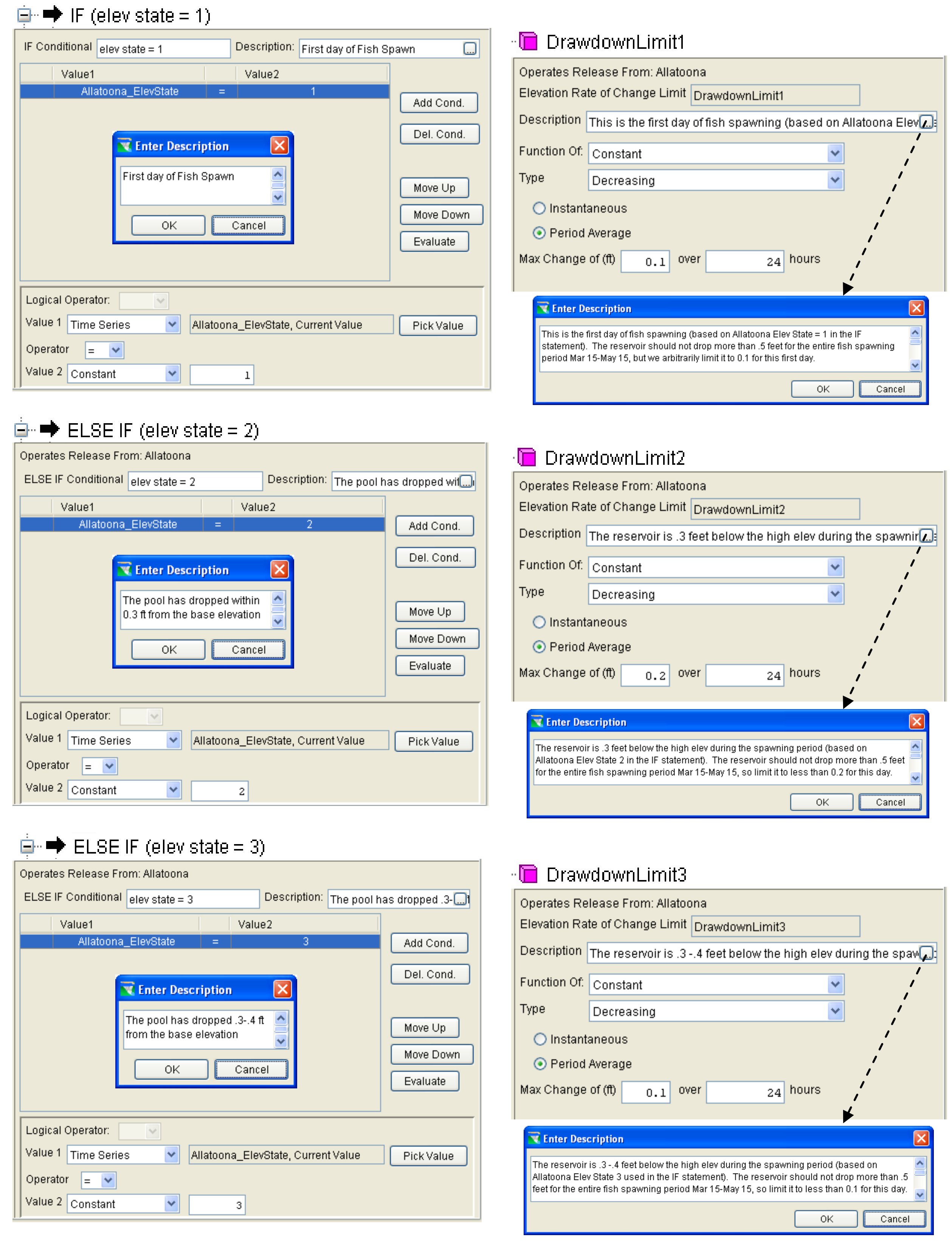
Type	Name	Description
IF	elev state = 1	First day of Fish Spawn
ELSE IF	elev state = 2	The pool has dropped within 0.3 ft from the base elevation
ELSE IF	elev state = 3	The pool has dropped .3-.4 ft from the base elevation
ELSE IF	elev state = 4	The pool has dropped 0.4-.45 ft from the base elevation
ELSE IF	elev state = 5	The pool has dropped 0.45-.49 ft from the base elevation
ELSE IF	elev state = 6 or 7	The pool has dropped .49-.5 or more ft from the base elevation

Figure B.11 Fish Spawning – "Conditional Blocks"



- { } FishSpawning
  - IF (15Mar-15May)
    - { } AllatoonaElev_State
      - IF (elev state = 1)
        - DrawdownLimit1
      - ELSE IF (elev state = 2)
        - DrawdownLimit2
      - ELSE IF (elev state = 3)
        - DrawdownLimit3
      - ELSE IF (elev state = 4)
        - DrawdownLimit4
      - ELSE IF (elev state = 5)
        - DrawdownLimit5
      - ELSE IF (elev state = 6 or 7)
        - DrawdownLimit6

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



IF (elev state = 1)

IF Conditional: elev state = 1

Description: First day of Fish Spawn

Value1		Value2
Allatoona_ElevState	=	1

Enter Description: First day of Fish Spawn

Logical Operator:

Value 1: Time Series — Allatoona_ElevState, Current Value

Operator: =

Value 2: Constant — 1

DrawdownLimit1

Operates Release From: Allatoona

Elevation Rate of Change Limit: DrawdownLimit1

Description: This is the first day of fish spawning (based on Allatoona Elev

Function Of: Constant

Type: Decreasing

○ Instantaneous

● Period Average

Max Change of (ft) 0.1 over 24 hours

Enter Description: 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.

ELSE IF (elev state = 2)

Operates Release From: Allatoona

ELSE IF Conditional: elev state = 2

Description: The pool has dropped wi

Value1		Value2
Allatoona_ElevState	=	2

Enter Description: The pool has dropped within 0.3 ft from the base elevation

Logical Operator:

Value 1: Time Series — Allatoona_ElevState, Current Value

Operator: =

Value 2: Constant — 2

DrawdownLimit2

Operates Release From: Allatoona

Elevation Rate of Change Limit: DrawdownLimit2

Description: The reservoir is .3 feet below the high elev during the spawnir

Function Of: Constant

Type: Decreasing

○ Instantaneous

● Period Average

Max Change of (ft) 0.2 over 24 hours

Enter Description: 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.

ELSE IF (elev state = 3)

Operates Release From: Allatoona

ELSE IF Conditional: elev state = 3

Description: The pool has dropped .3-

Value1		Value2
Allatoona_ElevState	=	3

Enter Description: The pool has dropped .3-.4 ft from the base elevation

Logical Operator:

Value 1: Time Series — Allatoona_ElevState, Current Value

Operator: =

Value 2: Constant — 3

DrawdownLimit3

Operates Release From: Allatoona

Elevation Rate of Change Limit: DrawdownLimit3

Description: The reservoir is .3 -.4 feet below the high elev during the spaw

Function Of: Constant

Type: Decreasing

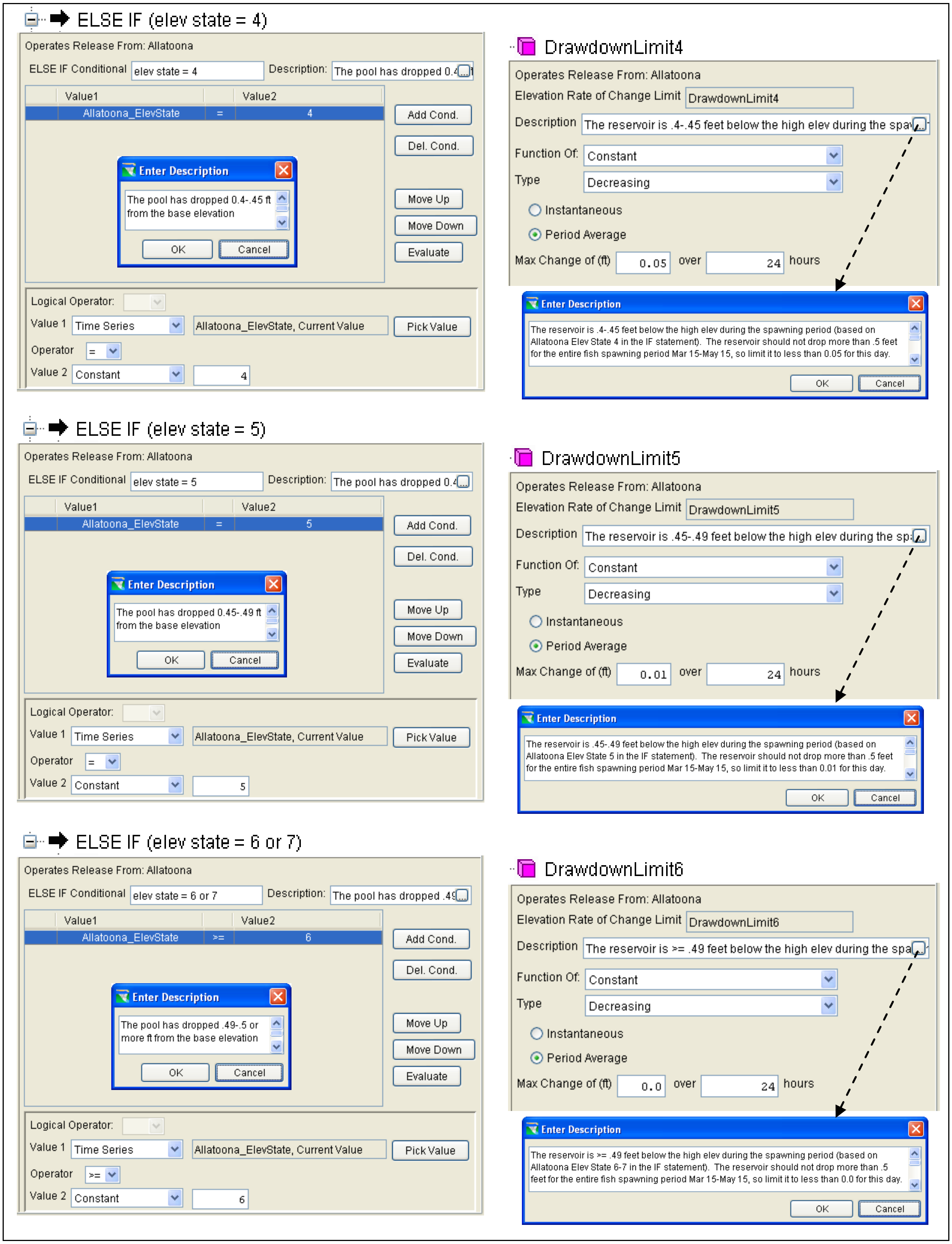
○ Instantaneous

● Period Average

Max Change of (ft) 0.1 over 24 hours

Enter Description: 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.

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



ELSE IF (elev state = 4)

Operates Release From: Allatoona
ELSE IF Conditional: elev state = 4
Description: The pool has dropped 0.4
Allatoona_ElevState = 4

Enter Description
The pool has dropped 0.4-.45 ft from the base elevation

Logical Operator:
Value 1: Time Series — Allatoona_ElevState, Current Value
Operator: =
Value 2: Constant — 4

DrawdownLimit4

Operates Release From: Allatoona
Elevation Rate of Change Limit: DrawdownLimit4
Description: The reservoir is .4-.45 feet below the high elev during the spa
Function Of: Constant
Type: Decreasing
○ Instantaneous
● Period Average
Max Change of (ft) 0.05 over 24 hours

Enter Description
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.

ELSE IF (elev state = 5)

Operates Release From: Allatoona
ELSE IF Conditional: elev state = 5
Description: The pool has dropped 0.4
Allatoona_ElevState = 5

Enter Description
The pool has dropped 0.45-.49 ft from the base elevation

Logical Operator:
Value 1: Time Series — Allatoona_ElevState, Current Value
Operator: =
Value 2: Constant — 5

DrawdownLimit5

Operates Release From: Allatoona
Elevation Rate of Change Limit: DrawdownLimit5
Description: The reservoir is .45-.49 feet below the high elev during the sp
Function Of: Constant
Type: Decreasing
○ Instantaneous
● Period Average
Max Change of (ft) 0.01 over 24 hours

Enter Description
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.

ELSE IF (elev state = 6 or 7)

Operates Release From: Allatoona
ELSE IF Conditional: elev state = 6 or 7
Description: The pool has dropped .49
Allatoona_ElevState >= 6

Enter Description
The pool has dropped .49-.5 or more ft from the base elevation

Logical Operator:
Value 1: Time Series — Allatoona_ElevState, Current Value
Operator: >=
Value 2: Constant — 6

DrawdownLimit6

Operates Release From: Allatoona
Elevation Rate of Change Limit: DrawdownLimit6
Description: The reservoir is >= .49 feet below the high elev during the spa
Function Of: Constant
Type: Decreasing
○ Instantaneous
● Period Average
Max Change of (ft) 0.0 over 24 hours

Enter Description
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.

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** (24 hours for Allatoona) 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.

IV. Alternative Operations

Twelve ResSim alternatives were developed to represent the Baseline operations and 11 Alternative operating plans.

A. Operation Sets

For the 12 ResSim alternatives, Allatoona Reservoir used seven different operation sets. The operation sets used with each alternative are given in Table B.02. Table B.03 describes each operation set.

Table B.02 Alternatives and Operation Sets Used at Allatoona

Alternative	Operation Set
Baseline	Baseline
DroughtPln	Baseline
Burkett	Burkett
DragoA	DragoA
DragoB	DragoB
RPlanA	Burkett B
RPlanB	Burkett B
RPlanC	Burkett B
RPlanD	Burkett B
RPlanE	Burkett C
RPlanF	Burkett C
RPlanG	Burkett D

Table B.03 Operation Sets Used at Allatoona

Operation Set	Description
Baseline	Current operation / no action
Burkett	4 action zones, revised hydropower requirement, range 0-6 hours
Burkett B	Same as Burkett with reduced hydropower requirement, range 0-4 hours
Drago A	3 action zones, revised hydropower requirement, range 0-6 hours
Drago B	3 action zones, with variation of zone 3, revised hydropower requirement, range 0-6 hours,
Burkett C	4 action zones, revised fall drawdown, hydropower requirement ranges from 0-4 hours
Burkett D	Same as Burkett C with reduce hydropower requirement during September and October

The seven operation sets used at Allatoona for the 12 alternatives have differences in the number of sub-zones in the conservation pool and the elevations assigned to the zones. In addition, the required power generation rules vary within the operation sets. The remaining rules are the same as was used in the “Baseline” operation set. The rule sets for the six alternative operation sets used at Allatoona are shown in Figure B.15, Figure B.17, Figure B.18, Figure B.20, Figure B.21, and Figure B.22.

The zones and elevations used for each of these rule sets are given in Table B.04 through Table B.07.

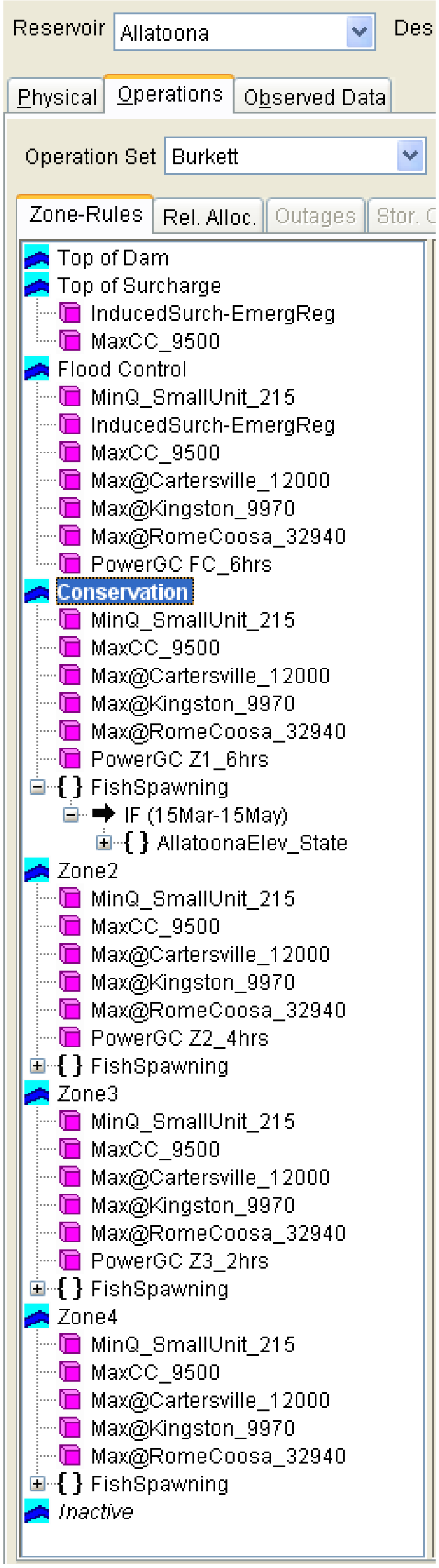
The “Baseline” operation set contains six zones. The “Burkett” and “Burkett B” operation sets contain an additional two sub-zones in the conservation pool. The top of dam, top of surcharge, top of flood control, top of conservation, and top of inactive are the same for all three operation sets. The sub-zones in the conservation pool have different elevations. The comparison of the zones for the “Baseline” and “Burkett” and “Burkett B” operation sets is given in Figure B.16.

The “DragoA” and “DragoB” operation sets contain one additional sub-zone in the conservation pool that is not in the “Baseline” operation set. All of the zones that are used in the “Baseline” operation set are used in “DragoA” and “DragoB” with the same elevations. The additional sub-zone, zone 3, is used in both “DragoA” and “DragoB”. The elevations for this sub-zone vary between the two operation sets. The zone comparison is shown in Figure B.19.

The “Burkett” and “Burkett B” operation set contain eight zones as does the “Burkett C” and “Burkett D” operation sets. The “Burkett” and “Burkett B” operation sets share the same zones as the “Burkett C” and “Burkett D” operation sets with the only difference being the elevations used for the top of conservation. The comparison of the zones for “Burkett” and “Burkett B” with the zones for “Burkett C” and “Burkett D” is given in Figure B.23.

The power rules used for the six alternative operation sets are provided in Section B and are shown in Figure B.24 through Figure B.28. An explanation of each rule not previously described is provided in Section C. A summary of the number of conservation pool sub-zones is given in Table B.08, and a summary of required power generation is given in Table B.09.

1. “Burkett” Operation Set



Reservoir Allatoona

Operation Set Burkett

- Top of Dam
- Top of Surcharge
  - InducedSurch-EmergReg
  - MaxCC_9500
- Flood Control
  - MinQ_SmallUnit_215
  - InducedSurch-EmergReg
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC FC_6hrs
- Conservation
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC Z1_6hrs
  - { } FishSpawning
    - IF (15Mar-15May)
      - { } AllatoonaElev_State
- Zone2
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC Z2_4hrs
  - { } FishSpawning
- Zone3
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC Z3_2hrs
  - { } FishSpawning
- Zone4
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - { } FishSpawning
- *Inactive*

Figure B.15 Rule Set for “Burkett” Operation Set

Table B.04 Zones and Elevations for “Burkett” and “Burkett B” Operation Sets

Seasons=	01-Jan	15-Jan	01-Feb	01-Mar	01-May	01-Jun	01-Jul	01-Sep	01-Oct	16-Nov	16-Dec
Zones:											
Top of Dam	880	880	880	880	880	880	880	880	880	880	880
Top of Surcharge	865	865	865	865	865	865	865	865	865	865	865
Flood Control	860	860	860	860	860	860	860	860	860	860	860
Conservation	823	823	linear	linear	840	840	840	840	840	linear	823
Zone 2	822.99999	823	linear	linear	840	840	840	linear	linear	829.71	823
Zone 3	822.99998	823	linear	linear	840	linear	linear	834	linear	linear	823
Zone 4	818	818	818	824	linear	836	828	linear	linear	linear	818
Inactive	800	800	800	800	800	800	800	800	800	800	800

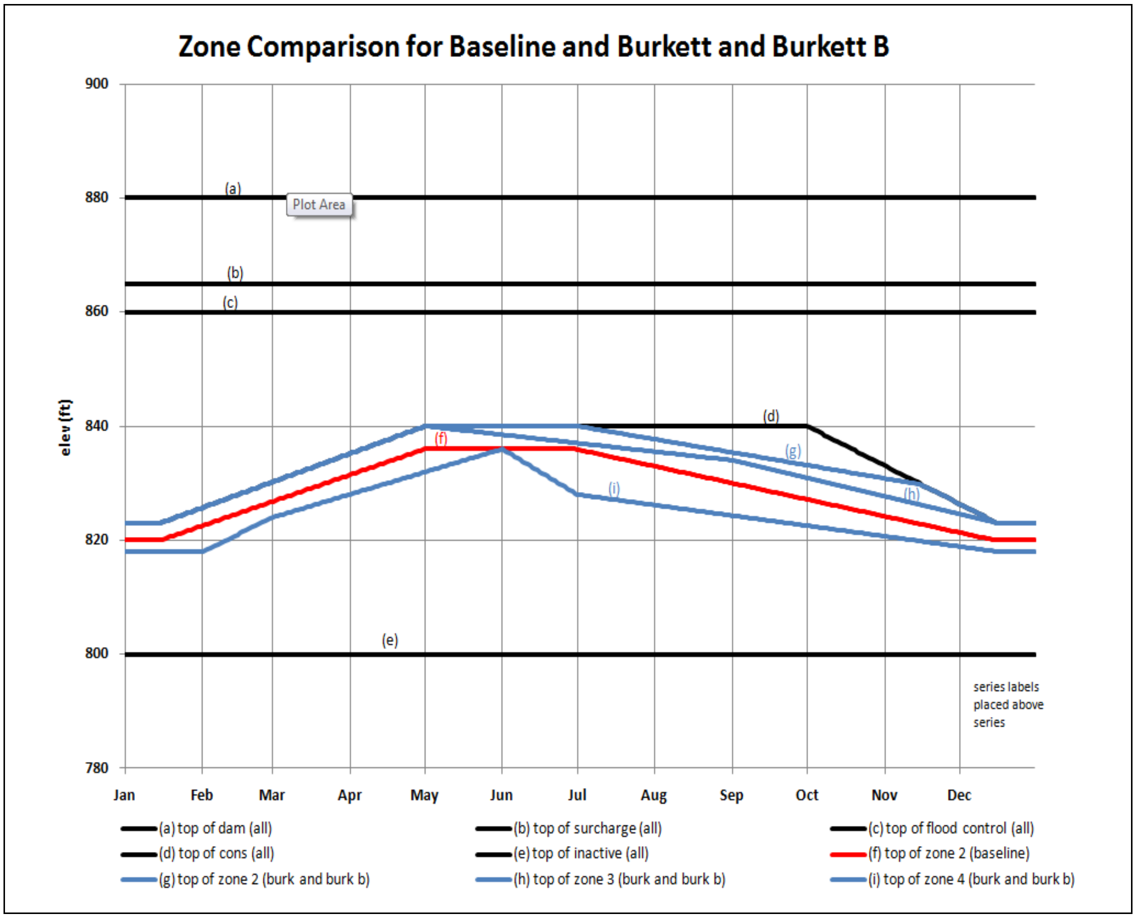
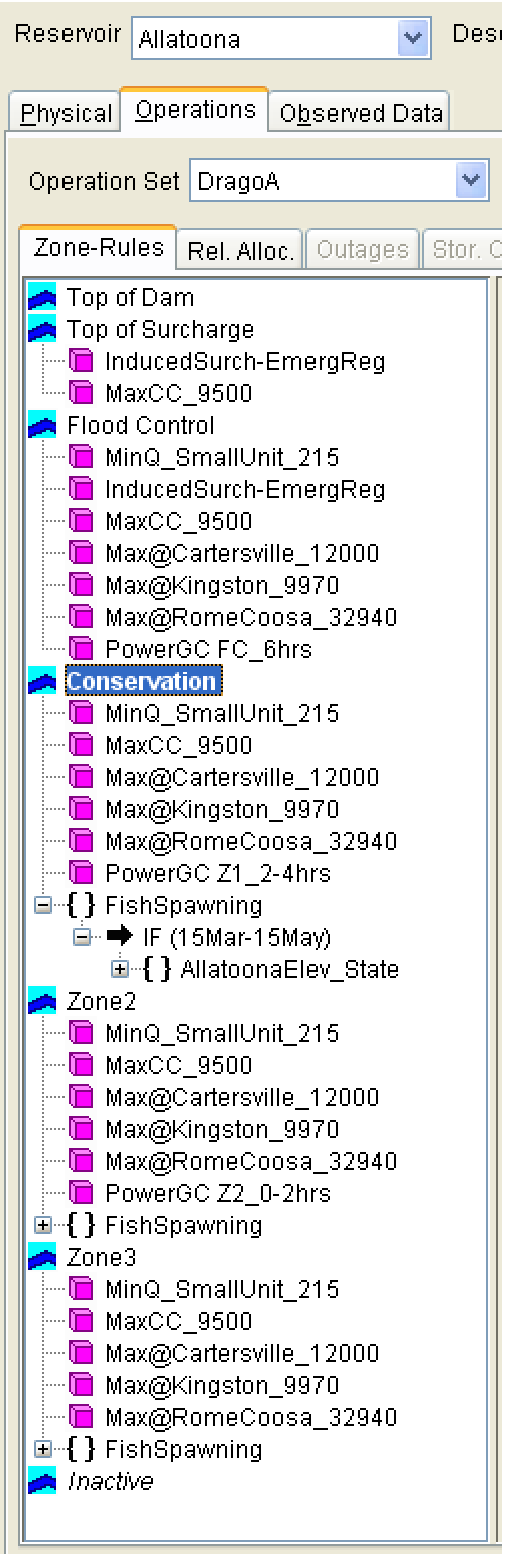


Figure B.16 Zone Comparison for “Baseline” and “Burkett” and “Burkett B” at Allatoona

2. “DragoA” Operation Set



Reservoir Allatoona

Operation Set DragoA

- Top of Dam
- Top of Surcharge
  - InducedSurch-EmergReg
  - MaxCC_9500
- Flood Control
  - MinQ_SmallUnit_215
  - InducedSurch-EmergReg
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC FC_6hrs
- Conservation
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC Z1_2-4hrs
  - { } FishSpawning
    - IF (15Mar-15May)
      - { } AllatoonaElev_State
- Zone2
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC Z2_0-2hrs
  - { } FishSpawning
- Zone3
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - { } FishSpawning
- *Inactive*

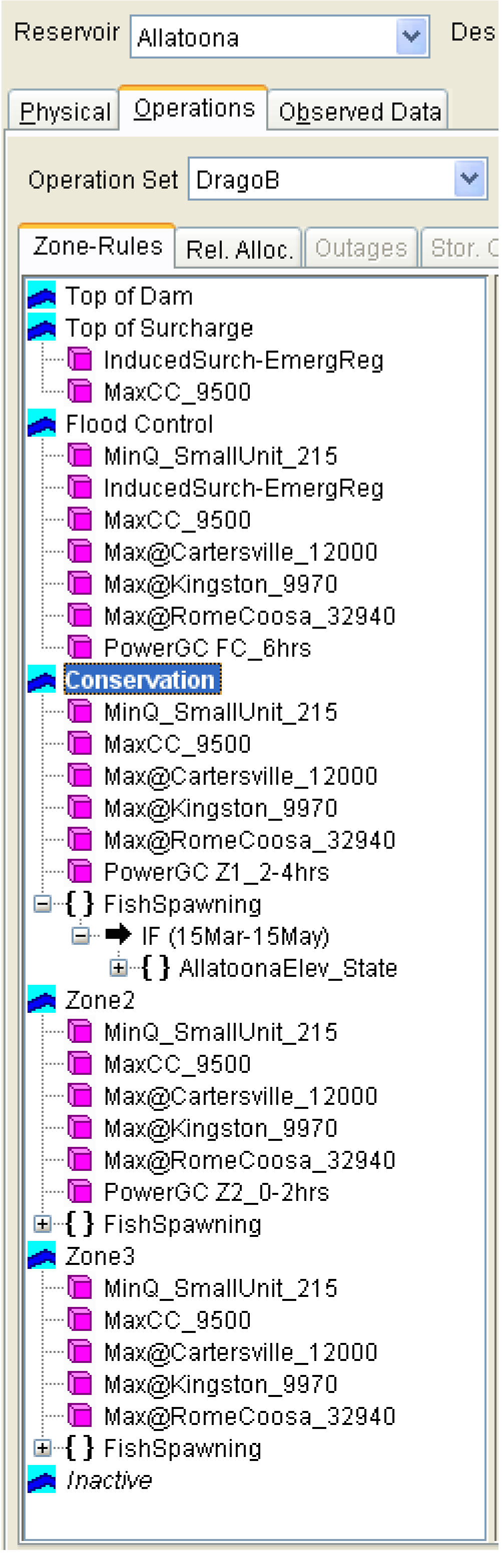
Figure B.17 Rule Set for “DragoA” Operation Set

Table B.05 Zones and Elevations for "DragoA" Operation Set

Seasons=	**01-Jan**	**15-Jan**	**01-Feb**	**01-Mar**	**01-May**	**01-Jul**	**01-Sep**	**01-Oct**	**16-Dec**
Zones:									
Top of Dam	880	880	880	880	880	880	880	880	880
Top of Surcharge	865	865	865	865	865	865	865	865	865
Flood Control	860	860	860	860	860	860	860	860	860
Conservation	823	823	linear	linear	840	840	840	840	823
Zone 2	820	820	linear	linear	836	836	linear	linear	820
Zone 3	818	818	818	824	832	828	828	linear	818
Inactive	800	800	800	800	800	800	800	800	800

For zone comparison plot, see Figure B.18.

3. “DragoB” Operation Set



Operation Set DragoB

- Top of Dam
- Top of Surcharge
  - InducedSurch-EmergReg
  - MaxCC_9500
- Flood Control
  - MinQ_SmallUnit_215
  - InducedSurch-EmergReg
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC FC_6hrs
- Conservation
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC Z1_2-4hrs
  - { } FishSpawning
    - IF (15Mar-15May)
      - { } AllatoonaElev_State
- Zone2
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC Z2_0-2hrs
  - { } FishSpawning
- Zone3
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - { } FishSpawning
- *Inactive*

Figure B.18 Rule Set for “DragoB” Operation Set

Table B.06 Zones and Elevations for "DragoB" Operation Set

Seasons=	01-Jan	15-Jan	01-Feb	01-May	01-Jul	01-Oct	01-Dec	16-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	linear	840	840	840	linear	823
Zone 2	820	820	linear	836	836	linear	linear	820
Zone 3	818	818	818	832	linear	linear	818	818
Inactive	800	800	800	800	800	800	800	800

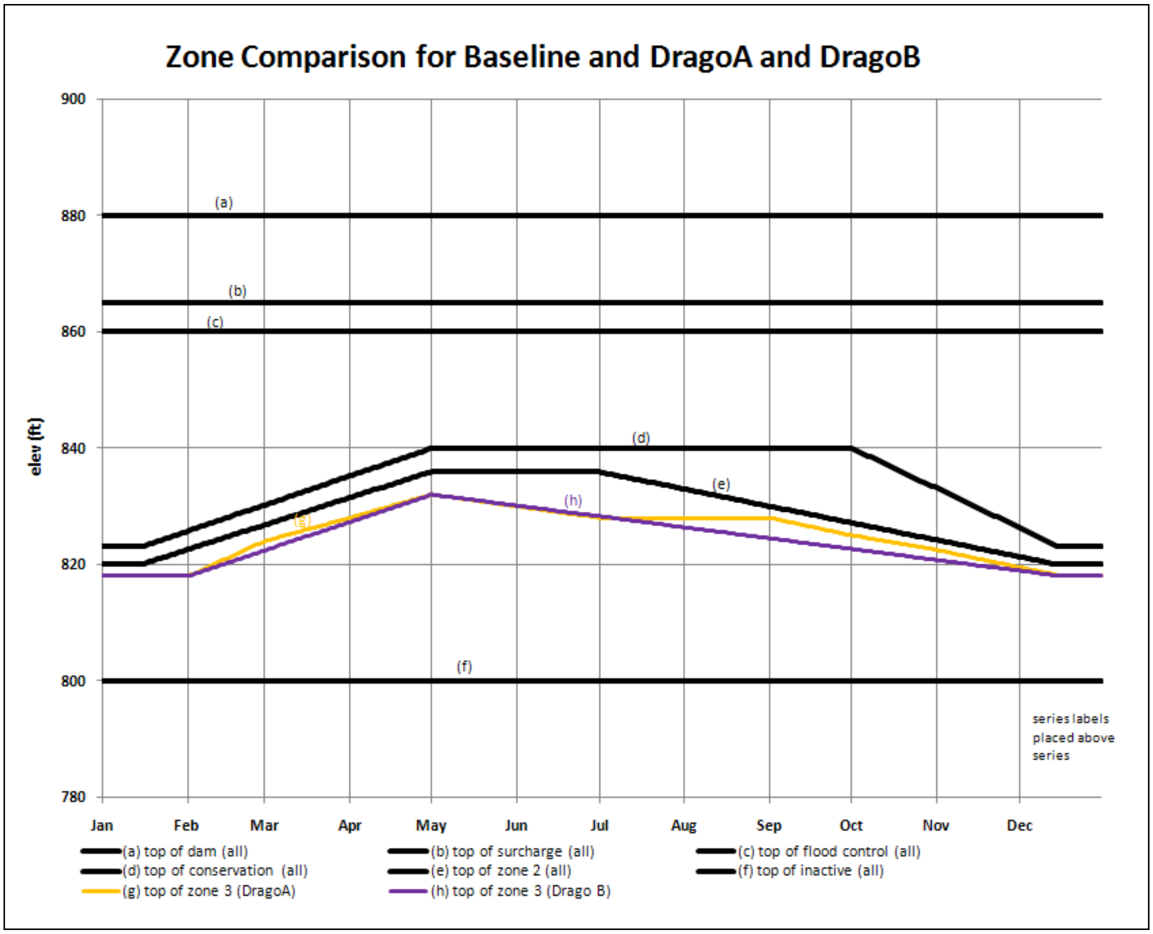
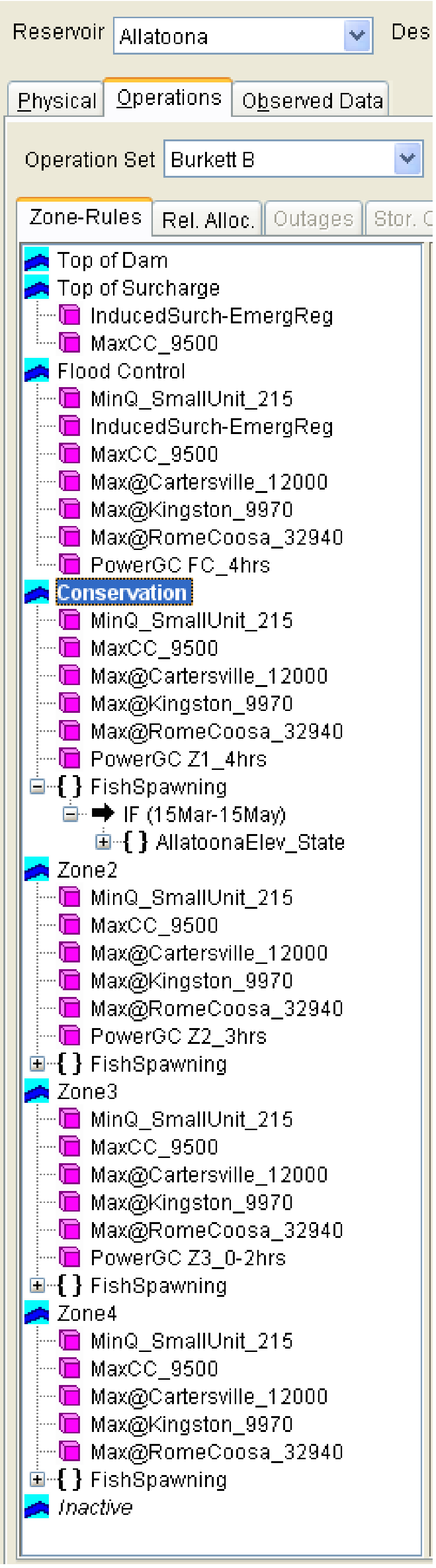


Figure B.19 Zone Comparison for "Baseline" and "DragoA" and "DragoB" at Allatoona

4. “Burkett B” Operation Set



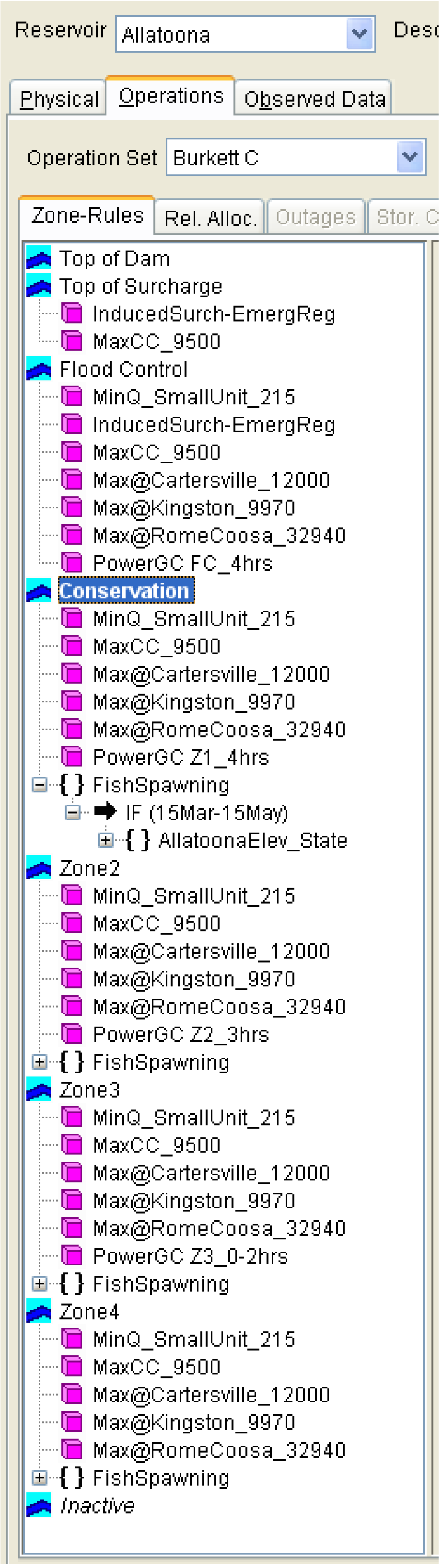
Reservoir Allatoona

Operation Set Burkett B

- Top of Dam
- Top of Surcharge
    - InducedSurch-EmergReg
    - MaxCC_9500
- Flood Control
    - MinQ_SmallUnit_215
    - InducedSurch-EmergReg
    - MaxCC_9500
    - Max@Cartersville_12000
    - Max@Kingston_9970
    - Max@RomeCoosa_32940
    - PowerGC FC_4hrs
- Conservation
    - MinQ_SmallUnit_215
    - MaxCC_9500
    - Max@Cartersville_12000
    - Max@Kingston_9970
    - Max@RomeCoosa_32940
    - PowerGC Z1_4hrs
    - { } FishSpawning
        - IF (15Mar-15May)
            - { } AllatoonaElev_State
- Zone2
    - MinQ_SmallUnit_215
    - MaxCC_9500
    - Max@Cartersville_12000
    - Max@Kingston_9970
    - Max@RomeCoosa_32940
    - PowerGC Z2_3hrs
    - { } FishSpawning
- Zone3
    - MinQ_SmallUnit_215
    - MaxCC_9500
    - Max@Cartersville_12000
    - Max@Kingston_9970
    - Max@RomeCoosa_32940
    - PowerGC Z3_0-2hrs
    - { } FishSpawning
- Zone4
    - MinQ_SmallUnit_215
    - MaxCC_9500
    - Max@Cartersville_12000
    - Max@Kingston_9970
    - Max@RomeCoosa_32940
    - { } FishSpawning
- *Inactive*

Figure B.20 Rule Set for “Burkett B” Operation Set

5. “Burkett C” Operation Set



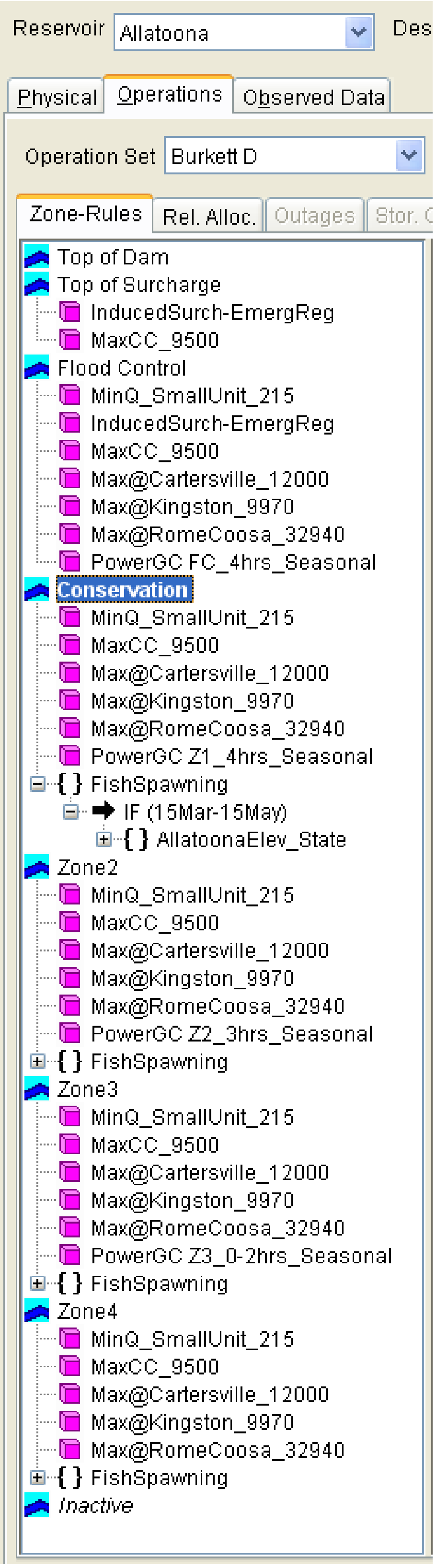
Reservoir Allatoona

Operation Set Burkett C

- Top of Dam
- Top of Surcharge
  - InducedSurch-EmergReg
  - MaxCC_9500
- Flood Control
  - MinQ_SmallUnit_215
  - InducedSurch-EmergReg
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC FC_4hrs
- Conservation
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC Z1_4hrs
  - { } FishSpawning
    - IF (15Mar-15May)
      - { } AllatoonaElev_State
- Zone2
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC Z2_3hrs
  - { } FishSpawning
- Zone3
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC Z3_0-2hrs
  - { } FishSpawning
- Zone4
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - { } FishSpawning
- *Inactive*

Figure B.21 Rule Set for “Burkett C” Operation Set

6. “Burkett D” Operation Set



Reservoir: Allatoona

Operation Set: Burkett D

- Top of Dam
- Top of Surcharge
  - InducedSurch-EmergReg
  - MaxCC_9500
- Flood Control
  - MinQ_SmallUnit_215
  - InducedSurch-EmergReg
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC FC_4hrs_Seasonal
- Conservation
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC Z1_4hrs_Seasonal
  - { } FishSpawning
    - IF (15Mar-15May)
      - { } AllatoonaElev_State
- Zone2
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC Z2_3hrs_Seasonal
  - { } FishSpawning
- Zone3
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC Z3_0-2hrs_Seasonal
  - { } FishSpawning
- Zone4
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - { } FishSpawning
- *Inactive*

Figure B.22 Rule Set for “Burkett D” Operation Set

Table B.07 Zones and Elevations for “Burkett C” and “Burkett D” Operation Sets

Seasons=	01-Jan	15-Jan	01-Feb	01-Mar	01-May	01-Jun	01-Jul	01-Sep	05-Sep	01-Oct	15-Nov	16-Nov	16-Dec	31-Dec
Zones:														
Top of Dam	880	880	880	880	880	880	880	880	880	880	880	880	880	880
Top of Surcharge	865	865	865	865	865	865	865	865	865	865	865	865	865	865
Flood Control	860	860	860	860	860	860	860	860	860	860	860	860	860	860
Conservation	823	823	lin	lin	840	840	840	840	840	835	835	lin	lin	823
Zone 2	822.99999	823	lin	lin	840	840	840	lin	lin	lin	lin	829.71	823	823
Zone 3	822.99998	823	lin	lin	840	lin	lin	834	lin	lin	lin	lin	823	823
Zone 4	818	818	818	824	lin	836	828	lin	lin	lin	lin	lin	818	818
Inactive	800	800	800	800	800	800	800	800	800	800	800	800	800	800

lin = linear

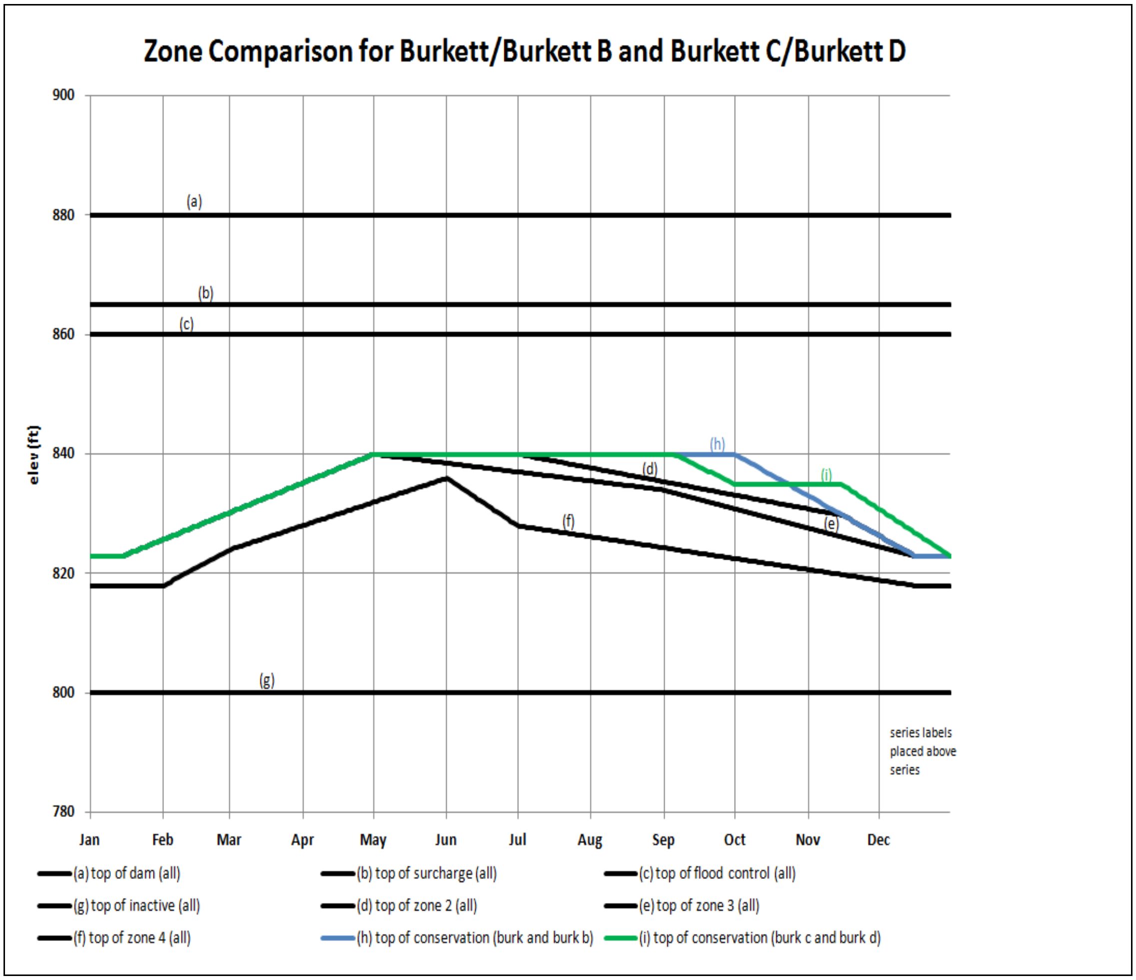
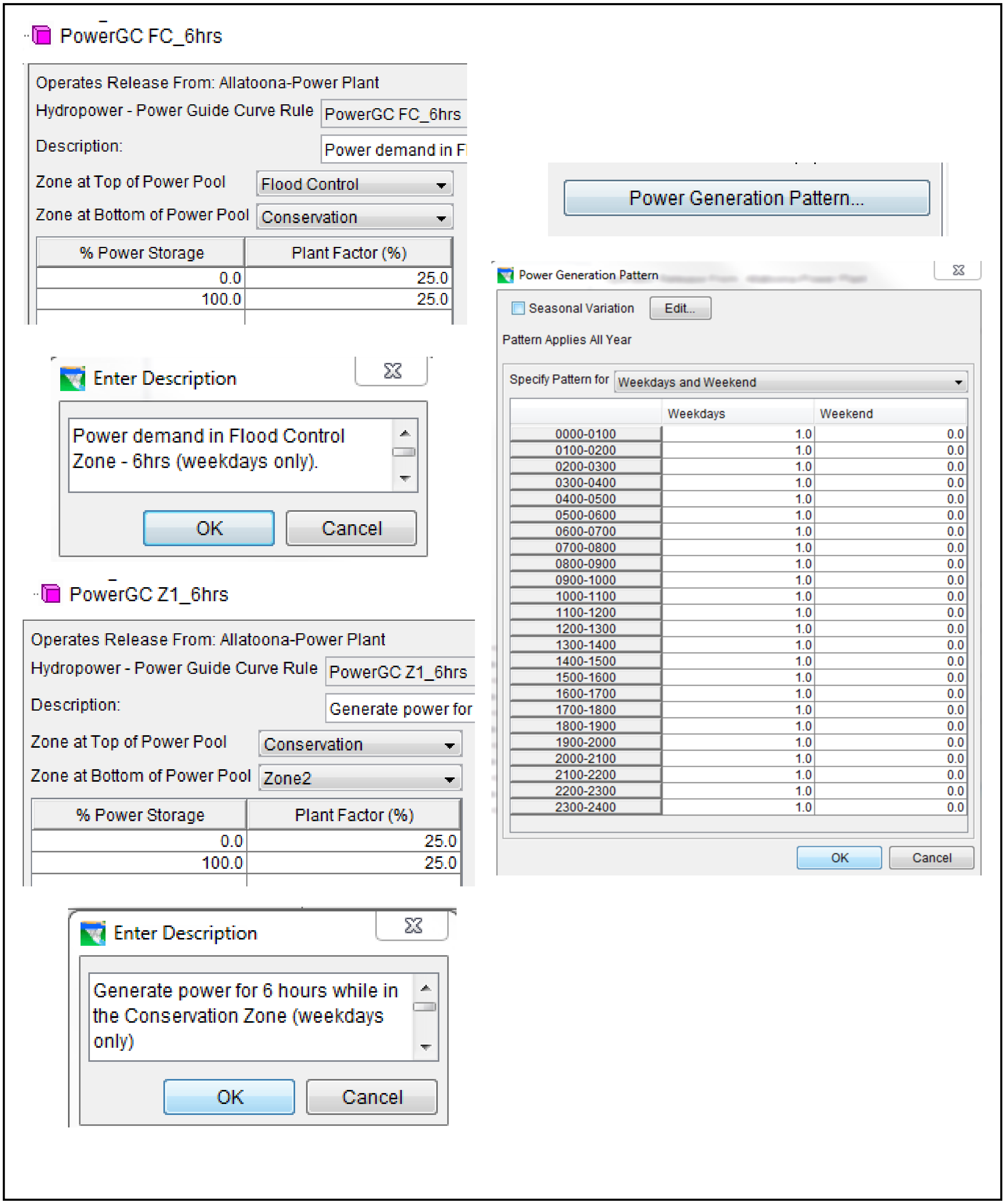


Figure B.23 Zone Comparison for “Burkett”/”Burkett B” and “Burkett C”/”Burkett D” at Allatoona

B. Rule Illustrations



PowerGC FC_6hrs

Operates Release From: Allatoona-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC FC_6hrs

Description: Power demand in F

Zone at Top of Power Pool: Flood Control

Zone at Bottom of Power Pool: Conservation

% Power Storage	Plant Factor (%)
0.0	25.0
100.0	25.0

Enter Description

Power demand in Flood Control Zone - 6hrs (weekdays only).

Power Generation Pattern

☐ Seasonal Variation

Pattern Applies All Year

Specify Pattern for: Weekdays and Weekend

	Weekdays	Weekend
0000-0100	1.0	0.0
0100-0200	1.0	0.0
0200-0300	1.0	0.0
0300-0400	1.0	0.0
0400-0500	1.0	0.0
0500-0600	1.0	0.0
0600-0700	1.0	0.0
0700-0800	1.0	0.0
0800-0900	1.0	0.0
0900-1000	1.0	0.0
1000-1100	1.0	0.0
1100-1200	1.0	0.0
1200-1300	1.0	0.0
1300-1400	1.0	0.0
1400-1500	1.0	0.0
1500-1600	1.0	0.0
1600-1700	1.0	0.0
1700-1800	1.0	0.0
1800-1900	1.0	0.0
1900-2000	1.0	0.0
2000-2100	1.0	0.0
2100-2200	1.0	0.0
2200-2300	1.0	0.0
2300-2400	1.0	0.0

PowerGC Z1_6hrs

Operates Release From: Allatoona-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC Z1_6hrs

Description: Generate power for

Zone at Top of Power Pool: Conservation

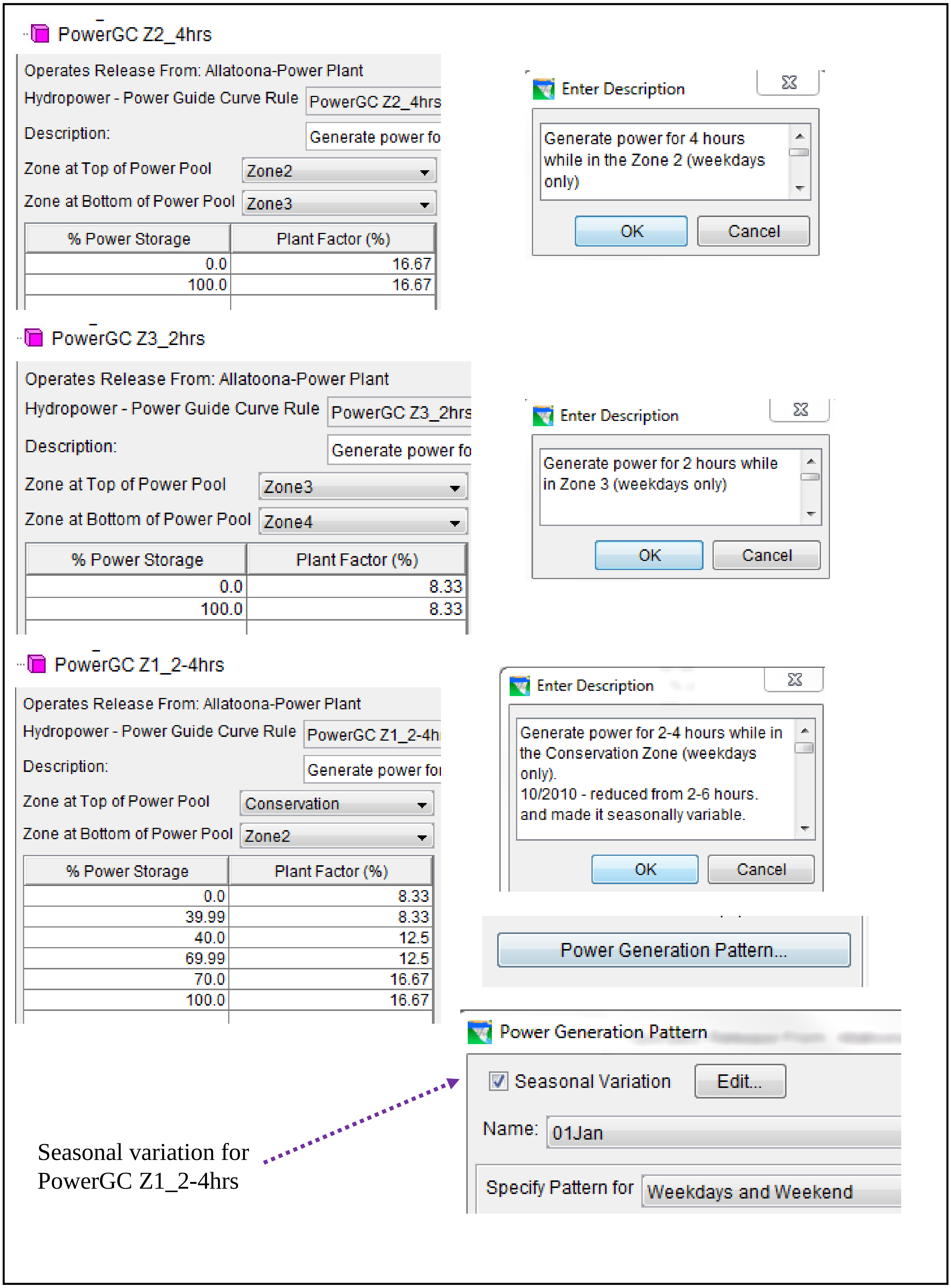
Zone at Bottom of Power Pool: Zone2

% Power Storage	Plant Factor (%)
0.0	25.0
100.0	25.0

Enter Description

Generate power for 6 hours while in the Conservation Zone (weekdays only)

Figure B.24 Power Rules for Allatoona Alternative Operation Sets (1 of 5)



PowerGC Z2_4hrs

Operates Release From: Allatoona-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC Z2_4hrs

Description: Generate power fo

Zone at Top of Power Pool: Zone2

Zone at Bottom of Power Pool: Zone3

% Power Storage	Plant Factor (%)
0.0	16.67
100.0	16.67

Enter Description

Generate power for 4 hours while in the Zone 2 (weekdays only)

PowerGC Z3_2hrs

Operates Release From: Allatoona-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC Z3_2hrs

Description: Generate power fo

Zone at Top of Power Pool: Zone3

Zone at Bottom of Power Pool: Zone4

% Power Storage	Plant Factor (%)
0.0	8.33
100.0	8.33

Enter Description

Generate power for 2 hours while in Zone 3 (weekdays only)

PowerGC Z1_2-4hrs

Operates Release From: Allatoona-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC Z1_2-4h

Description: Generate power fo

Zone at Top of Power Pool: Conservation

Zone at Bottom of Power Pool: Zone2

% Power Storage	Plant Factor (%)
0.0	8.33
39.99	8.33
40.0	12.5
69.99	12.5
70.0	16.67
100.0	16.67

Enter Description

Generate power for 2-4 hours while in the Conservation Zone (weekdays only).
10/2010 - reduced from 2-6 hours. and made it seasonally variable.

Power Generation Pattern

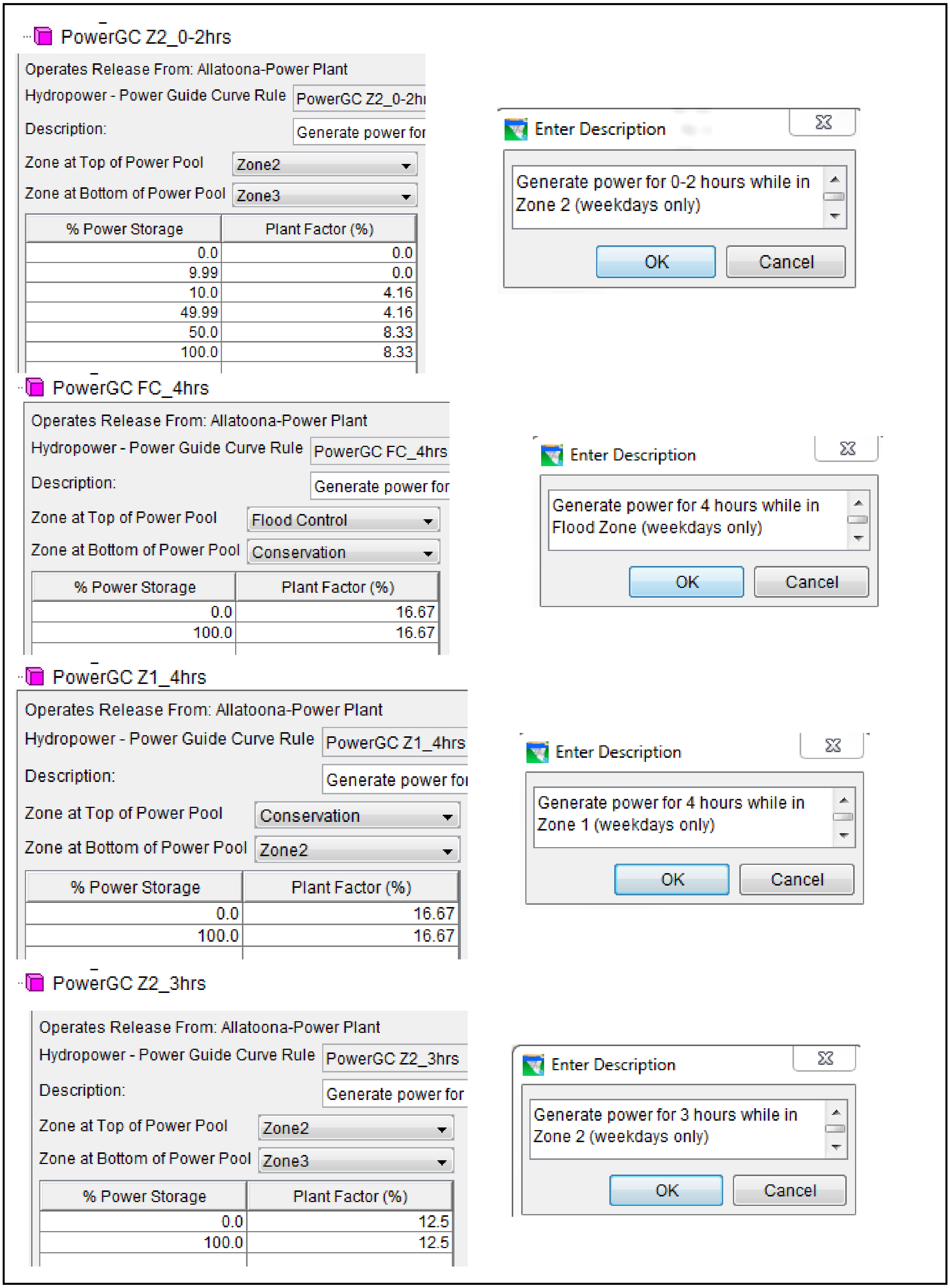
☑ Seasonal Variation

Name: 01Jan

Specify Pattern for: Weekdays and Weekend

Seasonal variation for PowerGC Z1_2-4hrs

Figure B.25 **Power Rules for Allatoona Alternative Operation Sets (2 of 5)**



PowerGC Z2_0-2hrs

Operates Release From: Allatoona-Power Plant
Hydropower - Power Guide Curve Rule: PowerGC Z2_0-2h
Description: Generate power for
Zone at Top of Power Pool: Zone2
Zone at Bottom of Power Pool: Zone3

% Power Storage	Plant Factor (%)
0.0	0.0
9.99	0.0
10.0	4.16
49.99	4.16
50.0	8.33
100.0	8.33

Enter Description

Generate power for 0-2 hours while in Zone 2 (weekdays only)

PowerGC FC_4hrs

Operates Release From: Allatoona-Power Plant
Hydropower - Power Guide Curve Rule: PowerGC FC_4hrs
Description: Generate power for
Zone at Top of Power Pool: Flood Control
Zone at Bottom of Power Pool: Conservation

% Power Storage	Plant Factor (%)
0.0	16.67
100.0	16.67

Enter Description

Generate power for 4 hours while in Flood Zone (weekdays only)

PowerGC Z1_4hrs

Operates Release From: Allatoona-Power Plant
Hydropower - Power Guide Curve Rule: PowerGC Z1_4hrs
Description: Generate power fo
Zone at Top of Power Pool: Conservation
Zone at Bottom of Power Pool: Zone2

% Power Storage	Plant Factor (%)
0.0	16.67
100.0	16.67

Enter Description

Generate power for 4 hours while in Zone 1 (weekdays only)

PowerGC Z2_3hrs

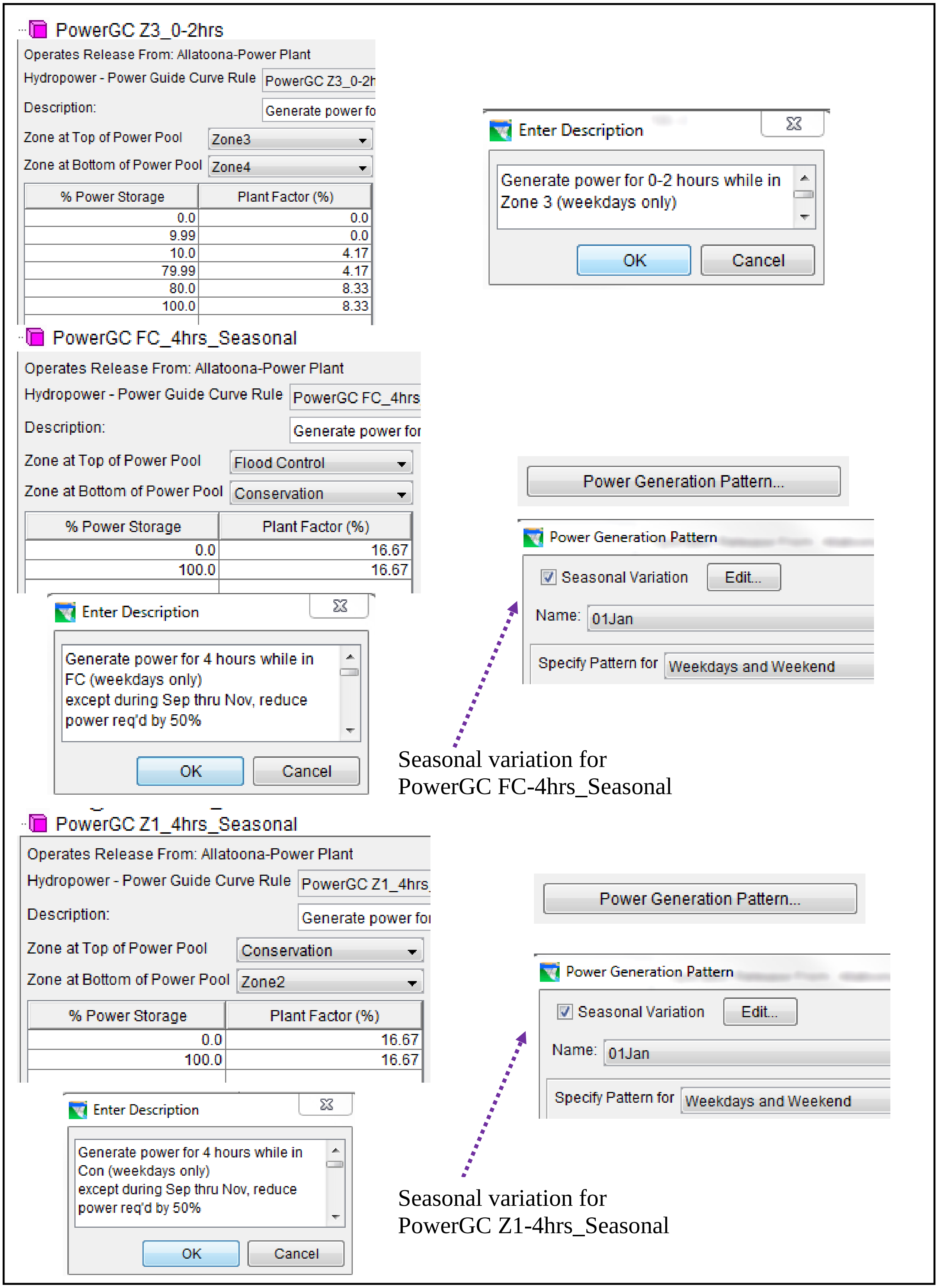
Operates Release From: Allatoona-Power Plant
Hydropower - Power Guide Curve Rule: PowerGC Z2_3hrs
Description: Generate power for
Zone at Top of Power Pool: Zone2
Zone at Bottom of Power Pool: Zone3

% Power Storage	Plant Factor (%)
0.0	12.5
100.0	12.5

Enter Description

Generate power for 3 hours while in Zone 2 (weekdays only)

Figure B.26 Power Rules for Allatoona Alternative Operation Sets (3 of 5)



PowerGC Z3_0-2hrs

Operates Release From: Allatoona-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC Z3_0-2h

Description: Generate power fo

Zone at Top of Power Pool: Zone3

Zone at Bottom of Power Pool: Zone4

% Power Storage	Plant Factor (%)
0.0	0.0
9.99	0.0
10.0	4.17
79.99	4.17
80.0	8.33
100.0	8.33

Enter Description

Generate power for 0-2 hours while in Zone 3 (weekdays only)

PowerGC FC_4hrs_Seasonal

Operates Release From: Allatoona-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC FC_4hrs

Description: Generate power for

Zone at Top of Power Pool: Flood Control

Zone at Bottom of Power Pool: Conservation

% Power Storage	Plant Factor (%)
0.0	16.67
100.0	16.67

Enter Description

Generate power for 4 hours while in FC (weekdays only)
except during Sep thru Nov, reduce power req'd by 50%

Power Generation Pattern

☑ Seasonal Variation

Name: 01Jan

Specify Pattern for: Weekdays and Weekend

Seasonal variation for
PowerGC FC-4hrs_Seasonal

PowerGC Z1_4hrs_Seasonal

Operates Release From: Allatoona-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC Z1_4hrs

Description: Generate power for

Zone at Top of Power Pool: Conservation

Zone at Bottom of Power Pool: Zone2

% Power Storage	Plant Factor (%)
0.0	16.67
100.0	16.67

Enter Description

Generate power for 4 hours while in Con (weekdays only)
except during Sep thru Nov, reduce power req'd by 50%

Power Generation Pattern

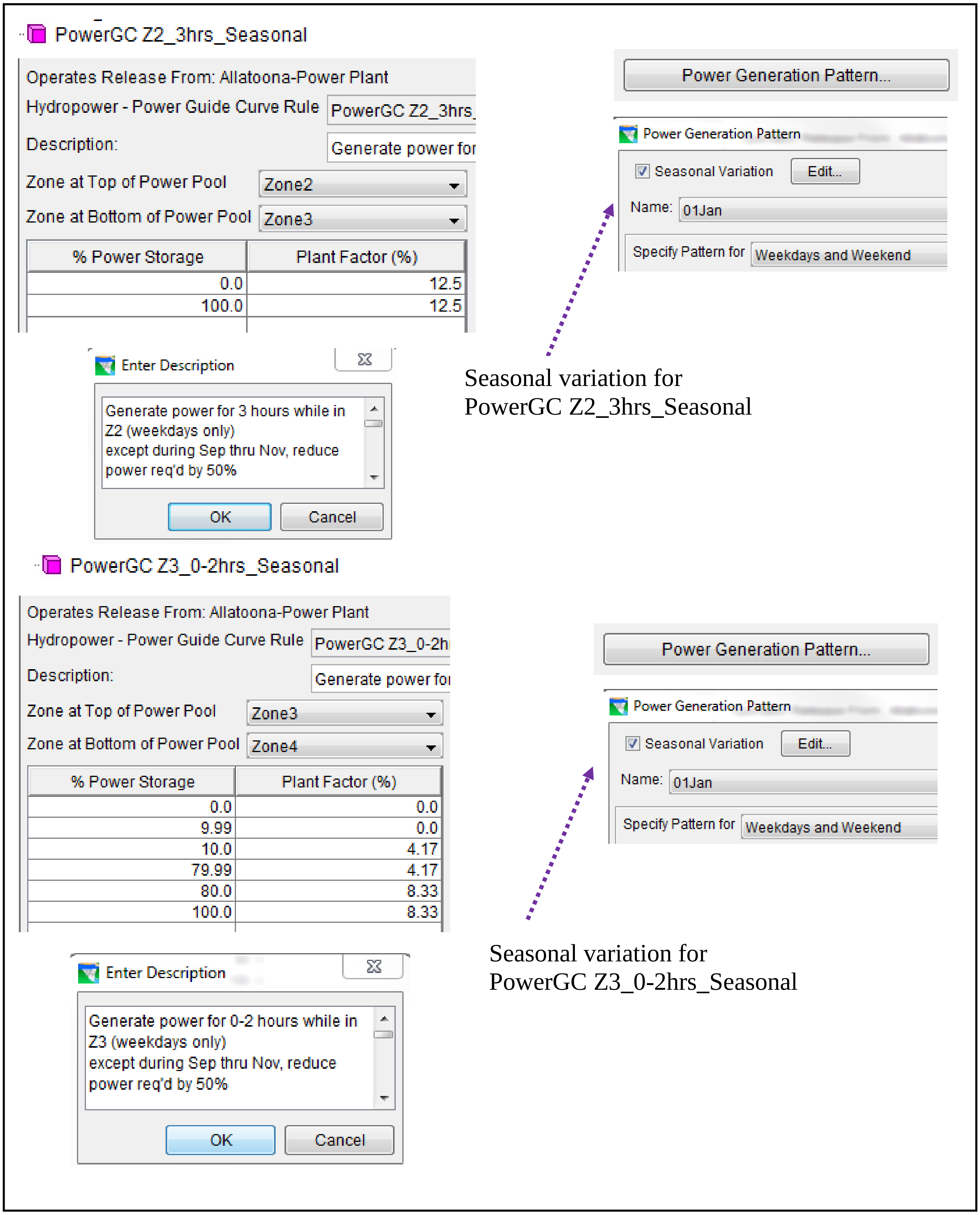
☑ Seasonal Variation

Name: 01Jan

Specify Pattern for: Weekdays and Weekend

Seasonal variation for
PowerGC Z1-4hrs_Seasonal

Figure B.27 Power Rules for Allatoona Alternative Operation Sets (4 of 5)



PowerGC Z2_3hrs_Seasonal

Operates Release From: Allatoona-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC Z2_3hrs_

Description: Generate power for

Zone at Top of Power Pool: Zone2

Zone at Bottom of Power Pool: Zone3

% Power Storage	Plant Factor (%)
0.0	12.5
100.0	12.5

Enter Description

Generate power for 3 hours while in Z2 (weekdays only)
except during Sep thru Nov, reduce power req'd by 50%

☑ Seasonal Variation

Name: 01Jan

Specify Pattern for: Weekdays and Weekend

Seasonal variation for
PowerGC Z2_3hrs_Seasonal

PowerGC Z3_0-2hrs_Seasonal

Operates Release From: Allatoona-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC Z3_0-2h

Description: Generate power fo

Zone at Top of Power Pool: Zone3

Zone at Bottom of Power Pool: Zone4

% Power Storage	Plant Factor (%)
0.0	0.0
9.99	0.0
10.0	4.17
79.99	4.17
80.0	8.33
100.0	8.33

Enter Description

Generate power for 0-2 hours while in Z3 (weekdays only)
except during Sep thru Nov, reduce power req'd by 50%

☑ Seasonal Variation

Name: 01Jan

Specify Pattern for: Weekdays and Weekend

Seasonal variation for
PowerGC Z3_0-2hrs_Seasonal

Figure B.28 Power Rules for Allatoona Alternative Operation Sets (5 of 5)

C. Rule Descriptions

1. PowerGC FC_6hrs

This rule (see Figure B.24) is a required power generation rule in the Flood Control zone for the "Burkett", "DragoA", and "DragoB" operation sets. 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 25%. 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 6 hours (25% 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.

2. PowerGC Z1_6hrs

This rule (see Figure B.24) is a required power generation rule in the Conservation zone for the "Burkett" operation set. For this rule, the zone for power storage is defined from the top of Conservation to the top of Zone2. For any value of percent full in this zone, the plant factor is set to 25%. 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 6 hours (25% 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.

3. PowerGC Z2_4hrs

This rule (see Figure B.25) is a required power generation rule in Zone 2 for the "Burkett" operation set. For this rule, the zone for power storage is defined from the top of Zone 2 to the top of Zone 3. 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.

4. PowerGC Z3_2hrs

This rule (see Figure B.25) is a required power generation rule in Zone 3 for the "Burkett" operation set. For this rule, the zone for power storage is defined from the top of Zone 3 to the top of Zone 4. For any value of percent full in this zone, the plant factor is set to 8.33%. 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 2 hours (8.33% 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.

5. *PowerGC Z1_2-4hrs*

This rule (see Figure B.25) is a required power generation rule in the Conservation zone for the "Baseline", "DragoA" and "DragoB" operation sets. For this rule, the zone for power storage is defined from the top of Conservation to the top of Zone 2. Depending on the percent full in this zone, the plant factor is set between 8.33% and 16.67% for power generation between 2 and 4 hours. 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.

6. *PowerGC Z2_0-2hrs*

This rule (see Figure B.26) is a required power generation rule in Zone 2 for the "DragoA" and "DragoB" operation sets. For this rule, the zone for power storage is defined from the top of Zone 2 to the top of Zone 3. Depending on the value of percent full in this zone, the plant factor is set between 0.0% and 8.33% for power generation between 0 and 2 hours. 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. This generation can be reduced by the maximum release rules since those rules are at a higher priority.

7. *PowerGC FC_4hrs*

This rule (see Figure B.26) is a required power generation rule in the Flood Control zone for the "Burkett B" and "Burkett C" operation sets. 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_4hrs*

This rule (see Figure B.26) is a required power generation rule in the Conservation zone for the "Burkett B" and "Burkett C" operation sets. For this rule, the zone for power storage is defined from the top of Conservation to the top of Zone 2. 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.

9. PowerGC Z2_3hrs

This rule (see Figure B.26) is a required power generation rule in Zone 2 for the "Burkett B" and "Burkett C" operation sets. For this rule, the zone for power storage is defined from the top of Zone 2 to the top of Zone 3. For any value of percent full in this zone, the plant factor is set to 12.5%. 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 3 hours (12.5% 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.

10. PowerGC Z3_0-2hrs

This rule (see Figure B.27) is a required power generation rule in Zone 3 for the "Burkett B" and "Burkett C" operation sets. For this rule, the zone for power storage is defined from the top of Zone 3 to the top of Zone 4. Depending on the value of percent full in this zone, the plant factor is set between 0.0% and 8.33% for power generation between 0 and 2 hours. 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. This generation can be reduced by the maximum release rules since those rules are at a higher priority.

11. PowerGC FC_4hrs_Seasonal

This rule (see Figure B.27) is a required power generation rule in the Flood Control zone for the "Burkett D" operation set. 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% for 4 hours of 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 through August and December. From September through November, the power generation amounts are set to 50% on weekdays. This generation can be reduced by the maximum release rules since those rules are at a higher priority.

12. PowerGC Z1_4hrs_Seasonal

This rule (see Figure B.27) is a required power generation rule in the Conservation zone for the "Burkett D" operation set. For this rule, the zone for power storage is defined from the top of Conservation to the top of Zone 2. For any value of percent full in this zone, the plant factor is set to 16.67% for 4 hours of 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 through August and December. From September through November, the power generation amounts are set to 50% on weekdays. This generation can be reduced by the maximum release rules since those rules are at a higher priority.

13. PowerGC Z2_3hrs_Seasonal

This rule (see Figure B.28) is a required power generation rule in Zone 2 for the "Burkett D" operation set. For this rule, the zone for power storage is defined from the top of Zone 2 to the top of Zone 3. For any value of percent full in this zone, the plant factor is set to 12.5% for 3 hours of 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 through August and December. From September through November, the power generation amounts are set to 50% on weekdays. This generation can be reduced by the maximum release rules since those rules are at a higher priority.

14. PowerGC Z3_0-2hrs_Seasonal

This rule (see Figure B.28) is a required power generation rule in Zone 3 for the "Burkett D" operation set. For this rule, the zone for power storage is defined from the top of Zone 3 to the top of Zone 4. Depending on the value of percent full in this zone, the plant factor is set between 0.0% and 8.33% for 0 to 2 hours of 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 through August and December. From September through November, the power generation amounts are set to 50% on weekdays. This generation can be reduced by the maximum release rules since those rules are at a higher priority.

Table B.08 Number of Conservation Pool Sub-Zones for Each Operation Set

Operation Set	Number of Sub-Zones in Conservation Pool
Baseline	2
Burkett	4
DragoA	3
DragoB	3
Burkett B	4
Burkett C	4
Burkett D	4

Table B.09 Required Power Generation by Zone for Each Operation Set

Operation Set	Flood Control	Conservation	Zone2	Zone3	Zone4
Baseline*	4 hrs	2 to 4 hrs	0 to 1 hr	No Zone3	No Zone4
Burkett	6 hrs	6 hrs	4 hrs	2 hrs	No req'd gen
DragoA*	6 hrs	2 to 4 hrs	0 to 2 hrs	No req'd gen	No Zone4
DragoB*	6 hrs	2 to 4 hrs	0 to 2 hrs	No req'd gen	No Zone4
Burkett B	4 hrs	4 hrs	3 hrs	0 to 2 hrs	No req'd gen
Burkett C	4 hrs	4 hrs	3 hrs	0 to 2 hrs	No req'd gen
Burkett D**	4 hrs	4 hrs	3 hrs	0 to 2 hrs	No req'd gen

* Generation decreased in Conservation zone for Feb, Apr-Jul and increased in Oct

** Generation reduced by one-half in the months of September through November

Alabama-Coosa-Tallapoosa (ACT) Watershed

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

Appendix C – Robert F Henry Lock and Dam

March 2011 (DRAFT)

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Appendix C – RF Henry (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.

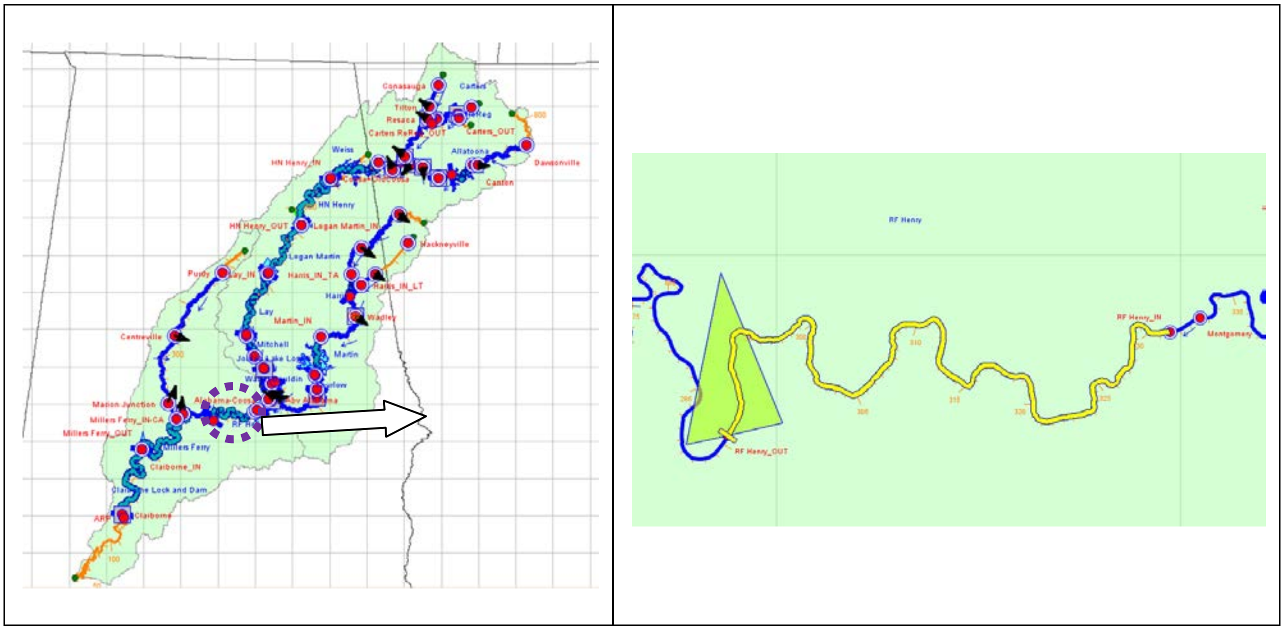


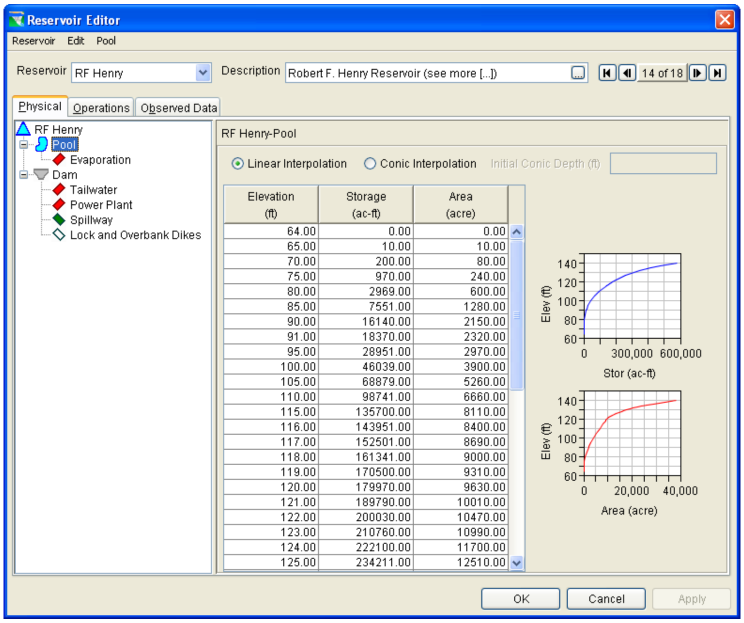
Figure C.01 HEC-ResSim Map Display Showing Location of RF HenryLock and Dam

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.



Reservoir: RF Henry

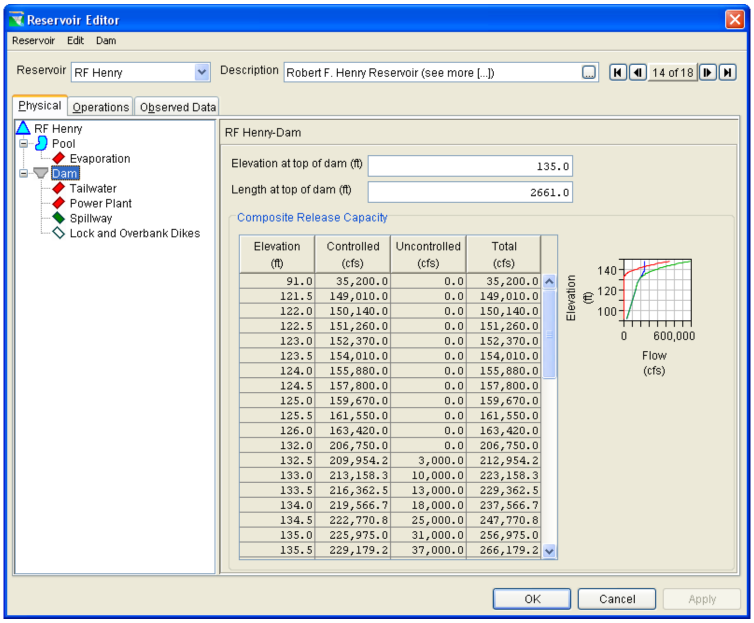
Description: Robert F. Henry Reservoir (see more [...])

RF Henry-Pool

● Linear Interpolation ○ Conic Interpolation

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



Reservoir: RF Henry

Description: Robert F. Henry Reservoir (see more [...])

RF Henry-Dam

Elevation at top of dam (ft): 135.0

Length at top of dam (ft): 2661.0

Composite Release Capacity

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

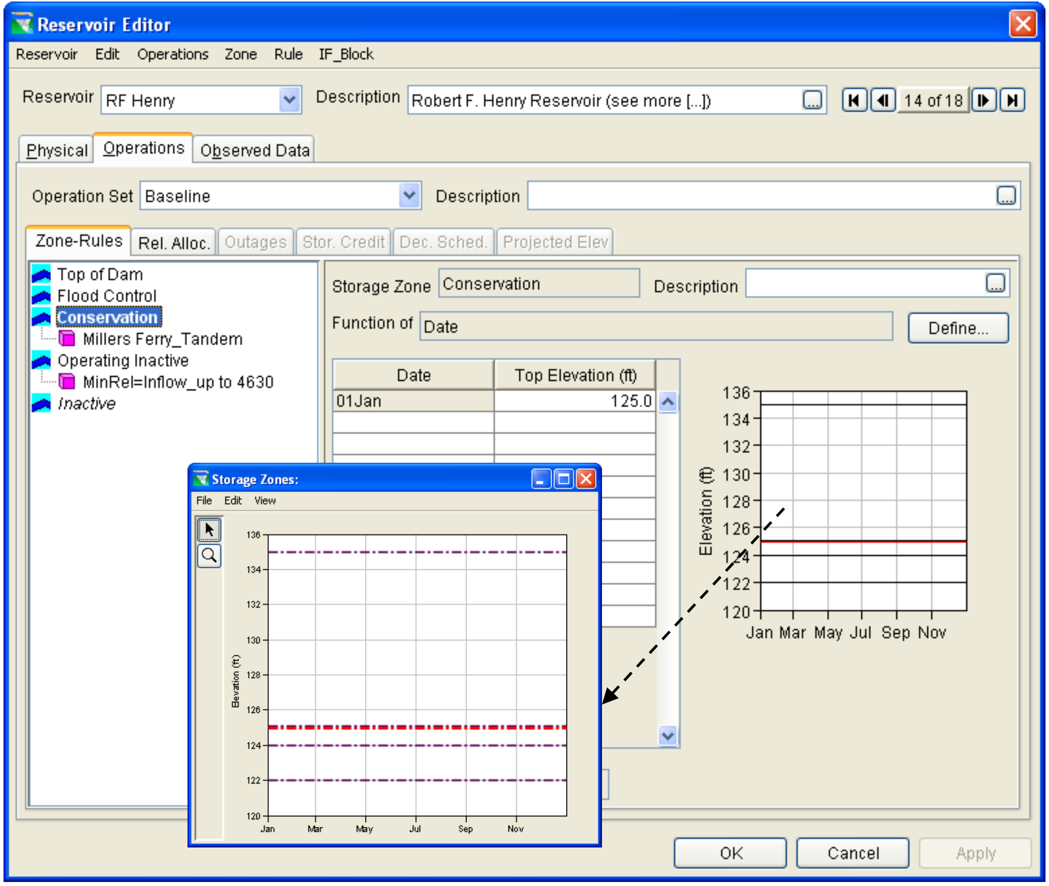
The zones for an operation set are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table C.01 shows the definition of RF Henry's "Baseline" operational zones, which consists of zones of flood control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



Reservoir: RF Henry

Description: Robert F. Henry Reservoir (see more [...])

14 of 18

Operation Set: Baseline

Description:

- Top of Dam
- Flood Control
- Conservation
  - Millers Ferry_Tandem
- Operating Inactive
  - MinRel=Inflow_up to 4630
- *Inactive*

Storage Zone: Conservation

Description:

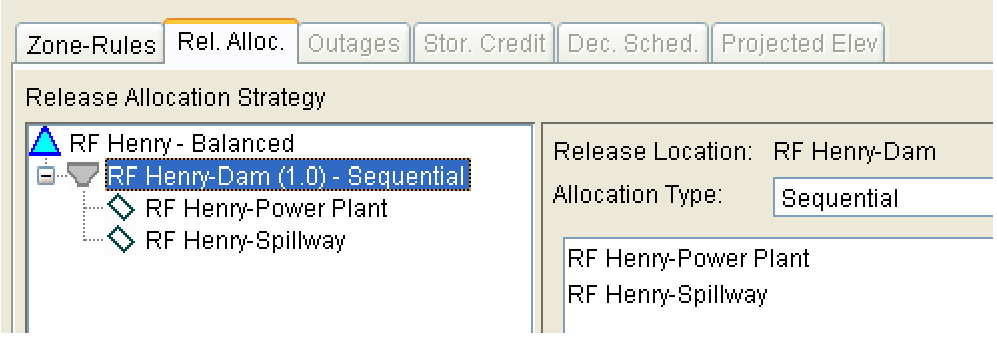
Function of: Date

Date	Top Elevation (ft)
01Jan	125.0

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:



Release Allocation Strategy

- RF Henry - Balanced
  - RF Henry-Dam (1.0) - Sequential
    - RF Henry-Power Plant
    - RF Henry-Spillway

Release Location: RF Henry-Dam

Allocation Type: Sequential

RF Henry-Power Plant
RF Henry-Spillway

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”.

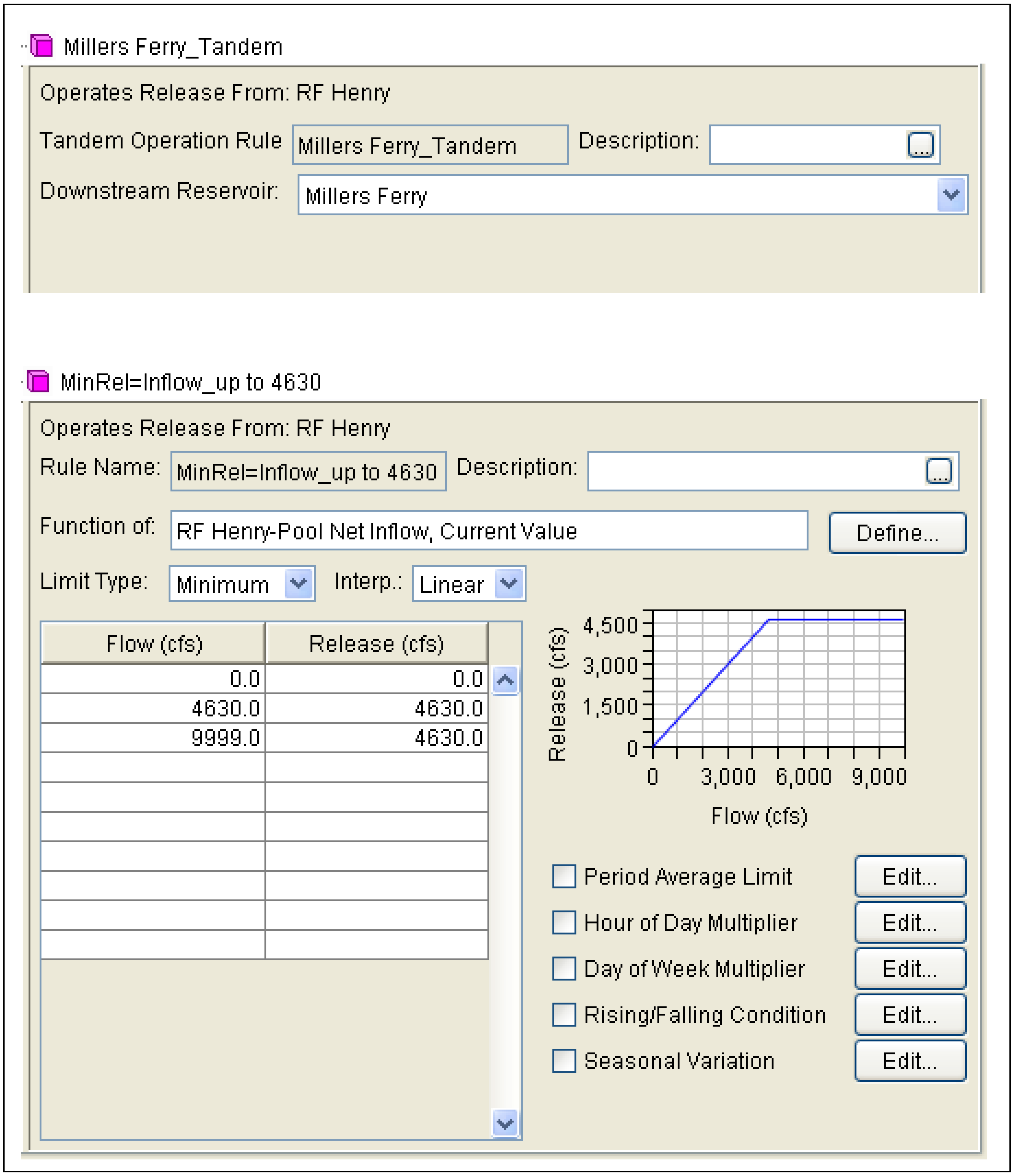
Reservoir: RF Henry

Operation Set: Baseline

- Top of Dam
- Flood Control
- Conservation
  - Millers Ferry_Tandem
- Operating Inactive
  - MinRel=Inflow_up to 4630
- *Inactive*

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.



Millers Ferry_Tandem

Operates Release From: RF Henry

Tandem Operation Rule: Millers Ferry_Tandem

Description:

Downstream Reservoir: Millers Ferry

MinRel=Inflow_up to 4630

Operates Release From: RF Henry

Rule Name: MinRel=Inflow_up to 4630

Description:

Function of: RF Henry-Pool Net Inflow, Current Value

Limit Type: Minimum

Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	0.0
4630.0	4630.0
9999.0	4630.0

☐ Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☐ Rising/Falling Condition

☐ Seasonal Variation

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.

IV. Alternative Operations (same as “Baseline”)

Twelve ResSim alternatives were developed to represent the Baseline operations and 11 Alternative operating plans. The “Baseline” operation set is used for all of the 12 ResSim alternatives at RF Henry.

Alabama-Coosa-Tallapoosa (ACT) Watershed

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

Appendix D – Millers Ferry Lock and Dam

March 2011 (DRAFT)

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Appendix D – Millers Ferry (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.

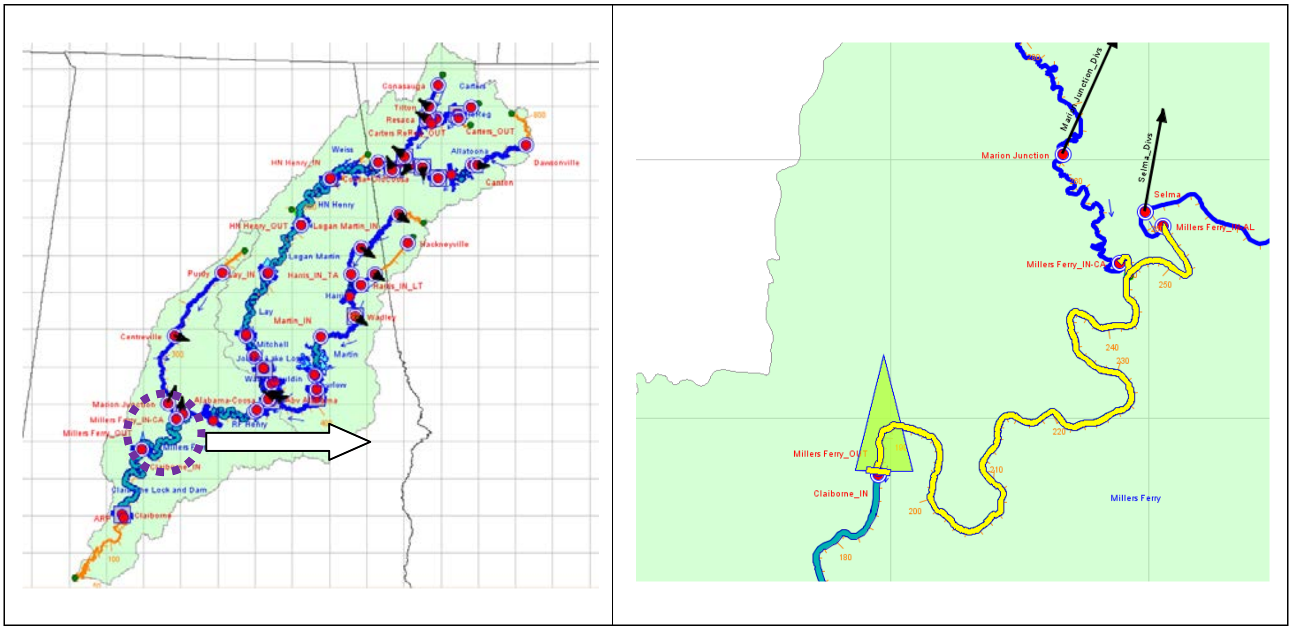


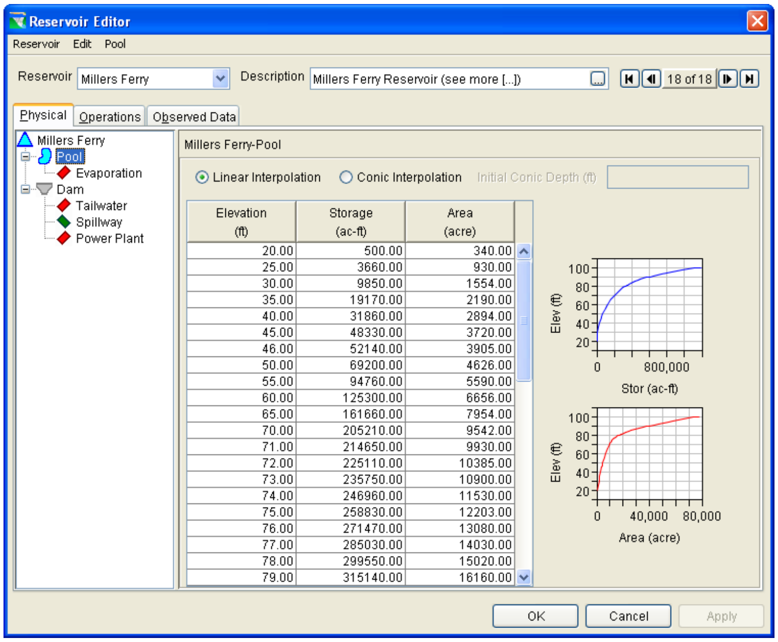
Figure D.01 HEC-ResSim Map Display Showing Location of Millers Ferry Lock and Dam

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.



Reservoir: Millers Ferry

Description: Millers Ferry Reservoir (see more [...])

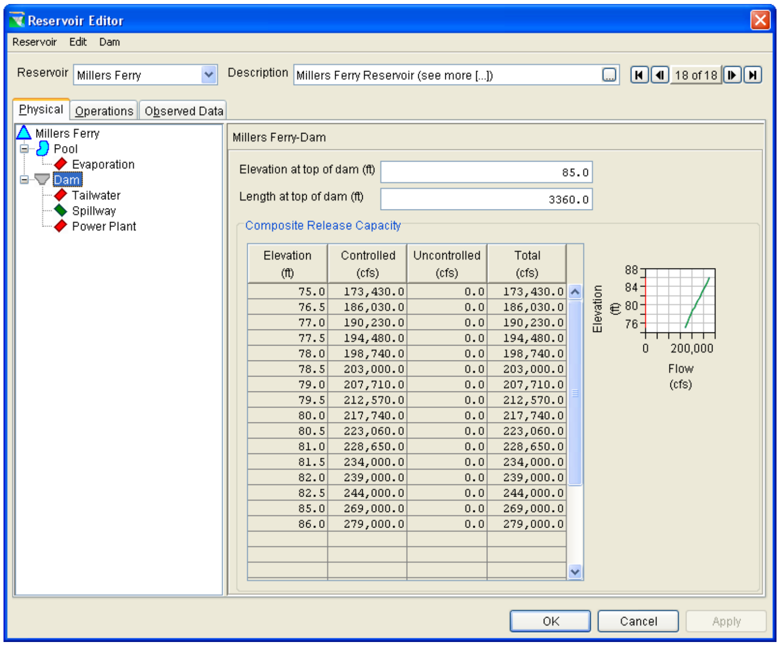
18 of 18

Millers Ferry-Pool

● Linear Interpolation ○ Conic Interpolation

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



Reservoir: Millers Ferry

Description: Millers Ferry Reservoir (see more [...])

18 of 18

Millers Ferry-Dam

Elevation at top of dam (ft): 85.0

Length at top of dam (ft): 3360.0

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

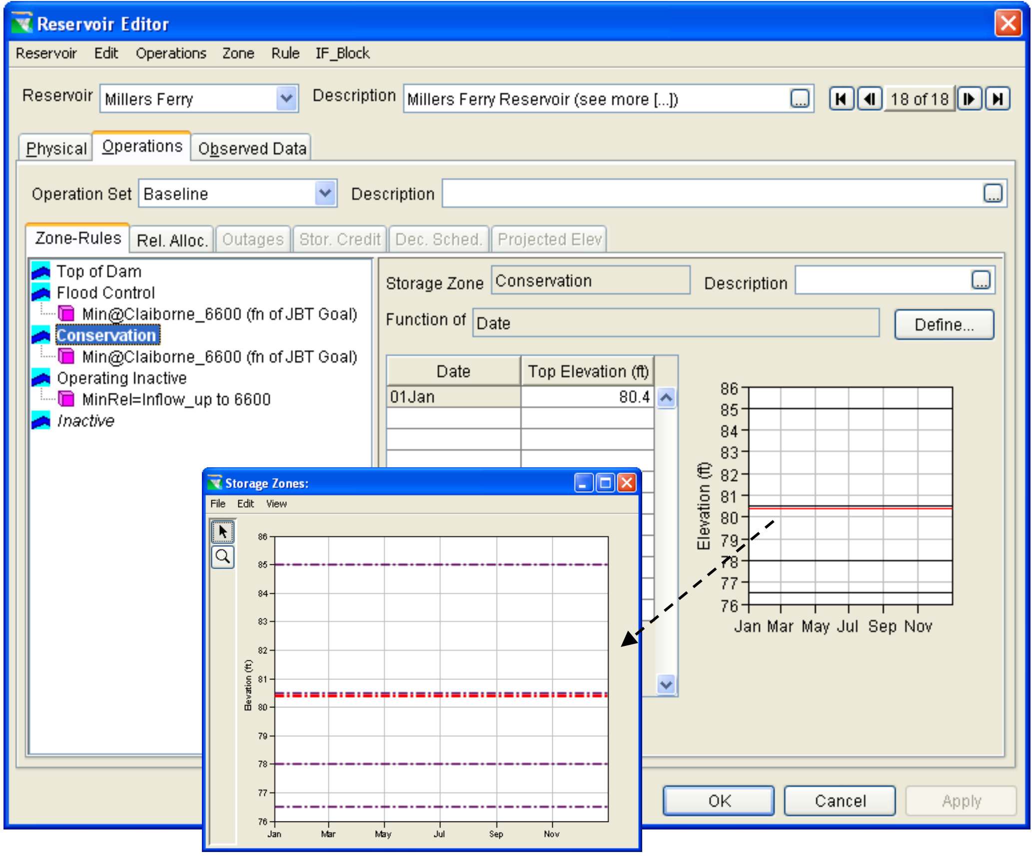
Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table D.01 shows the definition of Millers Ferry's "Baseline" operational zones, which consists of zones of flood control and conservation.

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)



Reservoir: Millers Ferry
Description: Millers Ferry Reservoir (see more [...])
18 of 18

Operation Set: Baseline
Description:

- Top of Dam
- Flood Control
  - Min@Claiborne_6600 (fn of JBT Goal)
- Conservation
  - Min@Claiborne_6600 (fn of JBT Goal)
- Operating Inactive
  - MinRel=Inflow_up to 6600
- *Inactive*

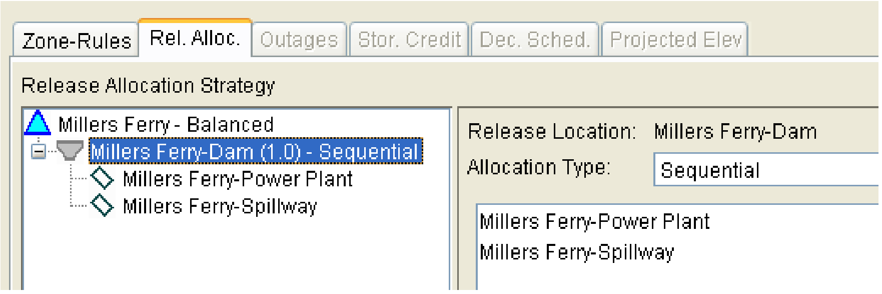
Storage Zone: Conservation
Description:
Function of: Date

Date	Top Elevation (ft)
01Jan	80.4

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:



Release Allocation Strategy

- Millers Ferry - Balanced
  - Millers Ferry-Dam (1.0) - Sequential
    - Millers Ferry-Power Plant
    - Millers Ferry-Spillway

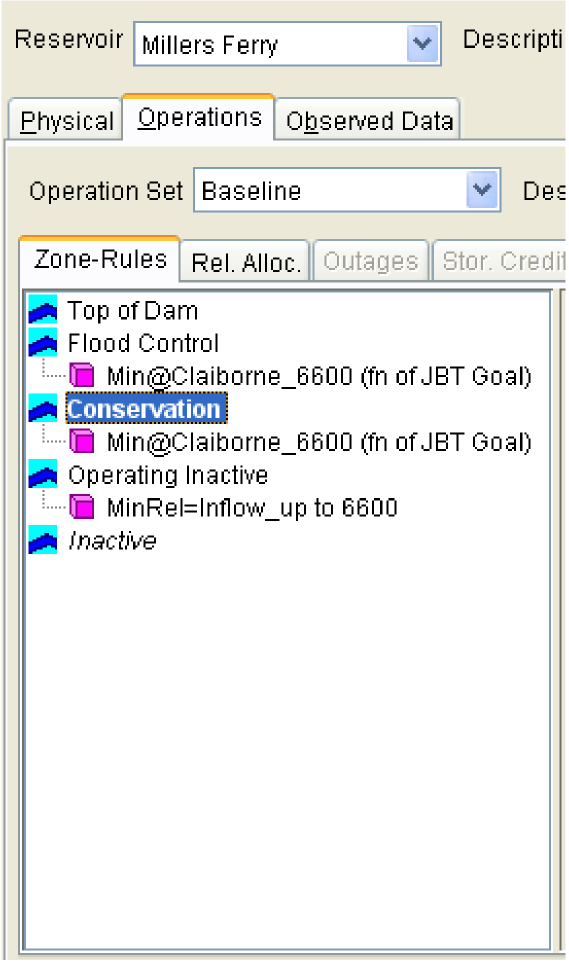
Release Location: Millers Ferry-Dam
Allocation Type: Sequential

Millers Ferry-Power Plant
Millers Ferry-Spillway

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”.

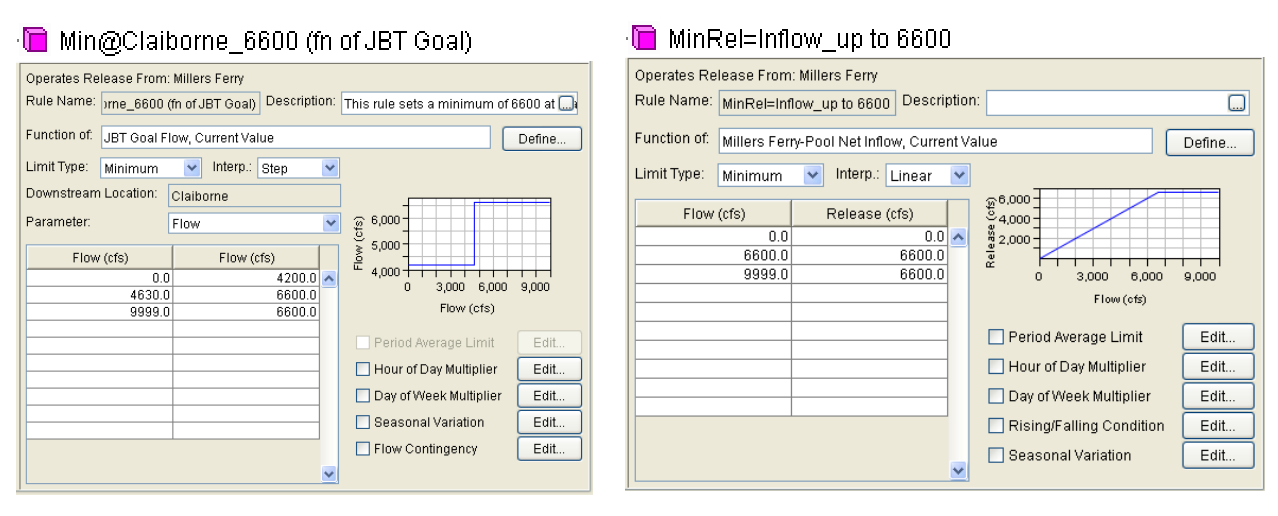

Reservoir: Millers Ferry

Operation Set: Baseline

- Top of Dam
- Flood Control
  - Min@Claiborne_6600 (fn of JBT Goal)
- Conservation
  - Min@Claiborne_6600 (fn of JBT Goal)
- Operating Inactive
  - MinRel=Inflow_up to 6600
- *Inactive*

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.



Min@Claiborne_6600 (fn of JBT Goal)

Operates Release From: Millers Ferry
Rule Name: orne_6600 (fn of JBT Goal)
Description: This rule sets a minimum of 6600 at
Function of: JBT Goal Flow, Current Value
Limit Type: Minimum
Interp.: Step
Downstream Location: Claiborne
Parameter: Flow

Flow (cfs)	Flow (cfs)
0.0	4200.0
4630.0	6600.0
9999.0	6600.0

MinRel=Inflow_up to 6600

Operates Release From: Millers Ferry
Rule Name: MinRel=Inflow_up to 6600
Description:
Function of: Millers Ferry-Pool Net Inflow, Current Value
Limit Type: Minimum
Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	0.0
6600.0	6600.0
9999.0	6600.0

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.

IV. Alternative Operations

Twelve ResSim alternatives were developed to represent the Baseline operations and 11 Alternative operating plans.

A. Operation Sets

For the 12 ResSim alternatives, Millers Ferry used 3 different operation sets. The operation set used for each alternative is shown in Table D.02. Table D.03 describes each operation set.

Table D.02 Alternatives and Operation Sets Used at Millers Ferry

Alternative	Operation Set
Baseline	Baseline
DroughtPln	Nav_Drought
Burkett	Nav_Drought
DragoA	Nav_Drought
DragoB	Nav_Drought
RPlanA	Nav_Drought
RPlanB	Nav_Drought
RPlanC	Nav_Drought-rev
RPlanD	Nav_Drought-rev
RPlanE	Nav_Drought-rev
RPlanF	Nav_Drought-rev
RPlanG	Nav_Drought-rev

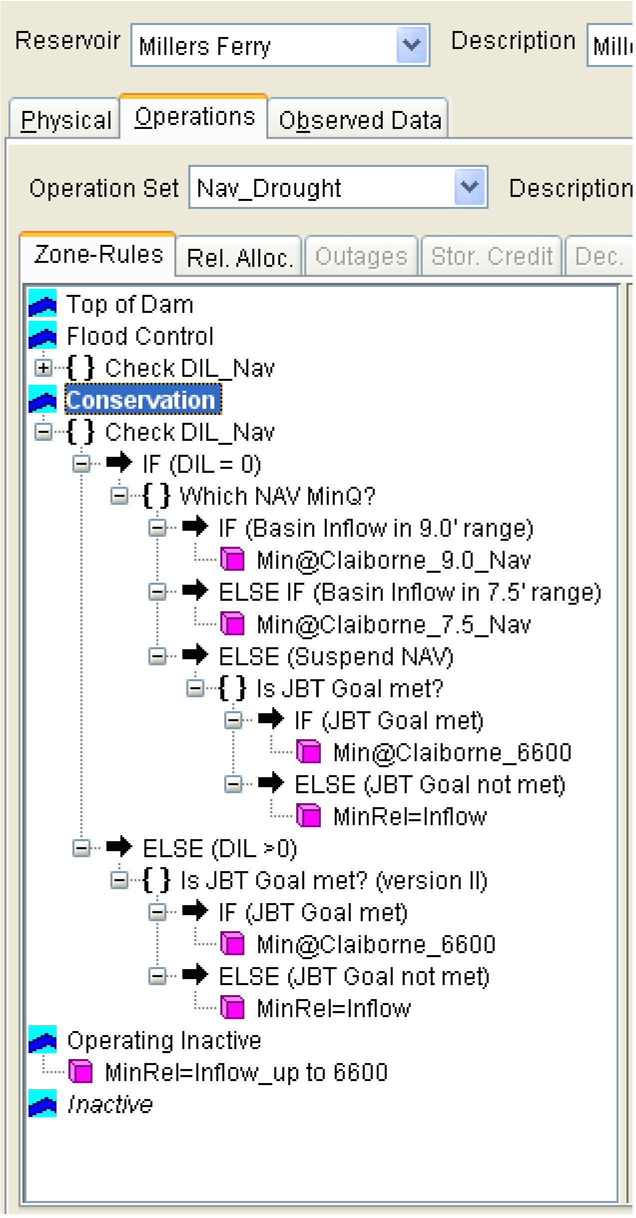
Table D.03 Operation Sets Used at Millers Ferry

Operation Set	Description
Baseline	Current operation / no action
Nav_Drought	Navigation flow target and drought plan with flow requirement reductions
Nav_Drought-rev	Same as Nav_Drought with revised Tallassee and Alabama River flow requirement

The difference in the “Baseline” operation set and the “Nav_Drought” operation set is the rules governing the minimum flow at Claiborne. In the “Baseline” operation set, the minimum flow at Claiborne is determined by the flow at JBT Goal. The “Nav_Drought” operation set uses the drought intensity level (DIL) along with the basin inflow computation (from the state variable NAV_CheckBI which is defined in detail in the state variable appendix) to determine the minimum flow at Claiborne.

The “Nav_Drought-rev” operation set is the same as the “Nav_Drought” operation set, but it uses different values to determine if the Low Basin Inflow criteria (one of the DIL triggers) has been activated. The rule set for the “Nav_Drought” operation set is shown in Figure D.09 and the rule set for the “Nav_Drought-rev” operation set is shown in Figure D.10. The Check DIL_Nav conditional block is used in both Flood Control and Conservation and is shown in its expanded form in the Conservation zone in these two figures. The individual rules not used in the “Baseline” operation set are shown in Figure D.11 (see Section B), followed by explanation of the rules in Section C. A summary of these rules is given in Table D.04.

1. “Nav_Drought” Operation Set



Reservoir: Millers Ferry

Description: Mill

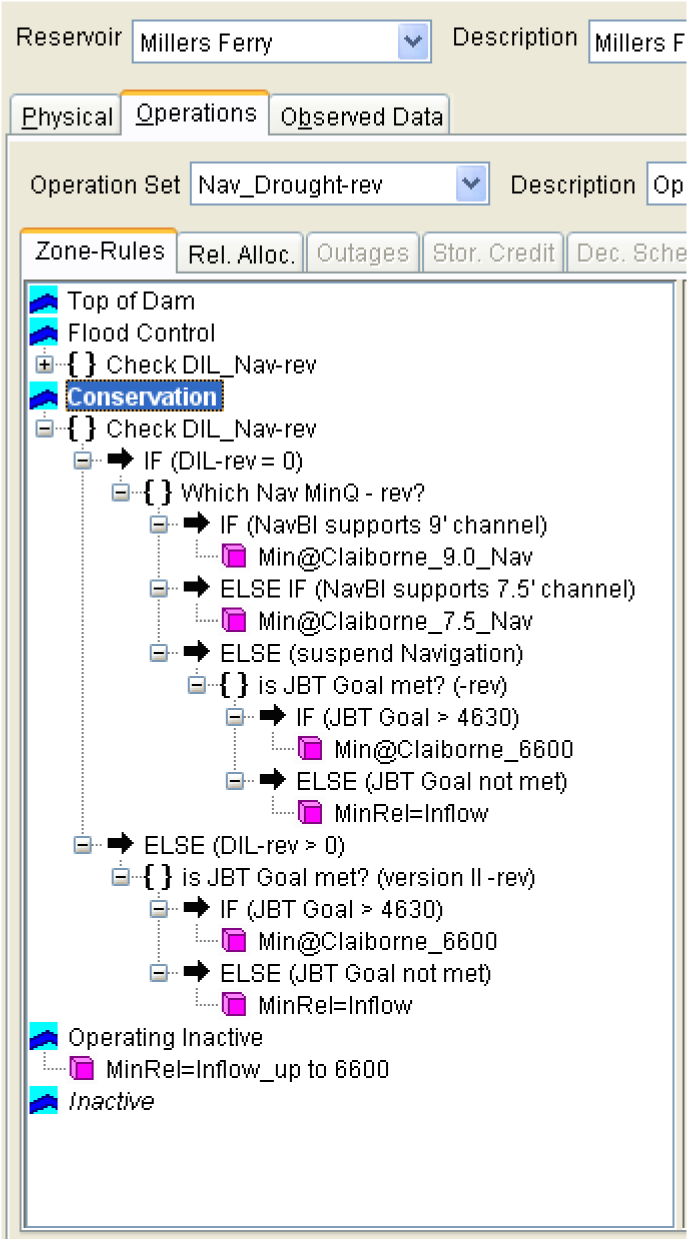
Operation Set: Nav_Drought

Description

- Top of Dam
- Flood Control
  - { } Check DIL_Nav
- Conservation
  - { } Check DIL_Nav
    - IF (DIL = 0)
      - { } Which NAV MinQ?
        - IF (Basin Inflow in 9.0' range)
          - Min@Claiborne_9.0_Nav
        - ELSE IF (Basin Inflow in 7.5' range)
          - Min@Claiborne_7.5_Nav
        - ELSE (Suspend NAV)
          - { } Is JBT Goal met?
            - IF (JBT Goal met)
              - Min@Claiborne_6600
            - ELSE (JBT Goal not met)
              - MinRel=Inflow
    - ELSE (DIL >0)
      - { } Is JBT Goal met? (version II)
        - IF (JBT Goal met)
          - Min@Claiborne_6600
        - ELSE (JBT Goal not met)
          - MinRel=Inflow
- Operating Inactive
  - MinRel=Inflow_up to 6600
- *Inactive*

Figure D.09 Reservoir Editor: Operations Tab – Nav_Drought OpSet – Zones and Rules

2. “Nav_Drought-rev” Operation Set



Reservoir: Millers Ferry

Description: Millers F

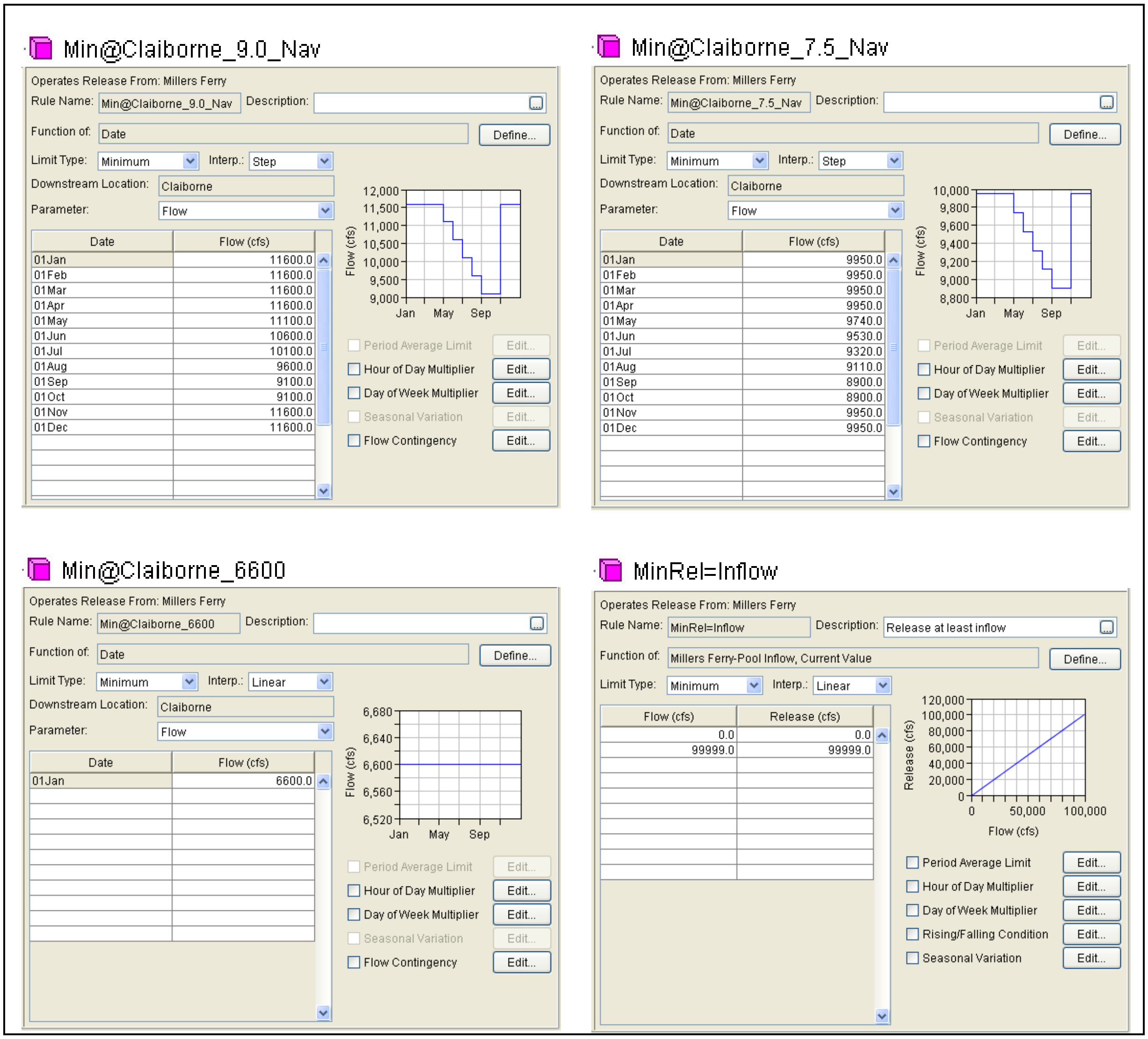
Operation Set: Nav_Drought-rev

Description: Op

```
Top of Dam
Flood Control
  { } Check DIL_Nav-rev
Conservation
  { } Check DIL_Nav-rev
      IF (DIL-rev = 0)
          { } Which Nav MinQ - rev?
              IF (NavBl supports 9' channel)
                  Min@Claiborne_9.0_Nav
              ELSE IF (NavBl supports 7.5' channel)
                  Min@Claiborne_7.5_Nav
              ELSE (suspend Navigation)
                  { } is JBT Goal met? (-rev)
                      IF (JBT Goal > 4630)
                          Min@Claiborne_6600
                      ELSE (JBT Goal not met)
                          MinRel=Inflow
      ELSE (DIL-rev > 0)
          { } is JBT Goal met? (version II -rev)
              IF (JBT Goal > 4630)
                  Min@Claiborne_6600
              ELSE (JBT Goal not met)
                  MinRel=Inflow
Operating Inactive
  MinRel=Inflow_up to 6600
Inactive
```

Figure D.10 Reservoir Editor: Operations Tab – Nav_Drought OpSet – Zones and Rules

B. Rule Illustrations



Min@Claiborne_9.0_Nav

Operates Release From: Millers Ferry
Rule Name: Min@Claiborne_9.0_Nav Description:
Function of: Date
Limit Type: Minimum Interp.: Step
Downstream Location: Claiborne
Parameter: Flow

Date	Flow (cfs)
01Jan	11600.0
01Feb	11600.0
01Mar	11600.0
01Apr	11600.0
01May	11100.0
01Jun	10600.0
01Jul	10100.0
01Aug	9600.0
01Sep	9100.0
01Oct	9100.0
01Nov	11600.0
01Dec	11600.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Min@Claiborne_7.5_Nav

Operates Release From: Millers Ferry
Rule Name: Min@Claiborne_7.5_Nav Description:
Function of: Date
Limit Type: Minimum Interp.: Step
Downstream Location: Claiborne
Parameter: Flow

Date	Flow (cfs)
01Jan	9950.0
01Feb	9950.0
01Mar	9950.0
01Apr	9950.0
01May	9740.0
01Jun	9530.0
01Jul	9320.0
01Aug	9110.0
01Sep	8900.0
01Oct	8900.0
01Nov	9950.0
01Dec	9950.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Min@Claiborne_6600

Operates Release From: Millers Ferry
Rule Name: Min@Claiborne_6600 Description:
Function of: Date
Limit Type: Minimum Interp.: Linear
Downstream Location: Claiborne
Parameter: Flow

Date	Flow (cfs)
01Jan	6600.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

MinRel=Inflow

Operates Release From: Millers Ferry
Rule Name: MinRel=Inflow Description: Release at least inflow
Function of: Millers Ferry-Pool Inflow, Current Value
Limit Type: Minimum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	0.0
99999.0	99999.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Figure D.11 Reservoir Editor: Operations Tab – Nav_Drought OpSet – Minimum Rules

C. Rule Descriptions

1. *Min@Claiborne_9.0_Nav*

This rule (see Figure D.11) sets the minimum release into Claiborne Lock and Dam when the DIL=0 and the basin inflow is sufficient to support a 9.0 ft navigation channel. The minimum release varies between 9,100 cfs and 11,600 cfs depending on the time of year.

2. *Min@Claiborne_7.5_Nav*

This rule (see Figure D.11) sets the minimum release into Claiborne Lock and Dam when the DIL=0 and the basin inflow is sufficient to support a 7.5 ft navigation channel. The minimum release varies between 8,900 cfs and 9,950 cfs depending on the time of year.

3. *Min@Claiborne_6600*

This rule (see Figure D.11) sets the minimum release into Claiborne Lock and Dam when the DIL=0, the basin inflow is not sufficient to support a 7.5 ft navigation channel, and the flow at JBT Goal is greater than or equal to 4,630 cfs. This rule also applies when the DIL is equal to 1, 2, or 3 and the flow at JBT Goal is greater than or equal to 4,630 cfs. The minimum release is set to a constant value of 4,630 cfs throughout the entire year.

4. *MinRel=Inflow*

This rule (see Figure D.11) sets the minimum release from Millers Ferry when the DIL=0, the basin inflow is not sufficient to support a 7.5 ft navigation channel, and the flow at JBT Goal is less than 4,630 cfs. This rule also applies when the DIL is equal to 1, 2, or 3 and the flow at JBT Goal is less than 4,630 cfs. The minimum release is set to the inflow into Millers Ferry.

Table D.03 Summary of Minimum Flow at Claiborne Rules for Millers Ferry

min flow at Claiborne for **Baseline** operation set		min flow at Claiborne for **Nav_Drought** operation set				
JBT Goal flow	min flow at Claiborne	Date	DIL=0 and basin Inflow in 9 ft range	DIL=0 and basin Inflow in 7.5 ft range	DIL=0 and basin inflow < 7.5 ft range with JBT Goal >= 4,630 or DIL>0 with JBT Goal flow >= 4,630	DIL=0 and basin inflow < 7.5 ft range with JBT Goal < 4,630 or DIL>0 with JBTGoal flow < 4,630
0	4,200	1-Jan	11,600	9,950	6,600	min release = inflow
4,630	6,600	1-Feb	11,600	9,950	6,600	min release = inflow
9,999	6,600	1-Mar	11,600	9,950	6,600	min release = inflow
		1-Apr	11,600	9,950	6,600	min release = inflow
		1-May	11,100	9,740	6,600	min release = inflow
		1-Jun	10,600	9,530	6,600	min release = inflow
		1-Jul	10,100	9,320	6,600	min release = inflow
		1-Aug	9,600	9,110	6,600	min release = inflow
		1-Sep	9,100	8,900	6,600	min release = inflow
		1-Oct	9,100	8,900	6,600	min release = inflow
*step function used between all values		1-Nov	11,600	9,950	6,600	min release = inflow
		1-Dec	11,600	9,950	6,600	min release = inflow

Alabama-Coosa-Tallapoosa (ACT) Watershed

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

Appendix E – Weiss Reservoir

March 2011 (DRAFT)

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Appendix E – Weiss (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.

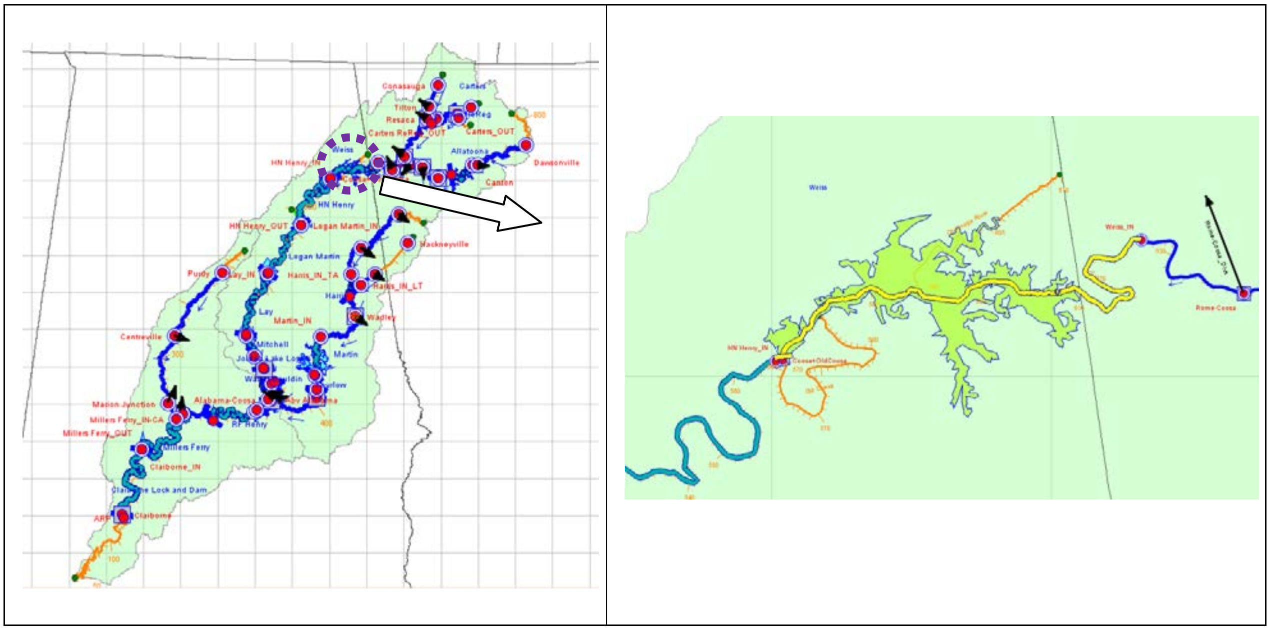


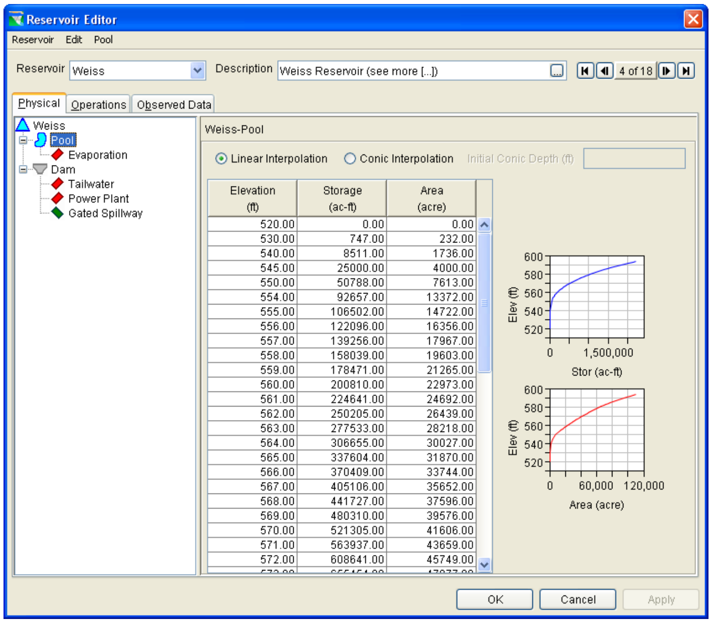
Figure E.01 HEC-ResSim Map Display Showing Location of Weiss Reservoir

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.



Reservoir: Weiss

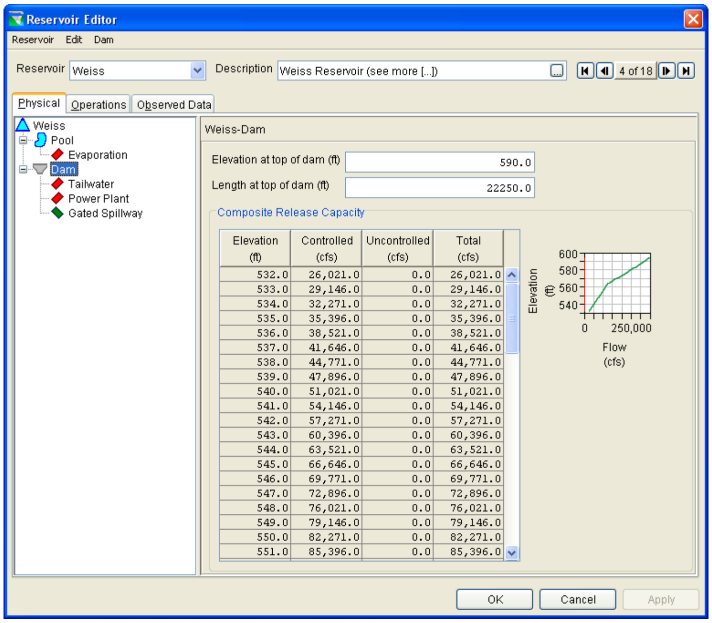
Description: Weiss Reservoir (see more [...])

Weiss-Pool

● Linear Interpolation ○ Conic Interpolation Initial Conic Depth (ft)

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



Reservoir: Weiss

Description: Weiss Reservoir (see more [...])

Weiss-Dam

Elevation at top of dam (ft): 590.0

Length at top of dam (ft): 22250.0

Composite Release Capacity

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

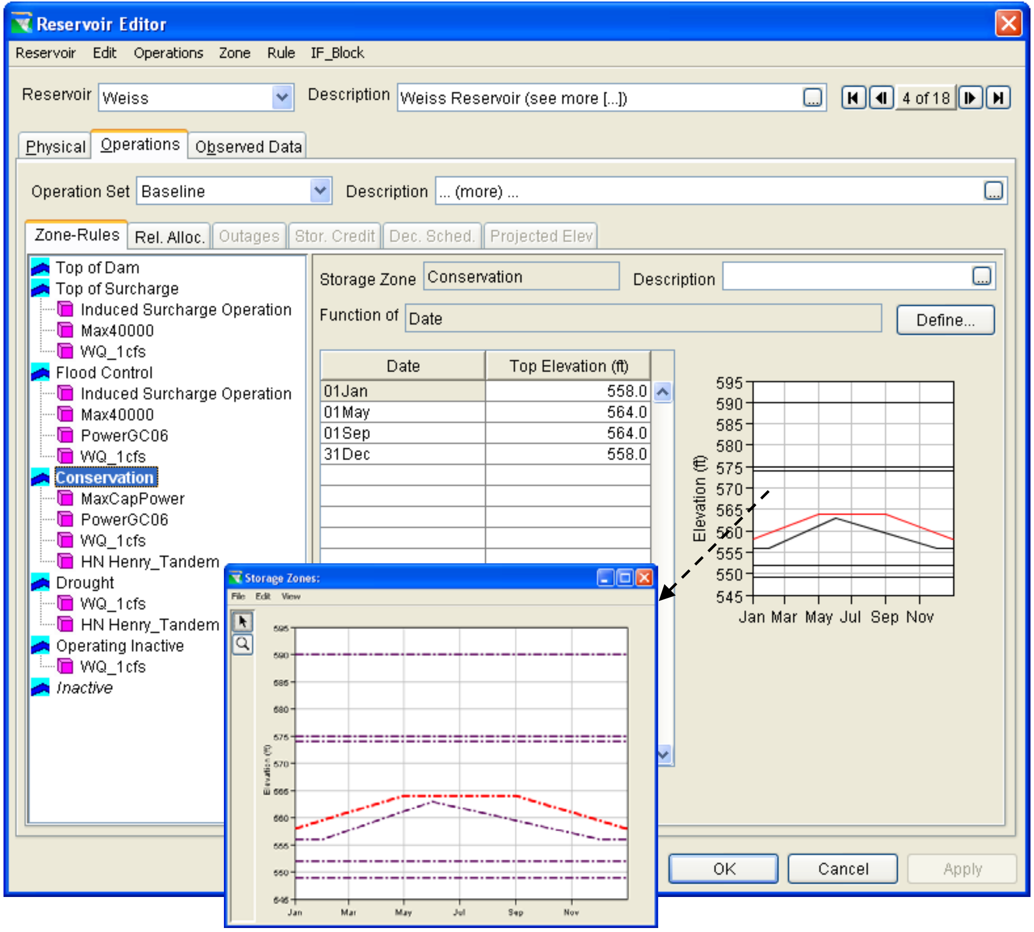
Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table E.01 shows the definition of "Baseline" operational zones for Weiss Reservoir, which consists of zones of flood control and conservation.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



Reservoir: Weiss
Description: Weiss Reservoir (see more [...])

Operation Set: Baseline
Description: ... (more) ...

- Top of Dam
- Top of Surcharge
  - Induced Surcharge Operation
  - Max40000
  - WQ_1cfs
- Flood Control
  - Induced Surcharge Operation
  - Max40000
  - PowerGC06
  - WQ_1cfs
- Conservation
  - MaxCapPower
  - PowerGC06
  - WQ_1cfs
  - HN Henry_Tandem
- Drought
  - WQ_1cfs
  - HN Henry_Tandem
- Operating Inactive
  - WQ_1cfs
- *Inactive*

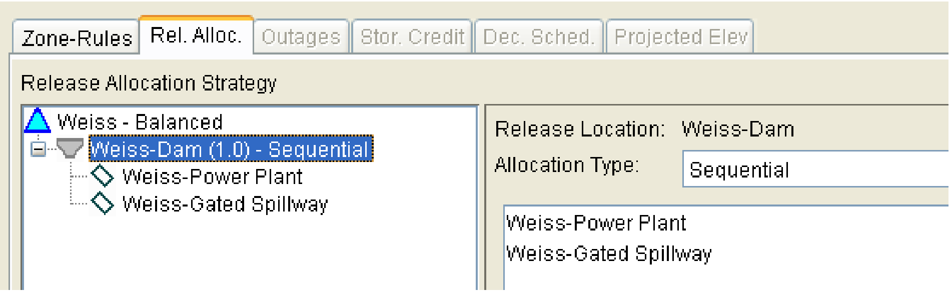
Storage Zone: Conservation
Description:
Function of: Date

Date	Top Elevation (ft)
01Jan	558.0
01May	564.0
01Sep	564.0
31Dec	558.0

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:



Release Allocation Strategy

- Weiss - Balanced
  - Weiss-Dam (1.0) - Sequential
    - Weiss-Power Plant
    - Weiss-Gated Spillway

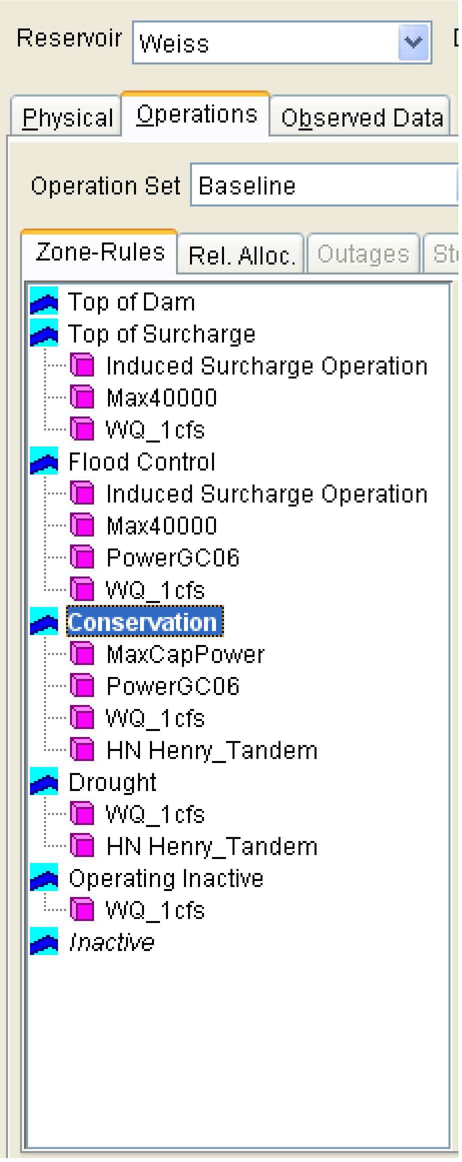
Release Location: Weiss-Dam
Allocation Type: Sequential

Weiss-Power Plant
Weiss-Gated Spillway

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”.



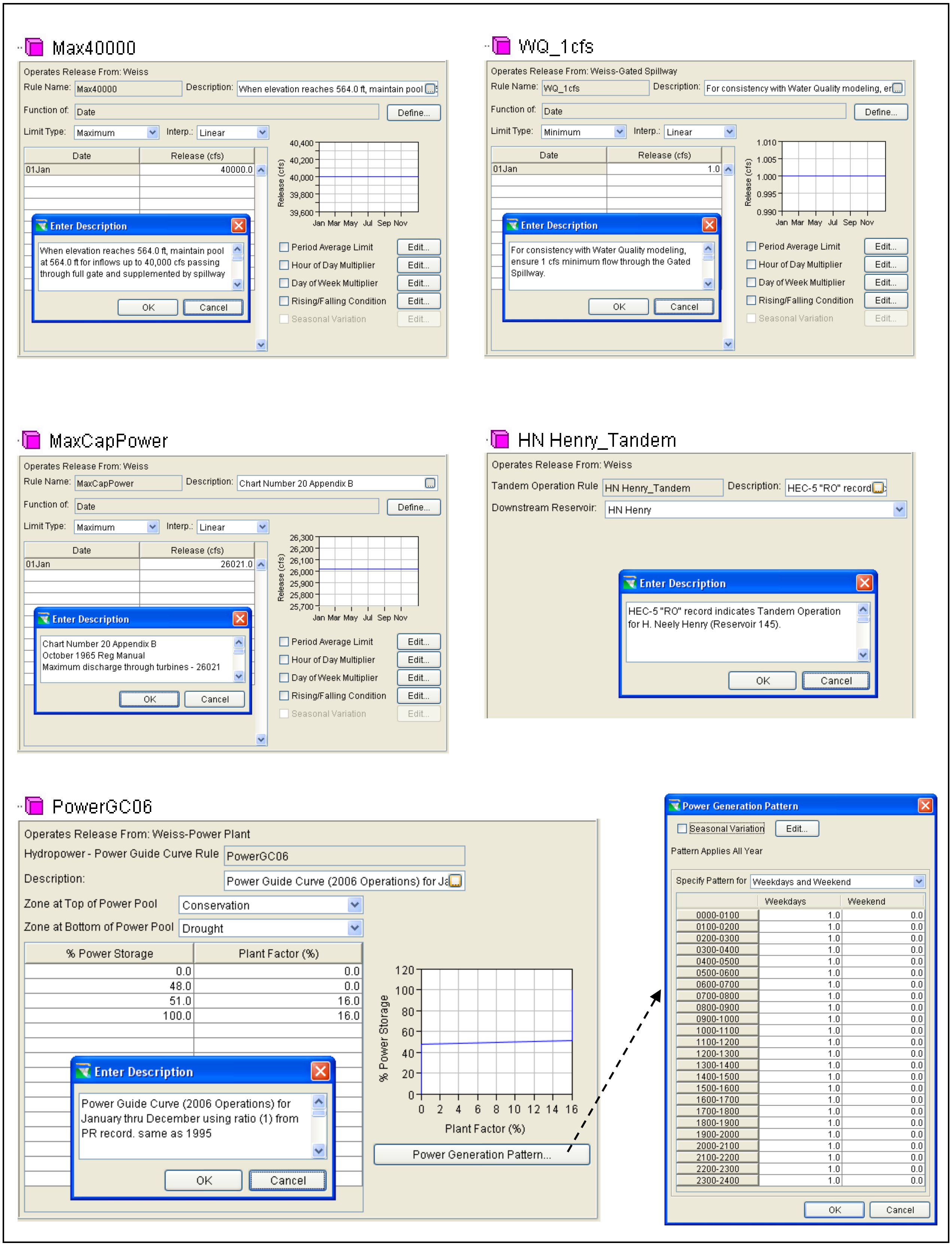
Reservoir Weiss

Operation Set Baseline

- Top of Dam
- Top of Surcharge
  - Induced Surcharge Operation
  - Max40000
  - WQ_1cfs
- Flood Control
  - Induced Surcharge Operation
  - Max40000
  - PowerGC06
  - WQ_1cfs
- Conservation
  - MaxCapPower
  - PowerGC06
  - WQ_1cfs
  - HN Henry_Tandem
- Drought
  - WQ_1cfs
  - HN Henry_Tandem
- Operating Inactive
  - WQ_1cfs
- *Inactive*

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.



Max40000

Operates Release From: Weiss
Rule Name: Max40000
Description: When elevation reaches 564.0 ft, maintain pool
Function of: Date
Limit Type: Maximum
Interp.: Linear

Date	Release (cfs)
01Jan	40000.0

Enter Description:
When elevation reaches 564.0 ft, maintain pool at 564.0 ft for inflows up to 40,000 cfs passing through full gate and supplemented by spillway

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

WQ_1cfs

Operates Release From: Weiss-Gated Spillway
Rule Name: WQ_1cfs
Description: For consistency with Water Quality modeling, er
Function of: Date
Limit Type: Minimum
Interp.: Linear

Date	Release (cfs)
01Jan	1.0

Enter Description:
For consistency with Water Quality modeling, ensure 1 cfs minimum flow through the Gated Spillway.

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

MaxCapPower

Operates Release From: Weiss
Rule Name: MaxCapPower
Description: Chart Number 20 Appendix B
Function of: Date
Limit Type: Maximum
Interp.: Linear

Date	Release (cfs)
01Jan	26021.0

Enter Description:
Chart Number 20 Appendix B
October 1965 Reg Manual
Maximum discharge through turbines - 26021

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

HN Henry_Tandem

Operates Release From: Weiss
Tandem Operation Rule: HN Henry_Tandem
Description: HEC-5 "RO" record
Downstream Reservoir: HN Henry

Enter Description:
HEC-5 "RO" record indicates Tandem Operation for H. Neely Henry (Reservoir 145).

PowerGC06

Operates Release From: Weiss-Power Plant
Hydropower - Power Guide Curve Rule: PowerGC06
Description: Power Guide Curve (2006 Operations) for Ja
Zone at Top of Power Pool: Conservation
Zone at Bottom of Power Pool: Drought

% Power Storage	Plant Factor (%)
0.0	0.0
48.0	0.0
51.0	16.0
100.0	16.0

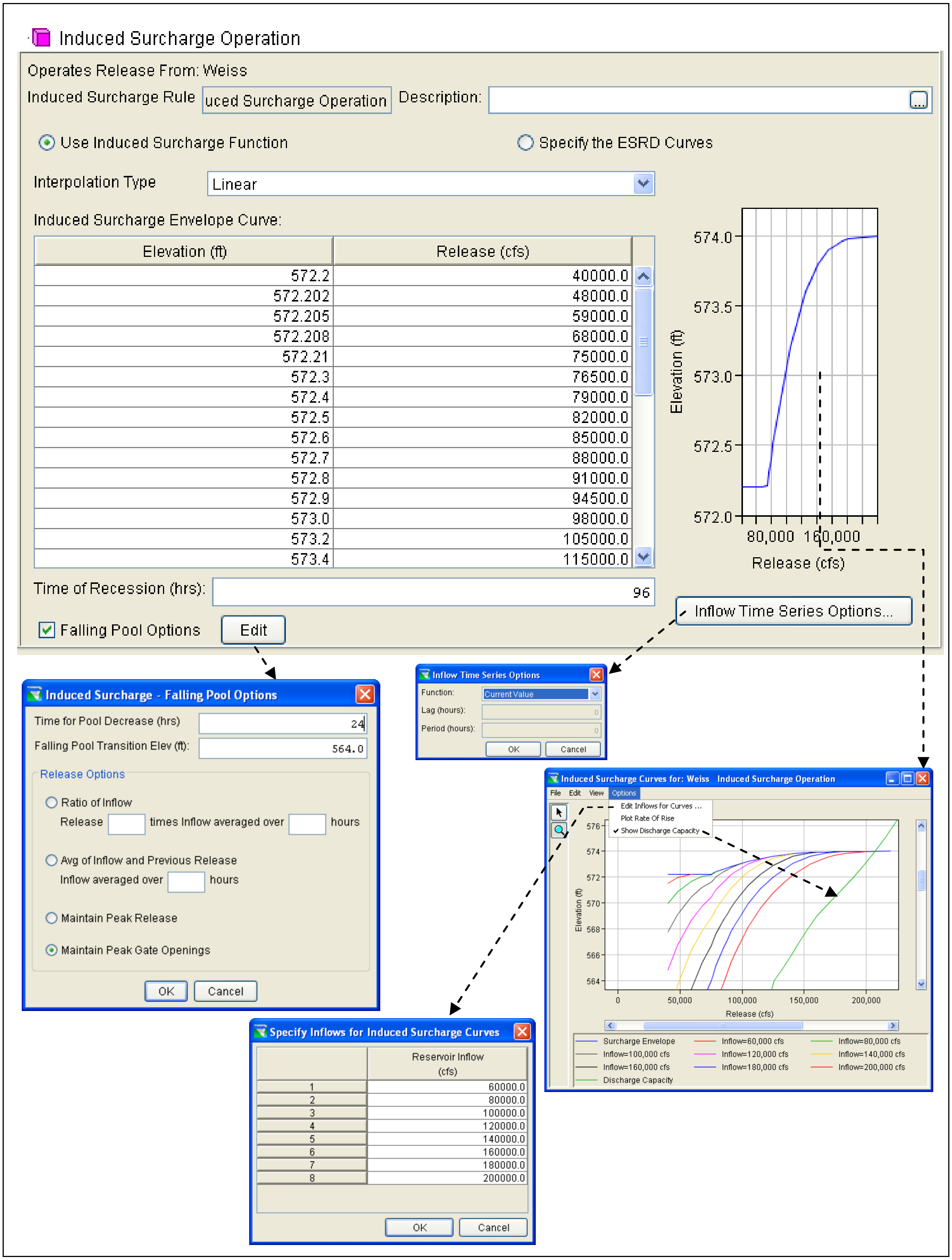
Enter Description:
Power Guide Curve (2006 Operations) for January thru December using ratio (1) from PR record. same as 1995

Power Generation Pattern

☐ Seasonal Variation
Pattern Applies All Year
Specify Pattern for: Weekdays and Weekend

	Weekdays	Weekend
0000-0100	1.0	0.0
0100-0200	1.0	0.0
0200-0300	1.0	0.0
0300-0400	1.0	0.0
0400-0500	1.0	0.0
0500-0600	1.0	0.0
0600-0700	1.0	0.0
0700-0800	1.0	0.0
0800-0900	1.0	0.0
0900-1000	1.0	0.0
1000-1100	1.0	0.0
1100-1200	1.0	0.0
1200-1300	1.0	0.0
1300-1400	1.0	0.0
1400-1500	1.0	0.0
1500-1600	1.0	0.0
1600-1700	1.0	0.0
1700-1800	1.0	0.0
1800-1900	1.0	0.0
1900-2000	1.0	0.0
2000-2100	1.0	0.0
2100-2200	1.0	0.0
2200-2300	1.0	0.0
2300-2400	1.0	0.0

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



Induced Surcharge Operation

Operates Release From: Weiss

Induced Surcharge Rule: uced Surcharge Operation

Description:

● Use Induced Surcharge Function

○ Specify the ESRD Curves

Interpolation Type: Linear

Induced Surcharge Envelope Curve:

Elevation (ft)	Release (cfs)
572.2	40000.0
572.202	48000.0
572.205	59000.0
572.208	68000.0
572.21	75000.0
572.3	76500.0
572.4	79000.0
572.5	82000.0
572.6	85000.0
572.7	88000.0
572.8	91000.0
572.9	94500.0
573.0	98000.0
573.2	105000.0
573.4	115000.0

Time of Recession (hrs): 96

☑ Falling Pool Options

Induced Surcharge - Falling Pool Options

Time for Pool Decrease (hrs): 24

Falling Pool Transition Elev (ft): 564.0

Release Options

○ Ratio of Inflow

Release ___ times Inflow averaged over ___ hours

○ Avg of Inflow and Previous Release

Inflow averaged over ___ hours

○ Maintain Peak Release

● Maintain Peak Gate Openings

Inflow Time Series Options

Function: Current Value

Lag (hours): 0

Period (hours): 0

Induced Surcharge Curves for: Weiss Induced Surcharge Operation

Specify Inflows for Induced Surcharge Curves

	Reservoir Inflow (cfs)
1	60000.0
2	80000.0
3	100000.0
4	120000.0
5	140000.0
6	160000.0
7	180000.0
8	200000.0

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.

IV. Alternative Operations (same as “Baseline”)

Twelve ResSim alternatives were developed to represent the Baseline operations and 11 Alternative operating plans. The “Baseline” operation set is used for all of the 12 ResSim alternatives at Weiss.

Alabama-Coosa-Tallapoosa (ACT) Watershed

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

Appendix F– H Neely Henry Reservoir

March 2011 (DRAFT)

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Appendix F – HN Henry (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.

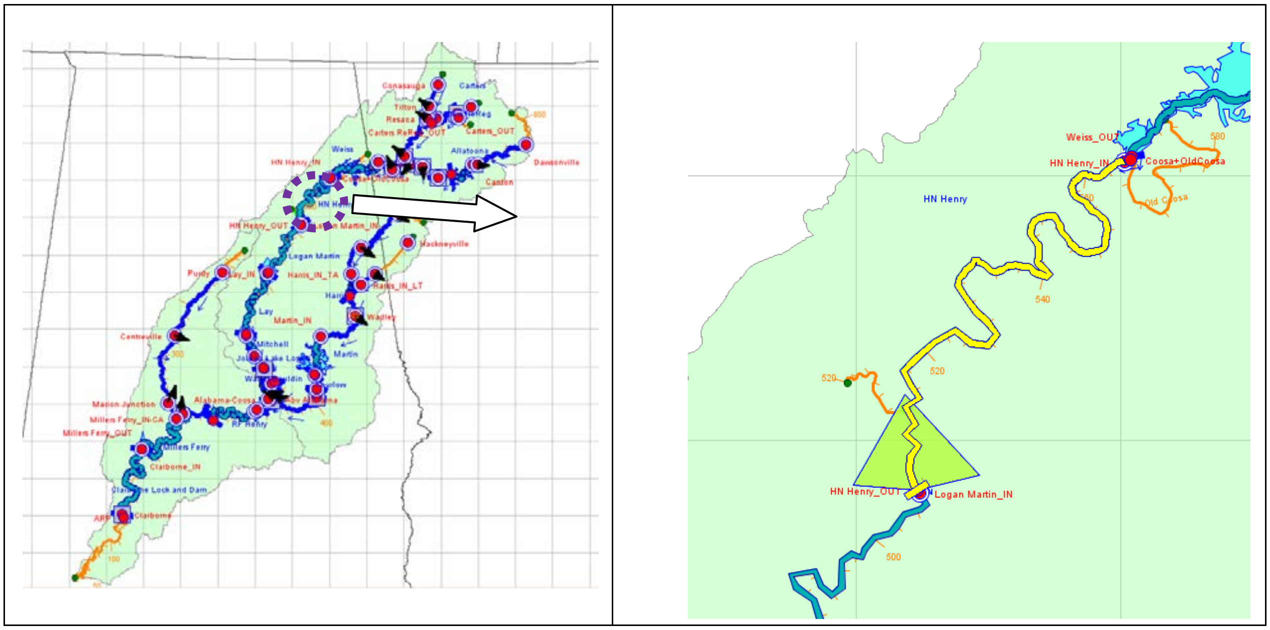


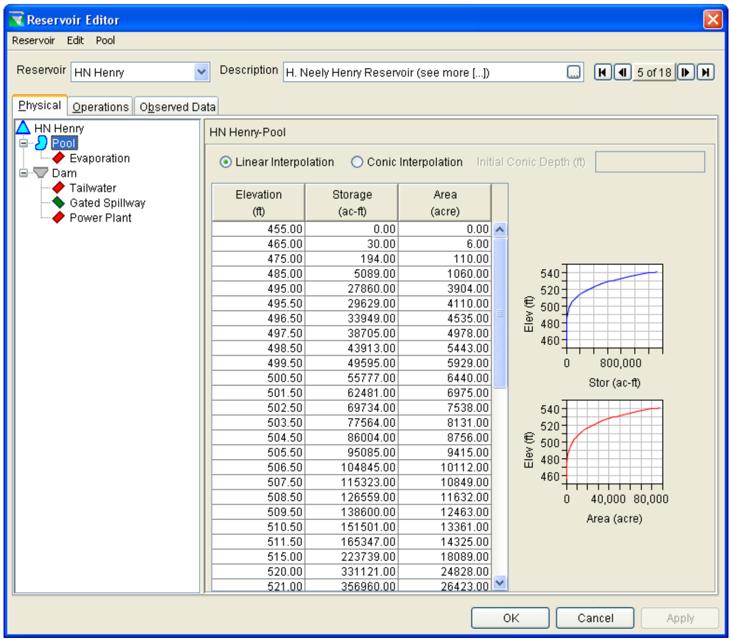
Figure F.01 HEC-ResSim Map Display Showing Location of HN Henry Reservoir

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.



Reservoir: HN Henry

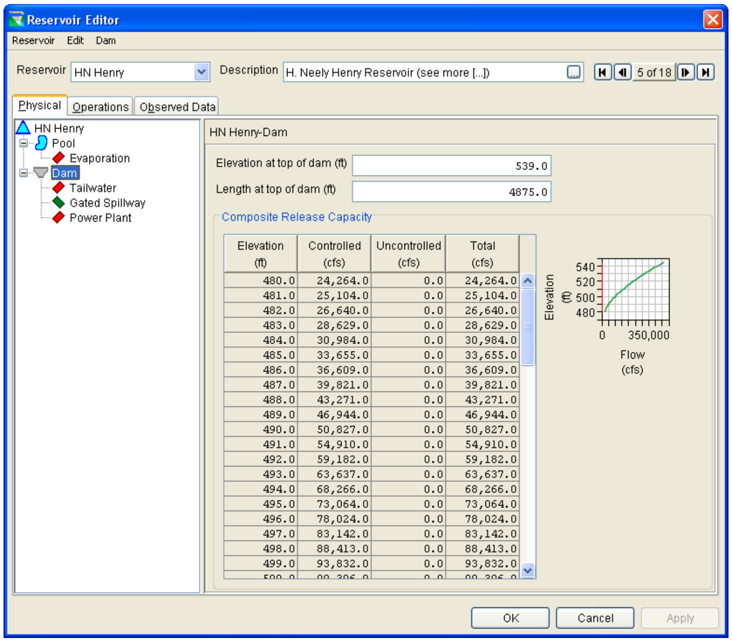
Description: H. Neely Henry Reservoir (see more [...])

HN Henry-Pool

● Linear Interpolation ○ Conic Interpolation Initial Conic Depth (ft)

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



Reservoir: HN Henry

Description: H. Neely Henry Reservoir (see more [...])

HN Henry-Dam

Elevation at top of dam (ft): 539.0

Length at top of dam (ft): 4875.0

Composite Release Capacity

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

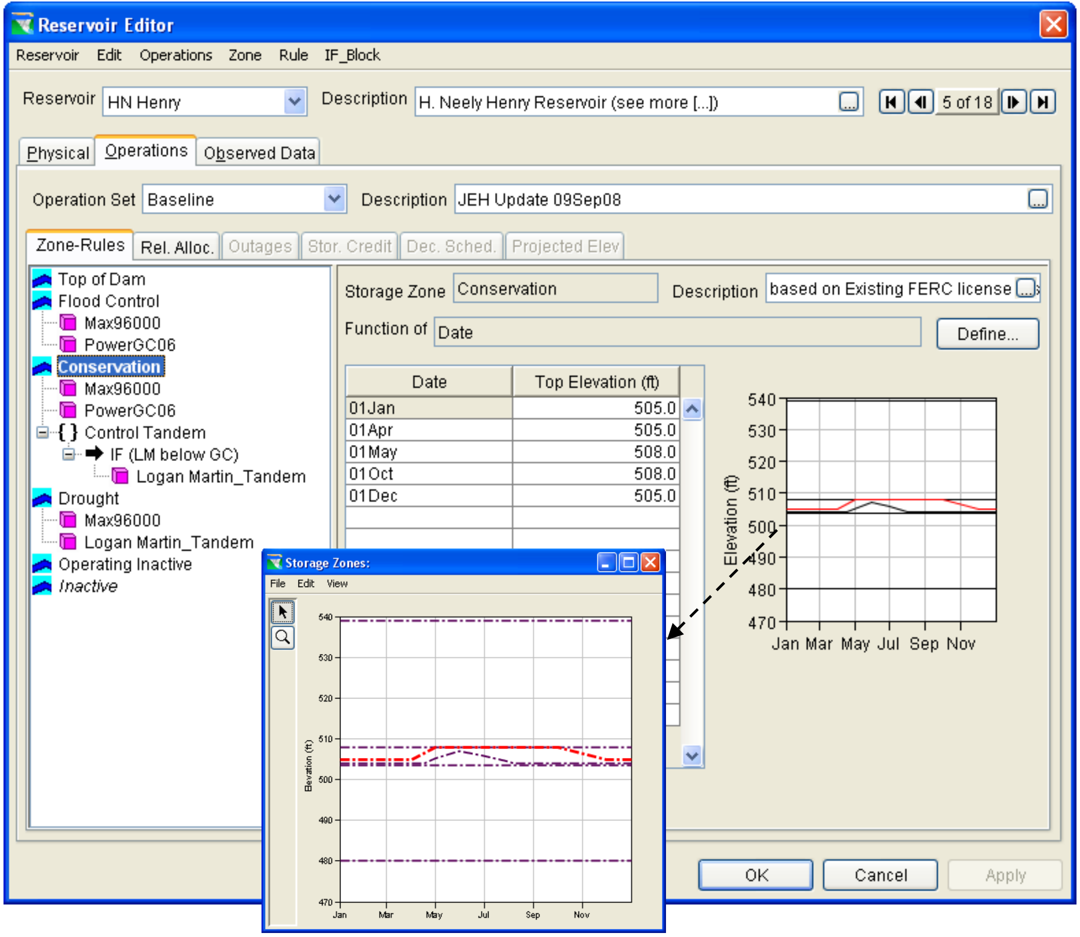
Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table F.01 shows the definition of “Baseline” operational zones for HN Henry Reservoir, which consists of zones of flood control and conservation. 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)



Reservoir: HN Henry
Description: H. Neely Henry Reservoir (see more [...])
5 of 18

Operation Set: Baseline
Description: JEH Update 09Sep08

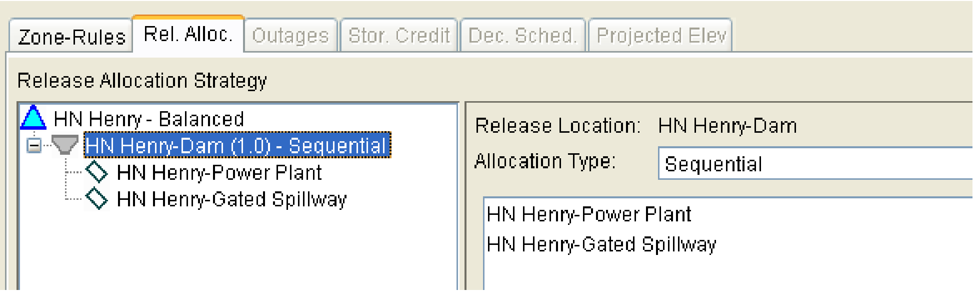
Storage Zone: Conservation
Description: based on Existing FERC license
Function of: Date

Date	Top Elevation (ft)
01Jan	505.0
01Apr	505.0
01May	508.0
01Oct	508.0
01Dec	505.0

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:



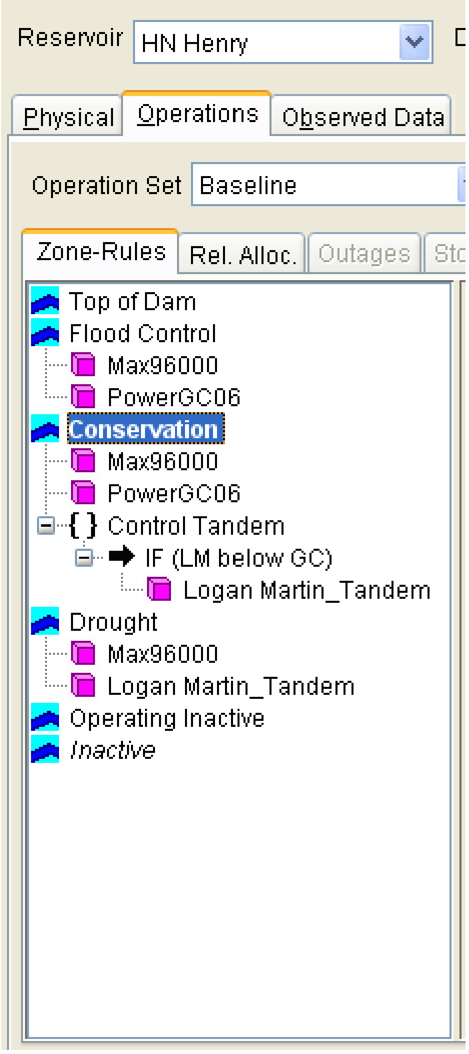
Release Location: HN Henry-Dam
Allocation Type: Sequential

HN Henry-Power Plant
HN Henry-Gated Spillway

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”.



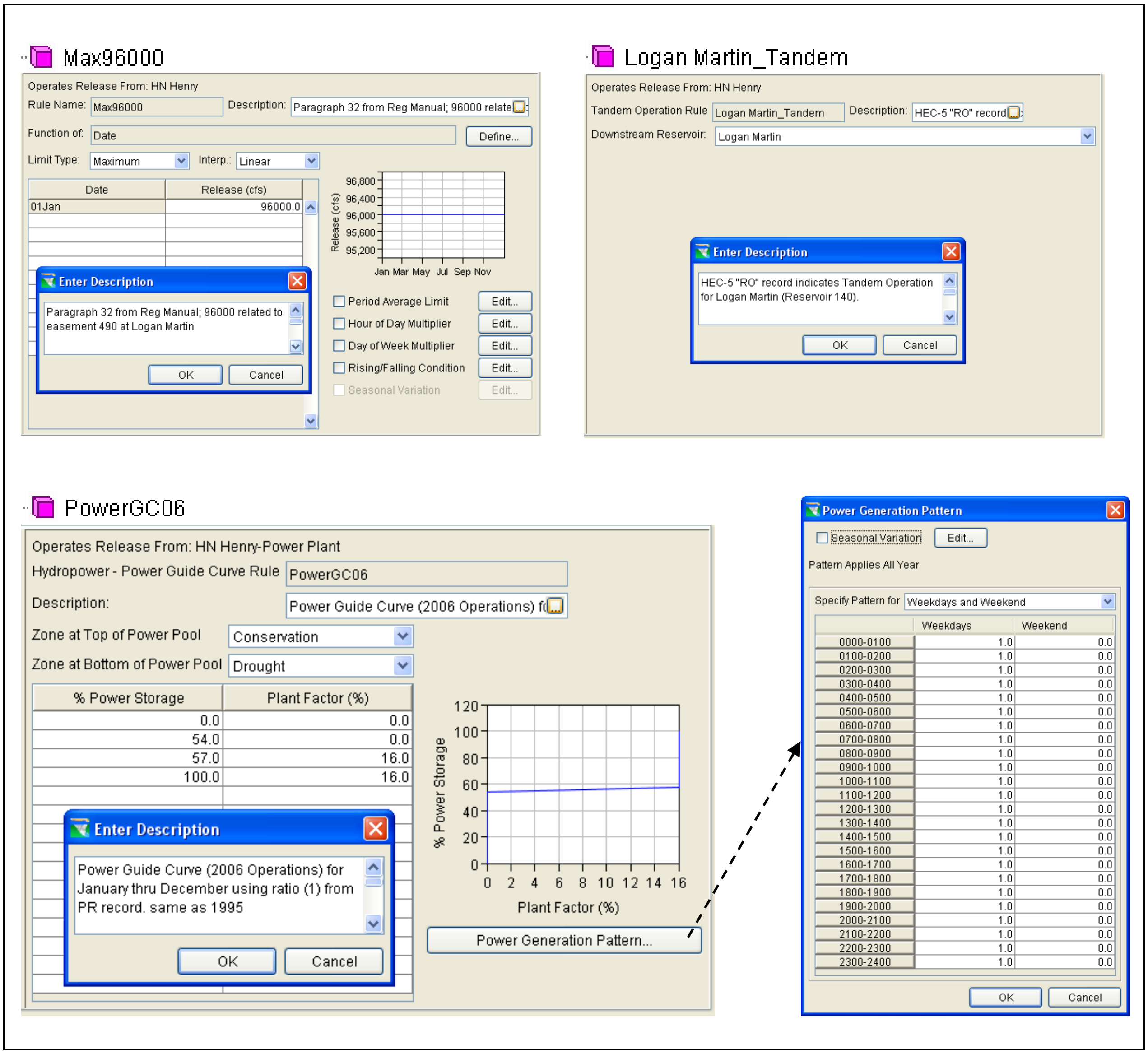
Reservoir: HN Henry

Operation Set: Baseline

- Top of Dam
- Flood Control
  - Max96000
  - PowerGC06
- Conservation
  - Max96000
  - PowerGC06
  - { } Control Tandem
    - IF (LM below GC)
      - Logan Martin_Tandem
- Drought
  - Max96000
  - Logan Martin_Tandem
- Operating Inactive
- *Inactive*

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.



Max96000

Operates Release From: HN Henry

Rule Name: Max96000

Description: Paragraph 32 from Reg Manual; 96000 relate

Function of: Date

Limit Type: Maximum

Interp.: Linear

Date	Release (cfs)
01Jan	96000.0

Enter Description

Paragraph 32 from Reg Manual; 96000 related to easement 490 at Logan Martin

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Logan Martin_Tandem

Operates Release From: HN Henry

Tandem Operation Rule: Logan Martin_Tandem

Description: HEC-5 "RO" record

Downstream Reservoir: Logan Martin

Enter Description

HEC-5 "RO" record indicates Tandem Operation for Logan Martin (Reservoir 140).

PowerGC06

Operates Release From: HN Henry-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC06

Description: Power Guide Curve (2006 Operations) fo

Zone at Top of Power Pool: Conservation

Zone at Bottom of Power Pool: Drought

% Power Storage	Plant Factor (%)
0.0	0.0
54.0	0.0
57.0	16.0
100.0	16.0

Enter Description

Power Guide Curve (2006 Operations) for January thru December using ratio (1) from PR record. same as 1995

Power Generation Pattern

☐ Seasonal Variation

Pattern Applies All Year

Specify Pattern for: Weekdays and Weekend

	Weekdays	Weekend
0000-0100	1.0	0.0
0100-0200	1.0	0.0
0200-0300	1.0	0.0
0300-0400	1.0	0.0
0400-0500	1.0	0.0
0500-0600	1.0	0.0
0600-0700	1.0	0.0
0700-0800	1.0	0.0
0800-0900	1.0	0.0
0900-1000	1.0	0.0
1000-1100	1.0	0.0
1100-1200	1.0	0.0
1200-1300	1.0	0.0
1300-1400	1.0	0.0
1400-1500	1.0	0.0
1500-1600	1.0	0.0
1600-1700	1.0	0.0
1700-1800	1.0	0.0
1800-1900	1.0	0.0
1900-2000	1.0	0.0
2000-2100	1.0	0.0
2100-2200	1.0	0.0
2200-2300	1.0	0.0
2300-2400	1.0	0.0

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.

IV. Alternative Operations

Twelve ResSim alternatives were developed to represent the Baseline operations and 11 Alternative operating plans.

A. Operation Set

The “Baseline” operation set is used for the Baseline alternative. The remaining eleven alternatives use the “Winter Pool 507” operation set. Table F.02 describes each operation set.

Table F.02 Operation Sets Used at HN Henry

Operation Set	Description
Baseline	Current operation / no action
Winter Pool 507	Same as baseline, with winter pool level raised from elevation 505’ to 507’

The elevations assigned to the top of Conservation and top of Drought are different in the two operation sets. The elevations assigned to these zones in the “Winter Pool 507” operation set are either higher or the same as the elevation assigned to these zones in the “Baseline” operation set. The comparison of the zones for the “Baseline” and “Winter Pool 507” operation sets is given in Figure F.09. A comparison of the elevations used for Top of Conservation and Top of Drought are given in Figure F.10 and Figure F.11. These zone definitions are the only differences between the two operation sets.

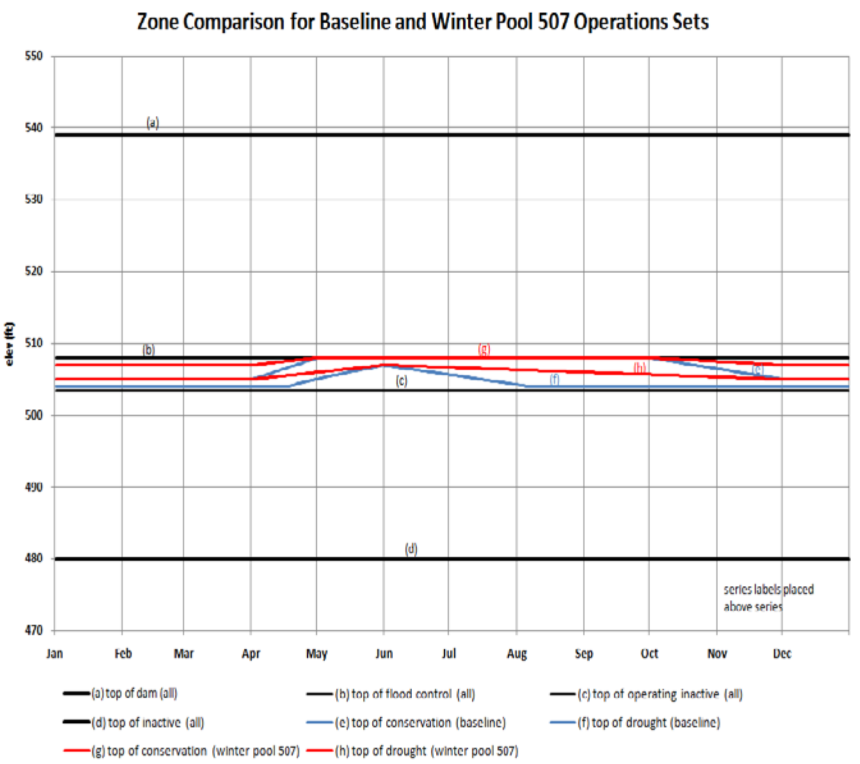


Figure F.09 Zone Comparison for “Baseline” and “Winter Pool 507” Operation Sets at HN Henry

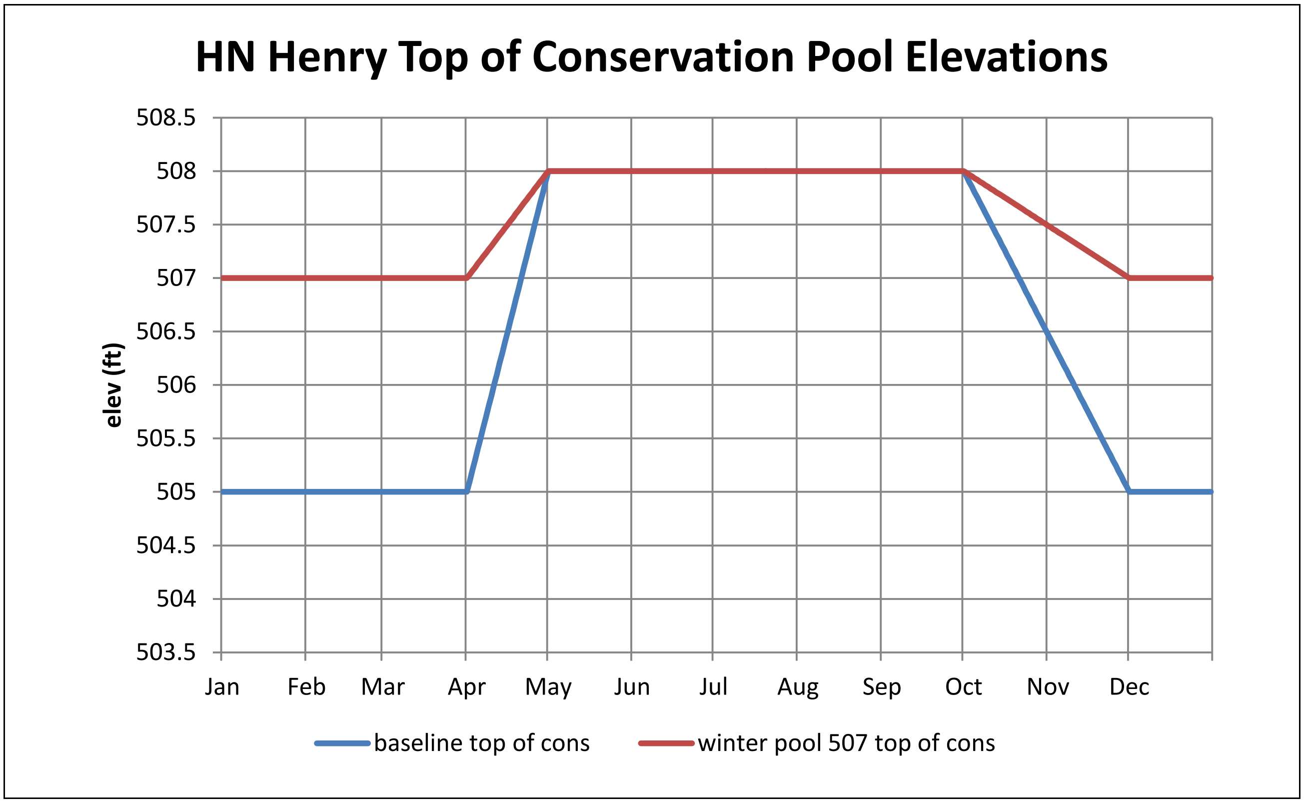


Figure F.10 Top of Conservation Elevations for “Baseline” and “Winter Pool 507” Operation Sets

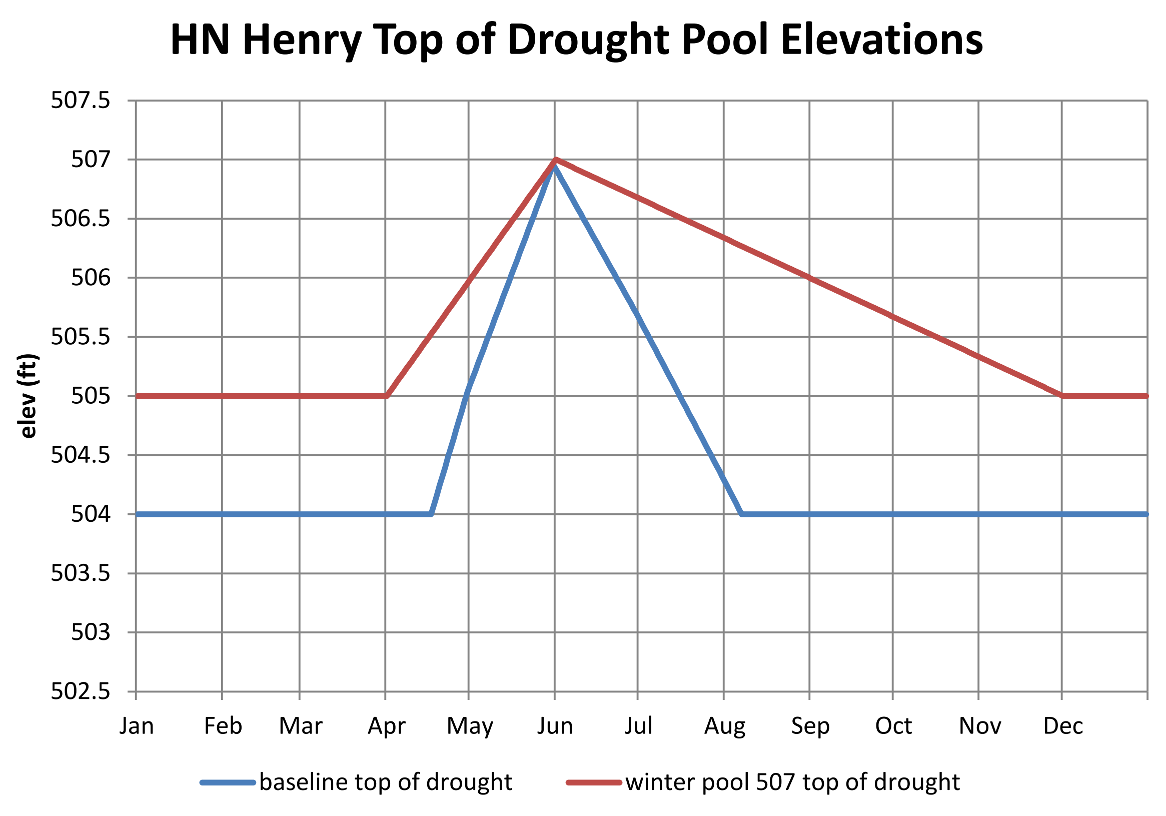
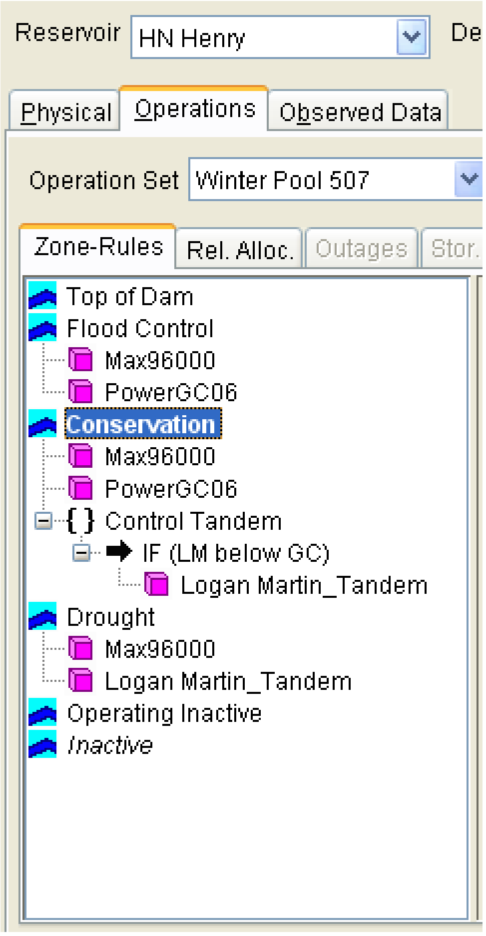


Figure F.11 Top of Drought Elevations for “Baseline” and “Winter Pool 507” Operation Sets

1. “Winter Pool 507” Operation Set

The rule sets for the “Winter Pool 507”operation set used at HN Henry is shown in Figure F.12.



Operation Set: Winter Pool 507

- Top of Dam
- Flood Control
  - Max96000
  - PowerGC06
- Conservation
  - Max96000
  - PowerGC06
  - { } Control Tandem
    - IF (LM below GC)
      - Logan Martin_Tandem
- Drought
  - Max96000
  - Logan Martin_Tandem
- Operating Inactive
- *Inactive*

Figure F.12 Rule Set for “Winter Pool 507” Operation Set

Alabama-Coosa-Tallapoosa (ACT) Watershed

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

Appendix G – Logan Martin Reservoir

March 2011 (DRAFT)

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Appendix G – Logan Martin (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.

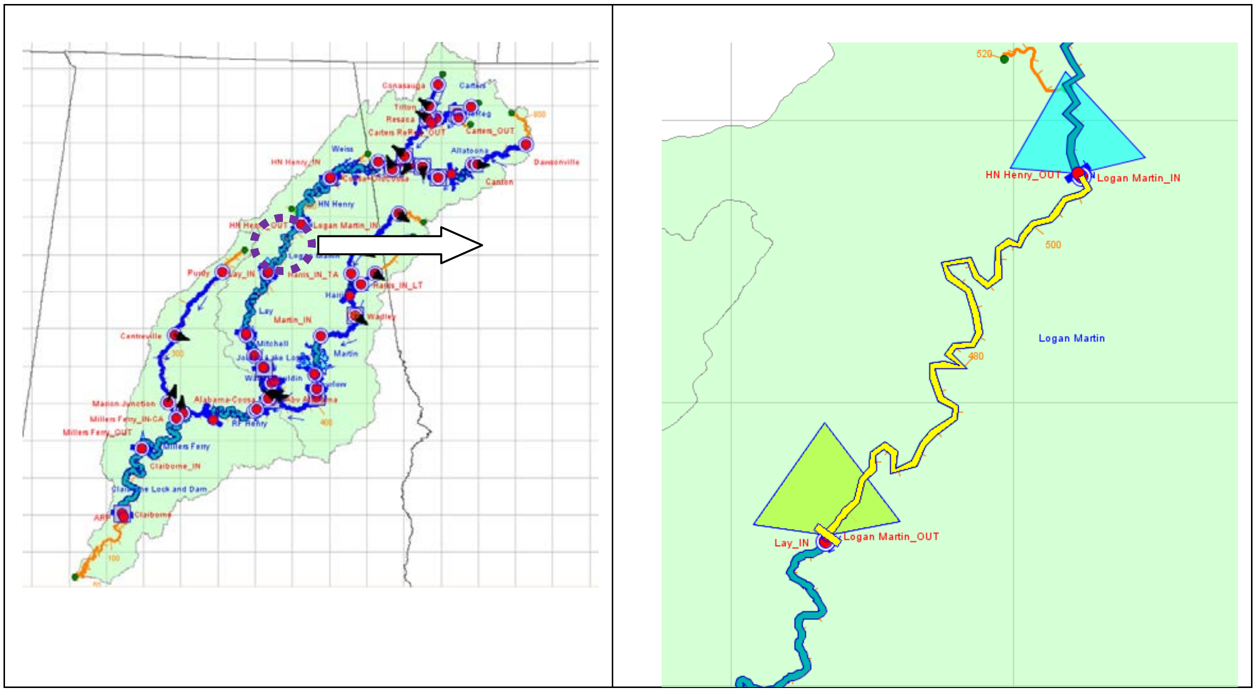


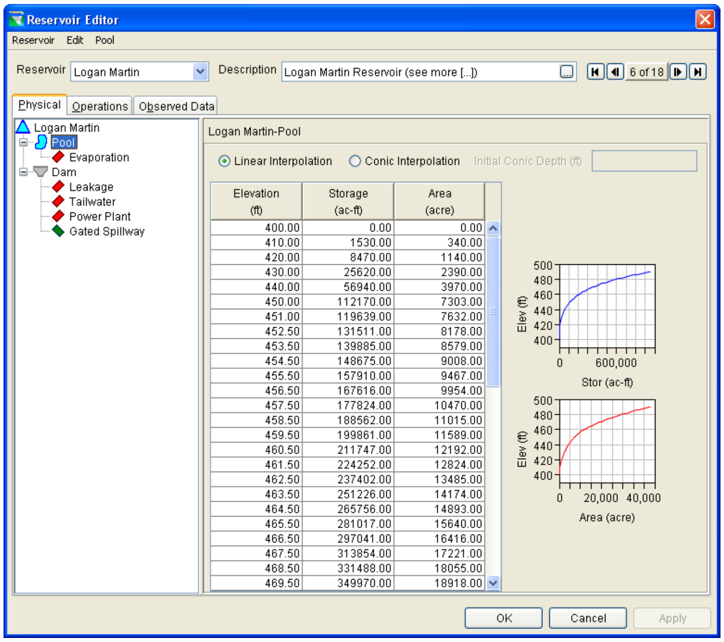
Figure G.01 HEC-ResSim Map Display Showing Location of Logan Martin Reservoir

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.



Reservoir: Logan Martin

Description: Logan Martin Reservoir (see more [...])

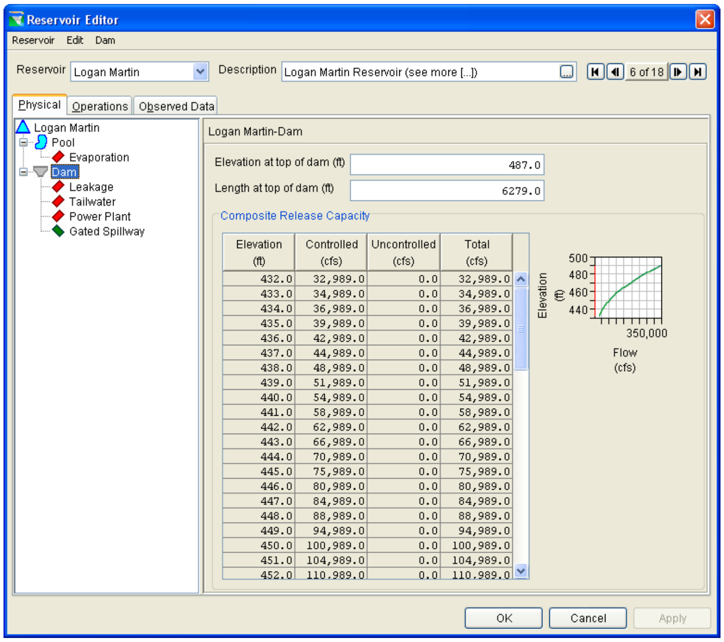
6 of 18

Logan Martin-Pool

● Linear Interpolation ○ Conic Interpolation Initial Conic Depth (ft)

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



Reservoir: Logan Martin

Description: Logan Martin Reservoir (see more [...])

6 of 18

Logan Martin-Dam

Elevation at top of dam (ft): 487.0

Length at top of dam (ft): 6279.0

Composite Release Capacity

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

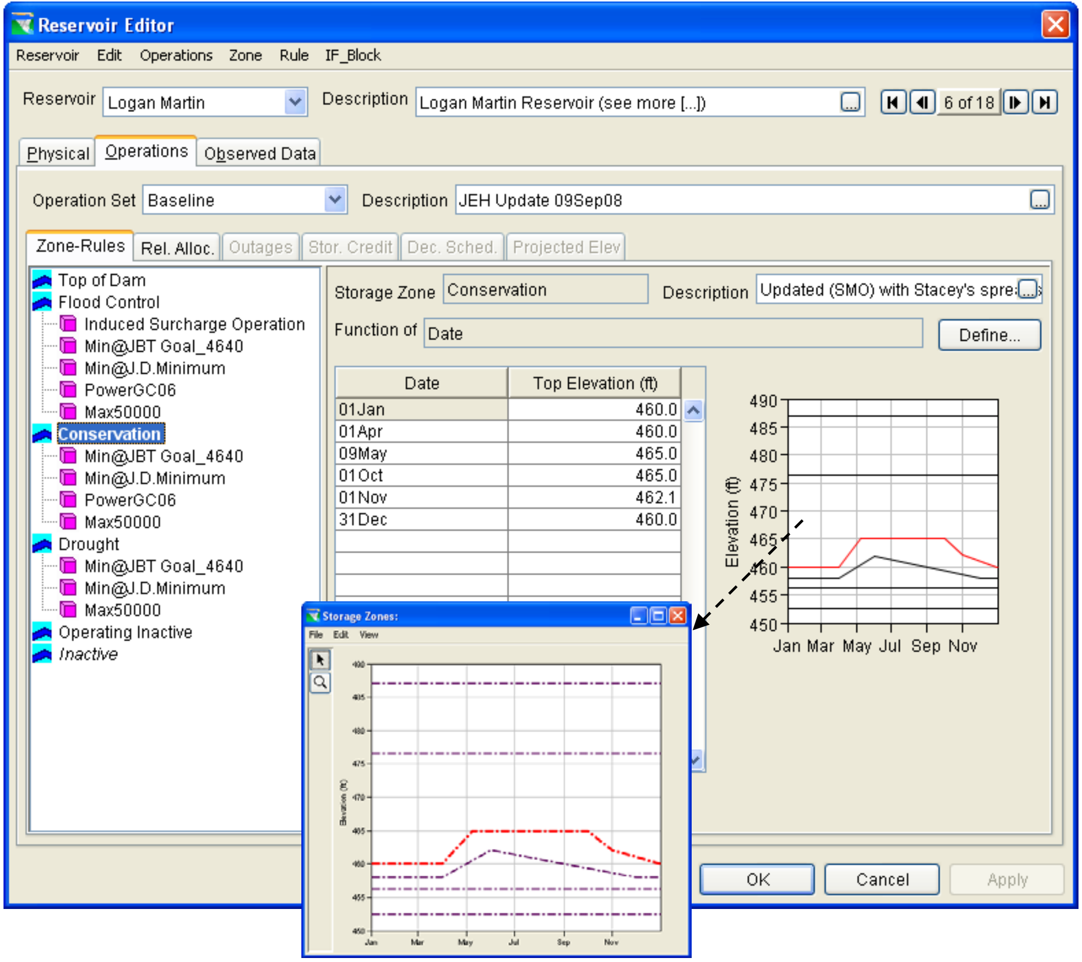
Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table G.01 shows the definition of “Baseline” operational zones for Logan Martin Reservoir, which consist of zones of flood control and conservation. 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)



Reservoir: Logan Martin
Description: Logan Martin Reservoir (see more [...])

Operation Set: Baseline
Description: JEH Update 09Sep08

- Top of Dam
- Flood Control
  - Induced Surcharge Operation
  - Min@JBT Goal_4640
  - Min@J.D.Minimum
  - PowerGC06
  - Max50000
- Conservation
  - Min@JBT Goal_4640
  - Min@J.D.Minimum
  - PowerGC06
  - Max50000
- Drought
  - Min@JBT Goal_4640
  - Min@J.D.Minimum
  - Max50000
- Operating Inactive
- *Inactive*

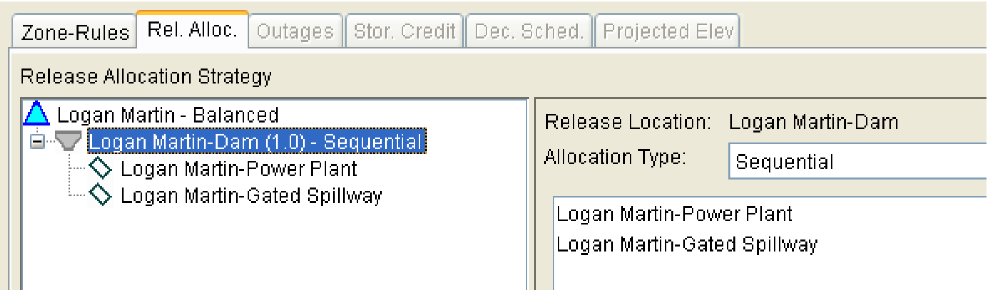
Storage Zone: Conservation
Description: Updated (SMO) with Stacey's spre
Function of: Date

Date	Top Elevation (ft)
01Jan	460.0
01Apr	460.0
09May	465.0
01Oct	465.0
01Nov	462.1
31Dec	460.0

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:



Release Allocation Strategy

- Logan Martin - Balanced
  - Logan Martin-Dam (1.0) - Sequential
    - Logan Martin-Power Plant
    - Logan Martin-Gated Spillway

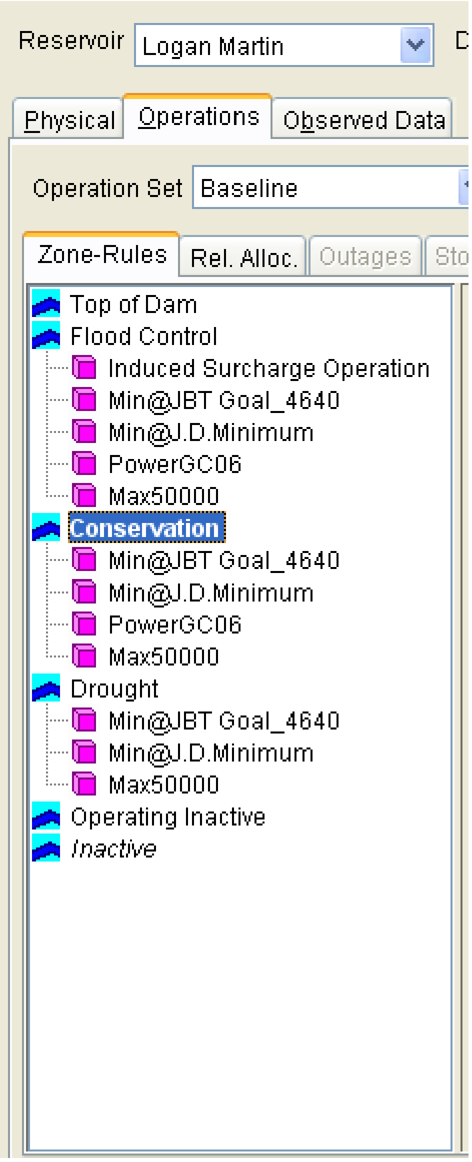
Release Location: Logan Martin-Dam
Allocation Type: Sequential

Logan Martin-Power Plant
Logan Martin-Gated Spillway

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".



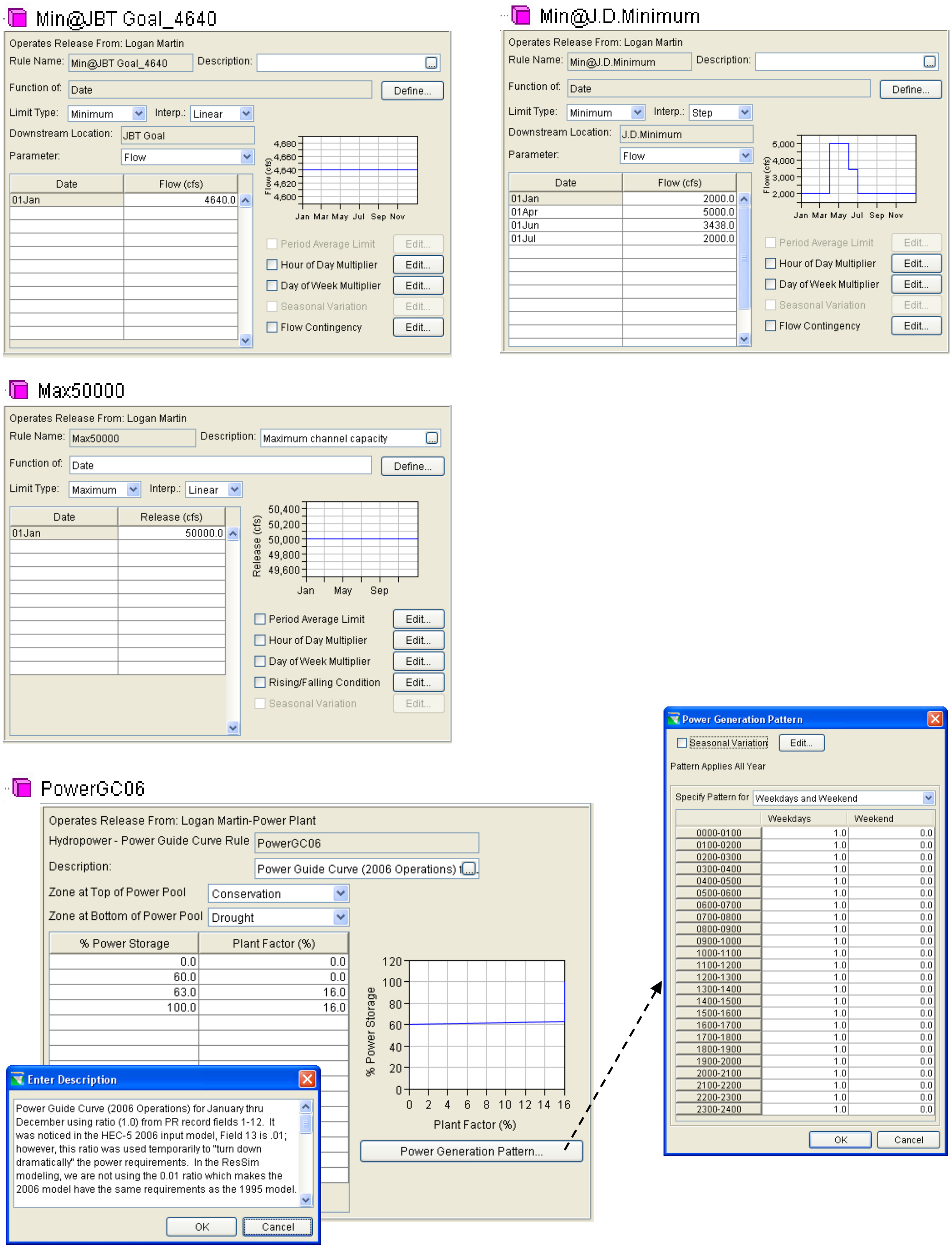
Reservoir: Logan Martin

Operation Set: Baseline

- Top of Dam
- Flood Control
  - Induced Surcharge Operation
  - Min@JBT Goal_4640
  - Min@J.D.Minimum
  - PowerGC06
  - Max50000
- Conservation
  - Min@JBT Goal_4640
  - Min@J.D.Minimum
  - PowerGC06
  - Max50000
- Drought
  - Min@JBT Goal_4640
  - Min@J.D.Minimum
  - Max50000
- Operating Inactive
- *Inactive*

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.



Min@JBT Goal_4640

Operates Release From: Logan Martin

Rule Name: Min@JBT Goal_4640

Description:

Function of: Date

Limit Type: Minimum

Interp.: Linear

Downstream Location: JBT Goal

Parameter: Flow

Date	Flow (cfs)
01Jan	4640.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Min@J.D.Minimum

Operates Release From: Logan Martin

Rule Name: Min@J.D.Minimum

Description:

Function of: Date

Limit Type: Minimum

Interp.: Step

Downstream Location: J.D.Minimum

Parameter: Flow

Date	Flow (cfs)
01Jan	2000.0
01Apr	5000.0
01Jun	3438.0
01Jul	2000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Max50000

Operates Release From: Logan Martin

Rule Name: Max50000

Description: Maximum channel capacity

Function of: Date

Limit Type: Maximum

Interp.: Linear

Date	Release (cfs)
01Jan	50000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

PowerGC06

Operates Release From: Logan Martin-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC06

Description: Power Guide Curve (2006 Operations) f

Zone at Top of Power Pool: Conservation

Zone at Bottom of Power Pool: Drought

% Power Storage	Plant Factor (%)
0.0	0.0
60.0	0.0
63.0	16.0
100.0	16.0

Enter Description

Power Guide Curve (2006 Operations) for January thru December using ratio (1.0) from PR record fields 1-12. It was noticed in the HEC-5 2006 input model, Field 13 is .01; however, this ratio was used temporarily to "turn down dramatically" the power requirements. In the ResSim modeling, we are not using the 0.01 ratio which makes the 2006 model have the same requirements as the 1995 model.

Power Generation Pattern

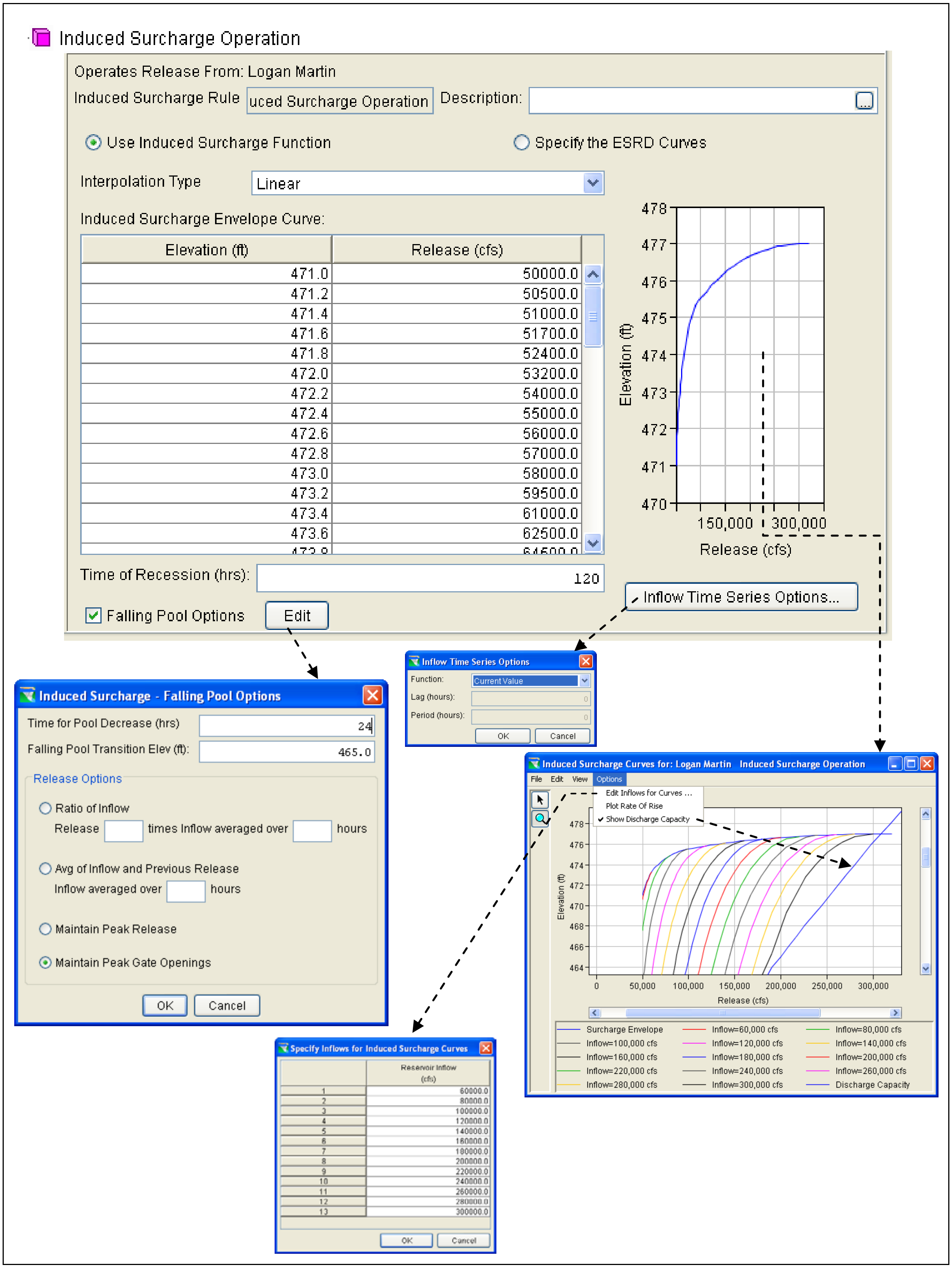
☐ Seasonal Variation

Pattern Applies All Year

Specify Pattern for: Weekdays and Weekend

	Weekdays	Weekend
0000-0100	1.0	0.0
0100-0200	1.0	0.0
0200-0300	1.0	0.0
0300-0400	1.0	0.0
0400-0500	1.0	0.0
0500-0600	1.0	0.0
0600-0700	1.0	0.0
0700-0800	1.0	0.0
0800-0900	1.0	0.0
0900-1000	1.0	0.0
1000-1100	1.0	0.0
1100-1200	1.0	0.0
1200-1300	1.0	0.0
1300-1400	1.0	0.0
1400-1500	1.0	0.0
1500-1600	1.0	0.0
1600-1700	1.0	0.0
1700-1800	1.0	0.0
1800-1900	1.0	0.0
1900-2000	1.0	0.0
2000-2100	1.0	0.0
2100-2200	1.0	0.0
2200-2300	1.0	0.0
2300-2400	1.0	0.0

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



Induced Surcharge Operation

Operates Release From: Logan Martin

Induced Surcharge Rule: uced Surcharge Operation

Description:

● Use Induced Surcharge Function ○ Specify the ESRD Curves

Interpolation Type: Linear

Induced Surcharge Envelope Curve:

Elevation (ft)	Release (cfs)
471.0	50000.0
471.2	50500.0
471.4	51000.0
471.6	51700.0
471.8	52400.0
472.0	53200.0
472.2	54000.0
472.4	55000.0
472.6	56000.0
472.8	57000.0
473.0	58000.0
473.2	59500.0
473.4	61000.0
473.6	62500.0

Time of Recession (hrs): 120

☑ Falling Pool Options

Induced Surcharge - Falling Pool Options

Time for Pool Decrease (hrs): 24

Falling Pool Transition Elev (ft): 465.0

Release Options

○ Ratio of Inflow

Release [ ] times Inflow averaged over [ ] hours

○ Avg of Inflow and Previous Release

Inflow averaged over [ ] hours

○ Maintain Peak Release

● Maintain Peak Gate Openings

Inflow Time Series Options

Function: Current Value

Lag (hours): 0

Period (hours): 0

Induced Surcharge Curves for: Logan Martin Induced Surcharge Operation

Specify Inflows for Induced Surcharge Curves

	Reservoir Inflow (cfs)
1	60000.0
2	80000.0
3	100000.0
4	120000.0
5	140000.0
6	160000.0
7	180000.0
8	200000.0
9	220000.0
10	240000.0
11	260000.0
12	280000.0
13	300000.0

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.

IV. Alternative Operations

Twelve ResSim alternatives were developed to represent the Baseline operations and 11 Alternative operating plans.

A. Operation Sets

For the 12 ResSim alternatives, Logan Martin Reservoir used 5 operation sets. The alternatives and operation sets are given in Table G.02. Table G.03 describes each operation set.

Table G.02 Alternatives and Operation Sets Used at Logan Martin

Alternative	Operation Set
Baseline	Baseline
DroughtPln	Nav_Drought
Burkett	Nav_Drought
DragoA	Nav_Drought
DragoB	Nav_Drought
RPlanA	Nav_Drought
RPlanB	Nav_Drought_Snail
RPlanC	Nav_Drought-rev
RPlanD	Nav_Drought_Snail-rev
RPlanE	Nav_Drought-rev
RPlanF	Nav_Drought_Snail-rev
RPlanG	Nav_Drought_Snail-rev

Table G.03 Operation Sets Used at Logan Martin

Operation Set	Description
Baseline	Current operation / no action
Nav_Drought	Navigation flow target and drought plan with flow requirement reductions
Nav_Drought_Snail	Same as Nav_Drought with USFWS flow requirement enhancement
Nav_Drought-rev	Same as Nav_Drought with revised Alabama River flow requirement
Nav_Drought_Snail-rev	Same as Nav_Drought_Snail with revised Alabama River flow requirement

The zone definitions and the elevations used for the zones are the same for all five operation sets. The difference between the operation sets involves the minimum flows at downstream model junctions named **JBT Goal** and **J.D.Minimum**.

The minimum flow values used at **JBT Goal** are the same for all four alternative operation sets when the drought intensity level is equal to zero or one (DIL=0 or DIL=1). These minimum flow values along with the values for the "Baseline" operation set are shown in Figure G.10. The minimum flow values are the same for the "Nav_Drought" and "Nav_Drought_Snail" operation sets when the drought intensity level is equal to 2 or 3 (DIL=2 or DIL=3). This is also true for the "Nav_Drought-rev" and "Nav_Drought_Snail-rev" operation sets. These values are shown in Figure G.11.

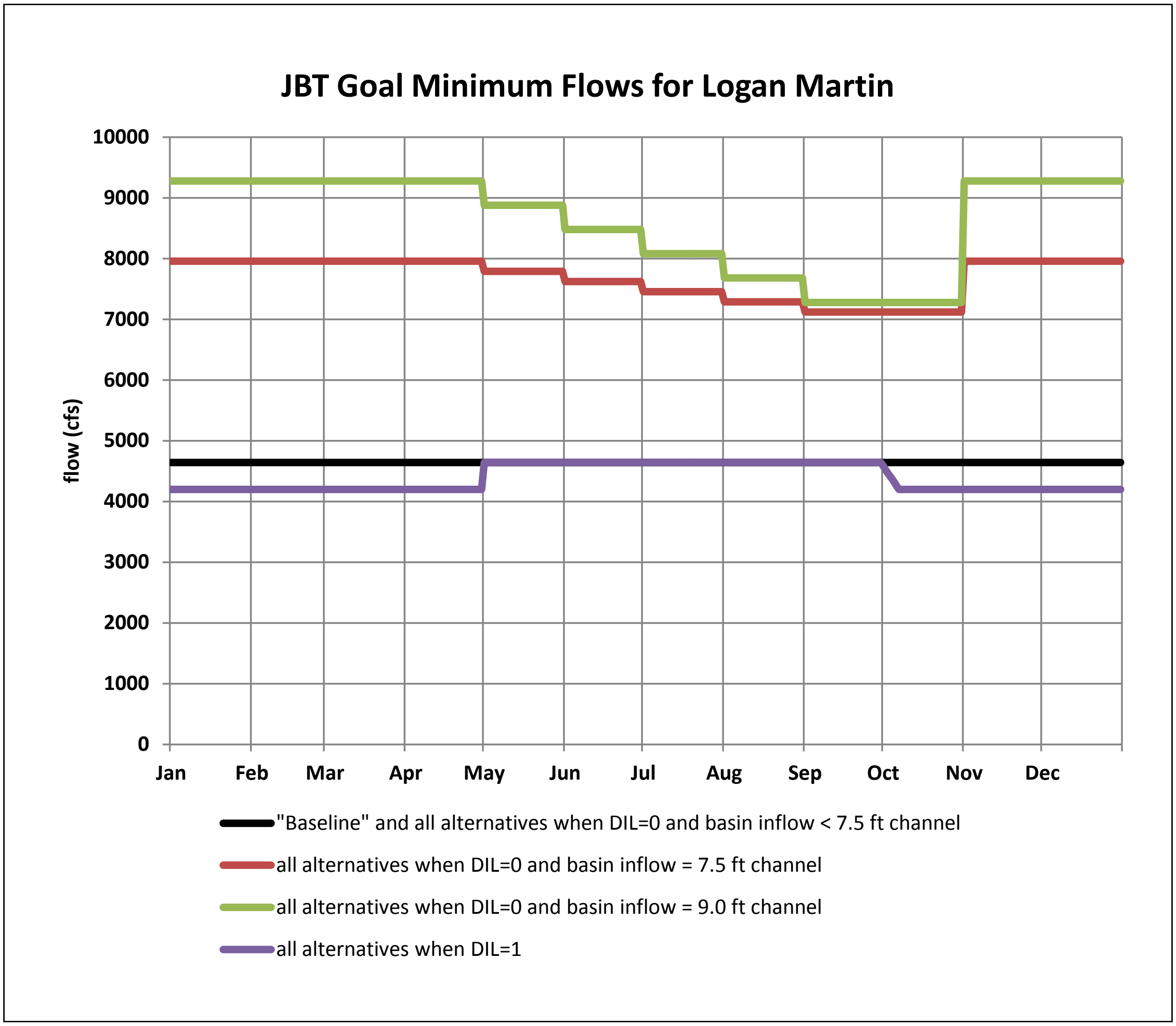


Figure G.10 JBT Goal Minimum Flows for Logan Martin "Baseline" and Alternatives when DIL=0 and DIL=1

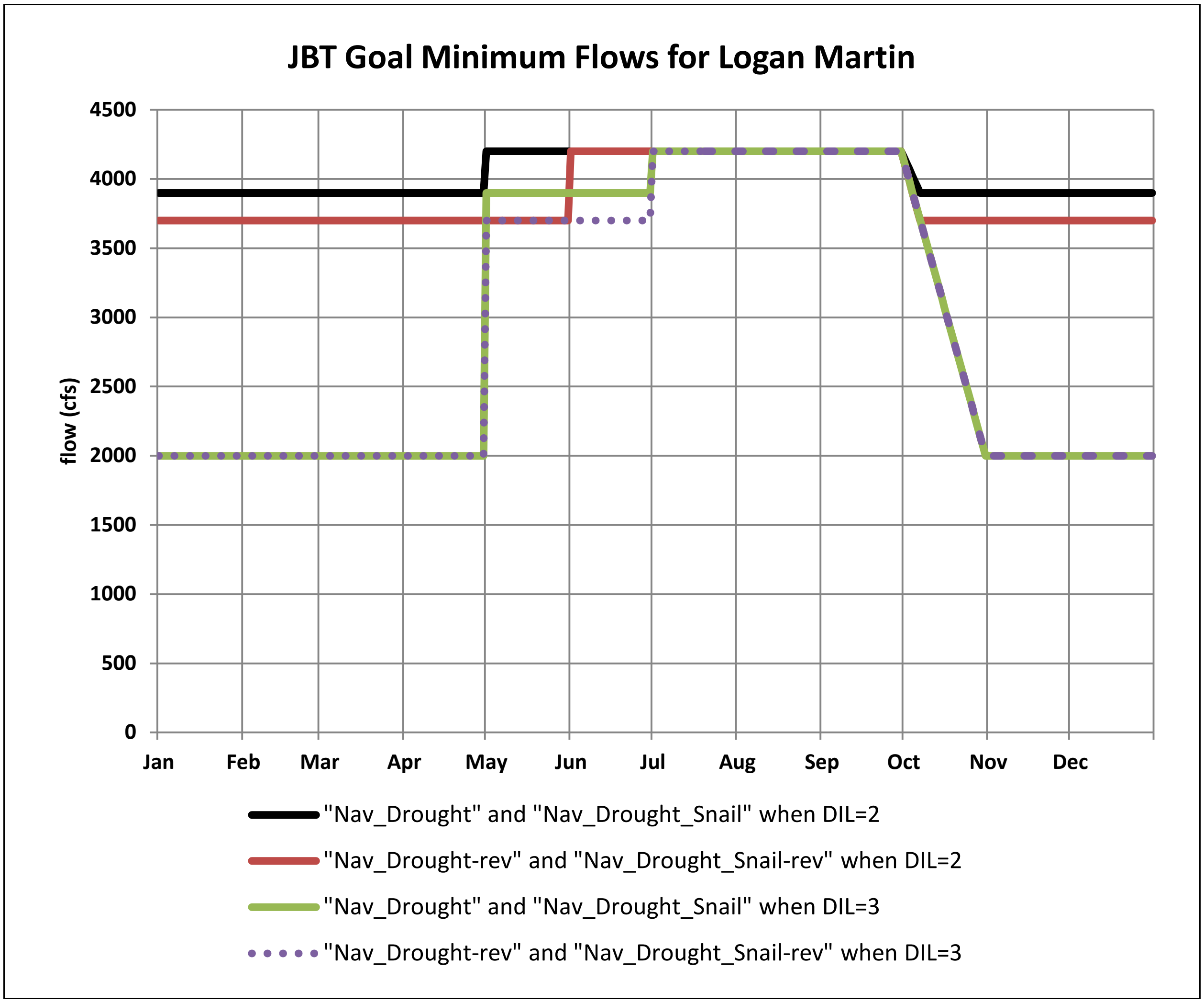


Figure G.11 JBT Goal Minimum Flows for Logan Martin Alternatives when DIL=2 and DIL=3

The minimum flow values used at **J.D.Minimum** are the same for all four alternative operation sets when the drought intensity level is equal to zero or one (DIL=0 or DIL=1). These values along with the values for the “Baseline” operation set are shown in Figure G.12. The minimum flow values are the same for the “Nav_Drought” and “Nav_Drought-rev” operation sets when the drought intensity level is equal to 2 or 3 (DIL=2 or DIL=3). This is also true for the “Nav_Drought_Snail” and “Nav_Drought_Snail-rev” operation sets. These values are shown in Figure G.13.

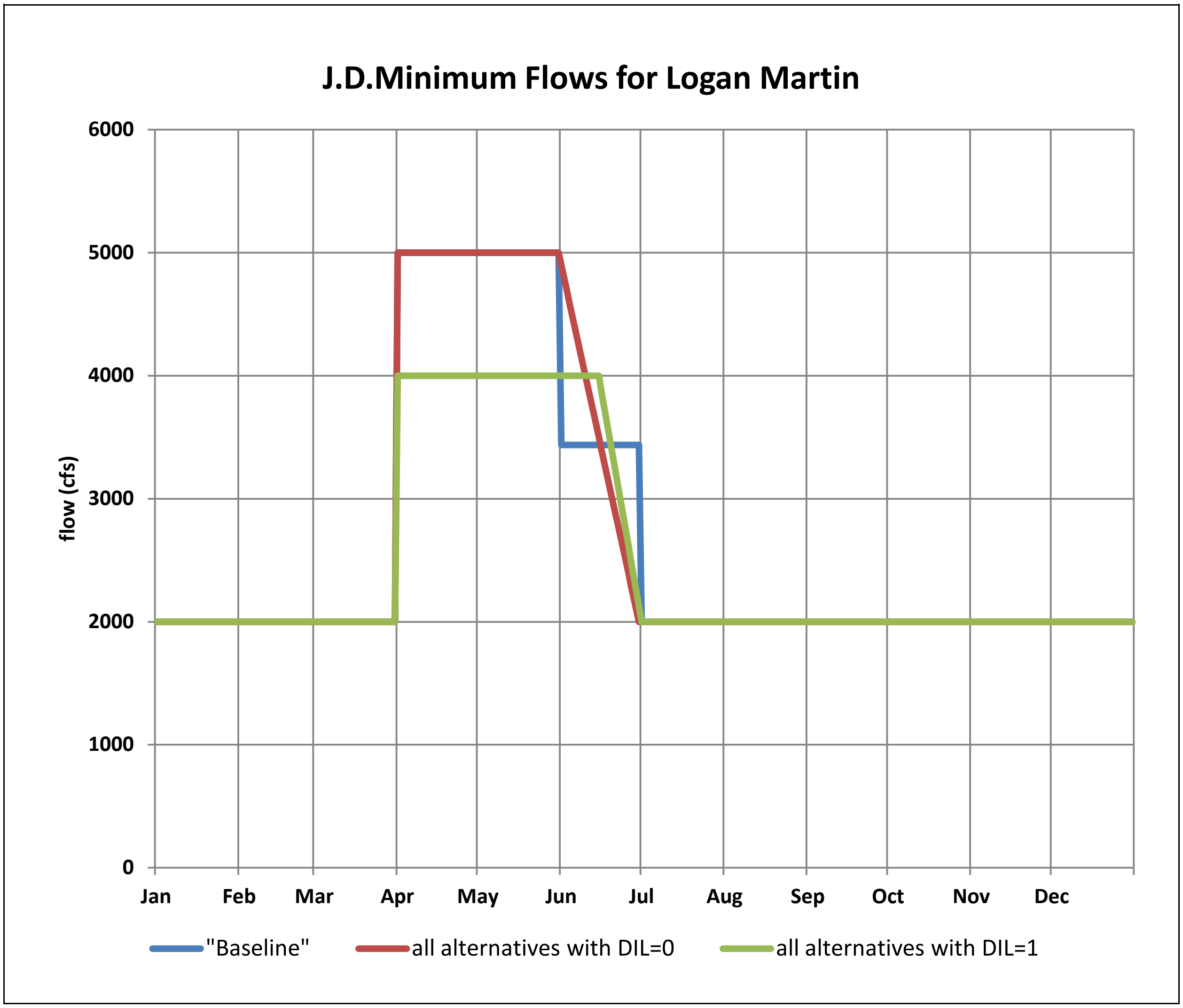


Figure G.12 J.D.Minimum Flows for Logan Martin "Baseline" and Alternatives when DIL=0 and DIL=1

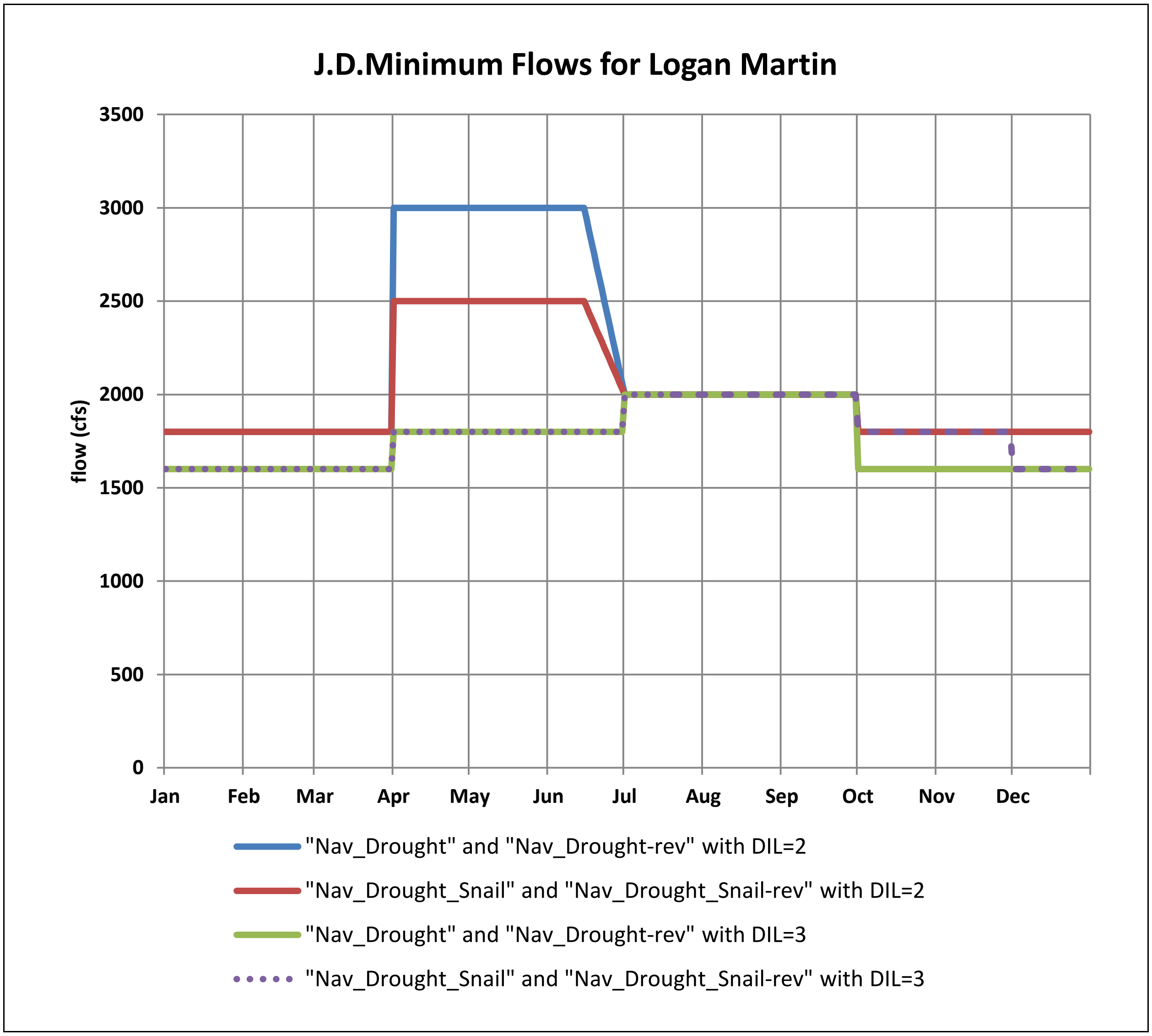
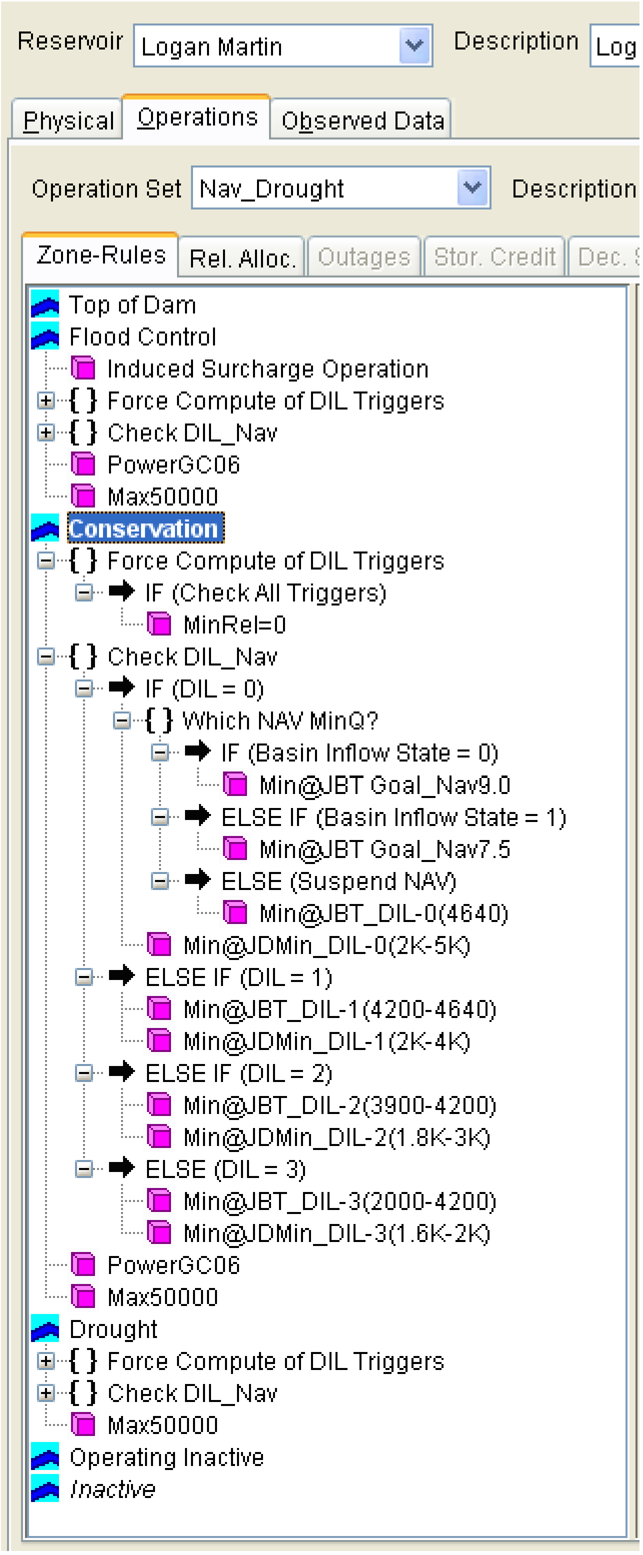


Figure G.13 J.D.Minimum Flows for Logan Martin Alternatives when DIL=2 and DIL=3

The rule sets for the “Nav_Drought”, “Nav_Drought_Snail”, “Nav_Drought-rev”, and “Nav_Drought_Snail-rev” operation sets are given in Section B (as shown in Figure G.14 through Figure G.17). The **Check DIL_Nav** conditional block is used in Flood Control, Conservation, and Drought zones and is reflected as a different version in each of the four alternative operation sets. Each version of this conditional block is shown in its expanded form in the Conservation zone in Figure G.14 through Figure G.17. The rules not used in the “Baseline” operation set are shown in Figure G.18 through Figure G.22. A description of these rules is provided in Section C.

To summarize, the differences in the operation sets involve the minimum flows at **JBT Goal** and **J.D.Minimum**. The minimum flows for the alternative operation sets are dependent on the Basin Inflow State along with the Drought Intensity Level (DIL). The differences are summarized in Table G.04 and Table G.05.

1. “Nav_Drought” Operation Set



Reservoir: Logan Martin

Description: Log

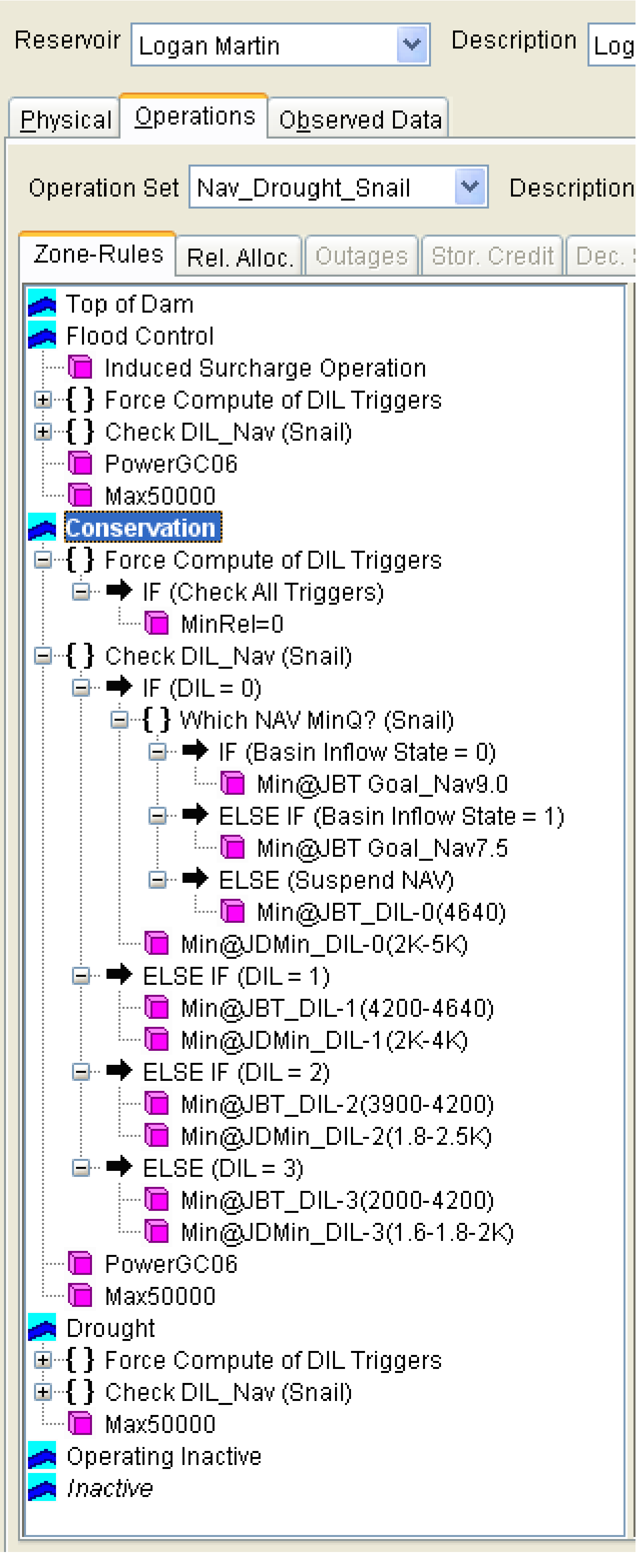
Operation Set: Nav_Drought

Description

- Top of Dam
- Flood Control
  - Induced Surcharge Operation
  - { } Force Compute of DIL Triggers
  - { } Check DIL_Nav
  - PowerGC06
  - Max50000
- Conservation
  - { } Force Compute of DIL Triggers
    - IF (Check All Triggers)
      - MinRel=0
  - { } Check DIL_Nav
    - IF (DIL = 0)
      - { } Which NAV MinQ?
        - IF (Basin Inflow State = 0)
          - Min@JBT Goal_Nav9.0
        - ELSE IF (Basin Inflow State = 1)
          - Min@JBT Goal_Nav7.5
        - ELSE (Suspend NAV)
          - Min@JBT_DIL-0(4640)
      - Min@JDMin_DIL-0(2K-5K)
    - ELSE IF (DIL = 1)
      - Min@JBT_DIL-1(4200-4640)
      - Min@JDMin_DIL-1(2K-4K)
    - ELSE IF (DIL = 2)
      - Min@JBT_DIL-2(3900-4200)
      - Min@JDMin_DIL-2(1.8K-3K)
    - ELSE (DIL = 3)
      - Min@JBT_DIL-3(2000-4200)
      - Min@JDMin_DIL-3(1.6K-2K)
  - PowerGC06
  - Max50000
- Drought
  - { } Force Compute of DIL Triggers
  - { } Check DIL_Nav
  - Max50000
- Operating Inactive
- *Inactive*

Figure G.14 Rule Set for the “Nav_Drought” Operation Set at Logan Margin

2. “Nav_Drought_Snail” Operation Set



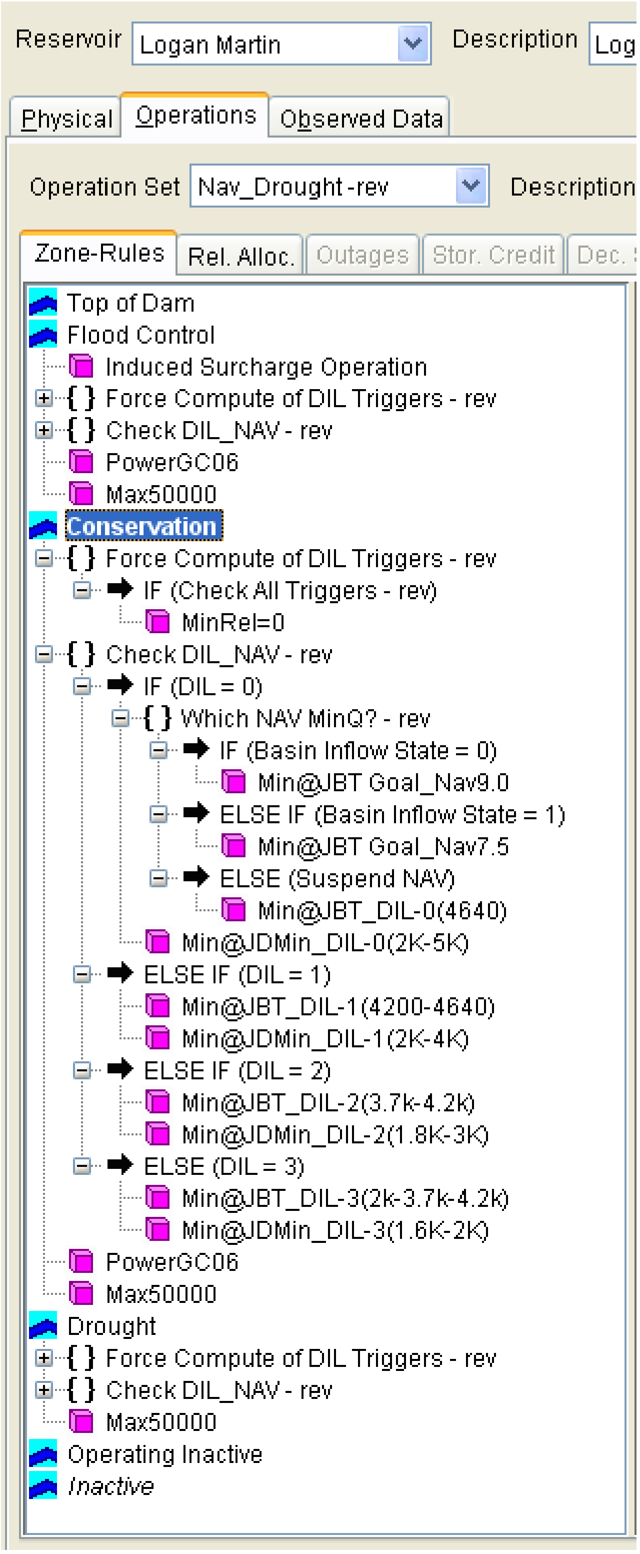
Reservoir Logan Martin

Operation Set Nav_Drought_Snail

- Top of Dam
- Flood Control
  - Induced Surcharge Operation
  - { } Force Compute of DIL Triggers
  - { } Check DIL_Nav (Snail)
  - PowerGC06
  - Max50000
- Conservation
  - { } Force Compute of DIL Triggers
    - IF (Check All Triggers)
      - MinRel=0
  - { } Check DIL_Nav (Snail)
    - IF (DIL = 0)
      - { } Which NAV MinQ? (Snail)
        - IF (Basin Inflow State = 0)
          - Min@JBT Goal_Nav9.0
        - ELSE IF (Basin Inflow State = 1)
          - Min@JBT Goal_Nav7.5
        - ELSE (Suspend NAV)
          - Min@JBT_DIL-0(4640)
      - Min@JDMin_DIL-0(2K-5K)
    - ELSE IF (DIL = 1)
      - Min@JBT_DIL-1(4200-4640)
      - Min@JDMin_DIL-1(2K-4K)
    - ELSE IF (DIL = 2)
      - Min@JBT_DIL-2(3900-4200)
      - Min@JDMin_DIL-2(1.8-2.5K)
    - ELSE (DIL = 3)
      - Min@JBT_DIL-3(2000-4200)
      - Min@JDMin_DIL-3(1.6-1.8-2K)
  - PowerGC06
  - Max50000
- Drought
  - { } Force Compute of DIL Triggers
  - { } Check DIL_Nav (Snail)
  - Max50000
- Operating Inactive
- *Inactive*

Figure G.15 Rule Set for the “Nav_Drought_Snail” Operation Set at Logan Margin

3. “Nav_Drought-rev” Operation Set



Reservoir Logan Martin

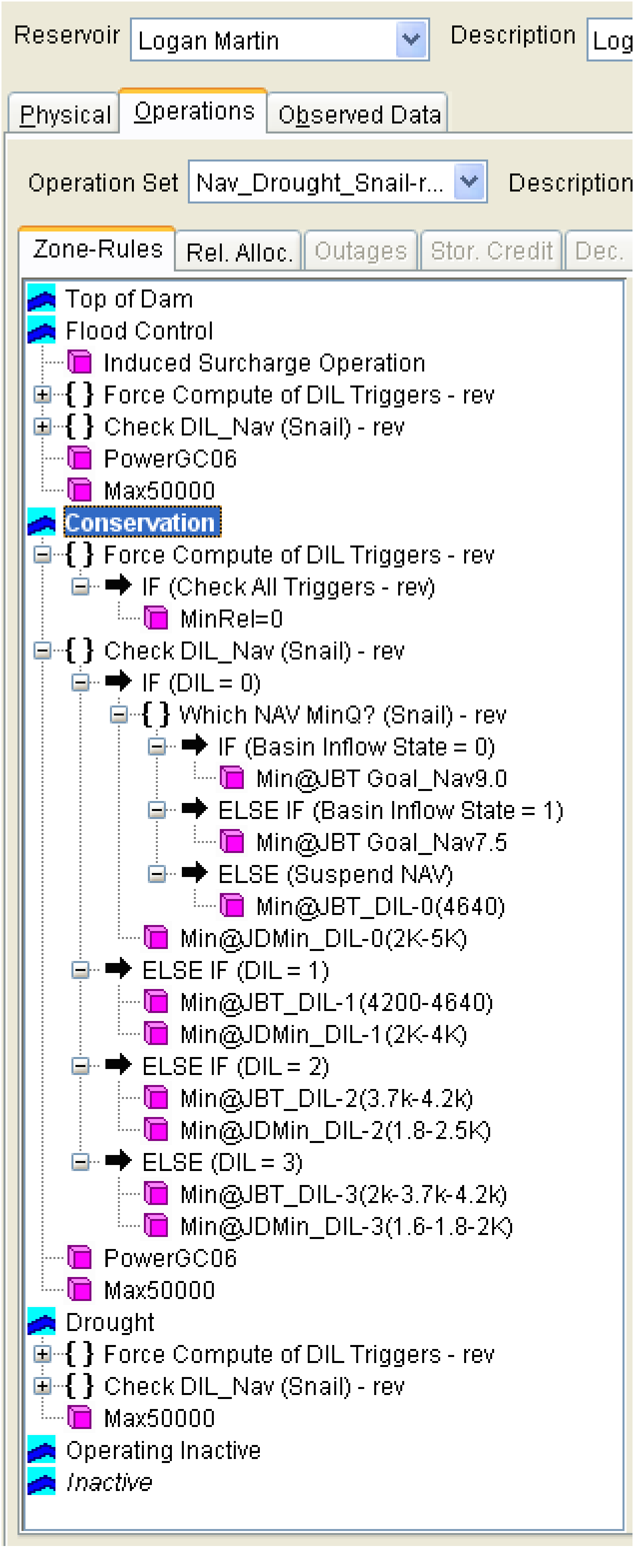
Description Log

Operation Set Nav_Drought-rev

- Top of Dam
- Flood Control
  - Induced Surcharge Operation
  - { } Force Compute of DIL Triggers - rev
  - { } Check DIL_NAV - rev
  - PowerGC06
  - Max50000
- Conservation
  - { } Force Compute of DIL Triggers - rev
    - IF (Check All Triggers - rev)
      - MinRel=0
  - { } Check DIL_NAV - rev
    - IF (DIL = 0)
      - { } Which NAV MinQ? - rev
        - IF (Basin Inflow State = 0)
          - Min@JBT Goal_Nav9.0
        - ELSE IF (Basin Inflow State = 1)
          - Min@JBT Goal_Nav7.5
        - ELSE (Suspend NAV)
          - Min@JBT_DIL-0(4640)
      - Min@JDMin_DIL-0(2K-5K)
    - ELSE IF (DIL = 1)
      - Min@JBT_DIL-1(4200-4640)
      - Min@JDMin_DIL-1(2K-4K)
    - ELSE IF (DIL = 2)
      - Min@JBT_DIL-2(3.7k-4.2k)
      - Min@JDMin_DIL-2(1.8K-3K)
    - ELSE (DIL = 3)
      - Min@JBT_DIL-3(2k-3.7k-4.2k)
      - Min@JDMin_DIL-3(1.6K-2K)
  - PowerGC06
  - Max50000
- Drought
  - { } Force Compute of DIL Triggers - rev
  - { } Check DIL_NAV - rev
  - Max50000
- Operating Inactive
- *Inactive*

Figure G.16 Rule Set for the “Nav_Drought-rev” Operation Set at Logan Margin

4. “Nav_Drought_Snail-rev” Operation Set

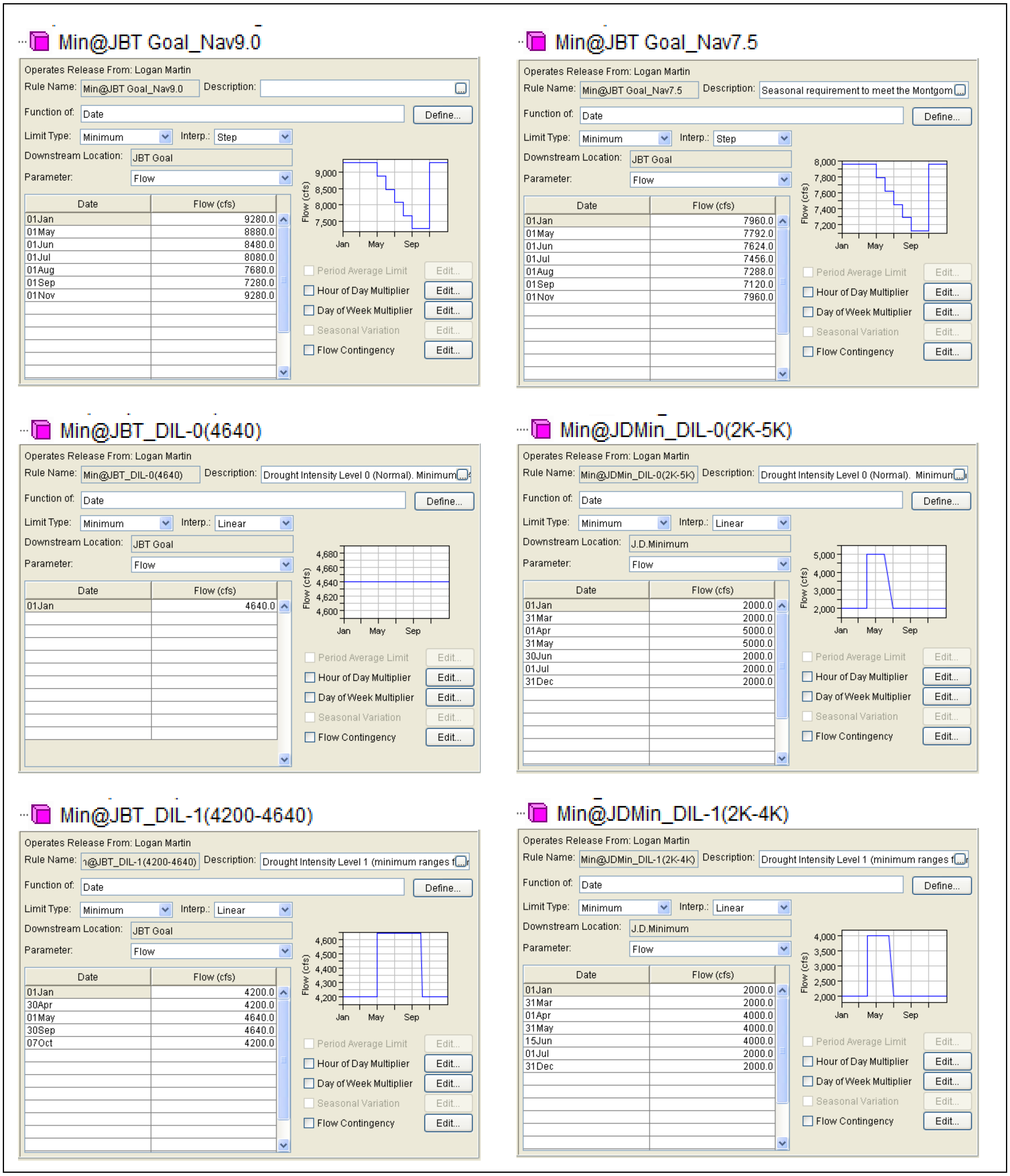


Reservoir: Logan Martin
Description: Log
Operation Set: Nav_Drought_Snail-r...
Description

- Top of Dam
- Flood Control
  - Induced Surcharge Operation
  - { } Force Compute of DIL Triggers - rev
  - { } Check DIL_Nav (Snail) - rev
  - PowerGC06
  - Max50000
- Conservation
  - { } Force Compute of DIL Triggers - rev
    - IF (Check All Triggers - rev)
      - MinRel=0
  - { } Check DIL_Nav (Snail) - rev
    - IF (DIL = 0)
      - { } Which NAV MinQ? (Snail) - rev
        - IF (Basin Inflow State = 0)
          - Min@JBT Goal_Nav9.0
        - ELSE IF (Basin Inflow State = 1)
          - Min@JBT Goal_Nav7.5
        - ELSE (Suspend NAV)
          - Min@JBT_DIL-0(4640)
      - Min@JDMin_DIL-0(2K-5K)
    - ELSE IF (DIL = 1)
      - Min@JBT_DIL-1(4200-4640)
      - Min@JDMin_DIL-1(2K-4K)
    - ELSE IF (DIL = 2)
      - Min@JBT_DIL-2(3.7k-4.2k)
      - Min@JDMin_DIL-2(1.8-2.5K)
    - ELSE (DIL = 3)
      - Min@JBT_DIL-3(2k-3.7k-4.2k)
      - Min@JDMin_DIL-3(1.6-1.8-2K)
  - PowerGC06
  - Max50000
- Drought
  - { } Force Compute of DIL Triggers - rev
  - { } Check DIL_Nav (Snail) - rev
  - Max50000
- Operating Inactive
- *Inactive*

Figure G.17 Rule Set for the “Nav_Drought_Snail-rev” Operation Set at Logan Margin

B. Rule Illustrations



Min@JBT Goal_Nav9.0

Operates Release From: Logan Martin
Rule Name: Min@JBT Goal_Nav9.0
Description:
Function of: Date
Limit Type: Minimum
Interp.: Step
Downstream Location: JBT Goal
Parameter: Flow

Date	Flow (cfs)
01Jan	9280.0
01May	8880.0
01Jun	8480.0
01Jul	8080.0
01Aug	7680.0
01Sep	7280.0
01Nov	9280.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Min@JBT Goal_Nav7.5

Operates Release From: Logan Martin
Rule Name: Min@JBT Goal_Nav7.5
Description: Seasonal requirement to meet the Montgom
Function of: Date
Limit Type: Minimum
Interp.: Step
Downstream Location: JBT Goal
Parameter: Flow

Date	Flow (cfs)
01Jan	7960.0
01May	7792.0
01Jun	7624.0
01Jul	7456.0
01Aug	7288.0
01Sep	7120.0
01Nov	7960.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Min@JBT_DIL-0(4640)

Operates Release From: Logan Martin
Rule Name: Min@JBT_DIL-0(4640)
Description: Drought Intensity Level 0 (Normal). Minimum
Function of: Date
Limit Type: Minimum
Interp.: Linear
Downstream Location: JBT Goal
Parameter: Flow

Date	Flow (cfs)
01Jan	4640.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Min@JDMin_DIL-0(2K-5K)

Operates Release From: Logan Martin
Rule Name: Min@JDMin_DIL-0(2K-5K)
Description: Drought Intensity Level 0 (Normal). Minimum
Function of: Date
Limit Type: Minimum
Interp.: Linear
Downstream Location: J.D.Minimum
Parameter: Flow

Date	Flow (cfs)
01Jan	2000.0
31Mar	2000.0
01Apr	5000.0
31May	5000.0
30Jun	2000.0
01Jul	2000.0
31Dec	2000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Min@JBT_DIL-1(4200-4640)

Operates Release From: Logan Martin
Rule Name: @JBT_DIL-1(4200-4640)
Description: Drought Intensity Level 1 (minimum ranges f
Function of: Date
Limit Type: Minimum
Interp.: Linear
Downstream Location: JBT Goal
Parameter: Flow

Date	Flow (cfs)
01Jan	4200.0
30Apr	4200.0
01May	4640.0
30Sep	4640.0
07Oct	4200.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

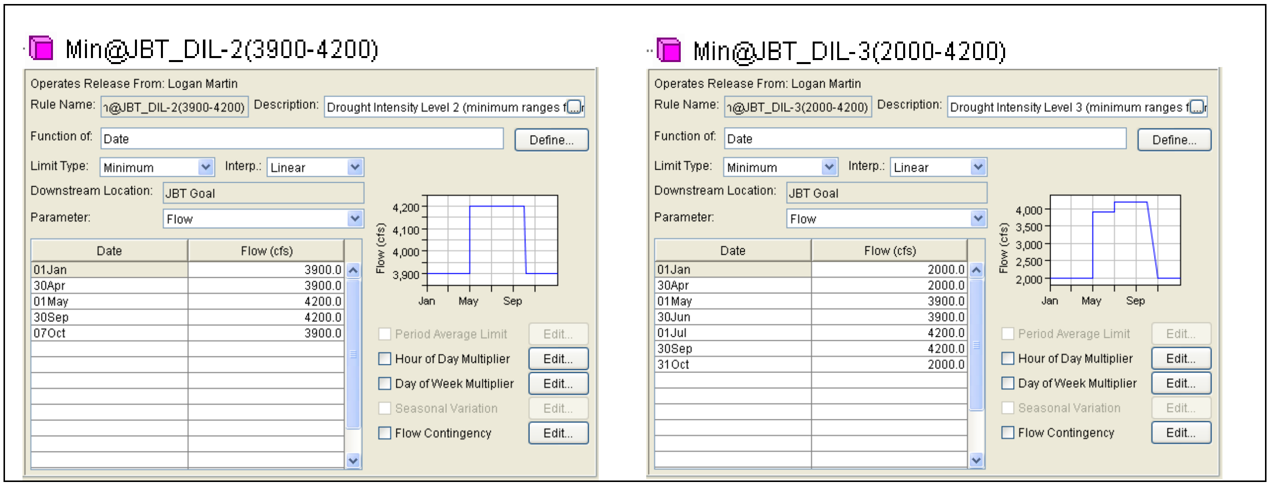
Min@JDMin_DIL-1(2K-4K)

Operates Release From: Logan Martin
Rule Name: Min@JDMin_DIL-1(2K-4K)
Description: Drought Intensity Level 1 (minimum ranges f
Function of: Date
Limit Type: Minimum
Interp.: Linear
Downstream Location: J.D.Minimum
Parameter: Flow

Date	Flow (cfs)
01Jan	2000.0
31Mar	2000.0
01Apr	4000.0
31May	4000.0
15Jun	4000.0
01Jul	2000.0
31Dec	2000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Figure G.18 Rules of Operation Applied to All Four Alternative Operation Sets


Min@JBT_DIL-2(3900-4200)

Operates Release From: Logan Martin
Rule Name: @JBT_DIL-2(3900-4200) Description: Drought Intensity Level 2 (minimum ranges f
Function of: Date
Limit Type: Minimum Interp.: Linear
Downstream Location: JBT Goal
Parameter: Flow

Date	Flow (cfs)
01Jan	3900.0
30Apr	3900.0
01May	4200.0
30Sep	4200.0
07Oct	3900.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

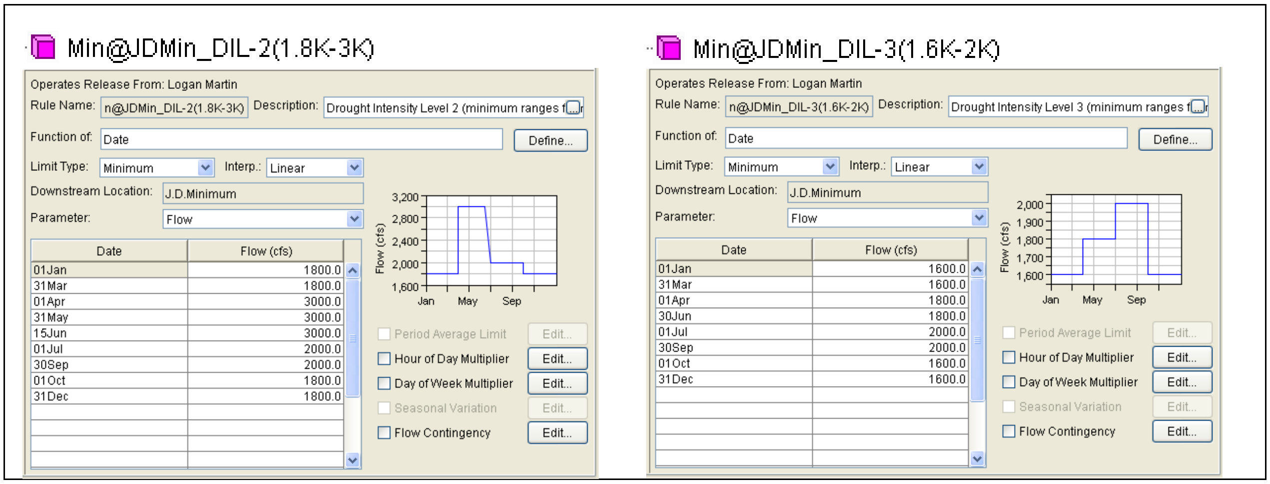
Min@JBT_DIL-3(2000-4200)

Operates Release From: Logan Martin
Rule Name: @JBT_DIL-3(2000-4200) Description: Drought Intensity Level 3 (minimum ranges f
Function of: Date
Limit Type: Minimum Interp.: Linear
Downstream Location: JBT Goal
Parameter: Flow

Date	Flow (cfs)
01Jan	2000.0
30Apr	2000.0
01May	3900.0
30Jun	3900.0
01Jul	4200.0
30Sep	4200.0
31Oct	2000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Figure G.19 Rules of Operation Applied to "Nav_Drought" and "Nav_Drought_Snail" Operation Sets


Min@JDMin_DIL-2(1.8K-3K)

Operates Release From: Logan Martin
Rule Name: n@JDMin_DIL-2(1.8K-3K) Description: Drought Intensity Level 2 (minimum ranges f
Function of: Date
Limit Type: Minimum Interp.: Linear
Downstream Location: J.D.Minimum
Parameter: Flow

Date	Flow (cfs)
01Jan	1800.0
31Mar	1800.0
01Apr	3000.0
31May	3000.0
15Jun	3000.0
01Jul	2000.0
30Sep	2000.0
01Oct	1800.0
31Dec	1800.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

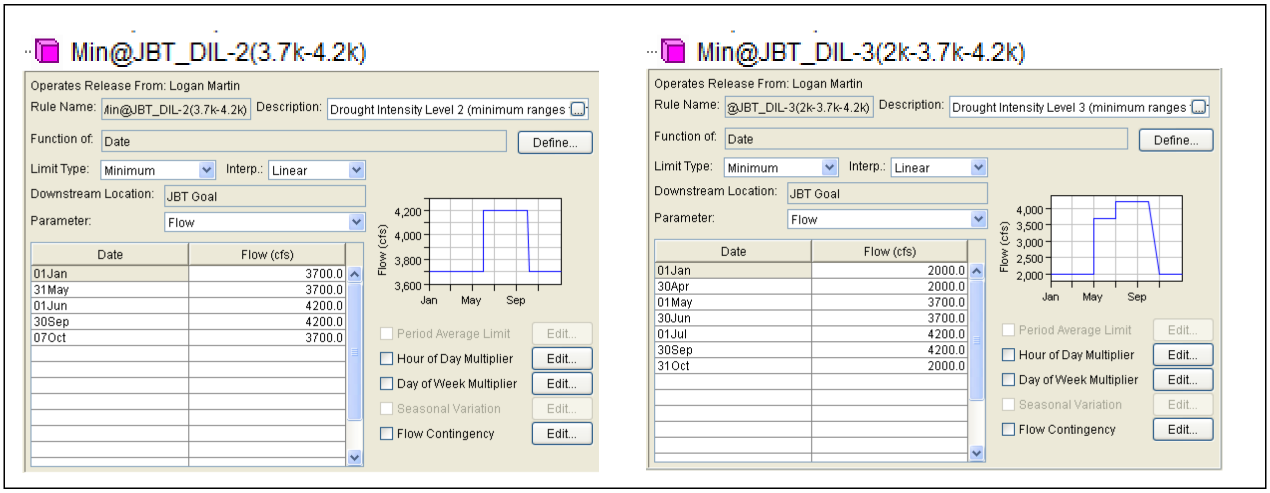
Min@JDMin_DIL-3(1.6K-2K)

Operates Release From: Logan Martin
Rule Name: n@JDMin_DIL-3(1.6K-2K) Description: Drought Intensity Level 3 (minimum ranges f
Function of: Date
Limit Type: Minimum Interp.: Linear
Downstream Location: J.D.Minimum
Parameter: Flow

Date	Flow (cfs)
01Jan	1600.0
31Mar	1600.0
01Apr	1800.0
30Jun	1800.0
01Jul	2000.0
30Sep	2000.0
01Oct	1600.0
31Dec	1600.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Figure G.20 Rules of Operation Applied to "Nav_Drought" and "Nav_Drought-rev" Operation Sets


Min@JBT_DIL-2(3.7k-4.2k)

Operates Release From: Logan Martin
Rule Name: in@JBT_DIL-2(3.7k-4.2k) Description: Drought Intensity Level 2 (minimum ranges
Function of: Date
Limit Type: Minimum Interp.: Linear
Downstream Location: JBT Goal
Parameter: Flow

Date	Flow (cfs)
01Jan	3700.0
31May	3700.0
01Jun	4200.0
30Sep	4200.0
07Oct	3700.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

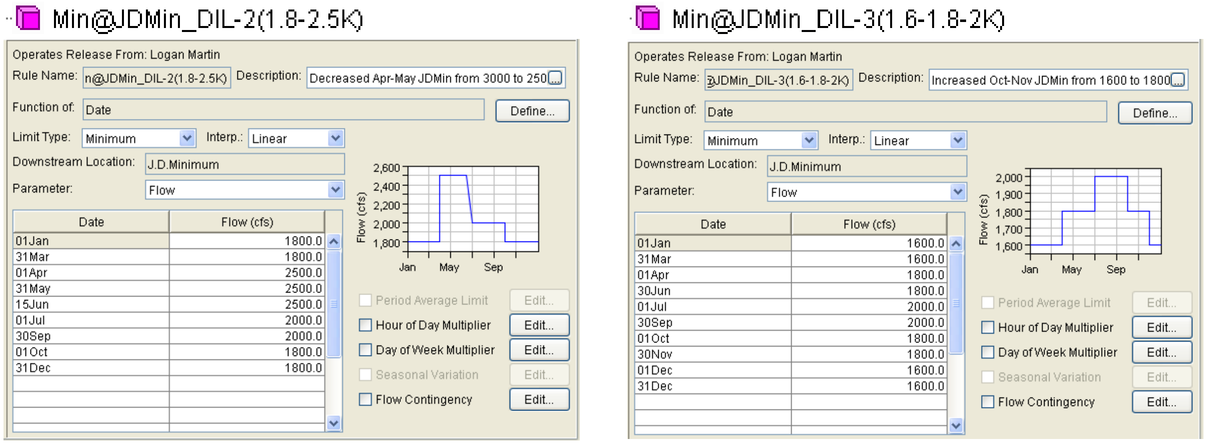
Min@JBT_DIL-3(2k-3.7k-4.2k)

Operates Release From: Logan Martin
Rule Name: @JBT_DIL-3(2k-3.7k-4.2k) Description: Drought Intensity Level 3 (minimum ranges
Function of: Date
Limit Type: Minimum Interp.: Linear
Downstream Location: JBT Goal
Parameter: Flow

Date	Flow (cfs)
01Jan	2000.0
30Apr	2000.0
01May	3700.0
30Jun	3700.0
01Jul	4200.0
30Sep	4200.0
31Oct	2000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Figure G.21 Rules of Operation Applied to "Nav_Drought-rev" and "Nav_Drought_Snail-rev" Operation Sets



Min@JDMin_DIL-2(1.8-2.5K)

Operates Release From: Logan Martin
Rule Name: n@JDMin_DIL-2(1.8-2.5K) Description: Decreased Apr-May JDMin from 3000 to 250
Function of: Date
Limit Type: Minimum Interp.: Linear
Downstream Location: J.D.Minimum
Parameter: Flow

Date	Flow (cfs)
01Jan	1800.0
31Mar	1800.0
01Apr	2500.0
31May	2500.0
15Jun	2500.0
01Jul	2000.0
30Sep	2000.0
01Oct	1800.0
31Dec	1800.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Min@JDMin_DIL-3(1.6-1.8-2K)

Operates Release From: Logan Martin
Rule Name: @JDMin_DIL-3(1.6-1.8-2K) Description: Increased Oct-Nov JDMin from 1600 to 1800
Function of: Date
Limit Type: Minimum Interp.: Linear
Downstream Location: J.D.Minimum
Parameter: Flow

Date	Flow (cfs)
01Jan	1600.0
31Mar	1600.0
01Apr	1800.0
30Jun	1800.0
01Jul	2000.0
30Sep	2000.0
01Oct	1800.0
30Nov	1800.0
01Dec	1600.0
31Dec	1600.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Figure G.22 Rules of Operation Applied to “Nav_Drought_Snail” and “Nav_Drought_Snail-rev” Operation Sets

C. Rule Descriptions

1. *Min@JBT Goal_Nav9.0*

This rule (see Figure G.18) sets the minimum release at JBT Goal when the DIL=0 and the basin inflow is sufficient to support a 9.0 ft navigation channel. The minimum release varies between 7,280 cfs and 9,280 cfs depending on the time of year. This rule applies to “Nav_Drought”, “Nav_Drought-rev”, “Nav_Drought_Snail”, and “Nav_Drought_Snail-rev” operation sets.

2. *Min@JBT Goal_Nav7.5*

This rule (see Figure G.18) sets the minimum release at JBT Goal when the DIL=0 and the basin inflow is sufficient to support a 7.5 ft navigation channel. The minimum release varies between 7,120 cfs and 7,960 cfs depending on the time of year. This rule applies to “Nav_Drought”, “Nav_Drought-rev”, “Nav_Drought_Snail”, and “Nav_Drought_Snail-rev” operation sets.

3. *Min@JBT_DIL-0(4640)*

This rule (see Figure G.18) sets the minimum release at JBT Goal when the DIL=0 and the basin inflow is not sufficient to support a 7.5 ft navigation channel. The minimum release is set to a constant 4,640 cfs throughout the entire year. This rule applies to “Nav_Drought”, “Nav_Drought-rev”, “Nav_Drought_Snail”, and “Nav_Drought_Snail-rev” operation sets.

4. *Min@JDMin_DIL-0(2K-5K)*

This rule (see Figure G.18) sets the minimum release at JD Minimum when the DIL=0. The minimum release varies between 2,000 cfs and 5,000 cfs depending on the time of year. This rule applies to “Nav_Drought”, “Nav_Drought-rev”, “Nav_Drought_Snail”, and “Nav_Drought_Snail-rev” operation sets.

5. Min@JBT_DIL-1(4200-4640)

This rule (see Figure G.18) sets the minimum release at JBT Goal when the DIL=1. The minimum release varies between 4,200 cfs and 4,640 cfs depending on the time of year. This rule applies to “Nav_Drought”, “Nav_Drought-rev”, “Nav_Drought_Snail”, and “Nav_Drought_Snail-rev” operation sets.

6. Min@JDMin_DIL-1(2K-4K)

This rule (see Figure G.18) sets the minimum release at JD Minimum when the DIL=1. The minimum release varies between 2,000 cfs and 4,000 cfs depending on the time of year. This rule applies to “Nav_Drought”, “Nav_Drought-rev”, “Nav_Drought_Snail”, and “Nav_Drought_Snail-rev” operation sets.

7. Min@JBT_DIL-2(3900-4200)

This rule (see Figure G.19) sets the minimum release at JBT Goal when the DIL=2. The minimum release varies between 3,900 cfs and 4,200 cfs depending on the time of year. This rule applies to “Nav_Drought” and “Nav_Drought_Snail” operation sets.

8. Min@JBT_DIL-3(2000-4200)

This rule (see Figure G.19) sets the minimum release at JBT Goal when the DIL=3. The minimum release varies between 2,000 cfs and 4,200 cfs depending on the time of year. This rule applies to “Nav_Drought” and “Nav_Drought_Snail” operation sets.

9. Min@JDMin_DIL-2(1.8K-3K)

This rule (see Figure G.20) sets the minimum release at JD Minimum when the DIL=2. The minimum release varies between 1,800 cfs and 3,000 cfs depending on the time of year. This rule applies to “Nav_Drought” and “Nav_Drought-rev” operation sets.

10. Min@JDMin_DIL-3(1.6K-2K)

This rule (see Figure G.20) sets the minimum release at JD Minimum when the DIL=3. The minimum release varies between 1,600 cfs and 2,000 cfs depending on the time of year. This rule applies to “Nav_Drought” and “Nav_Drought-rev” operation sets.

11. Min@JBT_DIL-2(3.7k-4.2k)

This rule (see Figure G.21) sets the minimum release at JBT Goal when the DIL=2. The minimum release varies between 3,700 cfs and 4,200 cfs depending on the time of year. This rule applies to “Nav_Drought-rev” and “Nav_Drought_Snail-rev” operation sets.

12. Min@JBT_DIL-3(2k-3.7k-4.2k)

This rule (see Figure G.21) sets the minimum release at JBT Goal when the DIL=3. The minimum release varies between 2,000 cfs and 4,200 cfs depending on the time of year. This rule applies to “Nav_Drought-rev” and “Nav_Drought_Snail-rev” operation sets.

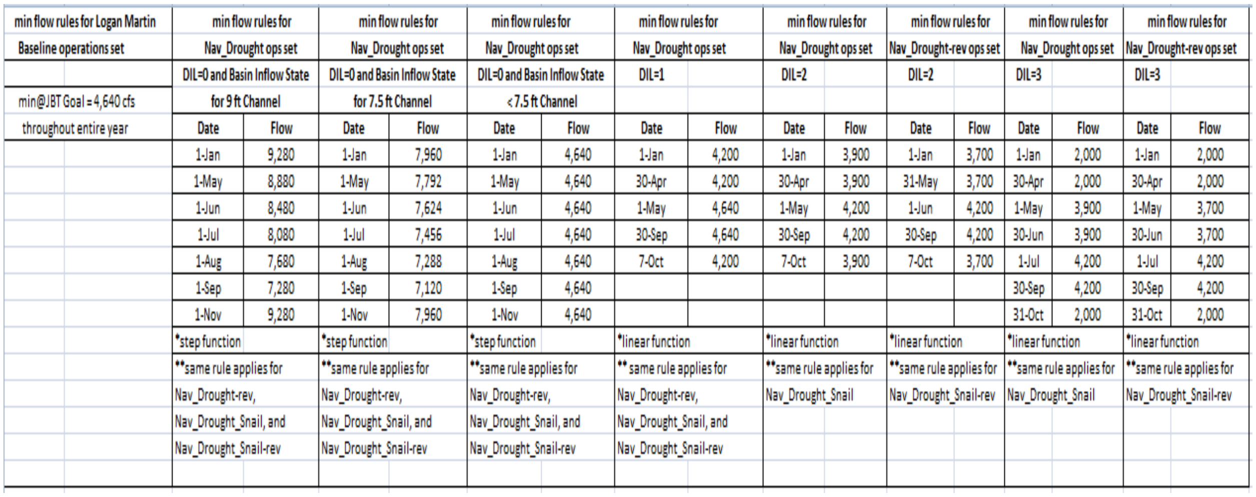
13. Min@JDMin_DIL-2(1.8K-2.5K)

This rule (see Figure G.22) sets the minimum release at JD Minimum when the DIL=2. The minimum release varies between 1,800 cfs and 2,500 cfs depending on the time of year. This rule applies to “Nav_Drought_Snail” and “Nav_Drought_Snail-rev” operation sets.

14. Min@JDMin_DIL-3(1.6-1.8-2K)

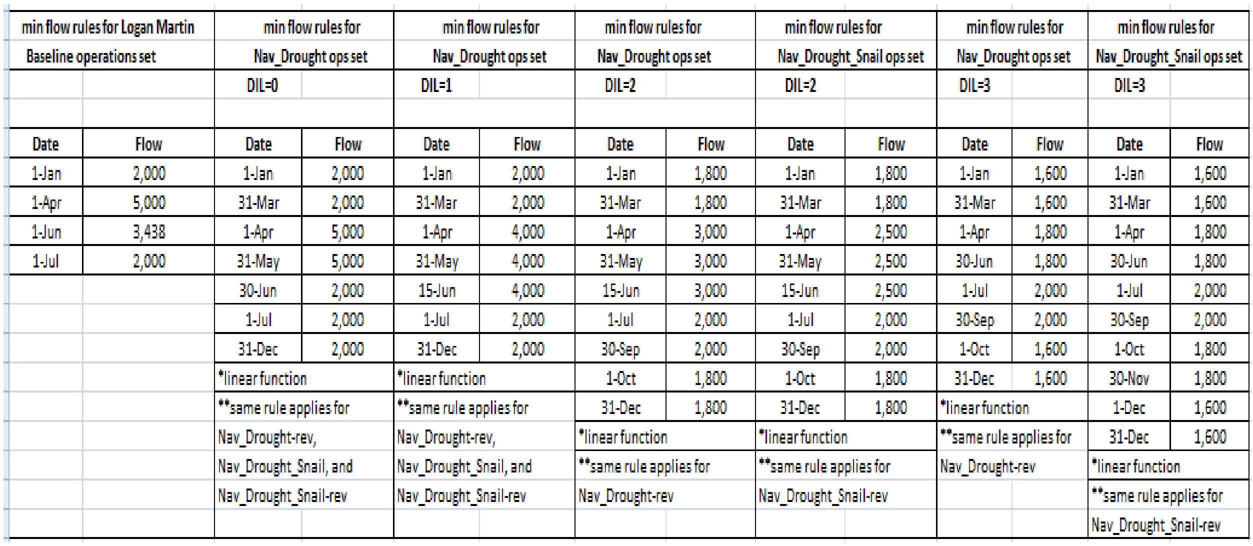
This rule (see Figure G.22) sets the minimum release at JD Minimum when the DIL=3. The minimum release varies between 1,600 cfs and 2,000 cfs depending on the time of year. This rule applies to “Nav_Drought_Snail” and “Nav_Drought_Snail-rev” operation sets.

Table G.04 Comparison of JBT Goal Minimum Release Rules for Logan Martin Operation Sets



min flow rules for Logan Martin	min flow rules for		min flow rules for		min flow rules for		min flow rules for		min flow rules for		min flow rules for		min flow rules for		min flow rules for	
Baseline operations set	Nav_Drought ops set		Nav_Drought ops set		Nav_Drought ops set		Nav_Drought ops set		Nav_Drought ops set		Nav_Drought-rev ops set		Nav_Drought ops set		Nav_Drought-rev ops set	
	DIL=0 and Basin Inflow State		DIL=0 and Basin Inflow State		DIL=0 and Basin Inflow State		DIL=1		DIL=2		DIL=2		DIL=3		DIL=3	
min@JBT Goal = 4,640 cfs	for 9 ft Channel		for 7.5 ft Channel		<7.5 ft Channel											
throughout entire year	Date	Flow	Date	Flow	Date	Flow	Date	Flow	Date	Flow	Date	Flow	Date	Flow	Date	Flow
	1-Jan	9,280	1-Jan	7,960	1-Jan	4,640	1-Jan	4,200	1-Jan	3,900	1-Jan	3,700	1-Jan	2,000	1-Jan	2,000
	1-May	8,880	1-May	7,792	1-May	4,640	30-Apr	4,200	30-Apr	3,900	31-May	3,700	30-Apr	2,000	30-Apr	2,000
	1-Jun	8,480	1-Jun	7,624	1-Jun	4,640	1-May	4,640	1-May	4,200	1-Jun	4,200	1-May	3,900	1-May	3,700
	1-Jul	8,080	1-Jul	7,456	1-Jul	4,640	30-Sep	4,640	30-Sep	4,200	30-Sep	4,200	30-Jun	3,900	30-Jun	3,700
	1-Aug	7,680	1-Aug	7,288	1-Aug	4,640	7-Oct	4,200	7-Oct	3,900	7-Oct	3,700	1-Jul	4,200	1-Jul	4,200
	1-Sep	7,280	1-Sep	7,120	1-Sep	4,640							30-Sep	4,200	30-Sep	4,200
	1-Nov	9,280	1-Nov	7,960	1-Nov	4,640							31-Oct	2,000	31-Oct	2,000
	*step function		*step function		*step function		*linear function		*linear function		*linear function		*linear function		*linear function	
	**same rule applies for		**same rule applies for		**same rule applies for		** same rule applies for		**same rule applies for		**same rule applies for		**same rule applies for		**same rule applies for	
	Nav_Drought-rev,		Nav_Drought-rev,		Nav_Drought-rev,		Nav_Drought-rev,		Nav_Drought_Snail		Nav_Drought_Snail-rev		Nav_Drought_Snail		Nav_Drought_Snail-rev	
	Nav_Drought_Snail, and		Nav_Drought_Snail, and		Nav_Drought_Snail, and		Nav_Drought_Snail, and									
	Nav_Drought_Snail-rev		Nav_Drought_Snail-rev		Nav_Drought_Snail-rev		Nav_Drought_Snail-rev									

Table G.05 Comparison of J.D.Minimum Release Rules for Logan Martin Operation Sets



min flow rules for Logan Martin		min flow rules for		min flow rules for		min flow rules for		min flow rules for		min flow rules for		min flow rules for	
Baseline operations set		Nav_Drought ops set		Nav_Drought ops set		Nav_Drought ops set		Nav_Drought_Snail ops set		Nav_Drought ops set		Nav_Drought_Snail ops set	
		DIL=0		DIL=1		DIL=2		DIL=2		DIL=3		DIL=3	
Date	Flow	Date	Flow	Date	Flow	Date	Flow	Date	Flow	Date	Flow	Date	Flow
1-Jan	2,000	1-Jan	2,000	1-Jan	2,000	1-Jan	1,800	1-Jan	1,800	1-Jan	1,600	1-Jan	1,600
1-Apr	5,000	31-Mar	2,000	31-Mar	2,000	31-Mar	1,800	31-Mar	1,800	31-Mar	1,600	31-Mar	1,600
1-Jun	3,438	1-Apr	5,000	1-Apr	4,000	1-Apr	3,000	1-Apr	2,500	1-Apr	1,800	1-Apr	1,800
1-Jul	2,000	31-May	5,000	31-May	4,000	31-May	3,000	31-May	2,500	30-Jun	1,800	30-Jun	1,800
		30-Jun	2,000	15-Jun	4,000	15-Jun	3,000	15-Jun	2,500	1-Jul	2,000	1-Jul	2,000
		1-Jul	2,000	1-Jul	2,000	1-Jul	2,000	1-Jul	2,000	30-Sep	2,000	30-Sep	2,000
		31-Dec	2,000	31-Dec	2,000	30-Sep	2,000	30-Sep	2,000	1-Oct	1,600	1-Oct	1,800
		*linear function		*linear function		1-Oct	1,800	1-Oct	1,800	31-Dec	1,600	30-Nov	1,800
		**same rule applies for		**same rule applies for		31-Dec	1,800	31-Dec	1,800	*linear function		1-Dec	1,600
		Nav_Drought-rev,		Nav_Drought-rev,		*linear function		*linear function		**same rule applies for		31-Dec	1,600
		Nav_Drought_Snail, and		Nav_Drought_Snail, and		**same rule applies for		**same rule applies for		Nav_Drought-rev		*linear function	
		Nav_Drought_Snail-rev		Nav_Drought_Snail-rev		Nav_Drought-rev		Nav_Drought_Snail-rev				**same rule applies for	
												Nav_Drought_Snail-rev	

Alabama-Coosa-Tallapoosa (ACT) Watershed

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

Appendix H – Harris Reservoir

March 2011 (DRAFT)

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Appendix H – Harris (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.

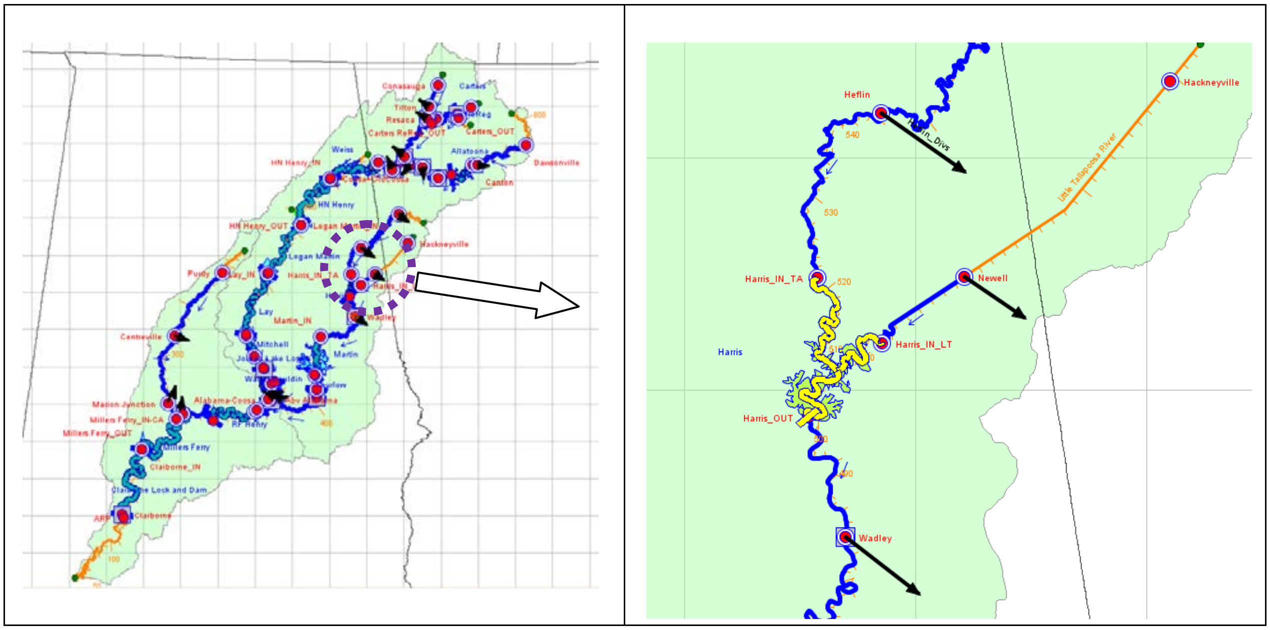


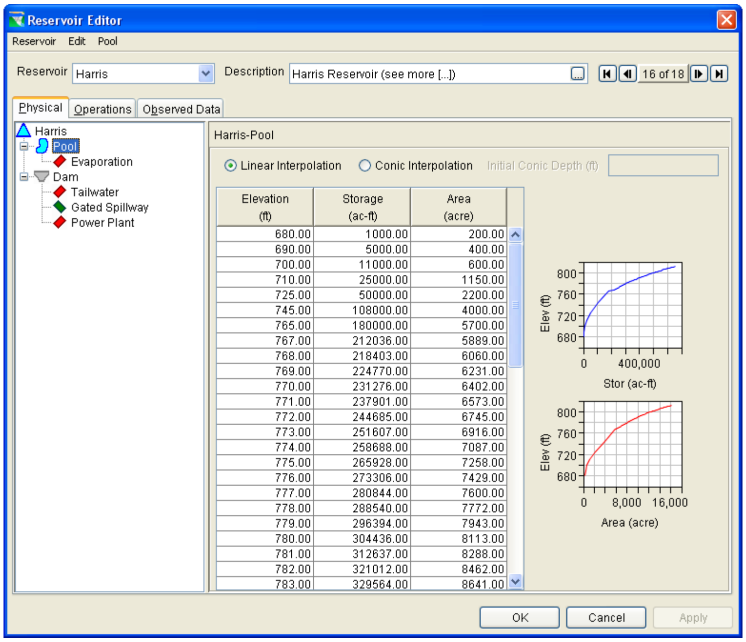
Figure H.01 HEC-ResSim Map Display Showing Location of Harris Reservoir

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.



Reservoir: Harris

Description: Harris Reservoir (see more [...])

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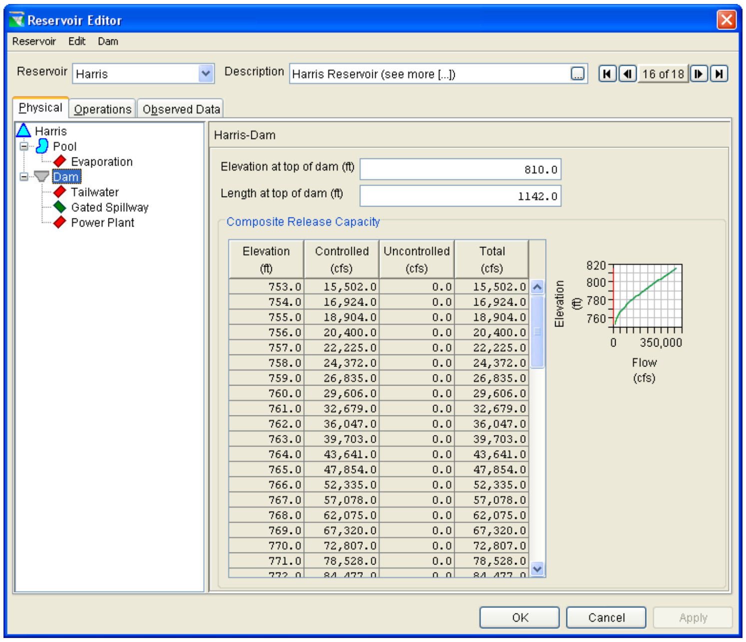
Harris-Pool

● Linear Interpolation ○ Conic Interpolation Initial Conic Depth (ft)

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



Reservoir: Harris

Description: Harris Reservoir (see more [...])

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Harris-Dam

Elevation at top of dam (ft): 810.0

Length at top of dam (ft): 1142.0

Composite Release Capacity

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

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

III. Baseline Operations

A. Operation Set

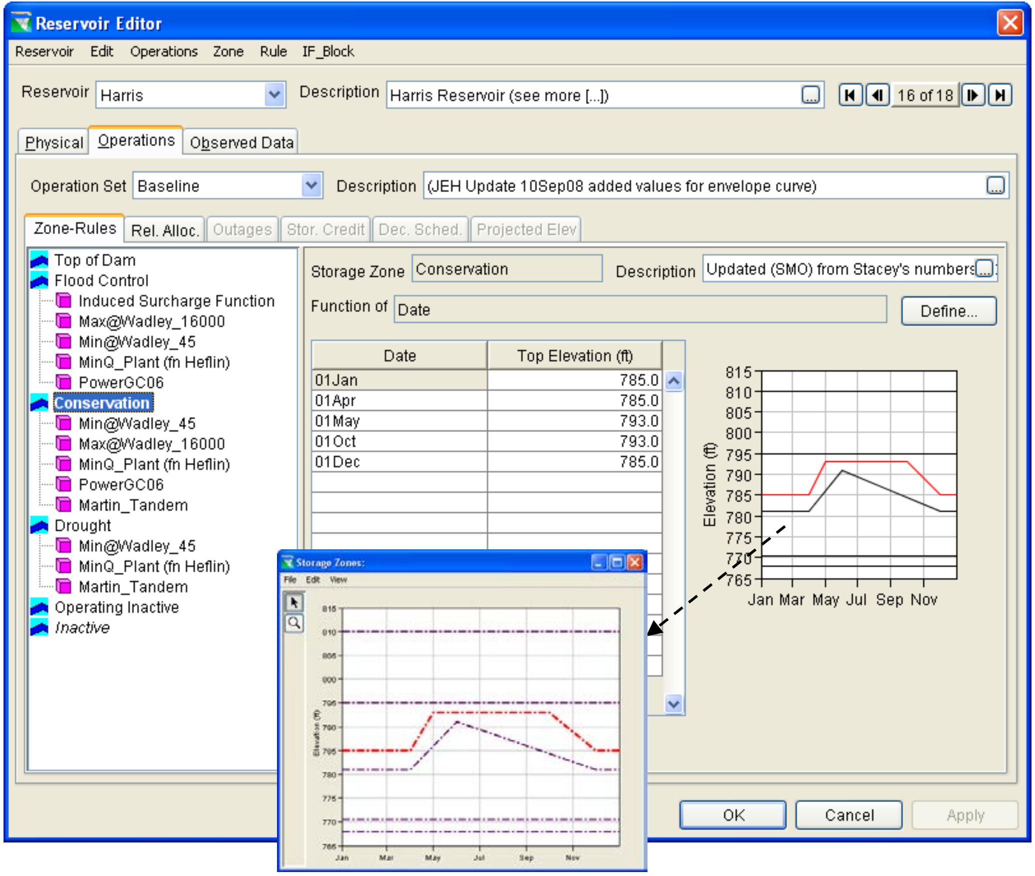
Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table H.01 shows the definition of "Baseline" operational zones for Harris Reservoir, which consist of zones of flood control and conservation.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



Reservoir: Harris

Description: Harris Reservoir (see more [...])

Operation Set: Baseline

Description: (JEH Update 10Sep08 added values for envelope curve)

Storage Zone: Conservation

Description: Updated (SMO) from Stacey's numbers

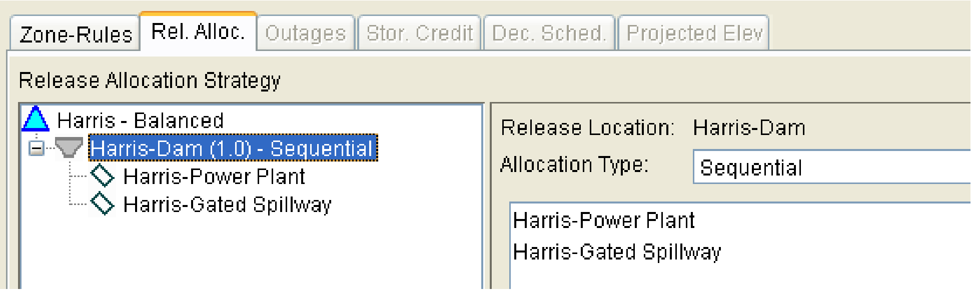
Function of: Date

Date	Top Elevation (ft)
01Jan	785.0
01Apr	785.0
01May	793.0
01Oct	793.0
01Dec	785.0

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:



Release Location: Harris-Dam

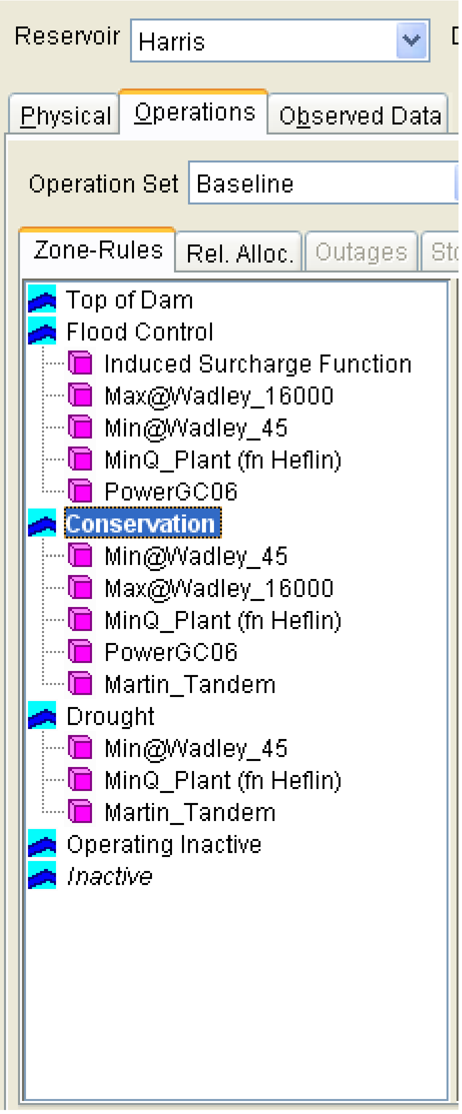
Allocation Type: Sequential

Harris-Power Plant
Harris-Gated Spillway

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”.



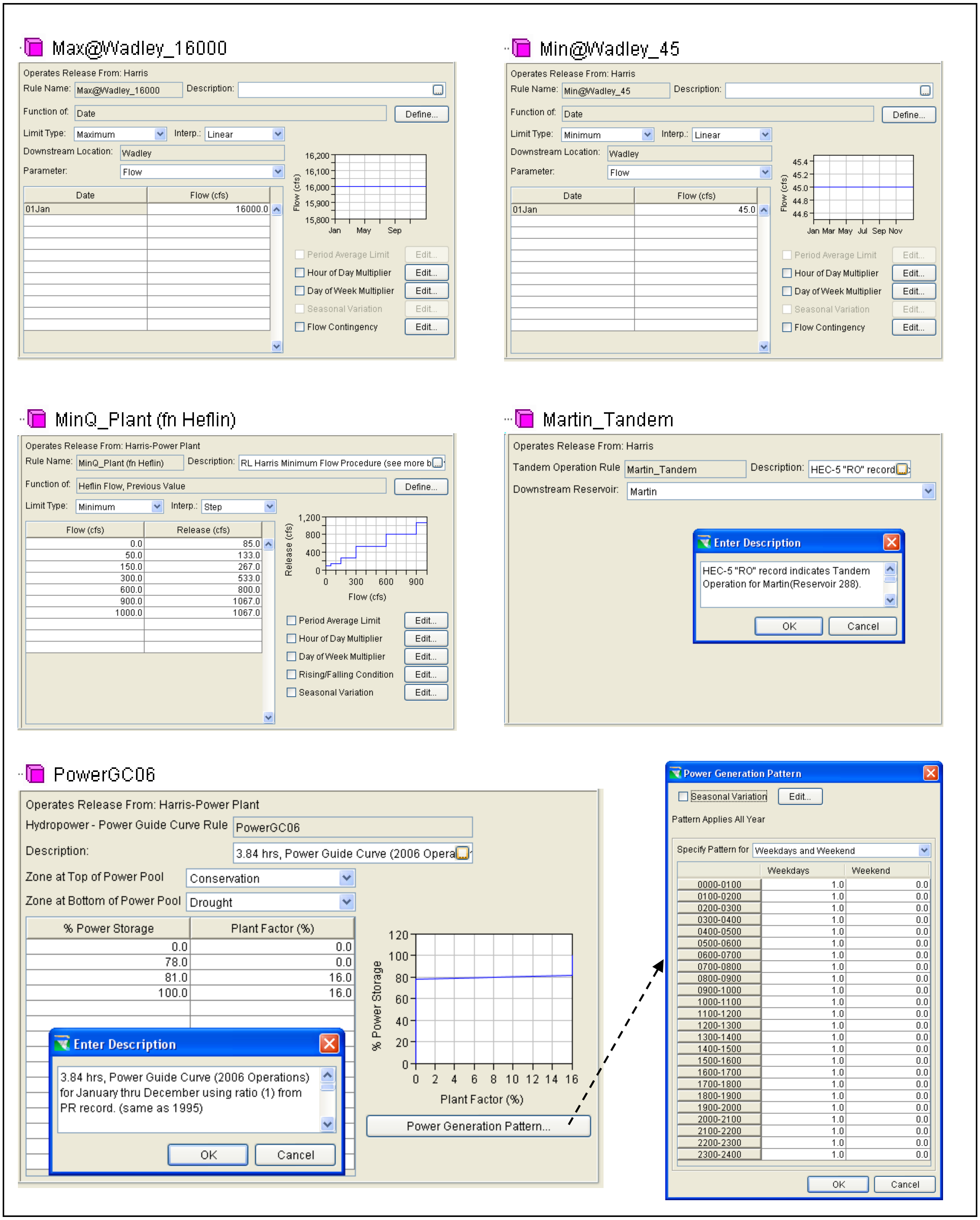
Reservoir: Harris

Operation Set: Baseline

- Top of Dam
- Flood Control
  - Induced Surcharge Function
  - Max@Wadley_16000
  - Min@Wadley_45
  - MinQ_Plant (fn Heflin)
  - PowerGC06
- Conservation
  - Min@Wadley_45
  - Max@Wadley_16000
  - MinQ_Plant (fn Heflin)
  - PowerGC06
  - Martin_Tandem
- Drought
  - Min@Wadley_45
  - MinQ_Plant (fn Heflin)
  - Martin_Tandem
- Operating Inactive
- *Inactive*

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.



Max@Wadley_16000

Operates Release From: Harris
Rule Name: Max@Wadley_16000
Description:
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: Wadley
Parameter: Flow

Date	Flow (cfs)
01Jan	16000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Min@Wadley_45

Operates Release From: Harris
Rule Name: Min@Wadley_45
Description:
Function of: Date
Limit Type: Minimum
Interp.: Linear
Downstream Location: Wadley
Parameter: Flow

Date	Flow (cfs)
01Jan	45.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

MinQ_Plant (fn Heflin)

Operates Release From: Harris-Power Plant
Rule Name: MinQ_Plant (fn Heflin)
Description: RL Harris Minimum Flow Procedure (see more b
Function of: Heflin Flow, Previous Value
Limit Type: Minimum
Interp.: Step

Flow (cfs)	Release (cfs)
0.0	85.0
50.0	133.0
150.0	267.0
300.0	533.0
600.0	800.0
900.0	1067.0
1000.0	1067.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Martin_Tandem

Operates Release From: Harris
Tandem Operation Rule: Martin_Tandem
Description: HEC-5 "RO" record
Downstream Reservoir: Martin

Enter Description

HEC-5 "RO" record indicates Tandem Operation for Martin(Reservoir 288).

PowerGC06

Operates Release From: Harris-Power Plant
Hydropower - Power Guide Curve Rule: PowerGC06
Description: 3.84 hrs, Power Guide Curve (2006 Opera
Zone at Top of Power Pool: Conservation
Zone at Bottom of Power Pool: Drought

% Power Storage	Plant Factor (%)
0.0	0.0
78.0	0.0
81.0	16.0
100.0	16.0

Enter Description

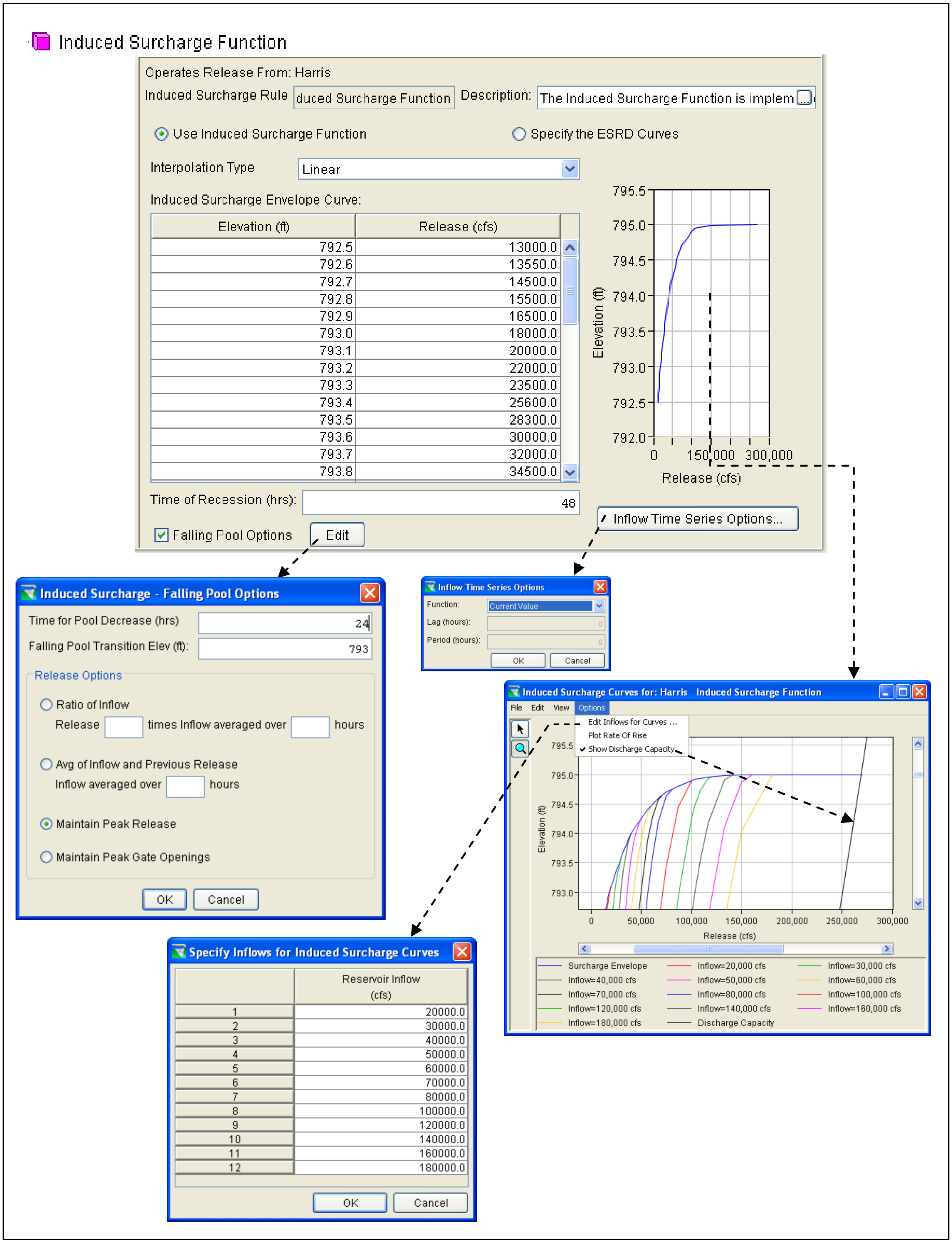
3.84 hrs, Power Guide Curve (2006 Operations) for January thru December using ratio (1) from PR record. (same as 1995)

Power Generation Pattern

☐ Seasonal Variation
Pattern Applies All Year
Specify Pattern for: Weekdays and Weekend

	Weekdays	Weekend
0000-0100	1.0	0.0
0100-0200	1.0	0.0
0200-0300	1.0	0.0
0300-0400	1.0	0.0
0400-0500	1.0	0.0
0500-0600	1.0	0.0
0600-0700	1.0	0.0
0700-0800	1.0	0.0
0800-0900	1.0	0.0
0900-1000	1.0	0.0
1000-1100	1.0	0.0
1100-1200	1.0	0.0
1200-1300	1.0	0.0
1300-1400	1.0	0.0
1400-1500	1.0	0.0
1500-1600	1.0	0.0
1600-1700	1.0	0.0
1700-1800	1.0	0.0
1800-1900	1.0	0.0
1900-2000	1.0	0.0
2000-2100	1.0	0.0
2100-2200	1.0	0.0
2200-2300	1.0	0.0
2300-2400	1.0	0.0

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



Induced Surcharge Function

Operates Release From: Harris

Induced Surcharge Rule: duced Surcharge Function

Description: The Induced Surcharge Function is implem

● Use Induced Surcharge Function ○ Specify the ESRD Curves

Interpolation Type: Linear

Induced Surcharge Envelope Curve:

Elevation (ft)	Release (cfs)
792.5	13000.0
792.6	13550.0
792.7	14500.0
792.8	15500.0
792.9	16500.0
793.0	18000.0
793.1	20000.0
793.2	22000.0
793.3	23500.0
793.4	25600.0
793.5	28300.0
793.6	30000.0
793.7	32000.0
793.8	34500.0

Time of Recession (hrs): 48

☑ Falling Pool Options

Induced Surcharge - Falling Pool Options

Time for Pool Decrease (hrs): 24

Falling Pool Transition Elev (ft): 793

Release Options

○ Ratio of Inflow

Release ___ times Inflow averaged over ___ hours

○ Avg of Inflow and Previous Release

Inflow averaged over ___ hours

● Maintain Peak Release

○ Maintain Peak Gate Openings

Inflow Time Series Options

Function: Current Value

Lag (hours): 0

Period (hours): 0

Induced Surcharge Curves for: Harris Induced Surcharge Function

Specify Inflows for Induced Surcharge Curves

	Reservoir Inflow (cfs)
1	20000.0
2	30000.0
3	40000.0
4	50000.0
5	60000.0
6	70000.0
7	80000.0
8	100000.0
9	120000.0
10	140000.0
11	160000.0
12	180000.0

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.

IV. Alternative Operations (same as “Baseline”)

Twelve ResSim alternatives were developed to represent the Baseline operations and 11 Alternative operating plans. The “Baseline” operation set is used for all of the 12 ResSim alternatives at Harris.

Alabama-Coosa-Tallapoosa (ACT) Watershed

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

Appendix I – Martin Reservoir

March 2011 (DRAFT)

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Appendix I – Martin (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.

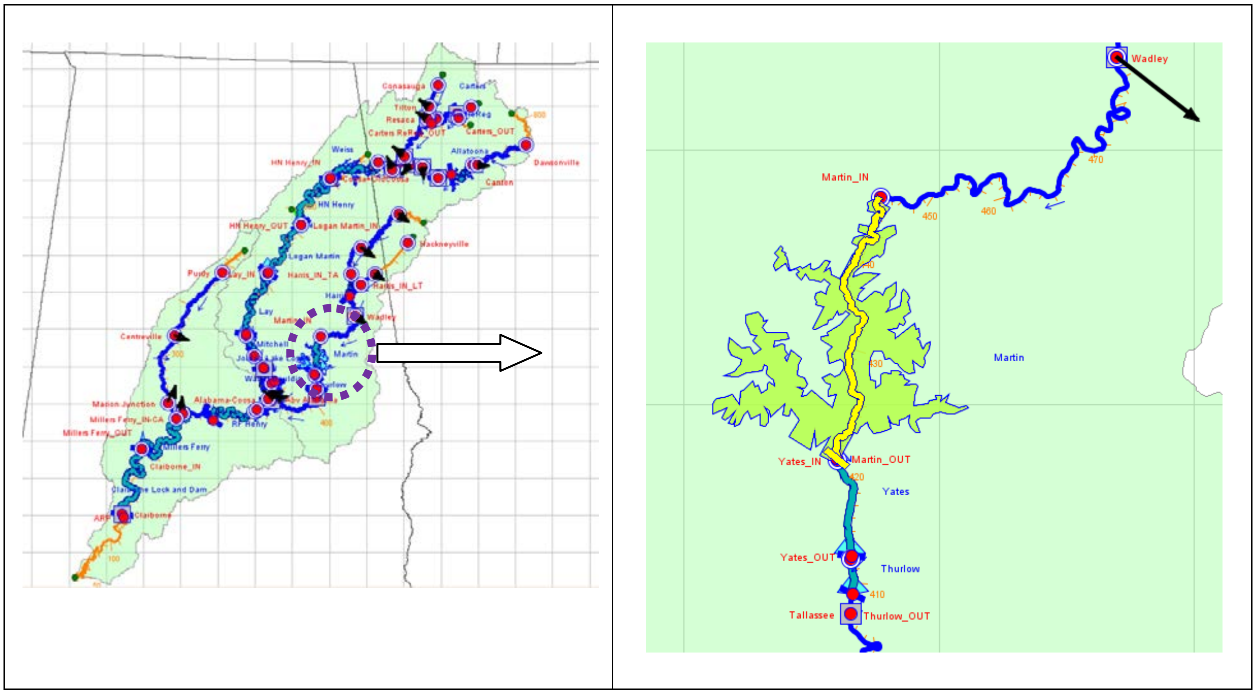


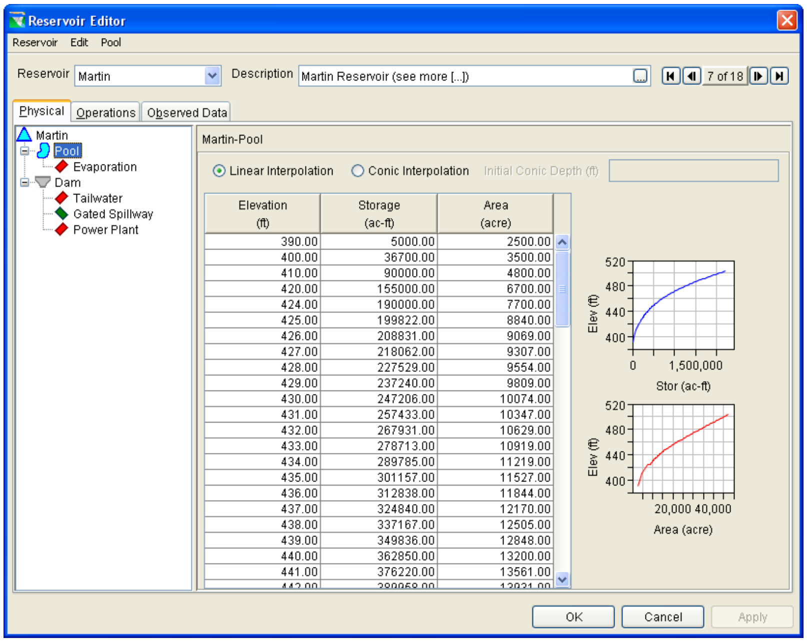
Figure I.01 HEC-ResSim Map Display Showing Location of Martin Reservoir

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.



Reservoir: Martin

Description: Martin Reservoir (see more [...])

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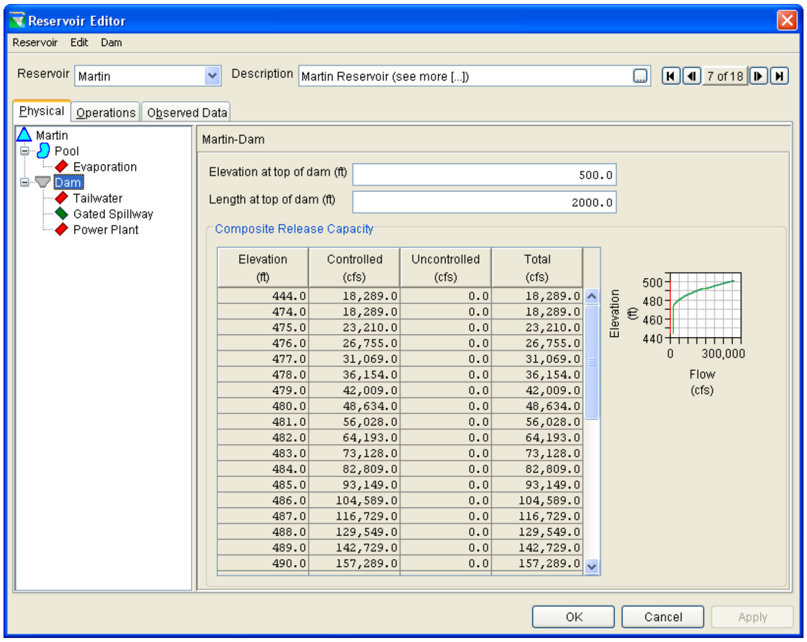
Martin-Pool

● Linear Interpolation ○ Conic Interpolation Initial Conic Depth (ft)

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



Reservoir: Martin

Description: Martin Reservoir (see more [...])

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Martin-Dam

Elevation at top of dam (ft): 500.0

Length at top of dam (ft): 2000.0

Composite Release Capacity

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

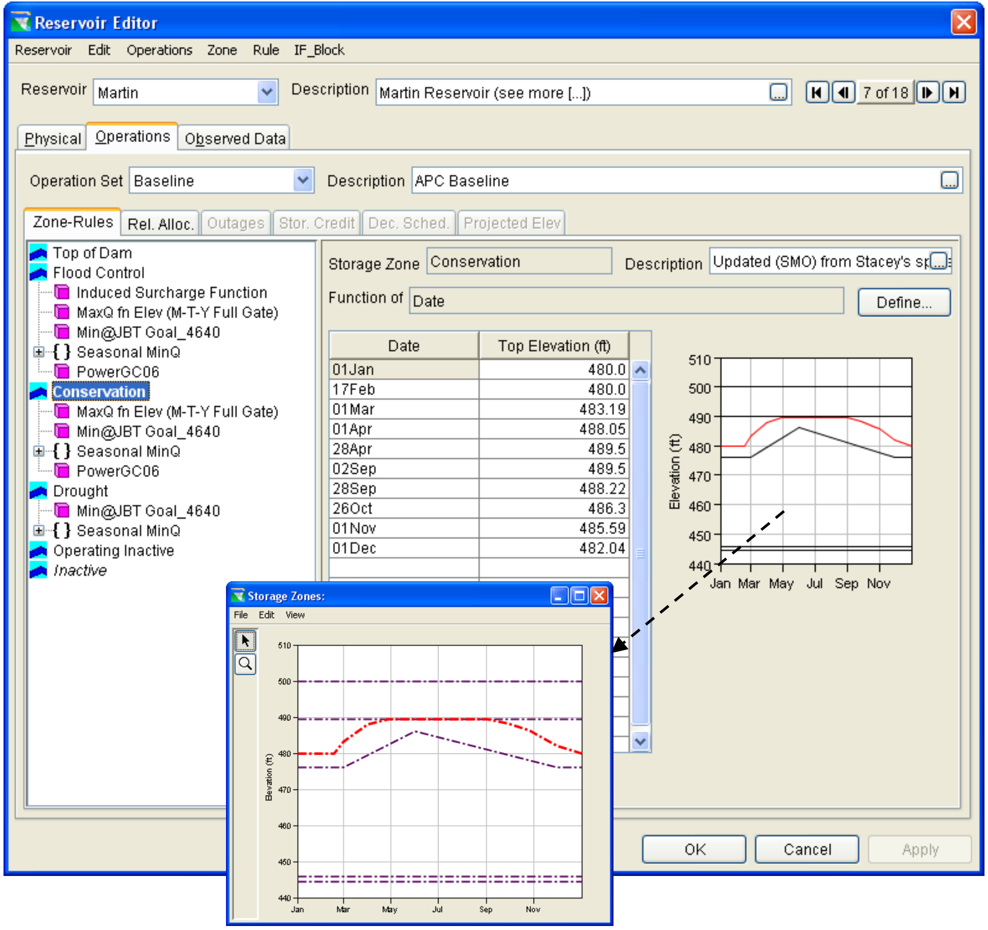
Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table I.01 shows the definition of "Baseline" operational zones for Martin Reservoir, which consists of zones of flood control and conservation.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



Reservoir: Martin
Description: Martin Reservoir (see more [...])
7 of 18

Operation Set: Baseline
Description: APC Baseline

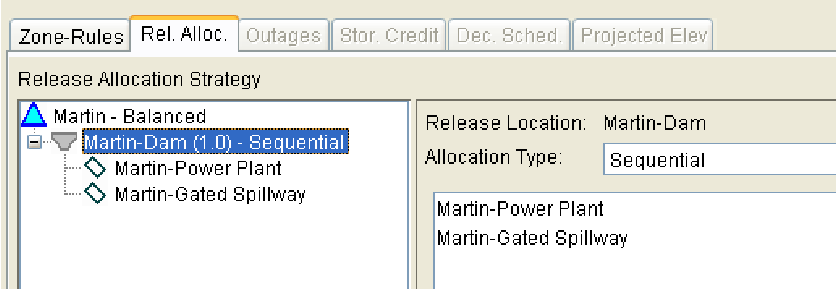
Storage Zone: Conservation
Description: Updated (SMO) from Stacey's sp
Function of: Date

Date	Top Elevation (ft)
01Jan	480.0
17Feb	480.0
01Mar	483.19
01Apr	488.05
28Apr	489.5
02Sep	489.5
28Sep	488.22
26Oct	486.3
01Nov	485.59
01Dec	482.04

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:



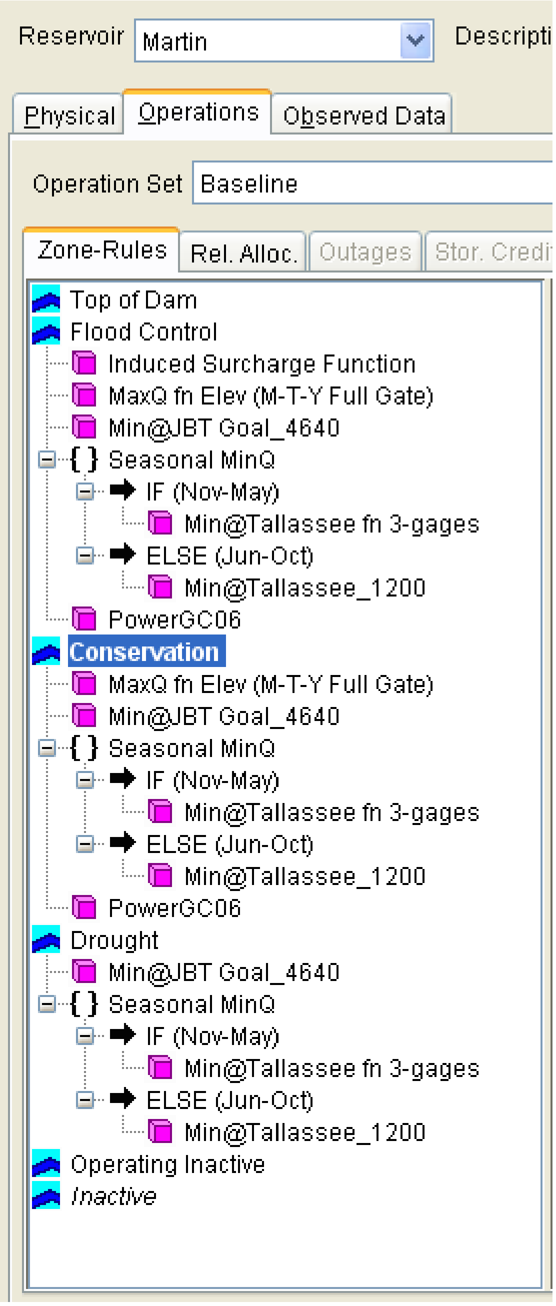
Release Location: Martin-Dam
Allocation Type: Sequential

Martin-Power Plant
Martin-Gated Spillway

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”.



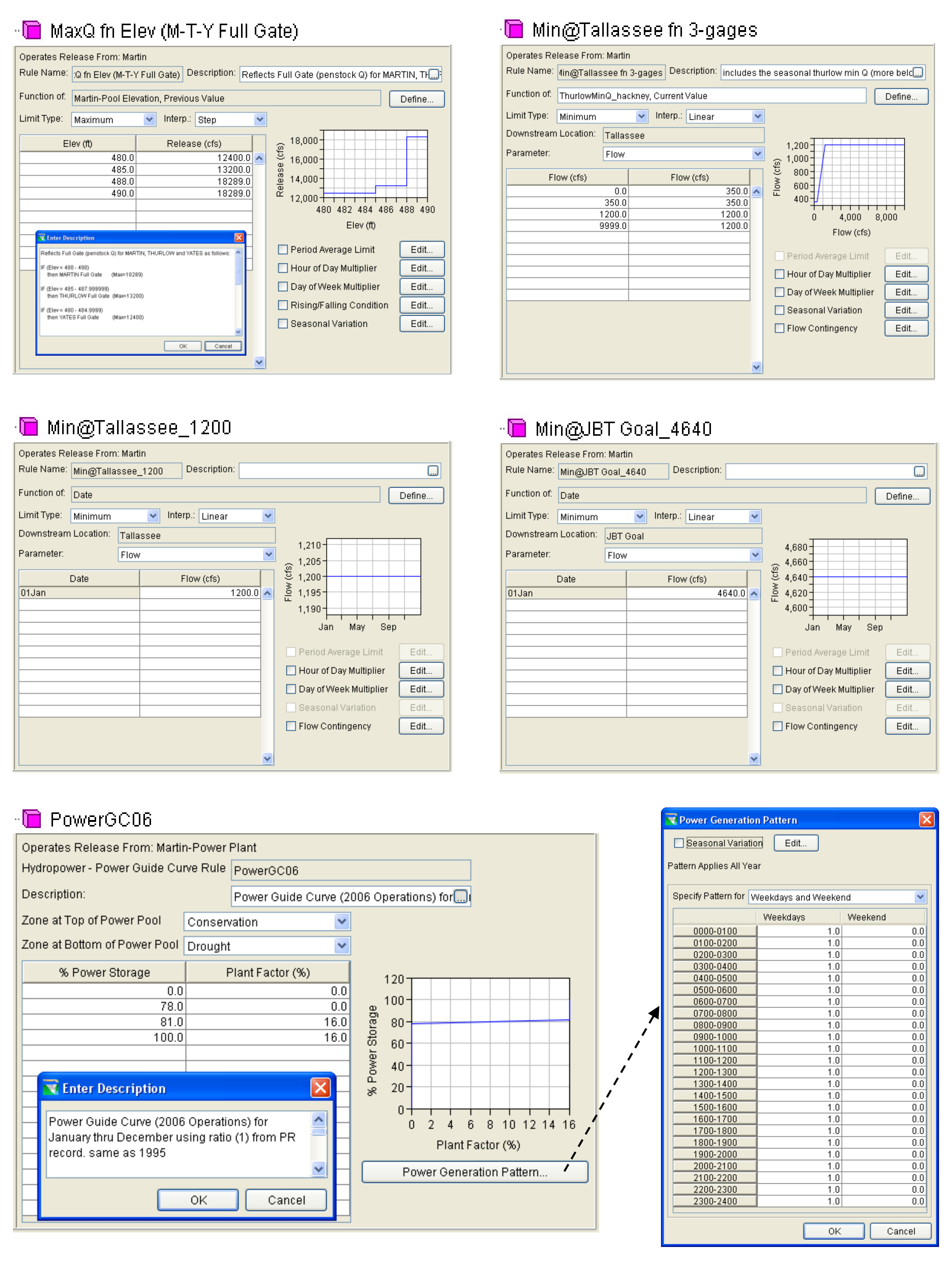
Reservoir: Martin

Operation Set: Baseline

- Top of Dam
- Flood Control
  - Induced Surcharge Function
  - MaxQ fn Elev (M-T-Y Full Gate)
  - Min@JBT Goal_4640
  - { } Seasonal MinQ
    - IF (Nov-May)
      - Min@Tallassee fn 3-gages
    - ELSE (Jun-Oct)
      - Min@Tallassee_1200
  - PowerGC06
- Conservation
  - MaxQ fn Elev (M-T-Y Full Gate)
  - Min@JBT Goal_4640
  - { } Seasonal MinQ
    - IF (Nov-May)
      - Min@Tallassee fn 3-gages
    - ELSE (Jun-Oct)
      - Min@Tallassee_1200
  - PowerGC06
- Drought
  - Min@JBT Goal_4640
  - { } Seasonal MinQ
    - IF (Nov-May)
      - Min@Tallassee fn 3-gages
    - ELSE (Jun-Oct)
      - Min@Tallassee_1200
- Operating Inactive
- *Inactive*

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.



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

Operates Release From: Martin

Rule Name: :Q fn Elev (M-T-Y Full Gate)

Description: Reflects Full Gate (penstock Q) for MARTIN, TH

Function of: Martin-Pool Elevation, Previous Value

Limit Type: Maximum

Interp.: Step

Elev (ft)	Release (cfs)
480.0	12400.0
485.0	13200.0
488.0	18289.0
490.0	18289.0

Enter Description

```
Reflects Full Gate (penstock Q) for MARTIN, THURLOW and YATES as follows:

IF (Elev = 488 - 490)
   then MARTIN Full Gate      (Max=18289)

IF (Elev = 485 - 487.999999)
   then THURLOW Full Gate  (Max=13200)

IF (Elev = 480 - 484.9999)
   then YATES Full Gate       (Max=12400)
```

☐ Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☐ Rising/Falling Condition

☐ Seasonal Variation

Min@Tallassee fn 3-gages

Operates Release From: Martin

Rule Name: /in@Tallassee fn 3-gages

Description: includes the seasonal thurlow min Q (more belc

Function of: ThurlowMinQ_hackney, Current Value

Limit Type: Minimum

Interp.: Linear

Downstream Location: Tallassee

Parameter: Flow

Flow (cfs)	Flow (cfs)
0.0	350.0
350.0	350.0
1200.0	1200.0
9999.0	1200.0

☐ Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☐ Seasonal Variation

☐ Flow Contingency

Min@Tallassee_1200

Operates Release From: Martin

Rule Name: Min@Tallassee_1200

Description:

Function of: Date

Limit Type: Minimum

Interp.: Linear

Downstream Location: Tallassee

Parameter: Flow

Date	Flow (cfs)
01Jan	1200.0

☐ Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☐ Seasonal Variation

☐ Flow Contingency

Min@JBT Goal_4640

Operates Release From: Martin

Rule Name: Min@JBT Goal_4640

Description:

Function of: Date

Limit Type: Minimum

Interp.: Linear

Downstream Location: JBT Goal

Parameter: Flow

Date	Flow (cfs)
01Jan	4640.0

☐ Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☐ Seasonal Variation

☐ Flow Contingency

PowerGC06

Operates Release From: Martin-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC06

Description: Power Guide Curve (2006 Operations) for

Zone at Top of Power Pool: Conservation

Zone at Bottom of Power Pool: Drought

% Power Storage	Plant Factor (%)
0.0	0.0
78.0	0.0
81.0	16.0
100.0	16.0

Enter Description

Power Guide Curve (2006 Operations) for January thru December using ratio (1) from PR record. same as 1995

Power Generation Pattern

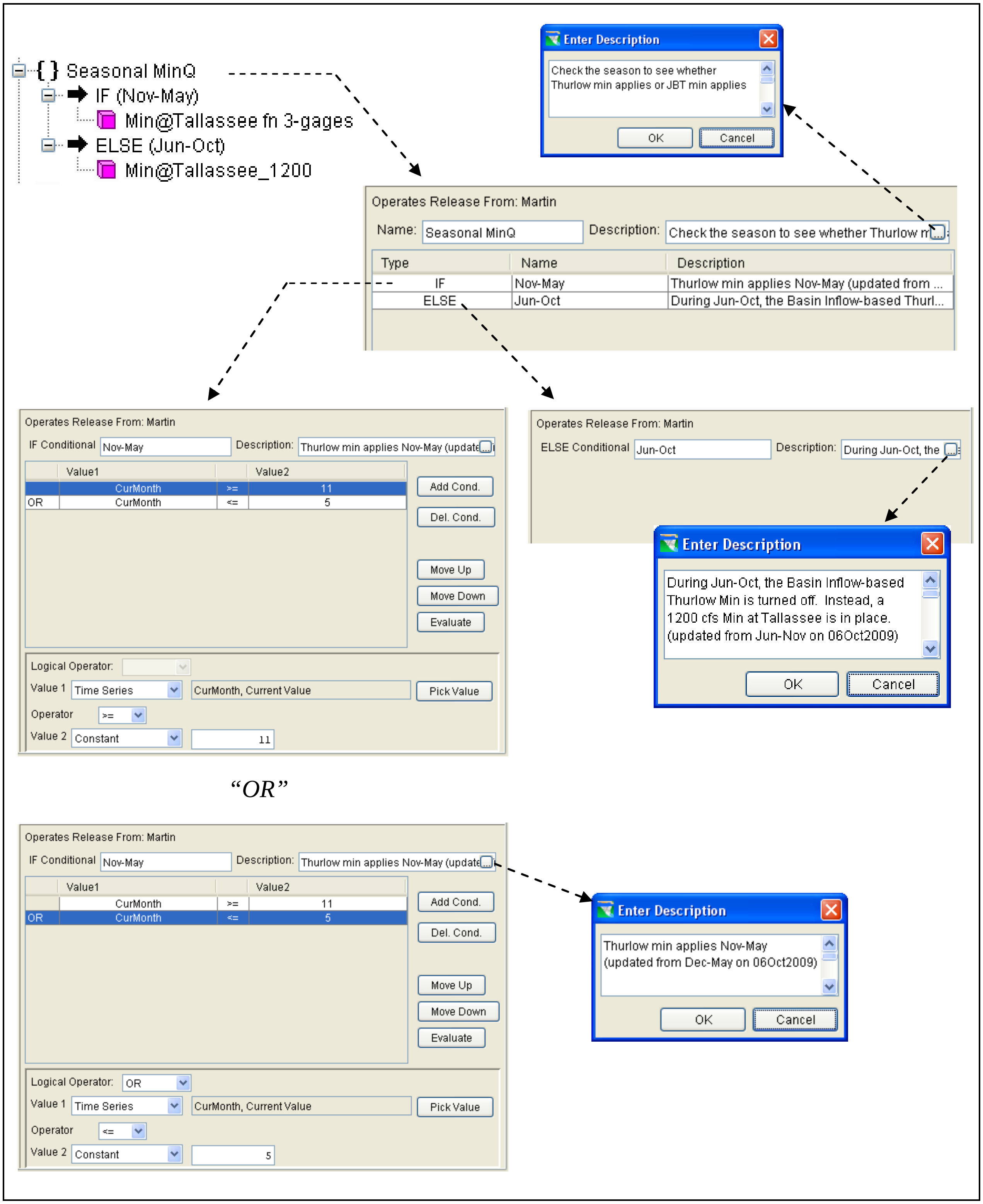
☐ Seasonal Variation

Pattern Applies All Year

Specify Pattern for: Weekdays and Weekend

	Weekdays	Weekend
0000-0100	1.0	0.0
0100-0200	1.0	0.0
0200-0300	1.0	0.0
0300-0400	1.0	0.0
0400-0500	1.0	0.0
0500-0600	1.0	0.0
0600-0700	1.0	0.0
0700-0800	1.0	0.0
0800-0900	1.0	0.0
0900-1000	1.0	0.0
1000-1100	1.0	0.0
1100-1200	1.0	0.0
1200-1300	1.0	0.0
1300-1400	1.0	0.0
1400-1500	1.0	0.0
1500-1600	1.0	0.0
1600-1700	1.0	0.0
1700-1800	1.0	0.0
1800-1900	1.0	0.0
1900-2000	1.0	0.0
2000-2100	1.0	0.0
2100-2200	1.0	0.0
2200-2300	1.0	0.0
2300-2400	1.0	0.0

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



{ } Seasonal MinQ
IF (Nov-May)
Min@Tallassee fn 3-gages
ELSE (Jun-Oct)
Min@Tallassee_1200

Enter Description

Check the season to see whether Thurlow min applies or JBT min applies

Operates Release From: Martin

Name: Seasonal MinQ
Description: Check the season to see whether Thurlow m

Type	Name	Description
IF	Nov-May	Thurlow min applies Nov-May (updated from ...
ELSE	Jun-Oct	During Jun-Oct, the Basin Inflow-based Thurl...

Operates Release From: Martin

IF Conditional: Nov-May
Description: Thurlow min applies Nov-May (update

	Value1		Value2
	CurMonth	>=	11
OR	CurMonth	<=	5

Logical Operator:
Value 1: Time Series — CurMonth, Current Value
Operator: >=
Value 2: Constant — 11

Operates Release From: Martin

ELSE Conditional: Jun-Oct
Description: During Jun-Oct, the

Enter Description

During Jun-Oct, the Basin Inflow-based Thurlow Min is turned off. Instead, a 1200 cfs Min at Tallassee is in place. (updated from Jun-Nov on 06Oct2009)

"OR"

Operates Release From: Martin

IF Conditional: Nov-May
Description: Thurlow min applies Nov-May (update

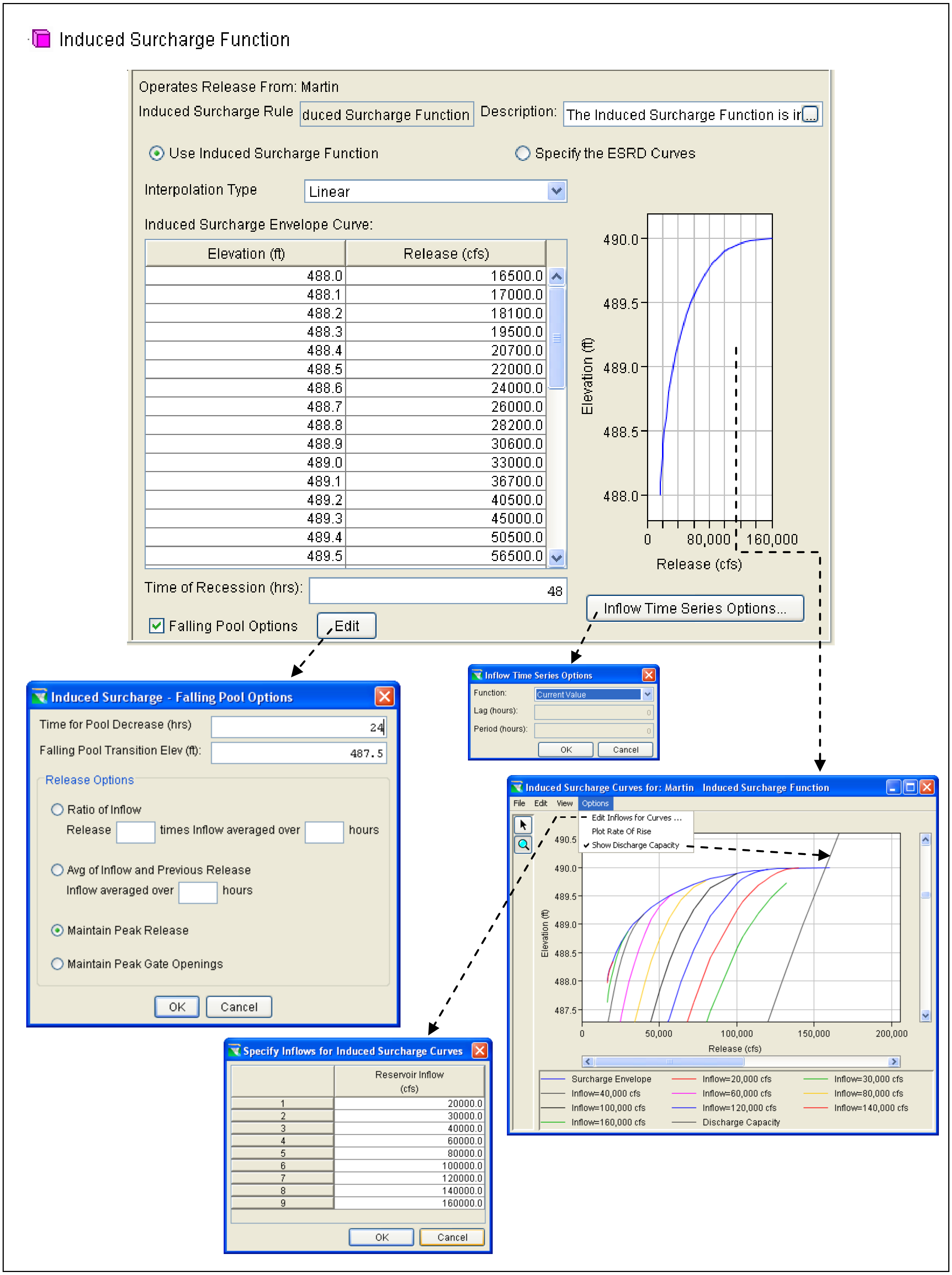
	Value1		Value2
	CurMonth	>=	11
OR	CurMonth	<=	5

Logical Operator: OR
Value 1: Time Series — CurMonth, Current Value
Operator: <=
Value 2: Constant — 5

Enter Description

Thurlow min applies Nov-May (updated from Dec-May on 06Oct2009)

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



Induced Surcharge Function

Operates Release From: Martin

Induced Surcharge Rule: duced Surcharge Function

Description: The Induced Surcharge Function is ir

● Use Induced Surcharge Function ○ Specify the ESRD Curves

Interpolation Type: Linear

Induced Surcharge Envelope Curve:

Elevation (ft)	Release (cfs)
488.0	16500.0
488.1	17000.0
488.2	18100.0
488.3	19500.0
488.4	20700.0
488.5	22000.0
488.6	24000.0
488.7	26000.0
488.8	28200.0
488.9	30600.0
489.0	33000.0
489.1	36700.0
489.2	40500.0
489.3	45000.0
489.4	50500.0
489.5	56500.0

Time of Recession (hrs): 48

☑ Falling Pool Options

Induced Surcharge - Falling Pool Options

Time for Pool Decrease (hrs): 24

Falling Pool Transition Elev (ft): 487.5

Release Options

○ Ratio of Inflow

Release [ ] times Inflow averaged over [ ] hours

○ Avg of Inflow and Previous Release

Inflow averaged over [ ] hours

● Maintain Peak Release

○ Maintain Peak Gate Openings

Inflow Time Series Options

Function: Current Value

Lag (hours): 0

Period (hours): 0

Induced Surcharge Curves for: Martin Induced Surcharge Function

Specify Inflows for Induced Surcharge Curves

	Reservoir Inflow (cfs)
1	20000.0
2	30000.0
3	40000.0
4	60000.0
5	80000.0
6	100000.0
7	120000.0
8	140000.0
9	160000.0

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.

IV. Alternative Operations

Twelve ResSim alternatives were developed to represent the Baseline operations and 11 Alternative operating plans.

A. Operation Sets

For the 12 ResSim alternatives, Martin Reservoir used 3 operation sets. The alternatives and operation sets are given in Table I.02. Table I.03 describes each operation set.

Table I.02 Alternatives and Operation Sets Used at Martin

Alternative	Operation Set
Baseline	Baseline
DroughtPln	Nav_Drought
Burkett	Nav_Drought
DragoA	Nav_Drought
DragoB	Nav_Drought
RPlanA	Nav_Drought
RPlanB	Nav_Drought
RPlanC	Nav_Drought-rev
RPlanD	Nav_Drought-rev
RPlanE	Nav_Drought-rev
RPlanF	Nav_Drought-rev
RPlanG	Nav_Drought-rev

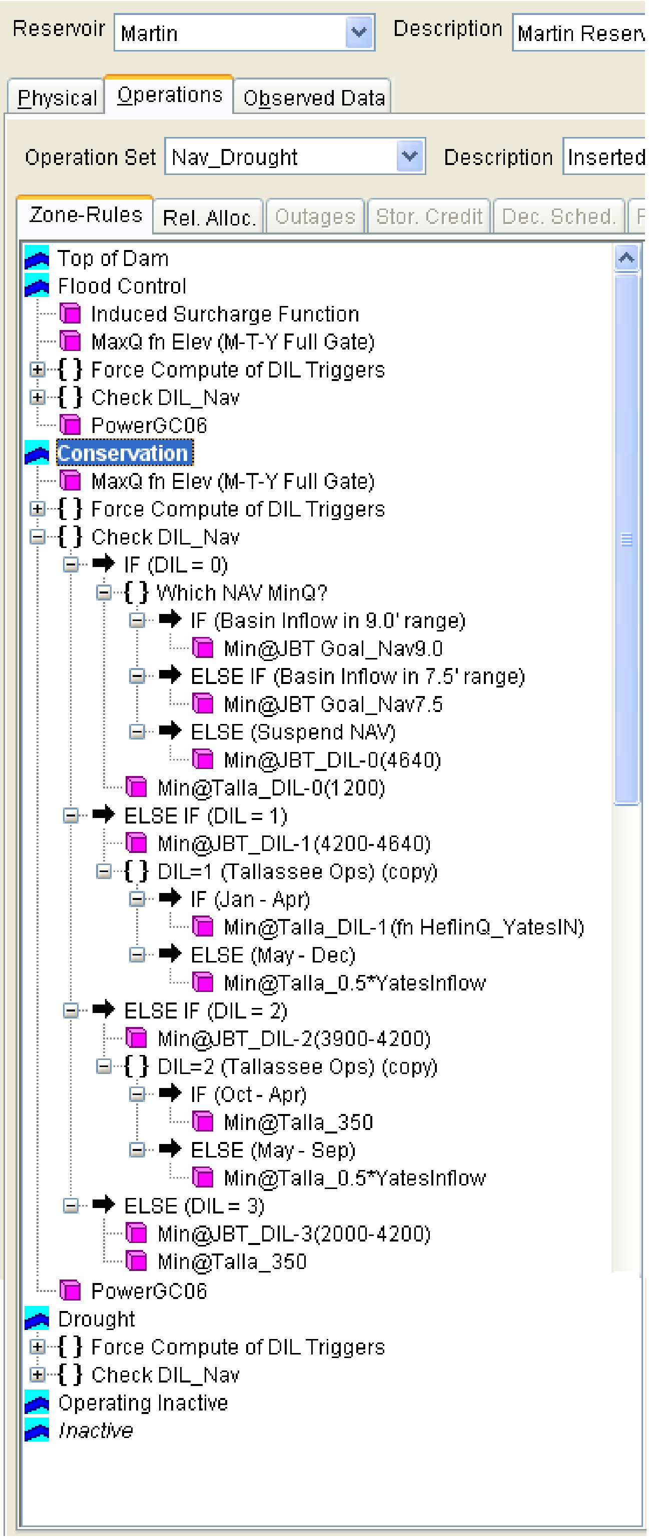
Table I.03 Operation Sets Used at Martin

Operation Set	Description
Baseline	Current operation / no action
Nav_Drought	Navigation flow target and drought plan with flow requirement reductions
Nav_Drought-rev	Same as Nav_Drought with revised Tallassee and Alabama River flow requirement

The rule sets for the “NAV_Drought” and “NAV_Drought-rev” operation sets are given in Section B (as shown in Figure I.11 and Figure I.12). The **Check DIL_Nav** conditional block is used in Flood Control, Conservation, and Drought zones and is reflected as a different version in each of the four alternative operation sets. Each version of this conditional block is shown in its expanded form in the Conservation zone in Figure I.11 and Figure I.12. The rules not used in the “Baseline” operation set are shown in Figure I.13 and Figure I.14. A description of these rules is provided in Section C.

The zone definitions and the elevations used for the zones are the same for all three operation sets. The difference in the Baseline and NAV_Drought operation sets involves the minimum flow values at JBT and Tallassee. These differences are summarized in Table I.03. The NAV_Drought-rev operation set varies from the NAV_Drought operation set in that the JBT Goal minimum flow values for DIL=2 and DIL=3 are different and the Low State Line flow criteria is different. The comparison of JBT Goal minimum flow values for these alternatives is given in Table I.04.

1. “Nav_Drought” Operation Set



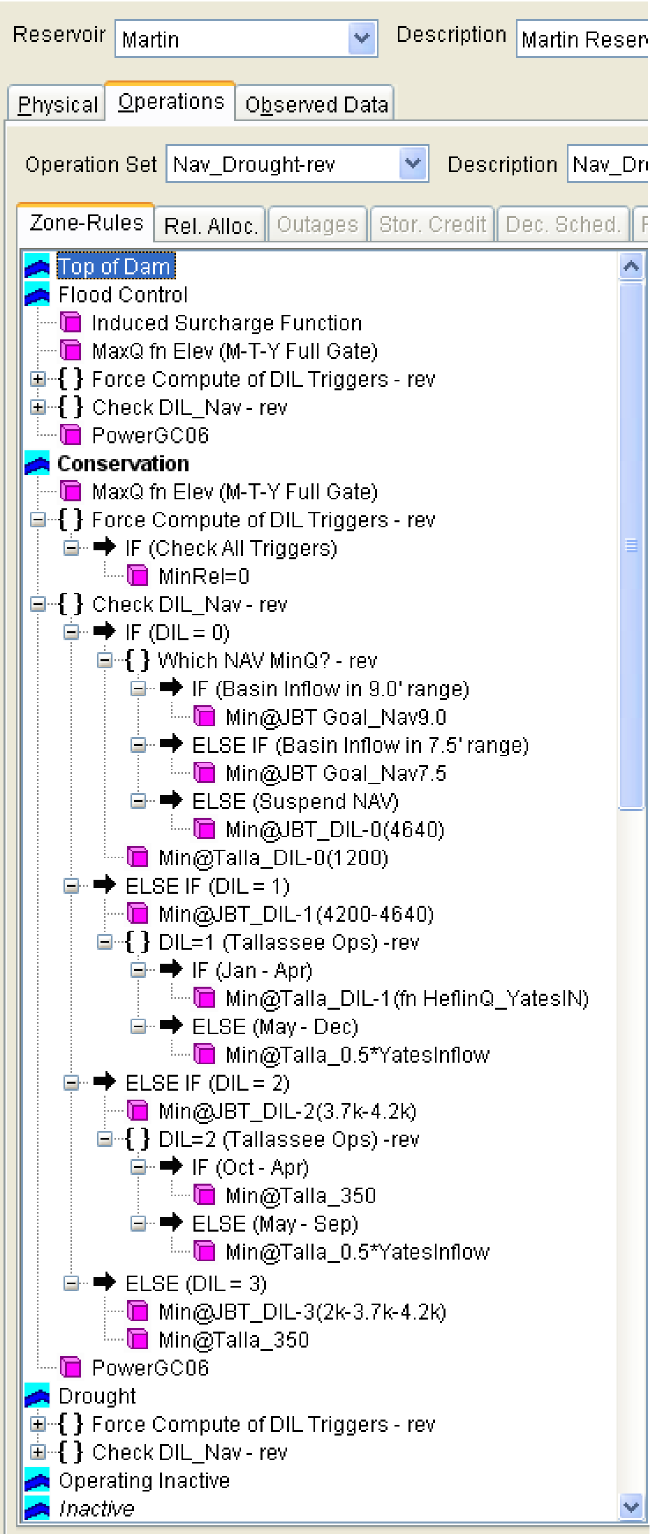
Reservoir Martin Description Martin Reserv

Operation Set Nav_Drought Description Inserted

- Top of Dam
- Flood Control
  - Induced Surcharge Function
  - MaxQ fn Elev (M-T-Y Full Gate)
  - { } Force Compute of DIL Triggers
  - { } Check DIL_Nav
  - PowerGC06
- Conservation
  - MaxQ fn Elev (M-T-Y Full Gate)
  - { } Force Compute of DIL Triggers
  - { } Check DIL_Nav
    - IF (DIL = 0)
      - { } Which NAV MinQ?
        - IF (Basin Inflow in 9.0' range)
          - Min@JBT Goal_Nav9.0
        - ELSE IF (Basin Inflow in 7.5' range)
          - Min@JBT Goal_Nav7.5
        - ELSE (Suspend NAV)
          - Min@JBT_DIL-0(4640)
      - Min@Talla_DIL-0(1200)
    - ELSE IF (DIL = 1)
      - Min@JBT_DIL-1(4200-4640)
      - { } DIL=1 (Tallassee Ops) (copy)
        - IF (Jan - Apr)
          - Min@Talla_DIL-1(fn HeflinQ_YatesIN)
        - ELSE (May - Dec)
          - Min@Talla_0.5*YatesInflow
    - ELSE IF (DIL = 2)
      - Min@JBT_DIL-2(3900-4200)
      - { } DIL=2 (Tallassee Ops) (copy)
        - IF (Oct - Apr)
          - Min@Talla_350
        - ELSE (May - Sep)
          - Min@Talla_0.5*YatesInflow
    - ELSE (DIL = 3)
      - Min@JBT_DIL-3(2000-4200)
      - Min@Talla_350
  - PowerGC06
- Drought
  - { } Force Compute of DIL Triggers
  - { } Check DIL_Nav
- Operating Inactive
- *Inactive*

Figure I.11 Rule Set for the “Nav_Drought” Operation Set at Martin

2. “Nav_Drought-rev” Operation Set



Reservoir: Martin; Description: Martin Reser

Physical | Operations | Observed Data

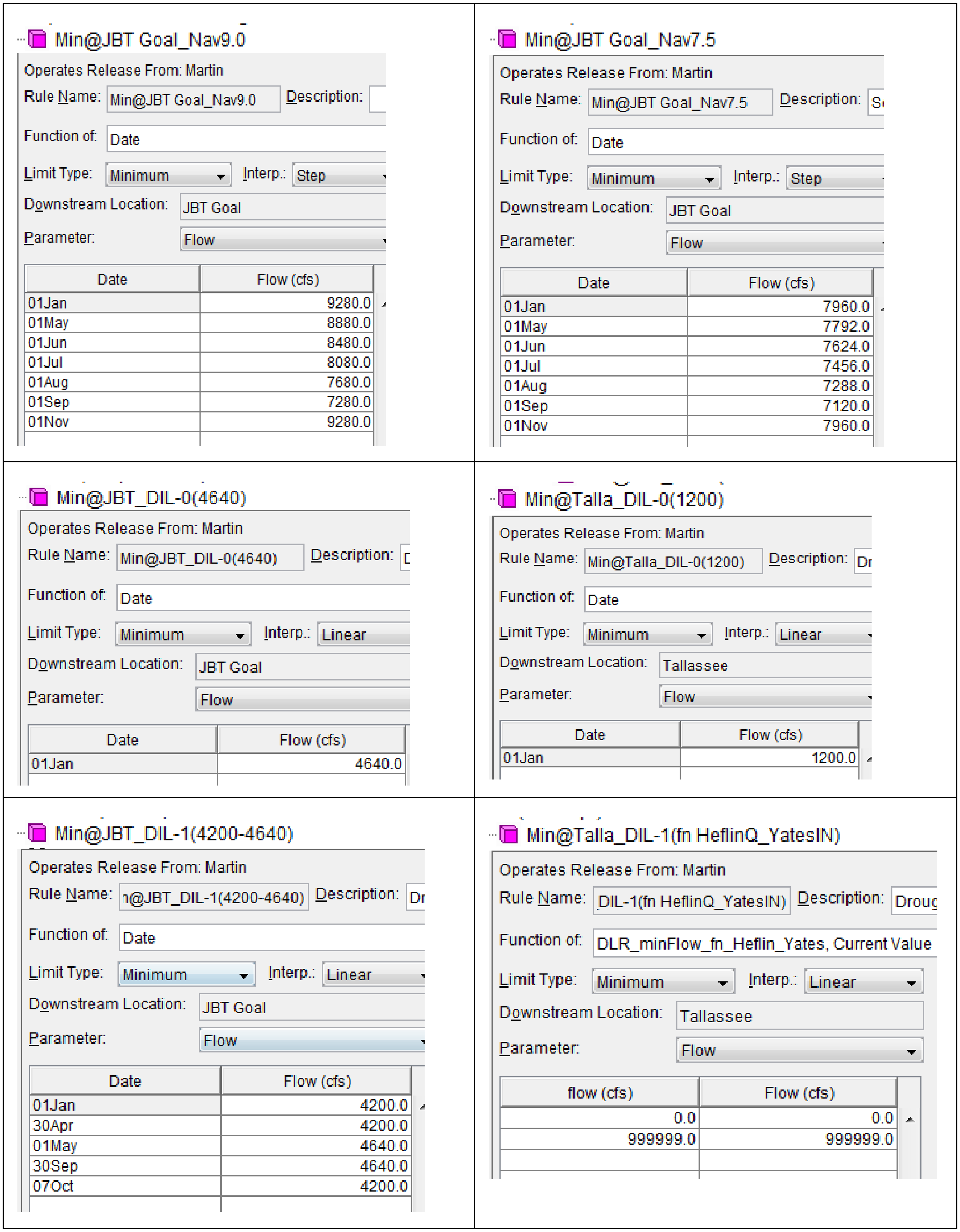
Operation Set: Nav_Drought-rev; Description: Nav_Dr

Zone-Rules | Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | F

- Top of Dam
- Flood Control
  - Induced Surcharge Function
  - MaxQ fn Elev (M-T-Y Full Gate)
  - { } Force Compute of DIL Triggers - rev
  - { } Check DIL_Nav - rev
  - PowerGC06
- **Conservation**
  - MaxQ fn Elev (M-T-Y Full Gate)
  - { } Force Compute of DIL Triggers - rev
    - ➡ IF (Check All Triggers)
      - MinRel=0
  - { } Check DIL_Nav - rev
    - ➡ IF (DIL = 0)
      - { } Which NAV MinQ? - rev
        - ➡ IF (Basin Inflow in 9.0' range)
          - Min@JBT Goal_Nav9.0
        - ➡ ELSE IF (Basin Inflow in 7.5' range)
          - Min@JBT Goal_Nav7.5
        - ➡ ELSE (Suspend NAV)
          - Min@JBT_DIL-0(4640)
      - Min@Talla_DIL-0(1200)
    - ➡ ELSE IF (DIL = 1)
      - Min@JBT_DIL-1(4200-4640)
      - { } DIL=1 (Tallassee Ops) -rev
        - ➡ IF (Jan - Apr)
          - Min@Talla_DIL-1(fn HeflinQ_YatesIN)
        - ➡ ELSE (May - Dec)
          - Min@Talla_0.5*YatesInflow
    - ➡ ELSE IF (DIL = 2)
      - Min@JBT_DIL-2(3.7k-4.2k)
      - { } DIL=2 (Tallassee Ops) -rev
        - ➡ IF (Oct - Apr)
          - Min@Talla_350
        - ➡ ELSE (May - Sep)
          - Min@Talla_0.5*YatesInflow
    - ➡ ELSE (DIL = 3)
      - Min@JBT_DIL-3(2k-3.7k-4.2k)
      - Min@Talla_350
  - PowerGC06
- Drought
  - { } Force Compute of DIL Triggers - rev
  - { } Check DIL_Nav - rev
- Operating Inactive
- *Inactive*

Figure I.12 Rule Set for the “Nav_Drought-rev” Operation Set at Martin

B. Rule Illustrations



Min@JBT Goal_Nav9.0

Operates Release From: Martin

Rule Name: Min@JBT Goal_Nav9.0 Description:

Function of: Date

Limit Type: Minimum Interp.: Step

Downstream Location: JBT Goal

Parameter: Flow

Date	Flow (cfs)
01Jan	9280.0
01May	8880.0
01Jun	8480.0
01Jul	8080.0
01Aug	7680.0
01Sep	7280.0
01Nov	9280.0

Min@JBT Goal_Nav7.5

Operates Release From: Martin

Rule Name: Min@JBT Goal_Nav7.5 Description: S

Function of: Date

Limit Type: Minimum Interp.: Step

Downstream Location: JBT Goal

Parameter: Flow

Date	Flow (cfs)
01Jan	7960.0
01May	7792.0
01Jun	7624.0
01Jul	7456.0
01Aug	7288.0
01Sep	7120.0
01Nov	7960.0

Min@JBT_DIL-0(4640)

Operates Release From: Martin

Rule Name: Min@JBT_DIL-0(4640) Description: D

Function of: Date

Limit Type: Minimum Interp.: Linear

Downstream Location: JBT Goal

Parameter: Flow

Date	Flow (cfs)
01Jan	4640.0

Min@Talla_DIL-0(1200)

Operates Release From: Martin

Rule Name: Min@Talla_DIL-0(1200) Description: Dr

Function of: Date

Limit Type: Minimum Interp.: Linear

Downstream Location: Tallassee

Parameter: Flow

Date	Flow (cfs)
01Jan	1200.0

Min@JBT_DIL-1(4200-4640)

Operates Release From: Martin

Rule Name: 1@JBT_DIL-1(4200-4640) Description: Dr

Function of: Date

Limit Type: Minimum Interp.: Linear

Downstream Location: JBT Goal

Parameter: Flow

Date	Flow (cfs)
01Jan	4200.0
30Apr	4200.0
01May	4640.0
30Sep	4640.0
07Oct	4200.0

Min@Talla_DIL-1(fn HeflinQ_YatesIN)

Operates Release From: Martin

Rule Name: DIL-1(fn HeflinQ_YatesIN) Description: Droug

Function of: DLR_minFlow_fn_Heflin_Yates, Current Value

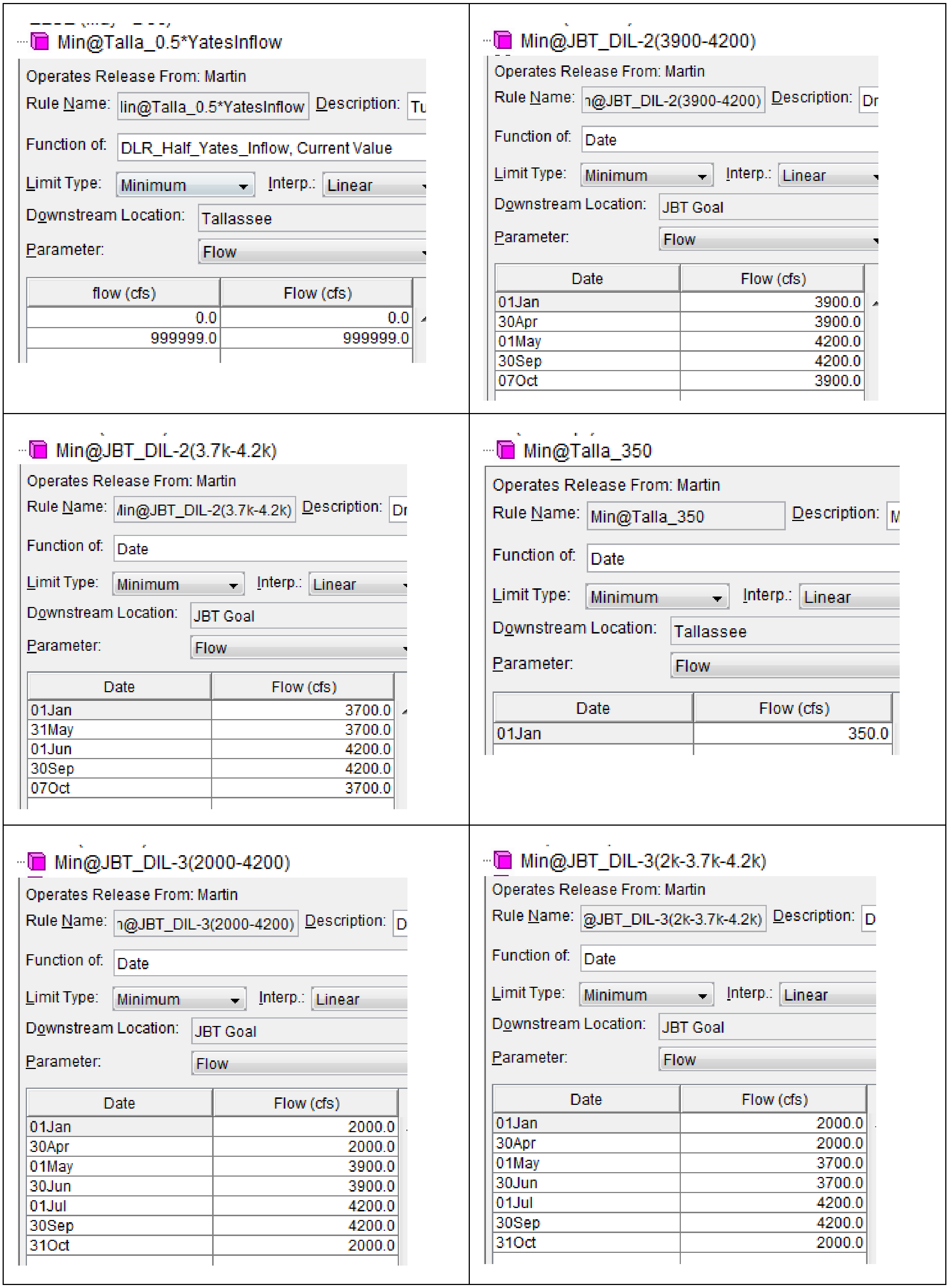
Limit Type: Minimum Interp.: Linear

Downstream Location: Tallassee

Parameter: Flow

flow (cfs)	Flow (cfs)
0.0	0.0
999999.0	999999.0

Figure I.13 Rules of Operation for "Nav_Drought" and "Nav_Drought-rev" Operations Sets ***(Part 1 of 2)***



Min@Talla_0.5*YatesInflow

Operates Release From: Martin

Rule Name: lin@Talla_0.5*YatesInflow Description: Tu

Function of: DLR_Half_Yates_Inflow, Current Value

Limit Type: Minimum Interp.: Linear

Downstream Location: Tallassee

Parameter: Flow

flow (cfs)	Flow (cfs)
0.0	0.0
999999.0	999999.0

Min@JBT_DIL-2(3900-4200)

Operates Release From: Martin

Rule Name: n@JBT_DIL-2(3900-4200) Description: Dr

Function of: Date

Limit Type: Minimum Interp.: Linear

Downstream Location: JBT Goal

Parameter: Flow

Date	Flow (cfs)
01Jan	3900.0
30Apr	3900.0
01May	4200.0
30Sep	4200.0
07Oct	3900.0

Min@JBT_DIL-2(3.7k-4.2k)

Operates Release From: Martin

Rule Name: Min@JBT_DIL-2(3.7k-4.2k) Description: Dr

Function of: Date

Limit Type: Minimum Interp.: Linear

Downstream Location: JBT Goal

Parameter: Flow

Date	Flow (cfs)
01Jan	3700.0
31May	3700.0
01Jun	4200.0
30Sep	4200.0
07Oct	3700.0

Min@Talla_350

Operates Release From: Martin

Rule Name: Min@Talla_350 Description: M

Function of: Date

Limit Type: Minimum Interp.: Linear

Downstream Location: Tallassee

Parameter: Flow

Date	Flow (cfs)
01Jan	350.0

Min@JBT_DIL-3(2000-4200)

Operates Release From: Martin

Rule Name: n@JBT_DIL-3(2000-4200) Description: D

Function of: Date

Limit Type: Minimum Interp.: Linear

Downstream Location: JBT Goal

Parameter: Flow

Date	Flow (cfs)
01Jan	2000.0
30Apr	2000.0
01May	3900.0
30Jun	3900.0
01Jul	4200.0
30Sep	4200.0
31Oct	2000.0

Min@JBT_DIL-3(2k-3.7k-4.2k)

Operates Release From: Martin

Rule Name: @JBT_DIL-3(2k-3.7k-4.2k) Description: D

Function of: Date

Limit Type: Minimum Interp.: Linear

Downstream Location: JBT Goal

Parameter: Flow

Date	Flow (cfs)
01Jan	2000.0
30Apr	2000.0
01May	3700.0
30Jun	3700.0
01Jul	4200.0
30Sep	4200.0
31Oct	2000.0

Figure I.14 Rules of Operation for "Nav_Drought" and "Nav_Drought-rev" Operations Sets *(Part 2 of 2)*

C. Rule Descriptions

1. Min@JBT Goal_Nav9.0

This rule (see Figure I.13) sets the minimum release at JBT Goal when the DIL=0 and the basin inflow is sufficient to support a 9.0 ft navigation channel. The minimum release varies between 7,280 cfs and 9,280 cfs depending on the time of year. This rule applies to both the “Nav_Drought” and “Nav_Drought-rev” operations sets.

2. Min@JBT Goal_Nav7.5

This rule (see Figure I.13) sets the minimum release at JBT Goal when the DIL=0 and the basin inflow is sufficient to support a 7.5 ft navigation channel. The minimum release varies between 7,120 cfs and 7,960 cfs depending on the time of year. This rule applies to both the “Nav_Drought” and “Nav_Drought-rev” operations sets.

3. Min@JBT_DIL-0(4640)

This rule (see Figure I.13) sets the minimum release at JBT Goal when the DIL=0 and the basin inflow is not sufficient to support a 7.5 ft navigation channel. The minimum release is set to a constant 4,640 cfs throughout the entire year. This rule applies to both the “Nav_Drought” and “Nav_Drought-rev” operations sets.

4. Min@Talla_DIL-0(1200)

This rule (see Figure I.13) sets the minimum release at Tallassee when the DIL=0. The minimum release is set to a constant 1,200 cfs throughout the entire year. This rule applies to both the “Nav_Drought” and “Nav_Drought-rev” operations sets.

5. Min@JBT_DIL-1(4200-4640)

This rule (see Figure I.13) sets the minimum release at JBT Goal when the DIL=1. The minimum release varies between 4,200 cfs and 4,640 cfs depending on the time of year. This rule applies to both the “Nav_Drought” and “Nav_Drought-rev” operations sets.

6. Min@Talla_DIL-1(fn HeflinQ_YatesIN)

This rule (see Figure I.13) sets the minimum release at Tallassee when the DIL=1 between the months of January and April. The minimum release is set to the maximum of one-half of the inflow to Yates and twice the flow at Heflin subject to the range of 350 cfs to 1,200 cfs. This rule applies to both the “Nav_Drought” and “Nav_Drought-rev” operations sets.

*7. Min@Talla_0.5*YatesInflow*

This rule (see Figure I.14) sets the minimum release at Tallassee when the DIL=1 between the months of May and December and when the DIL=2 between the months of May and September. The minimum release is set to one-half of the inflow to Yates subject to the range of 350 cfs to 1,200 cfs. This rule applies to both the “Nav_Drought” and “Nav_Drought-rev” operations sets.

8. Min@JBT_DIL-2(3900-4200)

This rule (see Figure I.14) sets the minimum release at JBT Goal when the DIL=2. The minimum release varies between 3,900 cfs and 4,200 cfs depending on the time of year. This rule applies to the “Nav_Drought” operations set only.

9. Min@JBT_DIL-2(3.7k-4.2k)

This rule (see Figure I.14) sets the minimum release at JBT Goal when the DIL=2. The minimum release varies between 3,700 cfs and 4,200 cfs depending on the time of year. This rule applies to the “Nav_Drought-rev” operations set only.

10. Min@Talla_350

This rule (see Figure I.14) sets the minimum release at Tallassee when the DIL=2 between the months of October and April and when the DIL=3 any time of the year. The minimum release is set to a constant value of 350 cfs. This rule applies to both the “Nav_Drought” and “Nav_Drought-rev” operations sets.

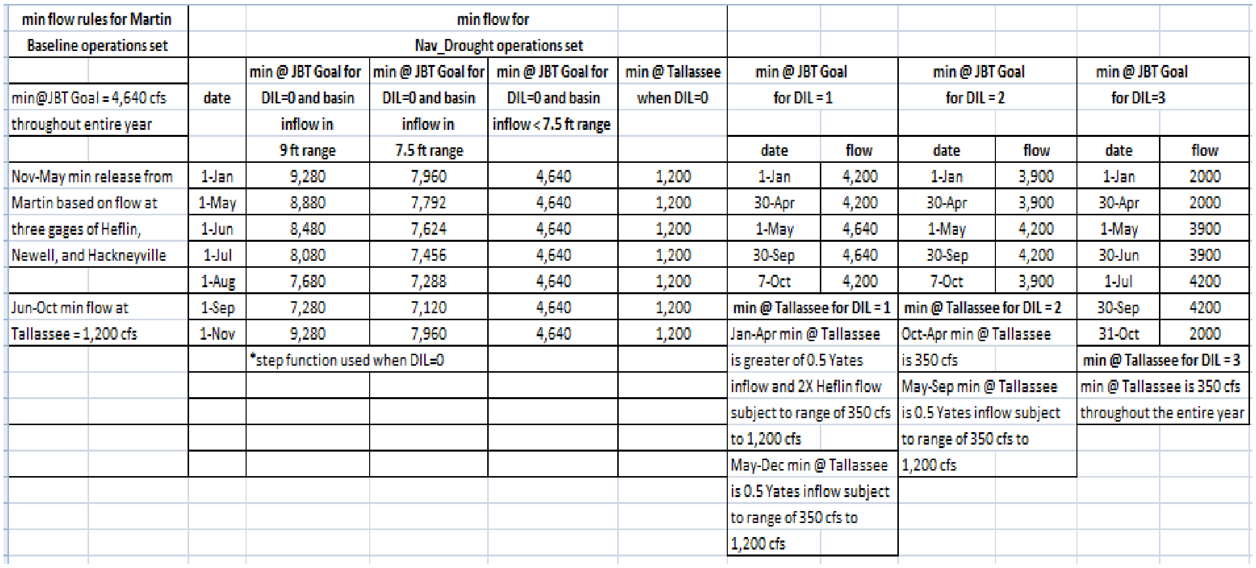
11. Min@JBT_DIL-3(2000-4200)

This rule (see Figure I.14) sets the minimum release at JBT Goal when the DIL=3. The minimum release varies between 2,000 cfs and 4,200 cfs depending on the time of year. This rule applies to the “Nav_Drought” operations set only.

12. Min@JBT_DIL-3(2k-3.7k-4.2k)

This rule (see Figure I.14) sets the minimum release at JBT Goal when the DIL=3. The minimum release varies between 2,000 cfs and 4,200 cfs depending on the time of year. This rule applies to the “Nav_Drought-rev” operations set only.

Table I.03 Summary of Differences in Rule Set for “Baseline” and “Nav_Drought” Operation Sets for Martin



min flow rules for Martin Baseline operations set		min flow for Nav_Drought operations set									
min@JBT Goal = 4,640 cfs throughout entire year	date	min @ JBT Goal for DIL=0 and basin inflow in 9 ft range	min @ JBT Goal for DIL=0 and basin inflow in 7.5 ft range	min @ JBT Goal for DIL=0 and basin inflow < 7.5 ft range	min @ Tallassee when DIL=0	min @ JBT Goal for DIL = 1		min @ JBT Goal for DIL = 2		min @ JBT Goal for DIL=3	
						date	flow	date	flow	date	flow
Nov-May min release from Martin based on flow at three gages of Heflin, Newell, and Hackneyville	1-Jan	9,280	7,960	4,640	1,200	1-Jan	4,200	1-Jan	3,900	1-Jan	2000
	1-May	8,880	7,792	4,640	1,200	30-Apr	4,200	30-Apr	3,900	30-Apr	2000
	1-Jun	8,480	7,624	4,640	1,200	1-May	4,640	1-May	4,200	1-May	3900
	1-Jul	8,080	7,456	4,640	1,200	30-Sep	4,640	30-Sep	4,200	30-Jun	3900
	1-Aug	7,680	7,288	4,640	1,200	7-Oct	4,200	7-Oct	3,900	1-Jul	4200
Jun-Oct min flow at Tallassee = 1,200 cfs	1-Sep	7,280	7,120	4,640	1,200	min @ Tallassee for DIL = 1		min @ Tallassee for DIL = 2		30-Sep	4200
	1-Nov	9,280	7,960	4,640	1,200	Jan-Apr min @ Tallassee is greater of 0.5 Yates inflow and 2X Heflin flow subject to range of 350 cfs to 1,200 cfs May-Dec min @ Tallassee is 0.5 Yates inflow subject to range of 350 cfs to 1,200 cfs		Oct-Apr min @ Tallassee is 350 cfs May-Sep min @ Tallassee is 0.5 Yates inflow subject to range of 350 cfs to 1,200 cfs		31-Oct	2000
		*step function used when DIL=0								min @ Tallassee for DIL = 3	
										min @ Tallassee is 350 cfs throughout the entire year	

Table I.04 Summary of Differences in Rule Set for “Nav_Drought” and “Nav_Drought-rev” Operation Sets for Martin

Date	Min@JBT Goal for DIL=2 in Nav_Drought	Min@JBT Goal for DIL=2 in Nav_Drought-rev	Min@JBT Goal for DIL=3 in Nav_Drought	Min@JBT Goal for DIL=3 in Nav_Drought-rev
01Jan	3,900	3,700	2,000	2,000
30Apr	3,900	3,700	2,000	2,000
01May	4,200	3,700	3,900	3,700
31May	4,200	3,700	3,900	3,700
01Jun	4,200	4,200	3,900	3,700
30Jun	4,200	4,200	3,900	3,700
01Jul	4,200	4,200	4,200	4,200
30Sep	4,200	4,200	4,200	4,200
07Oct	3,900	3,700	3,703	3,703
31Oct	3,900	3,700	2,000	2,000

Alabama-Coosa-Tallapoosa (ACT) Watershed

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

Appendix J – Jordan Reservoir and Walter Bouldin Reservoir

March 2011 (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.

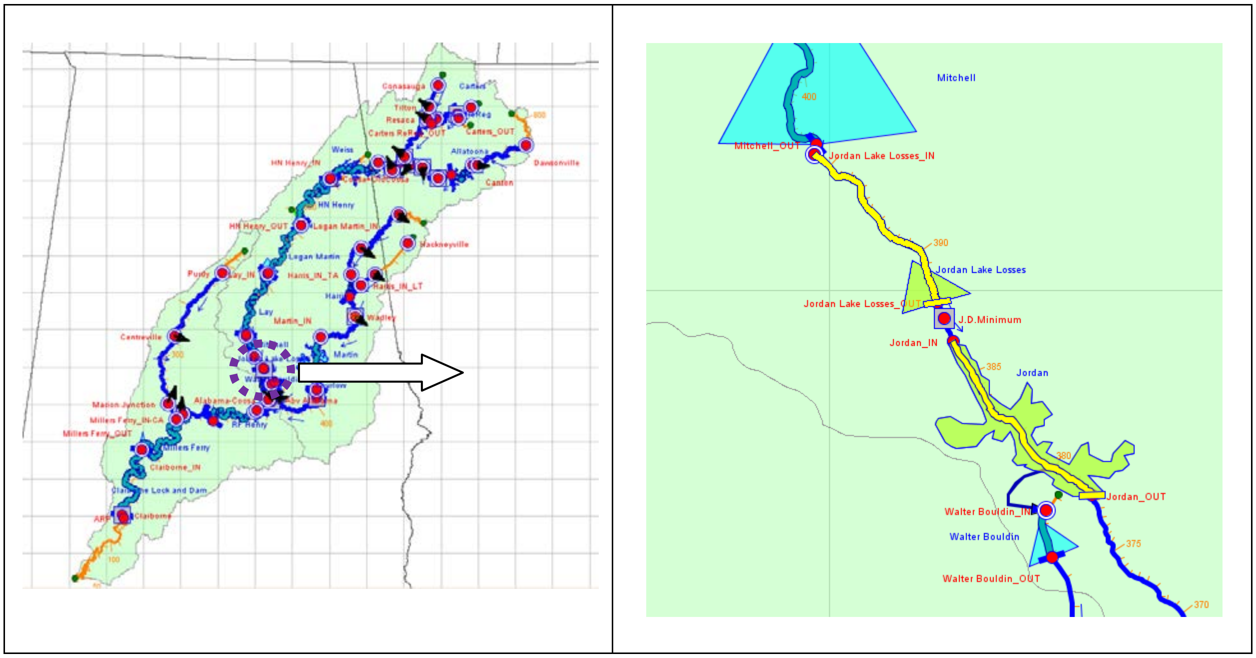


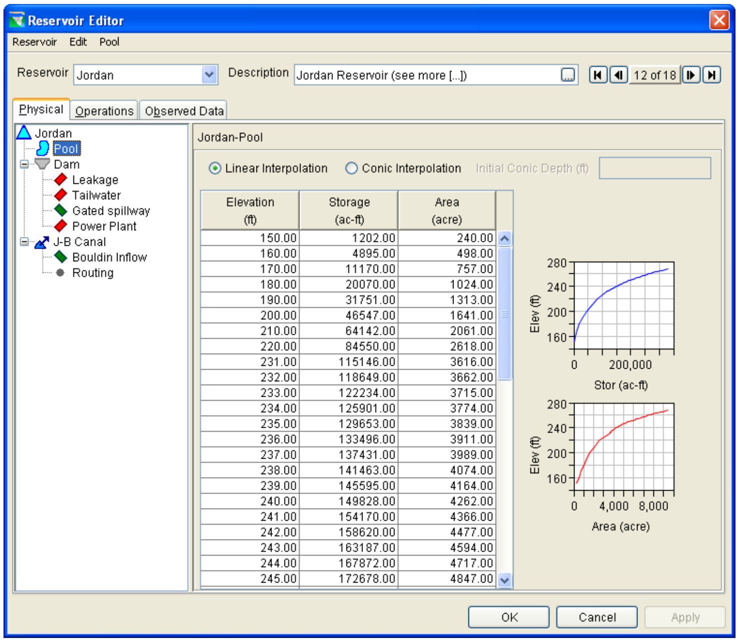
Figure J.01 HEC-ResSim Map Display Showing Location of Jordan Reservoir

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.



Reservoir: Jordan

Description: Jordan Reservoir (see more [...])

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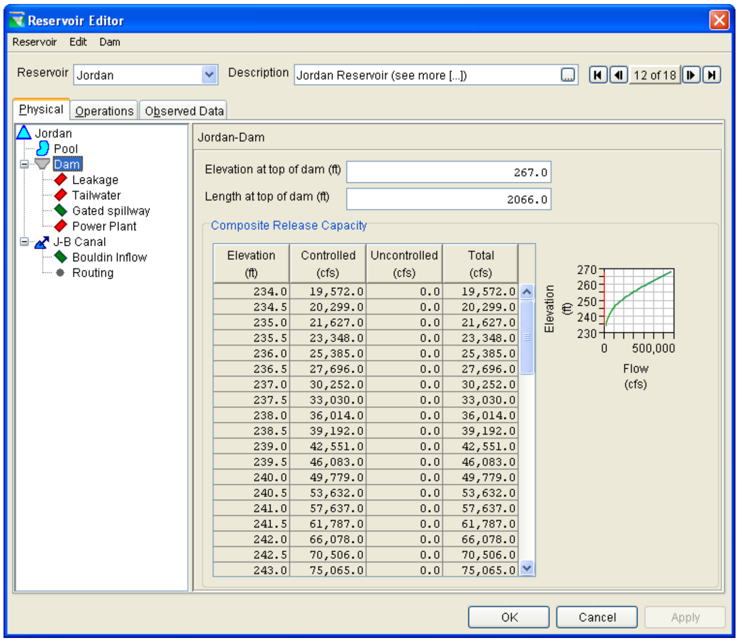
Jordan-Pool

● Linear Interpolation ○ Conic Interpolation

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



Reservoir: Jordan

Description: Jordan Reservoir (see more [...])

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Jordan-Dam

Elevation at top of dam (ft): 267.0

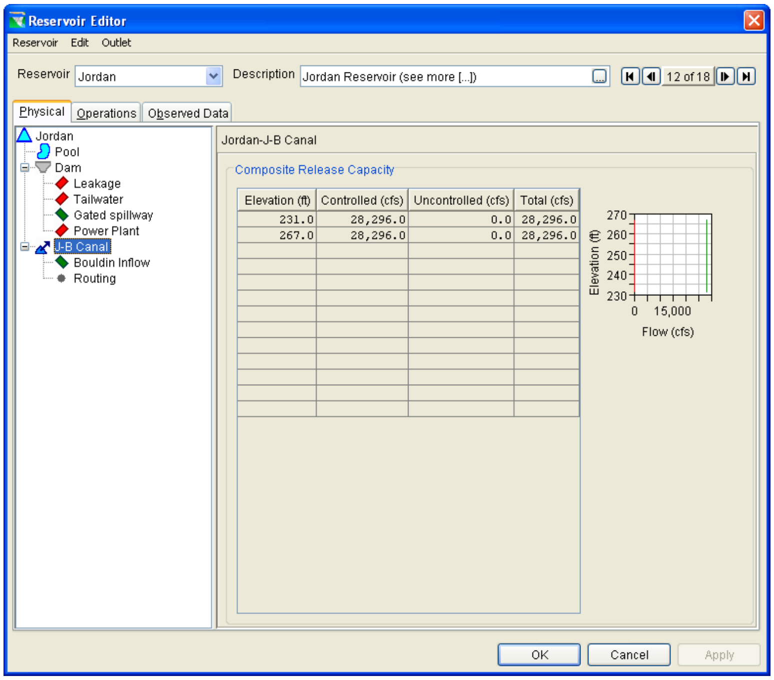
Length at top of dam (ft): 2066.0

Composite Release Capacity

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.



Reservoir: Jordan

Description: Jordan Reservoir (see more [...])

Jordan-J-B Canal

Composite Release Capacity

Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
231.0	28,296.0	0.0	28,296.0
267.0	28,296.0	0.0	28,296.0

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

III. Baseline Operations – Jordan

A. Operation Set

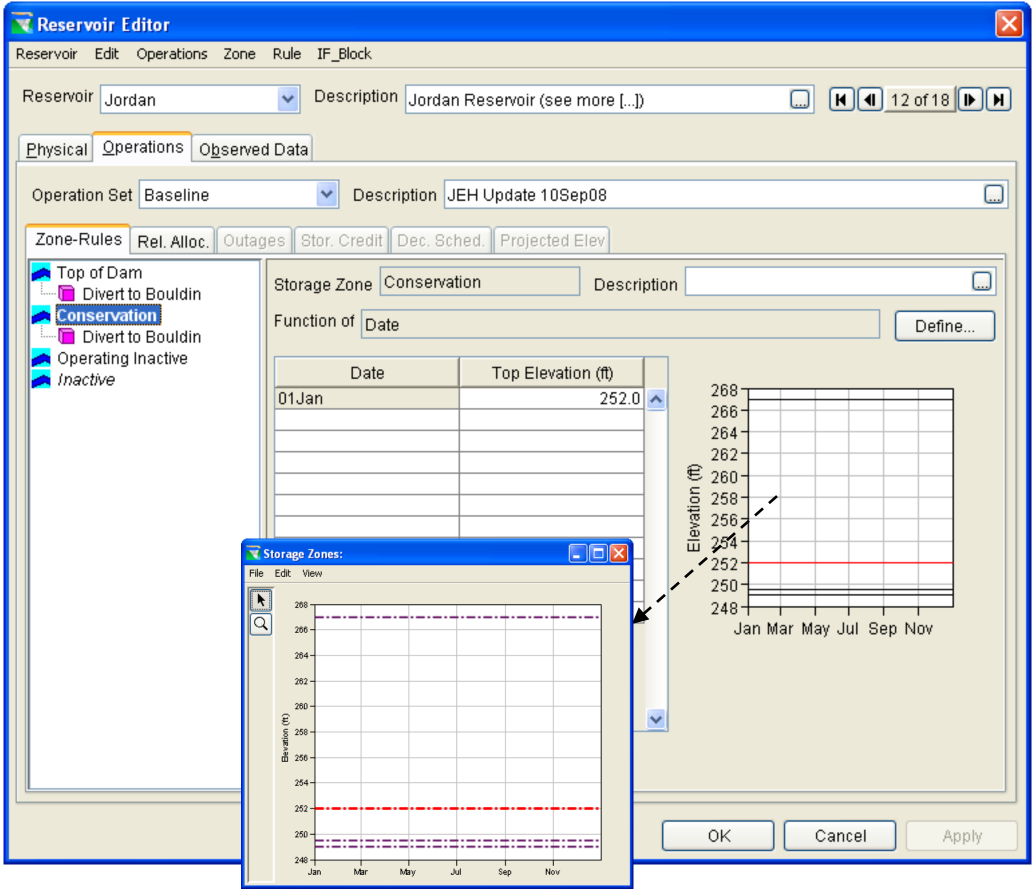
Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Table J.01 shows the definition of "Baseline" operational zones for Jordan Reservoir, which consists of zones above and below the conservation 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 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)



Reservoir: Jordan

Description: Jordan Reservoir (see more [...])

12 of 18

Operation Set: Baseline

Description: JEH Update 10Sep08

- Top of Dam
  - Divert to Bouldin
- Conservation
  - Divert to Bouldin
- Operating Inactive
- *Inactive*

Storage Zone: Conservation

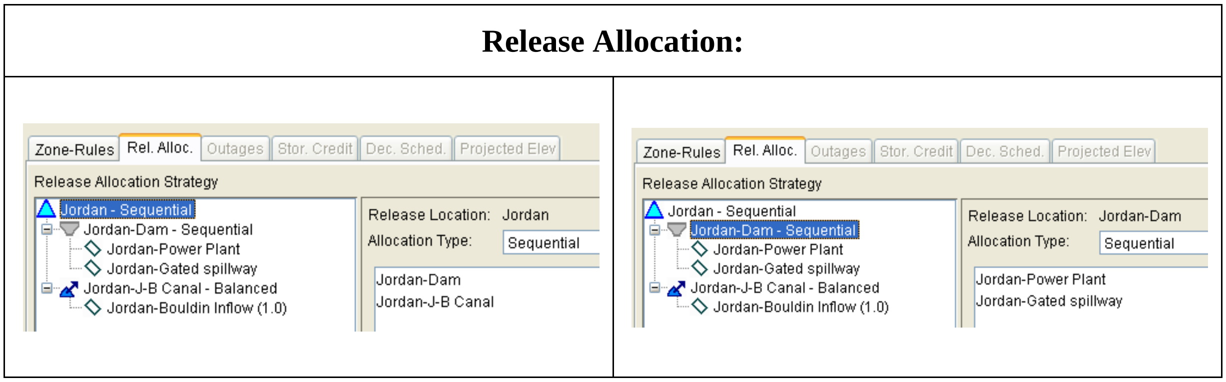
Description:

Function of: Date

Date	Top Elevation (ft)
01Jan	252.0

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:

Release Allocation Strategy

- Jordan - Sequential
  - Jordan-Dam - Sequential
    - Jordan-Power Plant
    - Jordan-Gated spillway
  - Jordan-J-B Canal - Balanced
    - Jordan-Bouldin Inflow (1.0)

Release Location: Jordan

Allocation Type: Sequential

Jordan-Dam
Jordan-J-B Canal

Release Allocation Strategy

- Jordan - Sequential
  - Jordan-Dam - Sequential
    - Jordan-Power Plant
    - Jordan-Gated spillway
  - Jordan-J-B Canal - Balanced
    - Jordan-Bouldin Inflow (1.0)

Release Location: Jordan-Dam

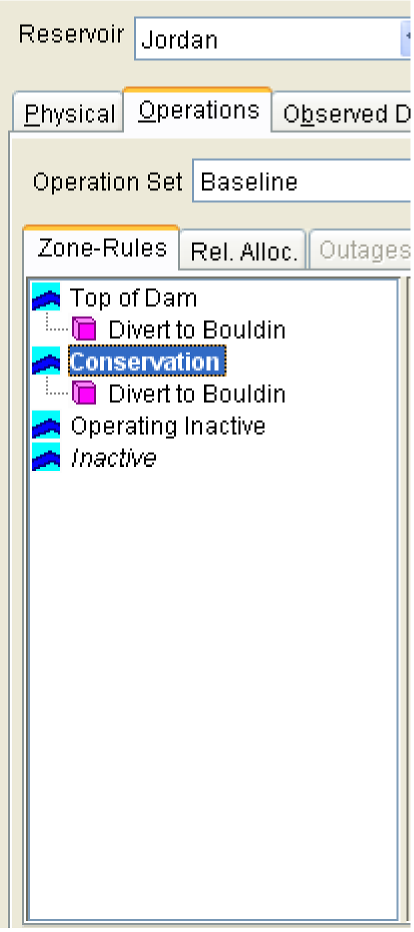
Allocation Type: Sequential

Jordan-Power Plant
Jordan-Gated spillway

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”.



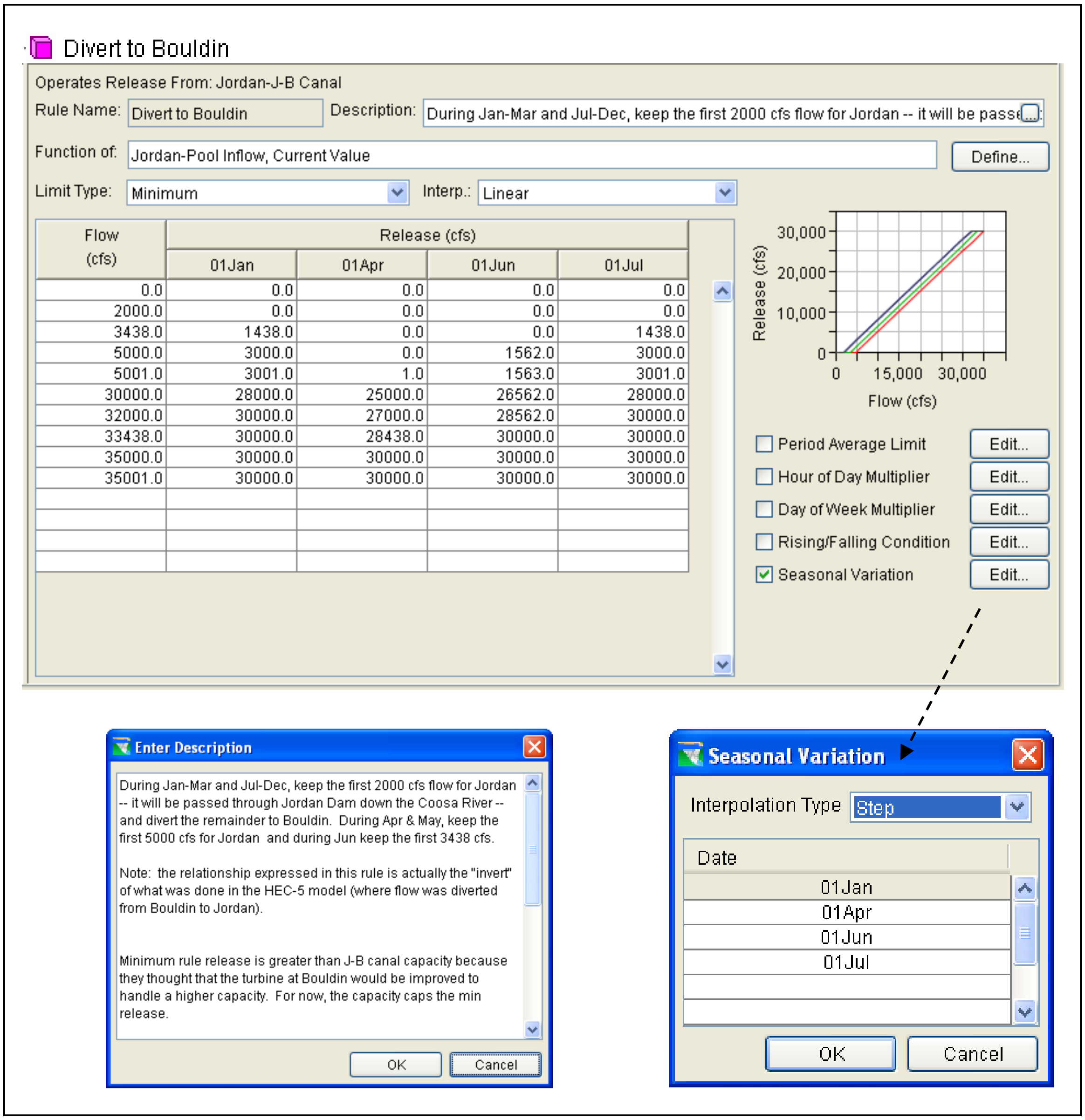
Reservoir Jordan

Operation Set Baseline

- Top of Dam
  - Divert to Bouldin
- Conservation
  - Divert to Bouldin
- Operating Inactive
- *Inactive*

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.



Divert to Bouldin

Operates Release From: Jordan-J-B Canal

Rule Name: Divert to Bouldin

Description: During Jan-Mar and Jul-Dec, keep the first 2000 cfs flow for Jordan -- it will be passe

Function of: Jordan-Pool Inflow, Current Value

Limit Type: Minimum

Interp.: Linear

Flow (cfs)	Release (cfs)			
	01Jan	01Apr	01Jun	01Jul
0.0	0.0	0.0	0.0	0.0
2000.0	0.0	0.0	0.0	0.0
3438.0	1438.0	0.0	0.0	1438.0
5000.0	3000.0	0.0	1562.0	3000.0
5001.0	3001.0	1.0	1563.0	3001.0
30000.0	28000.0	25000.0	26562.0	28000.0
32000.0	30000.0	27000.0	28562.0	30000.0
33438.0	30000.0	28438.0	30000.0	30000.0
35000.0	30000.0	30000.0	30000.0	30000.0
35001.0	30000.0	30000.0	30000.0	30000.0

☐ Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☐ Rising/Falling Condition

☑ Seasonal Variation

Enter Description

During Jan-Mar and Jul-Dec, keep the first 2000 cfs flow for Jordan -- it will be passed through Jordan Dam down the Coosa River -- and divert the remainder to Bouldin. During Apr & May, keep the first 5000 cfs for Jordan and during Jun keep the first 3438 cfs.

Note: the relationship expressed in this rule is actually the "invert" of what was done in the HEC-5 model (where flow was diverted from Bouldin to Jordan).

Minimum rule release is greater than J-B canal capacity because they thought that the turbine at Bouldin would be improved to handle a higher capacity. For now, the capacity caps the min release.

Seasonal Variation

Interpolation Type: Step

Date
01Jan
01Apr
01Jun
01Jul

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.

IV. Alternative Operations – Jordan

Twelve ResSim alternatives were developed to represent the Baseline operations and 11 Alternative operating plans.

A. Operation Sets

For the 12 ResSim alternatives, Jordan used 3 different operation sets. The operation set used for each alternative is shown in Table J.02. Table J.03 describes each operation set.

Table J.02 Alternatives and Operation Sets Used at Jordan

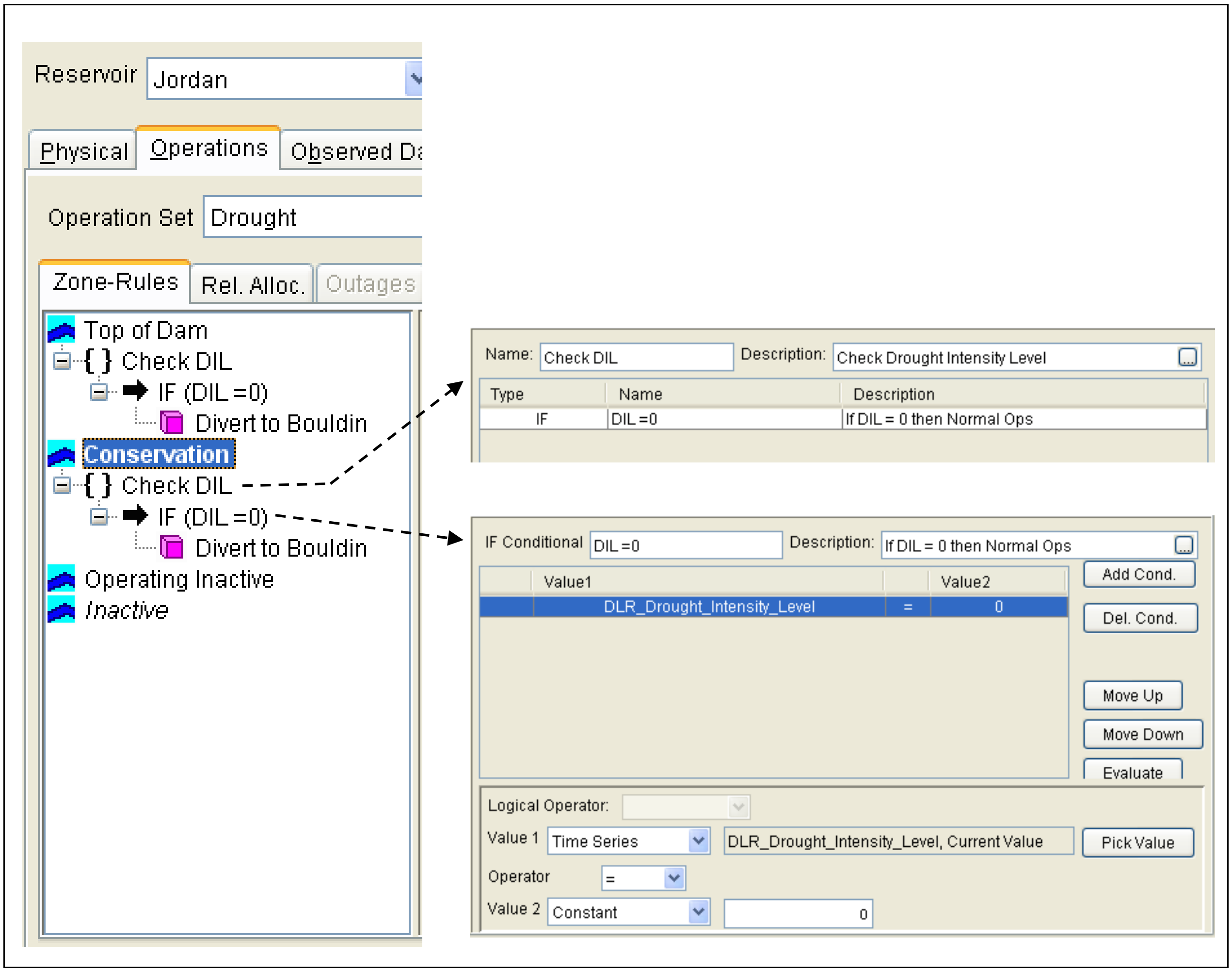
Alternative	Operation Set
Baseline	Baseline
DroughtPln	Drought
Burkett	Drought
DragoA	Drought
DragoB	Drought
RPlanA	Drought
RPlanB	Drought
RPlanC	Drought-rev
RPlanD	Drought-rev
RPlanE	Drought-rev
RPlanF	Drought-rev
RPlanG	Drought-rev

Table J.03 Operation Sets Used at Jordan

Operation Set	**Description**
Baseline	Current operation / no action
Drought	Introduction of drought operation, alters flow through Bouldin Dam
Drought-rev	Same as Drought with revised Low State Line flow trigger criteria

The “Drought” and “Drought-rev” operation sets differ from the “Baseline” operation set due to the diversion into Bouldin being dependent on the drought intensity level (DIL) being equal to zero meaning that none of the three low states has been triggered. The “Drought-rev” operation set uses different flow values for the Low State Line Flow criteria from the values used in the “Drought” operation set. The values used for both are given in Appendix N. The rule sets for the “Drought” and “Drought-rev” operation sets are shown in Figure J.10 and Figure J.11.

1. “Drought” Operation Set



Reservoir: Jordan

Operation Set: Drought

- Top of Dam
  - { } Check DIL
    - IF (DIL=0)
      - Divert to Bouldin
- Conservation
  - { } Check DIL
    - IF (DIL=0)
      - Divert to Bouldin
- Operating Inactive
- *Inactive*

Name: Check DIL
Description: Check Drought Intensity Level

Type	Name	Description
IF	DIL=0	If DIL = 0 then Normal Ops

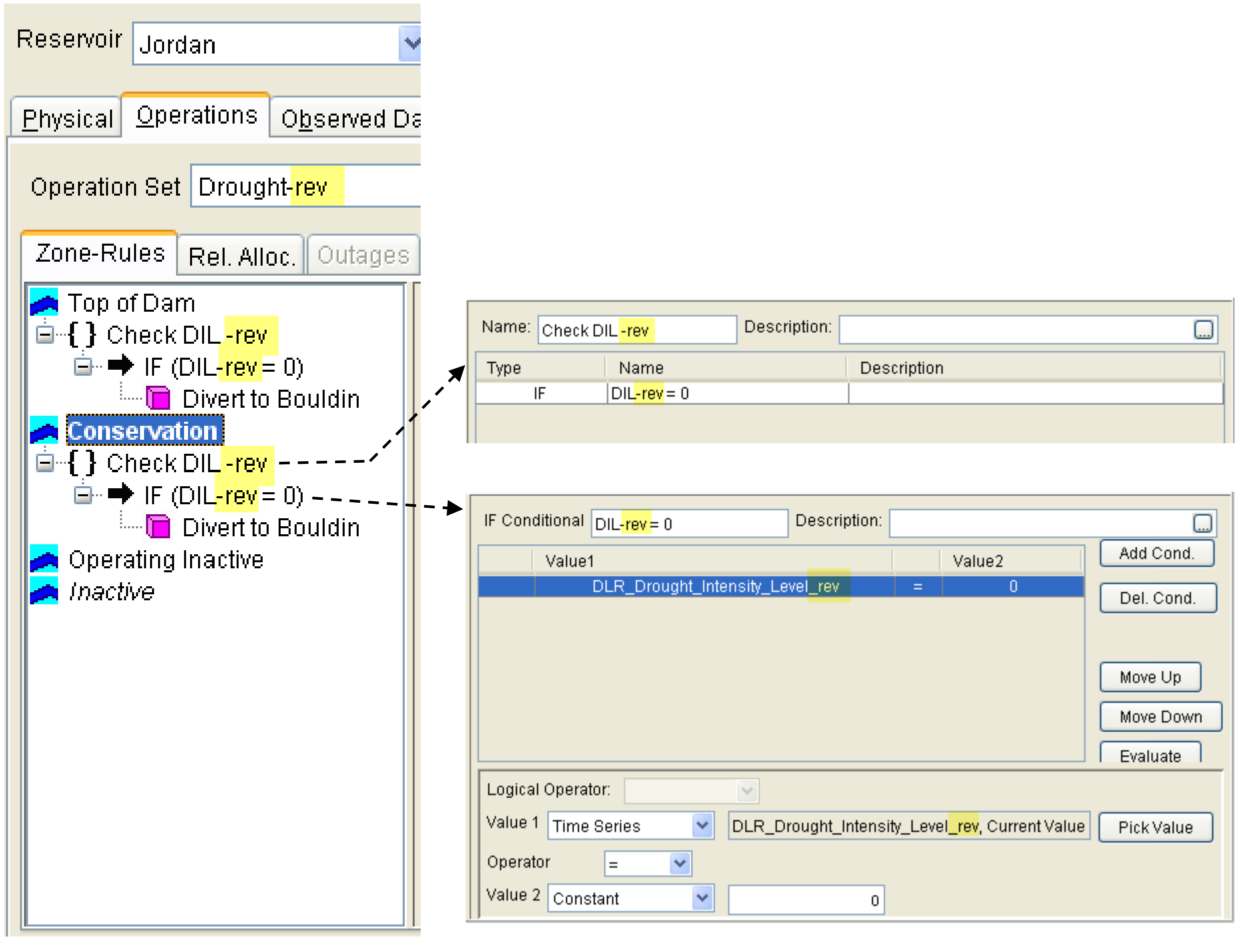
IF Conditional: DIL=0
Description: If DIL = 0 then Normal Ops

Value1		Value2
DLR_Drought_Intensity_Level	=	0

Logical Operator:
Value 1: Time Series — DLR_Drought_Intensity_Level, Current Value
Operator: =
Value 2: Constant — 0

Figure J.10 Rule Set for “Drought” Operation Set

2. “Drought-rev” Operation Set



Reservoir: Jordan

Physical | Operations | Observed Da

Operation Set: Drought-rev

Zone-Rules | Rel. Alloc. | Outages

- Top of Dam
  - { } Check DIL-rev
    - IF (DIL-rev = 0)
      - Divert to Bouldin
- Conservation
  - { } Check DIL-rev
    - IF (DIL-rev = 0)
      - Divert to Bouldin
- Operating Inactive
- *Inactive*

Name: Check DIL-rev Description:

Type	Name	Description
IF	DIL-rev = 0	

IF Conditional: DIL-rev = 0 Description:

	Value1		Value2
	DLR_Drought_Intensity_Level_rev	=	0

Logical Operator:

Value 1: Time Series — DLR_Drought_Intensity_Level_rev, Current Value

Operator: =

Value 2: Constant — 0

Figure J.11 Rule Set for “Drought-rev” Operation Set

Walter Bouldin Reservoir

V. 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.12 shows the location of Walter Bouldin Reservoir as it is represented in the HEC-ResSim model.

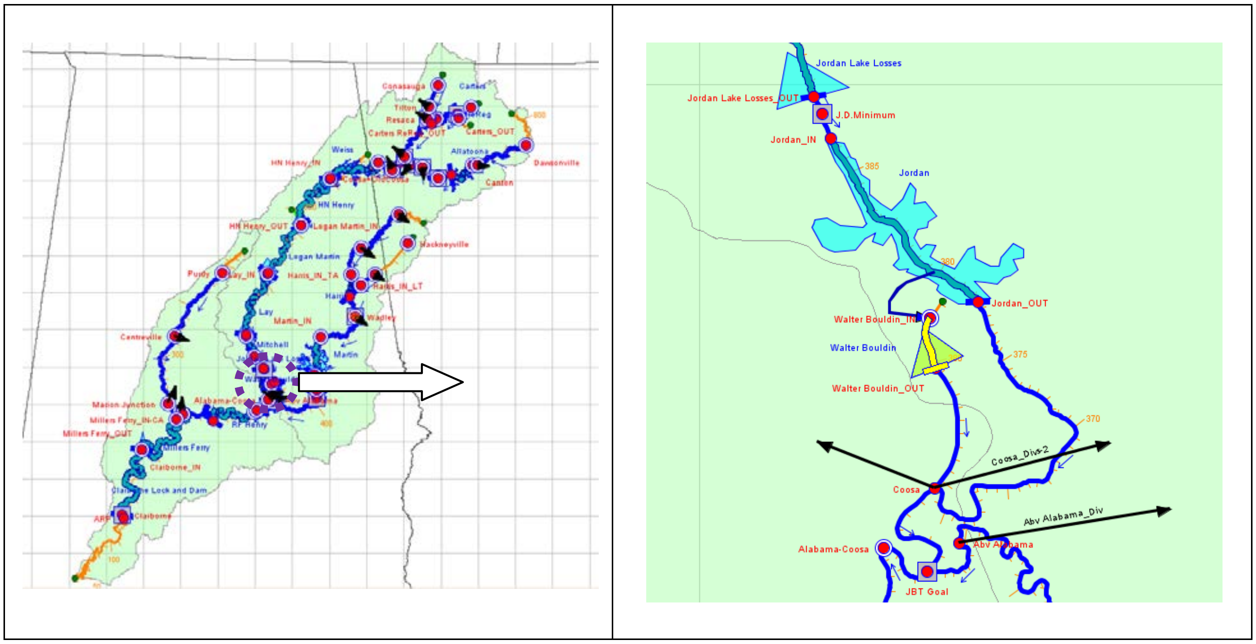


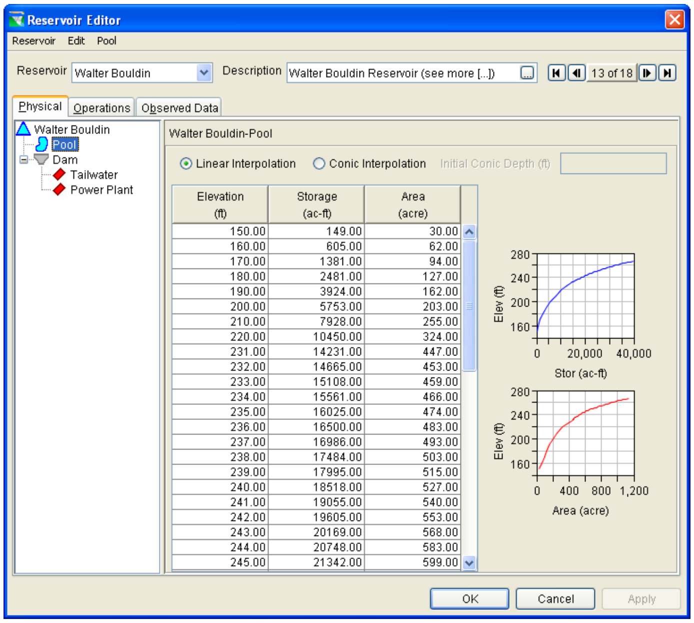
Figure J.12 HEC-ResSim Map Display Showing Location of Walter Bouldin Reservoir

Figure J.13 shows a photo of Bouldin Dam.

Figure J.13 Photo of Bouldin Dam

VI. 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.14. 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.15.



Reservoir: Walter Bouldin

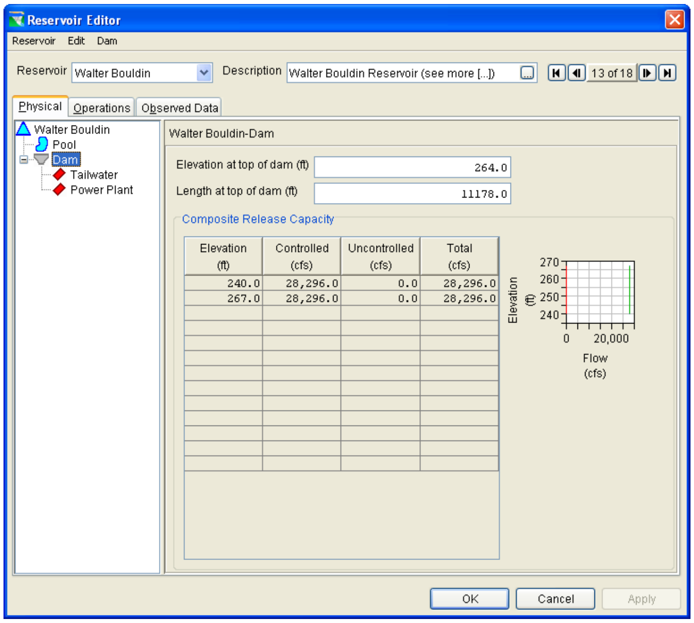
Description: Walter Bouldin Reservoir (see more [...])

Walter Bouldin-Pool

● Linear Interpolation ○ Conic Interpolation Initial Conic Depth (ft)

Elevation (ft)	Storage (ac-ft)	Area (acre)
150.00	149.00	30.00
160.00	605.00	62.00
170.00	1381.00	94.00
180.00	2481.00	127.00
190.00	3924.00	162.00
200.00	5753.00	203.00
210.00	7928.00	255.00
220.00	10450.00	324.00
231.00	14231.00	447.00
232.00	14665.00	453.00
233.00	15108.00	459.00
234.00	15561.00	466.00
235.00	16025.00	474.00
236.00	16500.00	483.00
237.00	16986.00	493.00
238.00	17484.00	503.00
239.00	17995.00	515.00
240.00	18518.00	527.00
241.00	19055.00	540.00
242.00	19605.00	553.00
243.00	20169.00	568.00
244.00	20748.00	583.00
245.00	21342.00	599.00

Figure J.14 2009 Network… Walter Bouldin Reservoir Editor: Physical Tab – Pool



Reservoir: Walter Bouldin

Description: Walter Bouldin Reservoir (see more [...])

Walter Bouldin-Dam

Elevation at top of dam (ft): 264.0

Length at top of dam (ft): 11178.0

Composite Release Capacity

Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
240.0	28,296.0	0.0	28,296.0
267.0	28,296.0	0.0	28,296.0

Figure J.15 2009 Network… Walter Bouldin Reservoir Editor: Physical Tab – Dam

VII. Baseline Operations – Bouldin

A. “Baseline” Operation Set

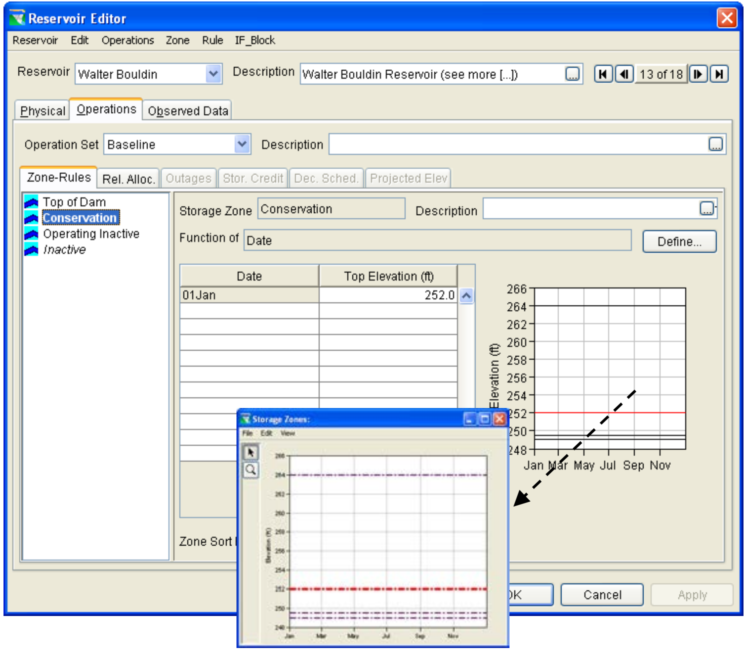
Table J.04 shows the definition of operational zones consisting of Top of Dam, Conservation, and Operating Inactive zone, as well as an Inactive zone.

Table J.04 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.16).

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



Reservoir: Walter Bouldin

Description: Walter Bouldin Reservoir (see more [...])

13 of 18

Operation Set: Baseline

Description:

- Top of Dam
- Conservation
- Operating Inactive
- *Inactive*

Storage Zone: Conservation

Description:

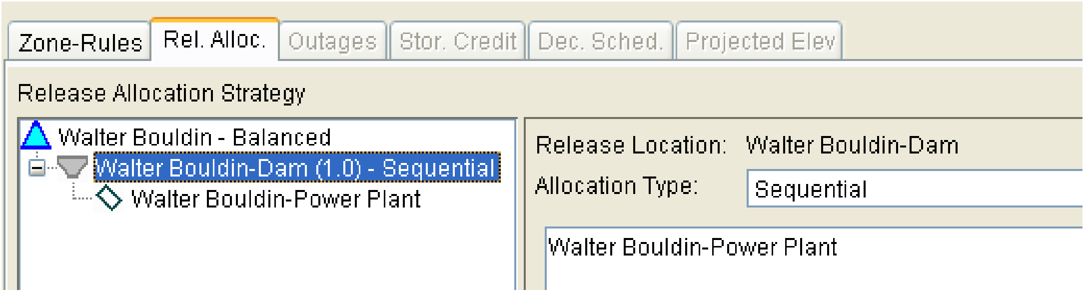
Function of: Date

Date	Top Elevation (ft)
01Jan	252.0

Figure J.16 Walter Bouldin Reservoir Editor: Operations Tab – “Baseline” Guide Curve

Figure J.17 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:

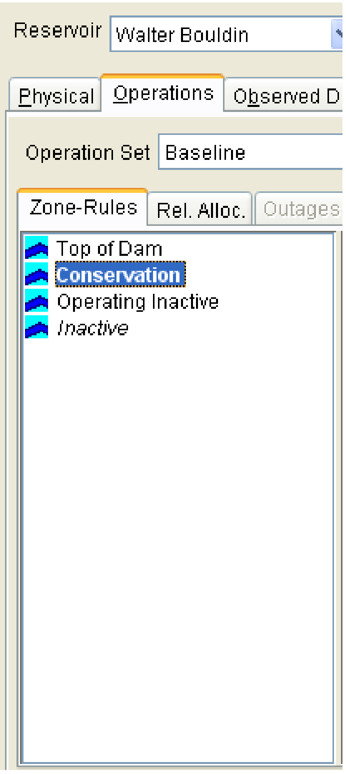


Walter Bouldin - Balanced
Walter Bouldin-Dam (1.0) - Sequential
Walter Bouldin-Power Plant

Release Location: Walter Bouldin-Dam
Allocation Type: Sequential
Walter Bouldin-Power Plant

Figure J.17 Walter Bouldin Reservoir Editor: Operations Tab – "Baseline" Release Allocation

Figure J.18 shows a set of operational zones that reflects the operation set named "Baseline".



Reservoir Walter Bouldin
Operation Set Baseline

Top of Dam
Conservation
Operating Inactive
Inactive

Figure J.18 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.

VIII. Alternative Operations – Bouldin (same as "Baseline")

The "Baseline" operation set is used for all of the alternatives at Walter Bouldin.

IX. 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.19 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, but vary under the alternatives that are being considered for the Reoperation. The Drought Plan alternatives (all alternatives except Baseline) temper the minimum flow objectives by decreasing the minimum in-stream flow requirements, relative to the severity of the drought.

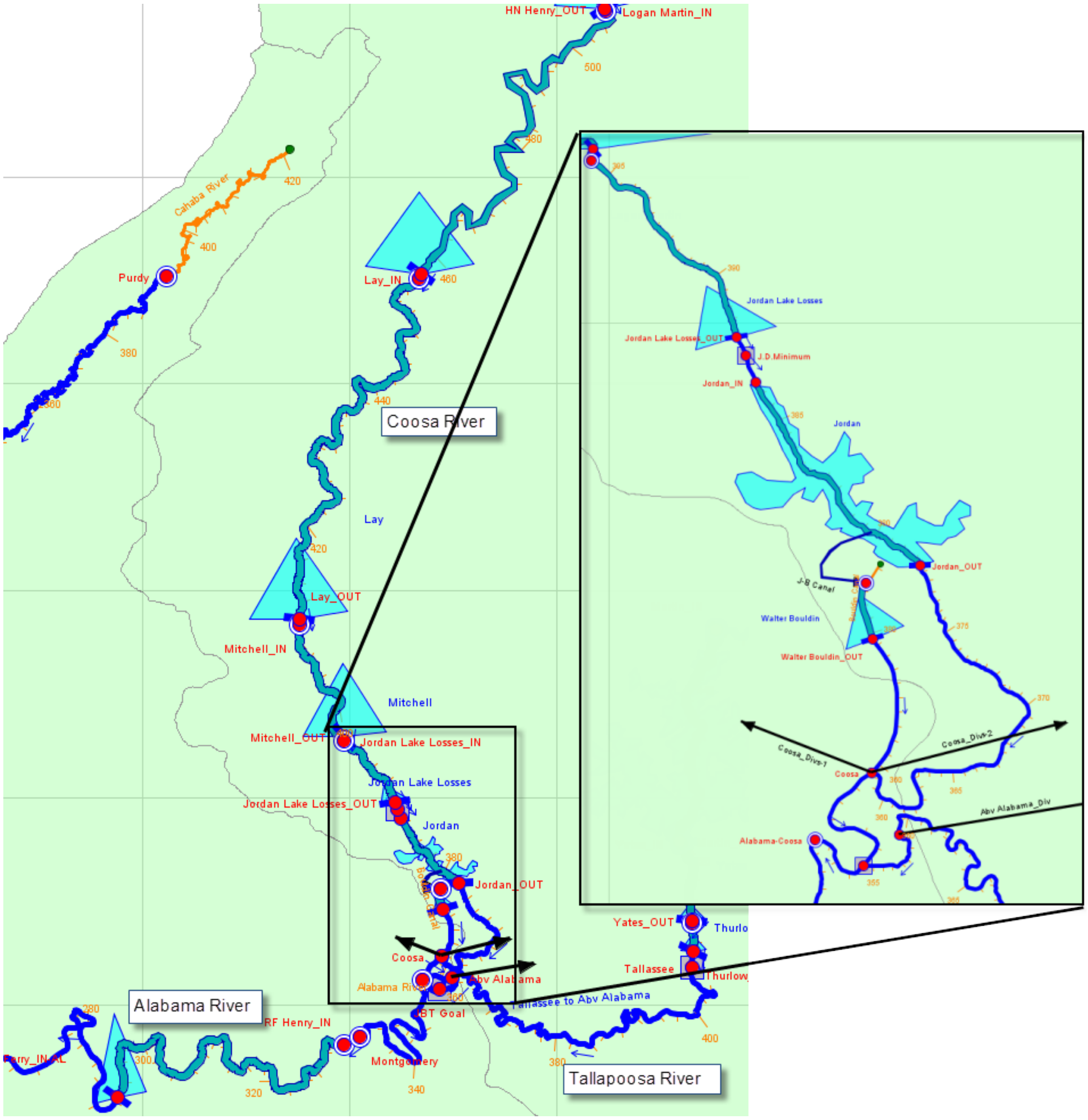
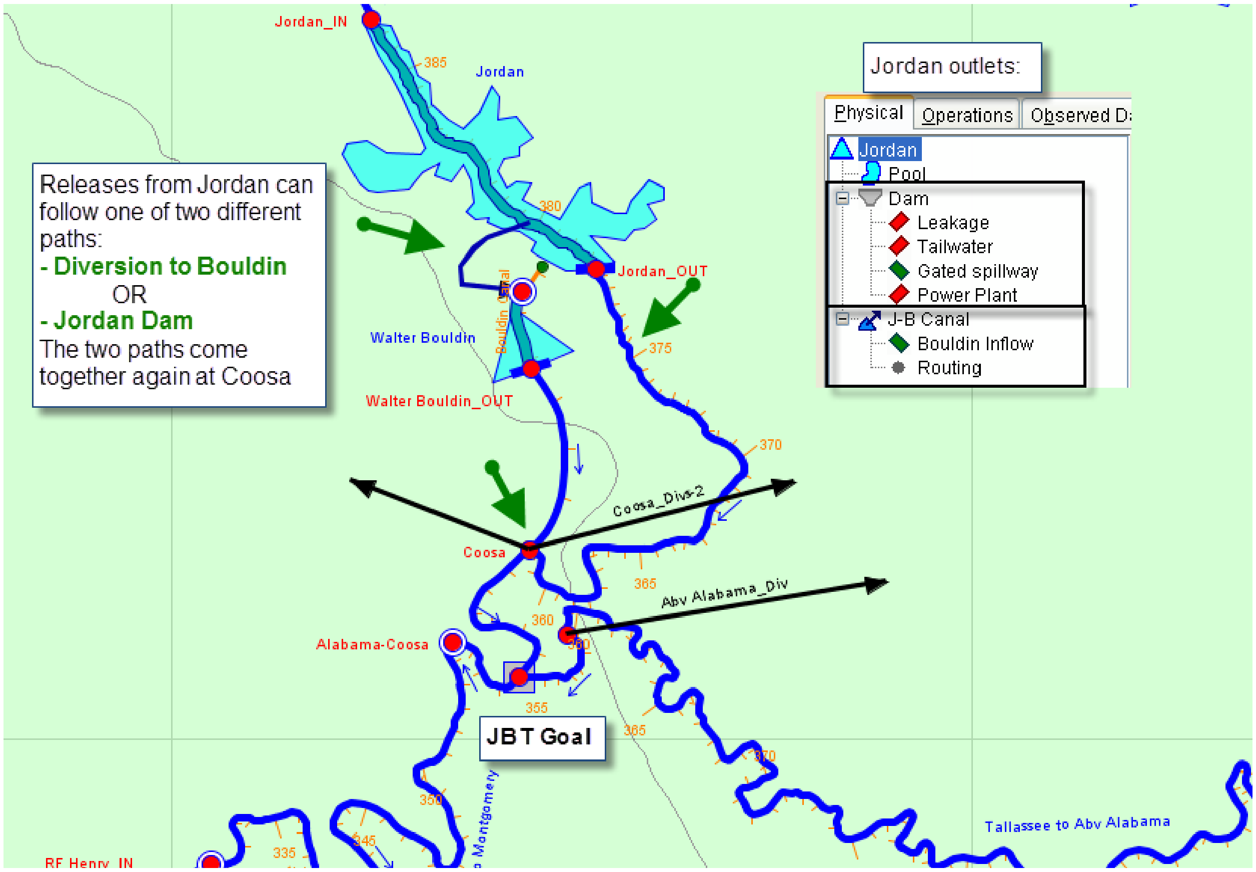


Figure J.19 ResSim Model of the ACT Basin: Confluence of the Coosa, Tallapoosa, and Alabama Rivers (with inset of the Jordan Lake region)

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.20 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.



Releases from Jordan can follow one of two different paths:

- Diversion to Bouldin

OR

- Jordan Dam

The two paths come together again at Coosa

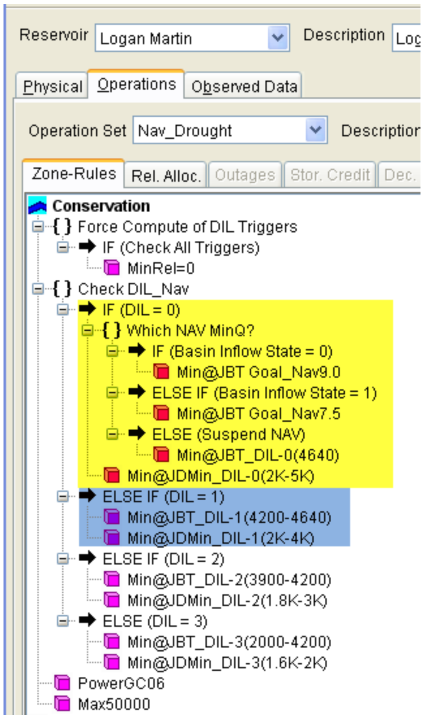
Figure J.20 ResSim Model of the Jordan Lake Region Depicting the Coosa River, the Bouldin Canal, and the Confluence of the Coosa, Tallapoosa, and Alabama Rivers (at JBT Goal)

Next, a "dummy" reservoir called "Jordan Lakes Losses" (previously shown in Figure J.19 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.19 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.

A Drought Intensity Level (DIL) is used to quantify the degree of drought in the basin for all modeled alternatives except Baseline. As part of the Drought Plan, minimum flow rules for JBT Goal and J.D.Minimum are decreased, relative to the DIL. Figure J.21 shows the "Nav_Drought" Operation Set rules in the conservation pool of Logan Martin (used for Alternative RPlanA). The downstream minimum flow rules are contained in a conditional statement that checks the DIL. The yellow-highlighted block shows the rules that apply if the DIL=0 (no drought conditions in the basin). The reservoir is operated to meet a minimum of 2,000-5,000 cfs at J.D.Minimum and at least a minimum flow of 4,640 cfs at JBT Goal (or higher for navigation, if Basin Inflow conditions are sufficient). If the DIL=1 (blue highlighted block), then mild drought conditions are present in the basin, and Logan Martin operates to meet a minimum flow of 2,000-4,000 cfs at J.D.Minimum and 4,200-4,640 cfs at JBT Goal. Minimum flows are even less when the DIL is 2 or 3.



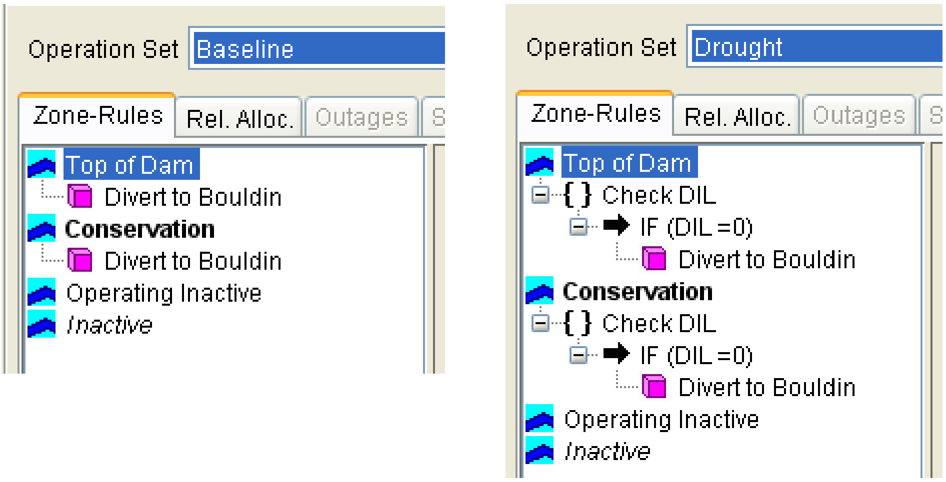
Reservoir: Logan Martin
Description: Log

Operation Set: Nav_Drought
Descriptior

```
Conservation
  { } Force Compute of DIL Triggers
      IF (Check All Triggers)
          MinRel=0
  { } Check DIL_Nav
      IF (DIL = 0)
          { } Which NAV MinQ?
              IF (Basin Inflow State = 0)
                  Min@JBT Goal_Nav9.0
              ELSE IF (Basin Inflow State = 1)
                  Min@JBT Goal_Nav7.5
              ELSE (Suspend NAV)
                  Min@JBT_DIL-0(4640)
          Min@JDMin_DIL-0(2K-5K)
      ELSE IF (DIL = 1)
          Min@JBT_DIL-1(4200-4640)
          Min@JDMin_DIL-1(2K-4K)
      ELSE IF (DIL = 2)
          Min@JBT_DIL-2(3900-4200)
          Min@JDMin_DIL-2(1.8K-3K)
      ELSE (DIL = 3)
          Min@JBT_DIL-3(2000-4200)
          Min@JDMin_DIL-3(1.6K-2K)
  PowerGC06
  Max50000
```

Figure J.21 Logan Martin's "Nav_Drought" Operation Set Showing the Downstream Rules' Dependency on the Drought Intensity Level (DIL)

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" and the "Drought" operation sets for Jordan are shown in Figure J.22. The "Divert to Bouldin" rule diverts a fraction of all flows greater than the Coosa channel requirement to Bouldin. Drought Operations call for the diversion only when the DIL=0 (no drought conditions).



Operation Set: Baseline

- Top of Dam
  - Divert to Bouldin
- Conservation
  - Divert to Bouldin
- Operating Inactive
- *Inactive*

Operation Set: Drought

- Top of Dam
  - { } Check DIL
    - IF (DIL=0)
      - Divert to Bouldin
- Conservation
  - { } Check DIL
    - IF (DIL=0)
      - Divert to Bouldin
- Operating Inactive
- *Inactive*

Figure J.22 Jordan "Baseline" and "Drought" Operation Sets

To summarize the impact of the "Divert to Bouldin" rule (as previously shown in Figure J.09), when normal conditions exist, then 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

Appendix K – Flow-thru Reservoirs:

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

March 2011 (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.

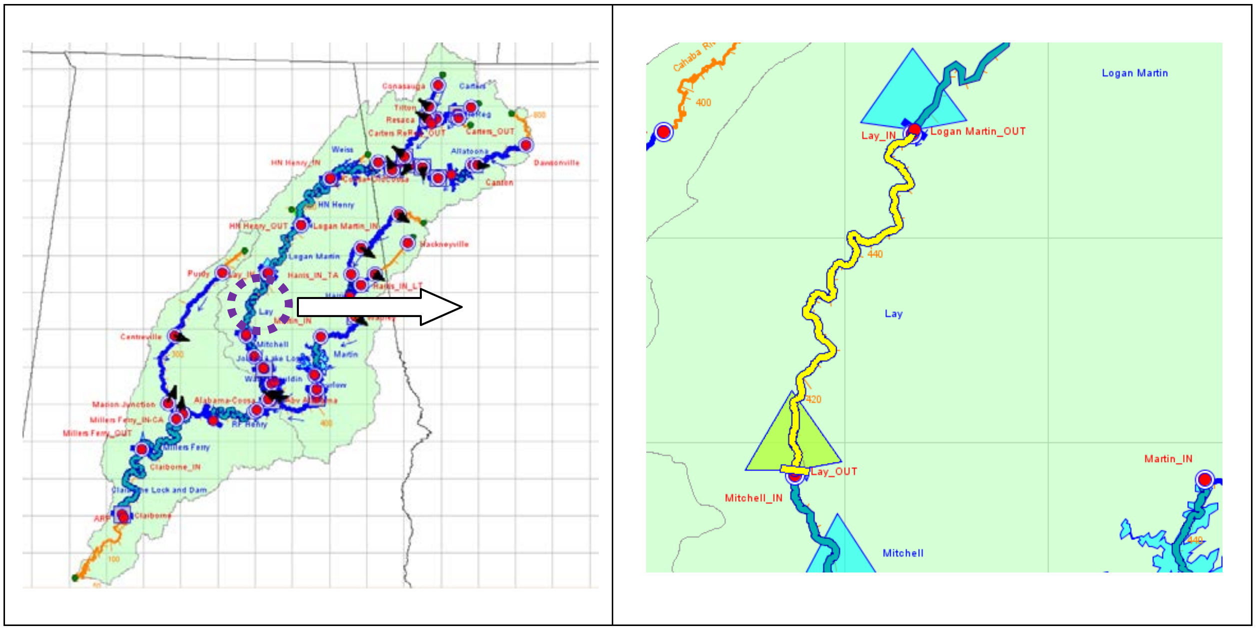


Figure K.01 HEC-ResSim Map Display Showing Location of Lay Reservoir

Figure K.02 shows a photo of Lay Dam.

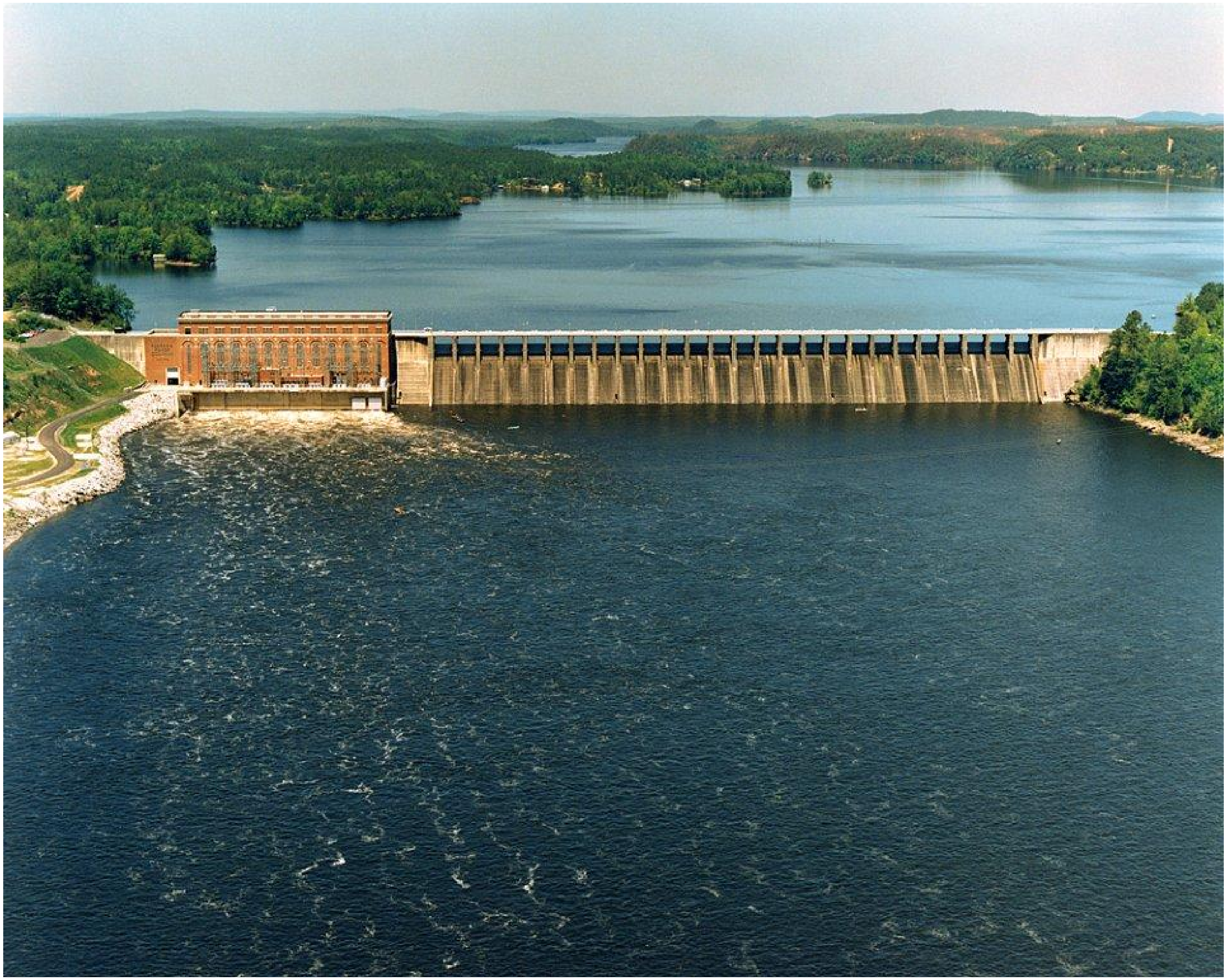
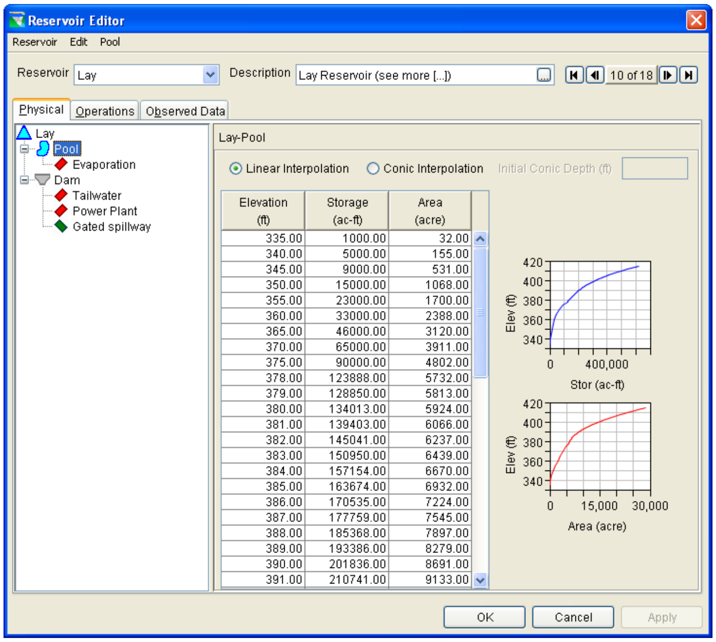


Figure K.02 Photo of Lay Dam

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.



Reservoir: Lay

Description: Lay Reservoir (see more [...])

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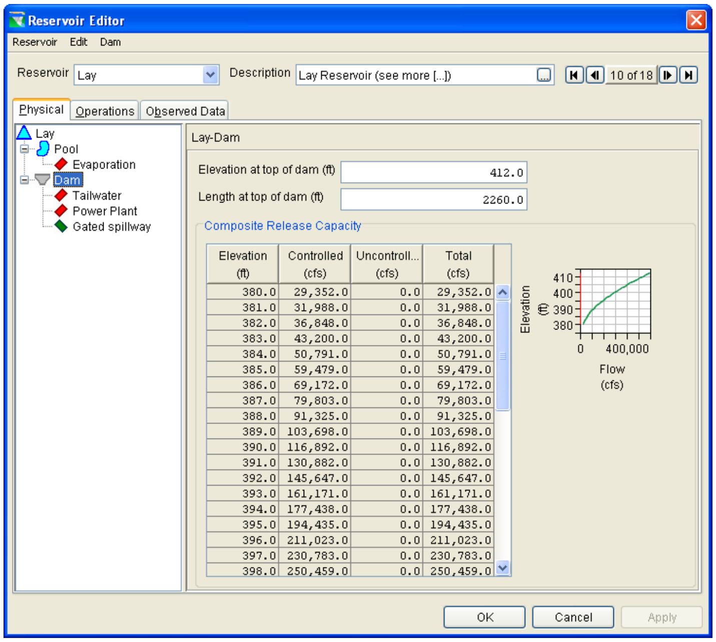
● Linear Interpolation ○ Conic Interpolation Initial Conic Depth (ft)

Elevation (ft)	Storage (ac-ft)	Area (acre)
335.00	1000.00	32.00
340.00	5000.00	155.00
345.00	9000.00	531.00
350.00	15000.00	1068.00
355.00	23000.00	1700.00
360.00	33000.00	2388.00
365.00	46000.00	3120.00
370.00	65000.00	3911.00
375.00	90000.00	4802.00
378.00	123888.00	5732.00
379.00	128850.00	5813.00
380.00	134013.00	5924.00
381.00	139403.00	6066.00
382.00	145041.00	6237.00
383.00	150950.00	6439.00
384.00	157154.00	6670.00
385.00	163674.00	6932.00
386.00	170535.00	7224.00
387.00	177759.00	7545.00
388.00	185368.00	7897.00
389.00	193386.00	8279.00
390.00	201836.00	8691.00
391.00	210741.00	9133.00

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



Reservoir: Lay

Description: Lay Reservoir (see more [...])

10 of 18

Elevation at top of dam (ft): 412.0

Length at top of dam (ft): 2260.0

Composite Release Capacity

Elevation (ft)	Controlled (cfs)	Uncontroll... (cfs)	Total (cfs)
380.0	29,352.0	0.0	29,352.0
381.0	31,988.0	0.0	31,988.0
382.0	36,848.0	0.0	36,848.0
383.0	43,200.0	0.0	43,200.0
384.0	50,791.0	0.0	50,791.0
385.0	59,479.0	0.0	59,479.0
386.0	69,172.0	0.0	69,172.0
387.0	79,803.0	0.0	79,803.0
388.0	91,325.0	0.0	91,325.0
389.0	103,698.0	0.0	103,698.0
390.0	116,892.0	0.0	116,892.0
391.0	130,882.0	0.0	130,882.0
392.0	145,647.0	0.0	145,647.0
393.0	161,171.0	0.0	161,171.0
394.0	177,438.0	0.0	177,438.0
395.0	194,435.0	0.0	194,435.0
396.0	211,023.0	0.0	211,023.0
397.0	230,783.0	0.0	230,783.0
398.0	250,459.0	0.0	250,459.0

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

C. Baseline Operations

1. “Flow-thru” Operation Set

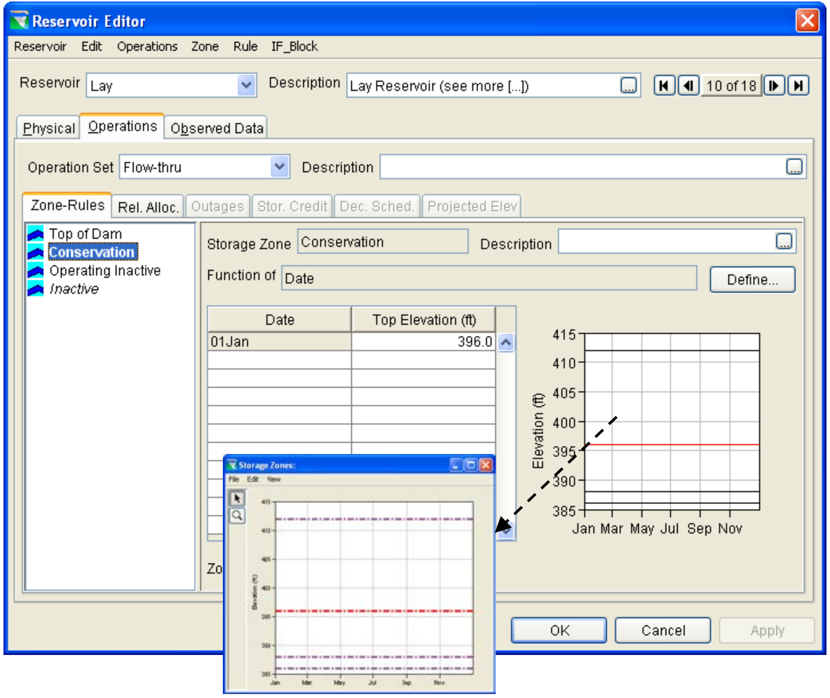
Table K.1 shows the definition of operational zones consisting of Top of Dam, Conservation, and Operating Inactive zone, as well as an Inactive zone.

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)



Reservoir: Lay
Description: Lay Reservoir (see more [...])
10 of 18

Operation Set: Flow-thru
Description:

Top of Dam
Conservation
Operating Inactive
Inactive

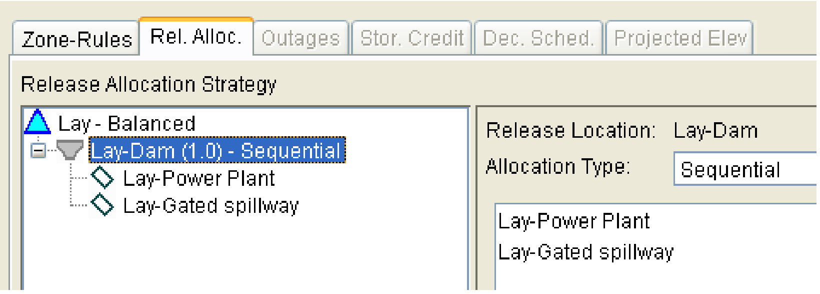
Storage Zone: Conservation
Description:
Function of: Date

Date	Top Elevation (ft)
01Jan	396.0

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:



Release Allocation Strategy

- Lay - Balanced
  - Lay-Dam (1.0) - Sequential
    - Lay-Power Plant
    - Lay-Gated spillway

Release Location: Lay-Dam
Allocation Type: Sequential

Lay-Power Plant
Lay-Gated spillway

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".

Reservoir Lay

Operation Set Flow-thru

Top of Dam
Conservation
Operating Inactive
Inactive

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.

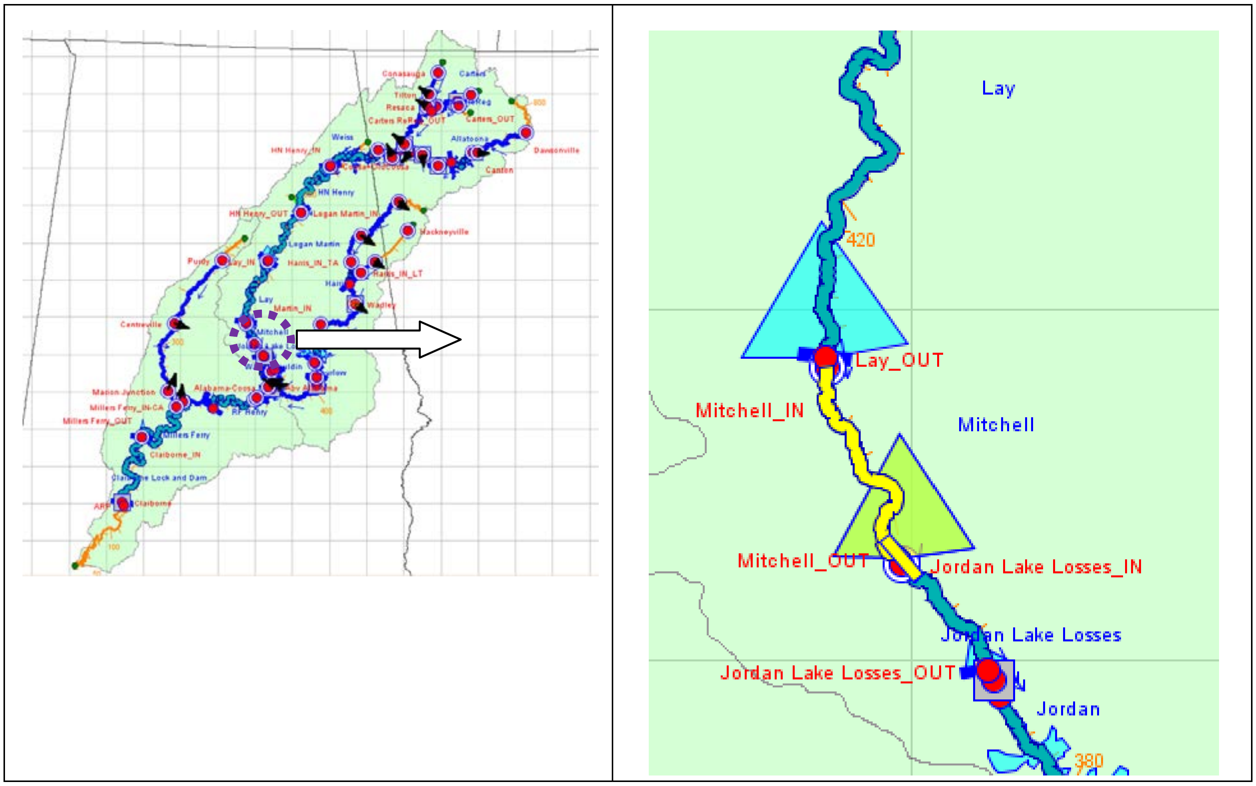


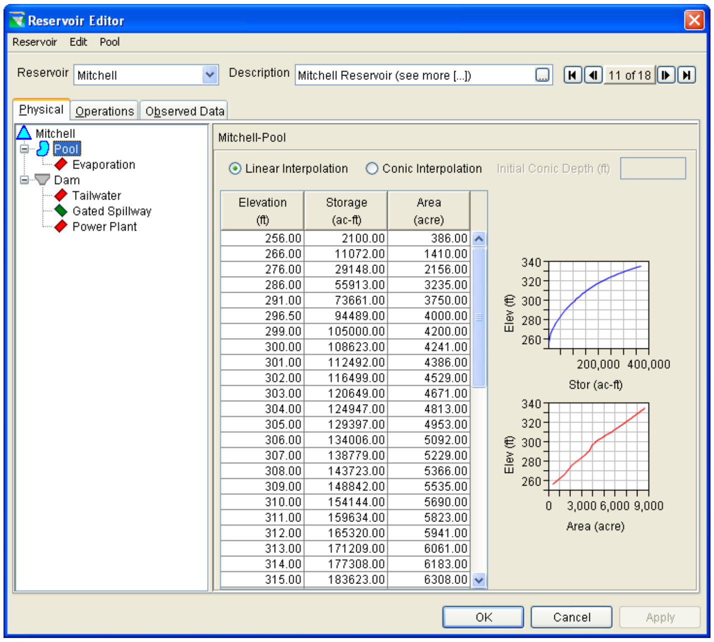
Figure K.08 HEC-ResSim Map Display Showing Location of Mitchell Reservoir

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.



Reservoir: Mitchell

Description: Mitchell Reservoir (see more [...])

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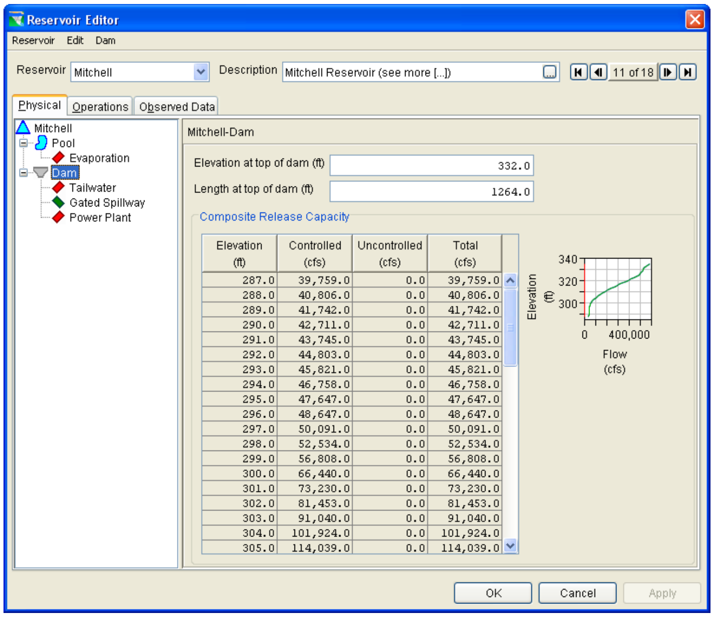
Mitchell-Pool

● Linear Interpolation ○ Conic Interpolation

Elevation (ft)	Storage (ac-ft)	Area (acre)
256.00	2100.00	386.00
266.00	11072.00	1410.00
276.00	29148.00	2156.00
286.00	55913.00	3235.00
291.00	73661.00	3750.00
296.50	94489.00	4000.00
299.00	105000.00	4200.00
300.00	108623.00	4241.00
301.00	112492.00	4386.00
302.00	116499.00	4529.00
303.00	120649.00	4671.00
304.00	124947.00	4813.00
305.00	129397.00	4953.00
306.00	134006.00	5092.00
307.00	138779.00	5229.00
308.00	143723.00	5366.00
309.00	148842.00	5535.00
310.00	154144.00	5690.00
311.00	159634.00	5823.00
312.00	165320.00	5941.00
313.00	171209.00	6061.00
314.00	177308.00	6183.00
315.00	183623.00	6308.00

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



Reservoir: Mitchell

Description: Mitchell Reservoir (see more [...])

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Mitchell-Dam

Elevation at top of dam (ft): 332.0

Length at top of dam (ft): 1264.0

Composite Release Capacity

Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
287.0	39,759.0	0.0	39,759.0
288.0	40,806.0	0.0	40,806.0
289.0	41,742.0	0.0	41,742.0
290.0	42,711.0	0.0	42,711.0
291.0	43,745.0	0.0	43,745.0
292.0	44,803.0	0.0	44,803.0
293.0	45,821.0	0.0	45,821.0
294.0	46,758.0	0.0	46,758.0
295.0	47,647.0	0.0	47,647.0
296.0	48,647.0	0.0	48,647.0
297.0	50,091.0	0.0	50,091.0
298.0	52,534.0	0.0	52,534.0
299.0	56,808.0	0.0	56,808.0
300.0	66,440.0	0.0	66,440.0
301.0	73,230.0	0.0	73,230.0
302.0	81,453.0	0.0	81,453.0
303.0	91,040.0	0.0	91,040.0
304.0	101,924.0	0.0	101,924.0
305.0	114,039.0	0.0	114,039.0

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

C. Baseline Operations

1. "Flow-thru" Operation Set

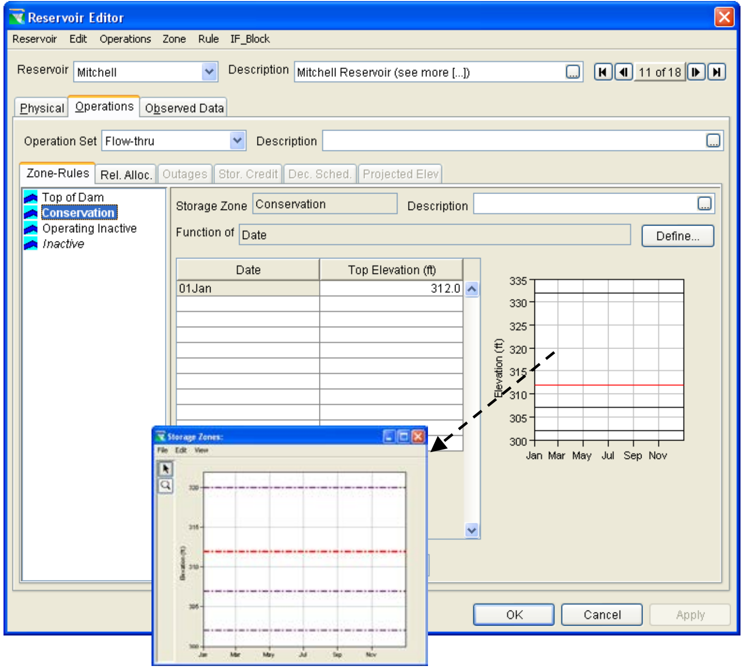
Table K.2 shows the definition of operational zones consisting of Top of Dam, Conservation, and Operating Inactive zone, as well as an Inactive zone.

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)



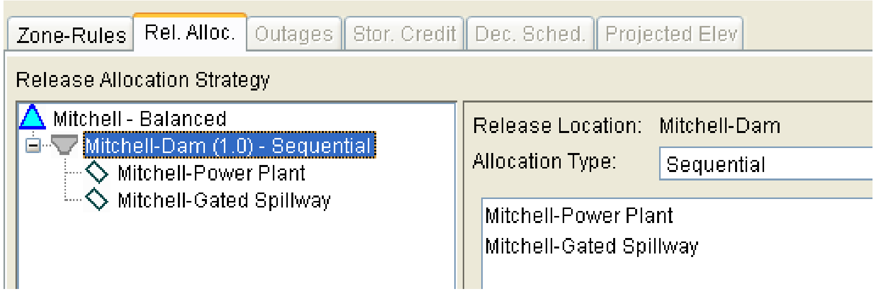
Reservoir: Mitchell
Description: Mitchell Reservoir (see more [...])
Operation Set: Flow-thru
Storage Zone: Conservation
Function of: Date

Date	Top Elevation (ft)
01Jan	312.0

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:



Release Allocation Strategy

- Mitchell - Balanced
  - Mitchell-Dam (1.0) - Sequential
    - Mitchell-Power Plant
    - Mitchell-Gated Spillway

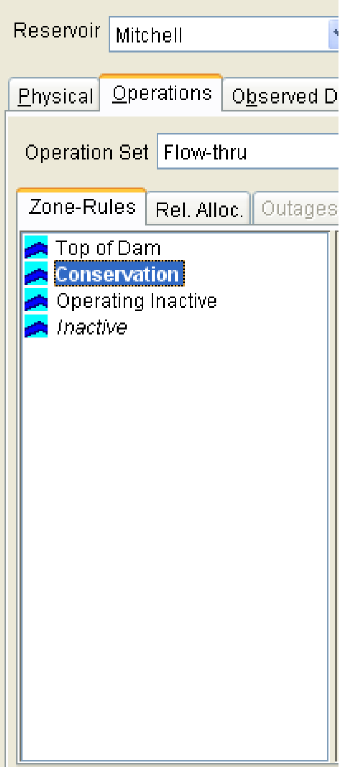
Release Location: Mitchell-Dam

Allocation Type: Sequential

Mitchell-Power Plant
Mitchell-Gated Spillway

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".



Reservoir: Mitchell

Operation Set: Flow-thru

- Top of Dam
- Conservation
- Operating Inactive
- *Inactive*

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.

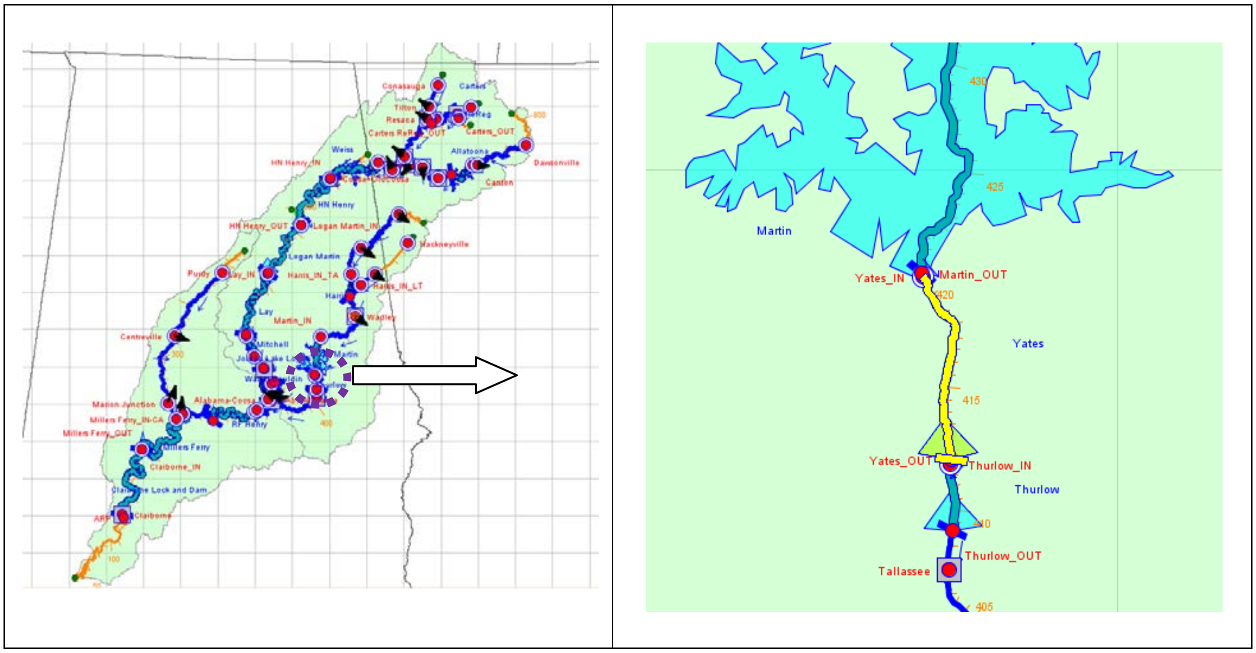


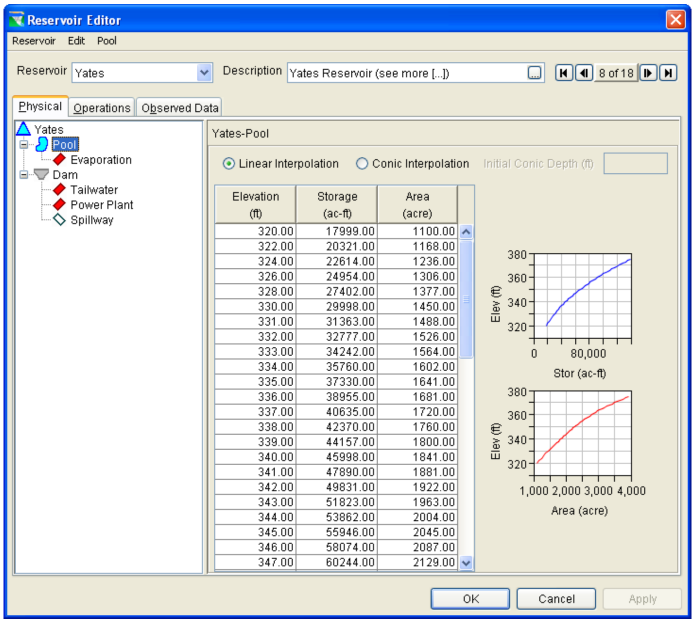
Figure K.15 HEC-ResSim Map Display Showing Location of Yates Reservoir

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.



Reservoir: Yates

Description: Yates Reservoir (see more [...])

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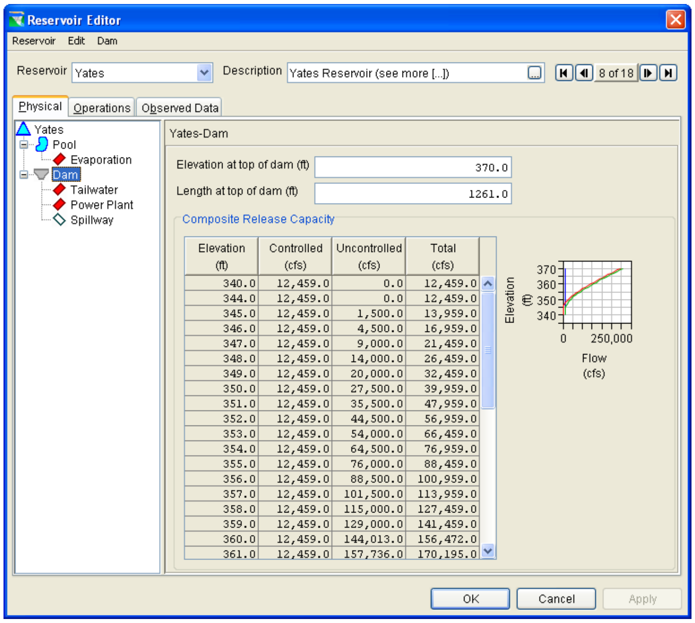
Yates-Pool

● Linear Interpolation ○ Conic Interpolation Initial Conic Depth (ft)

Elevation (ft)	Storage (ac-ft)	Area (acre)
320.00	17999.00	1100.00
322.00	20321.00	1168.00
324.00	22614.00	1236.00
326.00	24954.00	1306.00
328.00	27402.00	1377.00
330.00	29998.00	1450.00
331.00	31363.00	1488.00
332.00	32777.00	1526.00
333.00	34242.00	1564.00
334.00	35760.00	1602.00
335.00	37330.00	1641.00
336.00	38955.00	1681.00
337.00	40635.00	1720.00
338.00	42370.00	1760.00
339.00	44157.00	1800.00
340.00	45998.00	1841.00
341.00	47890.00	1881.00
342.00	49831.00	1922.00
343.00	51823.00	1963.00
344.00	53862.00	2004.00
345.00	55946.00	2045.00
346.00	58074.00	2087.00
347.00	60244.00	2129.00

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



Reservoir: Yates

Description: Yates Reservoir (see more [...])

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Yates-Dam

Elevation at top of dam (ft): 370.0

Length at top of dam (ft): 1261.0

Composite Release Capacity

Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
340.0	12,459.0	0.0	12,459.0
344.0	12,459.0	0.0	12,459.0
345.0	12,459.0	1,500.0	13,959.0
346.0	12,459.0	4,500.0	16,959.0
347.0	12,459.0	9,000.0	21,459.0
348.0	12,459.0	14,000.0	26,459.0
349.0	12,459.0	20,000.0	32,459.0
350.0	12,459.0	27,500.0	39,959.0
351.0	12,459.0	35,500.0	47,959.0
352.0	12,459.0	44,500.0	56,959.0
353.0	12,459.0	54,000.0	66,459.0
354.0	12,459.0	64,500.0	76,959.0
355.0	12,459.0	76,000.0	88,459.0
356.0	12,459.0	88,500.0	100,959.0
357.0	12,459.0	101,500.0	113,959.0
358.0	12,459.0	115,000.0	127,459.0
359.0	12,459.0	129,000.0	141,459.0
360.0	12,459.0	144,013.0	156,472.0
361.0	12,459.0	157,736.0	170,195.0

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

C. Baseline Operations

1. “Flow-thru” Operation Set

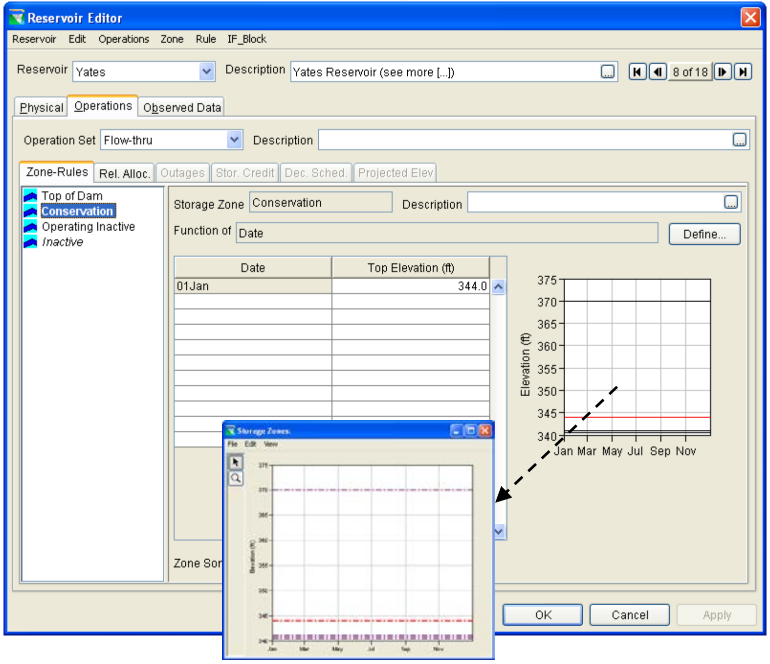
Table K.3 shows the definition of operational zones consisting of Top of Dam, Conservation, and Operating Inactive zone, as well as an Inactive zone.

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)



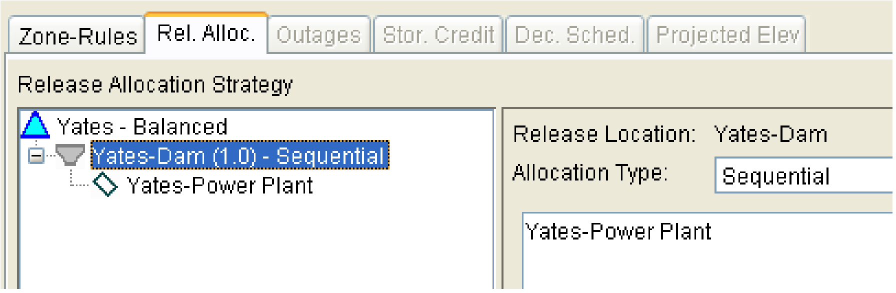
Reservoir: Yates
Description: Yates Reservoir (see more [...])
Operation Set: Flow-thru
Description:
Storage Zone: Conservation
Description:
Function of: Date

Date	Top Elevation (ft)
01Jan	344.0

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:



Release Allocation Strategy

- Yates - Balanced
  - Yates-Dam (1.0) - Sequential
    - Yates-Power Plant

Release Location: Yates-Dam

Allocation Type: Sequential

Yates-Power Plant

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".

Reservoir Yates

Operation Set Flow-thru

Top of Dam

Conservation

Operating Inactive

Inactive

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.

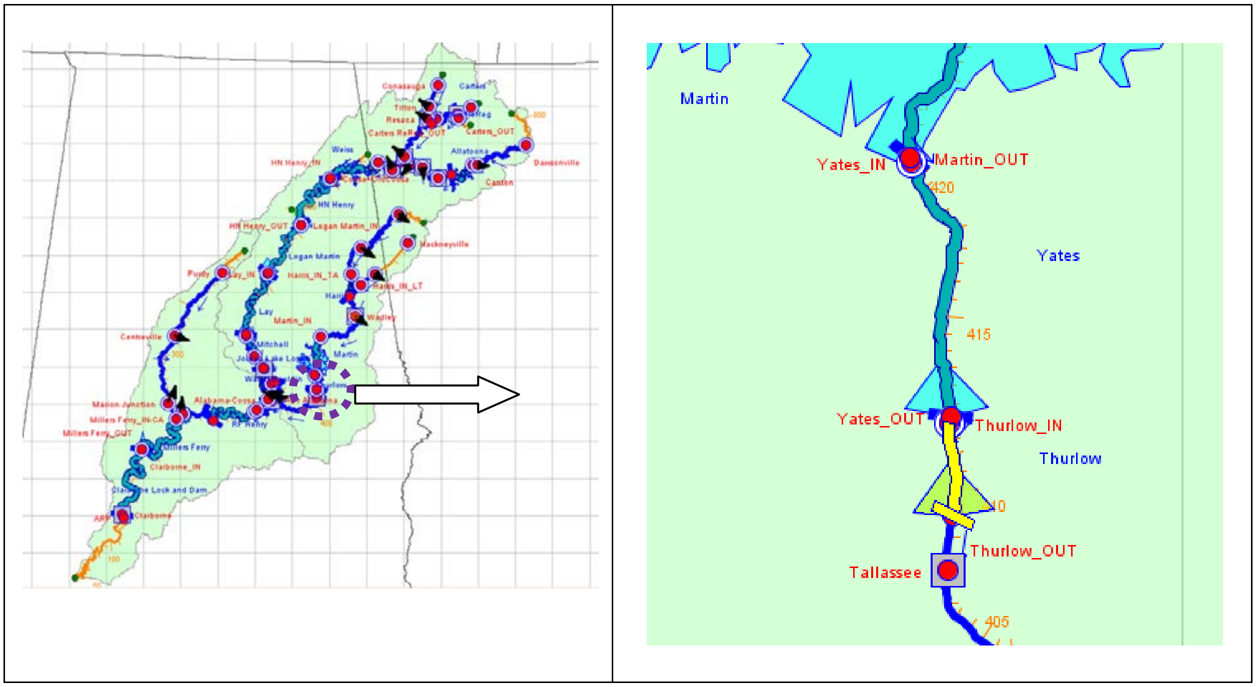


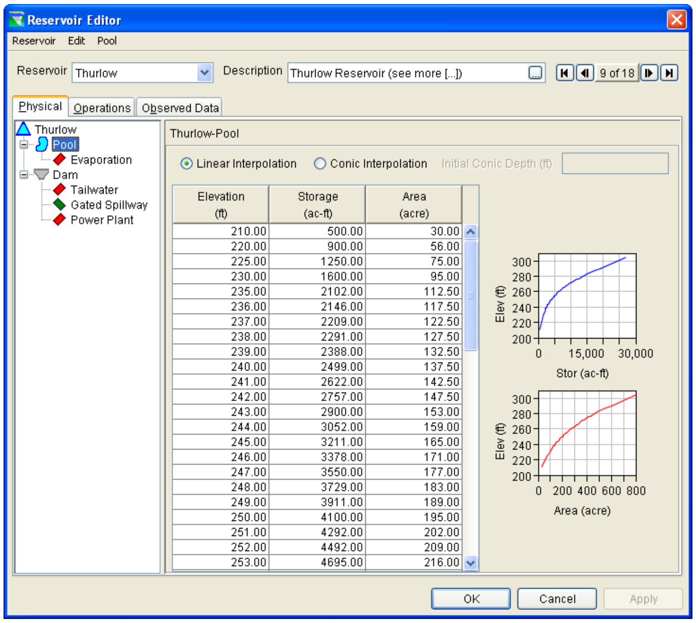
Figure K.22 HEC-ResSim Map Display Showing Location of Thurlow Reservoir

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.



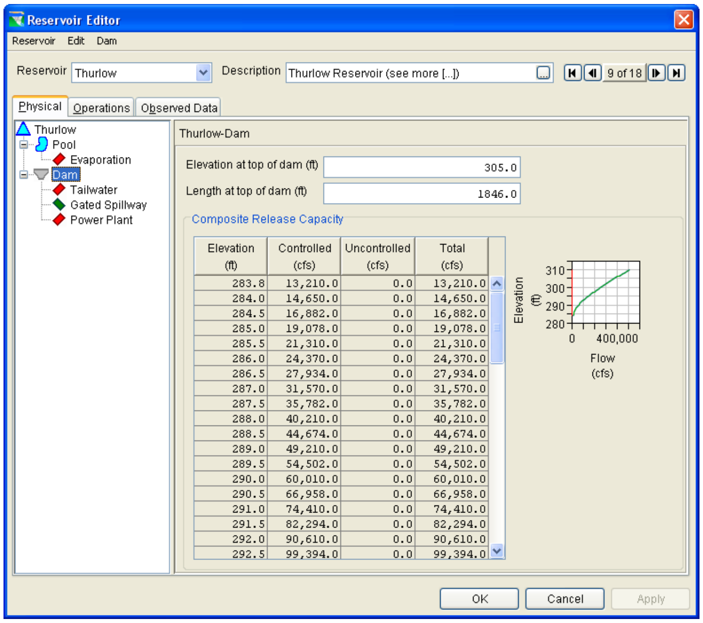
Reservoir: Thurlow
Description: Thurlow Reservoir (see more [...])

Thurlow-Pool

● Linear Interpolation ○ Conic Interpolation

Elevation (ft)	Storage (ac-ft)	Area (acre)
210.00	500.00	30.00
220.00	900.00	56.00
225.00	1250.00	75.00
230.00	1600.00	95.00
235.00	2102.00	112.50
236.00	2146.00	117.50
237.00	2209.00	122.50
238.00	2291.00	127.50
239.00	2388.00	132.50
240.00	2499.00	137.50
241.00	2622.00	142.50
242.00	2757.00	147.50
243.00	2900.00	153.00
244.00	3052.00	159.00
245.00	3211.00	165.00
246.00	3378.00	171.00
247.00	3550.00	177.00
248.00	3729.00	183.00
249.00	3911.00	189.00
250.00	4100.00	195.00
251.00	4292.00	202.00
252.00	4492.00	209.00
253.00	4695.00	216.00

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



Reservoir: Thurlow
Description: Thurlow Reservoir (see more [...])

Thurlow-Dam

Elevation at top of dam (ft): 305.0
Length at top of dam (ft): 1846.0

Composite Release Capacity

Elevation (ft)	Controlled (cfs)	Uncontrolled (cfs)	Total (cfs)
283.8	13,210.0	0.0	13,210.0
284.0	14,650.0	0.0	14,650.0
284.5	16,882.0	0.0	16,882.0
285.0	19,078.0	0.0	19,078.0
285.5	21,310.0	0.0	21,310.0
286.0	24,370.0	0.0	24,370.0
286.5	27,934.0	0.0	27,934.0
287.0	31,570.0	0.0	31,570.0
287.5	35,782.0	0.0	35,782.0
288.0	40,210.0	0.0	40,210.0
288.5	44,674.0	0.0	44,674.0
289.0	49,210.0	0.0	49,210.0
289.5	54,502.0	0.0	54,502.0
290.0	60,010.0	0.0	60,010.0
290.5	66,958.0	0.0	66,958.0
291.0	74,410.0	0.0	74,410.0
291.5	82,294.0	0.0	82,294.0
292.0	90,610.0	0.0	90,610.0
292.5	99,394.0	0.0	99,394.0

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

C. Baseline Operations

1. “Flow-thru” Operation Set

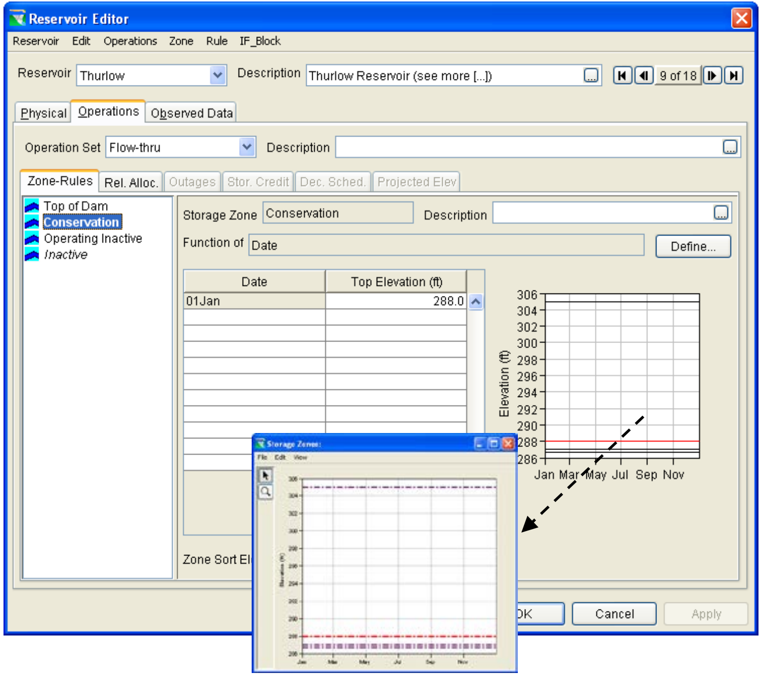
Table K.4 shows the definition of operational zones consisting of Top of Dam, Conservation, and Operating Inactive zone, as well as an Inactive zone.

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)



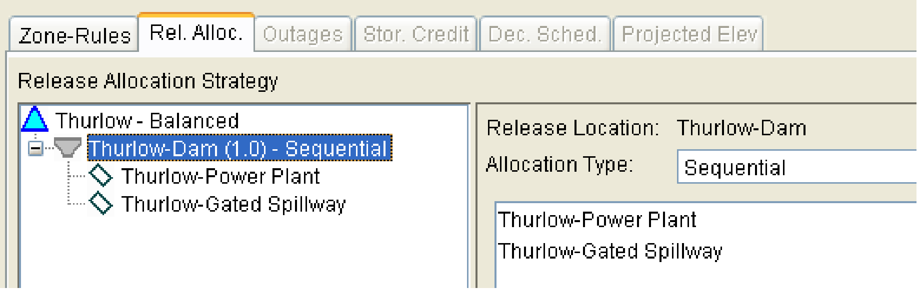
Reservoir: Thurlow
Description: Thurlow Reservoir (see more [...])
9 of 18
Operation Set: Flow-thru
Description:
Storage Zone: Conservation
Description:
Function of: Date

Date	Top Elevation (ft)
01Jan	288.0

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:



Release Location: Thurlow-Dam
Allocation Type: Sequential
Thurlow-Power Plant
Thurlow-Gated Spillway

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".

Reservoir: Thurlow
Operation Set: Flow-thru

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.

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

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.

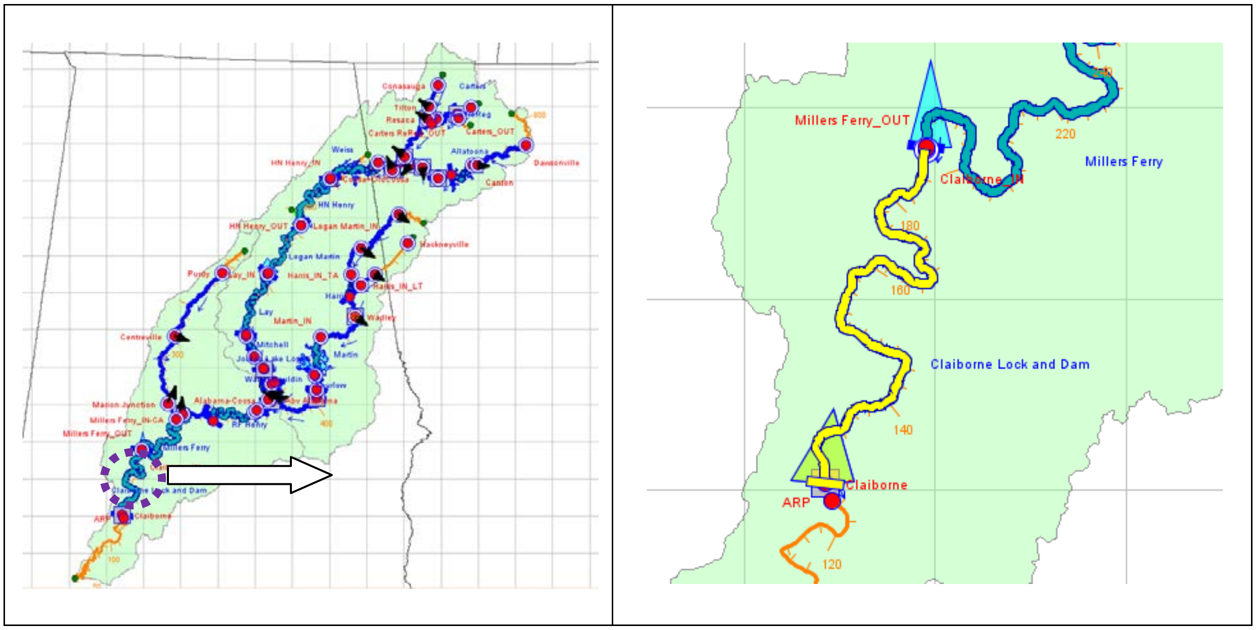


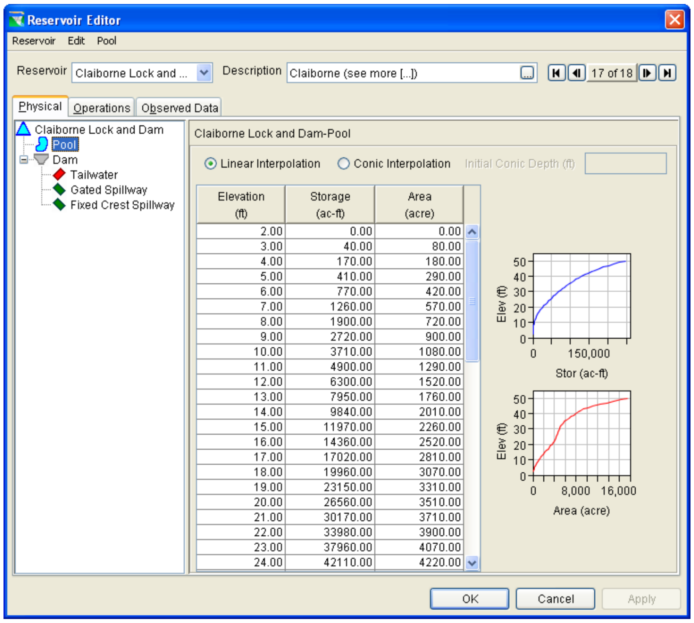
Figure K.29 HEC-ResSim Map Display Showing Location of Claiborne Lock and Dam Reservoir

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.



Reservoir: Claiborne Lock and ...

Description: Claiborne (see more [...])

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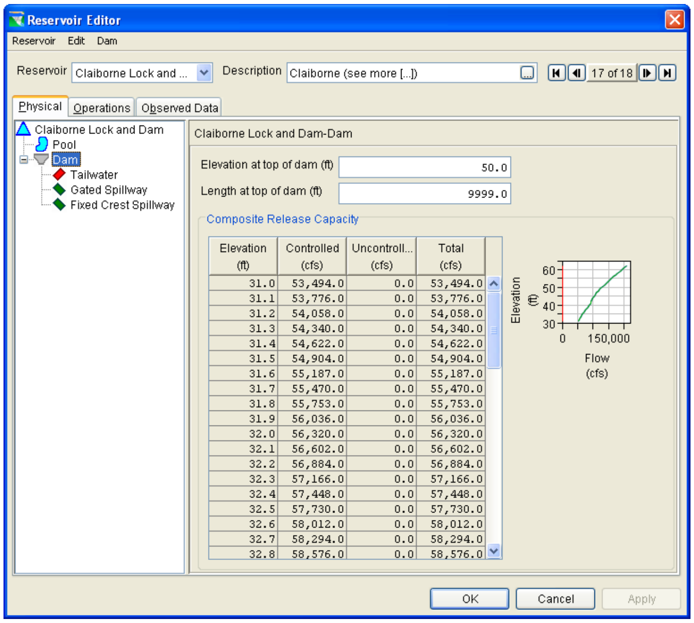
Claiborne Lock and Dam-Pool

● Linear Interpolation ○ Conic Interpolation Initial Conic Depth (ft)

Elevation (ft)	Storage (ac-ft)	Area (acre)
2.00	0.00	0.00
3.00	40.00	80.00
4.00	170.00	180.00
5.00	410.00	290.00
6.00	770.00	420.00
7.00	1260.00	570.00
8.00	1900.00	720.00
9.00	2720.00	900.00
10.00	3710.00	1080.00
11.00	4900.00	1290.00
12.00	6300.00	1520.00
13.00	7950.00	1760.00
14.00	9840.00	2010.00
15.00	11970.00	2260.00
16.00	14360.00	2520.00
17.00	17020.00	2810.00
18.00	19960.00	3070.00
19.00	23150.00	3310.00
20.00	26560.00	3510.00
21.00	30170.00	3710.00
22.00	33980.00	3900.00
23.00	37960.00	4070.00
24.00	42110.00	4220.00

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



Reservoir: Claiborne Lock and ...

Description: Claiborne (see more [...])

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Claiborne Lock and Dam-Dam

Elevation at top of dam (ft): 50.0

Length at top of dam (ft): 9999.0

Composite Release Capacity

Elevation (ft)	Controlled (cfs)	Uncontroll... (cfs)	Total (cfs)
31.0	53,494.0	0.0	53,494.0
31.1	53,776.0	0.0	53,776.0
31.2	54,058.0	0.0	54,058.0
31.3	54,340.0	0.0	54,340.0
31.4	54,622.0	0.0	54,622.0
31.5	54,904.0	0.0	54,904.0
31.6	55,187.0	0.0	55,187.0
31.7	55,470.0	0.0	55,470.0
31.8	55,753.0	0.0	55,753.0
31.9	56,036.0	0.0	56,036.0
32.0	56,320.0	0.0	56,320.0
32.1	56,602.0	0.0	56,602.0
32.2	56,884.0	0.0	56,884.0
32.3	57,166.0	0.0	57,166.0
32.4	57,448.0	0.0	57,448.0
32.5	57,730.0	0.0	57,730.0
32.6	58,012.0	0.0	58,012.0
32.7	58,294.0	0.0	58,294.0
32.8	58,576.0	0.0	58,576.0

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

C. Baseline Operations

1. “Flow-thru” Operation Set

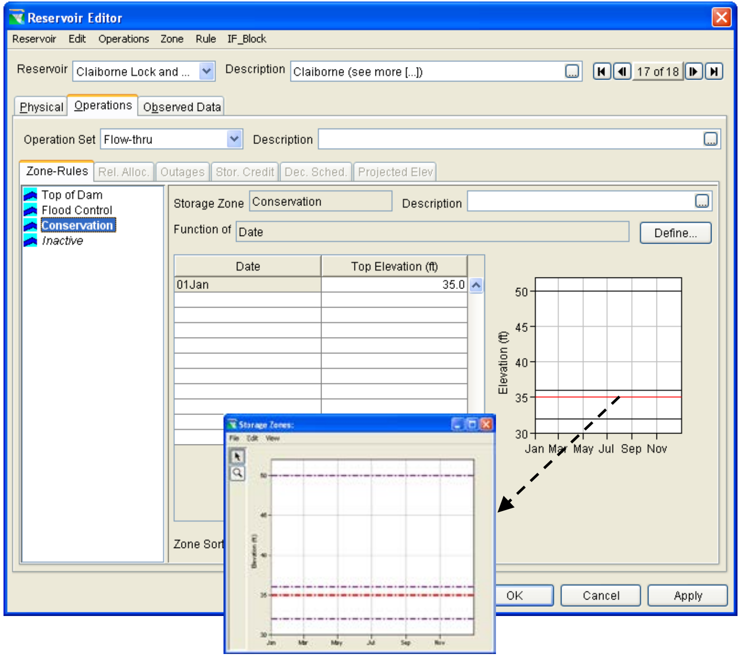
Table K.5 shows the definition of operational zones consisting of Top of Dam, Conservation, and Operating Inactive zone, as well as an Inactive zone.

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)



Reservoir: Claiborne Lock and ...

Description: Claiborne (see more [...])

Operation Set: Flow-thru

Storage Zone: Conservation

Function of: Date

Date	Top Elevation (ft)
01Jan	35.0

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”.


Reservoir: Claiborne Lock and ...

Operation Set: 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.

VI. Alternative Operations (same as “Baseline”)

The “Flow-thru” operation set is used for all of the alternatives at Claiborne, Lay, Mitchell, Thurlow, and Yates.

Alabama-Coosa-Tallapoosa (ACT) Watershed

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

Appendix L – State Variables and Utility Scripts

March 2011 (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.

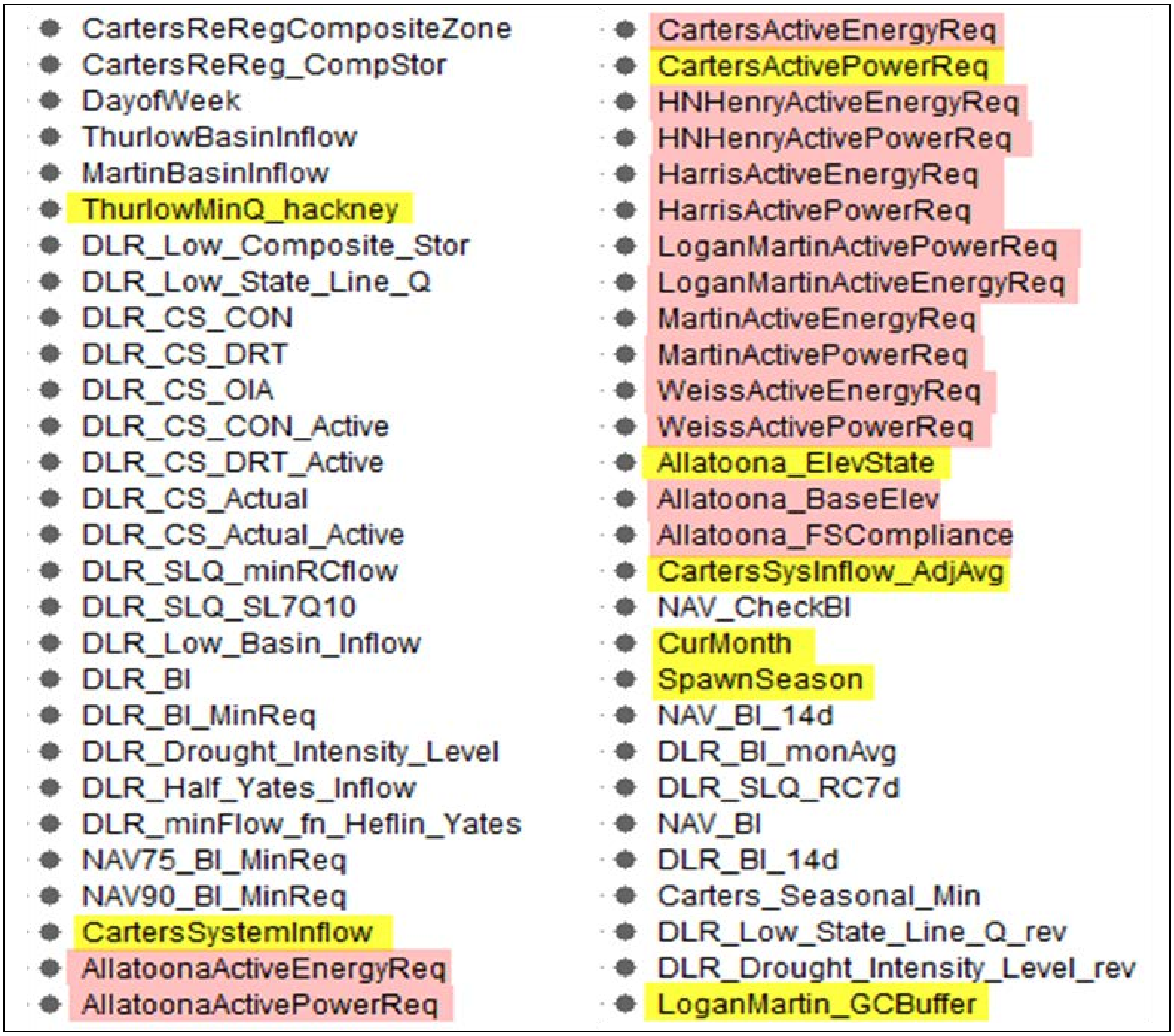
It should be noted that the ACT models operating at a daily time step compute the storage values based on the previous day, not the current period. This design reflects the District’s procedure for determining today’s operations based on conditions observed at the beginning of the workday. Using values 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) used in the ACT basin Baseline alternative. 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
- CartersReReg_CompStor
- DayofWeek
- ThurlowBasinInflow
- MartinBasinInflow
- ThurlowMinQ_hackney
- DLR_Low_Composite_Stor
- DLR_Low_State_Line_Q
- DLR_CS_CON
- DLR_CS_DRT
- DLR_CS_OIA
- DLR_CS_CON_Active
- DLR_CS_DRT_Active
- DLR_CS_Actual
- DLR_CS_Actual_Active
- DLR_SLQ_minRCflow
- DLR_SLQ_SL7Q10
- DLR_Low_Basin_Inflow
- DLR_BI
- DLR_BI_MinReq
- DLR_Drought_Intensity_Level
- DLR_Half_Yates_Inflow
- DLR_minFlow_fn_Heflin_Yates
- NAV75_BI_MinReq
- NAV90_BI_MinReq
- CartersSystemInflow
- AllatoonaActiveEnergyReq
- AllatoonaActivePowerReq
- CartersActiveEnergyReq
- CartersActivePowerReq
- HNHenryActiveEnergyReq
- HNHenryActivePowerReq
- HarrisActiveEnergyReq
- HarrisActivePowerReq
- LoganMartinActivePowerReq
- LoganMartinActiveEnergyReq
- MartinActiveEnergyReq
- MartinActivePowerReq
- WeissActiveEnergyReq
- WeissActivePowerReq
- Allatoona_ElevState
- Allatoona_BaseElev
- Allatoona_FSCompliance
- CartersSysInflow_AdjAvg
- NAV_CheckBI
- CurMonth
- SpawnSeason
- NAV_BI_14d
- DLR_BI_monAvg
- DLR_SLQ_RC7d
- NAV_BI
- DLR_BI_14d
- Carters_Seasonal_Min
- DLR_Low_State_Line_Q_rev
- DLR_Drought_Intensity_Level_rev
- 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

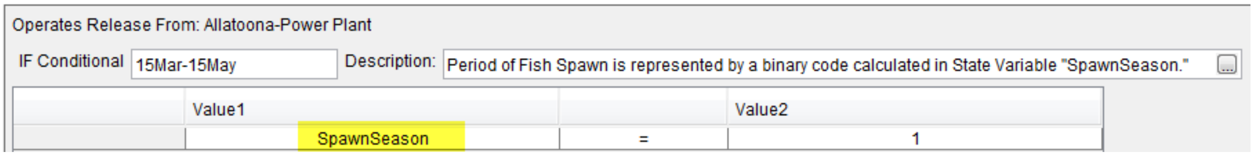
In accordance with the procedures of SAM standing operating procedure (SOP) 1130-2-9, entitled "Project Operations, Reservoir Regulation and Coordination for Fish Management Purposes, Mobile District, Corps of Engineers, Department of the Army, Draft, February 2005," during the spawning periods, the 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.



Operates Release From: Allatoona-Power Plant

IF Conditional: 15Mar-15May

Description: Period of Fish Spawn is represented by a binary code calculated in State Variable "SpawnSeason."

Value1		Value2
SpawnSeason	=	1

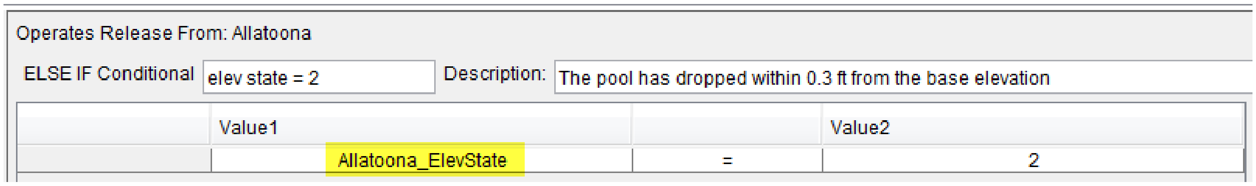
Figure L.02 Application of State Variable "SpawnSeason"

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
```



Operates Release From: Allatoona

ELSE IF Conditional: elev state = 2

Description: The pool has dropped within 0.3 ft from the base elevation

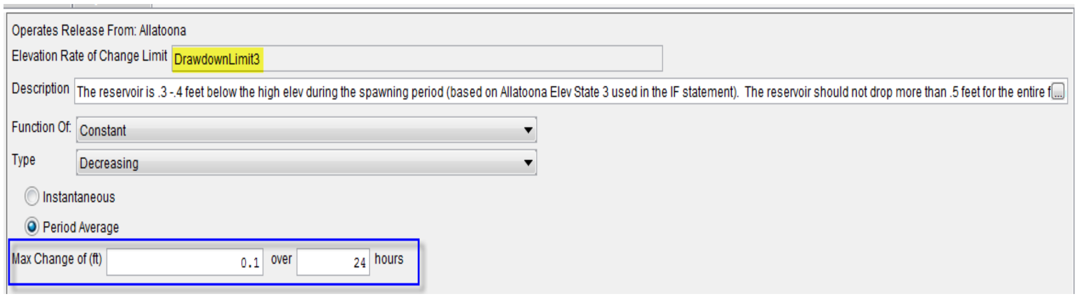
	Value1		Value2
	Allatoona_ElevState	=	2

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).



Operates Release From: Allatoona

Elevation Rate of Change Limit: DrawdownLimit3

Description: 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 f

Function Of: Constant

Type: Decreasing

○ Instantaneous

● Period Average

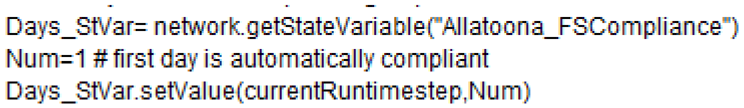
Max Change of (ft) 0.1 over 24 hours

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

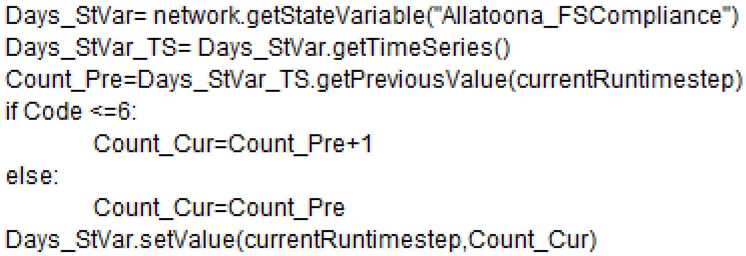
If the elevation for the current time step is higher than the base elevation value, then the base elevation value is reset to the current elevation. This indicates a rising pool and the code is set to zero:

```
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.

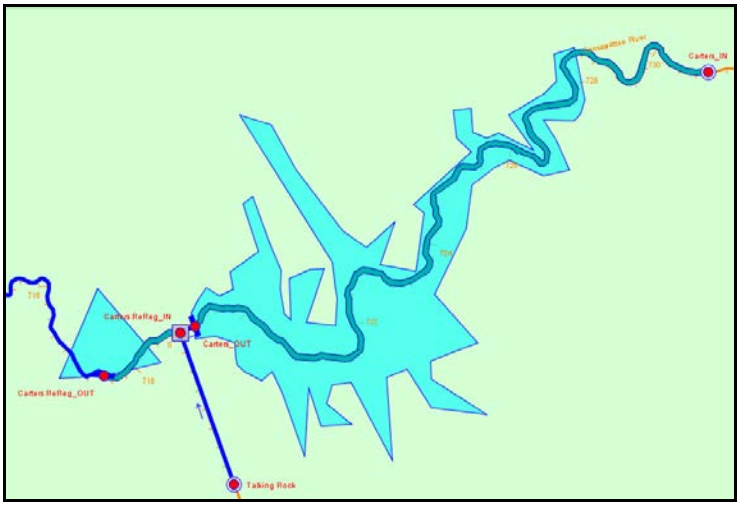
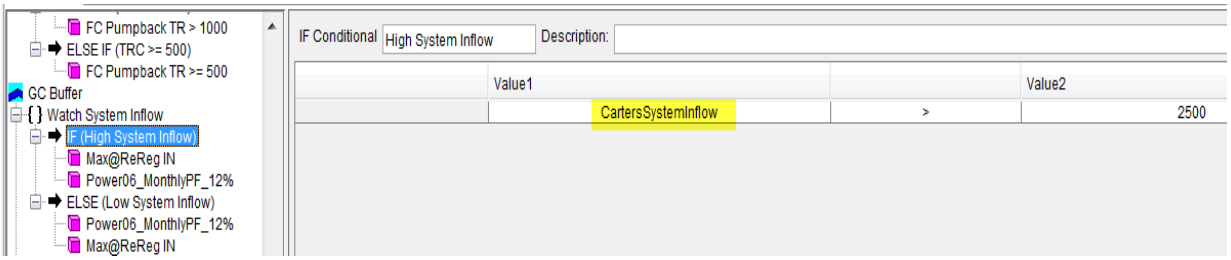


Figure L.05 Carters and Carters ReReg Reservoir System

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.



IF Conditional: High System Inflow

Description:

Value1		Value2
CartersSystemInflow	>	2500

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:

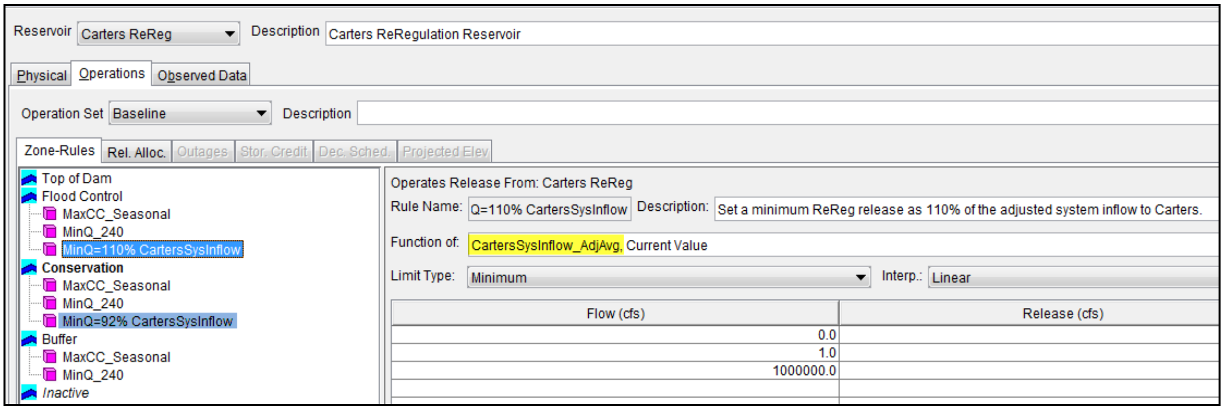
```
TalkingRockIn = network.getTimeSeries("Junction","Talking Rock", "", "Flow") .
        getPeriodAverage((currentRuntimestep.getStep()+2), 4)
```

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%.



Reservoir: Carters ReReg
Description: Carters ReRegulation Reservoir
Operation Set: Baseline
Description:
Operates Release From: Carters ReReg
Rule Name: Q=110% CartersSysInflow
Description: Set a minimum ReReg release as 110% of the adjusted system inflow to Carters.
Function of: CartersSysInflow_AdjAvg, Current Value
Limit Type: Minimum
Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	
1.0	
1000000.0	

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.

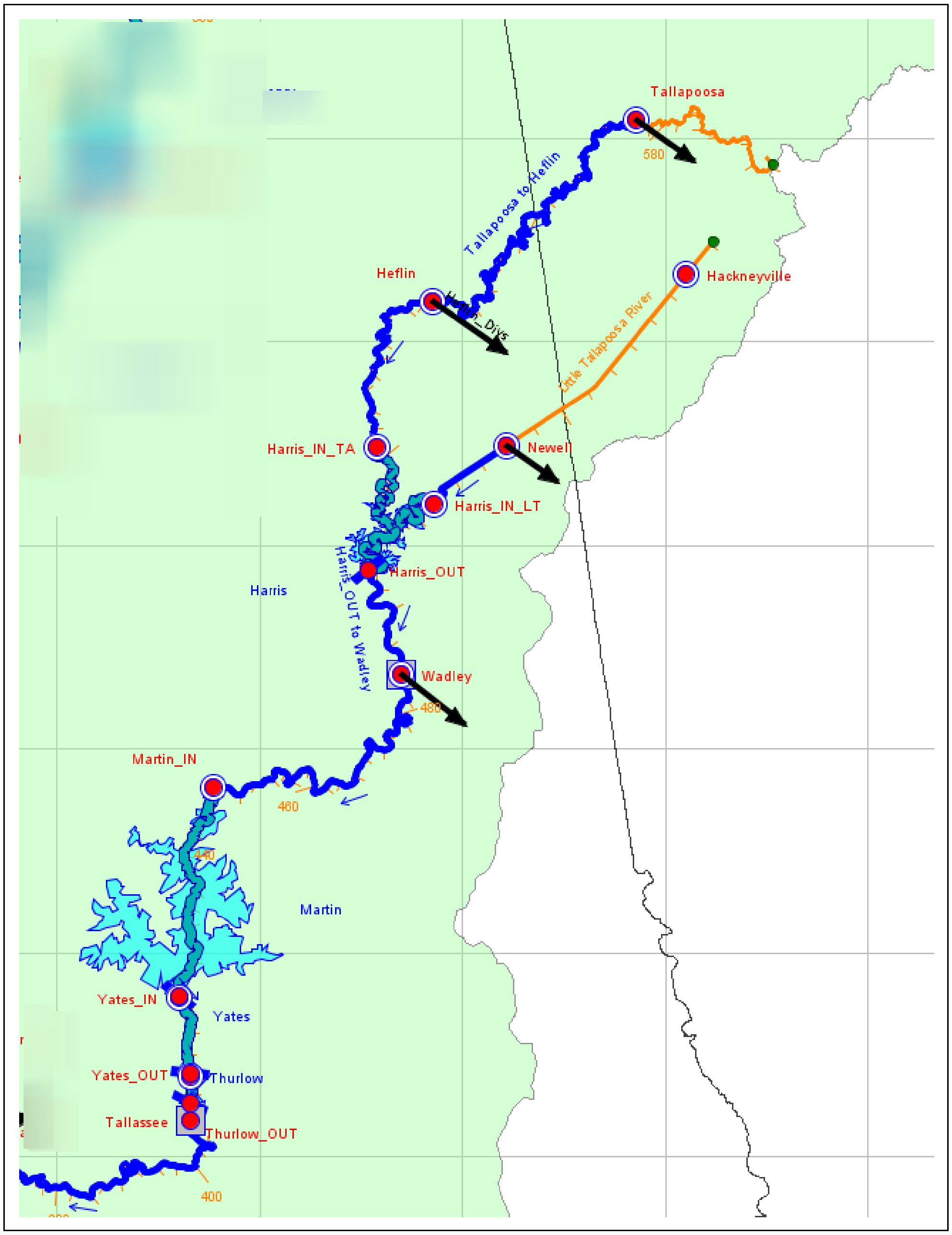
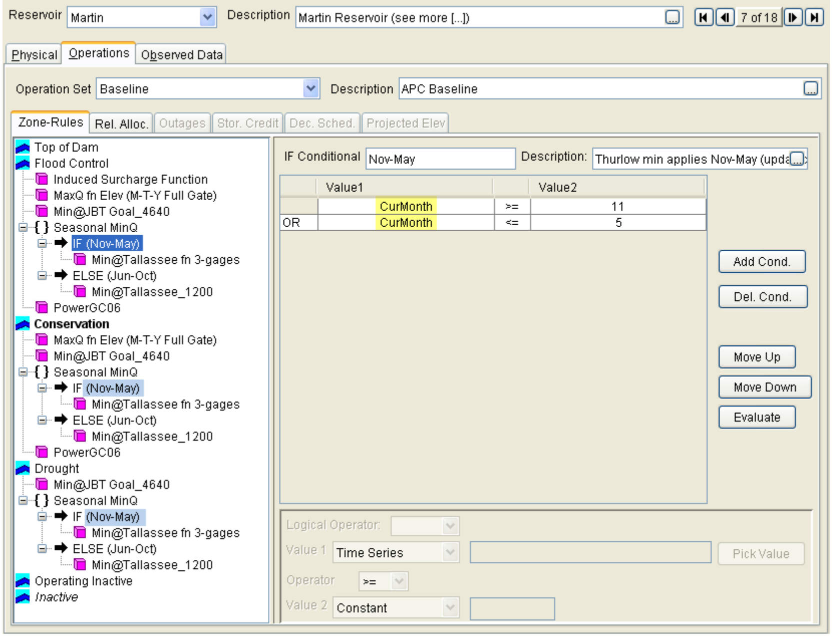


Figure L.08 Schematic of Martin Reservoir System

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.



Reservoir: Martin
Description: Martin Reservoir (see more [...])
7 of 18

Operation Set: Baseline
Description: APC Baseline

- Top of Dam
- Flood Control
  - Induced Surcharge Function
  - MaxQ fn Elev (M-T-Y Full Gate)
  - Min@JBT Goal_4640
  - { } Seasonal MinQ
    - IF (Nov-May)
      - Min@Tallassee fn 3-gages
    - ELSE (Jun-Oct)
      - Min@Tallassee_1200
  - PowerGC06
- Conservation
  - MaxQ fn Elev (M-T-Y Full Gate)
  - Min@JBT Goal_4640
  - { } Seasonal MinQ
    - IF (Nov-May)
      - Min@Tallassee fn 3-gages
    - ELSE (Jun-Oct)
      - Min@Tallassee_1200
  - PowerGC06
- Drought
  - Min@JBT Goal_4640
  - { } Seasonal MinQ
    - IF (Nov-May)
      - Min@Tallassee fn 3-gages
    - ELSE (Jun-Oct)
      - Min@Tallassee_1200
- Operating Inactive
- *Inactive*

IF Conditional: Nov-May
Description: Thurlow min applies Nov-May (upda

	Value1		Value2
	CurMonth	>=	11
OR	CurMonth	<=	5

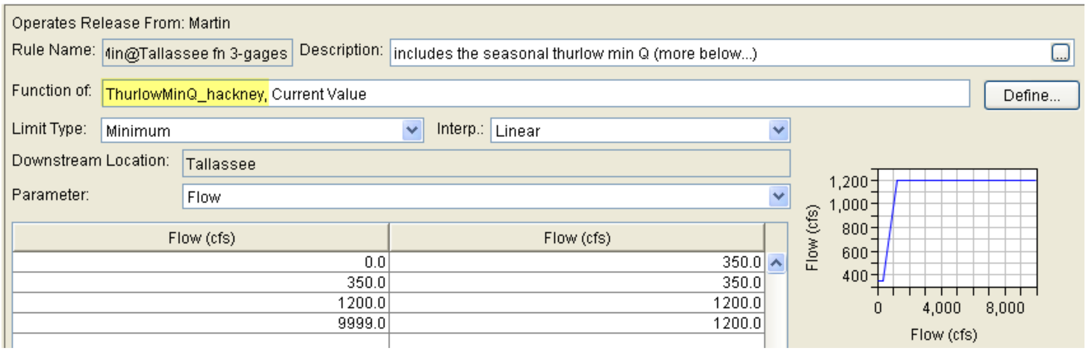
Logical Operator:
Value 1: Time Series
Operator: >=
Value 2: Constant

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).



Operates Release From: Martin
Rule Name: 1in@Tallassee fn 3-gages
Description: includes the seasonal thurlow min Q (more below...)
Function of: ThurlowMinQ_hackney, Current Value
Limit Type: Minimum
Interp.: Linear
Downstream Location: Tallassee
Parameter: Flow

Flow (cfs)	Flow (cfs)
0.0	350.0
350.0	350.0
1200.0	1200.0
9999.0	1200.0

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.

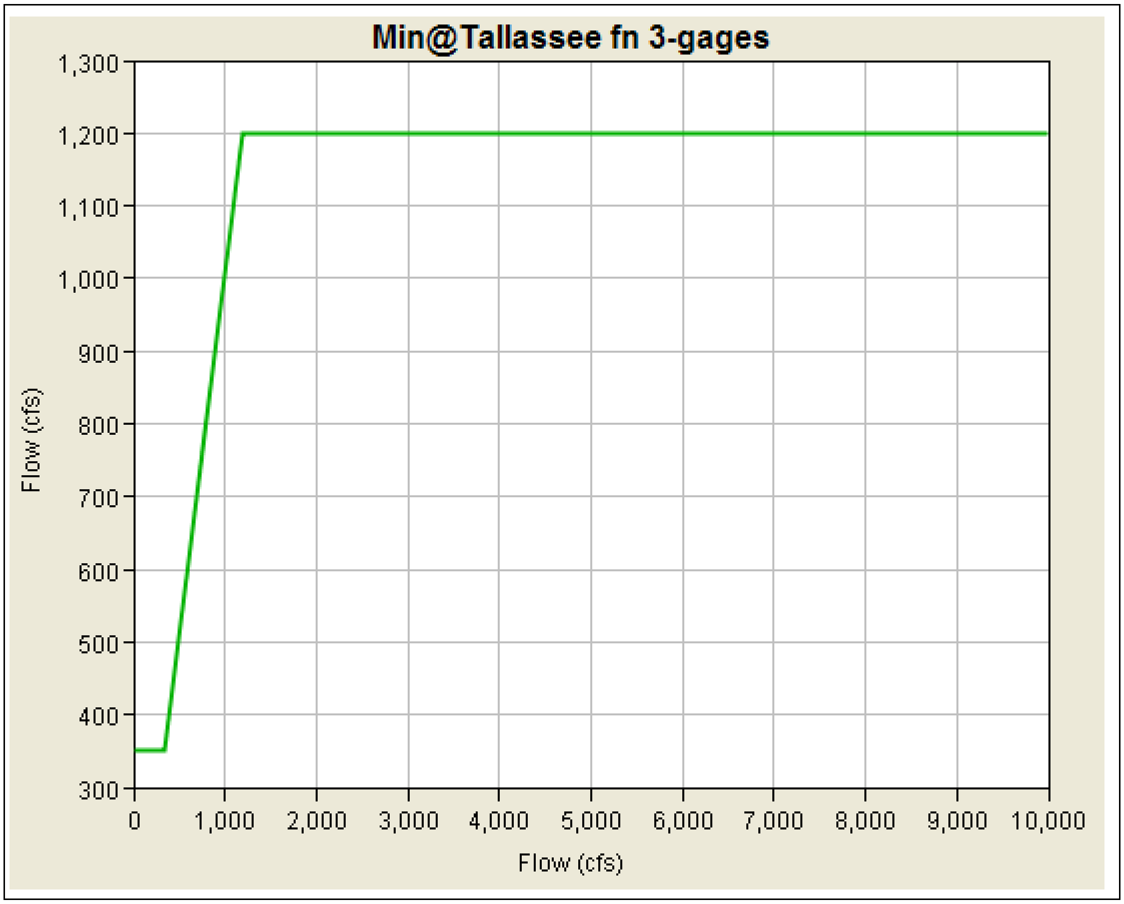
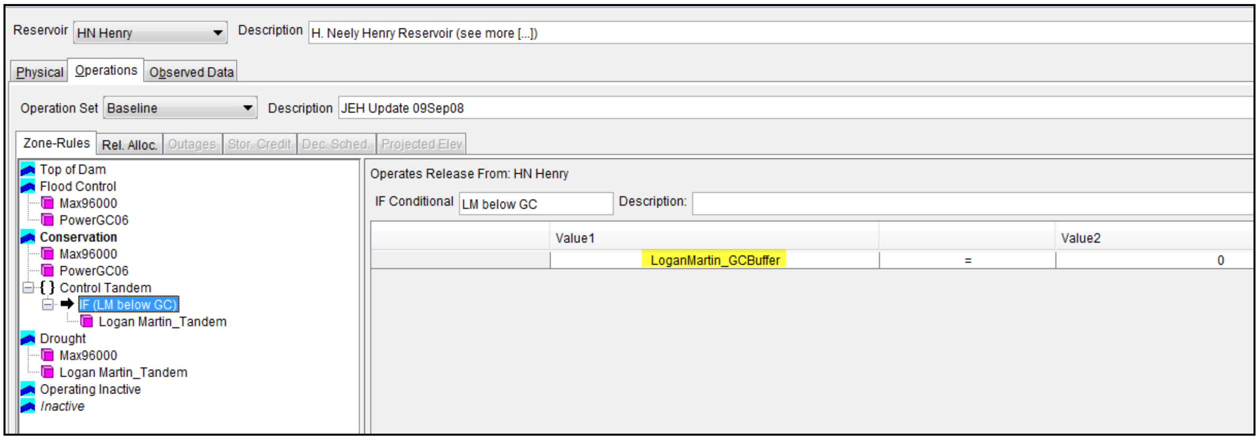


Figure L.11 Martin's Downstream Minimum Requirement Rule for Tallassee (as a Function of Flow from 3 Gages)

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.



Reservoir: HN Henry
Description: H. Neely Henry Reservoir (see more [...])
Operation Set: Baseline
Description: JEH Update 09Sep08
Operates Release From: HN Henry
IF Conditional: LM below GC
Description:

	Value1		Value2
	LoganMartin_GCBuffer	=	0

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). Allatoona is the only reservoir with differences between the Baseline alternative and other alternatives. Differences in the other alternatives at Allatoona will be dicussed in later sections. For the Baseline alternative at Allatoona, there is no Zone 3. The bottom of Zone 2 is the top of the Inactive pool so the required power generation in Zone 2 is shown down to the inactive pool. In the script, a false Zone 3 was used with the power generation being the same as Zone 2.

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
Zone 3 (Z3)	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.

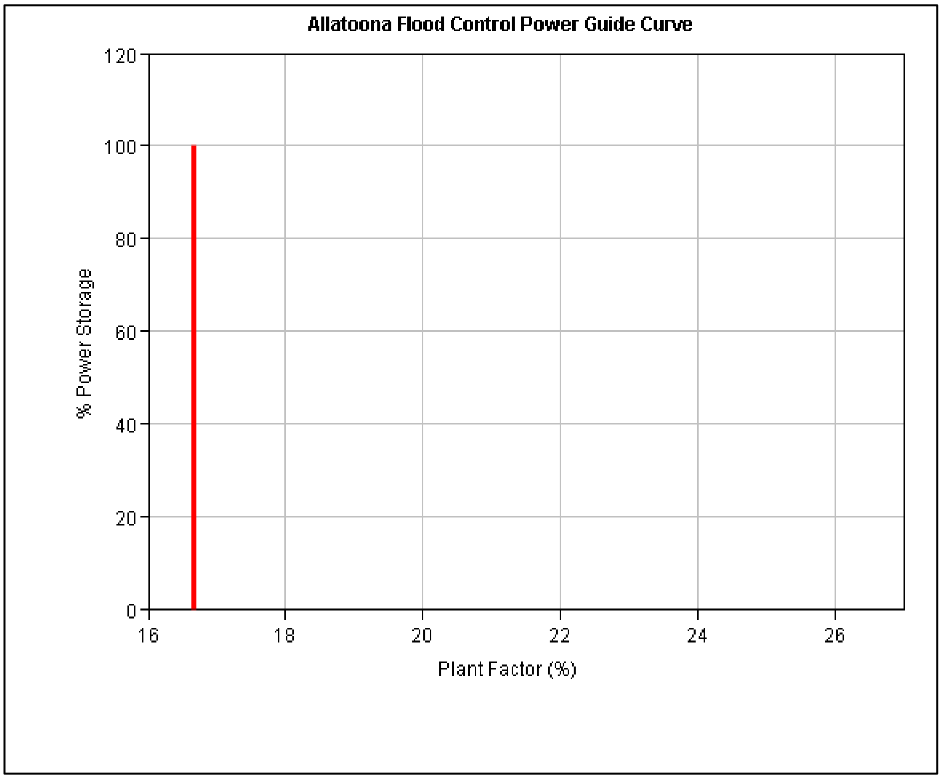


Figure L.13 PowerGC FC_4hrs Guide Curve

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.

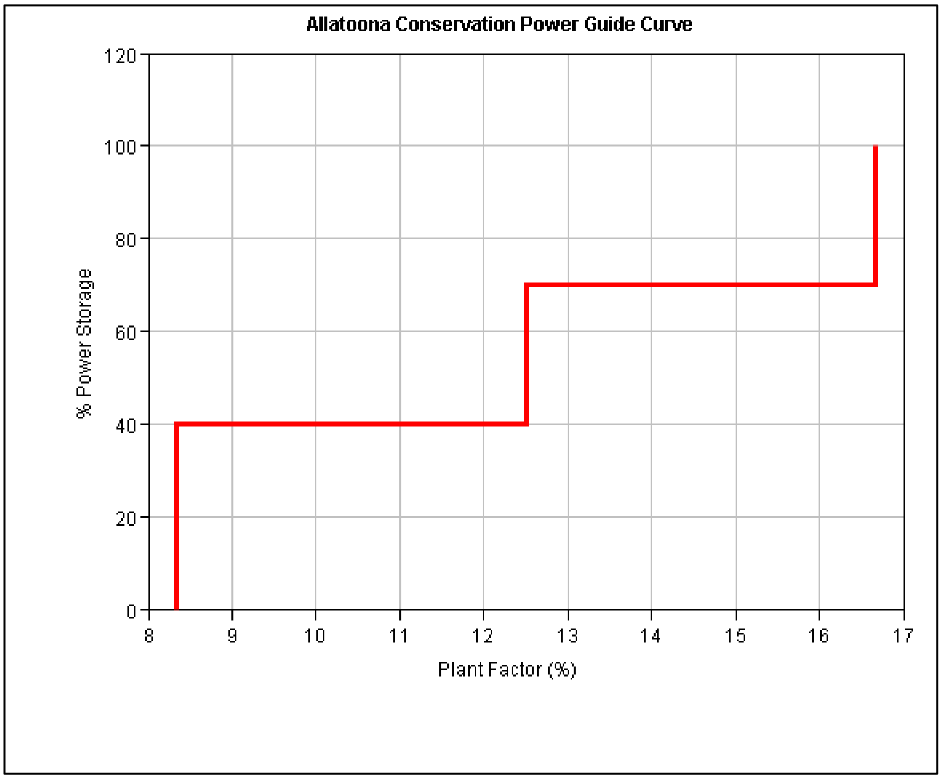


Figure L.14 PowerGC Z1_2-4hrs Guide Curve

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.

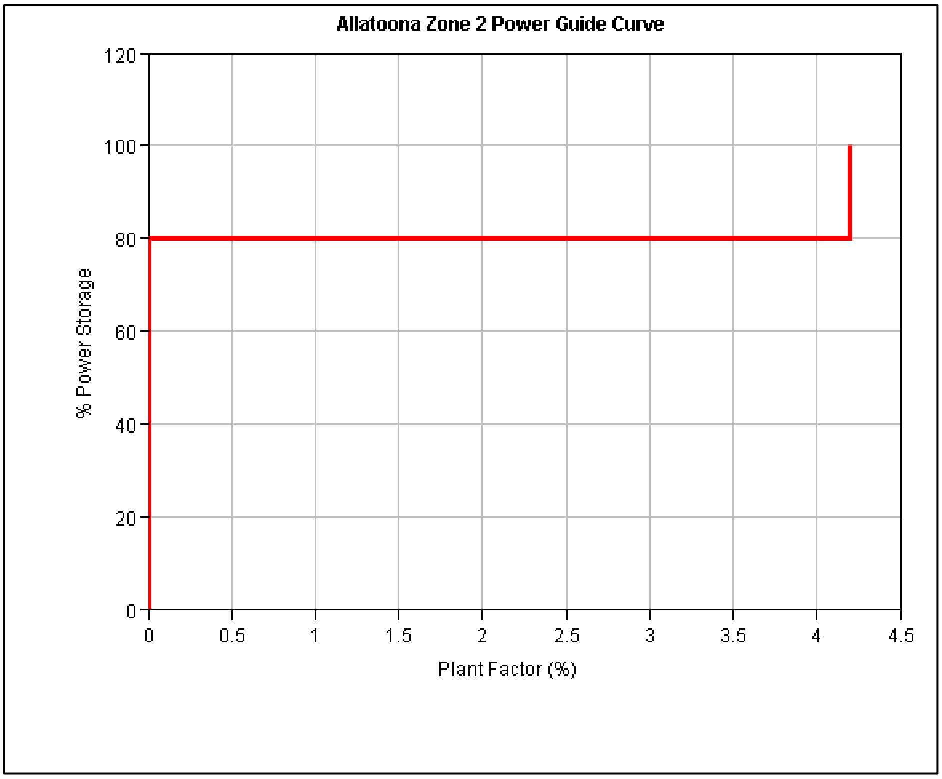


Figure L.15 PowerGC Z2_0-1hrs Guide Curve

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).

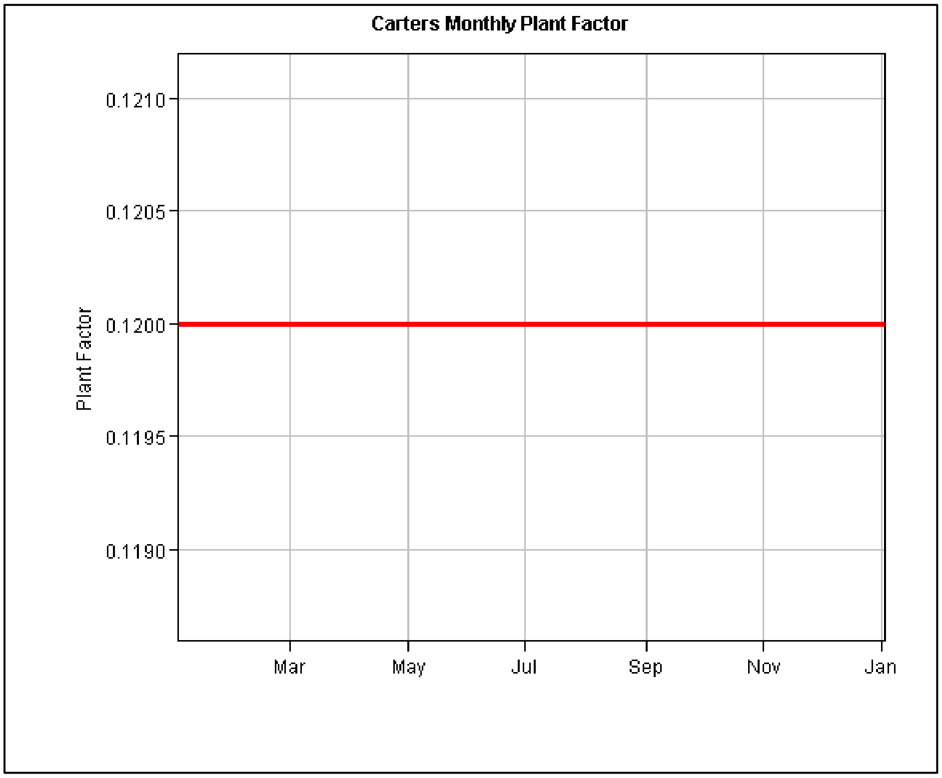


Figure L.16 Power06_MonthlyPF_12% Guide Curve

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).

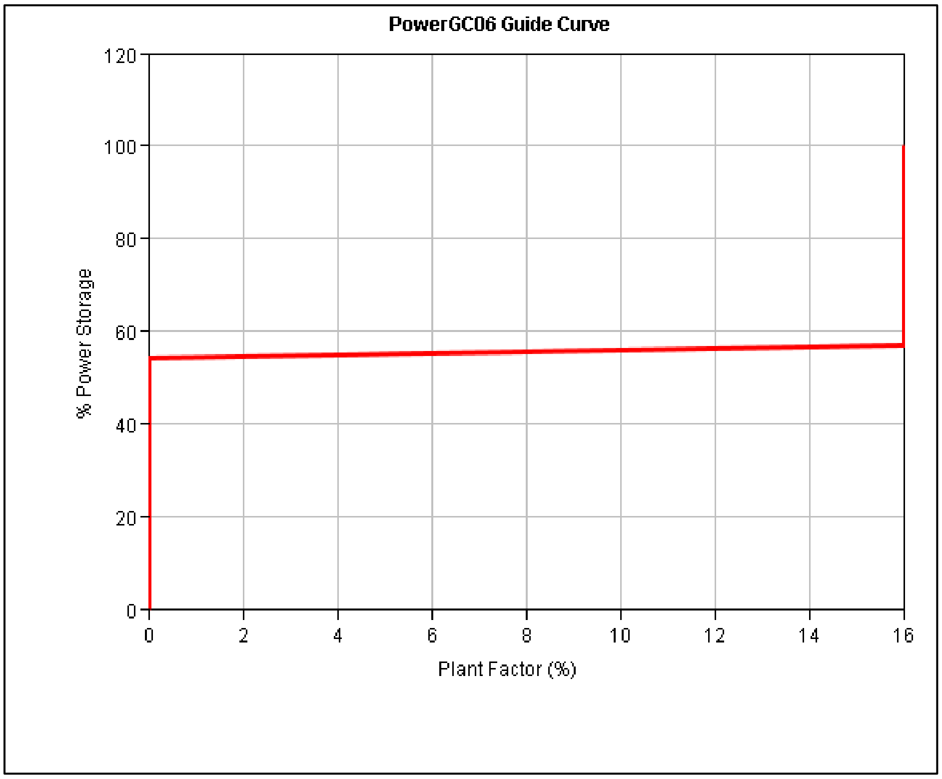


Figure L.17 PowerGC06 Guide Curve

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. State Variables in "DroughtPln" Alternative

The DroughtPln alternative uses 35 state variables in the operating rules, 27 of which have not been introduced yet in this report. The state variables in all of the projects except Allatoona, Jordan, Logan Martin, Martin, and Millers Ferry remain unchanged (from the Baseline Alternative). Figure L.18 shows a list of state variables; variables highlighted in yellow are within the operation rules, while those highlighted in pink are placeholders for the other state variables. These state variables are defined to establish operating rules for the following operational objectives in the DroughtPln alternative simulation:

- Fish spawning operational considerations at Allatoona
- Operation of Carters and Carters ReReg
- Guide Curve Buffer for the HN Henry and Logan Martin tandem operation rule
- Drought Level Response at Logan Martin
- Drought Level Response at Martin
- Drought Level Response at Millers Ferry
- Operations at Jordan used for Diversion to Bouldin
- Power and energy requirements

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

Figure L.18 List of State Variables in the DroughtPln Alternative

A. Fish Spawning Operational Considerations at Allatoona

The DroughtPln alternative operations at Allatoona are identical to the Baseline alternative operations, so new state variables were introduced.

B. Operation of Carters and Carters ReReg

The DroughtPln alternative operations at Carters and Carters ReReg are identical to the Baseline alternative operations, so new state variables were introduced.

C. Guide Curve Buffer for the HN Henry and Logan Martin Tandem Operation Rule

The DroughtPln alternative operations at HN Henry are identical to the Baseline alternative operations, so new state variables were introduced.

D. Drought Level Response Drought Intensity Level Background

The following figure (Figure L.19) is for use as a reference to the reservoirs and stations used in the DroughtPln Alternative.

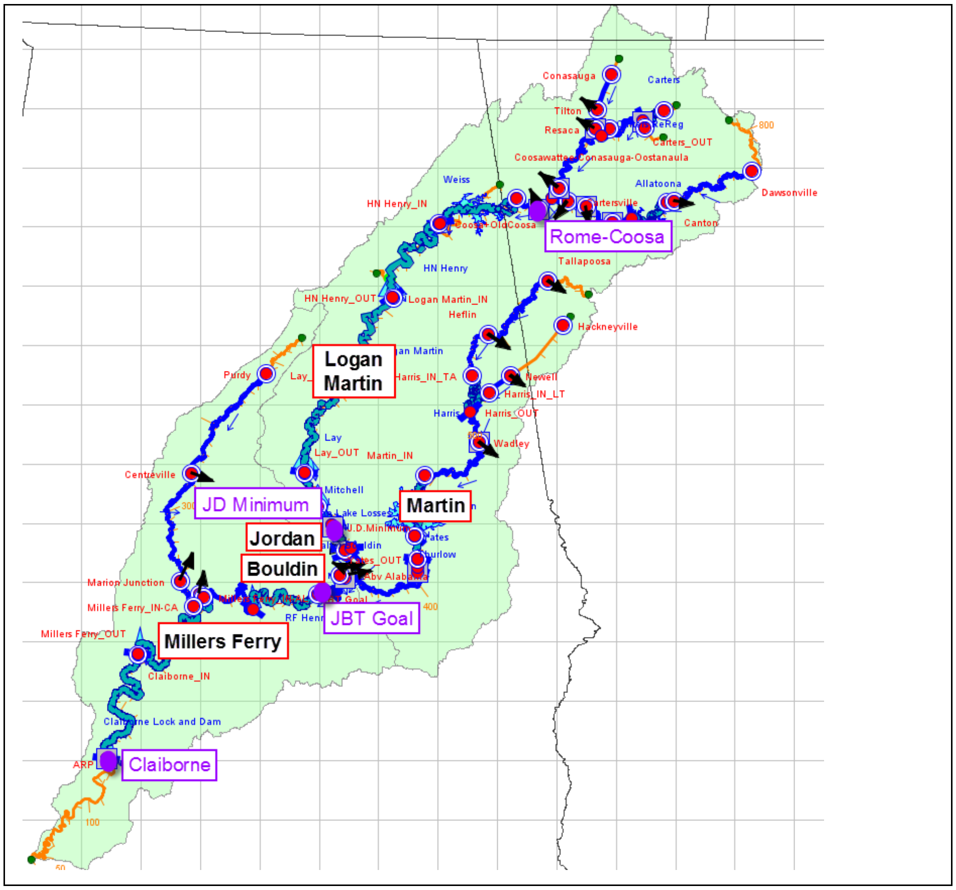
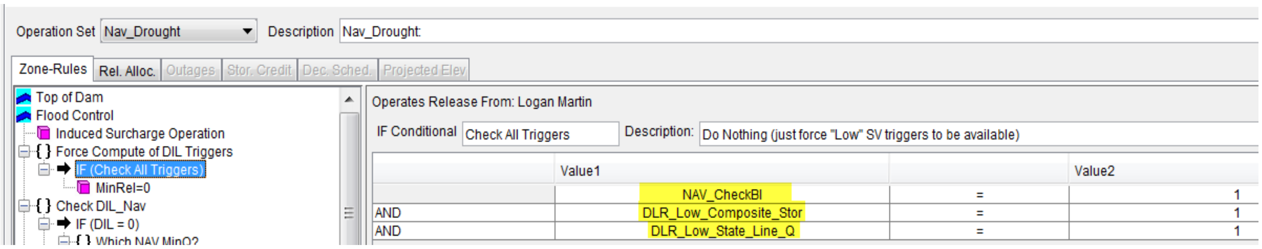


Figure L.19 ResSim Map of Reservoirs and Stream Flow Stations used in the DroughtPln Alternative

The minimum release from Logan Martin, Martin, Jordan and Millers Ferry during the DroughtPln Alternative is determined by the use of a Drought Intensity Level (DIL) using the DLR_Drought_Intensity_Level state variable. The DIL is determined using three state variable triggers: NAV_CheckBI, DLR_Low_Composite_Stor, and DLR_Low_State_Line_Q. Observations of precipitation and stream flow stations are used to indicate when the ACT is entering into or recovering from a "Low State". "Low States" are defined as:

- **Low Basin Inflow-** Inflow into the basin is less than the total needed for Montgomery 7Q10 flow (4,640) and to fill Alabama Power Company's (APC) reservoirs (State variable: NAV_CheckBI)
- **Low State Line Flow-** A flow at or below the local 7Q10 observed flows for Rome, Georgia as measured at the Alabama/Georgia state line gage. (State variable: DLR_Low_State_Line_Q)
- **Low Composite Storage-** APC projects composite storage equal to or less than drought contingency elevation/volumes (State variable: DLR_Low_Composite_Stor)

There is a conditional block called "Force Compute of DIL Triggers" that contains an IF-block to check the DIL triggers (Figure L.20) to make sure that the three state variable triggers are calculated before they are used in the DLR_Drought_Intensity_Level state variable).



Operation Set: Nav_Drought

Description: Nav_Drought:

Operates Release From: Logan Martin

IF Conditional: Check All Triggers

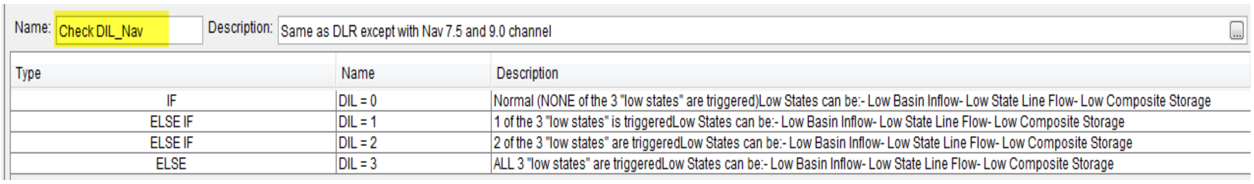
Description: Do Nothing (just force "Low" SV triggers to be available)

	Value1		Value2
	NAV_CheckBI	=	1
AND	DLR_Low_Composite_Stor	=	1
AND	DLR_Low_State_Line_Q	=	1

Figure L.20 Check DIL Triggers at Martin

1. State Variable – "DLR_Drought_Intensity_Level"

After the "Force Compute of DIL Triggers" logic statement computes the three DLR "Low state" state variables, the "Check DIL_Nav" conditional logic determines the appropriate rules to apply based on the DIL using the state variable "DLR_Drought_Intensity_Level" (Figure L.21). DIL response is based on the severity of drought conditions, which is determined by how many "low states" are triggered. If the DIL=0 ("DLR_Drought_Intensity_Level" state variable has a value of 0), then the system is in a normal state (NONE of the three "low states" are triggered). If the DIL=1, then one of the three "low states" is triggered. If the DIL=2, then two of the three "low states" are triggered. If the DIL=3, then ALL three of the "low states" are triggered. Both "DLR_Low_Basin_Inflow" and "DLR_Low_State_Line_Q" state variables output a value of 0 or 1. A value of 0 for each of these state variables indicates normal flows, while a value of 1 indicates drought. "DLR_Low_Composite_Stor" can give an output of -1, 0, or 1. A value of 1 for this state variable indicates a drought, while a value of 0 or -1 indicates normal flows.

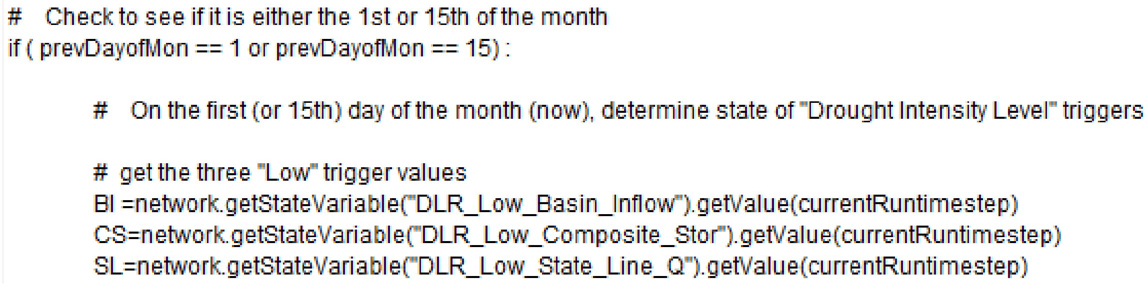


Name: Check DIL_Nav Description: Same as DLR except with Nav 7.5 and 9.0 channel

Type	Name	Description
IF	DIL = 0	Normal (NONE of the 3 "low states" are triggered)Low States can be:- Low Basin Inflow- Low State Line Flow- Low Composite Storage
ELSE IF	DIL = 1	1 of the 3 "low states" is triggeredLow States can be:- Low Basin Inflow- Low State Line Flow- Low Composite Storage
ELSE IF	DIL = 2	2 of the 3 "low states" are triggeredLow States can be:- Low Basin Inflow- Low State Line Flow- Low Composite Storage
ELSE	DIL = 3	ALL 3 "low states" are triggeredLow States can be:- Low Basin Inflow- Low State Line Flow- Low Composite Storage

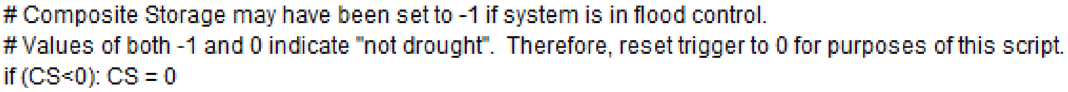
Figure L.21 Check DIL_Nav Conditional Logic at Martin

The script for "DLR_Drought_Intensity_Level" begins by checking if the day of the month is the first or fifteenth. The drought intensity level can be changed on either of these days. It then retrieves the values for state variables related to low basin inflow, low composite storage, and low state line flow.



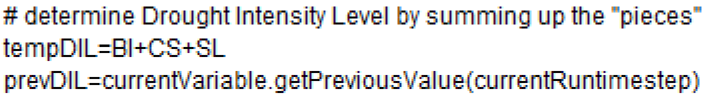
```
#   Check to see if it is either the 1st or 15th of the month
if ( prevDayofMon == 1 or prevDayofMon == 15) :

        #   On the first (or 15th) day of the month (now), determine state of "Drought Intensity Level" triggers

        #  get the three "Low" trigger values
        BI =network.getStateVariable("DLR_Low_Basin_Inflow").getValue(currentRuntimestep)
        CS=network.getStateVariable("DLR_Low_Composite_Stor").getValue(currentRuntimestep)
        SL=network.getStateVariable("DLR_Low_State_Line_Q").getValue(currentRuntimestep)
```

The state variable that calculates the composite storage may return a negative value if the system is in the Flood Control zone, so it must be reset to a value of 0, which indicated "not drought":



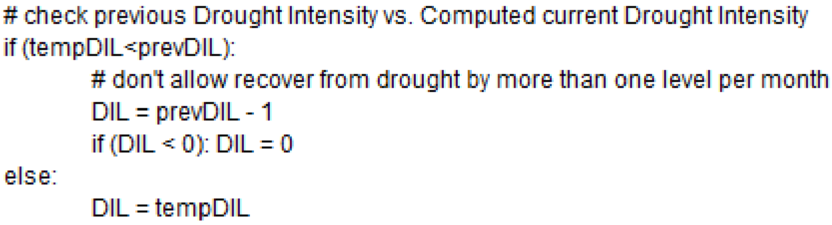
```
# Composite Storage may have been set to -1 if system is in flood control.
# Values of both -1 and 0 indicate "not drought".  Therefore, reset trigger to 0 for purposes of this script.
if (CS<0): CS = 0
```

The DIL is determined by summing the three state variables values. Each value is assigned a value of one if its low state has been triggered. The value for DIL can range from 0 to 3.



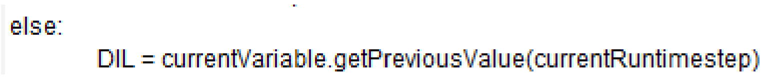
```
# determine Drought Intensity Level by summing up the "pieces"
tempDIL=BI+CS+SL
prevDIL=currentVariable.getPreviousValue(currentRuntimestep)
```

The previous DIL is then compared to the current DIL. To smooth the transition between drought and normal operations, the system cannot recover from drought by more than one DIL per period. However, the system can move more than one step into a drought in a single period:



```
# check previous Drought Intensity vs. Computed current Drought Intensity
if (tempDIL<prevDIL):
        # don't allow recover from drought by more than one level per month
        DIL = prevDIL - 1
        if (DIL < 0): DIL = 0
else:
        DIL = tempDIL
```

If the day of the month is not the first or the fifteenth, then the DIL value from the previous period is used:

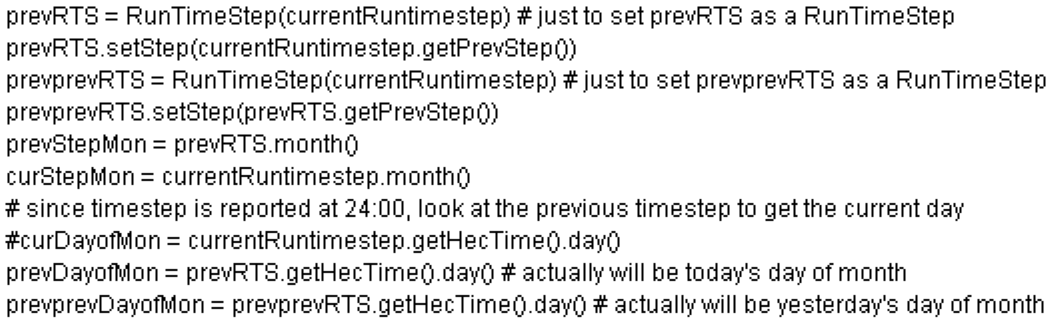


```
else:
        DIL = currentVariable.getPreviousValue(currentRuntimestep)
```

2. State Variable – "NAV_CheckBI"

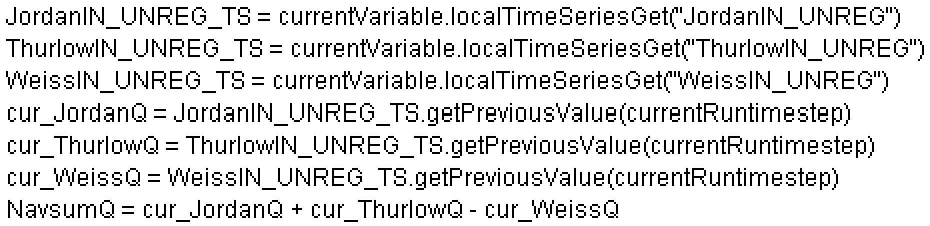
The "Nav_CheckBI" state variable in the "Force Compute of DIL Triggers" logic statement, computes the navigation state based on whether or not it meets the "low basin inflow" criteria.

The script for the "Nav_CheckBI" state variable starts by setting the variable prevRTS as a RunTimeStep and looks at the previous timestep to get the current day:



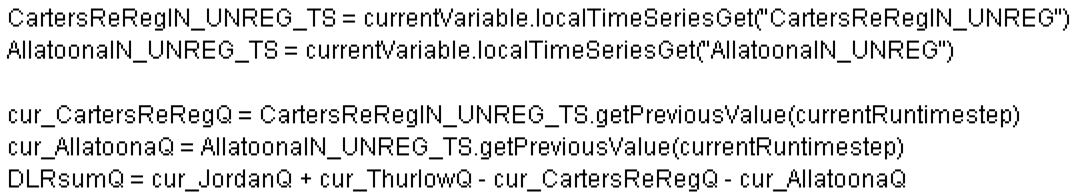
```
prevRTS = RunTimeStep(currentRuntimestep) # just to set prevRTS as a RunTimeStep
prevRTS.setStep(currentRuntimestep.getPrevStep())
prevprevRTS = RunTimeStep(currentRuntimestep) # just to set prevprevRTS as a RunTimeStep
prevprevRTS.setStep(prevRTS.getPrevStep())
prevStepMon = prevRTS.month()
curStepMon = currentRuntimestep.month()
# since timestep is reported at 24:00, look at the previous timestep to get the current day
#curDayofMon = currentRuntimestep.getHecTime().day()
prevDayofMon = prevRTS.getHecTime().day() # actually will be today's day of month
prevprevDayofMon = prevprevRTS.getHecTime().day() # actually will be yesterday's day of month
```

The next step directs the model to collect unregulated time-series records from Jordan, Thurlow, and Weiss, and sum the flows into the NavsumQ variable:



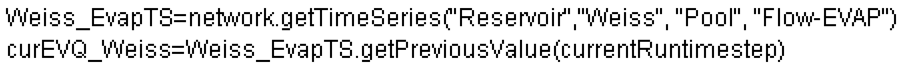
```
JordanIN_UNREG_TS = currentVariable.localTimeSeriesGet("JordanIN_UNREG")
ThurlowIN_UNREG_TS = currentVariable.localTimeSeriesGet("ThurlowIN_UNREG")
WeissIN_UNREG_TS = currentVariable.localTimeSeriesGet("WeissIN_UNREG")
cur_JordanQ = JordanIN_UNREG_TS.getPreviousValue(currentRuntimestep)
cur_ThurlowQ = ThurlowIN_UNREG_TS.getPreviousValue(currentRuntimestep)
cur_WeissQ = WeissIN_UNREG_TS.getPreviousValue(currentRuntimestep)
NavsumQ = cur_JordanQ + cur_ThurlowQ - cur_WeissQ
```

For the low basin inflow calculation, unregulated flows into Carters Rereg and Allatoona should not be counted. These reservoirs are upstream of Jordan and Thurlow, and their flows need to be subtracted from the flows into Jordan and Thurlow. This result is given in the variable DLRsumQ:



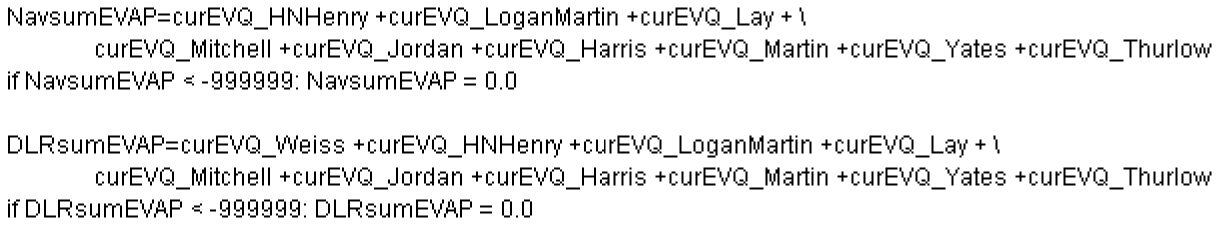
```
CartersReRegIN_UNREG_TS = currentVariable.localTimeSeriesGet("CartersReRegIN_UNREG")
AllatoonaIN_UNREG_TS = currentVariable.localTimeSeriesGet("AllatoonaIN_UNREG")

cur_CartersReRegQ = CartersReRegIN_UNREG_TS.getPreviousValue(currentRuntimestep)
cur_AllatoonaQ = AllatoonaIN_UNREG_TS.getPreviousValue(currentRuntimestep)
DLRsumQ = cur_JordanQ + cur_ThurlowQ - cur_CartersReRegQ - cur_AllatoonaQ
```

Next the “Nav_CheckBI” state variable script collects the evaporation time series records for all ten of the APC reservoirs on the Coosa and Tallapoosa rivers upstream of the JBT Goal station. An example of this script for Weiss is as follows:



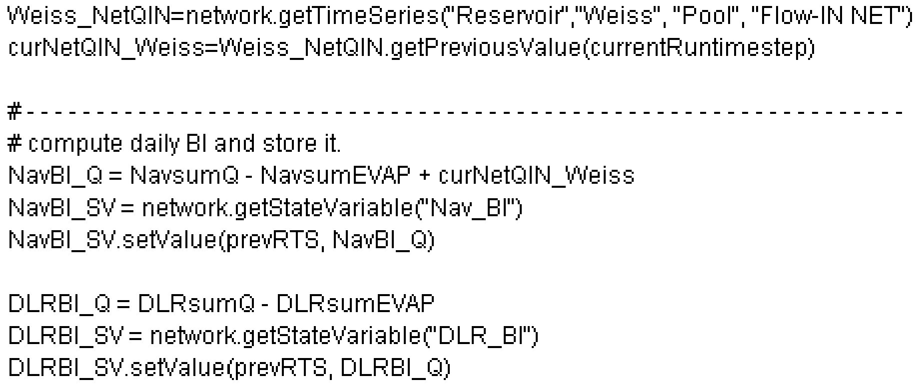
```
Weiss_EvapTS=network.getTimeSeries("Reservoir","Weiss", "Pool", "Flow-EVAP")
curEVQ_Weiss=Weiss_EvapTS.getPreviousValue(currentRuntimestep)
```

The evaporation is then summed for two purposes to be used later in the script-Navigation and DLR. Carter Rereg and Allatoona evaporation values are left out of the two sums:



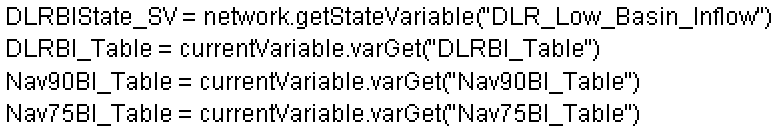
```
NavsumEVAP=curEVQ_HNHenry +curEVQ_LoganMartin +curEVQ_Lay + \
        curEVQ_Mitchell +curEVQ_Jordan +curEVQ_Harris +curEVQ_Martin +curEVQ_Yates +curEVQ_Thurlow
if NavsumEVAP < -999999: NavsumEVAP = 0.0

DLRsumEVAP=curEVQ_Weiss +curEVQ_HNHenry +curEVQ_LoganMartin +curEVQ_Lay + \
        curEVQ_Mitchell +curEVQ_Jordan +curEVQ_Harris +curEVQ_Martin +curEVQ_Yates +curEVQ_Thurlow
if DLRsumEVAP < -999999: DLRsumEVAP = 0.0
```

The basin inflow is computed as the sum of the inflows minus the sum of the evaporation plus the current net inflow to Weiss. Basin inflow is calculated for Navigation and DLR and stored in the state variables, “Nav_BI” and “DLR_BI”:



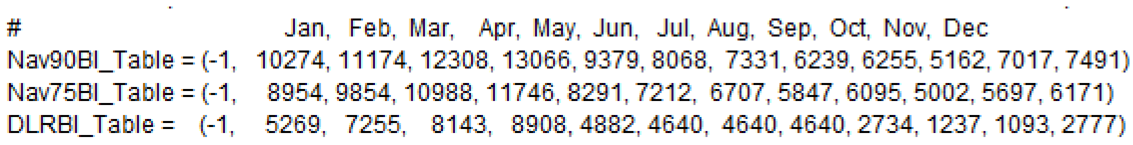
```
Weiss_NetQIN=network.getTimeSeries("Reservoir","Weiss", "Pool", "Flow-IN NET")
curNetQIN_Weiss=Weiss_NetQIN.getPreviousValue(currentRuntimestep)

#-----------------------------------------------------------------
# compute daily BI and store it.
NavBI_Q = NavsumQ - NavsumEVAP + curNetQIN_Weiss
NavBI_SV = network.getStateVariable("Nav_BI")
NavBI_SV.setValue(prevRTS, NavBI_Q)

DLRBI_Q = DLRsumQ - DLRsumEVAP
DLRBI_SV = network.getStateVariable("DLR_BI")
DLRBI_SV.setValue(prevRTS, DLRBI_Q)
```

Tables and state variables that are going to be used frequently later in the script are retrieved to simplify scripting and computation:



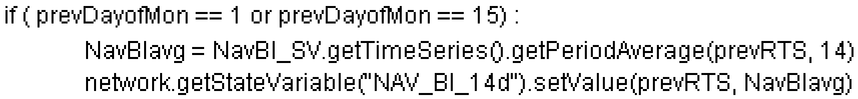
```
DLRBIState_SV = network.getStateVariable("DLR_Low_Basin_Inflow")
DLRBI_Table = currentVariable.varGet("DLRBI_Table")
Nav90BI_Table = currentVariable.varGet("Nav90BI_Table")
Nav75BI_Table = currentVariable.varGet("Nav75BI_Table")
```

The tables are shown below:



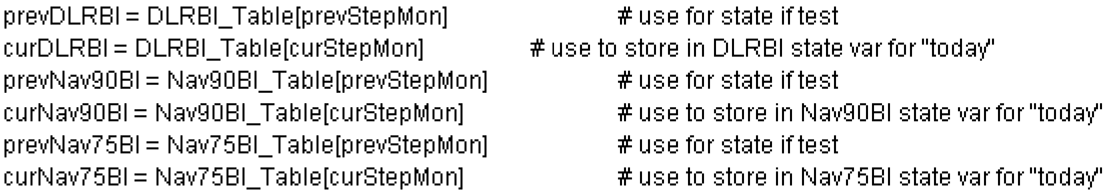
```
#                          Jan,   Feb, Mar,   Apr, May, Jun,  Jul, Aug, Sep, Oct, Nov, Dec
Nav90BI_Table = (-1,   10274, 11174, 12308, 13066, 9379, 8068,  7331, 6239, 6255, 5162, 7017, 7491)
Nav75BI_Table = (-1,    8954, 9854, 10988, 11746, 8291, 7212,  6707, 5847, 6095, 5002, 5697, 6171)
DLRBI_Table =   (-1,    5269,  7255,   8143,  8908, 4882, 4640,  4640, 4640, 2734, 1237, 1093, 2777)
```

To complete the calculation of the basin inflow for navigational purposes, the script checks the average value on a bi-monthly timestep and compares it to “normal” monthly values to evaluate if the basin inflow is higher or lower than normal conditions. If the timestep is currently the 1st or the 15th of the month, then the state of the “Low_Basin_Inflow” trigger must be determined. This is done by calculating the average basin inflow over the past 14 days:



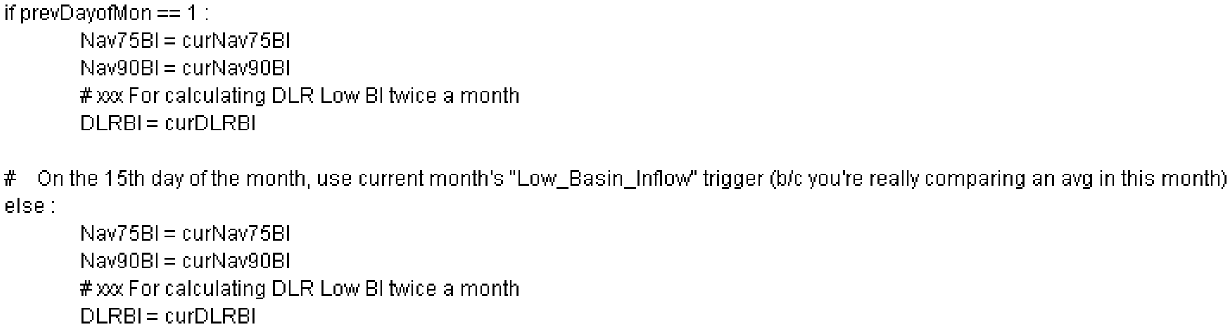
```
if ( prevDayofMon == 1 or prevDayofMon == 15) :
      NavBIavg = NavBI_SV.getTimeSeries().getPeriodAverage(prevRTS, 14)
      network.getStateVariable("NAV_BI_14d").setValue(prevRTS, NavBIavg)
```

Then the required basin inflow values are pulled from the basin inflow reference tables:



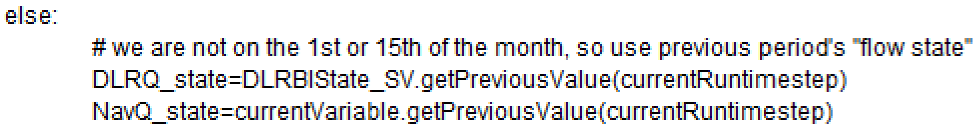
```
prevDLRBI = DLRBI_Table[prevStepMon]                   # use for state if test
curDLRBI = DLRBI_Table[curStepMon]              # use to store in DLRBI state var for "today"
prevNav90BI = Nav90BI_Table[prevStepMon]               # use for state if test
curNav90BI = Nav90BI_Table[curStepMon]                 # use to store in Nav90BI state var for "today"
prevNav75BI = Nav75BI_Table[prevStepMon]               # use for state if test
curNav75BI = Nav75BI_Table[curStepMon]                 # use to store in Nav75BI state var for "today"
```

The 14 day average is stored in the state variable, “NAV_BI_14d”. The average basin inflow is then compared to a reference basin inflow value for the current month. Since the 1st of the month is using the last 14 days of the previous month, it must be compared to the reference from the previous month:



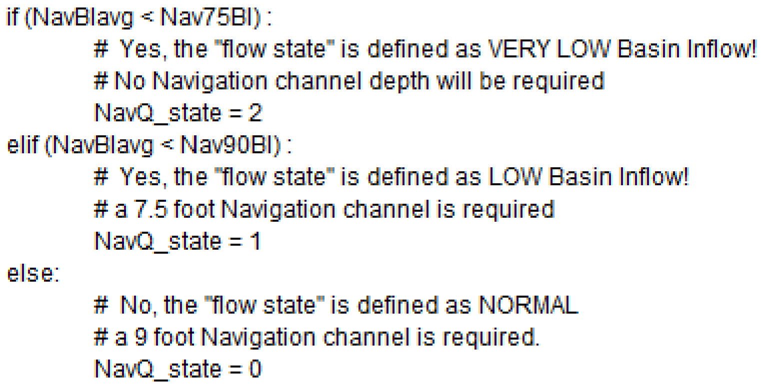
```
if prevDayofMon == 1 :
        Nav75BI = curNav75BI
        Nav90BI = curNav90BI
        # xxx For calculating DLR Low BI twice a month
        DLRBI = curDLRBI

#    On the 15th day of the month, use current month's "Low_Basin_Inflow" trigger (b/c you're really comparing an avg in this month)
else :
        Nav75BI = curNav75BI
        Nav90BI = curNav90BI
        # xxx For calculating DLR Low BI twice a month
        DLRBI = curDLRBI
```

If the current time step is not on the 1st or 15th of the month then use the previous period's "flow state":



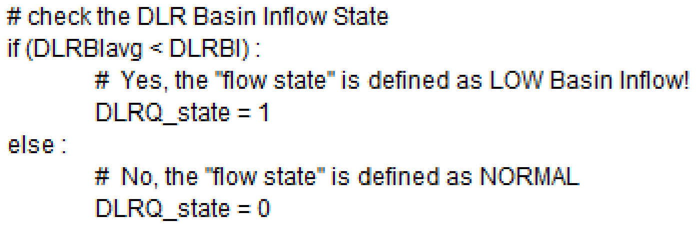
```
else:
      # we are not on the 1st or 15th of the month, so use previous period's "flow state"
      DLRQ_state=DLRBIState_SV.getPreviousValue(currentRuntimestep)
      NavQ_state=currentVariable.getPreviousValue(currentRuntimestep)
```

The “low basin inflow state” is calculated by comparing the two week average to the basin inflow required for navigation for the current time step. If the basin inflow average is less than the basin inflow needed for a 7.5 foot channel at Montgomery, then the NavQ_state is set to 2, and navigation is suspended. If the basin inflow average is less than the basin inflow needed for a 9 foot channel at Montgomery, then the NavQ_state is set to 1 and a 7.5 foot channel is used for navigation. If neither of these cases is true, then the basin inflow average must be greater than the basin inflow average required for a 9 foot channel, so a 9 foot channel is used by setting the NavQ_state to 0.



```
if (NavBIavg < Nav75BI) :
        # Yes, the "flow state" is defined as VERY LOW Basin Inflow!
        # No Navigation channel depth will be required
        NavQ_state = 2
elif (NavBIavg < Nav90BI) :
        # Yes, the "flow state" is defined as LOW Basin Inflow!
        # a 7.5 foot Navigation channel is required
        NavQ_state = 1
else:
        # No, the "flow state" is defined as NORMAL
        # a 9 foot Navigation channel is required.
        NavQ_state = 0
```

In addition to calculating the basin inflow for navigational purposes, the basin inflow must be calculated for DLR DIL calculations. This follows a similar process to the navigation basin inflow calculations by comparing a reference value on the 1st and 15th of the month to the previous 14 day average basin inflow. The 14 day average is stored in the "DLR_BI_minAvg" state variable. The "low basin inflow state" is calculated by comparing the current two week average to the previous two week average basin inflow. If the current basin inflow average is less than the basin inflow average at the previous timestep, then the "low basin inflow state" has been triggered and the DLRQ_state is given a value of 1. If the current basin inflow average is greater than or equal to the basin inflow average at the previous timestep, then the "low basin inflow state" has not been triggered and the DLRQ_state is set to 0.

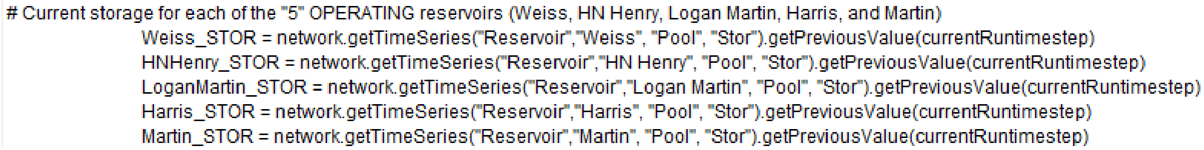


```
# check the DLR Basin Inflow State
if (DLRBIavg < DLRBI) :
        # Yes, the "flow state" is defined as LOW Basin Inflow!
        DLRQ_state = 1
else :
        # No, the "flow state" is defined as NORMAL
        DLRQ_state = 0
```

The value of the DLRQ_state is saved in the "DLR_Low_Basin_Inflow" state variable, which is used for the DIL determination. The NavQ_state value is used for the "Which NAV MinQ?" rule when the system is not in a drought state (DIL=0).

3. State Variable – “DLR_Low_Composite_Stor”

The “DLR_Low_Composite_Stor” state variable determines whether or not the current APC system composite storage meets the “low composite storage” criteria. First the script retrieves the current storage for each of the five operating reservoirs in the system (Weiss, HN Henry, Logan Martin, Harris and Martin):

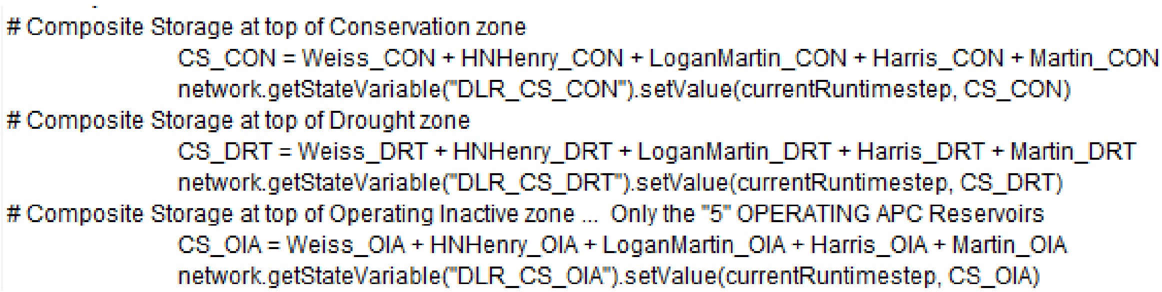


```
# Current storage for each of the "5" OPERATING reservoirs (Weiss, HN Henry, Logan Martin, Harris, and Martin)
		Weiss_STOR = network.getTimeSeries("Reservoir","Weiss", "Pool", "Stor").getPreviousValue(currentRuntimestep)
		HNHenry_STOR = network.getTimeSeries("Reservoir","HN Henry", "Pool", "Stor").getPreviousValue(currentRuntimestep)
		LoganMartin_STOR = network.getTimeSeries("Reservoir","Logan Martin", "Pool", "Stor").getPreviousValue(currentRuntimestep)
		Harris_STOR = network.getTimeSeries("Reservoir","Harris", "Pool", "Stor").getPreviousValue(currentRuntimestep)
		Martin_STOR = network.getTimeSeries("Reservoir","Martin", "Pool", "Stor").getPreviousValue(currentRuntimestep)
```

Next the script retrieves the time series records of the storage for the Conservation, Drought, and Operating Inactive Zones for each of the five operating reservoirs:

```
# Pertinant Zone storage values for each of the "5" OPERATING reservoirs (Weiss, HN Henry, Logan Martin, Harris, and Martin)
# Weiss	zone storages
		Weiss_CON = network.getTimeSeries("Reservoir","Weiss", "Conservation", "Stor-ZONE").getPreviousValue(currentRuntimestep)
		Weiss_DRT = network.getTimeSeries("Reservoir","Weiss", "Drought", "Stor-ZONE").getPreviousValue(currentRuntimestep)
		Weiss_OIA = network.getTimeSeries("Reservoir","Weiss", "Operating Inactive", "Stor-ZONE").getPreviousValue(currentRuntimestep)
# HN Henry	zone storages
		HNHenry_CON = network.getTimeSeries("Reservoir","HN Henry", "Conservation", "Stor-ZONE").getPreviousValue(currentRuntimestep)
		HNHenry_DRT = network.getTimeSeries("Reservoir","HN Henry", "Drought", "Stor-ZONE").getPreviousValue(currentRuntimestep)
		HNHenry_OIA = network.getTimeSeries("Reservoir","HN Henry", "Operating Inactive", "Stor-ZONE").getPreviousValue(currentRuntimestep)
# Logan Martin zone storages
		LoganMartin_CON = network.getTimeSeries("Reservoir","Logan Martin", "Conservation", "Stor-ZONE").getPreviousValue(currentRuntimestep)
		LoganMartin_DRT = network.getTimeSeries("Reservoir","Logan Martin", "Drought", "Stor-ZONE").getPreviousValue(currentRuntimestep)
		LoganMartin_OIA = network.getTimeSeries("Reservoir","Logan Martin", "Operating Inactive", "Stor-ZONE").getPreviousValue(currentRuntimestep)
# Harris	zone storages
		Harris_CON = network.getTimeSeries("Reservoir","Harris", "Conservation", "Stor-ZONE").getPreviousValue(currentRuntimestep)
		Harris_DRT = network.getTimeSeries("Reservoir","Harris", "Drought", "Stor-ZONE").getPreviousValue(currentRuntimestep)
		Harris_OIA = network.getTimeSeries("Reservoir","Harris", "Operating Inactive", "Stor-ZONE").getPreviousValue(currentRuntimestep)
# Martin	zone storages
		Martin_CON = network.getTimeSeries("Reservoir","Martin", "Conservation", "Stor-ZONE").getPreviousValue(currentRuntimestep)
		Martin_DRT = network.getTimeSeries("Reservoir","Martin", "Drought", "Stor-ZONE").getPreviousValue(currentRuntimestep)
		Martin_OIA = network.getTimeSeries("Reservoir","Martin", "Operating Inactive", "Stor-ZONE").getPreviousValue(currentRuntimestep)
```

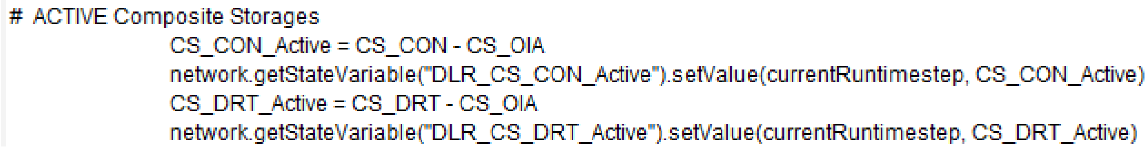
The composite storage at the top of each zone is then summed across the five reservoirs:



```
# Composite Storage at top of Conservation zone
		CS_CON = Weiss_CON + HNHenry_CON + LoganMartin_CON + Harris_CON + Martin_CON
		network.getStateVariable("DLR_CS_CON").setValue(currentRuntimestep, CS_CON)
# Composite Storage at top of Drought zone
		CS_DRT = Weiss_DRT + HNHenry_DRT + LoganMartin_DRT + Harris_DRT + Martin_DRT
		network.getStateVariable("DLR_CS_DRT").setValue(currentRuntimestep, CS_DRT)
# Composite Storage at top of Operating Inactive zone ...  Only the "5" OPERATING APC Reservoirs
		CS_OIA = Weiss_OIA + HNHenry_OIA + LoganMartin_OIA + Harris_OIA + Martin_OIA
		network.getStateVariable("DLR_CS_OIA").setValue(currentRuntimestep, CS_OIA)
```

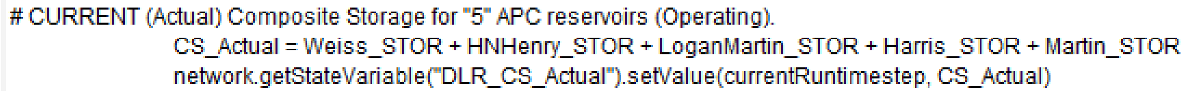
The values of the composite storage for each zone are stored in new state variables. Composite storage in the conservation zone is stored in the “DLR_CS_CON” state variable, while composite storage in the Drought zone is stored in the “DLR_CS_DRT” state variable and in the “DLR_CS_OIA” state variable for the Operating Inactive zone.

Active storage is calculated for the Conservation and the Drought Zones by subtracting the summed composite storage at the top of the Operating Inactive zone from the summed composite storage at the top of the Conservation zone and the top of the Drought zone (respectively). These values are also stored in their own state variables, “DLR_CS_CON_Active” and “DLR_CS-DRT_Active”.



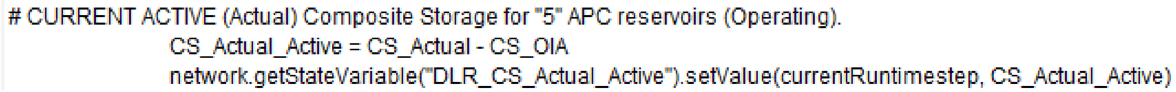
```
# ACTIVE Composite Storages
                CS_CON_Active = CS_CON - CS_OIA
                network.getStateVariable("DLR_CS_CON_Active").setValue(currentRuntimestep, CS_CON_Active)
                CS_DRT_Active = CS_DRT - CS_OIA
                network.getStateVariable("DLR_CS_DRT_Active").setValue(currentRuntimestep, CS_DRT_Active)
```

Actual (or current) composite storage for the five operating reservoirs is then summed and stored in the “DLR_CS_Actual” state variable:



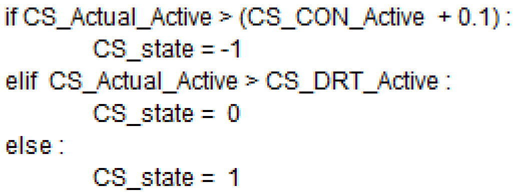
```
# CURRENT (Actual) Composite Storage for "5" APC reservoirs (Operating).
                CS_Actual = Weiss_STOR + HNHenry_STOR + LoganMartin_STOR + Harris_STOR + Martin_STOR
                network.getStateVariable("DLR_CS_Actual").setValue(currentRuntimestep, CS_Actual)
```

The actual active composite storage is found by subtracting the composite storage at the top of the Operating Inactive zone from the actual composite storage. This value is stored in the “DLR_CS_Actual_Active” state variable.



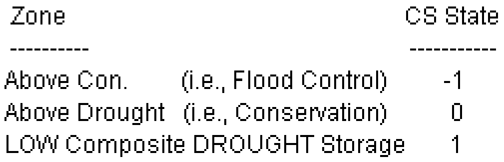
```
# CURRENT ACTIVE (Actual) Composite Storage for "5" APC reservoirs (Operating).
                CS_Actual_Active = CS_Actual - CS_OIA
                network.getStateVariable("DLR_CS_Actual_Active").setValue(currentRuntimestep, CS_Actual_Active)
```

If the Actual active composite storage is greater than the composite storage in the conservation zone, then the CS_state is assigned a value of -1. If the actual active composite storage is greater than the active composite storage in the drought zone, then the CS_state is assigned a value of 0 (normal operation). If it is neither greater than the conservation or drought storage, then the CS_state is assigned a value of 1, which triggers the “low composite storage” state.



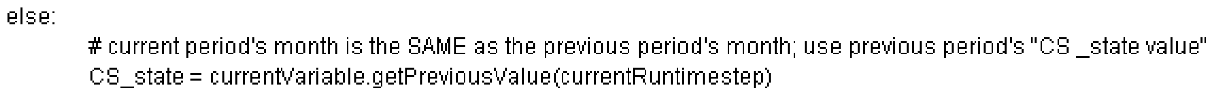
```
if CS_Actual_Active > (CS_CON_Active  + 0.1) :
        CS_state = -1
elif  CS_Actual_Active > CS_DRT_Active :
        CS_state =  0
else :
        CS_state =  1
```

The CS_state (or Composite Storage State) values have the following meanings:

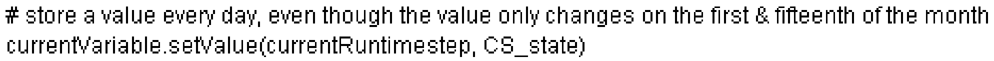


```
Zone                                          CS State
----------                                    -----------
Above Con.        (i.e., Flood Control)         -1
Above Drought   (i.e., Conservation)             0
LOW Composite DROUGHT Storage                    1
```

This script stores a value for every day; however the value only changes on the first and fifteenth of the month. When the previous time step is in the same month as the current time step, then the previous period's "CS_state" value is used:



```
else:
        # current period's month is the SAME as the previous period's month; use previous period's "CS _state value"
        CS_state = currentVariable.getPreviousValue(currentRuntimestep)
```



```
# store a value every day, even though the value only changes on the first & fifteenth of the month
currentVariable.setValue(currentRuntimestep, CS_state)
```

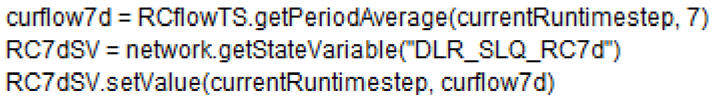
4. *State Variable – "DLR_Low_State_Line_Q"*

The "DLR_Low_State_Line_Q" state variable determines whether or not the flow at the Rome_Coosa station meets the "Low State Line Flow" criteria.

The script starts the same as the "NAV_CheckBI" state variable to determine the month and day of the current and previous time step. After the correct time step is set, the script retrieves the time series flow records from Rome-Coosa:

```
RCflowTS=network.getTimeSeries("Junction","Rome-Coosa", "", "Flow")
```

The flow is then averaged over a 7 day period and stored in the "DLR_SLQ_RC7d" state variable:

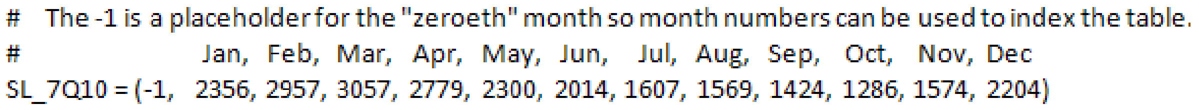


```
curflow7d = RCflowTS.getPeriodAverage(currentRuntimestep, 7)
RC7dSV = network.getStateVariable("DLR_SLQ_RC7d")
RC7dSV.setValue(currentRuntimestep, curflow7d)
```

Similar to the previous "NAV_CheckBI" and "DLR_Low_Composite_Stor" state variables, the value for the "DLR_Low_State_Line_Q" state variable is compared with a monthly value from a reference table. In this case, the current value is compared with the monthly 7Q10 value.

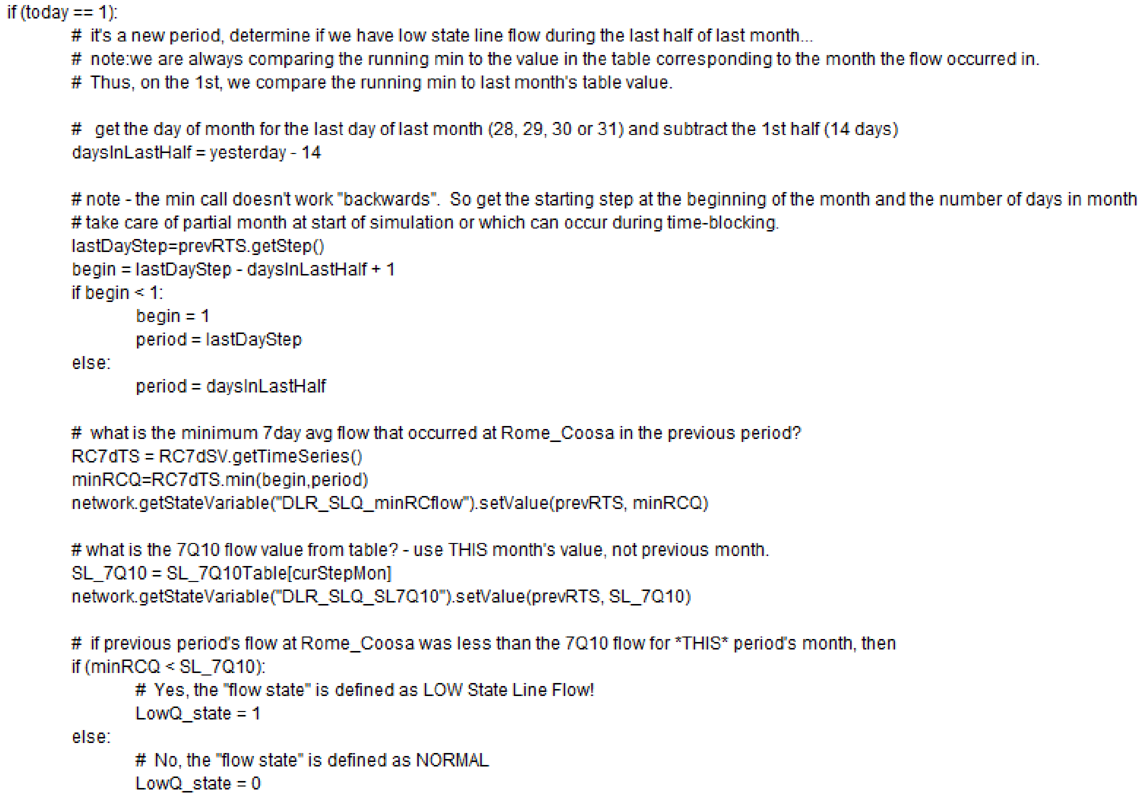
```
SL_7Q10Table = currentVariable.varGet("StateLine_7Q10")
```

7Q10 is defined as the lowest flow over a 7 day period that would occur once in 10 years. A Low State Line Flow occurs when the Rome-Coosa gage measures a flow below the monthly historical 7Q10 flow. The reference table that is retrieved by the script is described below:



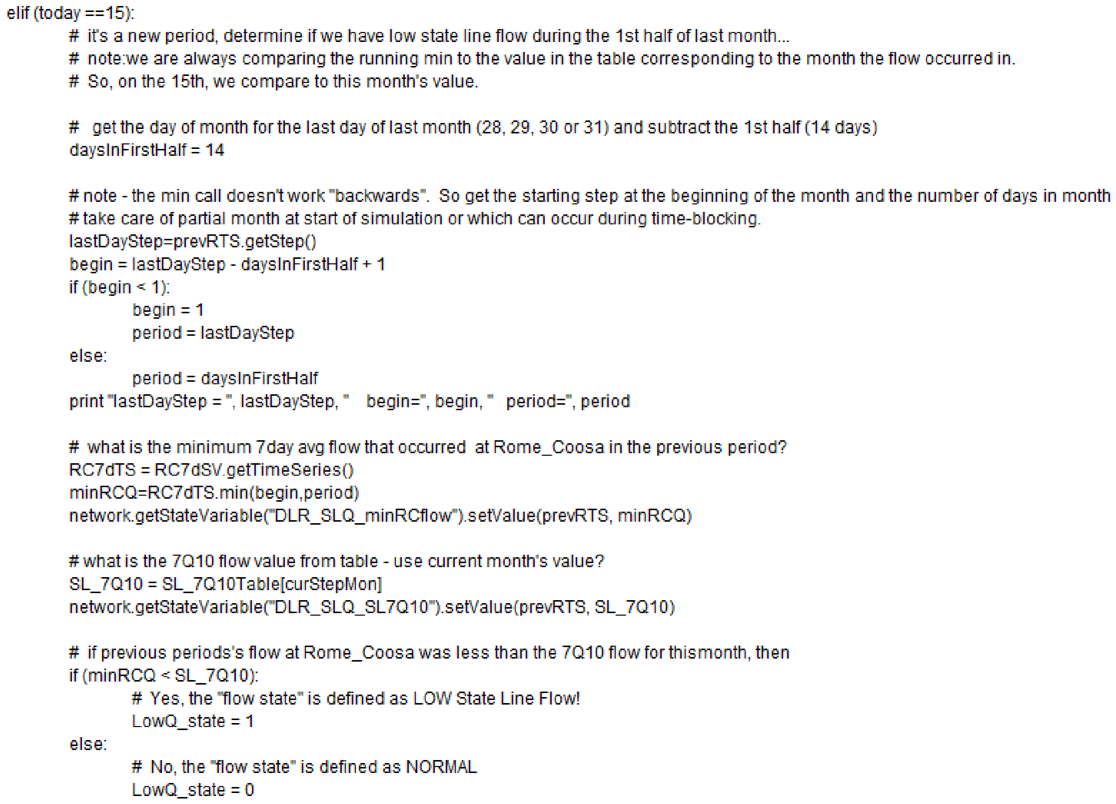
```
#   The -1 is a placeholder for the "zeroeth" month so month numbers can be used to index the table.
#                Jan,  Feb,  Mar,  Apr,  May,  Jun,   Jul,  Aug,  Sep,   Oct,   Nov, Dec
SL_7Q10 = (-1,  2356, 2957, 3057, 2779, 2300, 2014, 1607, 1569, 1424, 1286, 1574, 2204)
```

On the first day of the month, the minimum 7-day flow at Rome-Coosa is computed for the last half of the previous month. This result is then compared to the appropriate value in the reference table. If the minimum 7-day flow is less than the value in the reference table, the flow state is defined as “Low State Line Flow” and the variable LowQ_state is set equal to 1. If the minimum 7-day flow is not less than the value in the reference table, then the variable LowQ_state is set equal to zero indicating that the flow state is normal.



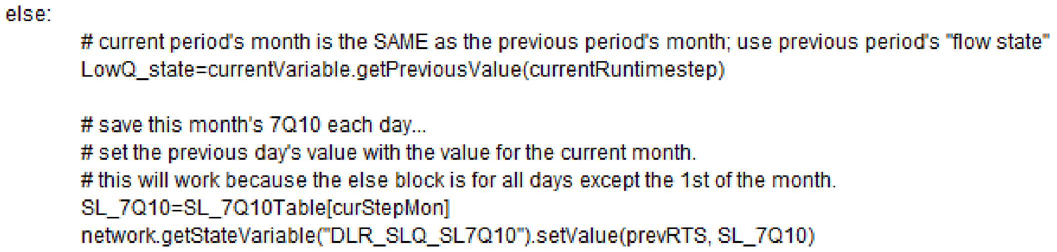
```
if (today == 1):
        #  it's a new period, determine if we have low state line flow during the last half of last month...
        #  note:we are always comparing the running min to the value in the table corresponding to the month the flow occurred in.
        #  Thus, on the 1st, we compare the running min to last month's table value.

        #   get the day of month for the last day of last month (28, 29, 30 or 31) and subtract the 1st half (14 days)
        daysInLastHalf = yesterday - 14

        # note - the min call doesn't work "backwards".  So get the starting step at the beginning of the month and the number of days in month
        # take care of partial month at start of simulation or which can occur during time-blocking.
        lastDayStep=prevRTS.getStep()
        begin = lastDayStep - daysInLastHalf + 1
        if begin < 1:
                begin = 1
                period = lastDayStep
        else:
                period = daysInLastHalf

        #  what is the minimum 7day avg flow that occurred at Rome_Coosa in the previous period?
        RC7dTS = RC7dSV.getTimeSeries()
        minRCQ=RC7dTS.min(begin,period)
        network.getStateVariable("DLR_SLQ_minRCflow").setValue(prevRTS, minRCQ)

        # what is the 7Q10 flow value from table? - use THIS month's value, not previous month.
        SL_7Q10 = SL_7Q10Table[curStepMon]
        network.getStateVariable("DLR_SLQ_SL7Q10").setValue(prevRTS, SL_7Q10)

        #  if previous period's flow at Rome_Coosa was less than the 7Q10 flow for *THIS* period's month, then
        if (minRCQ < SL_7Q10):
                #  Yes, the "flow state" is defined as LOW State Line Flow!
                LowQ_state = 1
        else:
                #  No, the "flow state" is defined as NORMAL
                LowQ_state = 0
```

On the fifteenth day of each month, the same computation described above is done for the first half of the current month.



```
elif (today ==15):
    # it's a new period, determine if we have low state line flow during the 1st half of last month...
    # note:we are always comparing the running min to the value in the table corresponding to the month the flow occurred in.
    # So, on the 15th, we compare to this month's value.

    #  get the day of month for the last day of last month (28, 29, 30 or 31) and subtract the 1st half (14 days)
    daysInFirstHalf = 14

    # note - the min call doesn't work "backwards".  So get the starting step at the beginning of the month and the number of days in month
    # take care of partial month at start of simulation or which can occur during time-blocking.
    lastDayStep=prevRTS.getStep()
    begin = lastDayStep - daysInFirstHalf + 1
    if (begin < 1):
        begin = 1
        period = lastDayStep
    else:
        period = daysInFirstHalf
    print "lastDayStep = ", lastDayStep, "    begin=", begin, "    period=", period

    # what is the minimum 7day avg flow that occurred  at Rome_Coosa in the previous period?
    RC7dTS = RC7dSV.getTimeSeries()
    minRCQ=RC7dTS.min(begin,period)
    network.getStateVariable("DLR_SLQ_minRCflow").setValue(prevRTS, minRCQ)

    # what is the 7Q10 flow value from table - use current month's value?
    SL_7Q10 = SL_7Q10Table[curStepMon]
    network.getStateVariable("DLR_SLQ_SL7Q10").setValue(prevRTS, SL_7Q10)

    # if previous periods's flow at Rome_Coosa was less than the 7Q10 flow for thismonth, then
    if (minRCQ < SL_7Q10):
        # Yes, the "flow state" is defined as LOW State Line Flow!
        LowQ_state = 1
    else:
        # No, the "flow state" is defined as NORMAL
        LowQ_state = 0
```

If the day of the month is not the first or the fifteenth, the current flow state remains the same.



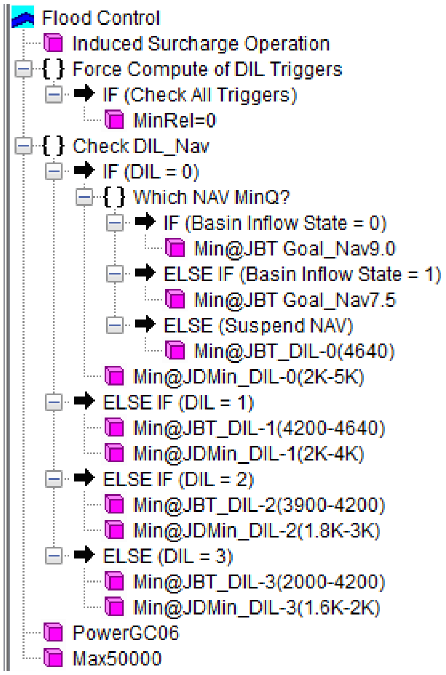
```
else:
    # current period's month is the SAME as the previous period's month; use previous period's "flow state"
    LowQ_state=currentVariable.getPreviousValue(currentRuntimestep)

    # save this month's 7Q10 each day...
    # set the previous day's value with the value for the current month.
    # this will work because the else block is for all days except the 1st of the month.
    SL_7Q10=SL_7Q10Table[curStepMon]
    network.getStateVariable("DLR_SLQ_SL7Q10").setValue(prevRTS, SL_7Q10)
```

The state variable “DLR_Low_State_Line_Q” is then set to the value of the variable LowQ_state.

```
currentVariable.setValue(currentRuntimestep, LowQ_state)
```

E. Drought Level Response at Logan Martin

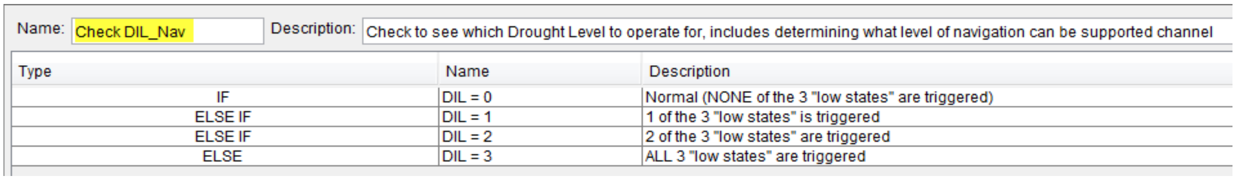
The “Force Compute of DIL Triggers” and “Check DIL_Nav” conditional blocks for Logan Martin are included in the Flood Control, Conservation and Drought Zones, as shown in Figure L.22.



- Flood Control
  - Induced Surcharge Operation
  - { } Force Compute of DIL Triggers
    - IF (Check All Triggers)
      - MinRel=0
  - { } Check DIL_Nav
    - IF (DIL = 0)
      - { } Which NAV MinQ?
        - IF (Basin Inflow State = 0)
          - Min@JBT Goal_Nav9.0
        - ELSE IF (Basin Inflow State = 1)
          - Min@JBT Goal_Nav7.5
        - ELSE (Suspend NAV)
          - Min@JBT_DIL-0(4640)
      - Min@JDMin_DIL-0(2K-5K)
    - ELSE IF (DIL = 1)
      - Min@JBT_DIL-1(4200-4640)
      - Min@JDMin_DIL-1(2K-4K)
    - ELSE IF (DIL = 2)
      - Min@JBT_DIL-2(3900-4200)
      - Min@JDMin_DIL-2(1.8K-3K)
    - ELSE (DIL = 3)
      - Min@JBT_DIL-3(2000-4200)
      - Min@JDMin_DIL-3(1.6K-2K)
  - PowerGC06
  - Max50000

Figure L.22 Placement of “Force Compute of DIL Triggers” and “Check DIL_Nav” Conditional Blocks for Logan Martin

After the “Force Compute of DIL Triggers” logic statement computes the three DIL “Low state” state variables, the “Check DIL_Nav” conditional logic (Figure L.23) determines the appropriate rules to apply based on the DIL using the state variable “DLR_Drought_Intensity_Level”. Varying minimum flows are set at JBT Goal and J.D. Minimum stations using the drought intensity level and the navigation minimum flow.

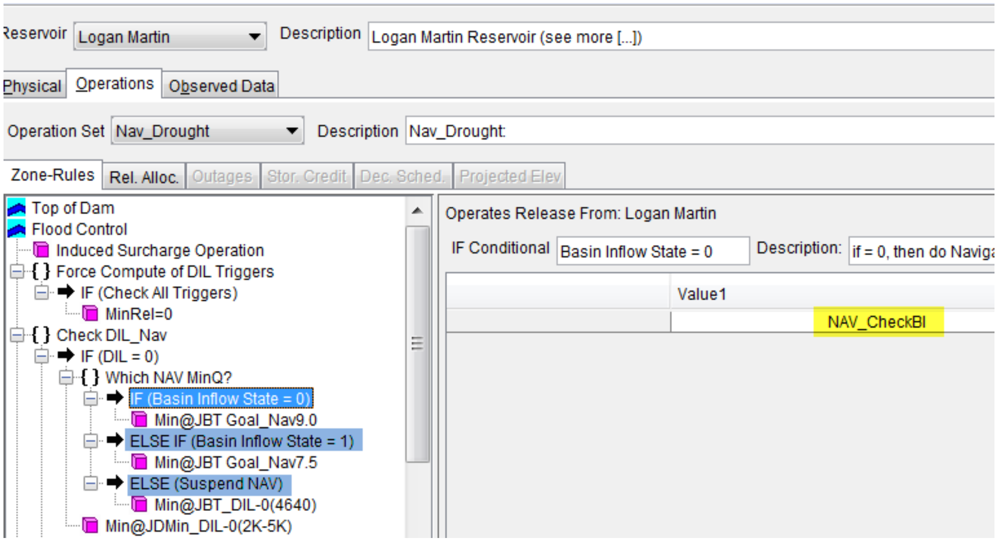


Name: Check DIL_Nav   Description: Check to see which Drought Level to operate for, includes determining what level of navigation can be supported channel

Type	Name	Description
IF	DIL = 0	Normal (NONE of the 3 "low states" are triggered)
ELSE IF	DIL = 1	1 of the 3 "low states" is triggered
ELSE IF	DIL = 2	2 of the 3 "low states" are triggered
ELSE	DIL = 3	ALL 3 "low states" are triggered

Figure L.23 “Check DIL_Nav” Conditional Logic at Logan Martin

If the DIL=0 (“DLR_Drought_Intensity_Level” state variable has a value of 0), then the system is in a normal state (NONE of the three "low states" are triggered). There are varying degrees of normal state/non-draught states which are determined with the “Which NAV MinQ?” rule to set the minimum releases for navigation. The “Which NAV MinQ?” rule uses the “Nav_CheckBI” state variable that was calculated in the “Force Compute of DIL Triggers” logic statement to calculate the NavQ_state value (Figure L.24). If the basin inflow average is less than the basin inflow needed for a 7.5 foot channel at Montgomery, then the NavQ_state is set to 2, and navigation is suspended. If the basin inflow average is less than the basin inflow needed for a 9 foot channel at Montgomery, then the NavQ_state is set to 1 and a 7.5 foot channel is used for navigation. If neither of these cases is true, then the basin inflow average must be greater than the basin inflow average required for a 9 foot channel, so a 9 foot channel is used by setting the NavQ_state to 0.



eservoir Logan Martin
Description Logan Martin Reservoir (see more [...])

Operation Set Nav_Drought
Description Nav_Drought

Top of Dam
Flood Control
  Induced Surcharge Operation
  { } Force Compute of DIL Triggers
    IF (Check All Triggers)
      MinRel=0
  { } Check DIL_Nav
    IF (DIL = 0)
      { } Which NAV MinQ?
        IF (Basin Inflow State = 0)
          Min@JBT Goal_Nav9.0
        ELSE IF (Basin Inflow State = 1)
          Min@JBT Goal_Nav7.5
        ELSE (Suspend NAV)
          Min@JBT_DIL-0(4640)
      Min@JDMin_DIL-0(2K-5K)

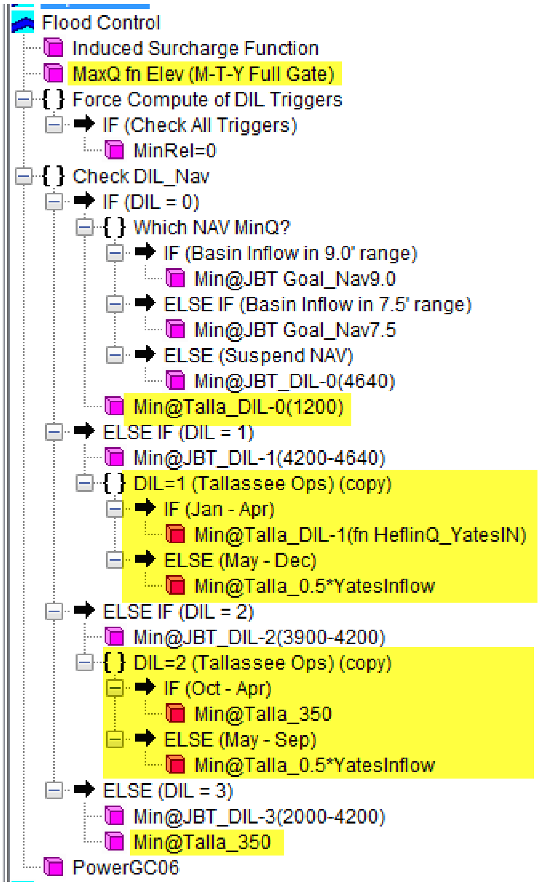
Operates Release From: Logan Martin
IF Conditional Basin Inflow State = 0
Description: if = 0, then do Naviga
NAV_CheckBI

Figure L.24 Use of "NAV_CheckBI" State Variable to Determine Navigation Level

If the DIL=1, 2 or 3, then different rules are applied that are based on goals for JBT Goal and JD Minimum stations to set the minimum release from Logan Martin. No additional state variables are used in the operation of Logan Martin that weren't previously explained in the DLR DIL background section. The following sections highlight the different state variables used for DroughtPln operations at other reservoirs.

F. Drought Level Response at Martin

The DLR plan for Martin and Logan Martin are very similar (Figure L.25). The rules highlighted in yellow are the changes from Logan Martin operation. The largest difference between the two reservoir operations is the inclusion of the following state variables in the operation of Martin: CurMonth, DLR_minFlow_fn_Heflin_Yates, and DLR_Half_Yates_Inflow. Neither the MaxQ fn Elev (M-T-Y Full Gate) rule or the Min@Talla_DIL-0(1200) rule associated with the Check DIL_Nav IF (DIL=0) scenario shown in the Flood Control Zone contain state variables, but these rules affect the operation of Martin. The previous section describes the rules and states variables used to determine the DIL of the system. The following section describes the state variables that are specifically associated with the rules when the DIL=1, 2 or 3 at Martin.

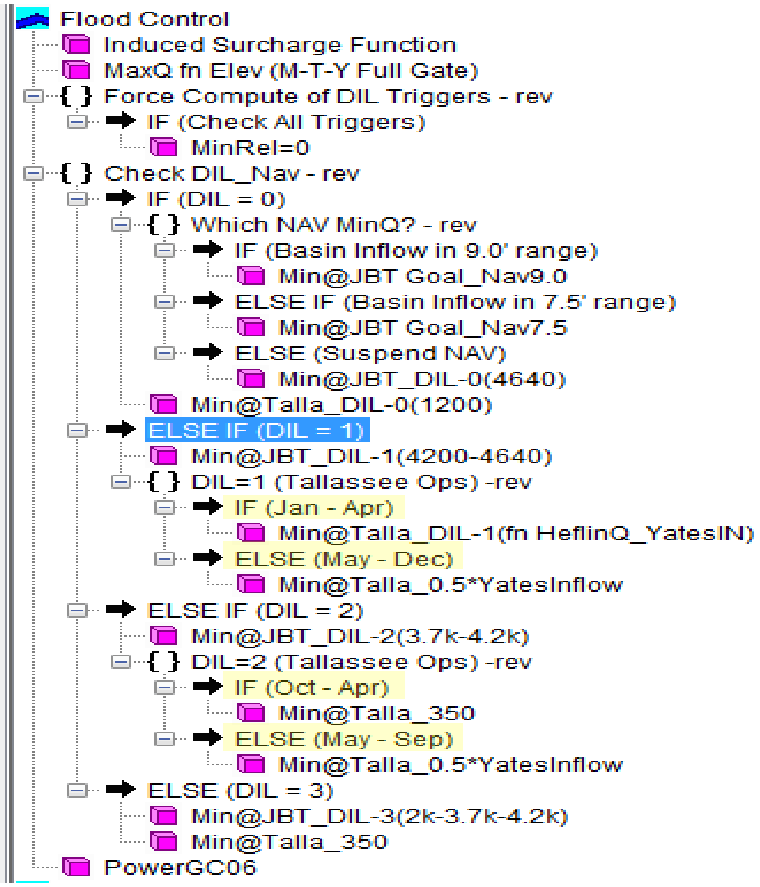


- Flood Control
  - Induced Surcharge Function
  - MaxQ fn Elev (M-T-Y Full Gate)
  - { } Force Compute of DIL Triggers
    - IF (Check All Triggers)
      - MinRel=0
  - { } Check DIL_Nav
    - IF (DIL = 0)
      - { } Which NAV MinQ?
        - IF (Basin Inflow in 9.0' range)
          - Min@JBT Goal_Nav9.0
        - ELSE IF (Basin Inflow in 7.5' range)
          - Min@JBT Goal_Nav7.5
        - ELSE (Suspend NAV)
          - Min@JBT_DIL-0(4640)
      - Min@Talla_DIL-0(1200)
    - ELSE IF (DIL = 1)
      - Min@JBT_DIL-1(4200-4640)
      - { } DIL=1 (Tallassee Ops) (copy)
        - IF (Jan - Apr)
          - Min@Talla_DIL-1(fn HeflinQ_YatesIN)
        - ELSE (May - Dec)
          - Min@Talla_0.5*YatesInflow
    - ELSE IF (DIL = 2)
      - Min@JBT_DIL-2(3900-4200)
      - { } DIL=2 (Tallassee Ops) (copy)
        - IF (Oct - Apr)
          - Min@Talla_350
        - ELSE (May - Sep)
          - Min@Talla_0.5*YatesInflow
    - ELSE (DIL = 3)
      - Min@JBT_DIL-3(2000-4200)
      - Min@Talla_350
  - PowerGC06

Figure L.25 Operations for Martin

1. *State Variable – "CurMonth"*

The "CurMonth" state variable calculates the current month of the current period for use in the DLR operations at Martin when DIL= 1 or 2 (Figure L.26).



```
Flood Control
    Induced Surcharge Function
    MaxQ fn Elev (M-T-Y Full Gate)
    { } Force Compute of DIL Triggers - rev
        ➡ IF (Check All Triggers)
            MinRel=0
    { } Check DIL_Nav - rev
        ➡ IF (DIL = 0)
            { } Which NAV MinQ? - rev
                ➡ IF (Basin Inflow in 9.0' range)
                    Min@JBT Goal_Nav9.0
                ➡ ELSE IF (Basin Inflow in 7.5' range)
                    Min@JBT Goal_Nav7.5
                ➡ ELSE (Suspend NAV)
                    Min@JBT_DIL-0(4640)
            Min@Talla_DIL-0(1200)
        ➡ ELSE IF (DIL = 1)
            Min@JBT_DIL-1(4200-4640)
            { } DIL=1 (Tallassee Ops) -rev
                ➡ IF (Jan - Apr)
                    Min@Talla_DIL-1(fn HeflinQ_YatesIN)
                ➡ ELSE (May - Dec)
                    Min@Talla_0.5*YatesInflow
        ➡ ELSE IF (DIL = 2)
            Min@JBT_DIL-2(3.7k-4.2k)
            { } DIL=2 (Tallassee Ops) -rev
                ➡ IF (Oct - Apr)
                    Min@Talla_350
                ➡ ELSE (May - Sep)
                    Min@Talla_0.5*YatesInflow
        ➡ ELSE (DIL = 3)
            Min@JBT_DIL-3(2k-3.7k-4.2k)
            Min@Talla_350
    PowerGC06
```

Figure L.26 “CurMonth” State Variable Locations

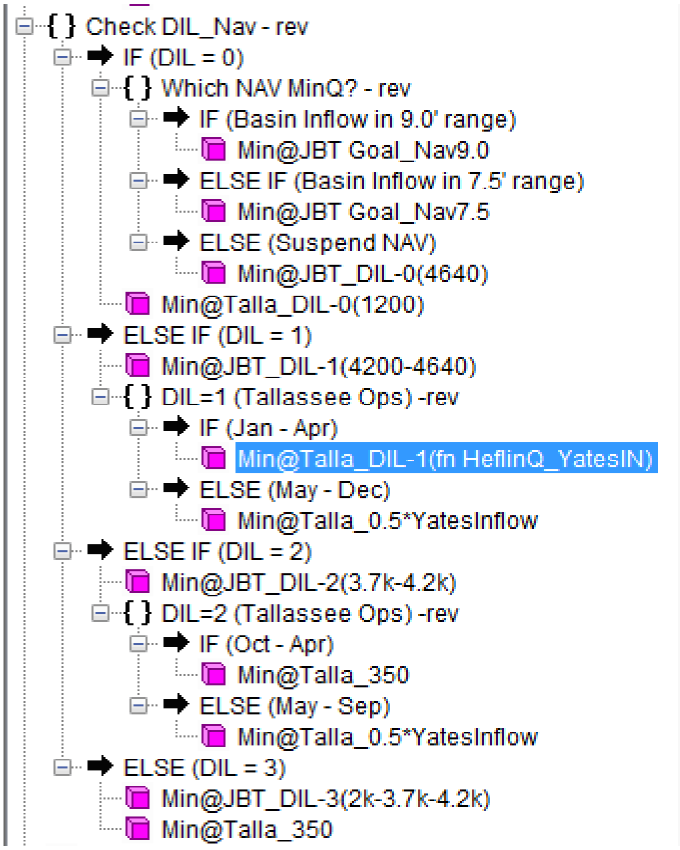
The month for the current period is used to determine which rule to execute. When DIL=1, the second rule, “DIL=1 (Tallassee Ops) (copy)” uses the “CurMonth” state variable to determine if the current month is less than or equal to 4 (between January and April). If it is, then the “Min@Talla_DIL-1(fn HeflinQ_YatesIN)” rule is used. If the month is not between January and April, then the “Min@Talla_0.5*YatesInflow” rule is used.

The state variable “CurMonth” is also used in conjunction with the second rule when DIL=2, “DIL=2 (Tallassee Ops) (copy)”. If “CurMonth” value is less than or equal to 4 (January - April), or greater than or equal to 10 (October - December), then the “Min@Talla_350” rule is used. If the “CurMonth” value is between 5 (May) and 9 (September), then the “Min@Talla_0.5*YatesInflow” rule is executed.

Since the operations in the Flood Control, Conservation, and Drought Zones at Martin are identical, this state variable is used identically in all of those zones.

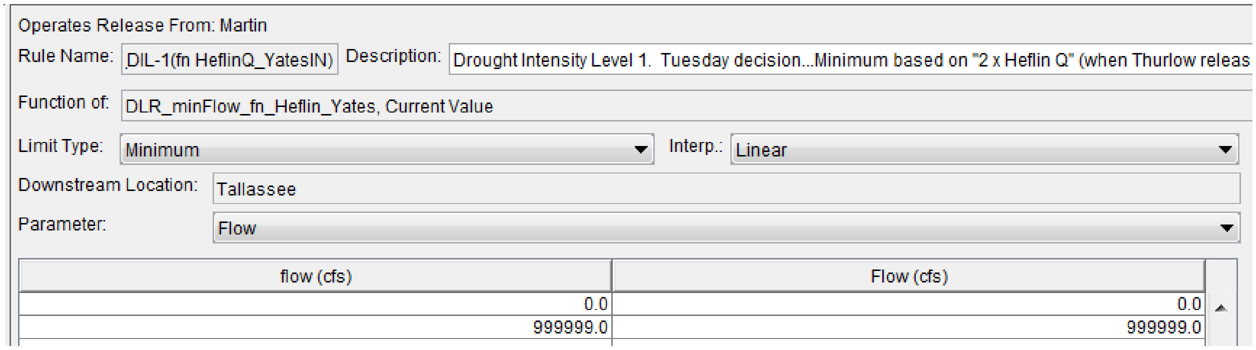
2. State Variable – "DLR_minFlow_fn_Heflin_Yates"

Under the conditions where the DIL=1, and the month is between January and April, the "Min@Talla_DIL-1(fn HeflinQ_YatesIN)" rule is used (Figure L.27). The "Min@Talla_DIL-1(fn HeflinQ_YatesIN)" rule is a function of the state variable "DLR_minFlow_fn_Heflin_Yates" using the value returned by the state variable as the minimum flow from Martin (Figure L.28).



- Check DIL_Nav - rev
  - IF (DIL = 0)
    - Which NAV MinQ? - rev
      - IF (Basin Inflow in 9.0' range)
        - Min@JBT Goal_Nav9.0
      - ELSE IF (Basin Inflow in 7.5' range)
        - Min@JBT Goal_Nav7.5
      - ELSE (Suspend NAV)
        - Min@JBT_DIL-0(4640)
    - Min@Talla_DIL-0(1200)
  - ELSE IF (DIL = 1)
    - Min@JBT_DIL-1(4200-4640)
    - DIL=1 (Tallassee Ops) -rev
      - IF (Jan - Apr)
        - Min@Talla_DIL-1(fn HeflinQ_YatesIN)
      - ELSE (May - Dec)
        - Min@Talla_0.5*YatesInflow
  - ELSE IF (DIL = 2)
    - Min@JBT_DIL-2(3.7k-4.2k)
    - DIL=2 (Tallassee Ops) -rev
      - IF (Oct - Apr)
        - Min@Talla_350
      - ELSE (May - Sep)
        - Min@Talla_0.5*YatesInflow
  - ELSE (DIL = 3)
    - Min@JBT_DIL-3(2k-3.7k-4.2k)
    - Min@Talla_350

Figure L.27 Location of "DLR_minFlow_fn_Heflin_Yates" State Variable



Operates Release From: Martin

Rule Name: DIL-1(fn HeflinQ_YatesIN)

Description: Drought Intensity Level 1. Tuesday decision...Minimum based on "2 x Heflin Q" (when Thurlow releas

Function of: DLR_minFlow_fn_Heflin_Yates, Current Value

Limit Type: Minimum

Interp.: Linear

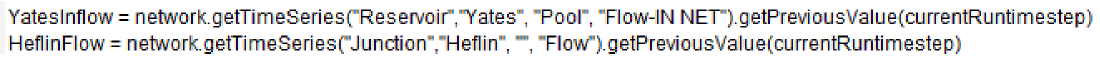
Downstream Location: Tallassee

Parameter: Flow

flow (cfs)	Flow (cfs)
0.0	0.0
999999.0	999999.0

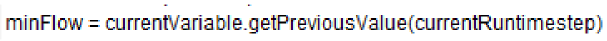
Figure L.28 Use of "DLR_minFlow_fn_Heflin_Yates" State Variable

The script starts by collecting the time series records of the flow at Heflin and Yates:



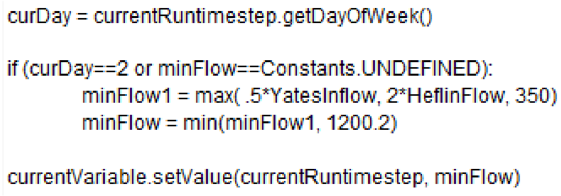
```
YatesInflow = network.getTimeSeries("Reservoir","Yates", "Pool", "Flow-IN NET").getPreviousValue(currentRuntimestep)
HeflinFlow = network.getTimeSeries("Junction","Heflin", "", "Flow").getPreviousValue(currentRuntimestep)
```

The minimum flow is set to the previous period’s value:



```
minFlow = currentVariable.getPreviousValue(currentRuntimestep)
```

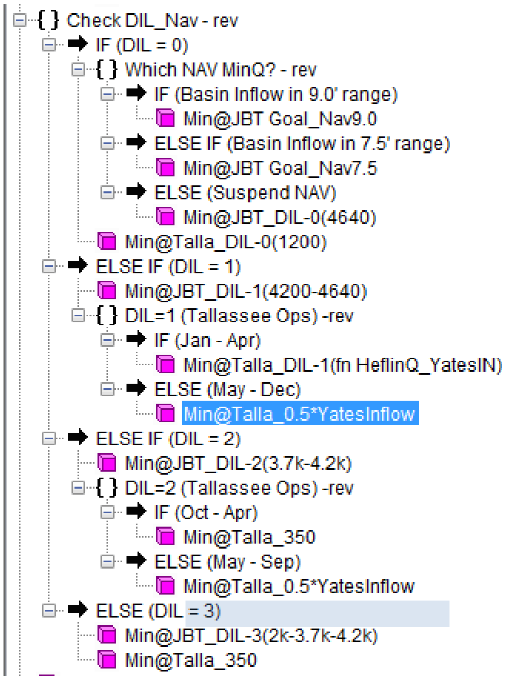
If the current day is Tuesday, then a new minimum flow is calculated and that value is held until the following Tuesday. The variable “minFlow1” is set to the largest value of one half of Yates inflow, twice the Heflin flow, or 350 cfs. The variable “minflow” is then set to the smallest value of “minfFlow1” or 1200.2 cfs. This sets the variable “minflow” between the range of 350 cfs and 1200.2 cfs:



```
curDay = currentRuntimestep.getDayOfWeek()

if (curDay==2 or minFlow==Constants.UNDEFINED):
	minFlow1 = max( .5*YatesInflow, 2*HeflinFlow, 350)
	minFlow = min(minFlow1, 1200.2)

currentVariable.setValue(currentRuntimestep, minFlow)
```

3. *State Variable – “DLR_Half_Yates_Inflow”*

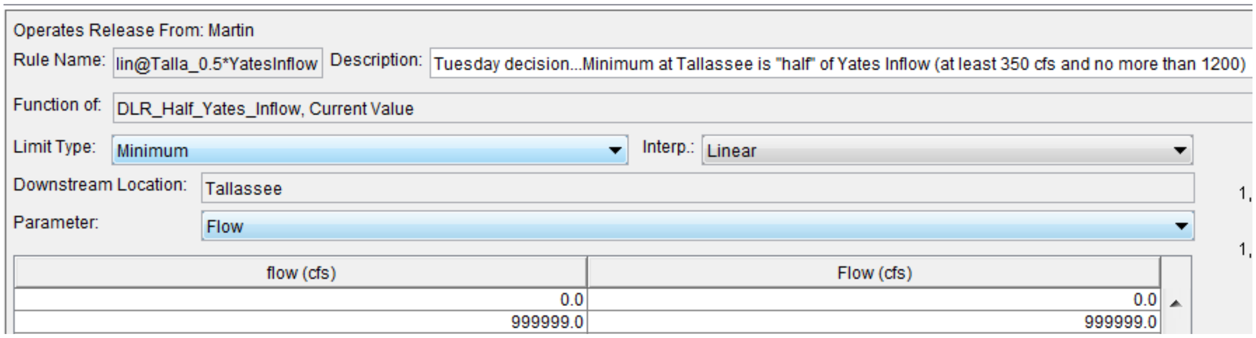
The “Min@Talla_0.5*YatesInflow” rule is a function of the state variable, “DLR_Half_Yates_Inflow”. The “Min@Talla_0.5*YatesInflow” rule is applied either when DIL=1, and the “CurMonth” value is between 5 (May) and 12 (December), or when DIL=2, and the “CurMonth” value is between 5 (May) and 9 (September) (Figure L.29).



```
{ } Check DIL_Nav - rev
    IF (DIL = 0)
        { } Which NAV MinQ? - rev
            IF (Basin Inflow in 9.0' range)
                Min@JBT Goal_Nav9.0
            ELSE IF (Basin Inflow in 7.5' range)
                Min@JBT Goal_Nav7.5
            ELSE (Suspend NAV)
                Min@JBT_DIL-0(4640)
        Min@Talla_DIL-0(1200)
    ELSE IF (DIL = 1)
        Min@JBT_DIL-1(4200-4640)
        { } DIL=1 (Tallassee Ops) -rev
            IF (Jan - Apr)
                Min@Talla_DIL-1(fn HeflinQ_YatesIN)
            ELSE (May - Dec)
                Min@Talla_0.5*YatesInflow
    ELSE IF (DIL = 2)
        Min@JBT_DIL-2(3.7k-4.2k)
        { } DIL=2 (Tallassee Ops) -rev
            IF (Oct - Apr)
                Min@Talla_350
            ELSE (May - Sep)
                Min@Talla_0.5*YatesInflow
    ELSE (DIL = 3)
        Min@JBT_DIL-3(2k-3.7k-4.2k)
        Min@Talla_350
```

Figure L.29 Location of “DLR_Yates_Inflow” State Variable

This state variable returns the minimum flow required at Tallassee as one-half of the Yates inflow between the bounds of 350 and 1200 cfs (Figure L.30). This is done by setting the minimum flow at Tallassee to the value of the state variable by the use of a linear relationship.



Operates Release From: Martin

Rule Name: lin@Talla_0.5*YatesInflow

Description: Tuesday decision...Minimum at Tallassee is "half" of Yates Inflow (at least 350 cfs and no more than 1200)

Function of: DLR_Half_Yates_Inflow, Current Value

Limit Type: Minimum

Interp.: Linear

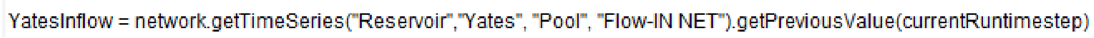
Downstream Location: Tallassee

Parameter: Flow

flow (cfs)	Flow (cfs)
0.0	0.0
999999.0	999999.0

Figure L.30 Use of "DLR_Half_Yates_Inflow" State Variable

The script starts by setting the previous value of the inflow to Yates to the variable "YatesInflow":

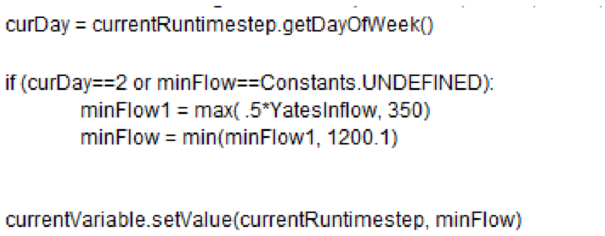


```
YatesInflow = network.getTimeSeries("Reservoir","Yates", "Pool", "Flow-IN NET").getPreviousValue(currentRuntimestep)
```

The minimum flow is set to the previous period's value. This causes the minimum flow value to remain constant except on Tuesday:

```
minFlow = currentVariable.getPreviousValue(currentRuntimestep)
```

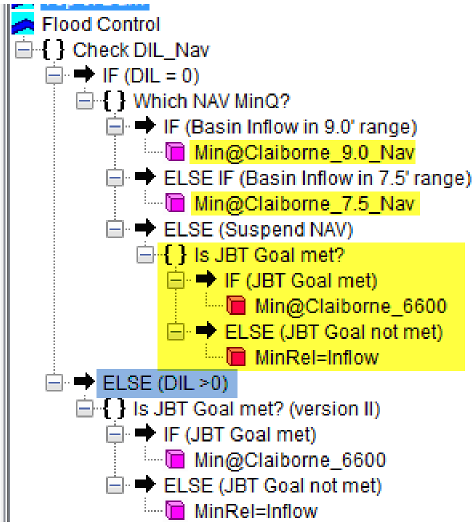
Similar to the "DLR_minFlow_fn_Heflin_Yates" state variable script, if the current day is Tuesday, then a new minimum flow is calculated and that value is held until the following Tuesday. The following script determines the current day of the current period. If this day is Tuesday, the variable "minFlow1" is set to the greater of one-half of Yates inflow or 350 cfs. The variable "minFlow" is then set to the lesser of "minFlow1" and 1200.1 cfs. This sets the range of allowable values between 350 cfs and 1200.1 cfs:



```
curDay = currentRuntimestep.getDayOfWeek()

if (curDay==2 or minFlow==Constants.UNDEFINED):
        minFlow1 = max( .5*YatesInflow, 350)
        minFlow = min(minFlow1, 1200.1)


currentVariable.setValue(currentRuntimestep, minFlow)
```

G. Drought Level Response at Millers Ferry

In the operations of Millers Ferry, the “DLR_Drought_Intensity_Level” state variable is calculated, but instead of having different operations for different DILs, the system is operated in drought (DIL>0) or not in drought (DIL =0). The “DLR_Drought_Intensity_Level” state variable is still calculated in the IF (DIL=0) rule under the Check DIL_Nav rule, and the NAV_CheckBI state variable is still calculated under the “Which NAV MinQ?” rule to determine the level of non-drought the system is in to set navigation levels. The differences are highlighted in Figure L.31. New rules are in place to set the target goals at the Claiborne project and not at the JBT Goal or JD Minimum stations. No new state variables are added for operation of Millers Ferry.

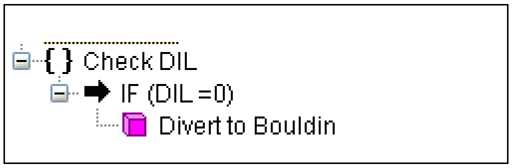


- Flood Control
- { } Check DIL_Nav
  - IF (DIL = 0)
    - { } Which NAV MinQ?
      - IF (Basin Inflow in 9.0' range)
        - Min@Claiborne_9.0_Nav
      - ELSE IF (Basin Inflow in 7.5' range)
        - Min@Claiborne_7.5_Nav
      - ELSE (Suspend NAV)
        - { } Is JBT Goal met?
          - IF (JBT Goal met)
            - Min@Claiborne_6600
          - ELSE (JBT Goal not met)
            - MinRel=Inflow
  - ELSE (DIL >0)
    - { } Is JBT Goal met? (version II)
      - IF (JBT Goal met)
        - Min@Claiborne_6600
      - ELSE (JBT Goal not met)
        - MinRel=Inflow

Figure L.31 Use of “DLR_Drought_Intensity_Level” State Variable for Millers Ferry

H. Operations at Jordan Used for Diversion to Bouldin

The operations at Jordan under the DroughtPln alternative are very similar to its Baseline operations. The only difference is that in the DroughtPln alternative Jordan uses the “DLR_Drought_Intensity_Level” state variable to decide whether to divert to Bouldin. Jordan now contains a rule that only allows it to divert to Bouldin if the system is not in drought (DIL is 0) (Figure L.32). No new state variables exist in this scenario.



- { } Check DIL
  - IF (DIL=0)
    - Divert to Bouldin

Figure L.32 Operations for Jordan

I. Power and Energy Requirements

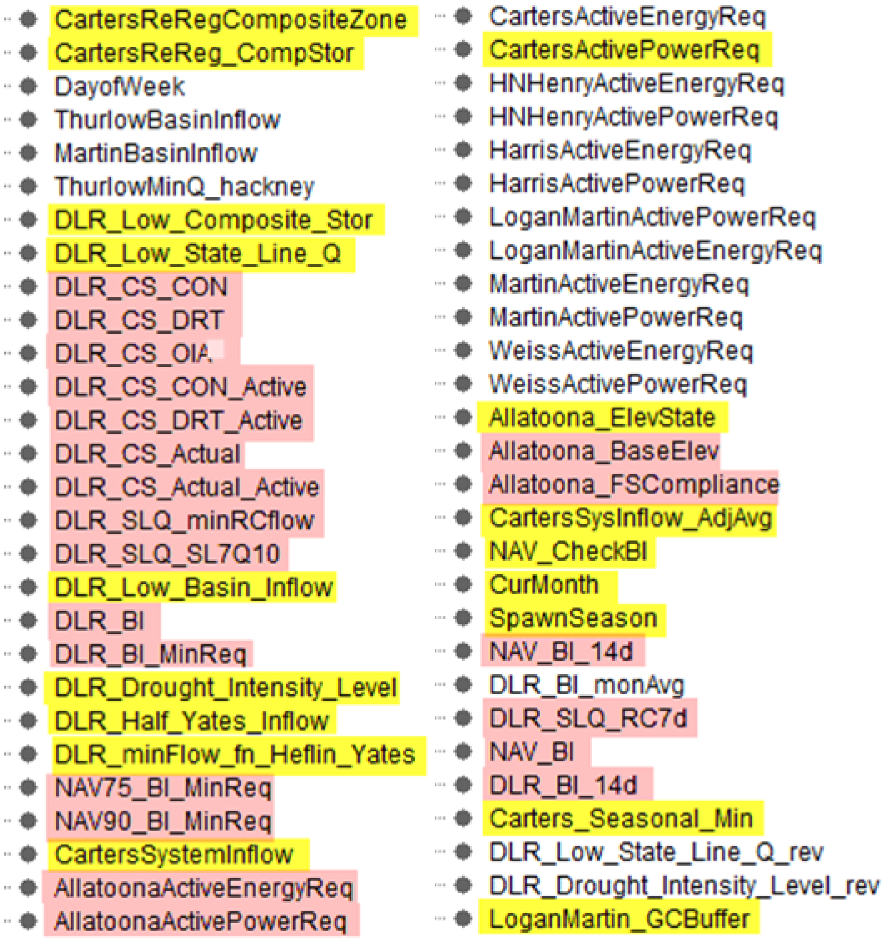
The DroughtPln alternative operations are identical to the Baseline alternative operations, so new state variables were introduced.

IV. State Variables in “Burkett” Alternative

The Burkett alternative changes operations at Allatoona, Carters and Carters ReReg (compared to the DroughtPln Alternative). The Burkett alternative has 38 state variables in the operating rules, three of which are new to the discussion. Figure L.33 shows a list of state variables; variables highlighted in yellow are within the operation rules, while those highlighted in pink are placeholders for other state variables. The new state variables are defined to establish operating rules for the following operational objectives in the Burkett alternative:

- Burkett fish spawning operational considerations at Allatoona
- Seasonal Minimum Release Targets at Carters and Carters ReReg
- Guide Curve Buffer for the HN Henry and Logan Martin tandem operation rule
- Drought Level Response at Logan Martin
- Drought Level Response at Martin
- Drought Level Response at Millers Ferry
- Operations at Jordan used for Diversion to Bouldin
- Power and energy requirements

This section will only cover state variables that were different from previously discussed alternatives.



CartersReRegCompositeZone
CartersReReg_CompStor
DayofWeek
ThurlowBasinInflow
MartinBasinInflow
ThurlowMinQ_hackney
DLR_Low_Composite_Stor
DLR_Low_State_Line_Q
DLR_CS_CON
DLR_CS_DRT
DLR_CS_OIA
DLR_CS_CON_Active
DLR_CS_DRT_Active
DLR_CS_Actual
DLR_CS_Actual_Active
DLR_SLQ_minRCflow
DLR_SLQ_SL7Q10
DLR_Low_Basin_Inflow
DLR_BI
DLR_BI_MinReq
DLR_Drought_Intensity_Level
DLR_Half_Yates_Inflow
DLR_minFlow_fn_Heflin_Yates
NAV75_BI_MinReq
NAV90_BI_MinReq
CartersSystemInflow
AllatoonaActiveEnergyReq
AllatoonaActivePowerReq

CartersActiveEnergyReq
CartersActivePowerReq
HNHenryActiveEnergyReq
HNHenryActivePowerReq
HarrisActiveEnergyReq
HarrisActivePowerReq
LoganMartinActivePowerReq
LoganMartinActiveEnergyReq
MartinActiveEnergyReq
MartinActivePowerReq
WeissActiveEnergyReq
WeissActivePowerReq
Allatoona_ElevState
Allatoona_BaseElev
Allatoona_FSCompliance
CartersSysInflow_AdjAvg
NAV_CheckBI
CurMonth
SpawnSeason
NAV_BI_14d
DLR_BI_monAvg
DLR_SLQ_RC7d
NAV_BI
DLR_BI_14d
Carters_Seasonal_Min
DLR_Low_State_Line_Q_rev
DLR_Drought_Intensity_Level_rev
LoganMartin_GCBuffer

Figure L.33 List of State Variables in the Burkett Alternative

A. Fish Spawning Operational Considerations at Allatoona

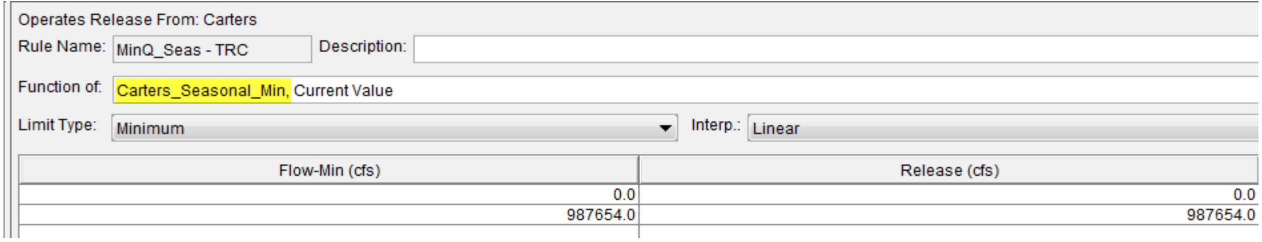
The rules that control operations during the fish spawning season at Allatoona in the Burkett alternative are identical to the operations from the Baseline alternative, except that the Baseline alternative only includes the spawning operation set in the Conservation Zone and in Zone 2. In the Burkett alternative fish spawning operations are included in the Conservation Zone, Zone 2, Zone 3, and Zone 4. No new state variables are introduced.

B. Seasonal Minimum Release Targets at Carters and Carters ReReg

In the Burkett alternative the Carters and Carters ReReg system uses two additional state variables, “Carters_Seasonal_Min” and “CartersReRegCompositeZone” in addition to the “CartersSystemInflow” and “CartersSysInflow_AdjAvg” state variables that have been used in previous alternatives. “Carters_Seasonal_Min” is used under the “MinQ_Seas – TRC” rule and the “CartersReRegCompositeZone” is used in the operation of both Carters and Carters ReReg. Both of these state variables are used to help set minimum release targets.

1. State Variable – “Carters_Seasonal_Min”

The “Carters_Seasonal_Min” state variable is used to determine the minimum flow that Carters should release to support Carters ReReg in meeting its seasonal minimum. The state variable is located in the operations of Carters under the MinQ_Seas-TRC rule (Figure L.34) in the Flood Control, GC Buffer, Conservation and CompositeZone2 Zones.



Operates Release From: Carters

Rule Name: MinQ_Seas - TRC

Description:

Function of: Carters_Seasonal_Min, Current Value

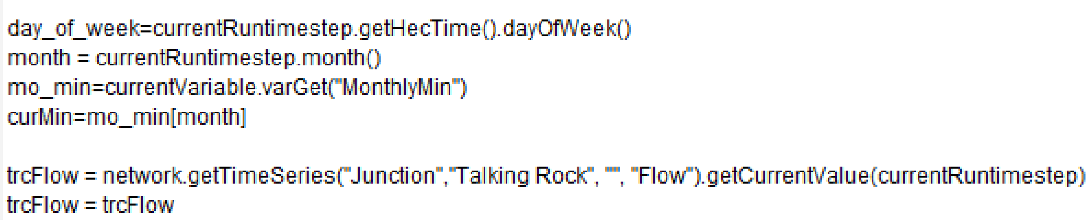
Limit Type: Minimum

Interp.: Linear

Flow-Min (cfs)	Release (cfs)
0.0	0.0
987654.0	987654.0

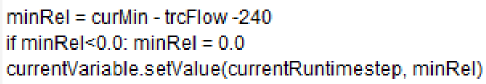
Figure L.34 Carters Operations for Burkett Alternative: Release Rule “MinQ_Seas – TRC” Function of State Variable “Carters_Seasonal_Min”

The script starts by considering the inflow from Talking Rock (which is an additional inflow between the outlet of Carters and the inlet of Carters ReReg) at the current timestep.



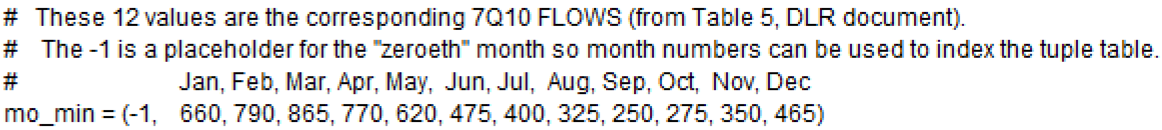
```
day_of_week=currentRuntimestep.getHecTime().dayOfWeek()
month = currentRuntimestep.month()
mo_min=currentVariable.varGet("MonthlyMin")
curMin=mo_min[month]

trcFlow = network.getTimeSeries("Junction","Talking Rock", "", "Flow").getCurrentValue(currentRuntimestep)
trcFlow = trcFlow
```

The seasonal minimum release is then calculated to be the current monthly minimum flow minus the flow from Talking Rock and minus a set flow of 240 cfs.



```
minRel = curMin - trcFlow -240
if minRel<0.0: minRel = 0.0
currentVariable.setValue(currentRuntimestep, minRel)
```

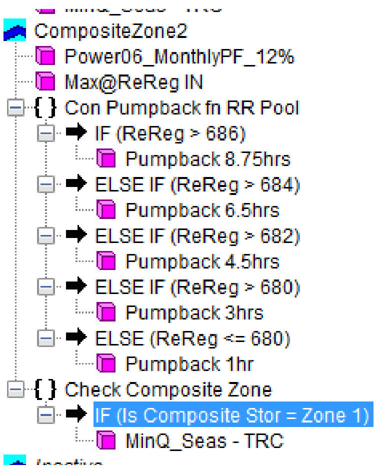
The table of values for the monthly minimum flow are given below:



```
#   These 12 values are the corresponding 7Q10 FLOWS (from Table 5, DLR document).
#   The -1 is a placeholder for the "zeroeth" month so month numbers can be used to index the tuple table.
#                   Jan, Feb, Mar, Apr, May,  Jun, Jul,  Aug, Sep, Oct,  Nov, Dec
mo_min = (-1,   660, 790, 865, 770, 620, 475, 400, 325, 250, 275, 350, 465)
```

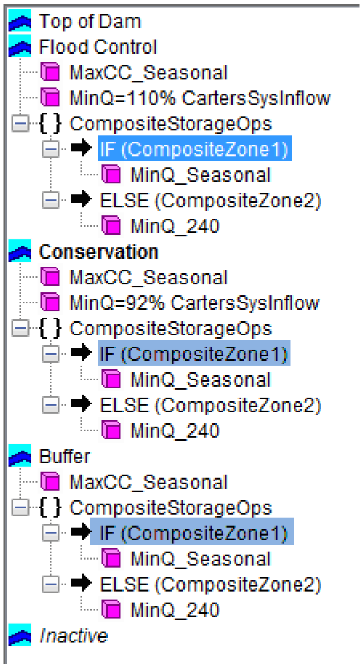
2. *State Variable – "CartersReRegCompositeZone"*

The "CartersReRegCompositeZone" state variable creates a minumum flow requirement of seasonal or constant depending on the composite zone of Carters and Carters ReReg. The total storage of Carters + ReReg is in CompositeZone1, where CompositeZone1 is defined as a reference zone in Carters and Carters ReReg reservoirs. The use of the state variable is located in the CompositeZone2 zone of Carters operations (Figure L.35) and in the Flood Control, Conservation and Buffer Zones at Carters ReReg (Figure L.36).



- CompositeZone2
  - Power06_MonthlyPF_12%
  - Max@ReReg IN
  - { } Con Pumpback fn RR Pool
    - IF (ReReg > 686)
      - Pumpback 8.75hrs
    - ELSE IF (ReReg > 684)
      - Pumpback 6.5hrs
    - ELSE IF (ReReg > 682)
      - Pumpback 4.5hrs
    - ELSE IF (ReReg > 680)
      - Pumpback 3hrs
    - ELSE (ReReg <= 680)
      - Pumpback 1hr
  - { } Check Composite Zone
    - IF (Is Composite Stor = Zone 1)
      - MinQ_Seas - TRC

Figure L.35 Carters Operations for Burkett Alternative: Placement for Checking State Variable "CartersReRegCompositeZone" to Determine when to Apply "MinQ_Seas - TRC" Release Rule



- Top of Dam
- Flood Control
  - MaxCC_Seasonal
  - MinQ=110% CartersSysInflow
  - { } CompositeStorageOps
    - IF (CompositeZone1)
      - MinQ_Seasonal
    - ELSE (CompositeZone2)
      - MinQ_240
- Conservation
  - MaxCC_Seasonal
  - MinQ=92% CartersSysInflow
  - { } CompositeStorageOps
    - IF (CompositeZone1)
      - MinQ_Seasonal
    - ELSE (CompositeZone2)
      - MinQ_240
- Buffer
  - MaxCC_Seasonal
  - { } CompositeStorageOps
    - IF (CompositeZone1)
      - MinQ_Seasonal
    - ELSE (CompositeZone2)
      - MinQ_240
- *Inactive*

Figure L.36 Carters ReReg Operations for Burkett Alternative: Placement for Checking State Variable "CartersReRegCompositeZone" to Determine when to Apply "MinQ_Seasonal" Release Rule

This script calculates this state variable only on a user defined day of the week. If the current Runtimestep falls on that day of the week, the script sets the trigger that will calculate and set the current Composite Storage zone.

```
# 0=Sun; 1=Mon; 2=Tue; 3=Wed; 4=Thu; 5=Fri; 6=Sat
DayOfWeek = 0

curDay = currentRuntimestep.getDayOfWeek()


if curDay == DayOfWeek :
   TriggerCheckCompZone = 1
else :
   TriggerCheckCompZone = 0
```

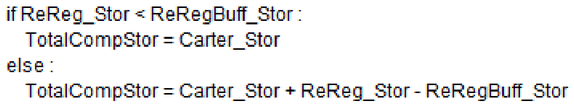
First, the current value of Storage in Carters and in Carters ReReg must be determined.

```
Carter_Stor = network.getTimeSeries("Reservoir","Carters", "Pool", "Stor").getPreviousValue(currentRuntimestep)
ReReg_Stor = network.getTimeSeries("Reservoir","Carters ReReg", "Pool", "Stor").getPreviousValue(currentRuntimestep)

ReRegBuff_Stor = network.getTimeSeries("Reservoir","Carters ReReg", "Buffer", "Stor-ZONE").getCurrentValue(currentRuntimestep)
ReRegToC_Stor = network.getTimeSeries("Reservoir","Carters ReReg", "Conservation", "Stor-ZONE").getCurrentValue(currentRuntimestep)
```

The storage above the Top of Conservation pool in Carters ReReg is not included in the calculation.

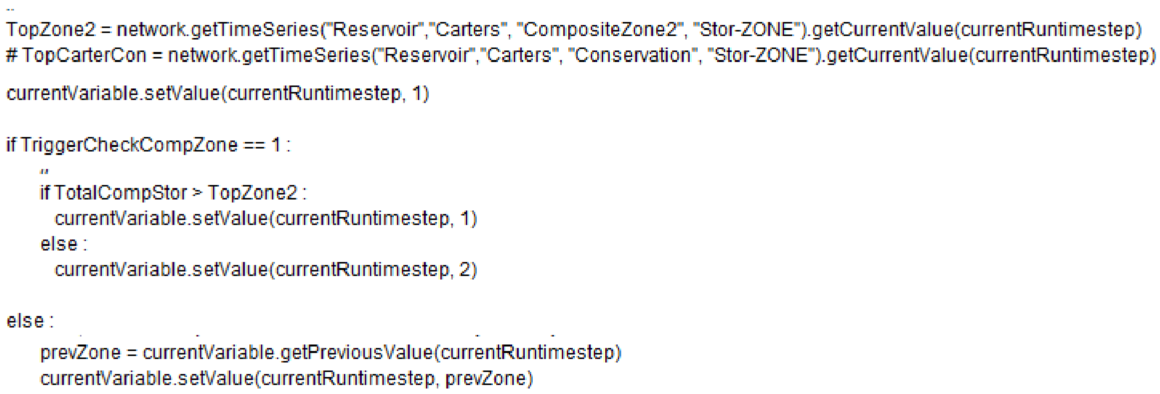
```
if ReReg_Stor > ReRegToC_Stor :
   ReReg_Stor = ReRegToC_Stor
```

If the storage in Carters ReReg is below the Buffer pool, it should not be counted towards to composite storage. The total composite storage is then computed to be the amount of ReReg storage in use between the top of the Buffer zone and top of Conservation zone added to the total storage in use at Carters.



```
if ReReg_Stor < ReRegBuff_Stor :
   TotalCompStor = Carter_Stor
else :
   TotalCompStor = Carter_Stor + ReReg_Stor - ReRegBuff_Stor
```

The current composite storage is then compared to the previous value of Storage for the system if the current day is equal to the day defined by the user. If the computed composite storage is greater than the total storage at the top of CompositeZone2 at Carters, the state variable is set to 1 and the rules for IF(Composite Zone 1) are used. If the computed composite storage is less than or equal to the total storage at the top of CompositeZone2 at Carters, the state variable is set to 2 and the rules for ELSE(Composite Zone 2) are used.



```
TopZone2 = network.getTimeSeries("Reservoir","Carters", "CompositeZone2", "Stor-ZONE").getCurrentValue(currentRuntimestep)
# TopCarterCon = network.getTimeSeries("Reservoir","Carters", "Conservation", "Stor-ZONE").getCurrentValue(currentRuntimestep)

currentVariable.setValue(currentRuntimestep, 1)

if TriggerCheckCompZone == 1 :
     if TotalCompStor > TopZone2 :
       currentVariable.setValue(currentRuntimestep, 1)
     else :
       currentVariable.setValue(currentRuntimestep, 2)

else :
     prevZone = currentVariable.getPreviousValue(currentRuntimestep)
     currentVariable.setValue(currentRuntimestep, prevZone)
```

The value of Composite Storage is stored in the placeholder state variable, “CartersReReg_CompStor”.

```
network.getStateVariable("CartersReReg_CompStor").setValue(currentRuntimestep, TotalCompStor)
```

C. Guide Curve Buffer for the HN Henry and Logan Martin Tandem Operation Rule

The Burkett alternative operations at HN Henry are identical to the Baseline alternative operations, so new state variables were introduced.

D. Drought Level Response at Logan Martin

The Burkett alternative operations at Logan Martin are identical to the DroughtPln alternative operations, so new state variables were introduced.

E. Drought Level Response at Martin

The Burkett alternative operations at Martin are identical to the DroughtPln alternative operations, so new state variables were introduced.

F. Drought Level Response at Millers Ferry

The Burkett alternative operations at Millers Ferry are identical to the DroughtPln alternative operations, so new state variables were introduced.

G. Operations at Jordan Used for Diversion to Bouldin

The Burkett alternative operations at Jordan are identical to the DroughtPln alternative operations, so new state variables were introduced.

H. Power and Energy Requirements

The Burkett alternative power and energy operations at Allatoona are different from the Baseline alternative operations, although no new state variables were introduced. Within the “CartersActivePowerReq” state variable, the power rules associated with different zones at Allatoona are defined below in Table L.04. The power rules at the other projects remain the same as they were in the Baseline alternative.

Table L.04 List of Zones and Associated Power Rules at Allatoona for the Burkett Alternative

Zone	Rule Name
Top of Dam (TOD)- Surcharge	(No Power Rule)
Flood Control (FC)	PowerGC FC_6hrs
Conservation (Con)	PowerGC Z1_6hrs
Zone 2 (Z2)	PowerGC Z2_4hrs
Zone 3 (Z3)	PowerGC Z3_2hrs
Inactive	(No Power Rule)

In the Flood Control zone, the “PowerGC FC_6hrs” rule sets the plant factor to 25% for 0-100% of power storage in use at Allatoona (6 hours of power generated per day) (Figure L.37). The baseline alternative only produced power for 16.67% of the day in the Flood Control zone (4 hours). 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.

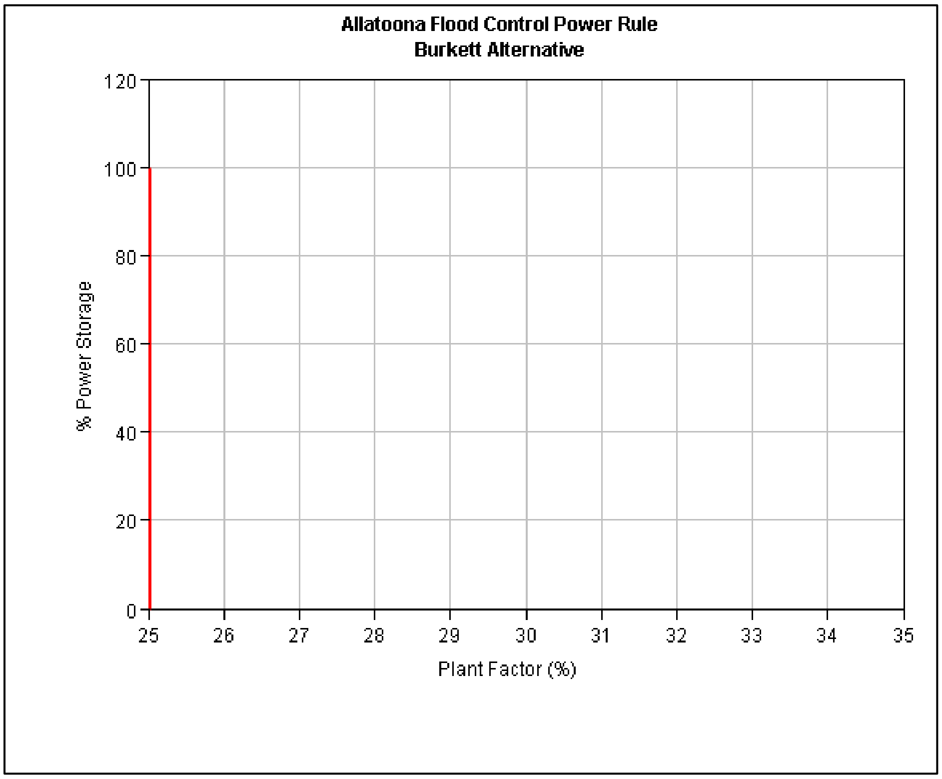


Figure L.37 PowerGC FC_6hrs Guide Curve

The “PowerGC Z1_6hrs” guide curve used in the Conservation zone is identical to the “PowerGC FC_6hrs” guide curve used in the Flood Control zone in the Burkett alternative (Figure L.38). At this elevation, Allatoona produces power and energy for 6 hours of the day from 0-100% of power storage in use. 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.

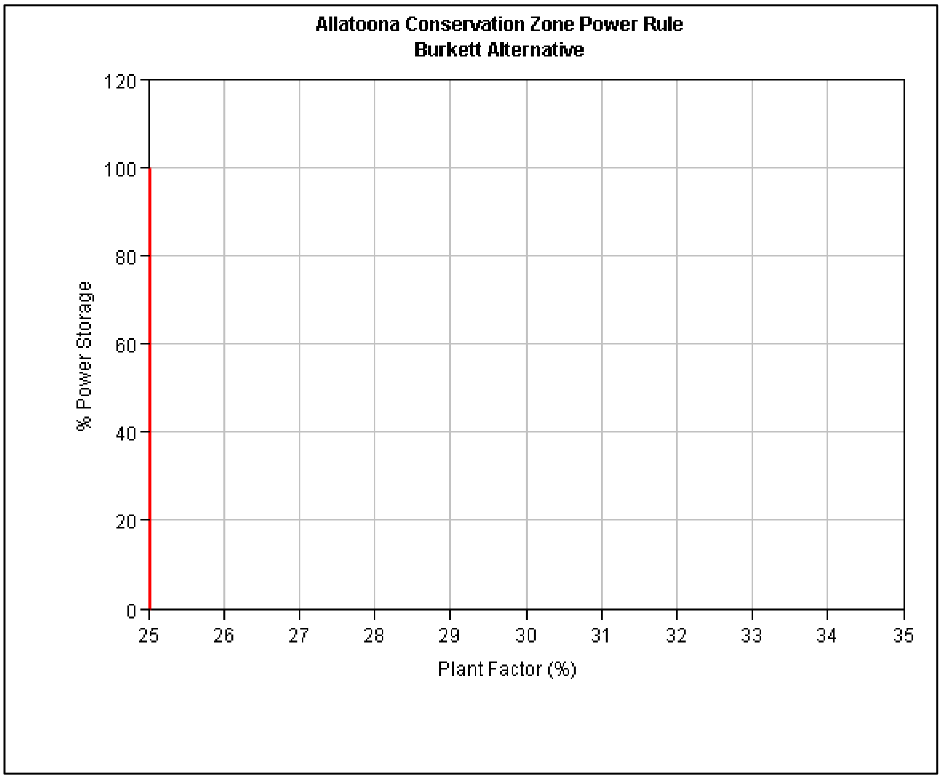


Figure L.38 PowerGC Z1_6hrs Guide Curve

The power produced when the elevation is in Zone 2 during the Burkett alternative is set by the “PowerGC Z2_4hrs” rule. This rule sets the plant factor to16.67% (4 hours) for all amounts of power storage in use (Figure L.39). The zone at the top of the power pool is Zone 2 and the zone at the bottom of the power pool is Zone 3. This alternative produces more power than Zone 2 in the Baseline alternative, which only uses a plant factor of 4.2% in the top 20% of the power pool to give the equivalent of 1 hour of generation each day.

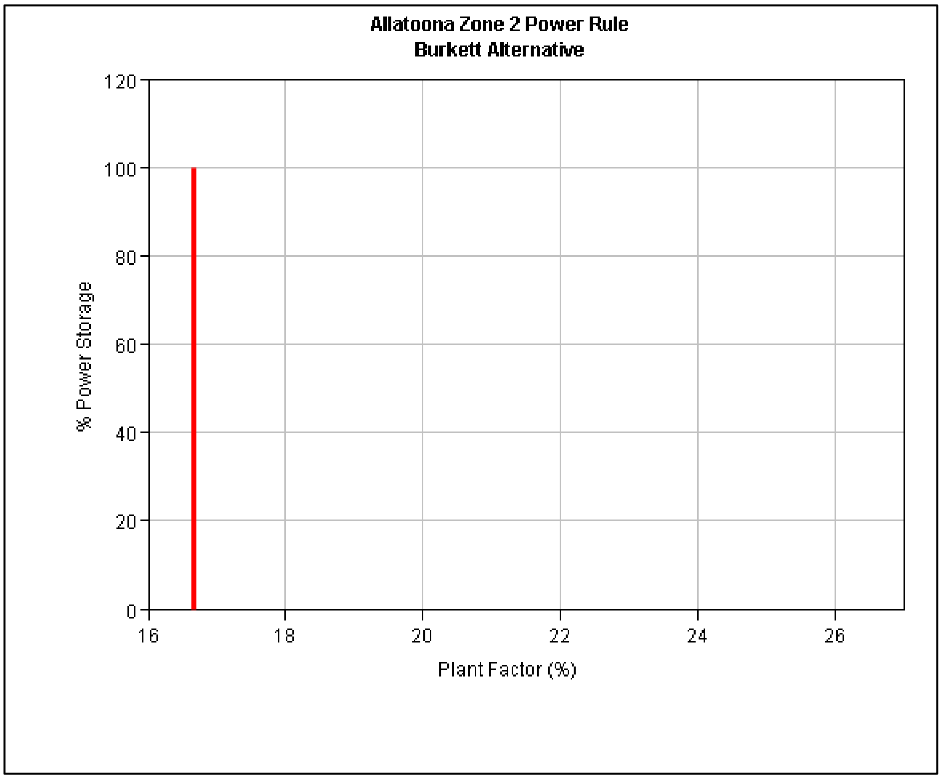


Figure L.39 PowerGC Z2_4hrs Guide Curve

A constant plant factor of 8.33% (2 hours of power generation) for all amounts of power storage in use is set by the “PowerGC Z3_2hrs” rule when the elevation at Allatoona in the Burkett alternative is in Zone 3 (Figure L.40). The zone at the top of the power pool is Zone 3 and the zone at the bottom of the power pool is Zone 4.

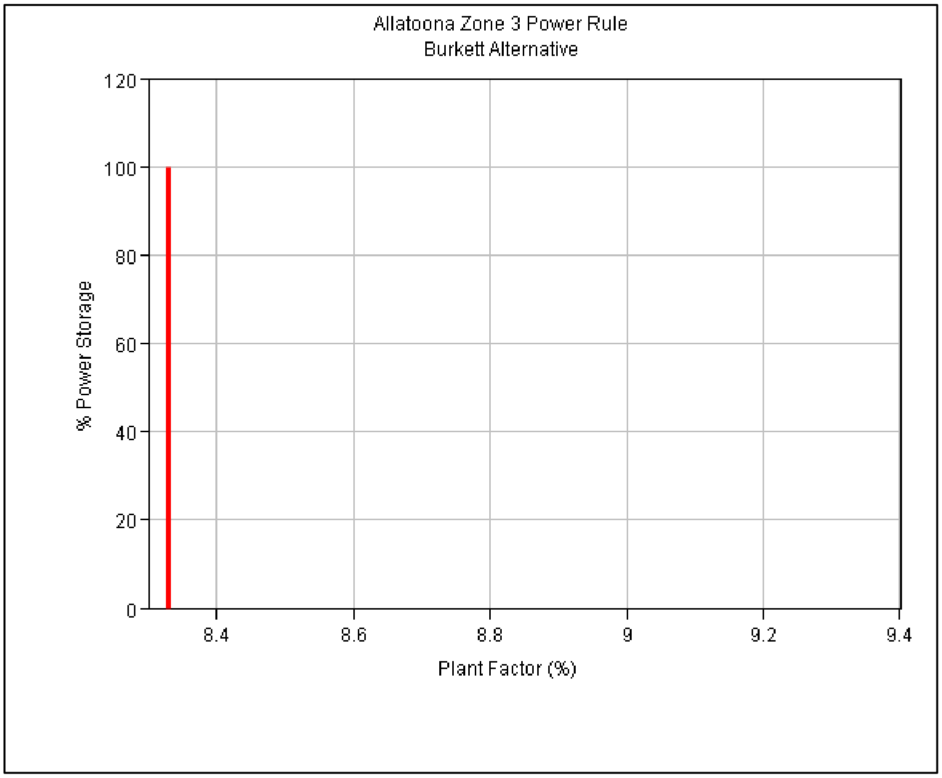


Figure L.40 PowerGC Z3_2hrs Guide Curve

V. “DragoA” Alternative

The DragoA alternative only changes operations at Allatoona (compared to the Burkett Alternative). The DragoA alternative uses the same 38 state variables in the operating rules as Burkett, so there are no new state variables introduced in this section. The state variables are defined to establish operating rules for the following operational objectives in the DragoA alternative:

- Fish spawning operational considerations at Allatoona
- Seasonal Minimum Release Targets at Carters and Carters ReReg
- Guide Curve Buffer for the HN Henry and Logan Martin tandem operation rule
- Drought Level Response at Logan Martin
- Drought Level Response at Martin
- Drought Level Response at Millers Ferry
- Operations at Jordan used for Diversion to Bouldin
- Power and energy requirements

This section will only cover state variables that are different from previously discussed alternatives.

A. Fish Spawning Operational Consideration at Allatoona

The rules that control operations during the fish spawning season at Allatoona in the DragoA alternative are identical to the operations from the Burkett alternative, except that the Baseline alternative included the spawning operation set in the Conservation Zone, Zone 2, Zone 3, and Zone 4. In the DragoA alternative, fish spawning operations are only included in the Conservation Zone, Zone 2, and Zone 3. No new state variables are introduced.

B. Power and Energy Requirements

The DragoA alternative power and energy operations at Allatoona are different from the baseline alternative operations, although no new state variables were introduced. Within the “CartersActivePowerReq” state variable, the power rules associated with different zones at Allatoona are defined below in Table L.05. The power rules at the other projects remain the same as they were in the baseline alternative.

Table L.05 List of Zones and Associated Power Rules at Allatoona for the DragoA Alternative

Zone	Rule Name
Top of Dam (TOD)- Surcharge	(No Power Rule)
Flood Control (FC)	PowerGC FC_6hrs
Conservation (Con)	PowerGC Z1_2-4hrs
Zone 2 (Z2)	PowerGC Z2_0-2hrs
Zone 3 (Z3)	(No Power Rule)
Inactive	(No Power Rule)

The “PowerGC FC_6hrs” rule in the Flood Control zone in the DragoA alternative uses a plant factor of 25% (6 hours of power generation per day) at Allatoona for all amounts of power storage in use (Figure L.41). 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.

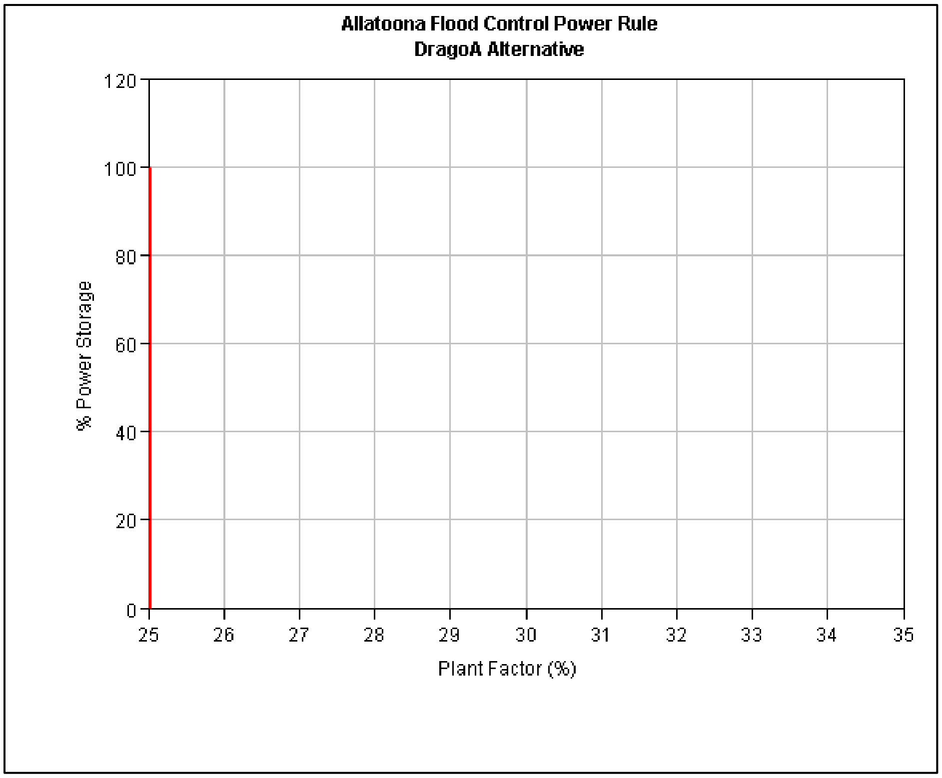


Figure L.41 PowerGC FC_6hrs Guide Curve

In the Conservation zone, the "PowerGC Z1_2-4hrs" generates power for two to four hours, depending on the amount of power storage in use (Figure L.42). From 0-39.99% of storage in use in the Conservation zone, an 8.33% plant factor (2 hours of power) is used. From 40-69.99% of storage in use, a 12.5% plant factor (3 hours of power) is used. From 70-100% of storage in use, a plant factor of 16.67% (4 hours of power) 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.

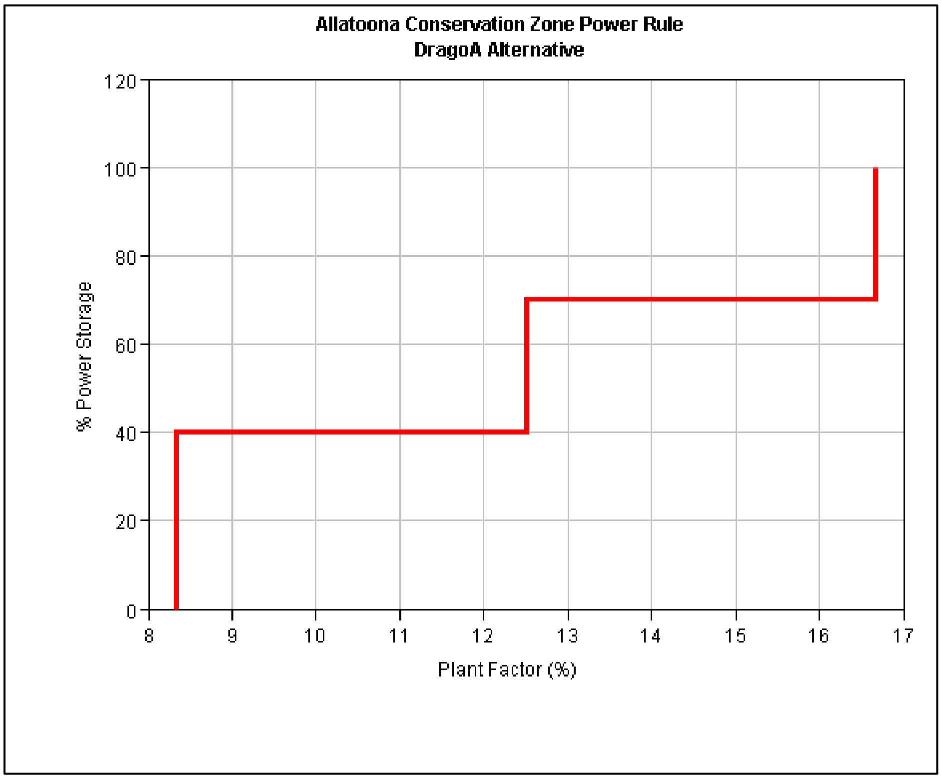


Figure L.42 PowerGC Z1_2-4hrs Guide Curve

When the elevation is in Zone 2 at Allatoona during the DragoA alternative, the power generated varies depending on the amount of power storage in use (Figure L.43). Below 10% storage, no power is generated. From 10-49.99% of storage in use, a plant factor of 4.16% is used (1 hour). Above 50% storage in use, a plant factor of 8.33% is used (2 hours). The zone at the top of the power pool is Zone 2 and the zone at the bottom of the power pool is Zone 3.

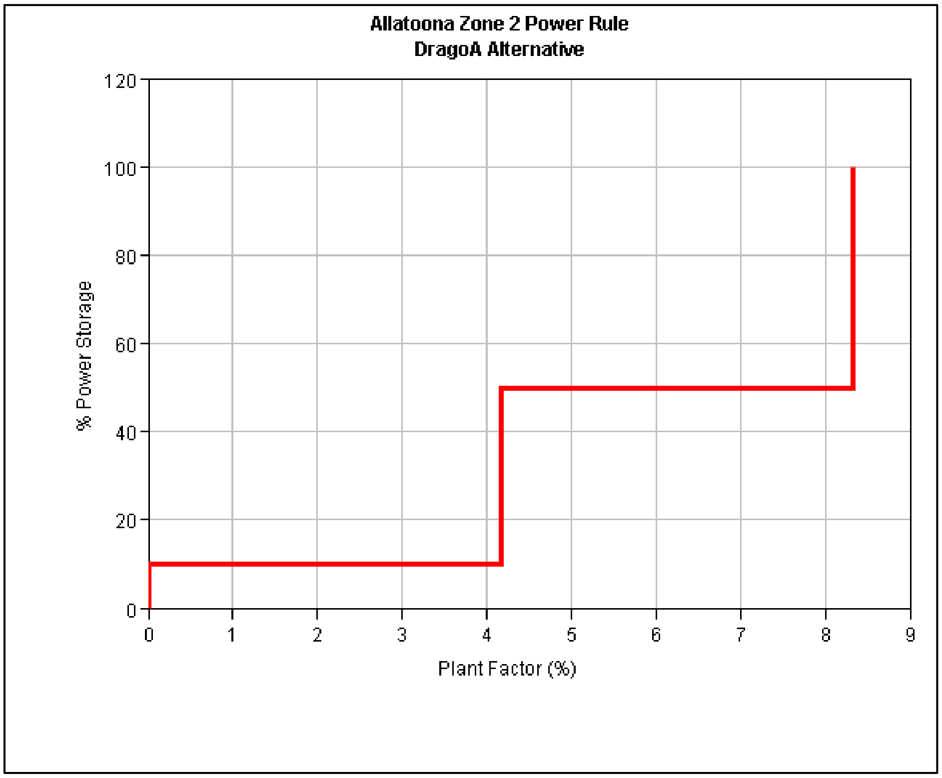


Figure L.43 PowerGC Z2_0-2hrs Guide Curve

VI. "DragoB" Alternative

The DragoB alternative uses the same 38 state variables in the operating rules as DragoA, and there is no change in the state variable operation in this alternative.

VII. "RPlanA" Alternative

The RPlanA alternative only changes operations at Allatoona (compared to the DragoB Alternative). The RPlanA alternative uses the same 38 state variables in the operating rules as DragoB, so there are no new state variables introduced in this section. The state variables are defined to establish operating rules for the following operational objectives in the RPlanA alternative:

- Fish spawning operational considerations at Allatoona
- Seasonal Minimum Release Targets at Carters and Carters ReReg
- Guide Curve Buffer for the HN Henry and Logan Martin tandem operation rule
- Drought Level Response at Logan Martin
- Drought Level Response at Martin
- Drought Level Response at Millers Ferry
- Operations at Jordan used for Diversion to Bouldin
- Power and energy requirements

This section will only cover state variables that are different from previously discussed alternatives.

A. Fish Spawning Operational Considerations at Allatoona

The state variable rules that control operations during the fish spawning season at Allatoona in the RPlanA alternative are identical to the operations from the DragoB alternative, except that the DragoB alternative only included the spawning operation set in the Conservation Zone, Zone 2, and Zone 3. In the RPlanA alternative, fish spawning operations are included in the Conservation Zone, Zone 2, Zone 3, and Zone 4. No new state variables are introduced. The state variable operations in the RPlanA alternative are identical to the Burkett alternative.

B. Power and Energy Requirements

The RPlanA alternative power and energy operations at Allatoona are different from the baseline alternative operations, although no new state variables were introduced. Within the "CartersActivePowerReq" state variable, the power rules associated with different zones at Allatoona are defined below in Table L.06. The power rules at the other projects remain the same as they were in the baseline alternative. The power rules used for RPlanA are also used through RPlanF.

Table L.06 List of Zones and Associated Power Rules at Allatoona for the RPlanA through the RPlanF Alternatives

Zone	Rule Name
Top of Dam (TOD)- Surcharge	(No Power Rule)
Flood Control (FC)	PowerGC FC_4hrs
Conservation (Con)	PowerGC Z1_4hrs
Zone 2 (Z2)	PowerGC Z2_3hrs
Zone 3 (Z3)	PowerGC Z3_0-2hrs
Inactive	(No Power Rule)

The "PowerGC FC_4hrs" rule in the Flood Control zone in the RPlanA alternative uses a plant factor of 16.67% (4 hours of power per day) at Allatoona for all amounts of power storage in use (Figure L.44). 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.

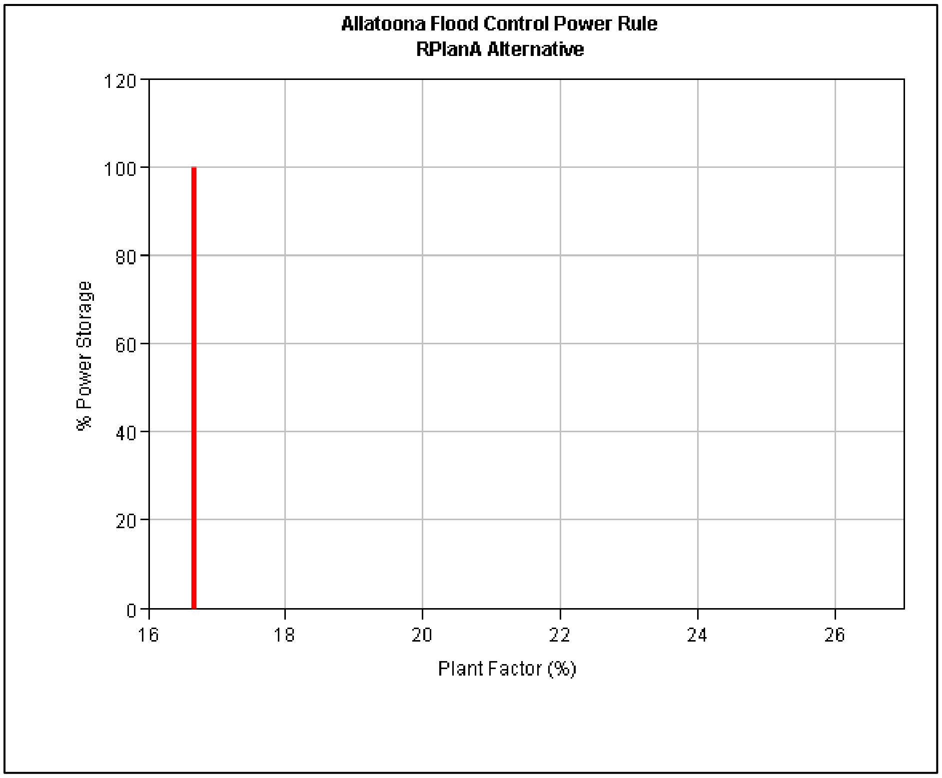


Figure L.44 PowerGC FC_4hrs Guide Curve

The “PowerGC Z1_4hrs” guide curve used in the Conservation zone is identical to the “PowerGC FC_4hrs” guide curve used in the Flood Control zone in the RPlanA alternative (Figure L.45). At this elevation, Allatoona uses a plant factor of 16.67% (power and energy for 4 hours of the day) from 0-100% of power storage in use. 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.

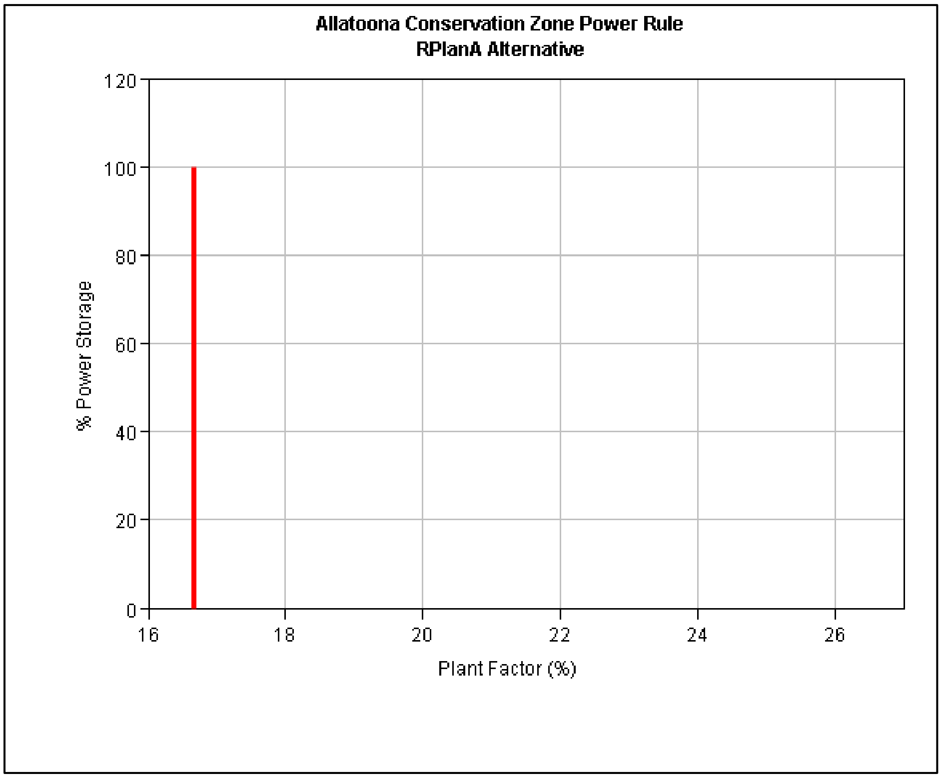


Figure L.45 PowerGC Z1_4hrs Guide Curve

The "PowerGC Z2_3hrs" rule in Zone 2 in the RPlanA alternative uses a plant factor of 12.5% (3 hours of power per day) at Allatoona for all amounts of power storage in use (Figure L.46). The zone at the top of the power pool is Zone 2 and the zone at the bottom of the power pool is Zone 3.

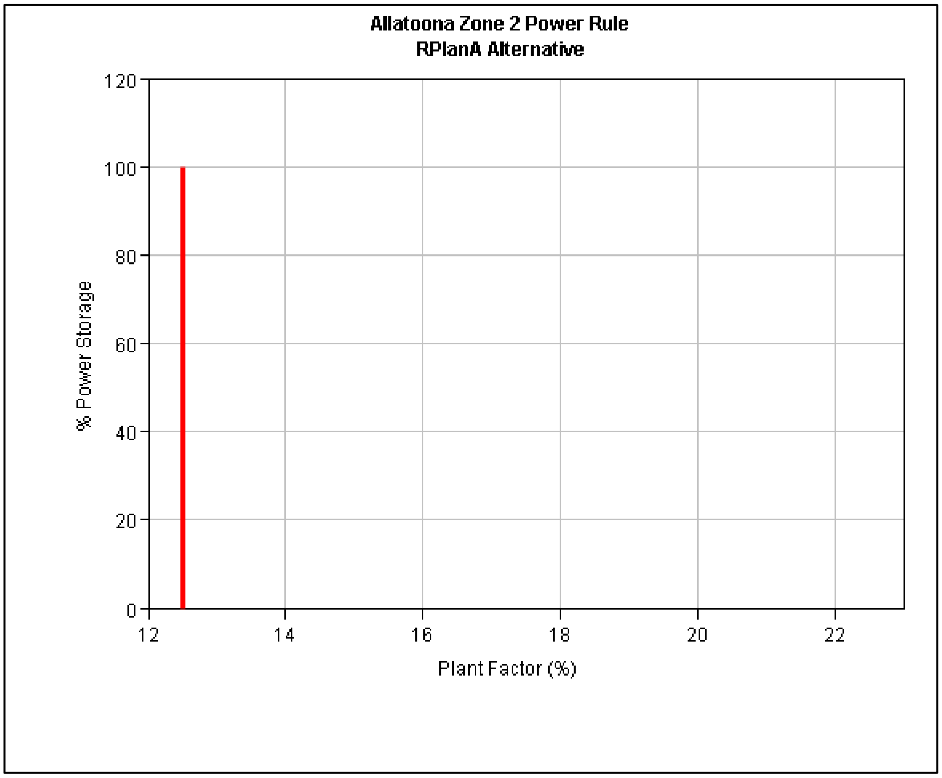


Figure L.46 PowerGC Z2_3hrs Guide Curve

In Zone 3, the "PowerGC Z3_0-2hrs" generates power for zero to two hours, depending on the amount of power storage in use (Figure L.47). When under 10% power storage in Zone 3, no power is generated. From 10-79.99% of power storage in use, a 4.17% plant factor (1 hour of power) is used. From 80-100% a plant factor of 8.33% (2 hours of power) is used. The zone at the top of the power pool is Zone 3 and the zone at the bottom of the power pool is Zone 4.

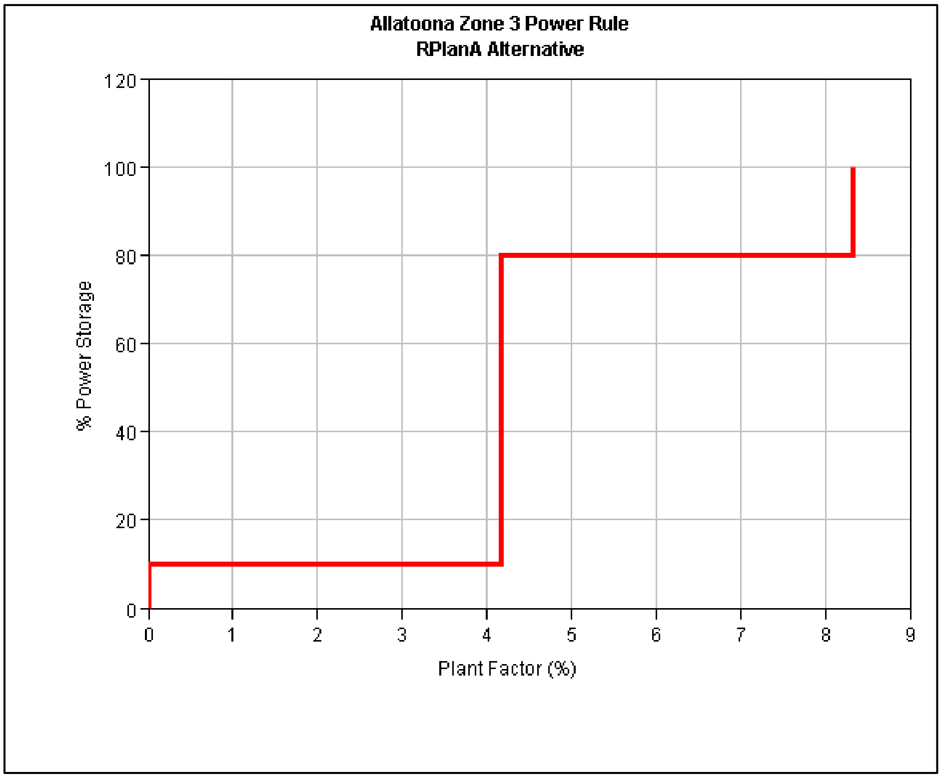


Figure L.47 PowerGC Z3_0-2hrs Guide Curve

VIII. “RPlanB” Alternative

The RPlanB alternative only changes operations at Logan Martin (compared to the RPlanA alternative). The RPlanB alternative uses the same 38 state variables in the operating rules as RPlanA, so there are no new state variables introduced in this section. The state variables are defined to establish operating rules for the following operational objectives in the RPlanB alternative:

- Fish spawning operational considerations at Allatoona
- Seasonal Minimum Release Targets at Carters and Carters ReReg
- Guide Curve Buffer for the HN Henry and Logan Martin tandem operation rule
- Drought Level Response at Logan Martin
- Drought Level Response at Martin
- Drought Level Response at Millers Ferry
- Operations at Jordan used for Diversion to Bouldin
- Power and energy requirements

This section will only cover state variables that are different from previously discussed alternatives.

A. Drought Level Response at Logan Martin

The RPlanB alternative uses the Nav_Drought_Snail operation set as opposed to the Nav_Drought operation set that has been in use for the previously mentioned drought plan alteratives. This operation set does not introduce any new state variables. The only difference in operation is the minimum required flows at J.D. Minimum when the DIL is equal to 2 or 3.

IX. “RPlanC” Alternative

The RPlanC alternative changes operations at Jordan, Logan Martin, Martin, and Millers Ferry (compared to the RPlanB Alternative). Two new state variables are introduced in this alternative, “DLR_Drought_Intensity_Level_rev” and “DLR_Low_State_Line_Q_rev”. These state variables are used instead of the “DLR_Drought_Intensity_Level” and “DLR_Low_State_Line_Q” state variables that were used in previous drought plan alternatives. Figure L.48 shows a list of state variables, variables highlighted in yellow are within the operation rules, while those highlighted in pink are placeholders for other state variables. The new state variables are defined to establish operating rules for the following operational objectives in the RPlanC alternative:

- Fish spawning operational considerations at Allatoona
- Seasonal Minimum Release Targets at Carters and Carters ReReg
- Guide Curve Buffer for the HN Henry and Logan Martin tandem operation rule
- Revised Drought Level Response at Logan Martin
- Revised Drought Level Response at Martin
- Revised Drought Level Response at Millers Ferry
- Revised operations at Jordan used for Diversion to Bouldin
- Power and energy requirements

This section will only cover state variables that were different from previously discussed alternatives.

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

Figure L.48 List of State Variables in the RPlanC Alternative

A. Fish Spawning Operational Consideration at Allatoona

The RPlanC alternative operation set at Allatoona uses the same operation set as RPlanB, BurkettB, so new state variables were introduced.

B. Seasonal Minimum Release Targets at Carters and Carters ReReg

The RPlanC alternative operation set at Carters and Carters ReReg uses the same operation set as the other drought plan operations, Seasonal, so new state variables were introduced.

C. Guide Curve Buffer for the HN Henry and Logan Martin Tandem Operation Rule

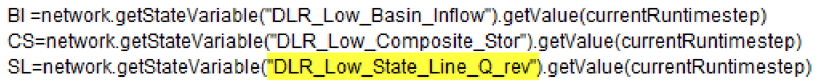
The RPlanC alternative operations at HN Henry uses the same operation set as the other drought plan operations, Winter Pool 507, so new state variables were introduced.

D. Revised Drought Level Response at Logan Martin

The RPlanC alternative operations at Logan Martin are identical to the previous drought plan alternatives with the exception of two new state variables, “DLR_Drought_Intensity_Level_rev” and “DLR_Low_State_Line_Q_rev” that are used instead of the “DLR_Drought_Intensity_Level” and “DLR_Low_State_Line_Q” state variables that were used in previous drought plan alternatives.

1. State Variable – “DLR_Drought_Intensity_Level_rev”

This state variable is identical to the state variable that it replaces in the revised operation set, “DLR_Drought_Intensity_Level”, except that the script now calls for the revised State line flow definitions (DLR_Low_State_Line_Q_rev).



```
BI =network.getStateVariable("DLR_Low_Basin_Inflow").getValue(currentRuntimestep)
CS=network.getStateVariable("DLR_Low_Composite_Stor").getValue(currentRuntimestep)
SL=network.getStateVariable("DLR_Low_State_Line_Q_rev").getValue(currentRuntimestep)
```

2. State Variable – “DLR_Low_State_Line_Q_rev”

The state variable “DLR_Low_State_Line_Q_rev” is identical to the “DLR_Low_State_Line_Q” state variable state in that it determines whether or not the flow at the Rome_Coosa station meets the “Low State Line Flow” criteria. The only difference between the two models is in the step when the value is compared with the monthly 7Q10 value. 7Q10 is defined as the lowest flow over a 7 day period that would occur once in 10 years. A Low State Line Flow occurs when the Rome-Coosa gage measures a flow below the monthly historical 7Q10 flow. The difference between the two reference tables that are retrieved by the scripts is described in Table L.07.

Table L.07 Difference Between 7Q10 Monthly Flows Between State Variables

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Low_State_Line_Q	2356	2957	3057	2779	2300	2014	1607	1569	1424	1286	1574	2204
Low_State_Line_Q_rev	2544	2982	3258	2911	2497	2153	1693	1601	1406	1325	1608	2043

E. Revised Drought Level Response at Martin

The RPlanC alternative operations at Martin are identical to the previous drought plan alternatives with the exception of two new state variables, "DLR_Drought_Intensity_Level_rev" and "DLR_Low_State_Line_Q_rev" that are used instead of the "DLR_Drought_Intensity_Level" and "DLR_Low_State_Line_Q" state variables that were used in previous drought plan alternatives.

F. Revised Drought Level Response at Millers Ferry

The RPlanC alternative operations at Millers Ferry are identical to the previous drought plan alternatives with the exception of two new state variables, "DLR_Drought_Intensity_Level_rev" and "DLR_Low_State_Line_Q_rev" that are used instead of the "DLR_Drought_Intensity_Level" and "DLR_Low_State_Line_Q" state variables that were used in previous drought plan alternatives.

G. Revised Operations at Jordan Used for Diversion to Bouldin

The RPlanC alternative operations at Jordan are identical to the previous drought plan alternatives with the exception of two new state variables: "DLR_Drought_Intensity_Level_rev" and "DLR_Low_State_Line_Q_rev" are used instead of the "DLR_Drought_Intensity_Level" and "DLR_Low_State_Line_Q" state variables that were used in previous drought plan alternatives.

X. "RPlanD" Alternative

The RPlanD alternative introduces no new state variables. The difference between this alternative and previous alternatives is in the difference of operation sets at Logan Martin. The RPlanD alternative uses the Nav_Drought_Snail-rev operation set at Logan Martin, which also uses the state variables, "DLR_Drought_Intensity_Level_rev" and "DLR_Low_State_Line_Q_rev" to determine the flows to be used at JBT Goal and J.D. Minimum.

XI. "RPlanE" Alternative

The RPlanE alternative is identical to the RPlanC alternative with the exception of the operation set at Allatoona. Allatoona uses the Burkett C operation set as opposed to the Burkett B operation set in the RPlanE alternative. The difference between Burkett B and Burkett C is in the rule set and not in the state variables. No new state variables were introduced and are all used in a similar manner as described in the RPlanC alternative.

XII. "RPlanF" Alternative

The RPlanF alternative is identical to the RPlanD alternative with the exception of the operation set at Allatoona. Allatoona uses the Burkett C operation set as opposed to the Burkett B operation set in the RPlanE alternative. The difference between Burkett B and Burkett C is in the rule set and not in the state variables. No new state variables were introduced and are all used in a similar manner as described in the RPlanD alternative.

XIII. "RPlanG" Alternative

The "RPlanG" alternative is identical to the RPlanF alternative with the exception of the operation set at Allatoona. Allatoona uses the Burkett D operation set as opposed to the Burkett C operation set in the RPlanE alternative. The difference between Burkett C and Burkett D is in the rule set and not in the state variables. No new state variables were introduced and are all used in a similar manner as described in the RPlanF alternative with the exception of different power rules in the "CartersActivePowerReq" state variable.

A. Power and Energy Requirements

The RPlanG alternative power and energy operations at Allatoona are different from the baseline alternative operations, although no new state variables were introduced. Within the “CartersActivePowerReq” state variable, the power rules associated with different zones at Allatoona are defined below in Table L.08. The power rules at the other projects remain the same as they were in the baseline alternative.

Table L.08 List of Zones and Associated Power Rules at Allatoona for the RPlanG Alternative

Zone	Rule Name
Top of Dam (TOD)- Surcharge	(No Power Rule)
Flood Control (FC)	PowerGC FC_4hrs_Seasonal
Conservation (Con)	PowerGC Z1_4hrs_Seasonal
Zone 2 (Z2)	PowerGC Z2_3hrs_Seasonal
Zone 3 (Z3)	PowerGC Z3_0-2hrs_Seasonal
Inactive	(No Power Rule)

The “PowerGC FC_4hrs_Seasonal” rule in the Flood Control zone in the RPlanG alternative uses a plant factor of 16.67% (4 hours of power per day) at Allatoona for all amounts of power storage in use for all months of the year except for September through November (Figure L.49). The Power Generation Pattern reduces the amount of weekday power generation from September through November from 100% to 50% of the guide curve (4 hours of power per day to 2 hours of power per day). 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.

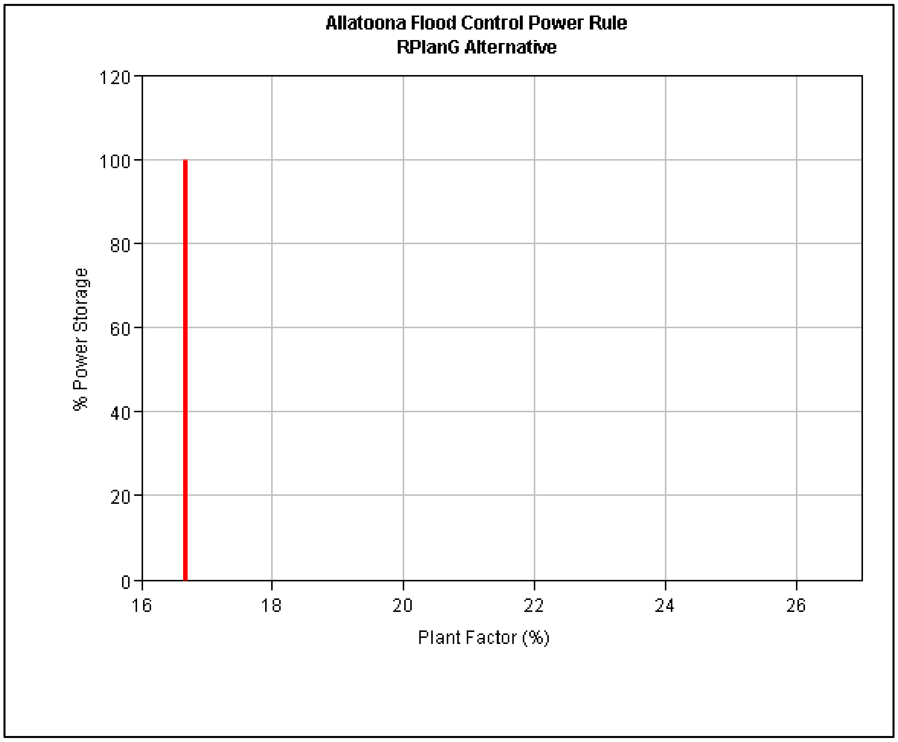


Figure L.49 PowerGC FC_4hrs_Seasonal Guide Curve

The “PowerGC Z1_4hrs_Seasonal” guide curve used in the Conservation zone is identical to the “PowerGC FC_4hrs_Seasonal” guide curve used in the Flood Control zone in this alternative (Figure L.50). At this elevation, Allatoona uses a plant factor of 16.67% (power and energy for 4 hours of the day) from 0-100% of power storage in use for all months of the year except for September through November. The Power Generation Pattern reduces the amount of weekday power generation from September through November from 100% to 50% of the guide curve (4 hours of power per day to 2 hours of power per day). 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.

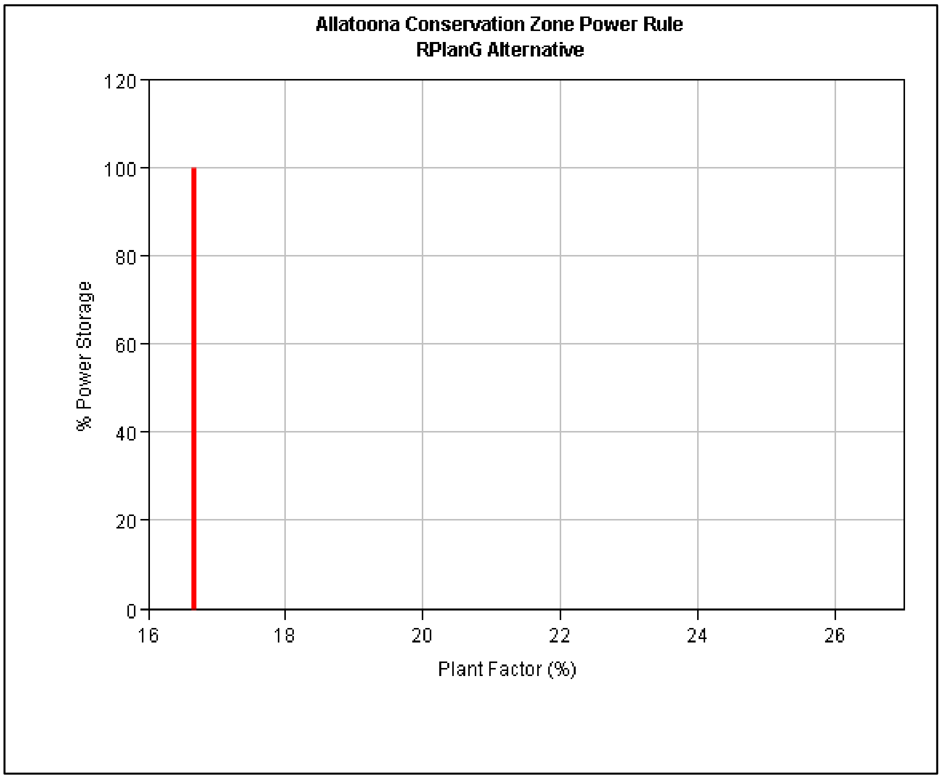


Figure L.50 PowerGC Z1_4hrs_Seasonal Guide Curve

The "PowerGC Z2_3hrs_Seasonal" rule in Zone 2 in the RPlanA alternative uses a plant factor of 12.5% (3 hours of power per day) at Allatoona for all amounts of power storage in use for all months of the year except for September through November (Figure L.51). The Power Generation Pattern reduces the amont of weekday power generation from September through November from 100% to 50% of the guide curve (3 hours of power per day to 1.5 hours of power per day). The zone at the top of the power pool is Zone 2 and the zone at the bottom of the power pool is Zone 3.

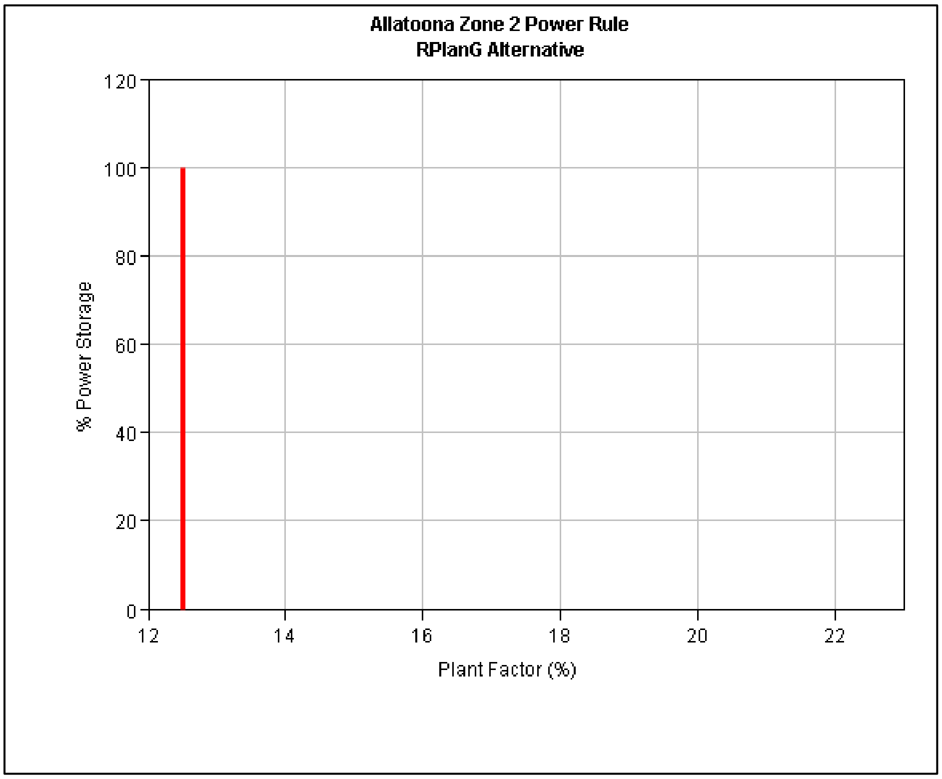


Figure L.51 PowerGC Z2_3hrs_Seasonal Guide Curve

For all months of the year except September through November, the "PowerGC Z3_0-2hrs_Seasonal" rule in Zone 3 generates power for zero to two hours, depending on the amount of power storage in use (Figure L.52). When under 10% of power storage is in use in Zone 3, no power is generated. From 10-79.99% of power storage in use, a 4.17% plant factor (1 hour of power) is used. From 80-100% a plant factor of 8.33% (2 hours of power) is used. From September 1st through November 30th, the Power Generation Pattern is set to 50% of the power guide, reducing the power generation at each amount of power storage in use by 50%. The zone at the top of the power pool is Zone 3 and the zone at the bottom of the power pool is Zone 4.

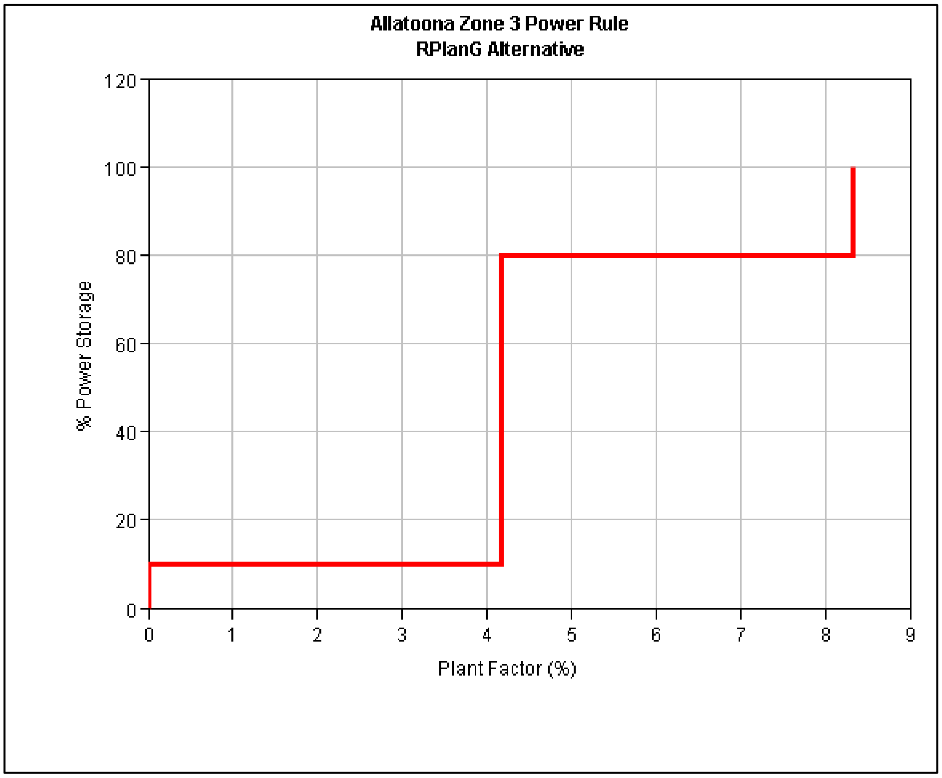


Figure L.52 PowerGC Z3_0-2hrs_Seasonal Guide Curve

XIV. Contents of State Variable Scripts

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State Variable – Allatoona_ElevState........L-76
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State Variable – DLR_Low_Basin_Inflow........L-122
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State Variable – LoganMartin_GCBuffer........L-145
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State Variable – NAV_CheckBI........L-151
State Variable – SpawnSeason........L-162
State Variable – ThurlowMinQ_hackney........L-164

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 – Carters_Seasonal_Min

```
#####
##### 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.

            #   These 12 values are the corresponding 7Q10 FLOWS (from Table 5, DLR document).
            #    The -1 is a placeholder for the "zeroeth" month so month numbers can be used to index the tuple table.
            #            Jan, Feb, Mar, Apr, May,  Jun, Jul,  Aug, Sep, Oct,  Nov, Dec
            mo_min = (-1,      660, 790, 865, 770, 620, 475, 400, 325, 250, 275, 350, 465)

            currentVariable.varPut("MonthlyMin", mo_min)
            return Constants.TRUE

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

# determine the minimum flow that Carters should release to support the rereg in meeting the seasonal minimum.
# this value should consider the inflow from Talking Rock Creek.

day_of_week=currentRuntimestep.getHecTime().dayOfWeek()
month = currentRuntimestep.month()
mo_min=currentVariable.varGet("MonthlyMin")
curMin=mo_min[month]
```

```
trcFlow = network.getTimeSeries("Junction","Talking Rock", "", "Flow").getCurrentValue(currentRuntimestep)
trcFlow = trcFlow

minRel = curMin - trcFlow -240
if minRel<0.0: minRel = 0.0
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 – CartersReReg_CompStor

```
#####
##### 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
#####

# Holder for comp storage calculated in CartersReRegCompositeZone

#####
##### 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 – CartersReRegCompositeZone

```
#####
##### 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 script calculates whether the composite storage in Carters and Carters Rereg is Zone1 or Zone2
 # It uses a Composite Zone defined at Carters # quoth RAA:
#     "It includes the storage in rereg between elev. 677-696 (or current definition of Buffer-ToC)
#     but not more than would fill the main dam above its seasonal level (1072/1074)"
# SMO 06/26/2009
# updated 07/01/2009
#------------------------------------------------------------------------------------------------------------------------------------



# ------------------------------------------------------------------------------------------------------------------------------------
# Set up the test to calculate this variable only on a certain day of the week
# ------------------------------------------------------------------------------------------------------------------------------------

# Set DayOfWeek to be the day you would like the Composite Zone decision to be made.
# 0=Sun; 1=Mon; 2=Tue; 3=Wed; 4=Thu; 5=Fri; 6=Sat
DayOfWeek = 0

curDay = currentRuntimestep.getDayOfWeek()
```

```
# If the current Runtimestep falls on the correct day of the week, set the trigger
# that will calculate and set the current Composite Storage zone.
if curDay == DayOfWeek :
    TriggerCheckCompZone = 1
else :
    TriggerCheckCompZone = 0

# ----------------------------------------------------------------------------------------------------------------------------------------
# Get the current value of Storage in Carters and the ReReg
# ----------------------------------------------------------------------------------------------------------------------------------------
Carter_Stor = network.getTimeSeries("Reservoir","Carters", "Pool", "Stor").getPreviousValue(currentRuntimestep)
ReReg_Stor = network.getTimeSeries("Reservoir","Carters ReReg", "Pool", "Stor").getPreviousValue(currentRuntimestep)

# ----------------------------------------------------------------------------------------------------------------------------------------
# Get the current value of Storage for ReReg Buffer and Top of Conservation
# ----------------------------------------------------------------------------------------------------------------------------------------
ReRegBuff_Stor = network.getTimeSeries("Reservoir","Carters ReReg", "Buffer", "Stor-ZONE").getCurrentValue(currentRuntimestep)
ReRegToC_Stor = network.getTimeSeries("Reservoir","Carters ReReg", "Conservation", "Stor-ZONE").getCurrentValue(currentRuntimestep)

# ----------------------------------------------------------------------------------------------------------------------------------------
# Do not count ReReg storage above the Top of Con pool
# ----------------------------------------------------------------------------------------------------------------------------------------
if ReReg_Stor > ReRegToC_Stor :
    ReReg_Stor = ReRegToC_Stor

# ----------------------------------------------------------------------------------------------------------------------------------------
# If the storage in the ReReg is below the Buffer pool, do not count it towards composite storage.
# ----------------------------------------------------------------------------------------------------------------------------------------
if ReReg_Stor < ReRegBuff_Stor :
    TotalCompStor = Carter_Stor
else :
    TotalCompStor = Carter_Stor + ReReg_Stor - ReRegBuff_Stor

# ----------------------------------------------------------------------------------------------------------------------------------------
# Get the previous value of Storage for Top of Composite Zone 2
# ----------------------------------------------------------------------------------------------------------------------------------------
TopZone2 = network.getTimeSeries("Reservoir","Carters", "CompositeZone2", "Stor-ZONE").getCurrentValue(currentRuntimestep)
# TopCarterCon = network.getTimeSeries("Reservoir","Carters", "Conservation", "Stor-ZONE").getCurrentValue(currentRuntimestep)

# ----------------------------------------------------------------------------------------------------------------------------------------
# If the current RunTimeStep is on the given day of the week, set the Composite Storage Zone.
# ----------------------------------------------------------------------------------------------------------------------------------------
```

```
# initialize the current Variable.
# The lookback time-series will also cover this.
currentVariable.setValue(currentRuntimestep, 1)

if TriggerCheckCompZone == 1 :

    # Composite Storage must fall above Zone2 Storage in Carters
    # -----------------------------------------------------------------------------------------
    if TotalCompStor > TopZone2 :
      currentVariable.setValue(currentRuntimestep, 1)
    else :
      currentVariable.setValue(currentRuntimestep, 2)

else :
    # it is not the chosen day of the week for making the comp zone decision.
    # so, set the Comp Zone to be the same value as yesterday.
    prevZone = currentVariable.getPreviousValue(currentRuntimestep)
    currentVariable.setValue(currentRuntimestep, prevZone)

# ---------------------------------------------------------------------------------------------------------------------------------------------
# Store the value of Composite Storage to another State variable
# ---------------------------------------------------------------------------------------------------------------------------------------------
network.getStateVariable("CartersReReg_CompStor").setValue(currentRuntimestep, TotalCompStor)

# print currentRuntimestep.dateTimeString(), TotalCompStor, currentVariable.getValue(currentRuntimestep)

#####
##### 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 – DLR_BI

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

from hec.script import Constants
#
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
#####

#Daily Basin Inflow, calculated in "Nav_CheckBI"

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

# do nothing.
```

State Variable – DLR_BI_14d

```
#####
##### 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
#####

# Holder for the 14-day average Basin Inflow for DLR.  Calculated in  state variable "Nav_CheckBI"

#####
##### 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 – DLR_BI_MinReq

```
#####
##### 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
#####

# Holder for the required minimum average monthly Basin Inflow found in BI_Table in "Nav_CheckBI"

#####
##### 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 – DLR_BI_monAvg

```
#####
##### 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
#####

# Holder for the average monthly Basin Inflow.  Calculated in  state variable "Nav_CheckBI"

#####
##### 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 – DLR_CS_Actual

```
#####
##### 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
#####

# Holder for Composite current Storage calculated in "DLR_Low_Composite_Stor"

#####
##### 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 – DLR_CS_Actual_Active

```
#####
##### 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
#####

# Holder for the Composite current "Active" Storage calculated in "DLR_Low_Composite_Stor"

#####
##### 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 – DLR_CS_CON

```
#####
##### 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
#####

# Holder for Composite Conservation Storage calculated in "DLR_Low_Composite_Stor"

#####
##### 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 – DLR_CS_CON_Active

```
#####
##### 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
#####

# Holder for Composite "active" Conservation Storage calculated in "DLR_Low_Composite_Stor"

#####
##### 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 – DLR_CS_DRT

```
#####
##### 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
#####

# Holder for Composite Drought Storage calculated in "DLR_Low_Composite_Stor"

#####
##### 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 – DLR_CS_DRT_Active

```
#####
##### 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
#####

# Holder for Composite "active" Drought Storage calculated in "DLR_Low_Composite_Stor"

#####
##### 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 – DLR_CS_OIA

```
#####
##### 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
#####

# Holder for Composite "Operating Inactive" Storage calculated in "DLR_Low_Composite_Stor"

#####
##### 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 – DLR_Drought_Intensity_Level

```
#####
##### 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
#####

from hec.model import RunTimeStep

# Drought Intensity Level
# Determine the drought intensity level based on Low Basin Inflow, Low Composite Storage and Low StateLine Flow (RomeCoosa).
# 0 = Normal (0 of 3)
# 1 = 1 of 3
# 2 = 2 of 3
# 3 = 3 of 3

#  *** NOTE *** NOTE *** NOTE *** NOTE
#  In order to keep this script clean and simple, it relies on the premise that the three DLR "Low" state vars used below have already been computed.
#  The only way to guarantee this is to force a rule or if block to access those state vars before the if block that uses THIS state var.
#  If the dummy if block and rule is removed from the reservoir(s) then the script code from the other three state vars will need to be moved here
#  making this state var a "master" script (but it wouldn't be "pretty").
# 10/2010 adjusted to calculate twice a month instead of once a month.
#  *** NOTE *** NOTE *** NOTE *** NOTE
```

```
#		----------Month Stuff----------
prevRTS = RunTimeStep(currentRuntimestep)
prevRTS.setStep(currentRuntimestep.getPrevStep())
prevStepMon = prevRTS.month()
curStepMon = currentRuntimestep.month()
# since timestep is reported at 24:00, look at the previous timestep to get the current day
#curDayofMon = currentRuntimestep.getHecTime().day()
prevDayofMon = prevRTS.getHecTime().day() # actually will be today's day of month

#	Check to see if it is either the 1st or 15th of the month
if ( prevDayofMon == 1 or prevDayofMon == 15) :

	#	On the first (or 15th) day of the month (now), determine state of "Drought Intensity Level" triggers

	#  get the three "Low" trigger values
	BI =network.getStateVariable("DLR_Low_Basin_Inflow").getValue(currentRuntimestep)
	CS=network.getStateVariable("DLR_Low_Composite_Stor").getValue(currentRuntimestep)
	SL=network.getStateVariable("DLR_Low_State_Line_Q").getValue(currentRuntimestep)

	# Composite Storage may have been set to -1 if system is in flood control.
	# Values of both -1 and 0 indicate "not drought".  Therefore, reset trigger to 0 for purposes of this script.
	if (CS<0): CS = 0

	# determine Drought Intensity Level by summing up the "pieces"
	tempDIL=BI+CS+SL
	prevDIL=currentVariable.getPreviousValue(currentRuntimestep)

	# check previous Drought Intensity vs. Computed current Drought Intensity
	if (tempDIL<prevDIL):
		# don't allow recover from drought by more than one level per month
		DIL = prevDIL - 1
		if (DIL < 0): DIL = 0
	else:
		DIL = tempDIL
else:
	DIL = currentVariable.getPreviousValue(currentRuntimestep)

currentVariable.setValue(currentRuntimestep, DIL)
```

```
#####
##### 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 – DLR_Drought_Intensity_Level_rev

```
#####
##### 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
#####

# ------------------------------------------------------------------------------------------------------------------------
# ------------------------------------------------------------------------------------------------------------------------
# Drought Intensity Level
# Determine the drought intensity level based on Low Basin Inflow, Low Composite Storage and Low StateLine Flow (RomeCoosa).
# 0 = Normal (0 of 3)
# 1 = 1 of 3
# 2 = 2 of 3
# 3 = 3 of 3

#  *** NOTE *** NOTE *** NOTE *** NOTE
#  In order to keep this script clean and simple, it relies on the premise that the three DLR "Low" state vars used below have already been computed.
#  The only way to guarantee this is to force a rule or if block to access those state vars before the if block that uses THIS state var.
#  If the dummy if block and rule is removed from the reservoir(s) then the script code from the other three state vars will need to be moved here
#  making this state var a "master" script (but it wouldn't be "pretty").
# 10/2010 - adjusted to calculate twice a month instead of once a month.
#
# 10/27/2010 - This state variable was changed to use the revised State line flow definitions (DLR_Low_State_Line_Q_rev).
#  *** NOTE *** NOTE *** NOTE *** NOTE
# ------------------------------------------------------------------------------------------------------------------------
# ------------------------------------------------------------------------------------------------------------------------
```

```
from hec.model import RunTimeStep

#	----------Month Stuff----------
prevRTS = RunTimeStep(currentRuntimestep)
prevRTS.setStep(currentRuntimestep.getPrevStep())
prevStepMon = prevRTS.month()
curStepMon = currentRuntimestep.month()
# since timestep is reported at 24:00, look at the previous timestep to get the current day
#curDayofMon = currentRuntimestep.getHecTime().day()
prevDayofMon = prevRTS.getHecTime().day() # actually will be today's day of month

#    Check to see if it is either the 1st or 15th of the month
if ( prevDayofMon == 1 or prevDayofMon == 15) :

	#    On the first (or 15th) day of the month (now), determine state of "Drought Intensity Level" triggers

	#  get the three "Low" trigger values
	BI =network.getStateVariable("DLR_Low_Basin_Inflow").getValue(currentRuntimestep)
	CS=network.getStateVariable("DLR_Low_Composite_Stor").getValue(currentRuntimestep)
	SL=network.getStateVariable("DLR_Low_State_Line_Q_rev").getValue(currentRuntimestep)

	# Composite Storage may have been set to -1 if system is in flood control.
	# Values of both -1 and 0 indicate "not drought".  Therefore, reset trigger to 0 for purposes of this script.
	if (CS<0): CS = 0

	# determine Drought Intensity Level by summing up the "pieces"
	tempDIL=BI+CS+SL
	prevDIL=currentVariable.getPreviousValue(currentRuntimestep)

	# check previous Drought Intensity vs. Computed current Drought Intensity
	if (tempDIL<prevDIL):
		# don't allow recover from drought by more than one level per month
		DIL = prevDIL - 1
		if (DIL < 0): DIL = 0
	else:
		DIL = tempDIL
else:
	DIL = currentVariable.getPreviousValue(currentRuntimestep)

currentVariable.setValue(currentRuntimestep, DIL)
```

```
#####
##### 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 – DLR_Half_Yates_Inflow

```
#####
##### 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
#####

from hec.script import Constants
# Return the minimum flow required at Tallassee as 5xYatesInflow with the bounds of 350 to 1200.
# Each Tuesday, decide what the minimum flow is and hold that minimum until the next Tuesday decision.

YatesInflow = network.getTimeSeries("Reservoir","Yates", "Pool", "Flow-IN NET").getPreviousValue(currentRuntimestep)
curDay = currentRuntimestep.getDayOfWeek()

#  set min flow to previous period's value
minFlow = currentVariable.getPreviousValue(currentRuntimestep)

#  if Tuesday or if the first simulation period, then reset the minimum flow value
if (curDay==2 or minFlow==Constants.UNDEFINED):
            minFlow1 = max( .5*YatesInflow, 350)
            minFlow = min(minFlow1, 1200.1)


currentVariable.setValue(currentRuntimestep, minFlow)
```

```
#####
##### 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 – DLR_Low_Basin_Inflow

```
#####
##### 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 is now calculated in NAV_CheckBI

#####
##### 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 – DLR_Low_Composite_Stor

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

from hec.script import Constants
from hec.heclib.util import intContainer
#
# initialization function. optional.
#
# set up tables and other things that only need to be performed once during
# 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):
	# establish and initialize any variables local to the state variable that are needed from once script execution to another
	currentVariable.varPut("checkStep", intContainer(-1))
#	- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

#	- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
# 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
#####

#  DLR_Low_Composite_Stor ... (3/10/2010, mbh & jdk)
# adjusted 10/19/2010 in order to calculate on the 1st and 15th instead of only on the 1st.
# This state variable, determines whether or not the current APC system composite storage
# meets the "LOW COMPOSITE STORAGE" criteria (i.e., in DROUGHT storage).
# System Composite Storage "State" is set as follows:
#	< 0	system is in FLOOD CONTROL
#	= 0	system is in CONSERVATION
#	> 0	system is in DROUGHT
```

```
from hec.script import Constants
#from hec.hecmath import DSS
#from hec.model import Interpolate
from hec.heclib.util import intContainer
from hec.model import RunTimeStep


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

# -------------------------------------------------------------------------------------------------------------------------
#
#    Main()
#
# -------------------------------------------------------------------------------------------------------------------------

# establish some testing variables so that the major portion of the script only gets executed once per timestep.
# Note: checkStep was setup in the init script of this state variable.

checkStep = currentVariable.varGet("checkStep")
current_step = currentRuntimestep.getStep()

if  (checkStep.value  != current_step) :
	checkStep.value = current_step
	# -------------------------------------------------------------------------------------------------------------------------
	#     Determine if in a "LOW Composite Storage" state
	# -------------------------------------------------------------------------------------------------------------------------
	prevRTS = RunTimeStep(currentRuntimestep) # just to set prevRTS as a RunTimeStep
	prevRTS.setStep(currentRuntimestep.getPrevStep())
	prevStepMon = prevRTS.month()
	curStepMon = currentRuntimestep.month()
	# since timestep is reported at 24:00, look at the previous timestep to get the current day
	prevDayofMon = prevRTS.getHecTime().day() # actually will be today's day of month


	#    Check to see if it is either the 1st or 15th of the month
	if ( prevDayofMon == 1 or prevDayofMon == 15) :
```

```
                    #     current period's month is NOT the same as the previous period's month
                    #     therefore, it's a NEW MONTH and need to compare the 7Q10 flow value (from table)
                    #                 vs.  previous month's minimum flow at Rome_Coosa.
                    #

#                   print "performing DLR composite storage calculation for step ", current_step, "  ", currentRuntimestep.dateTimeString(),"
PASS=",network.getComputePassCounter()

# Current storage for each of the "5" OPERATING reservoirs (Weiss, HN Henry, Logan Martin, Harris, and Martin)
                    Weiss_STOR = network.getTimeSeries("Reservoir","Weiss", "Pool", "Stor").getPreviousValue(currentRuntimestep)
                    HNHenry_STOR = network.getTimeSeries("Reservoir","HN Henry", "Pool", "Stor").getPreviousValue(currentRuntimestep)
                    LoganMartin_STOR = network.getTimeSeries("Reservoir","Logan Martin", "Pool", "Stor").getPreviousValue(currentRuntimestep)
                    Harris_STOR = network.getTimeSeries("Reservoir","Harris", "Pool", "Stor").getPreviousValue(currentRuntimestep)
                    Martin_STOR = network.getTimeSeries("Reservoir","Martin", "Pool", "Stor").getPreviousValue(currentRuntimestep)


# Pertinant Zone storage values for each of the "5" OPERATING reservoirs (Weiss, HN Henry, Logan Martin, Harris, and Martin)
# Weiss      zone storages
                    Weiss_CON = network.getTimeSeries("Reservoir","Weiss", "Conservation", "Stor-ZONE").getPreviousValue(currentRuntimestep)
                    Weiss_DRT = network.getTimeSeries("Reservoir","Weiss", "Drought", "Stor-ZONE").getPreviousValue(currentRuntimestep)
                    Weiss_OIA = network.getTimeSeries("Reservoir","Weiss", "Operating Inactive", "Stor-ZONE").getPreviousValue(currentRuntimestep)
# HN Henry   zone storages
                    HNHenry_CON = network.getTimeSeries("Reservoir","HN Henry", "Conservation", "Stor-ZONE").getPreviousValue(currentRuntimestep)
                    HNHenry_DRT = network.getTimeSeries("Reservoir","HN Henry", "Drought", "Stor-ZONE").getPreviousValue(currentRuntimestep)
                    HNHenry_OIA = network.getTimeSeries("Reservoir","HN Henry", "Operating Inactive", "Stor-
ZONE").getPreviousValue(currentRuntimestep)
# Logan Martin zone storages
                    LoganMartin_CON = network.getTimeSeries("Reservoir","Logan Martin", "Conservation", "Stor-
ZONE").getPreviousValue(currentRuntimestep)
                    LoganMartin_DRT = network.getTimeSeries("Reservoir","Logan Martin", "Drought", "Stor-ZONE").getPreviousValue(currentRuntimestep)
                    LoganMartin_OIA = network.getTimeSeries("Reservoir","Logan Martin", "Operating Inactive", "Stor-
ZONE").getPreviousValue(currentRuntimestep)
# Harris     zone storages
                    Harris_CON = network.getTimeSeries("Reservoir","Harris", "Conservation", "Stor-ZONE").getPreviousValue(currentRuntimestep)
                    Harris_DRT = network.getTimeSeries("Reservoir","Harris", "Drought", "Stor-ZONE").getPreviousValue(currentRuntimestep)
                    Harris_OIA = network.getTimeSeries("Reservoir","Harris", "Operating Inactive", "Stor-ZONE").getPreviousValue(currentRuntimestep)
# Martin     zone storages
                    Martin_CON = network.getTimeSeries("Reservoir","Martin", "Conservation", "Stor-ZONE").getPreviousValue(currentRuntimestep)
                    Martin_DRT = network.getTimeSeries("Reservoir","Martin", "Drought", "Stor-ZONE").getPreviousValue(currentRuntimestep)
                    Martin_OIA = network.getTimeSeries("Reservoir","Martin", "Operating Inactive", "Stor-ZONE").getPreviousValue(currentRuntimestep)
```

```
# ----------------------------------------------------------------------------------------------------------------------
# Define Composite Storages & set corresponding State Variable values
#          and assign the computed composite storage values to their respective state variables
# ----------------------------------------------------------------------------------------------------------------------

# for only the "5" OPERATING Reservoirs...
# Composite Storage at top of Conservation zone
                    CS_CON = Weiss_CON + HNHenry_CON + LoganMartin_CON + Harris_CON + Martin_CON
                    network.getStateVariable("DLR_CS_CON").setValue(currentRuntimestep, CS_CON)
# Composite Storage at top of Drought zone
                    CS_DRT = Weiss_DRT + HNHenry_DRT + LoganMartin_DRT + Harris_DRT + Martin_DRT
                    network.getStateVariable("DLR_CS_DRT").setValue(currentRuntimestep, CS_DRT)
# Composite Storage at top of Operating Inactive zone ...  Only the "5" OPERATING APC Reservoirs
                    CS_OIA = Weiss_OIA + HNHenry_OIA + LoganMartin_OIA + Harris_OIA + Martin_OIA
                    network.getStateVariable("DLR_CS_OIA").setValue(currentRuntimestep, CS_OIA)

#  ACTIVE Composite Storages
                    CS_CON_Active = CS_CON - CS_OIA
                    network.getStateVariable("DLR_CS_CON_Active").setValue(currentRuntimestep, CS_CON_Active)
                    CS_DRT_Active = CS_DRT - CS_OIA
                    network.getStateVariable("DLR_CS_DRT_Active").setValue(currentRuntimestep, CS_DRT_Active)

# CURRENT (Actual) Composite Storage for "5" APC reservoirs (Operating).
                    CS_Actual = Weiss_STOR + HNHenry_STOR + LoganMartin_STOR + Harris_STOR + Martin_STOR
                    network.getStateVariable("DLR_CS_Actual").setValue(currentRuntimestep, CS_Actual)

# CURRENT ACTIVE (Actual) Composite Storage for "5" APC reservoirs (Operating).
                    CS_Actual_Active = CS_Actual - CS_OIA
                    network.getStateVariable("DLR_CS_Actual_Active").setValue(currentRuntimestep, CS_Actual_Active)

# ----------------------------------------------------------------------------------------------------------------------
# Define the Composite Storage State and set the resulting value for this state variable
# ----------------------------------------------------------------------------------------------------------------------

# Check where the Actual Composite Storage lies with respect to the defined
# Composite Storage Zones.  Use the following Composite Storage state definition:
#
#           Zone                                    CS State
#           ----------                              -----------
#          Above Con.        (i.e., Flood Control)          -1
#          Above Drought   (i.e., Conservation)             0
#          LOW Composite DROUGHT Storage                    1
```

```
#
#           tolerance of 0.1 ac-ft used on Con pool to address DSS precision  issue (double vs. single)

                        if CS_Actual_Active > (CS_CON_Active  + 0.1) :
                                    CS_state = -1
                        elif  CS_Actual_Active > CS_DRT_Active :
                                    CS_state =  0
                        else :
                                    CS_state =  1



            else:
                        # current period's month is the SAME as the previous period's month; use previous period's "CS _state value"
                        CS_state = currentVariable.getPreviousValue(currentRuntimestep)

#           store a value every day, even though the value only changes on the first & fifteenth of the month
            currentVariable.setValue(currentRuntimestep, CS_state)

#####
##### 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
currentVariable.varsClear()
```

State Variable – DLR_Low_State_Line_Q

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

from hec.script import Constants
from hec.heclib.util import intContainer
# from hec.heclib.util import doubleContainer
#
# initialization function. optional.
#
# set up tables and other things that only need to be performed once during 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):
        # establish and initialize any variables local to the state variable that are needed from once script execution to another
        currentVariable.varPut("checkStep", intContainer(-1))
#       - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
#
        #   These 12 values are the corresponding 7Q10 FLOWS (from Table 5, DLR document).
        #    The -1 is a placeholder for the "zeroeth" month so month numbers can be used to index the tuple table.
        #             Jan,   Feb,   Mar,     Apr,   May,    Jun,
        SL_7Q10 = (-1,   2356, 2957, 3057, 2779, 2300, 2014,  \
        #
        #              Jul,   Aug,   Sep,    Oct,     Nov,    Dec
                1607, 1569, 1424, 1286, 1574, 2204)

        currentVariable.varPut("StateLine_7Q10", SL_7Q10)
#       - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

        RCflowTS=network.getTimeSeries("Junction","Rome-Coosa", "", "Flow")
        RC7dTS = network.getStateVariable("DLR_SLQ_RC7d").getTimeSeries()

        # get timewindow for using in DSS read/open
        tw=network.getRssRun().getCurrentComputeBlockRunTimeWindow()

        numLBsteps=tw.getNumLookbackSteps()
        i=6
```

```
        while i <= numLBsteps:
                curflow7d = RCflowTS.getPeriodAverage(i, 7)
                RC7dTS.setCurrentValue(i, curflow7d)
                i=i+1

#       - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

#       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
#####

# ---------------------------------------------------------------------------------------------------------------------
# ---------------------------------------------------------------------------------------------------------------------
# DLR_LowStateLineQ... written 3/10/2010, mbh & jdk.
# --------------------------------------------------------------------------------------------------------------------
# ---------------------------------------------------------------------------------------------------------------------
# This state variable, determines whether or not the flow at Rome_Coosa (i.e., Mayo's Bar)
# meets the "LOW STATE LINE FLOW" criteria (see Table 5, DLR document).
# Flag is set as follows:
#       = 0     NORMAL flow
#       > 0     LOW flow

# modified 9/2/10, mbh & jdk to replace computation of 7day average.  original was producing
# invalid and unexplainable results.
# modified 10/8/2010, jdk to change from 1/month (1st) computation to 2/month (1st and 15th).
# ---------------------------------------------------------------------------------------------------------------------
# ---------------------------------------------------------------------------------------------------------------------

#from hec.script import Constants
#from hec.hecmath import DSS
#from hec.model import Interpolate
from hec.heclib.util import intContainer
from hec.model import RunTimeStep
```

```
# ---------------------------------------------------------------------------------------------------------------------
#
#    Main()
#
# ---------------------------------------------------------------------------------------------------------------------

# establish some testing variables so that the major portion of the script only gets executed once per timestep.
# Note: checkStep was setup in the init portion of this state variable.

checkStep = currentVariable.varGet("checkStep")
current_step = currentRuntimestep.getStep()

if  (checkStep.value  != current_step) :
        checkStep.value = current_step

#       print "performing DLR LowStateLineQ calculation for step ", current_step, "  ", currentRuntimestep.dateTimeString(),"
PASS=",network.getComputePassCounter()

        # ---------------------------------------------------------------------------------------------------------------------
        #     Determine if in a LOW Stateline "Flow State"
        # ---------------------------------------------------------------------------------------------------------------------

        #       ----------Month and Day Stuff----------
                # Note: due to issues with hectime objects and ResSim daily timestep, the HecTime call for day() consistently returns "tomorrow" for today.
                #       In other words, if the currentRunTimeStep thinks today is 05Jan2010 24:00, then the hecTime.day() will return 6.  Rather than
                #       trying to keep track of each month and so on, we establish a previous runtimestep to get TODAY from it.  And we do the same for
                #       yesterday (we get a previous of the previous).
                #       In short: since timestep is reported at 24:00 (which java thinks is tomorrow), look at the previous timestep to get the current day.
                #       Now, if you understand that, you can follow the next block of code.


        curStepMon = currentRuntimestep.month()

        prevRTS = RunTimeStep(currentRuntimestep)                       # using constructor to get an RTS for the previous timestep (current -1) (to get today)
        prevRTS.setStep(currentRuntimestep.getPrevStep())
        prevStepMon = prevRTS.month()
        today =  prevRTS.getHecTime().day()

        prevprevRTS = RunTimeStep(currentRuntimestep)    # and another new RTS to be current -2 (to get yesterday)
        prevprevRTS.setStep(prevRTS.getPrevStep())
        yesterday = prevprevRTS.getHecTime().day()
```

```
# print "yesterday = ", yesterday, "     today = ", today
#           ----------end Month and Day Stuff----------

RCflowTS=network.getTimeSeries("Junction","Rome-Coosa", "", "Flow")
curflow7d = RCflowTS.getPeriodAverage(currentRuntimestep, 7)
RC7dSV = network.getStateVariable("DLR_SLQ_RC7d")
RC7dSV.setValue(currentRuntimestep, curflow7d)

SL_7Q10Table = currentVariable.varGet("StateLine_7Q10")

if (today == 1):
        #  it's a new period, determine if we have low state line flow during the last half of last month...
        #  note:we are always comparing the running min to the value in the table corresponding to the month the flow occurred in.
        #  Thus, on the 1st, we compare the running min to last month's table value.

        #   get the day of month for the last day of last month (28, 29, 30 or 31) and subtract the 1st half (14 days)
        daysInLastHalf = yesterday - 14

        # note - the min call doesn't work "backwards".  So get the starting step at the beginning of the month and the number of days in month
        # take care of partial month at start of simulation or which can occur during time-blocking.
        lastDayStep=prevRTS.getStep()
        begin = lastDayStep - daysInLastHalf + 1
        if begin < 1:
                begin = 1
                period = lastDayStep
        else:
                period = daysInLastHalf

        #  what is the minimum 7day avg flow that occurred at Rome_Coosa in the previous period?
        RC7dTS = RC7dSV.getTimeSeries()
        minRCQ=RC7dTS.min(begin,period)
        network.getStateVariable("DLR_SLQ_minRCflow").setValue(prevRTS, minRCQ)

        # what is the 7Q10 flow value from table? - use THIS month's value, not previous month.
        SL_7Q10 = SL_7Q10Table[curStepMon]
        network.getStateVariable("DLR_SLQ_SL7Q10").setValue(prevRTS, SL_7Q10)

        #  if previous period's flow at Rome_Coosa was less than the 7Q10 flow for *THIS* period's month, then
        if (minRCQ < SL_7Q10):
                #  Yes, the "flow state" is defined as LOW State Line Flow!
                LowQ_state = 1
        else:
```

```
            #  No, the "flow state" is defined as NORMAL
            LowQ_state = 0


    elif (today ==15):
        #  it's a new period, determine if we have low state line flow during the 1st half of last month...
        #  note:we are always comparing the running min to the value in the table corresponding to the month the flow occurred in.
        #  So, on the 15th, we compare to this month's value.

        #   get the day of month for the last day of last month (28, 29, 30 or 31) and subtract the 1st half (14 days)
        daysInFirstHalf = 14

        # note - the min call doesn't work "backwards".  So get the starting step at the beginning of the month and the number of days in month
        # take care of partial month at start of simulation or which can occur during time-blocking.
        lastDayStep=prevRTS.getStep()
        begin = lastDayStep - daysInFirstHalf + 1
        if (begin < 1):
            begin = 1
            period = lastDayStep
        else:
            period = daysInFirstHalf
#       print "lastDayStep = ", lastDayStep, "    begin=", begin, "   period=", period

        #  what is the minimum 7day avg flow that occurred  at Rome_Coosa in the previous period?
        RC7dTS = RC7dSV.getTimeSeries()
        minRCQ=RC7dTS.min(begin,period)
        network.getStateVariable("DLR_SLQ_minRCflow").setValue(prevRTS, minRCQ)

        # what is the 7Q10 flow value from table - use current month's value?
        SL_7Q10 = SL_7Q10Table[curStepMon]
        network.getStateVariable("DLR_SLQ_SL7Q10").setValue(prevRTS, SL_7Q10)

        #  if previous periods's flow at Rome_Coosa was less than the 7Q10 flow for thismonth, then
        if (minRCQ < SL_7Q10):
            #  Yes, the "flow state" is defined as LOW State Line Flow!
            LowQ_state = 1
        else:
            #  No, the "flow state" is defined as NORMAL
            LowQ_state = 0
    else:
        # current period's month is the SAME as the previous period's month; use previous period's "flow state"
        LowQ_state=currentVariable.getPreviousValue(currentRuntimestep)
```

```
                # save this month's 7Q10 each day...
                # set the previous day's value with the value for the current month.
                # this will work because the else block is for all days except the 1st of the month.
                SL_7Q10=SL_7Q10Table[curStepMon]
                network.getStateVariable("DLR_SLQ_SL7Q10").setValue(prevRTS, SL_7Q10)

        #message =  currentRuntimestep.dateTimeString() + "\tSL_LowQ_state " + `LowQ_state` + "current value\n"
        #network.printLogMessage(message)

        currentVariable.setValue(currentRuntimestep, LowQ_state)

#####
##### 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
currentVariable.varsClear()
```

State Variable – DLR_Low_State_Line_Q_rev

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

from hec.script import Constants
from hec.heclib.util import intContainer
# from hec.heclib.util import doubleContainer
#
# initialization function. optional.
#
# set up tables and other things that only need to be performed once during 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):
	# establish and initialize any variables local to the state variable that are needed from once script execution to another
	currentVariable.varPut("checkStep", intContainer(-1))
#	- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
#
	#   These 12 values are the corresponding 7Q10 FLOWS (from Table 5, DLR document).
	#    The -1 is a placeholder for the "zeroeth" month so month numbers can be used to index the tuple table.
	#  10/27/2010 - revised per JEH email after meeting with APC
	#              Jan,   Feb,   Mar,     Apr,   May,    Jun,
	SL_7Q10 = (-1,   2544, 2982, 3258, 2911, 2497, 2153,  \
	#
	#               Jul,   Aug,   Sep,    Oct,    Nov,    Dec
		1693, 1601, 1406, 1325, 1608, 2043)

	currentVariable.varPut("StateLine_7Q10", SL_7Q10)
#	- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

	RCflowTS=network.getTimeSeries("Junction","Rome-Coosa", "", "Flow")
	RC7dTS = network.getStateVariable("DLR_SLQ_RC7d").getTimeSeries()

	# get timewindow for using in DSS read/open
	tw=network.getRssRun().getCurrentComputeBlockRunTimeWindow()

	numLBsteps=tw.getNumLookbackSteps()
	i=6
```

```
        while i <= numLBsteps:
                curflow7d = RCflowTS.getPeriodAverage(i, 7)
                RC7dTS.setCurrentValue(i, curflow7d)
                i=i+1

#       - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

#       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
#####

# ------------------------------------------------------------------------------------------------------------------------
# ------------------------------------------------------------------------------------------------------------------------
# DLR_LowStateLineQ_rev... written 3/10/2010, mbh & jdk.
# -----------------------------------------------------------------------------------------------------------------------
# ------------------------------------------------------------------------------------------------------------------------
# This state variable, determines whether or not the flow at Rome_Coosa (i.e., Mayo's Bar)
# meets the "LOW STATE LINE FLOW" criteria (see Table 5, DLR document).
# Flag is set as follows:
#       = 0     NORMAL flow
#       > 0     LOW flow

# modified 9/2/10, mbh & jdk to replace computation of 7day average.  original was producing
# invalid and unexplainable results.
# modified 10/8/2010, jdk to change from 1/month (1st) computation to 2/month (1st and 15th).
# modified 10/27/2010, smo to use revised Low State Line flow values (see init tab)
# ------------------------------------------------------------------------------------------------------------------------
# ------------------------------------------------------------------------------------------------------------------------

#from hec.script import Constants
#from hec.hecmath import DSS
#from hec.model import Interpolate
from hec.heclib.util import intContainer
from hec.model import RunTimeStep
```

```
# -----------------------------------------------------------------------------------------------------------------
#
#   Main()
#
# -----------------------------------------------------------------------------------------------------------------

# establish some testing variables so that the major portion of the script only gets executed once per timestep.
# Note: checkStep was setup in the init portion of this state variable.

checkStep = currentVariable.varGet("checkStep")
current_step = currentRuntimestep.getStep()

if  (checkStep.value  != current_step) :
        checkStep.value = current_step

#       print "performing DLR LowStateLineQ calculation for step ", current_step, "  ", currentRuntimestep.dateTimeString()," PASS=",network.getComputePassCounter()

        # -----------------------------------------------------------------------------------------------------------------
        #    Determine if in a LOW Stateline "Flow State"
        # -----------------------------------------------------------------------------------------------------------------

        #       ----------Month and Day Stuff----------
                # Note: due to issues with hectime objects and ResSim daily timestep, the HecTime call for day() consistently returns "tomorrow" for today.
                #       In other words, if the currentRunTimeStep thinks today is 05Jan2010 24:00, then the hecTime.day() will return 6.  Rather than
                #       trying to keep track of each month and so on, we establish a previous runtimestep to get TODAY from it.  And we do the same for
                #       yesterday (we get a previous of the previous).
                #       In short: since timestep is reported at 24:00 (which java thinks is tomorrow), look at the previous timestep to get the current day.
                #       Now, if you understand that, you can follow the next block of code.


        curStepMon = currentRuntimestep.month()

        prevRTS = RunTimeStep(currentRuntimestep)                # using constructor to get an RTS for the previous timestep (current -1) (to get today)
        prevRTS.setStep(currentRuntimestep.getPrevStep())
        prevStepMon = prevRTS.month()
        today =  prevRTS.getHecTime().day()

        prevprevRTS = RunTimeStep(currentRuntimestep)    # and another new RTS to be current -2 (to get yesterday)
        prevprevRTS.setStep(prevRTS.getPrevStep())
        yesterday = prevprevRTS.getHecTime().day()
```

```
# print "yesterday = ", yesterday, "     today = ", today
#           ----------end Month and Day Stuff----------

RCflowTS=network.getTimeSeries("Junction","Rome-Coosa", "", "Flow")
curflow7d = RCflowTS.getPeriodAverage(currentRuntimestep, 7)
RC7dSV = network.getStateVariable("DLR_SLQ_RC7d")
RC7dSV.setValue(currentRuntimestep, curflow7d)

SL_7Q10Table = currentVariable.varGet("StateLine_7Q10")

if (today == 1):
            #  it's a new period, determine if we have low state line flow during the last half of last month...
            #  note:we are always comparing the running min to the value in the table corresponding to the month the flow occurred in.
            #  Thus, on the 1st, we compare the running min to last month's table value.

            #   get the day of month for the last day of last month (28, 29, 30 or 31) and subtract the 1st half (14 days)
            daysInLastHalf = yesterday - 14

            # note - the min call doesn't work "backwards".  So get the starting step at the beginning of the month and the number of days in month
            # take care of partial month at start of simulation or which can occur during time-blocking.
            lastDayStep=prevRTS.getStep()
            begin = lastDayStep - daysInLastHalf + 1
            if begin < 1:
                        begin = 1
                        period = lastDayStep
            else:
                        period = daysInLastHalf

            #  what is the minimum 7day avg flow that occurred at Rome_Coosa in the previous period?
            RC7dTS = RC7dSV.getTimeSeries()
            minRCQ=RC7dTS.min(begin,period)
            network.getStateVariable("DLR_SLQ_minRCflow").setValue(prevRTS, minRCQ)

            # what is the 7Q10 flow value from table? - use THIS month's value, not previous month.
            SL_7Q10 = SL_7Q10Table[curStepMon]
            network.getStateVariable("DLR_SLQ_SL7Q10").setValue(prevRTS, SL_7Q10)

            #  if previous period's flow at Rome_Coosa was less than the 7Q10 flow for *THIS* period's month, then
            if (minRCQ < SL_7Q10):
                        #  Yes, the "flow state" is defined as LOW State Line Flow!
                        LowQ_state = 1
            else:
```

```
            #  No, the "flow state" is defined as NORMAL
            LowQ_state = 0


    elif (today ==15):
        #  it's a new period, determine if we have low state line flow during the 1st half of last month...
        #  note:we are always comparing the running min to the value in the table corresponding to the month the flow occurred in.
        #  So, on the 15th, we compare to this month's value.

        #   get the day of month for the last day of last month (28, 29, 30 or 31) and subtract the 1st half (14 days)
        daysInFirstHalf = 14

        # note - the min call doesn't work "backwards".  So get the starting step at the beginning of the month and the number of days in month
        # take care of partial month at start of simulation or which can occur during time-blocking.
        lastDayStep=prevRTS.getStep()
        begin = lastDayStep - daysInFirstHalf + 1
        if (begin < 1):
            begin = 1
            period = lastDayStep
        else:
            period = daysInFirstHalf
#       print "lastDayStep = ", lastDayStep, "    begin=", begin, "   period=", period

        #  what is the minimum 7day avg flow that occurred  at Rome_Coosa in the previous period?
        RC7dTS = RC7dSV.getTimeSeries()
        minRCQ=RC7dTS.min(begin,period)
        network.getStateVariable("DLR_SLQ_minRCflow").setValue(prevRTS, minRCQ)

        # what is the 7Q10 flow value from table - use current month's value?
        SL_7Q10 = SL_7Q10Table[curStepMon]
        network.getStateVariable("DLR_SLQ_SL7Q10").setValue(prevRTS, SL_7Q10)

        #  if previous periods's flow at Rome_Coosa was less than the 7Q10 flow for thismonth, then
        if (minRCQ < SL_7Q10):
            #  Yes, the "flow state" is defined as LOW State Line Flow!
            LowQ_state = 1
        else:
            #  No, the "flow state" is defined as NORMAL
            LowQ_state = 0
    else:
        # current period's month is the SAME as the previous period's month; use previous period's "flow state"
        LowQ_state=currentVariable.getPreviousValue(currentRuntimestep)
```

```
                    # save this month's 7Q10 each day...
                    # set the previous day's value with the value for the current month.
                    # this will work because the else block is for all days except the 1st of the month.
                    SL_7Q10=SL_7Q10Table[curStepMon]
                    network.getStateVariable("DLR_SLQ_SL7Q10").setValue(prevRTS, SL_7Q10)

          #message =  currentRuntimestep.dateTimeString() + "\tSL_LowQ_state " + `LowQ_state` + "current value\n"
          #network.printLogMessage(message)

          currentVariable.setValue(currentRuntimestep, LowQ_state)

#####
##### 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
currentVariable.varsClear()
```

State Variable – DLR_minFlow_fn_Heflin_Yates

```
#####
##### 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
#####

from hec.script import Constants
# Return the minimum flow required at Tallassee as a function of 2xHeflin flow and .5xYatesInflow with the bounds of 350 to 1200.
# Each Tuesday, decide what the minimum flow is and hold that minimum until the next Tuesday decision.

YatesInflow = network.getTimeSeries("Reservoir","Yates", "Pool", "Flow-IN NET").getPreviousValue(currentRuntimestep)
HeflinFlow = network.getTimeSeries("Junction","Heflin", "", "Flow").getPreviousValue(currentRuntimestep)
curDay = currentRuntimestep.getDayOfWeek()

#  set min flow to previous period's value
minFlow = currentVariable.getPreviousValue(currentRuntimestep)

#  if Tuesday or if the first simulation period, then reset the minimum flow value
if (curDay==2 or minFlow==Constants.UNDEFINED):
	minFlow1 = max( .5*YatesInflow, 2*HeflinFlow, 350)
	minFlow = min(minFlow1, 1200.2)

currentVariable.setValue(currentRuntimestep, minFlow)
```

```
#####
##### 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 – DLR_SLQ_minRCflow

```
#####
##### 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
#####

# Holder for the running monthly minimum flow at RomeCoosa computed in DLR_Low_State_Line_Q

#####
##### 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 – DLR_SLQ_RC7d

```
#####
##### 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
#####

#  Holder of Rome-Coosa 7-day average flow, calculated by DLR_Low_State_Line_Q

#####
##### 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 – DLR_SLQ_SL7Q10

```
#####
##### 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
#####

# Holder for running SL7Q10 flow found in SL_7Q10 table in "DLR_Low_State_Line_Q"

#####
##### 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 – NAV75_BI_MinReq

```
#####
##### 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
#####

# Holder for the running monthly Required Basin Inflow found in BI_Table in "NAV_CheckBI"

#####
##### 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 – NAV90_BI_MinReq

```
#####
##### 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
#####

# Holder for the running monthly Basin Inflow found in BI_Table in "NAV90_CheckBI"

#####
##### 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 – Nav_BI

```
#####
##### 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
#####

# Holder for the daily Basin Inflow.  Calculated in  state variable "Nav_CheckBI"

#####
##### 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 – NAV_BI_14d

```
#####
##### 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
#####

# Holder for the 14-day average Basin Inflow.  Calculated in  state variable "Nav_CheckBI"

#####
##### 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 – NAV_CheckBI

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

from hec.script import Constants
from hec.heclib.util import intContainer
from hec.heclib.util import doubleContainer
from hec.hecmath import DSS

# -----------------------------------------------------------------------------------------------------------------------------------------------------
# initialization function. ..
# -----------------------------------------------------------------------------------------------------------------------------------------------------
#   *   establish data table for use in main...
#   *   read UNREG flows at inflow JCTs at Jordan and Thurlow for use in main...
#   *   In main, the sum of the Jordan and Thurlow UNREG Qs will be adjusted
#   *    for EVAP and stored in state variable: NAV_BI

def initStateVariable(currentVariable, network):
    # establish var needed to keep from computing more than once per timestep.  This is valid since all data used is previous value and thus the same for each state var compute in a timestep.
    currentVariable.varPut("checkStep", intContainer(-1))

#   - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

    #   These 2 arrays consist of the monthly "Required Natural Flow" corresponding to Navigation Draft of 7.5' or 9'
    # (from 4/9/2010 ppt, slide 11, for 9.0' Navigation Template, and slide 14, for 7.5' Navigation Template).
    #    The -1 is a placeholder for the "zeroeth" month so month numbers can be used to index the tuple table.
    #                           Jan,   Feb,  Mar,    Apr,  May,  Jun,   Jul,  Aug,  Sep,  Oct,  Nov,  Dec
    Nav90BI_Table = (-1,   10754, 12099, 13124, 13568, 9437, 7940,  6972, 5765, 5917, 4635, 6494, 7191)
    Nav75BI_Table = (-1,     9434, 10779, 11804, 12248, 8349, 7084,  6348, 5373, 5757, 4475, 5174, 5871)
    DLRBI_Table =    (-1,     5269,   7255,    8143,   8908, 4882, 4640,  4640, 4640, 2734, 1237, 1093, 2777)

    currentVariable.varPut("Nav90BI_Table", Nav90BI_Table)
    currentVariable.varPut("Nav75BI_Table", Nav75BI_Table)
    currentVariable.varPut("DLRBI_Table", DLRBI_Table)

#   - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

```
	# get timewindow for using in DSS read/open
	tw=network.getRssRun().getCurrentComputeBlockRunTimeWindow()
	tws = tw.getTimeWindowString()
	# print "tws = ", tws

#	- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

#	Read the Jordan and Thurlow Flow-UNREG records from DSS and store to the state var as localTimeSeries records.
#	Do the same for CartersReReg and Allatoona
#	Assume that All Diversion Elements have the "BOX" for computing diversions during UnReg "CHECKED"
#	The only remaining adjustment needed (to be done in main) is to subtract the EVAP from the sum of the two UnRegs.

	# get the model vars for the inflow junction flows to setup the pathnames, etc, for the DSS reads
	JordanIN_TS=network.getTimeSeries("Junction","Jordan Lake Losses_IN", "", "Flow")
	ThurlowIN_TS=network.getTimeSeries("Junction","Thurlow_IN", "", "Flow")
	CartersReRegIN_TS=network.getTimeSeries("Junction","Carters ReReg_IN", "", "Flow")
	AllatoonaIN_TS=network.getTimeSeries("Junction","Allatoona_IN", "", "Flow")

	# ask one of the model vars for DSS filename it expects to write itself to - so we don't have to 'figure it out'
	# and open the DSS file.  Use the timewindow on the open so that all reads get data that match with the data in the model variables
	dssfilename=JordanIN_TS.getDSSFilename()
	dssfile = DSS.open(dssfilename,tws)

	# ask the model vars for their DSS pathnames, parse 'em, modify the C-part to FLOW-UNREG, and reassemble the pathnames.
	JordanIN_pathname=JordanIN_TS.getDSSPathname()
	JordanIN_pathparts=JordanIN_pathname.split("/")
	A, B, C, D, E, F = 1, 2, 3, 4, 5, 6
	JordanIN_pathparts[C] += "-UNREG"
	JordanIN_pathname = "/".join(JordanIN_pathparts)

	ThurlowIN_pathname=ThurlowIN_TS.getDSSPathname()
	ThurlowIN_pathparts=ThurlowIN_pathname.split("/")
	ThurlowIN_pathparts[C] += "-UNREG"
	ThurlowIN_pathname = "/".join(ThurlowIN_pathparts)

	CartersReRegIN_pathname=CartersReRegIN_TS.getDSSPathname()
	CartersReRegIN_pathparts=CartersReRegIN_pathname.split("/")
	CartersReRegIN_pathparts[C] += "-UNREG"
	CartersReRegIN_pathname = "/".join(CartersReRegIN_pathparts)
```

```
            AllatoonaIN_pathname=AllatoonaIN_TS.getDSSPathname()
            AllatoonaIN_pathparts=AllatoonaIN_pathname.split("/")
            AllatoonaIN_pathparts[C] += "-UNREG"
            AllatoonaIN_pathname = "/".join(AllatoonaIN_pathparts)

            dssfile = DSS.open(dssfilename,tws)

            JI_tsmath = dssfile.read(JordanIN_pathname)
            JI_TS = currentVariable.localTimeSeriesNew("JordanIN_UNREG", JI_tsmath.getData())

            TI_tsmath = dssfile.read(ThurlowIN_pathname)
            TI_TS = currentVariable.localTimeSeriesNew("ThurlowIN_UNREG", TI_tsmath.getData())

            CI_tsmath = dssfile.read(CartersReRegIN_pathname)
            CI_TS = currentVariable.localTimeSeriesNew("CartersReRegIN_UNREG", CI_tsmath.getData())

            AI_tsmath = dssfile.read(AllatoonaIN_pathname)
            AI_TS = currentVariable.localTimeSeriesNew("AllatoonaIN_UNREG", AI_tsmath.getData())
#           - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

            # establish vars needed to compute BI for monthly average comps in main.
            # lookback evap ignored.
            # establish the same for the DLR monthly average (which does not include Carters and the ReReg)

            NavBI_TS = network.getStateVariable("NAV_BI").getTimeSeries()
            DLRBI_TS = network.getStateVariable("DLR_BI").getTimeSeries()
            numLBsteps=tw.getNumLookbackSteps()
            i=0
            while i <= numLBsteps:
                        NavBIsum =  JI_TS.getValue(i) + TI_TS.getValue(i)
                        NavBI_TS.setCurrentValue(i, NavBIsum)
                        DLRBIsum =  JI_TS.getValue(i) + TI_TS.getValue(i) - CI_TS.getValue(i) - AI_TS.getValue(i)
                        DLRBI_TS.setCurrentValue(i, DLRBIsum)
#                       print "curstep, numsteps, NavBI, DLRBI, = ", i, numLBsteps, NavBIsum,DLRBIsum
                        i += 1

            # 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
#####

# ----------------------------------------------------------------------------------------------------------------------------------------------------------------
#  NAV_CheckBI
#  Determine the current Basin Inflow as calculated for determining Drought Index Level and Navigation
#  BasinInflow is the sum of the UNREG flow at Jordan and Thurlow In adjusted by the diversions and pool evaps.
#  BI is computed daily, but the running average is compared to the table value either monthly or bimonthly:

#  DIL trigger is determined once monthly and is does not include Carters and Allatoona UNREG flows.
#  Nav trigger is determined twice monthly and includes Carters and Allatoona UNREG flows.

# DIL state is saved as "DLR_Low_Basin_Inflow"
#           If = 0, then normal
#           If = 1, then drought state

#  "NAV_CheckBI" is the navigation state
#  The Minimum Navigation depth required at Montgomery is set based on this trigger.

#         If = 0, then conditions are normal, do 9' navigation (basin inflow is sufficient);
#         If = 1, then conditions are low, do 7.5' navigation
#         If = 2, then conditions are very low, do environmental only (since low basin inflow)

#
# 7/1/2010 smo edited to recalculate bi-monthly, as per 6/30 meeting between James and APC.
# 8/2010 smo combined calculations with DLR_Low_Basin_Inflow to save comp time
# 9/3/2010 smo & jdk - modified script to correct period average calculations.  Semi-monthly will average over
# last 14 days.  Monthly will "carefully" average over the days in the month.  Results will only go out on averaging
# interval, not every day/timestep.
# 10/2010 adjusted to calculate BOTH Navigation BI and DIL BI twice a month instead of once a month.

# ----------------------------------------------------------------------------------------------------------------------------------------------------------------
#
#
from hec.heclib.util import intContainer
from hec.heclib.util import doubleContainer
from hec.model import RunTimeStep
```

```
checkStep = currentVariable.varGet("checkStep")
curStep = currentRuntimestep.getStep()

if (curStep != checkStep.value):
	checkStep.value = curStep

#	----------Daily Stuff----------

	prevRTS = RunTimeStep(currentRuntimestep) # just to set prevRTS as a RunTimeStep
	prevRTS.setStep(currentRuntimestep.getPrevStep())
	prevprevRTS = RunTimeStep(currentRuntimestep) # just to set prevprevRTS as a RunTimeStep
	prevprevRTS.setStep(prevRTS.getPrevStep())
	prevStepMon = prevRTS.month()
	curStepMon = currentRuntimestep.month()
	# since timestep is reported at 24:00, look at the previous timestep to get the current day
	#curDayofMon = currentRuntimestep.getHecTime().day()
	prevDayofMon = prevRTS.getHecTime().day() # actually will be today's day of month
	prevprevDayofMon = prevprevRTS.getHecTime().day() # actually will be yesterday's day of month

	#print prevRTS.getHecTime().date(), curDayofMon

#	- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
	# Get the 2 UNREG records and compute the sum

	JordanIN_UNREG_TS = currentVariable.localTimeSeriesGet("JordanIN_UNREG")
	ThurlowIN_UNREG_TS = currentVariable.localTimeSeriesGet("ThurlowIN_UNREG")

	cur_JordanQ = JordanIN_UNREG_TS.getPreviousValue(currentRuntimestep)
	cur_ThurlowQ = ThurlowIN_UNREG_TS.getPreviousValue(currentRuntimestep)
	NavsumQ = cur_JordanQ + cur_ThurlowQ

	# for the DLR Low Basin Inflow, flows into Carters and Allatoona should not be counted
	CartersReRegIN_UNREG_TS = currentVariable.localTimeSeriesGet("CartersReRegIN_UNREG")
	AllatoonaIN_UNREG_TS = currentVariable.localTimeSeriesGet("AllatoonaIN_UNREG")

	cur_CartersReRegQ = CartersReRegIN_UNREG_TS.getPreviousValue(currentRuntimestep)
	cur_AllatoonaQ = AllatoonaIN_UNREG_TS.getPreviousValue(currentRuntimestep)
	DLRsumQ = cur_JordanQ + cur_ThurlowQ - cur_CartersReRegQ - cur_AllatoonaQ
```

```
#           - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
            # Get the EVAP for the 12 Coosa and Tallapoosa reservoirs upstream of JBT Goal and compute the sum
            # if getting the current period's UNREG, should we be getting the previous or current period's evap?  We are storing to current period BI.

            Carters_EvapTS=network.getTimeSeries("Reservoir","Carters", "Pool", "Flow-EVAP")
            curEVQ_Carters=Carters_EvapTS.getPreviousValue(currentRuntimestep)

            Allatoona_EvapTS=network.getTimeSeries("Reservoir","Allatoona", "Pool", "Flow-EVAP")
            curEVQ_Allatoona=Allatoona_EvapTS.getPreviousValue(currentRuntimestep)

            Weiss_EvapTS=network.getTimeSeries("Reservoir","Weiss", "Pool", "Flow-EVAP")
            curEVQ_Weiss=Weiss_EvapTS.getPreviousValue(currentRuntimestep)

            HNHenry_EvapTS=network.getTimeSeries("Reservoir","HN Henry", "Pool", "Flow-EVAP")
            curEVQ_HNHenry=HNHenry_EvapTS.getPreviousValue(currentRuntimestep)

            LoganMartin_EvapTS=network.getTimeSeries("Reservoir","Logan Martin", "Pool", "Flow-EVAP")
            curEVQ_LoganMartin=LoganMartin_EvapTS.getPreviousValue(currentRuntimestep)

            Lay_EvapTS=network.getTimeSeries("Reservoir","Lay", "Pool", "Flow-EVAP")
            curEVQ_Lay=Lay_EvapTS.getPreviousValue(currentRuntimestep)

            Mitchell_EvapTS=network.getTimeSeries("Reservoir","Mitchell", "Pool", "Flow-EVAP")
            curEVQ_Mitchell=Mitchell_EvapTS.getPreviousValue(currentRuntimestep)

            Jordan_EvapTS=network.getTimeSeries("Reservoir","Jordan Lake Losses", "Pool", "Flow-EVAP")
            curEVQ_Jordan=Jordan_EvapTS.getPreviousValue(currentRuntimestep)

            Harris_EvapTS=network.getTimeSeries("Reservoir","Harris", "Pool", "Flow-EVAP")
            curEVQ_Harris=Harris_EvapTS.getPreviousValue(currentRuntimestep)

            Martin_EvapTS=network.getTimeSeries("Reservoir","Martin", "Pool", "Flow-EVAP")
            curEVQ_Martin=Martin_EvapTS.getPreviousValue(currentRuntimestep)

            Yates_EvapTS=network.getTimeSeries("Reservoir","Yates", "Pool", "Flow-EVAP")
            curEVQ_Yates=Yates_EvapTS.getPreviousValue(currentRuntimestep)

            Thurlow_EvapTS=network.getTimeSeries("Reservoir","Thurlow", "Pool", "Flow-EVAP")
            curEVQ_Thurlow=Thurlow_EvapTS.getPreviousValue(currentRuntimestep)
```

```
        NavsumEVAP=curEVQ_Carters +curEVQ_Allatoona +curEVQ_Weiss +curEVQ_HNHenry +curEVQ_LoganMartin +curEVQ_Lay + \
                curEVQ_Mitchell +curEVQ_Jordan +curEVQ_Harris +curEVQ_Martin +curEVQ_Yates +curEVQ_Thurlow
        if NavsumEVAP < -999999: NavsumEVAP = 0.0

        DLRsumEVAP=curEVQ_Weiss +curEVQ_HNHenry +curEVQ_LoganMartin +curEVQ_Lay + \
                curEVQ_Mitchell +curEVQ_Jordan +curEVQ_Harris +curEVQ_Martin +curEVQ_Yates +curEVQ_Thurlow
        if DLRsumEVAP < -999999: DLRsumEVAP = 0.0

#       - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
#       compute daily BI and store it.
        NavBI_Q = NavsumQ - NavsumEVAP
        NavBI_SV = network.getStateVariable("Nav_BI")
        NavBI_SV.setValue(prevRTS, NavBI_Q)

        DLRBI_Q = DLRsumQ - DLRsumEVAP
        DLRBI_SV = network.getStateVariable("DLR_BI")
        DLRBI_SV.setValue(prevRTS, DLRBI_Q)
#       - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
        # get the state variable that holds the DLR Basin Inflow State (0 or 1)
        # do this here because it gets accessed multiple times below
        # (same is true for the reference tables that hold required BI)
        DLRBIState_SV = network.getStateVariable("DLR_Low_Basin_Inflow")
        DLRBI_Table = currentVariable.varGet("DLRBI_Table")
        Nav90BI_Table = currentVariable.varGet("Nav90BI_Table")
        Nav75BI_Table = currentVariable.varGet("Nav75BI_Table")


#       ----------Monthly Stuff----------

        #    Check to see if it is either the 1st or 15th of the month
        if ( prevDayofMon == 1 or prevDayofMon == 15) :

                #    On the first (or 15th) day of the month (now), determine state of "Low_Basin_Inflow" trigger

                #print prevRTS.getHecTime().date(), curDayofMon,  prevDayofMon, DLRBI_SV.getTimeSeries().getPeriodAverage(curRTS, 1),
DLRBI_SV.getTimeSeries().getPeriodAverage(curRTS, 2),DLRBI_SV.getTimeSeries().getPeriodAverage(curRTS, 29)
                #print prevRTS.getHecTime().date(), curDayofMon,  prevDayofMon, DLRBI_SV.getTimeSeries().getPeriodAverage(prevRTS, 1),
DLRBI_SV.getTimeSeries().getPeriodAverage(prevRTS, 2),DLRBI_SV.getTimeSeries().getPeriodAverage(prevRTS, 29)
                #    start by calculating the average BI for the last 14 days
                NavBIavg = NavBI_SV.getTimeSeries().getPeriodAverage(prevRTS, 14)
                network.getStateVariable("NAV_BI_14d").setValue(prevRTS, NavBIavg)
```

```
# what is the Required Basin Inflow value from table?
prevDLRBI = DLRBI_Table[prevStepMon]            # use for state if test
curDLRBI = DLRBI_Table[curStepMon]              # use to store in DLRBI state var for "today"
prevNav90BI = Nav90BI_Table[prevStepMon]                # use for state if test
curNav90BI = Nav90BI_Table[curStepMon]                  # use to store in Nav90BI state var for "today"
prevNav75BI = Nav75BI_Table[prevStepMon]                # use for state if test
curNav75BI = Nav75BI_Table[curStepMon]                  # use to store in Nav75BI state var for "today"

# For Navigation Basin Inflow , compare the average BI for the last 14 day to the current month's reference value.
#    On the 1st day of the month, use last month's "Low_Basin_Inflow" trigger (b/c you're really comparing an avg for the end of last month)
#    Update: On the 1st day of the month, use THIS month's "Low_Basin_Inflow" trigger (b/c you're really comparing an avg for the end of last month)
#    Update: changed prev to cur.
if prevDayofMon == 1 :
        Nav75BI = curNav75BI
        Nav90BI = curNav90BI
        # xxx For calculating DLR Low BI twice a month
        DLRBI = curDLRBI

#    On the 15th day of the month, use current month's "Low_Basin_Inflow" trigger (b/c you're really comparing an avg in this month)
else :
        Nav75BI = curNav75BI
        Nav90BI = curNav90BI
        # xxx For calculating DLR Low BI twice a month
        DLRBI = curDLRBI

# ----------------------------------------------------------------------------------------------------------------
#     Determine if in a LOW Basin Inflow "State" for DLR DIL calc
#     10/08/2010 - Decision will be made 2x per month instead of only on the first.
#      The logic commented out here was for setting the BI once a month.
# ----------------------------------------------------------------------------------------------------------------
#  if previous month's flow BI was less than the DLR BI flow for that month, then
#if prevDayofMon == 1 :
#       # set the value for average basin inflow for the end of last month
#       DLRBIavg = DLRBI_SV.getTimeSeries().getPeriodAverage(prevRTS, prevprevDayofMon)
#       network.getStateVariable("DLR_BI_monAvg").setValue(prevRTS, DLRBIavg)
#
#       # check the DLR Basin Inflow State
#       if (DLRBIavg < prevDLRBI) :
#               #  Yes, the "flow state" is defined as LOW Basin Inflow!
#               DLRQ_state = 1
```

```
#		else :
#			#  No, the "flow state" is defined as NORMAL
#			DLRQ_state = 0
#
#else :
#		# Yesterday was not the end of the month, so set today's DLR Basin Inflow State as the value from yesterday
#		DLRQ_state=DLRBIState_SV.getPreviousValue(currentRuntimestep)

# ---------------------------------------------------------------------------------------------------------------
#	Determine if in a LOW Basin Inflow "State" for DLR DIL calc
#	10/08/2010 - Decision will be made 2x per month instead of only on the first.
#	 The logic hereis for setting the BI twice a month.
# ---------------------------------------------------------------------------------------------------------------
#  if previous month's flow BI was less than the DLR BI flow for that month, then
# set the value for average basin inflow for the end of last month
DLRBIavg = DLRBI_SV.getTimeSeries().getPeriodAverage(prevRTS, 14)
network.getStateVariable("DLR_BI_14d").setValue(prevRTS, DLRBIavg)

# ---------------------------------------------------------------------------------------------------------------
#	Determine if in a LOW Basin Inflow "State" for DLR calc
# ---------------------------------------------------------------------------------------------------------------
# check the DLR Basin Inflow State
if (DLRBIavg < DLRBI) :
		#  Yes, the "flow state" is defined as LOW Basin Inflow!
		DLRQ_state = 1
else :
		#  No, the "flow state" is defined as NORMAL
		DLRQ_state = 0



# ---------------------------------------------------------------------------------------------------------------
#	Determine if in a LOW Basin Inflow "State" for Navigation calc
# ---------------------------------------------------------------------------------------------------------------
#  if previous two weeks' average Basin Inflow was less than the required Nav_BI flow for that month, then...
if (NavBIavg < Nav75BI) :
		#  Yes, the "flow state" is defined as VERY LOW Basin Inflow!
		# No Navigation channel depth will be required
		NavQ_state = 2
elif (NavBIavg < Nav90BI) :
		#  Yes, the "flow state" is defined as LOW Basin Inflow!
		# a 7.5 foot Navigation channel is required
		NavQ_state = 1
```

```
        else:
            #  No, the "flow state" is defined as NORMAL
            # a 9 foot Navigation channel is required.
            NavQ_state = 0


    else:
        # we are not on the 1st or 15th of the month, so use previous period's "flow state"
        DLRQ_state=DLRBIState_SV.getPreviousValue(currentRuntimestep)
        NavQ_state=currentVariable.getPreviousValue(currentRuntimestep)

        # get the required Basin Inflow values just for writing out to DSS
        curDLRBI = DLRBI_Table[curStepMon]
        curNav90BI = Nav90BI_Table[curStepMon]
        curNav75BI = Nav75BI_Table[curStepMon]

    # end if block: 1st or 15th -------------------------------------------------

    currentVariable.setValue(currentRuntimestep, NavQ_state)

    # store other vars for access in simulation.dss file
    DLRBIState_SV.setValue(currentRuntimestep, DLRQ_state)

    DLRreqBI_SV = network.getStateVariable("DLR_BI_MinReq")
    DLRreqBI_SV.setValue(currentRuntimestep, curDLRBI)
    Nav90reqBI_SV = network.getStateVariable("Nav90_BI_MinReq")
    Nav90reqBI_SV.setValue(currentRuntimestep, curNav90BI)
    Nav75reqBI_SV = network.getStateVariable("Nav75_BI_MinReq")
    Nav75reqBI_SV.setValue(currentRuntimestep, curNav75BI)
```

```
#####
##### 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


# TS = currentVariable.localTimeSeriesGet("Nav_BI_RunningAvg")
# TS.setDSSPathname("///flow////")
# TS.setUnits("CFS")
# currentVariable.localTimeSeriesWrite("Nav_BI_RunningAvg")

# TS = currentVariable.localTimeSeriesGet("DLR_BI_RunningAvg")
# TS.setDSSPathname("///flow////")
# TS.setUnits("CFS")
# currentVariable.localTimeSeriesWrite("DLR_BI_RunningAvg")

currentVariable.varsClear()
currentVariable.localTimeSeriesClear()
```

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...
```

Alabama-Coosa-Tallapoosa (ACT) Watershed

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

Appendix M – Flood Modeling above Rome, Georgia

March 2011 (DRAFT)

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Flood Modeling above Rome, Georgia

(Evaluation of Flood Impact of Allatoona Flood Operation at Kingston and Rome-Coosa)

I. Introduction

The Mobile District is evaluating three flood operation alternatives at Allatoona Dam. Figure M.01 shows the conservation zone guide curves for four scenarios: Baseline, September Drawdown, Phased Drawdown, and November Drawdown. The Baseline operation starts to drop its elevation from 840 ft on October 1st and continues until it reaches 823 ft on December 15th. The three alternatives evaluate different drawdown operation plans at the end of the year. Operations at the beginning of the year though the summer remain the same for every alternative. In the September Drawdown condition, Allatoona Reservoir starts its winter drawdown a month earlier on September 6th until it reaches 823 ft on December 1st. During the Phased Drawdown condition, drawdown begins the same time as the September Drawdown alternative on September 6th, but only until it October 1st when it levels off at 835 ft for a month and a half. On November 16th, drawdown begins again until the elevation reaches 823 ft on December 31st. The November Drawdown alternative begins its drawdown a month later than the Baseline Condition on November 2nd. It continues drawing down until December 31st when the elevation reaches 823 ft.

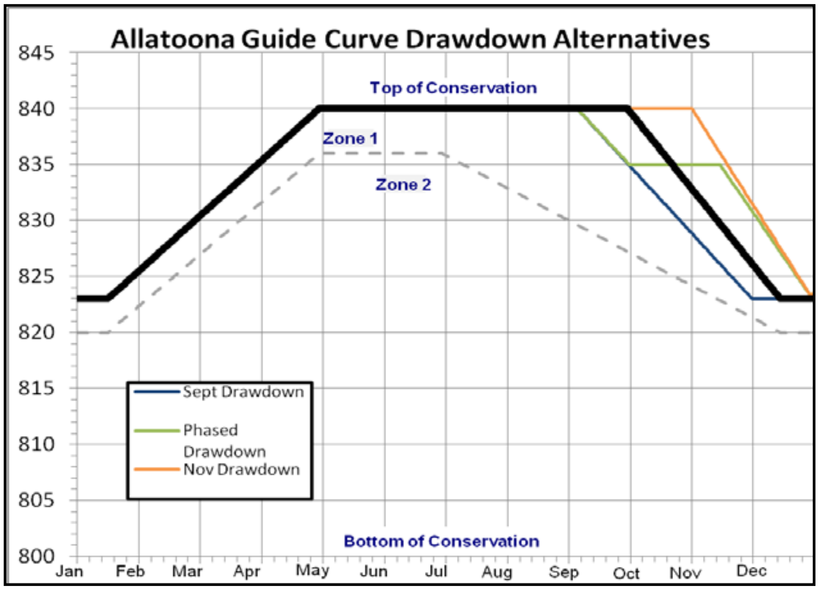


Figure M.01 Allatoona Guide Curve Drawdown Alternatives

Because the guide curve determines the available flood storage, which affects the peak and volume of the reservoir release during flood operations, any modification to the guide curve may have some direct impacts on the flood conditions downstream. Two flood damage sites are evaluated for this system. Downstream of Allatoona on the Etowah River, the flood damage site is Kingston. Further downstream of the confluence with the Conasauga River on the Coosa

River, the flood damage site is Rome-Coosa. A flood operation alternative is acceptable only if it does not significantly increase the flood frequency curves at Kingston and at Rome-Coosa. This report describes the approach used to evaluate the flood impacts of Allatoona Dam operations on the flood conditions at Kingston and Rome-Coosa. The report also presents the results.

II. Study Approach

The flow in the upper ACT system is regulated (Figure M.02). The magnitude of flood discharge at Kingston and Rome-Coosa is primarily influenced by the magnitude of storms. At the same time, due to the flow regulation, it is also affected by flood operations at Allatoona Dam and the upstream dams, Carters and Carter ReReg, which typically vary month to month as indicated in Figure M.01. Therefore, the combined regulated flood frequency relationship at the flood damage sites are a function of two variables, storm and month. For each month, a regulated flood frequency relationship can be developed by applying a series of hypothetical flow hydrographs with different exceedance probabilities to a reservoir model and by associating the resulting regulated peak flows at Kingston and Rome-Coosa with the exceedance probabilities of the input hypothetical hydrographs. The monthly regulated flood frequency curves can then be combined to produce a combined regulated flood frequency curve at Kingston and Rome-Coosa using the total probability theorem (U.S. Army Corps of Engineers, 1993). This approach is illustrated in detail in the following Section.

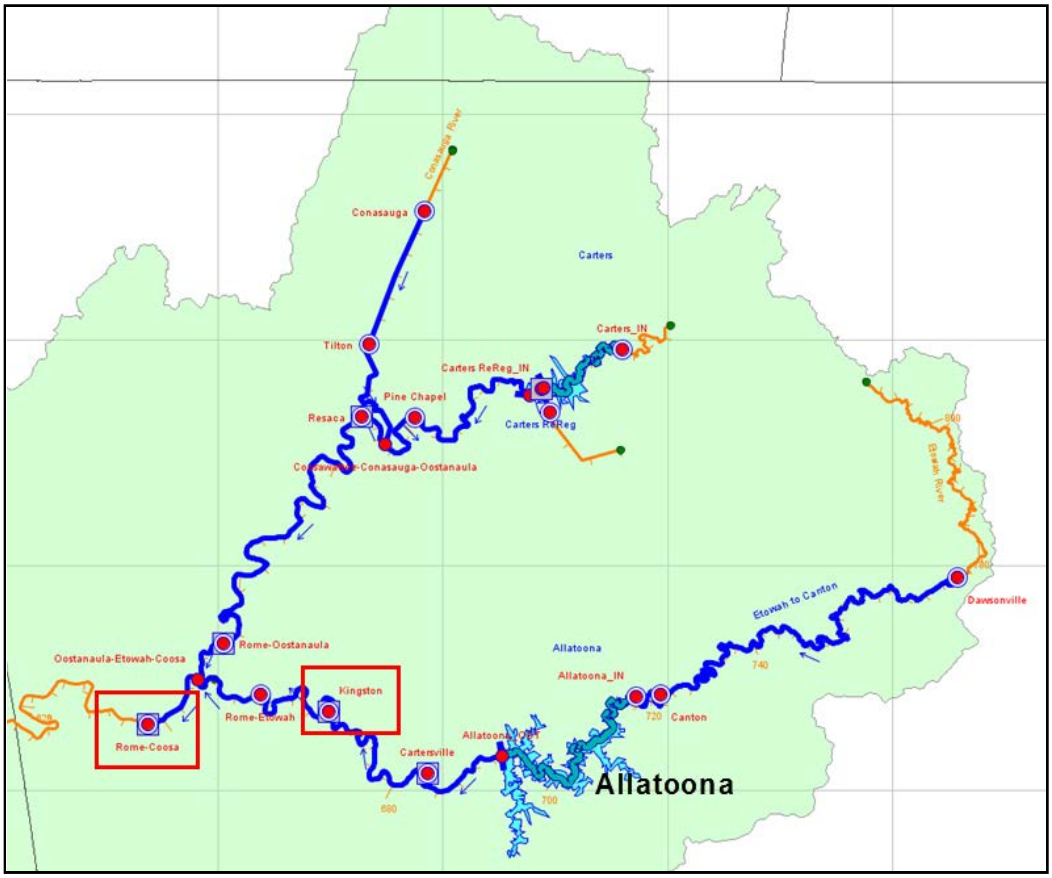


Figure M.02 Schematic of Upper ACT Hourly Flood Model

III. Procedures to Develop Combined Regulated Flood Frequency Curves

A. Step 1 – Develop Hypothetical Hydrographs

This step has been completed by the Mobile District (U.S. Army Corps of Engineers, 2009). Three historic flood events (December 1961, March 1979 and March1990) that had distinctly different storm patterns in the Upper ACT were selected to use as patterns for five frequency events (0.2, 0.5, 1.0, 2.0, and 5.0 percent). The time series of the five frequency events reflect the historical "dates" and were used for copying the original data to be used for creating the "shifted" time series data for each month. Figure M.03 shows an example of one of the monthly hypothetical storm events. See Appendix O for a detailed discussion of the development of sub-daily flows for the Upper Coosa basin.

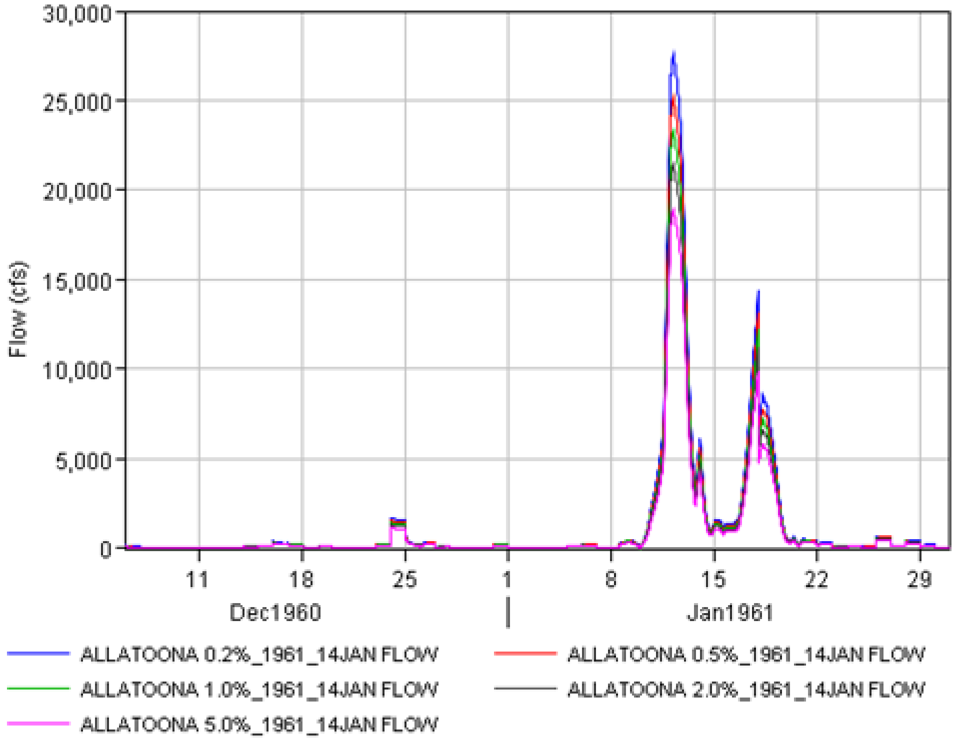


Figure M.03 Hypothetical Hydrographs at Allatoona Based on Shape of 1961 Event

B. Step 2 – Develop and Run a Reservoir Model

An hourly HEC-ResSim flood model for the Upper ACT has been developed as part of the ACT Water Control Manual Update Study. Using the three sets of hypothetical hydrographs and the four sets of the Allatoona guide curves (Figure M.01), a series of monthly simulation alternatives were created in HEC-ResSim. Table M.01 summarizes all of the simulations.

Table M.01 Summary of HEC-ResSim Simulation Alternatives

	Baseline	September Drawdown	November Drawdown	Phased Drawdown
JAN1961	X	X	X	X
FEB1961	X			
MAR1961	X			
APR1961	X			
MAY1961	X			
JUN1961	X			
JUL1961	X			
AUG1961	X			
SEP1961	X	X		X
OCT1961	X	X	X	X
NOV1961	X	X	X	X
DEC1961	X	X	X	X
JAN1979	X	X	X	X
FEB1979	X	X	X	X
MAR1979	X			
APR1979	X			
MAY1979	X			
JUN1979	X			
JUL1979	X			
AUG1979	X			
SEP1979	X	X		X
OCT1979	X	X	X	X
NOV1979	X	X	X	X
DEC1979	X	X	X	X
JAN1990	X	X	X	X
FEB1990	X			
MAR1990	X			
APR1990	X			
MAY1990	X			
JUN1990	X			
JUL1990	X			
AUG1990	X	X		X
SEP1990	X	X	X	X
OCT1990	X	X	X	X
NOV1990	X	X	X	X
DEC1990	X	X	X	X

Note: The alternative simulations were only run when the monthly simulation dates overlapped with a change in the guide curve from the "Baseline" condition.

C. Step 3 – Construct Monthly Regulated Flood Frequency Curves

The flow hydrographs computed by HEC-ResSim for each month at Kingston and Rome-Coosa represent the monthly regulated hypothetical hydrographs. Figure M.04 shows the November regulated 1% hypothetical storm hydrographs at Kingston for the Baseline, September Drawdown, Phased Drawdown, and November Drawdown conditions (based on 1961 event hydrograph shape).

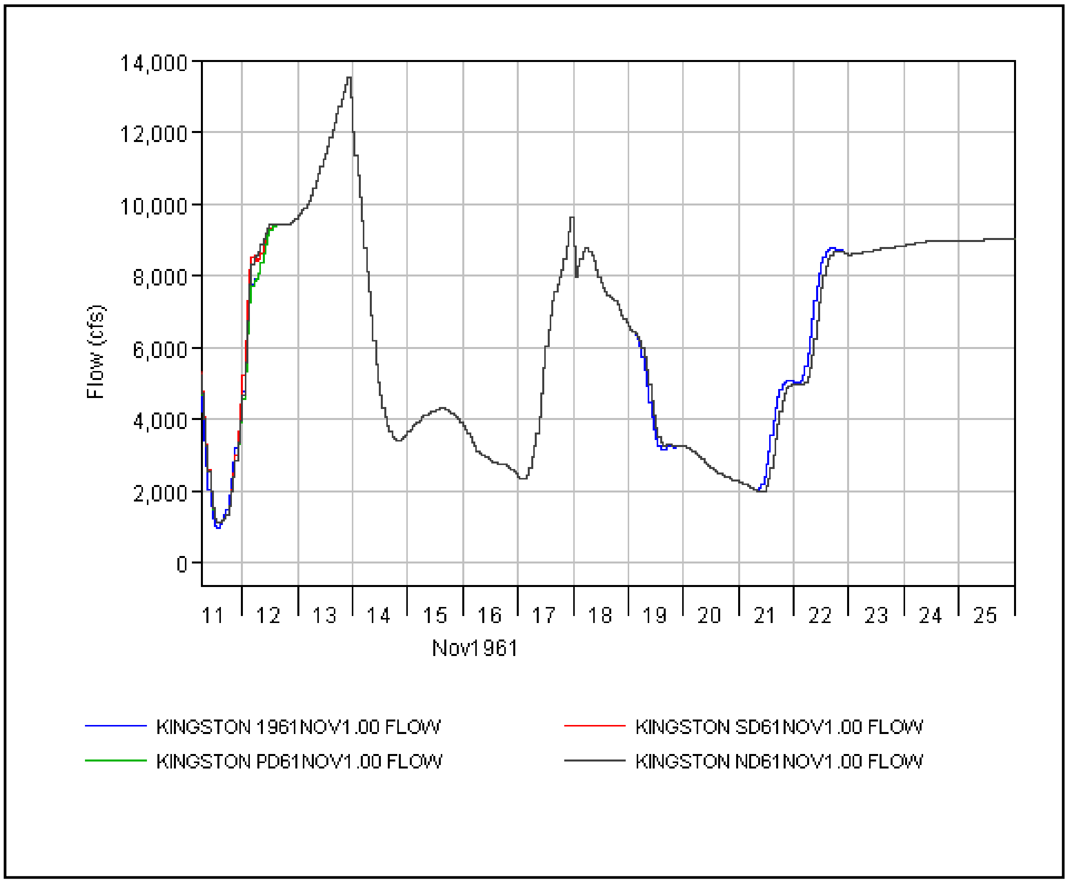


Figure M.04 Regulated November 1% storm hydrographs at Kingston

For each month, the peak discharges of the 5-, 2-, 1-, 0.5-, and 0.2-percent regulated hydrographs at Kingston and Rome-Coosa define the regulated flood frequency curves for the Baseline, September Drawdown, Phased Drawdown, and November Drawdown conditions. The peak discharge for each month and alternative combination was extracted from the ResSim simulation results using a Fortran Code. Tables M.02 and M.03 include the monthly regulated flood frequency flows at Kingston and Rome-Coosa (respectively).

Table M.02 Monthly Regulated Flood Frequency Flow at Kingston

(Note: The frequency flows are same for the "September Drawdown", "Phased Drawdown" and "November Drawdown" as the "Baseline" simulation as the Allatoona guide curves remain the same.)

January Regulated Frequency Flow in cfs at Kingston.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	15,874	15,874	15,874	15,874	37,441	37,441	37,441	37,441	25,231	25,231	25,231	25,231
0.5	14,534	14,534	14,534	14,534	34,223	34,223	34,223	34,223	23,282	23,282	23,282	23,282
1	13,500	13,500	13,500	13,500	31,791	31,791	31,791	31,791	21,778	21,778	21,778	21,778
2	12,442	12,442	12,442	12,442	29,243	29,243	29,243	29,243	20,062	20,062	20,062	20,062
5	10,988	10,988	10,988	10,988	25,777	25,777	25,777	25,777	17,526	17,526	17,526	17,526

February Regulated Frequency Flow in cfs at Kingston.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	15,874	--	--	--	37,441	37,441	37,441	37,441	25,231	--	--	--
0.5	14,534	--	--	--	34,223	34,223	34,223	34,223	23,282	--	--	--
1	13,500	--	--	--	31,791	31,791	31,791	31,791	21,778	--	--	--
2	12,442	--	--	--	29,243	29,243	29,243	29,243	20,062	--	--	--
5	10,988	--	--	--	25,777	25,777	25,777	25,777	17,526	--	--	--

March Regulated Frequency Flow in cfs at Kingston.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	15,874	--	--	--	37,441	--	--	--	25,231	--	--	--
0.5	14,534	--	--	--	34,223	--	--	--	23,282	--	--	--
1	13,500	--	--	--	31,791	--	--	--	21,778	--	--	--
2	12,442	--	--	--	29,243	--	--	--	20,062	--	--	--
5	10,988	--	--	--	25,777	--	--	--	17,526	--	--	--

… Continued …

Table M.02 Monthly Regulated Flood Frequency Flow at Kingston -- *Continued*

April Regulated Frequency Flow in cfs at Kingston.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	15,874	--	--	--	37,441	--	--	--	25,231	--	--	--
0.5	14,534	--	--	--	34,223	--	--	--	23,282	--	--	--
1	13,500	--	--	--	31,791	--	--	--	21,778	--	--	--
2	12,442	--	--	--	29,243	--	--	--	20,062	--	--	--
5	10,988	--	--	--	25,777	--	--	--	17,526	--	--	--

May Regulated Frequency Flow in cfs at Kingston.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	15,874	--	--	--	42,226	--	--	--	25,231	--	--	--
0.5	14,534	--	--	--	34,223	--	--	--	23,282	--	--	--
1	13,500	--	--	--	31,791	--	--	--	21,778	--	--	--
2	12,442	--	--	--	29,243	--	--	--	20,062	--	--	--
5	10,988	--	--	--	25,777	--	--	--	17,526	--	--	--

June Regulated Frequency Flow in cfs at Kingston.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	15,874	--	--	--	45,742	--	--	--	25,231	--	--	--
0.5	14,534	--	--	--	35,356	--	--	--	23,282	--	--	--
1	13,500	--	--	--	31,791	--	--	--	21,778	--	--	--
2	12,442	--	--	--	29,243	--	--	--	20,062	--	--	--
5	10,988	--	--	--	25,777	--	--	--	17,526	--	--	--

… Continued …

Table M.02 Monthly Regulated Flood Frequency Flow at Kingston -- *Continued*

July Regulated Frequency Flow in cfs at Kingston.

Exceedance Probability (%)	**1961 Hydrograph Shape**				**1979 Hydrograph Shape**				**1990 Hydrograph Shape**			
	Baseline	**September Drawdown**	**Phased Drawdown**	**November Drawdown**	**Baseline**	**September Drawdown**	**Phased Drawdown**	**November Drawdown**	**Baseline**	**September Drawdown**	**Phased Drawdown**	**November Drawdown**
0.2	15,874	--	--	--	45,827	--	--	--	25,231	--	--	--
0.5	14,534	--	--	--	35,433	--	--	--	23,282	--	--	--
1	13,500	--	--	--	31,791	--	--	--	21,778	--	--	--
2	12,442	--	--	--	29,243	--	--	--	20,062	--	--	--
5	10,988	--	--	--	25,777	--	--	--	17,526	--	--	--

August Regulated Frequency Flow in cfs at Kingston.

Exceedance Probability (%)	**1961 Hydrograph Shape**				**1979 Hydrograph Shape**				**1990 Hydrograph Shape**			
	Baseline	**September Drawdown**	**Phased Drawdown**	**November Drawdown**	**Baseline**	**September Drawdown**	**Phased Drawdown**	**November Drawdown**	**Baseline**	**September Drawdown**	**Phased Drawdown**	**November Drawdown**
0.2	15,874	--	--	--	45,880	--	--	--	25,231	25,231	25,231	--
0.5	14,534	--	--	--	35,470	--	--	--	23,282	23,282	23,282	--
1	13,500	--	--	--	31,791	--	--	--	21,778	21,778	21,778	--
2	12,442	--	--	--	29,243	--	--	--	20,062	20,062	20,062	--
5	10,988	--	--	--	25,777	--	--	--	17,526	17,526	17,526	--

September Regulated Frequency Flow in cfs at Kingston.

Exceedance Probability (%)	**1961 Hydrograph Shape**				**1979 Hydrograph Shape**				**1990 Hydrograph Shape**			
	Baseline	**September Drawdown**	**Phased Drawdown**	**November Drawdown**	**Baseline**	**September Drawdown**	**Phased Drawdown**	**November Drawdown**	**Baseline**	**September Drawdown**	**Phased Drawdown**	**November Drawdown**
0.2	15,874	15,874	15,874	--	45,851	45,851	45,851	--	25,231	25,231	25,231	25,231
0.5	14,534	14,534	14,534	--	35,452	35,452	35,452	--	23,282	23,282	23,282	23,282
1	13,500	13,500	13,500	--	31,791	31,791	31,791	--	21,778	21,778	21,778	21,778
2	12,442	12,442	12,442	--	29,243	29,243	29,243	--	20,062	20,062	20,062	20,062
5	10,988	10,988	10,988	--	25,777	25,777	25,777	--	17,526	17,526	17,526	17,526

… Continued …

Table M.02 Monthly Regulated Flood Frequency Flow at Kingston -- *Continued*

October Regulated Frequency Flow in cfs at Kingston.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	15,874	15,874	15,874	15,874	46,004	37,617	37,441	46,004	25,231	25,231	25,231	25,231
0.5	14,534	14,534	14,534	14,534	35,573	34,223	34,223	35,573	23,282	23,282	23,282	23,282
1	13,500	13,500	13,500	13,500	31,791	31,791	31,791	31,791	21,778	21,778	21,778	21,778
2	12,442	12,442	12,442	12,442	29,243	29,243	29,243	29,243	20,062	20,062	20,062	20,062
5	10,988	10,988	10,988	10,988	25,777	25,777	25,777	25,777	17,526	17,526	17,526	17,526

November Regulated Frequency Flow in cfs at Kingston.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	15,874	15,874	15,874	15,874	37,441	37,441	37,441	46,142	25,231	25,231	25,231	25,231
0.5	14,534	14,534	14,534	14,534	34,223	34,223	34,223	35,708	23,282	23,282	23,282	23,282
1	13,500	13,500	13,500	13,500	31,791	31,791	31,791	31,791	21,778	21,778	21,778	21,778
2	12,442	12,442	12,442	12,442	29,243	29,243	29,243	29,243	20,062	20,062	20,062	20,062
5	10,988	10,988	10,988	10,988	25,777	25,777	25,777	25,777	17,526	17,526	17,526	17,526

December Regulated Frequency Flow in cfs at Kingston.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	15,874	15,874	15,874	15,874	37,441	37,441	37,441	37,441	25,231	25,231	25,231	25,231
0.5	14,534	14,534	14,534	14,534	34,223	34,223	34,223	34,223	23,282	23,282	23,282	23,282
1	13,500	13,500	13,500	13,500	31,791	31,791	31,791	31,791	21,778	21,778	21,778	21,778
2	12,442	12,442	12,442	12,442	29,243	29,243	29,243	29,243	20,062	20,062	20,062	20,062
5	10,988	10,988	10,988	10,988	25,777	25,777	25,777	25,777	17,526	17,526	17,526	17,526

Table M.03 Monthly Regulated Flood Frequency Flow at Rome-Coosa

(Note: The frequency flows are same for the "September Drawdown", "Phased Drawdown" and "November Drawdown" as the "Baseline" simulation as the Allatoona guide curves remain the same.)

January Regulated Frequency Flow in cfs at Rome-Coosa.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	83,105	83,105	83,105	83,105	77,455	77,455	77,455	77,455	78,998	78,998	78,998	78,998
0.5	75,948	75,948	75,948	75,948	71,265	71,265	71,265	71,265	72,832	72,832	72,832	72,832
1	70,384	70,384	70,384	70,384	66,539	66,539	66,539	66,539	68,084	68,084	68,084	68,084
2	64,895	64,895	64,895	64,895	61,633	61,633	61,633	61,633	63,170	63,170	63,170	63,170
5	57,363	57,363	57,363	57,363	54,998	54,998	54,998	54,998	55,425	55,425	55,425	55,425

February Regulated Frequency Flow in cfs at Rome-Coosa.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	83,105	--	--	--	77,766	77,766	77,766	77,766	78,998	--	--	--
0.5	75,948	--	--	--	71,324	71,324	71,324	71,324	72,833	--	--	--
1	70,384	--	--	--	66,530	66,530	66,530	66,530	68,084	--	--	--
2	64,894	--	--	--	61,633	61,633	61,633	61,633	63,170	--	--	--
5	57,363	--	--	--	54,998	54,998	54,998	54,998	55,431	--	--	--

March Regulated Frequency Flow in cfs at Rome-Coosa.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	83,105	--	--	--	77,766	--	--	--	78,998	--	--	--
0.5	75,948	--	--	--	71,543	--	--	--	72,832	--	--	--
1	70,384	--	--	--	66,527	--	--	--	68,084	--	--	--
2	64,894	--	--	--	61,633	--	--	--	63,170	--	--	--
5	57,362	--	--	--	54,998	--	--	--	55,119	--	--	--

… Continued …

Table M.03 Monthly Regulated Flood Frequency Flow at Rome-Coosa -- *Continued*

April Regulated Frequency Flow in cfs at Rome-Coosa.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	82,459	--	--	--	77,186	--	--	--	81,711	--	--	--
0.5	75,377	--	--	--	69,680	--	--	--	72,861	--	--	--
1	69,888	--	--	--	64,936	--	--	--	68,054	--	--	--
2	64,392	--	--	--	60,021	--	--	--	63,126	--	--	--
5	56,842	--	--	--	53,310	--	--	--	55,099	--	--	--

May Regulated Frequency Flow in cfs at Rome-Coosa.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	82,459	--	--	--	87,203	--	--	--	82,198	--	--	--
0.5	75,375	--	--	--	75,637	--	--	--	76,036	--	--	--
1	69,886	--	--	--	65,189	--	--	--	70,972	--	--	--
2	64,389	--	--	--	60,155	--	--	--	65,615	--	--	--
5	56,843	--	--	--	53,310	--	--	--	55,099	--	--	--

June Regulated Frequency Flow in cfs at Rome-Coosa.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	82,459	--	--	--	93,952	--	--	--	84,963	--	--	--
0.5	75,375	--	--	--	78,017	--	--	--	76,246	--	--	--
1	69,886	--	--	--	65,189	--	--	--	70,975	--	--	--
2	65,971	--	--	--	60,164	--	--	--	65,949	--	--	--
5	56,839	--	--	--	53,310	--	--	--	55,099	--	--	--

… Continued …

Table M.03 Monthly Regulated Flood Frequency Flow at Rome-Coosa -- *Continued*

July Regulated Frequency Flow in cfs at Rome-Coosa.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	82,459	--	--	--	95,339	--	--	--	82,705	--	--	--
0.5	75,378	--	--	--	78,092	--	--	--	76,099	--	--	--
1	69,889	--	--	--	64,947	--	--	--	70,971	--	--	--
2	64,393	--	--	--	60,021	--	--	--	65,988	--	--	--
5	56,842	--	--	--	53,310	--	--	--	55,099	--	--	--

August Regulated Frequency Flow in cfs at Rome-Coosa.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	82,459	--	--	--	95,624	--	--	--	84,900	84,900	84,900	--
0.5	75,375	--	--	--	78,104	--	--	--	76,149	76,149	76,149	--
1	69,886	--	--	--	65,189	--	--	--	70,971	70,971	70,971	--
2	64,391	--	--	--	60,165	--	--	--	65,877	65,877	65,877	--
5	56,841	--	--	--	53,310	--	--	--	55,099	55,099	55,099	--

September Regulated Frequency Flow in cfs at Rome-Coosa.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	82,459	82,459	82,459	--	102,379	102,379	102,379	--	85,220	85,220	85,220	85,220
0.5	76,417	76,417	76,417	--	79,847	79,847	79,847	--	76,146	76,146	76,146	76,146
1	70,702	70,702	70,702	--	65,246	65,246	65,246	--	70,969	70,969	70,969	70,969
2	65,103	65,103	65,103	--	60,165	60,165	60,165	--	65,926	65,926	65,926	65,926
5	56,840	56,840	56,840	--	53,310	53,310	53,310	--	55,099	55,099	55,099	55,099

… *Continued* …

Table M.03 Monthly Regulated Flood Frequency Flow at Rome-Coosa -- *Continued*

October Regulated Frequency Flow in cfs at Rome-Coosa.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	82,459	82,459	82,459	82,459	96,396	92,552	91,559	96,396	83,958	82,942	82,942	83,958
0.5	75,375	75,375	75,375	75,375	78,193	72,561	72,450	78,193	76,150	76,150	76,150	76,150
1	69,886	69,886	69,886	69,886	65,179	65,179	65,179	65,179	70,972	70,972	70,972	70,972
2	64,391	64,391	64,391	64,391	60,086	60,086	60,086	60,086	65,764	65,764	65,764	65,764
5	56,841	56,841	56,841	56,841	53,310	53,310	53,310	53,310	55,099	55,099	55,099	55,099

November Regulated Frequency Flow in cfs at Rome-Coosa.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	83,105	83,105	83,105	83,105	80,126	78,813	80,084	91,149	81,311	81,311	81,311	84,686
0.5	75,948	75,948	75,948	75,948	71,752	71,752	71,752	79,860	73,178	73,178	73,178	73,178
1	70,384	70,384	70,384	70,384	66,806	66,806	66,806	66,806	68,091	68,091	68,091	68,091
2	64,896	64,896	64,896	64,896	61,760	61,760	61,760	61,760	63,173	63,173	63,173	63,173
5	57,364	57,364	57,364	57,364	55,000	55,000	55,000	55,000	55,126	55,126	55,126	55,126

December Regulated Frequency Flow in cfs at Rome-Coosa.

Exceedance Probability (%)	1961 Hydrograph Shape				1979 Hydrograph Shape				1990 Hydrograph Shape			
	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.2	83,105	83,105	83,105	83,105	77,495	77,495	77,495	77,495	78,998	78,998	78,998	78,998
0.5	76,737	76,737	76,737	76,737	71,307	71,307	71,307	71,307	72,832	72,832	72,832	72,832
1	70,384	70,384	70,384	70,384	66,586	66,586	66,586	66,586	68,084	68,084	68,084	68,084
2	65,576	65,576	65,576	65,576	61,634	61,634	61,634	61,634	63,170	63,170	63,170	63,170
5	57,965	57,965	57,965	57,965	54,998	54,998	54,998	54,998	55,129	55,129	55,129	55,129

D. Step 4 – Determine Probabilities of Hypothetical Hydrographs Occurring in Each Month

A flood event in the ACT basin is primarily caused by two distinct types of storms. One is general cyclonic storms typically occurring in winter and spring months. The other is intense tropical storms typically occurring between the summer and fall seasons. As a result, large flood events do show seasonal distribution. In this study, to evaluate the seasonal likelihood of a large flood, the unimpaired daily flow records at Kingston and Rome-Coosa from 1939 through 2008 were used to extract the monthly maximum annual daily mean discharges. This is accomplished using HEC-SSP. The monthly maximum annual daily mean discharges were then converted to the instantaneous values using the instantaneous peak flow versus daily average flow relationship at the Rome-Coosa gage (Figure M.05) and the Kingston gage (Figure M.06).

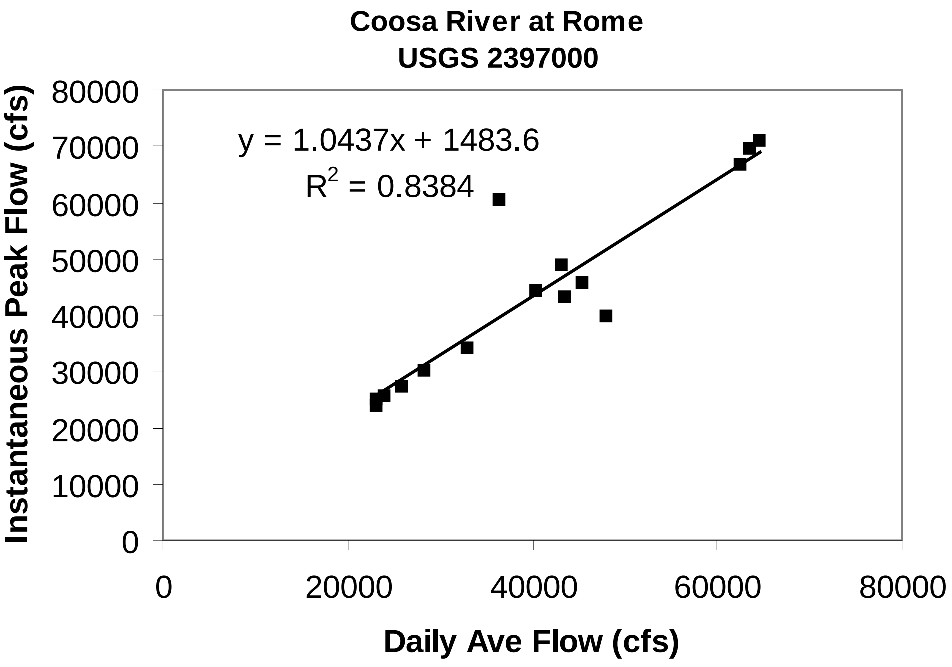


Figure M.05 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Rome-Coosa Gage (U.S. Army Corps of Engineers, 2009)

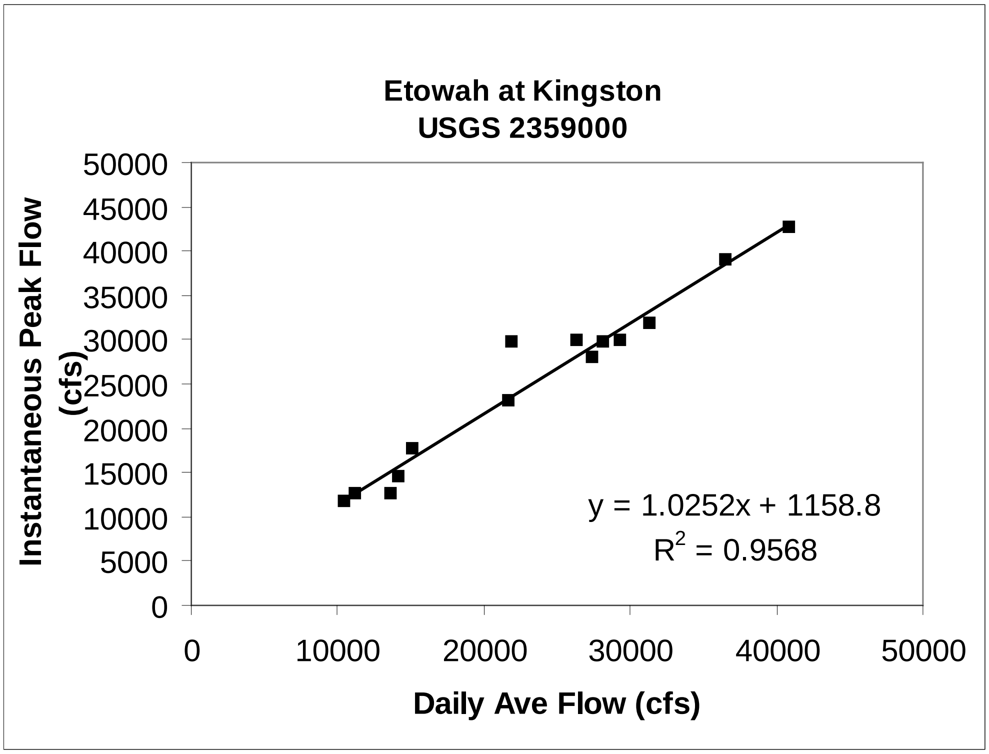


Figure M.06 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Kingston Gage (U.S. Army Corps of Engineers, 2009)

A Log-Pearson III flood frequency analysis was then conducted using HEC-SSP and the monthly maximum annual instantaneous discharges. Figures M.07 through M.30 include the flood frequency plots for each month at Kingston and Rome-Coosa.

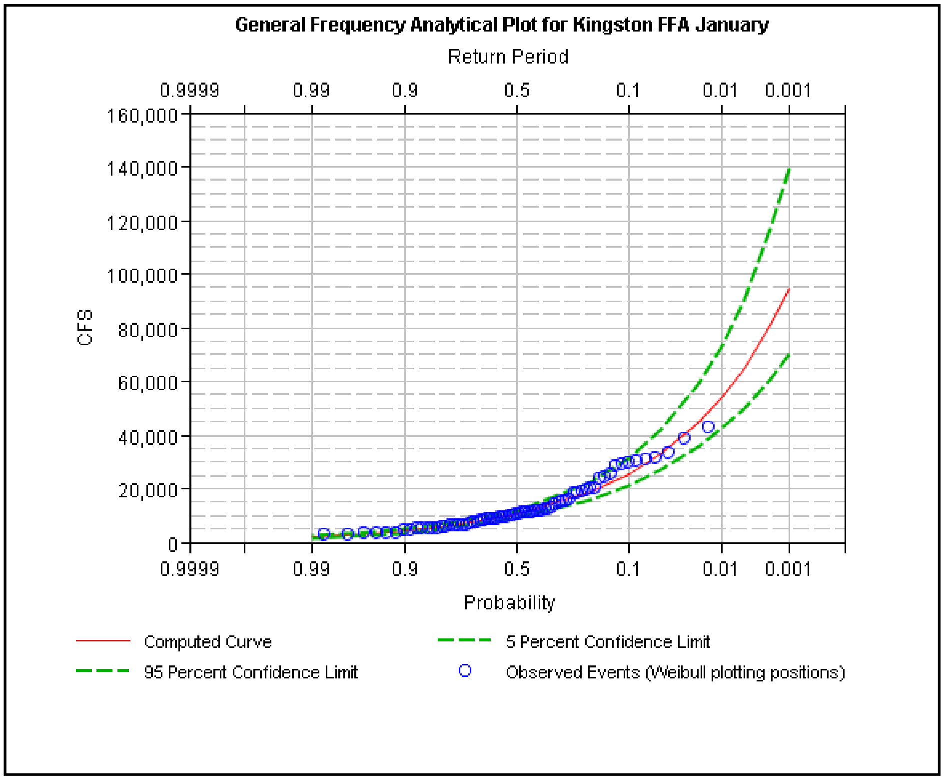


Figure M.07 January Unregulated Flood Frequency Curve at Kingston

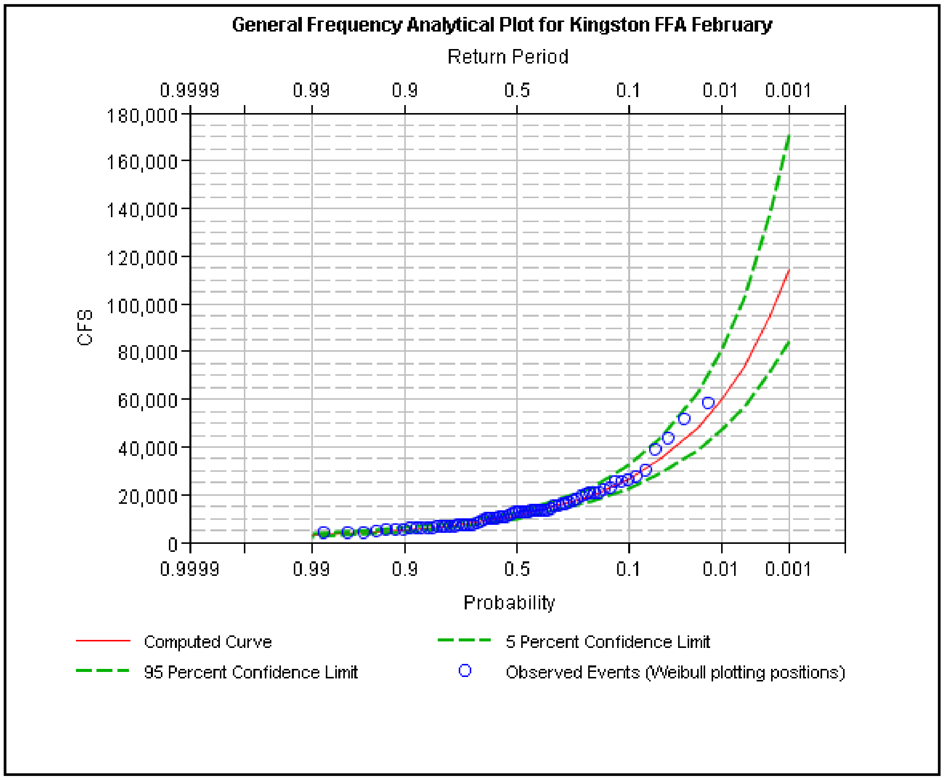


Figure M.08 February Unregulated Flood Frequency Curve at Kingston

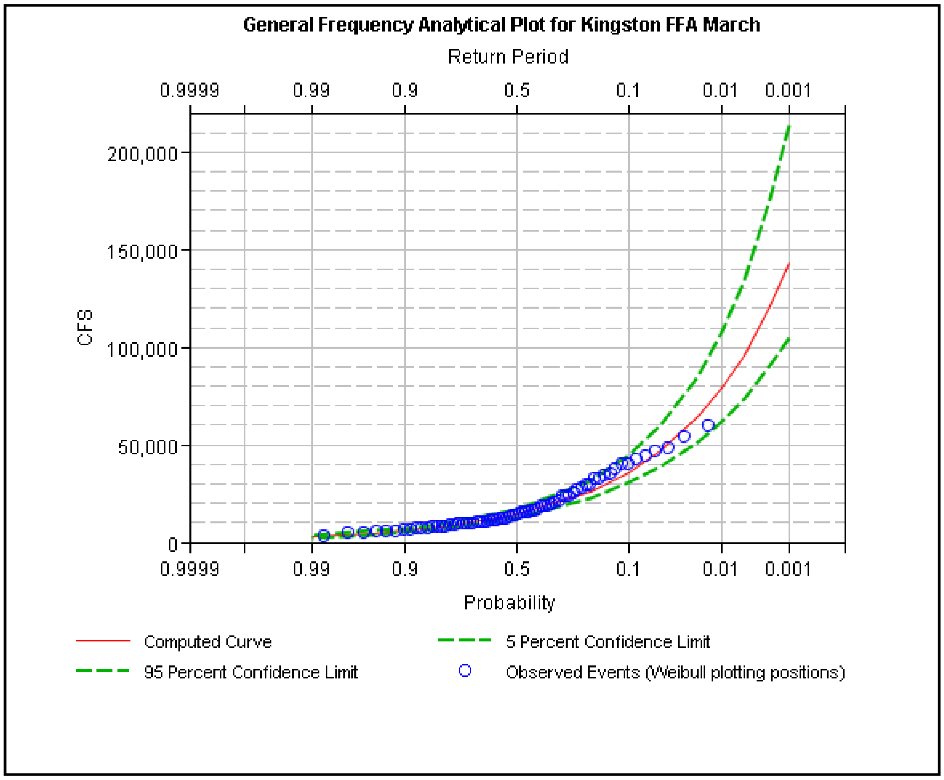


Figure M.09 March Unregulated Flood Frequency Curve at Kingston

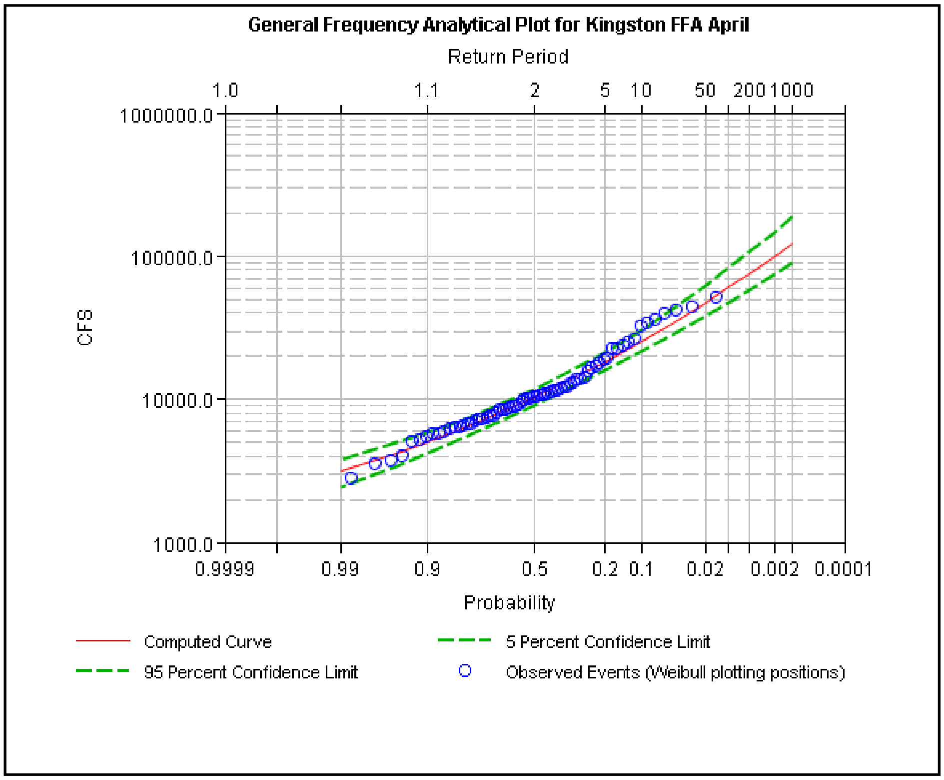


Figure M.10 April Unregulated Flood Frequency Curve at Kingston

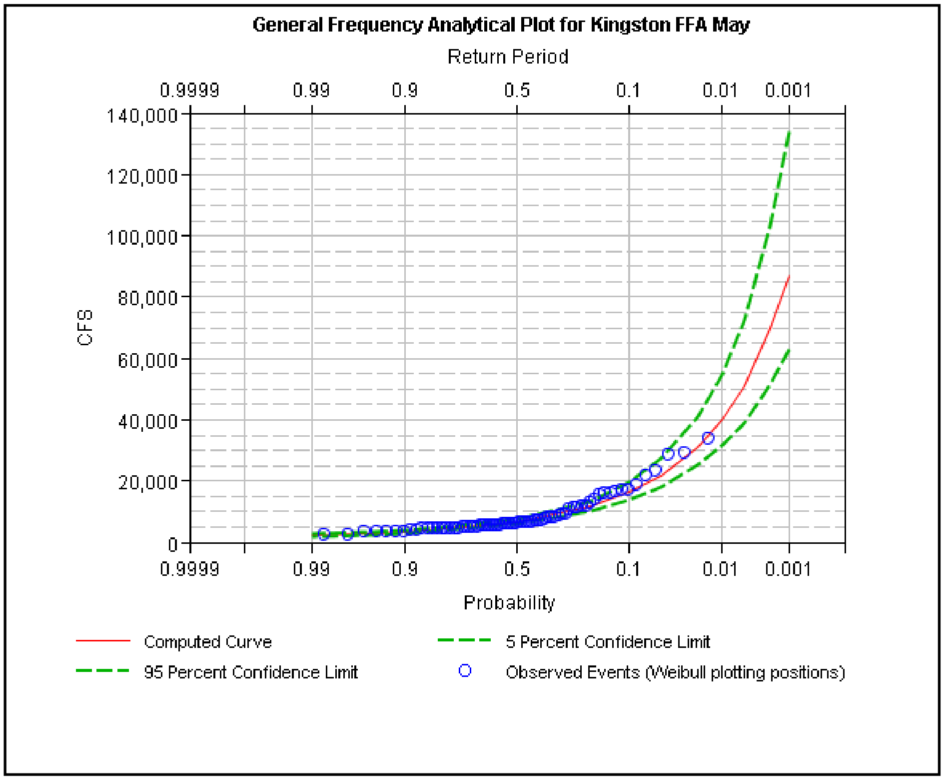


Figure M.11 May Unregulated Flood Frequency Curve at Kingston

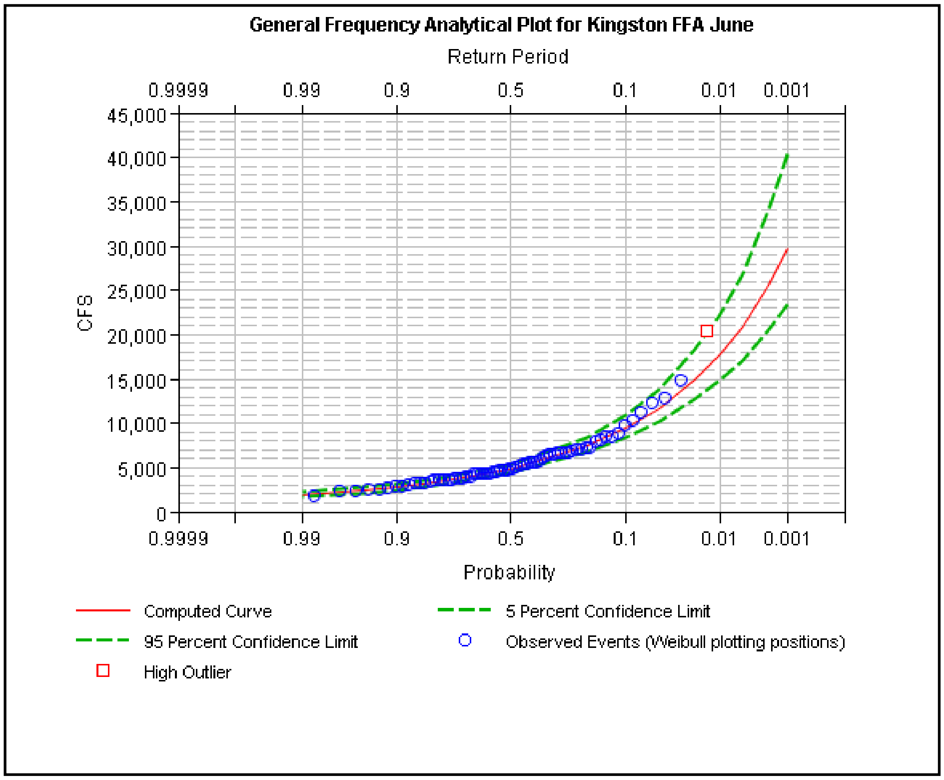


Figure M.12 June Unregulated Flood Frequency Curve at Kingston

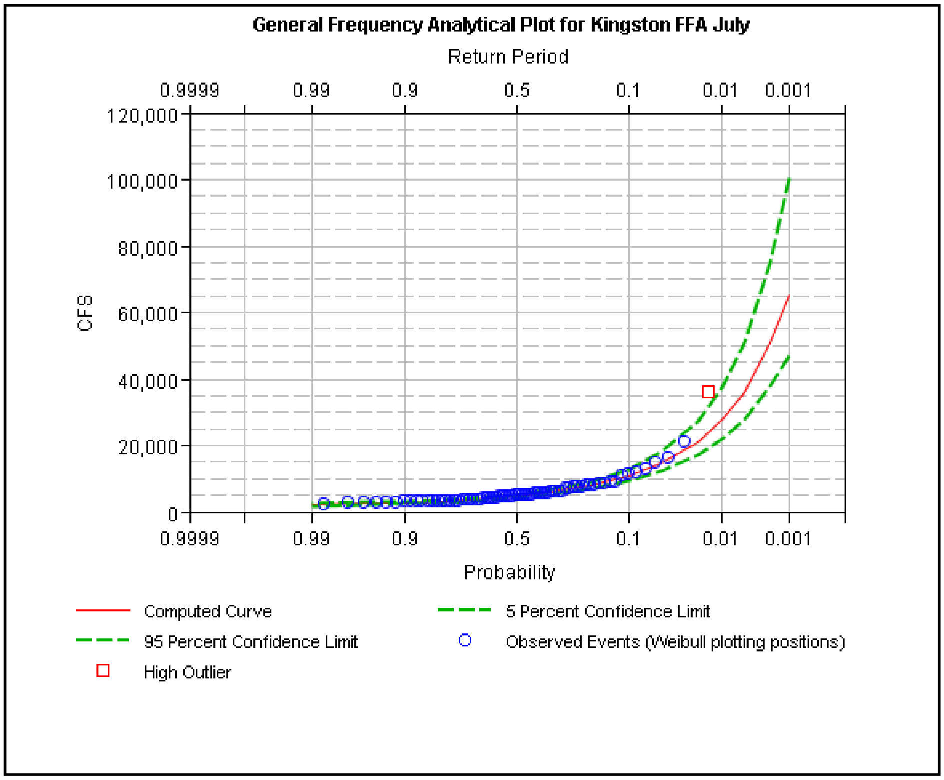


Figure M.13 July Unregulated Flood Frequency Curve at Kingston

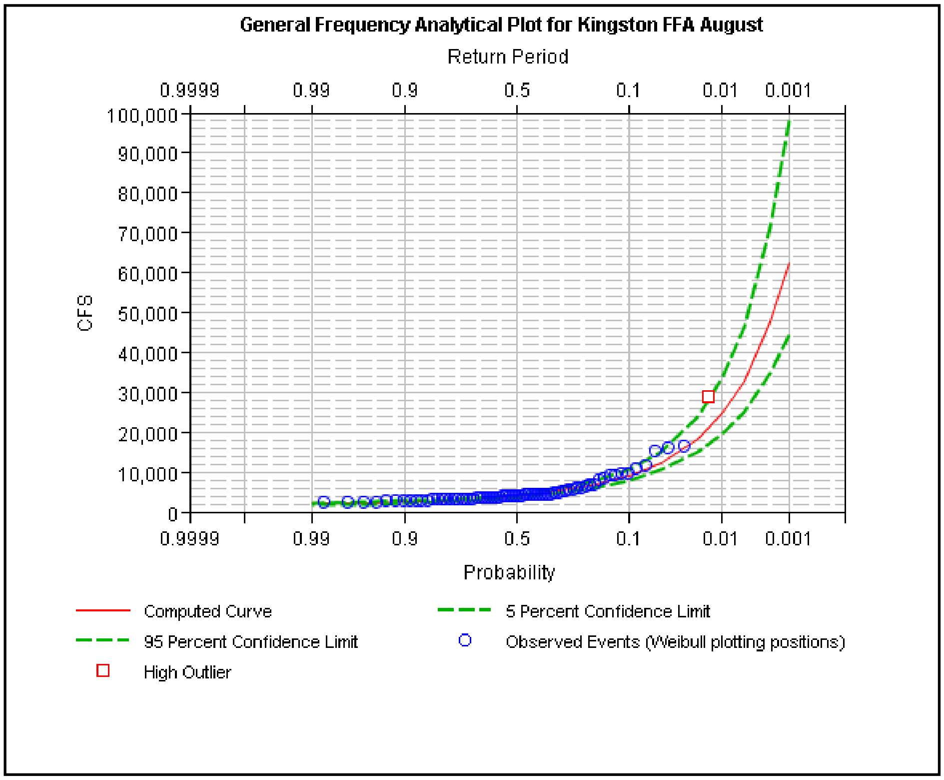


Figure M.14 August Unregulated Flood Frequency Curve at Kingston

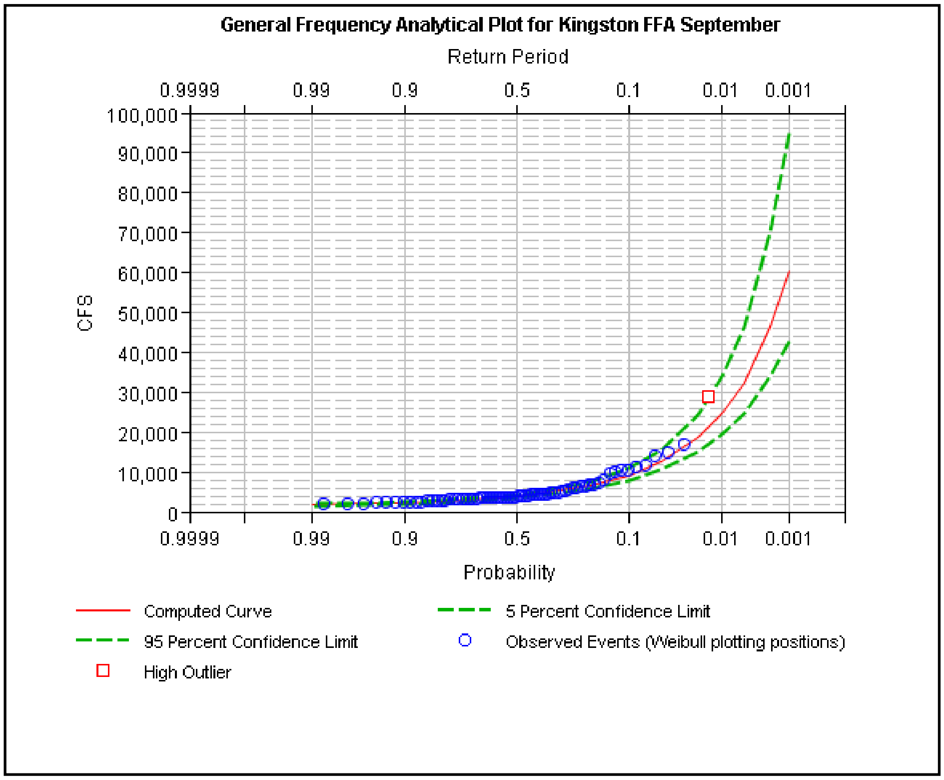


Figure M.15 September Unregulated Flood Frequency Curve at Kingston

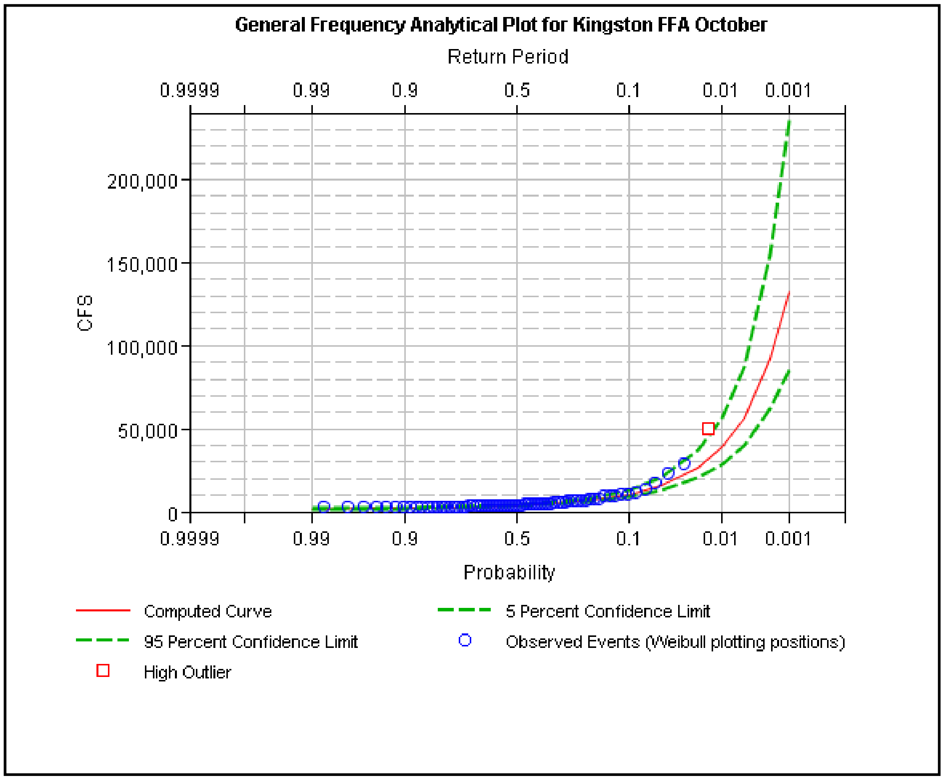


Figure M.16 October Unregulated Flood Frequency Curve at Kingston

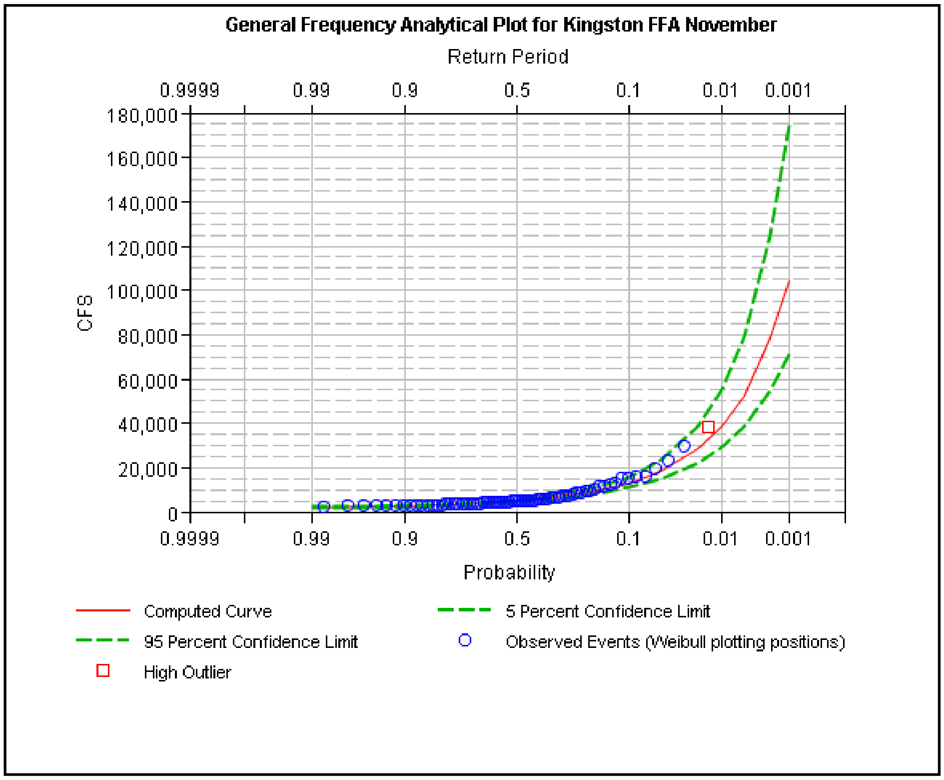


Figure M.17 November Unregulated Flood Frequency Curve at Kingston

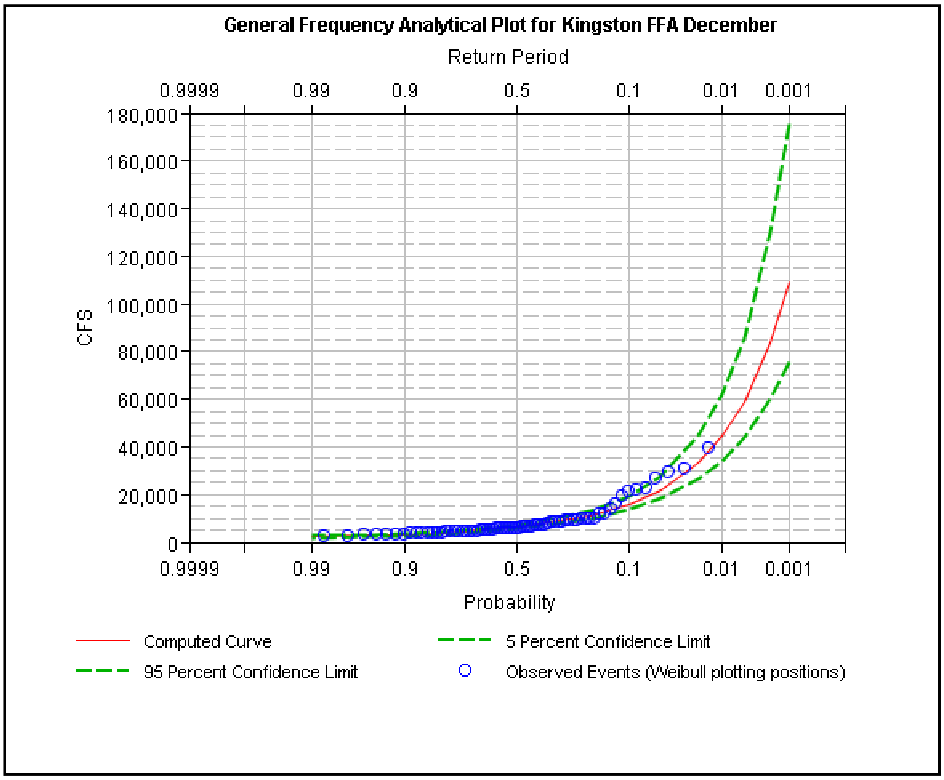


Figure M.18 December Unregulated Flood Frequency Curve at Kingston

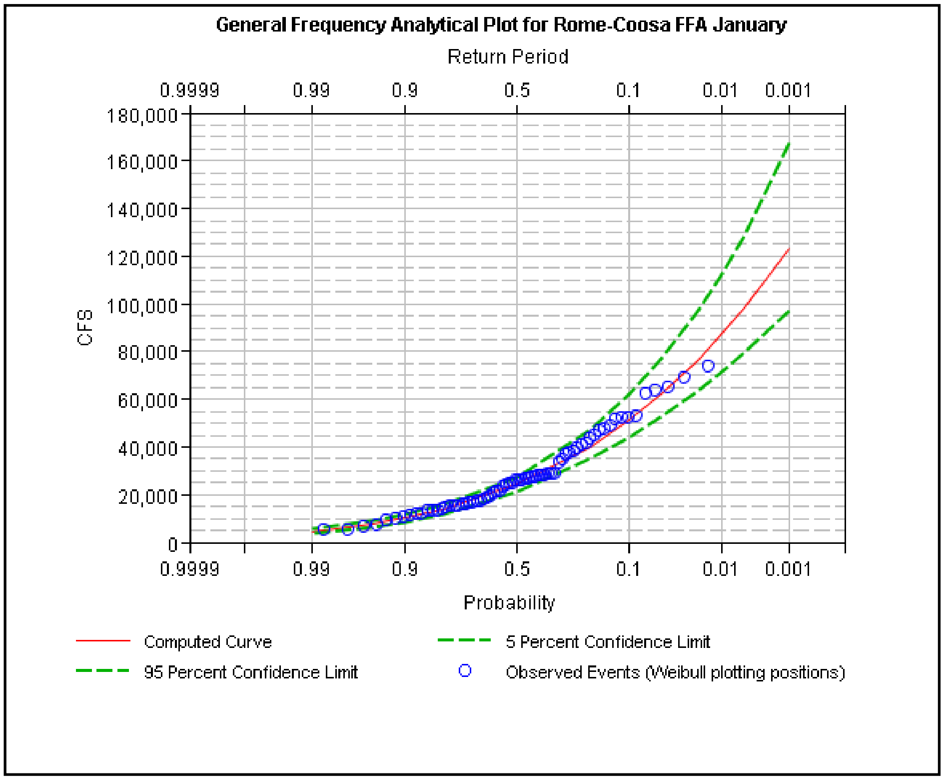


Figure M.19 January Unregulated Flood Frequency Curve at Rome-Coosa

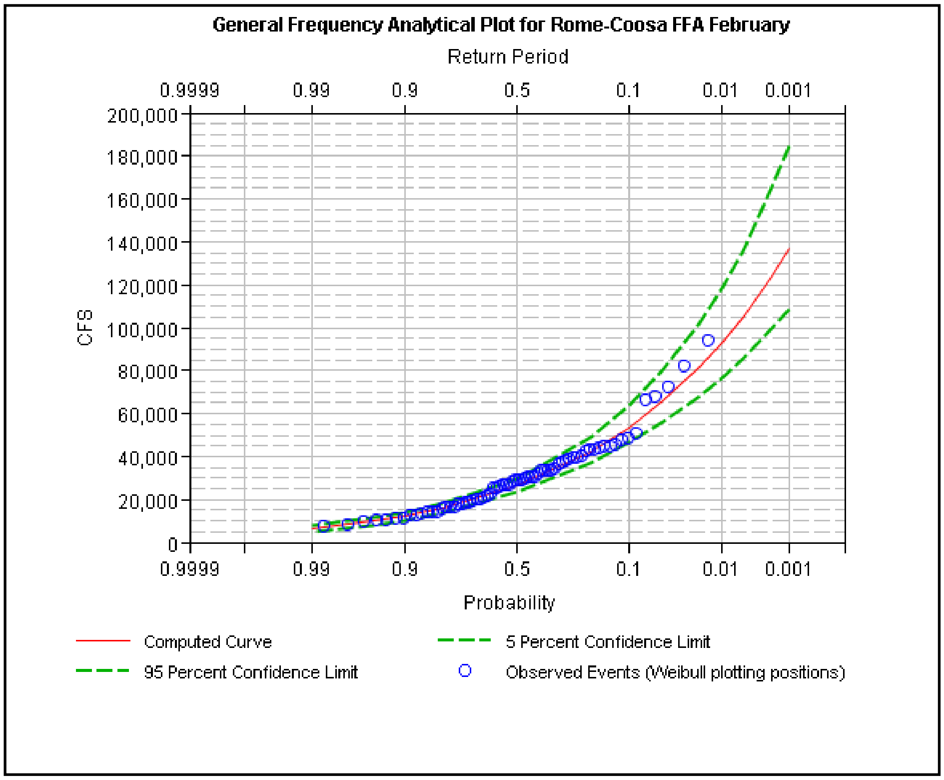


Figure M.20 February Unregulated Flood Frequency Curve at Rome-Coosa

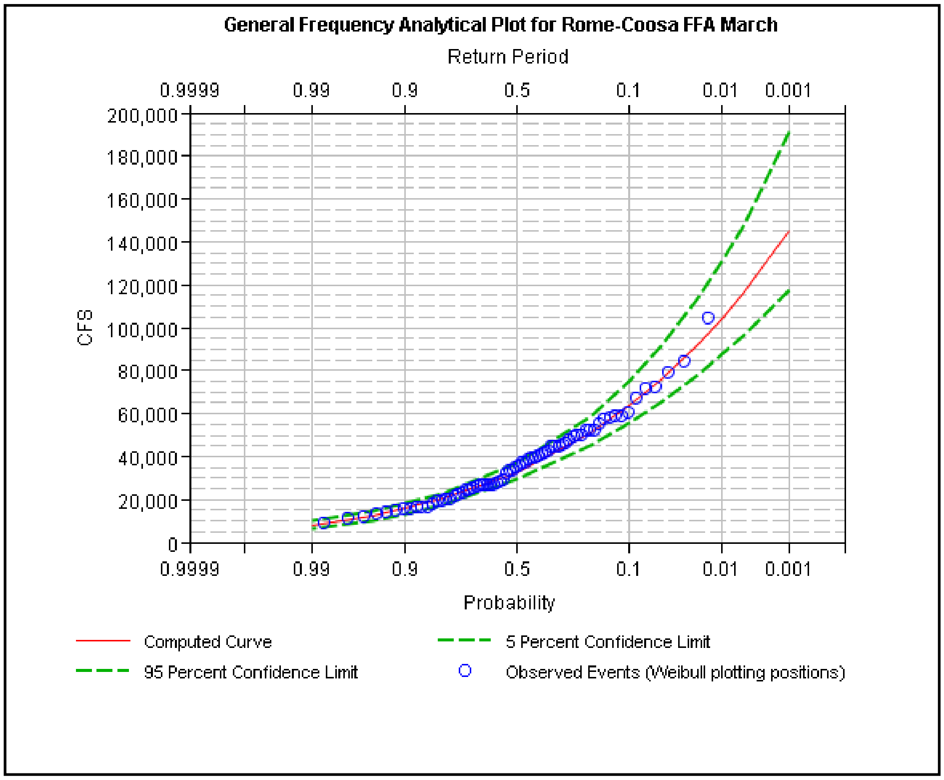


Figure M.21 March Unregulated Flood Frequency Curve at Rome-Coosa

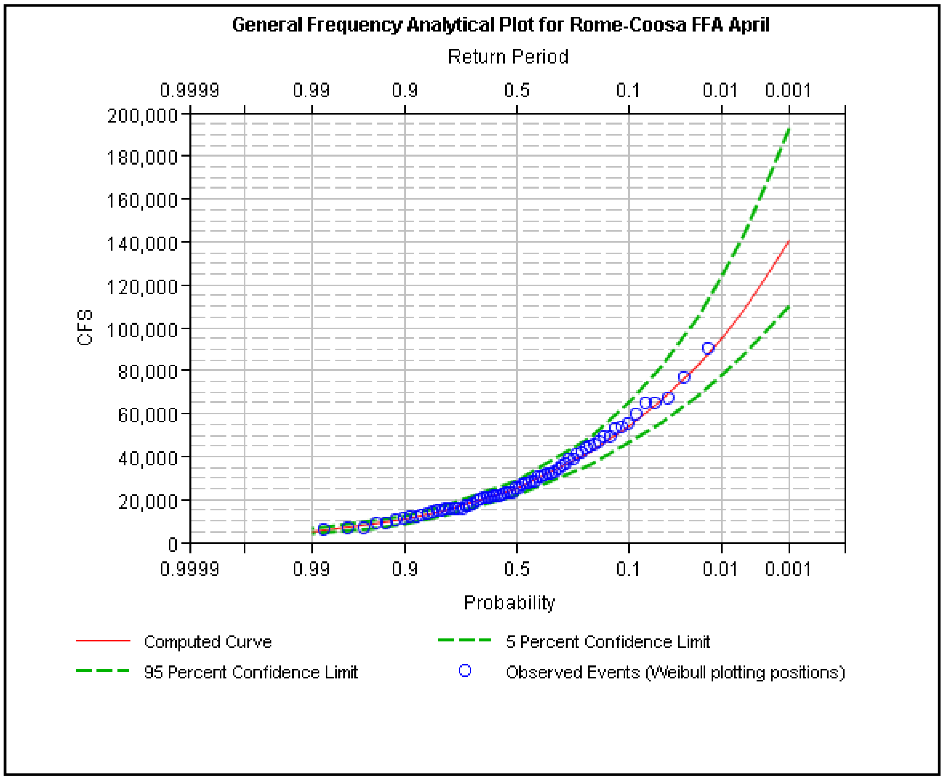


Figure M.22 April Unregulated Flood Frequency Curve at Rome-Coosa

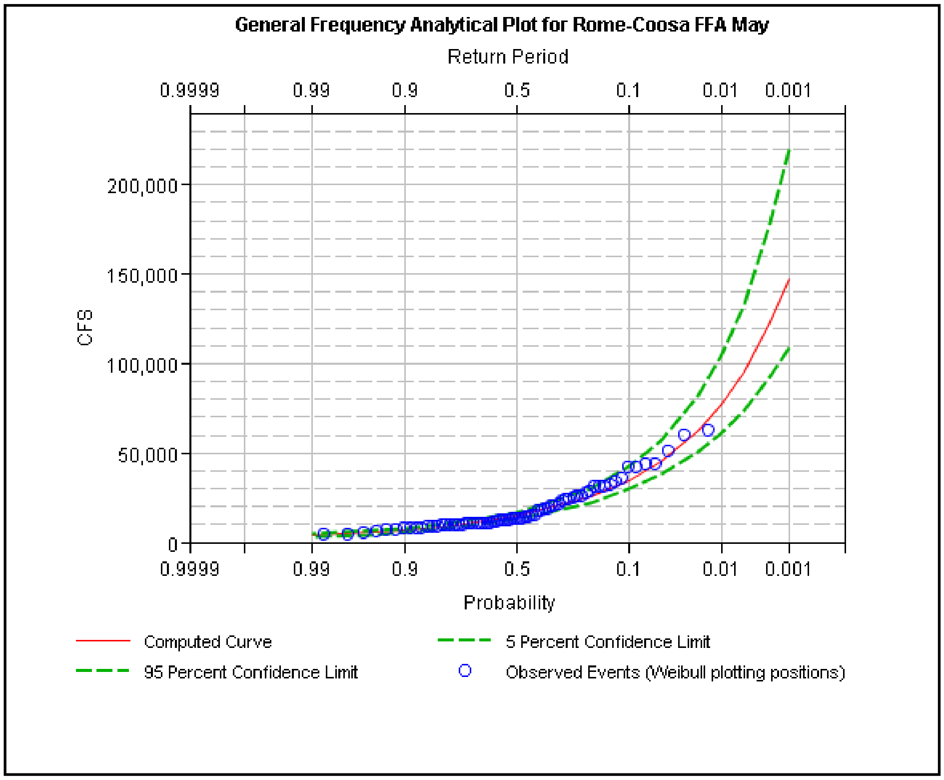


Figure M.23 May Unregulated Flood Frequency Curve at Rome-Coosa

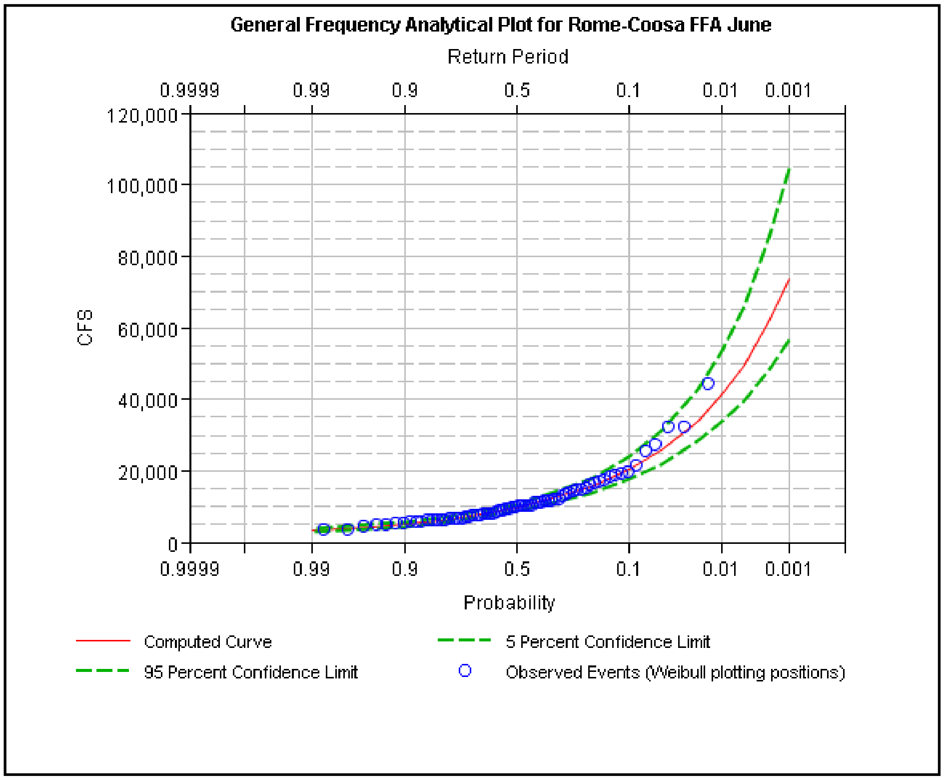


Figure M.24 June Unregulated Flood Frequency Curve at Rome-Coosa

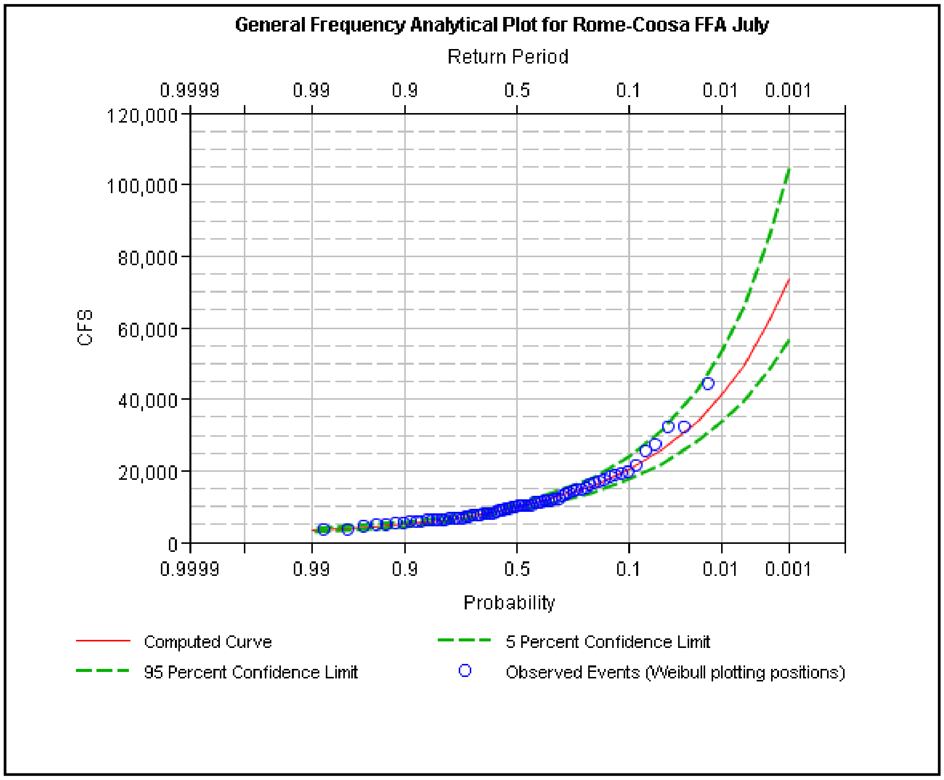


Figure M.25 July Unregulated Flood Frequency Curve at Rome-Coosa

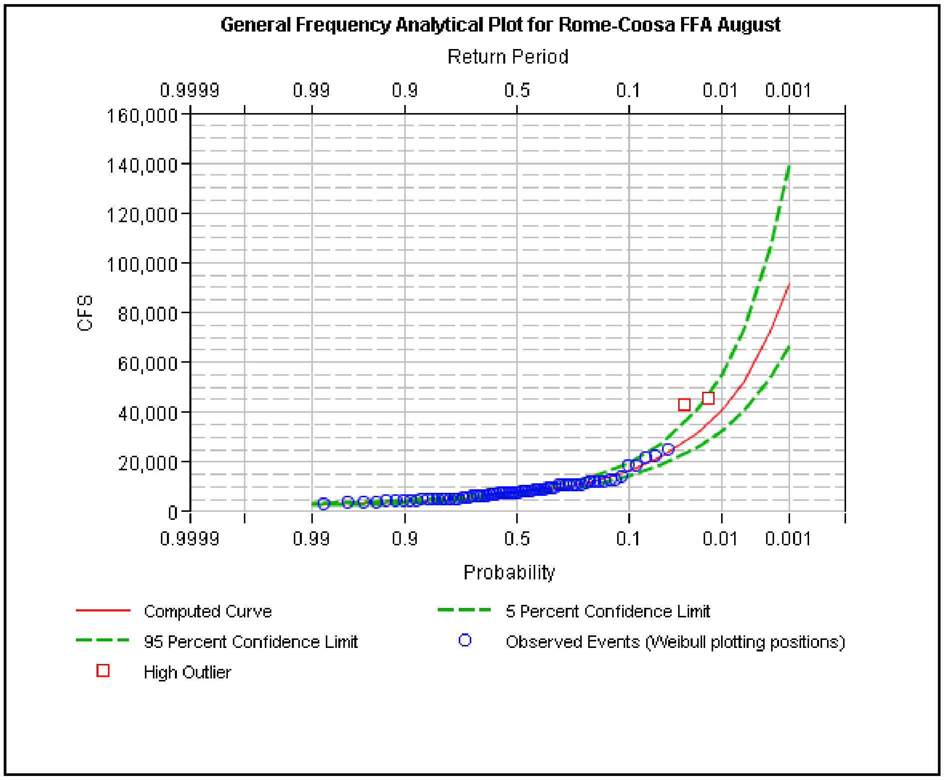


Figure M.26 August Unregulated Flood Frequency Curve at Rome-Coosa

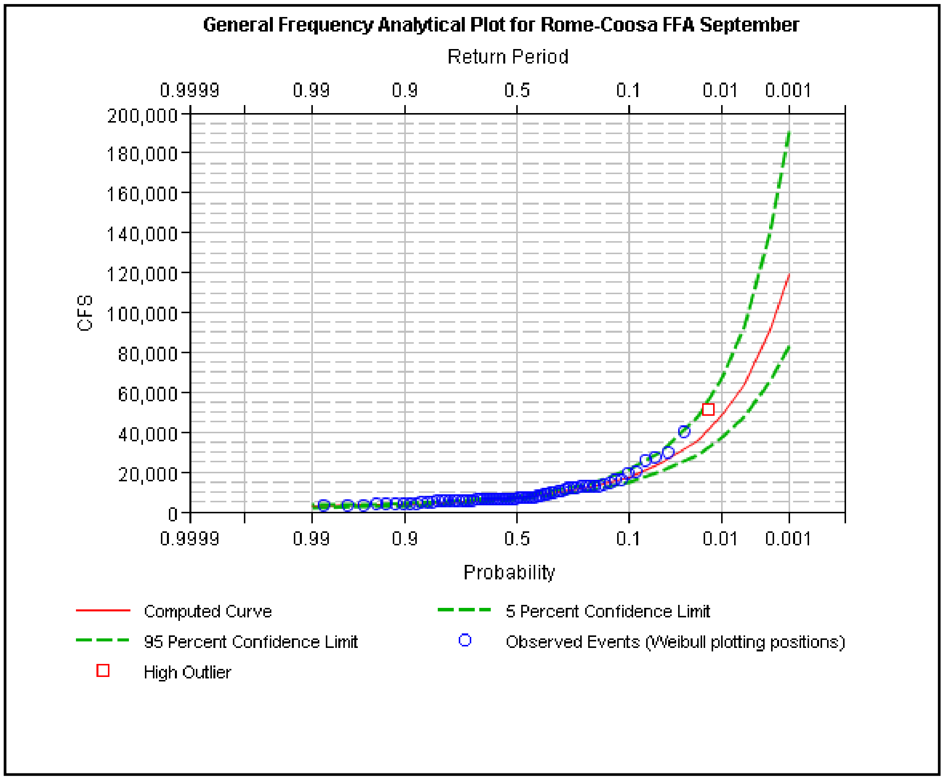


Figure M.27 September Unregulated Flood Frequency Curve at Rome-Coosa

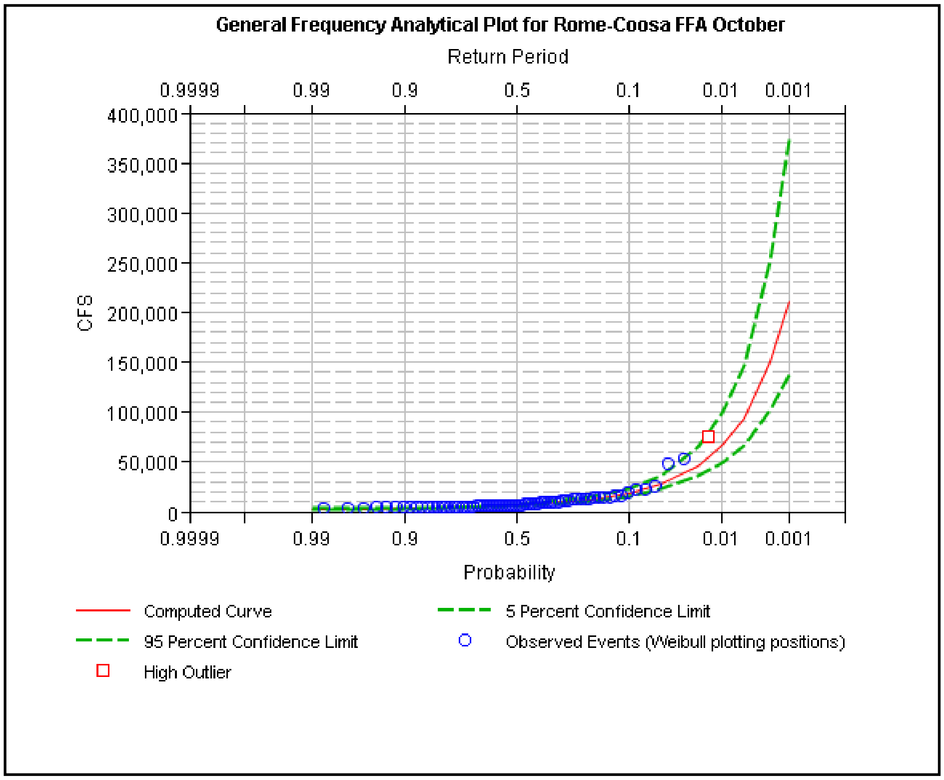


Figure M.28 October Unregulated Flood Frequency Curve at Rome-Coosa

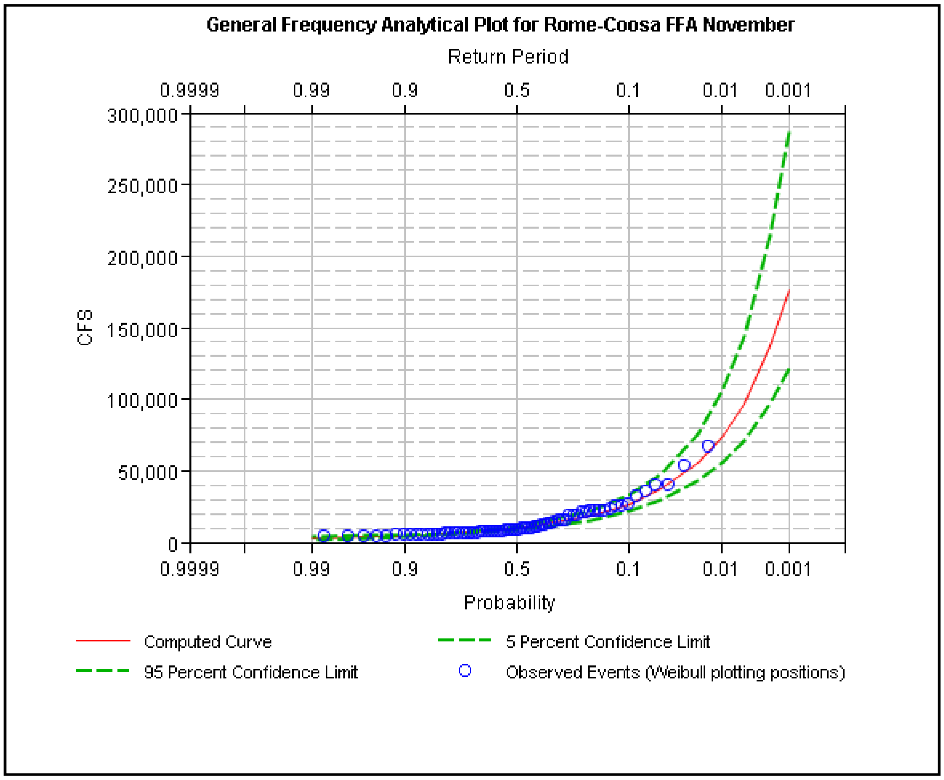


Figure M.29 November Unregulated Flood Frequency Curve at Rome-Coosa

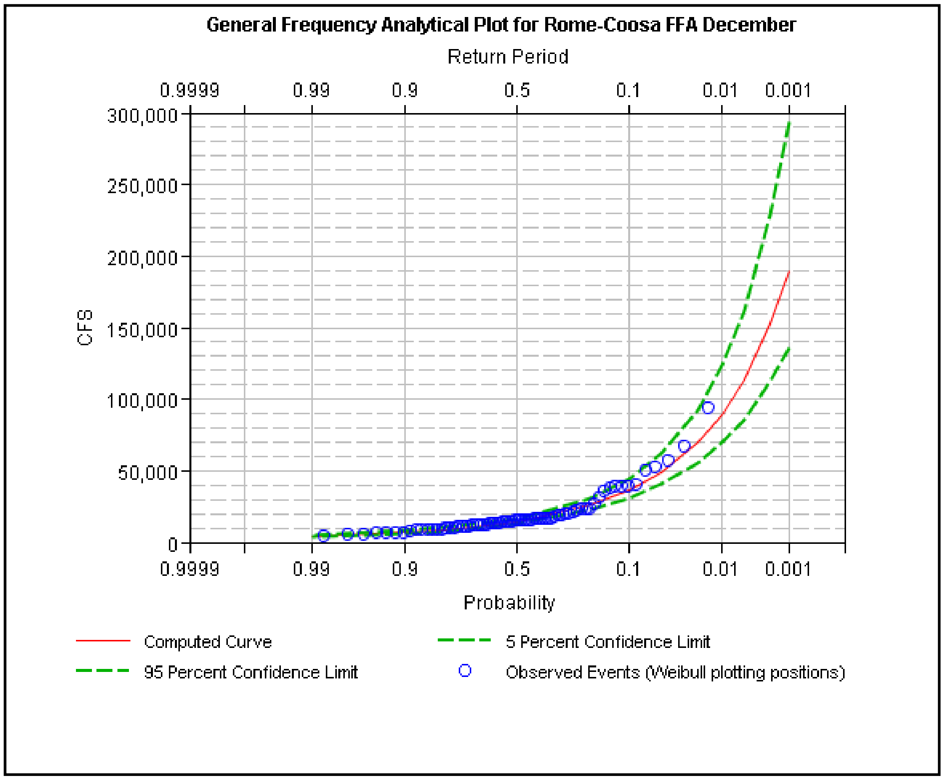


Figure M.30 December Unregulated Flood Frequency Curve at Rome-Coosa

To determine the conditional exceedance probabilities of an overall hypothetical event occurring at a given month, 6 discharge values that cover the range of the regulated peak flows were selected to represent the range of the regulated 5-, 2-, 1-, 0.5, and 0.2-percent flood frequency flows at Kingston and Rome-Coosa. For every flow value, the conditional exceedance probability of a hypothetical flood event that has the peak discharge equal to the selected flow value and that will occur in each month is determined from the flood frequency curves previously shown in Figures M.07 through M.30. Tables M.04 and M.05 show the conditional exceedance probabilities at each flow value for Kingston and Rome-Coosa.

Table M.04 Conditional Exceedance Probability for Each Month at Selected Flow Values for Kingston

Q (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50000	0.01317	0.01773	0.04252	0.01735	0.00535	0.00006	0.00209	0.00176	0.00165	0.00626	0.00567	0.00748
40000	0.02792	0.03454	0.07764	0.03239	0.01011	0.00022	0.00384	0.00309	0.00296	0.00941	0.00937	0.01289
30000	0.06532	0.07491	0.15223	0.06764	0.02222	0.00095	0.00820	0.00626	0.00615	0.01599	0.01769	0.02547
20000	0.17343	0.18927	0.32372	0.16811	0.06197	0.00601	0.02321	0.01665	0.01675	0.03342	0.04183	0.06263
15000	0.29803	0.32573	0.48027	0.29193	0.11967	0.01953	0.04680	0.03294	0.03345	0.05492	0.07452	0.11320
10000	0.52055	0.56873	0.70721	0.52429	0.27189	0.08328	0.11962	0.08180	0.08315	0.11020	0.15919	0.24326

Table M.05 Conditional Exceedance Probability for Each Month at Selected Flow Values for Rome-Coosa

Q (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
110000	0.00234	0.00397	0.00723	0.00467	0.00302	0.00016	0.00151	0.00056	0.00124	0.00375	0.00361	0.00548
95000	0.00611	0.00897	0.01700	0.01027	0.00507	0.00032	0.00230	0.00089	0.00181	0.00498	0.00527	0.00842
85000	0.01161	0.01571	0.03000	0.01759	0.00744	0.00054	0.00316	0.00124	0.00242	0.00622	0.00702	0.01156
75000	0.02205	0.02791	0.05320	0.03039	0.01127	0.00093	0.00447	0.00180	0.00335	0.00794	0.00959	0.01637
60000	0.05759	0.06793	0.12342	0.07067	0.02273	0.00236	0.00823	0.00346	0.00586	0.01222	0.01659	0.02981
50000	0.10852	0.12427	0.21286	0.12500	0.03879	0.00484	0.01337	0.00580	0.00919	0.01729	0.02556	0.04700

Tables M.06 and M.07 show the normalized conditional exceedance probabilities. As expected, October through April have greater conditional exceedance probabilities than the other months. The conditional exceedance probability in March is the greatest among all the months. In June, the conditional exceedance probability is the smallest.

Table M.06 Normalized Conditional Exceedance Probability for Each Month at Selected Flow Values for Kingston

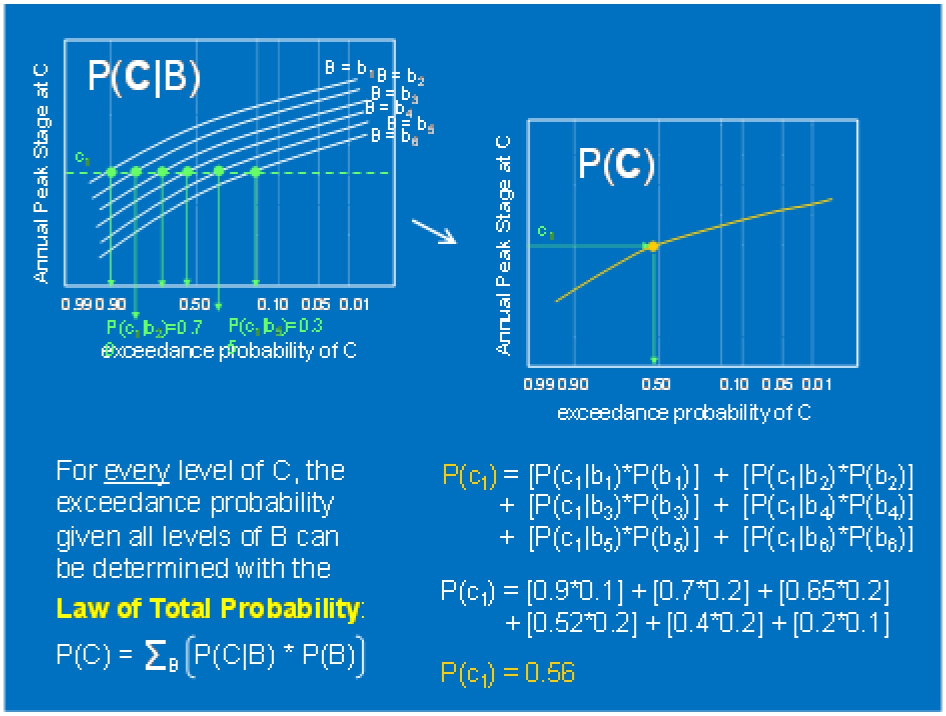
Q (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50000	10.9%	14.6%	35.1%	14.3%	4.4%	0.1%	1.7%	1.5%	1.4%	5.2%	4.7%	6.2%
40000	12.4%	15.4%	34.6%	14.4%	4.5%	0.1%	1.7%	1.4%	1.3%	4.2%	4.2%	5.7%
30000	14.1%	16.2%	32.9%	14.6%	4.8%	0.2%	1.8%	1.4%	1.3%	3.5%	3.8%	5.5%
20000	15.5%	16.9%	29.0%	15.1%	5.5%	0.5%	2.1%	1.5%	1.5%	3.0%	3.7%	5.6%
15000	15.8%	17.2%	25.4%	15.4%	6.3%	1.0%	2.5%	1.7%	1.8%	2.9%	3.9%	6.0%
10000	15.0%	16.4%	20.4%	15.1%	7.8%	2.4%	3.4%	2.4%	2.4%	3.2%	4.6%	7.0%

Table M.07 Normalized Conditional Exceedance Probability for Each Month at Selected Flow Values for Rome-Coosa

Q (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
110000	6.2%	10.6%	19.3%	12.5%	8.0%	0.4%	4.0%	1.5%	3.3%	10.0%	9.6%	14.6%
95000	8.6%	12.6%	23.8%	14.4%	7.1%	0.5%	3.2%	1.2%	2.5%	7.0%	7.4%	11.8%
85000	10.1%	13.7%	26.2%	15.4%	6.5%	0.5%	2.8%	1.1%	2.1%	5.4%	6.1%	10.1%
75000	11.7%	14.7%	28.1%	16.1%	6.0%	0.5%	2.4%	1.0%	1.8%	4.2%	5.1%	8.7%
60000	13.7%	16.1%	29.3%	16.8%	5.4%	0.6%	2.0%	0.8%	1.4%	2.9%	3.9%	7.1%
50000	14.8%	17.0%	29.1%	17.1%	5.3%	0.7%	1.8%	0.8%	1.3%	2.4%	3.5%	6.4%

E. Step 5 – Application of Total Probability Theorem

As discussed previously, the flood frequency flow at Kingston and Rome-Coosa depends on the storm hydrographs and the month for which the storm hydrographs are applied. For each month, a regulated flood frequency curve was generated using the HEC-ResSim model in Step 3. These curves need to be combined to produce a “composite” flood frequency curve by considering the exceedance probabilities of flood events occurring in different months. According to the total probability theorem, for each selected flow value (described in Step 4), the exceedance probabilities from the regulated flood frequency curve in each month were multiplied by the corresponding relative exceedance probabilities of each month at the given flow value to obtain the combined exceedance probability. Figure M.31 shows an example of the calculation of the combined exceedance probability.



For *every* level of C, the exceedance probability given all levels of B can be determined with the **Law of Total Probability**:

$$P(C) = \sum_B \left(P(C|B) * P(B)\right)$$

$$P(c_1) = [P(c_1|b_1)*P(b_1)] + [P(c_1|b_2)*P(b_2)] + [P(c_1|b_3)*P(b_3)] + [P(c_1|b_4)*P(b_4)] + [P(c_1|b_5)*P(b_5)] + [P(c_1|b_6)*P(b_6)]$$

$$P(c_1) = [0.9*0.1] + [0.7*0.2] + [0.65*0.2] + [0.52*0.2] + [0.4*0.2] + [0.2*0.1]$$

$$P(c_1) = 0.56$$

Figure M.31 Example of Total Probability Calculation

For each selected flow value, the exceedance probabilities from the regulated flood frequency curves for each month were determined by interpolating or extrapolating the flow values. Tables M.08 through M.13 show the values of the monthly exceedance probabilities of regulated flows at Kingston and Rome-Coosa based on the shapes of 1961, 1979, and 1990 hydrograph shapes, respectively.

Table M.08 Exceedance Probabilities of Regulated Flood Flows at Kingston based on the Shapes of the 1961 Hydrographs

Q (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline												
50000	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12
40000	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10
30000	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07
20000	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04
15000	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03
10000	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02
September Drawdown												
50000	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12
40000	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10
30000	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07
20000	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04
15000	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03
10000	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02
Phased Drawdown												
50000	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12
40000	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10
30000	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07
20000	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04
15000	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03
10000	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02
November Drawdown												
50000	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12	4.83E-12
40000	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10	7.41E-10
30000	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07	2.09E-07
20000	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04	1.21E-04
15000	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03	3.64E-03
10000	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02	9.10E-02

Table M.09 Exceedance Probabilities of Regulated Flood Flows at Kingston based on the Shapes of the 1979 Hydrographs

Q (cfs)	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Baseline												
50000	5.88E-05	5.88E-05	5.88E-05	5.88E-05	9.00E-04	1.43E-03	1.44E-03	1.45E-03	1.44E-03	1.46E-03	5.88E-05	5.88E-05
40000	9.66E-04	9.66E-04	9.66E-04	9.66E-04	2.55E-03	3.26E-03	3.28E-03	3.29E-03	3.29E-03	3.33E-03	9.66E-04	9.66E-04
30000	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02
20000	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01
15000	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01
10000	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01
September Drawdown												
50000	5.88E-05	5.88E-05	5.88E-05	5.88E-05	9.00E-04	1.43E-03	1.44E-03	1.45E-03	1.44E-03	7.59E-05	5.88E-05	5.88E-05
40000	9.66E-04	9.66E-04	9.66E-04	9.66E-04	2.55E-03	3.26E-03	3.28E-03	3.29E-03	3.29E-03	1.05E-03	9.66E-04	9.66E-04
30000	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02
20000	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01
15000	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01
10000	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01
Phased Drawdown												
50000	5.88E-05	5.88E-05	5.88E-05	5.88E-05	9.00E-04	1.43E-03	1.44E-03	1.45E-03	1.44E-03	5.88E-05	5.88E-05	5.88E-05
40000	9.66E-04	9.66E-04	9.66E-04	9.66E-04	2.55E-03	3.26E-03	3.28E-03	3.29E-03	3.29E-03	9.66E-04	9.66E-04	9.66E-04
30000	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02
20000	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01
15000	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01
10000	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01
November Drawdown												
50000	5.88E-05	5.88E-05	5.88E-05	5.88E-05	9.00E-04	1.43E-03	1.44E-03	1.45E-03	1.44E-03	1.46E-03	1.48E-03	5.88E-05
40000	9.66E-04	9.66E-04	9.66E-04	9.66E-04	2.55E-03	3.26E-03	3.28E-03	3.29E-03	3.29E-03	3.33E-03	3.37E-03	9.66E-04
30000	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02	1.63E-02
20000	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01	2.05E-01
15000	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01	5.44E-01
10000	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01	9.23E-01

Table M.10 Exceedance Probabilities of Regulated Flood Flows at Kingston based on the Shapes of the 1990 Hydrographs

Q (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline												
50000	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08
40000	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06
30000	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04
20000	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02
15000	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01
10000	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01
September Drawdown												
50000	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08
40000	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06
30000	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04
20000	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02
15000	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01
10000	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01
Phased Drawdown												
50000	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08
40000	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06
30000	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04
20000	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02
15000	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01
10000	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01
November Drawdown												
50000	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08	2.51E-08
40000	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06
30000	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04	2.08E-04
20000	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02	2.05E-02
15000	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01	1.20E-01
10000	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01	5.21E-01

Table M.11 Exceedance Probabilities of Regulated Flood Flows at Rome-Coosa based on the Shapes of the 1961 Hydrographs

Q (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline												
110000	6.69E-05	6.69E-05	6.69E-05	5.95E-05	5.95E-05	5.95E-05	5.94E-05	5.95E-05	2.87E-05	5.95E-05	6.69E-05	4.05E-05
95000	4.39E-04	4.39E-04	4.39E-04	3.97E-04	3.97E-04	3.97E-04	3.97E-04	3.97E-04	2.90E-04	3.97E-04	4.39E-04	3.55E-04
85000	1.57E-03	1.57E-03	1.57E-03	1.44E-03	1.44E-03	1.44E-03	1.44E-03	1.44E-03	1.36E-03	1.44E-03	1.57E-03	1.52E-03
75000	5.63E-03	5.63E-03	5.63E-03	5.24E-03	5.24E-03	5.24E-03	5.25E-03	5.24E-03	5.94E-03	5.24E-03	5.63E-03	6.04E-03
60000	3.64E-02	3.64E-02	3.64E-02	3.42E-02	3.42E-02	3.65E-02	3.42E-02	3.42E-02	3.53E-02	3.42E-02	3.64E-02	3.93E-02
50000	1.17E-01	1.17E-01	1.17E-01	1.10E-01	1.10E-01	9.80E-02	1.10E-01	1.10E-01	1.04E-01	1.10E-01	1.17E-01	1.24E-01
September Drawdown												
110000	6.69E-05	6.69E-05	6.69E-05	5.95E-05	5.95E-05	5.95E-05	5.94E-05	5.95E-05	2.87E-05	5.95E-05	6.69E-05	4.05E-05
95000	4.39E-04	4.39E-04	4.39E-04	3.97E-04	3.97E-04	3.97E-04	3.97E-04	3.97E-04	2.90E-04	3.97E-04	4.39E-04	3.55E-04
85000	1.57E-03	1.57E-03	1.57E-03	1.44E-03	1.44E-03	1.44E-03	1.44E-03	1.44E-03	1.36E-03	1.44E-03	1.57E-03	1.52E-03
75000	5.63E-03	5.63E-03	5.63E-03	5.24E-03	5.24E-03	5.24E-03	5.25E-03	5.24E-03	5.94E-03	5.24E-03	5.63E-03	6.04E-03
60000	3.64E-02	3.64E-02	3.64E-02	3.42E-02	3.42E-02	3.65E-02	3.42E-02	3.42E-02	3.53E-02	3.42E-02	3.64E-02	3.93E-02
50000	1.17E-01	1.17E-01	1.17E-01	1.10E-01	1.10E-01	9.80E-02	1.10E-01	1.10E-01	1.04E-01	1.10E-01	1.17E-01	1.24E-01
Phased Drawdown												
110000	6.69E-05	6.69E-05	6.69E-05	5.95E-05	5.95E-05	5.95E-05	5.94E-05	5.95E-05	2.87E-05	5.95E-05	6.69E-05	4.05E-05
95000	4.39E-04	4.39E-04	4.39E-04	3.97E-04	3.97E-04	3.97E-04	3.97E-04	3.97E-04	2.90E-04	3.97E-04	4.39E-04	3.55E-04
85000	1.57E-03	1.57E-03	1.57E-03	1.44E-03	1.44E-03	1.44E-03	1.44E-03	1.44E-03	1.36E-03	1.44E-03	1.57E-03	1.52E-03
75000	5.63E-03	5.63E-03	5.63E-03	5.24E-03	5.24E-03	5.24E-03	5.25E-03	5.24E-03	5.94E-03	5.24E-03	5.63E-03	6.04E-03
60000	3.64E-02	3.64E-02	3.64E-02	3.42E-02	3.42E-02	3.65E-02	3.42E-02	3.42E-02	3.53E-02	3.42E-02	3.64E-02	3.93E-02
50000	1.17E-01	1.17E-01	1.17E-01	1.10E-01	1.10E-01	9.80E-02	1.10E-01	1.10E-01	1.04E-01	1.10E-01	1.17E-01	1.24E-01
November Drawdown												
110000	6.69E-05	6.69E-05	6.69E-05	5.95E-05	5.95E-05	5.95E-05	5.94E-05	5.95E-05	2.87E-05	5.95E-05	6.69E-05	4.05E-05
95000	4.39E-04	4.39E-04	4.39E-04	3.97E-04	3.97E-04	3.97E-04	3.97E-04	3.97E-04	2.90E-04	3.97E-04	4.39E-04	3.55E-04
85000	1.57E-03	1.57E-03	1.57E-03	1.44E-03	1.44E-03	1.44E-03	1.44E-03	1.44E-03	1.36E-03	1.44E-03	1.57E-03	1.52E-03
75000	5.63E-03	5.63E-03	5.63E-03	5.24E-03	5.24E-03	5.24E-03	5.25E-03	5.24E-03	5.94E-03	5.24E-03	5.63E-03	6.04E-03
60000	3.64E-02	3.64E-02	3.64E-02	3.42E-02	3.42E-02	3.65E-02	3.42E-02	3.42E-02	3.53E-02	3.42E-02	3.64E-02	3.93E-02
50000	1.17E-01	1.17E-01	1.17E-01	1.10E-01	1.10E-01	9.80E-02	1.10E-01	1.10E-01	1.04E-01	1.10E-01	1.17E-01	1.24E-01

Table M.12 Exceedance Probabilities of Regulated Flood Flows at Rome-Coosa based on the Shapes of the 1979 Hydrographs

Q (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline												
110000	1.65E-05	2.15E-05	1.77E-05	4.33E-05	3.74E-04	8.60E-04	9.84E-04	1.01E-03	1.51E-03	1.07E-03	8.98E-05	1.66E-05
95000	1.48E-04	1.73E-04	1.57E-04	2.40E-04	1.11E-03	1.89E-03	2.03E-03	2.06E-03	2.66E-03	2.14E-03	4.12E-04	1.48E-04
85000	6.51E-04	7.13E-04	6.86E-04	7.80E-04	2.37E-03	3.31E-03	3.42E-03	3.44E-03	4.00E-03	3.50E-03	1.18E-03	6.55E-04
75000	2.88E-03	2.97E-03	3.01E-03	2.61E-03	5.21E-03	5.85E-03	5.85E-03	5.87E-03	6.24E-03	5.89E-03	3.50E-03	2.90E-03
60000	2.52E-02	2.52E-02	2.52E-02	2.01E-02	2.04E-02	2.05E-02	2.01E-02	2.05E-02	2.05E-02	2.02E-02	2.55E-02	2.52E-02
50000	9.63E-02	9.63E-02	9.63E-02	7.73E-02	7.67E-02	7.66E-02	7.73E-02	7.66E-02	7.66E-02	7.70E-02	9.53E-02	9.63E-02
September Drawdown												
110000	1.65E-05	2.15E-05	1.77E-05	4.33E-05	3.74E-04	8.60E-04	9.84E-04	1.01E-03	1.51E-03	9.92E-04	3.87E-05	1.66E-05
95000	1.48E-04	1.73E-04	1.57E-04	2.40E-04	1.11E-03	1.89E-03	2.03E-03	2.06E-03	2.66E-03	1.80E-03	2.51E-04	1.48E-04
85000	6.51E-04	7.13E-04	6.86E-04	7.80E-04	2.37E-03	3.31E-03	3.42E-03	3.44E-03	4.00E-03	2.78E-03	8.99E-04	6.55E-04
75000	2.88E-03	2.97E-03	3.01E-03	2.61E-03	5.21E-03	5.85E-03	5.85E-03	5.87E-03	6.24E-03	4.44E-03	3.28E-03	2.90E-03
60000	2.52E-02	2.52E-02	2.52E-02	2.01E-02	2.04E-02	2.05E-02	2.01E-02	2.05E-02	2.05E-02	2.02E-02	2.55E-02	2.52E-02
50000	9.63E-02	9.63E-02	9.63E-02	7.73E-02	7.67E-02	7.66E-02	7.73E-02	7.66E-02	7.66E-02	7.70E-02	9.53E-02	9.63E-02
Phased Drawdown												
110000	1.65E-05	2.15E-05	1.77E-05	4.33E-05	3.74E-04	8.60E-04	9.84E-04	1.01E-03	1.51E-03	9.19E-04	8.78E-05	1.66E-05
95000	1.48E-04	1.73E-04	1.57E-04	2.40E-04	1.11E-03	1.89E-03	2.03E-03	2.06E-03	2.66E-03	1.72E-03	4.07E-04	1.48E-04
85000	6.51E-04	7.13E-04	6.86E-04	7.80E-04	2.37E-03	3.31E-03	3.42E-03	3.44E-03	4.00E-03	2.70E-03	1.17E-03	6.55E-04
75000	2.88E-03	2.97E-03	3.01E-03	2.61E-03	5.21E-03	5.85E-03	5.85E-03	5.87E-03	6.24E-03	4.39E-03	3.49E-03	2.90E-03
60000	2.52E-02	2.52E-02	2.52E-02	2.01E-02	2.04E-02	2.05E-02	2.01E-02	2.05E-02	2.05E-02	2.02E-02	2.55E-02	2.52E-02
50000	9.63E-02	9.63E-02	9.63E-02	7.73E-02	7.67E-02	7.66E-02	7.73E-02	7.66E-02	7.66E-02	7.70E-02	9.53E-02	9.63E-02
November Drawdown												
110000	1.65E-05	2.15E-05	1.77E-05	4.33E-05	3.74E-04	8.60E-04	9.84E-04	1.01E-03	1.51E-03	1.07E-03	4.70E-04	1.66E-05
95000	1.48E-04	1.73E-04	1.57E-04	2.40E-04	1.11E-03	1.89E-03	2.03E-03	2.06E-03	2.66E-03	2.14E-03	1.48E-03	1.48E-04
85000	6.51E-04	7.13E-04	6.86E-04	7.80E-04	2.37E-03	3.31E-03	3.42E-03	3.44E-03	4.00E-03	3.50E-03	3.28E-03	6.55E-04
75000	2.88E-03	2.97E-03	3.01E-03	2.61E-03	5.21E-03	5.85E-03	5.85E-03	5.87E-03	6.24E-03	5.89E-03	6.42E-03	2.90E-03
60000	2.52E-02	2.52E-02	2.52E-02	2.01E-02	2.04E-02	2.05E-02	2.01E-02	2.05E-02	2.05E-02	2.02E-02	2.55E-02	2.52E-02
50000	9.63E-02	9.63E-02	9.63E-02	7.73E-02	7.67E-02	7.66E-02	7.73E-02	7.66E-02	7.66E-02	7.70E-02	9.53E-02	9.63E-02

Table M.13 Exceedance Probabilities of Regulated Flood Flows at Rome-Coosa based on the Shapes of the 1990 Hydrographs

Q (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline												
110000	1.98E-05	1.98E-05	1.98E-05	1.25E-04	3.05E-05	1.59E-04	4.54E-05	1.60E-04	1.83E-04	1.02E-04	9.02E-05	1.98E-05
95000	1.82E-04	1.82E-04	1.82E-04	5.27E-04	2.91E-04	7.11E-04	3.60E-04	7.10E-04	7.62E-04	5.55E-04	4.43E-04	1.82E-04
85000	8.15E-04	8.15E-04	8.15E-04	1.43E-03	1.31E-03	1.99E-03	1.45E-03	1.98E-03	2.04E-03	1.77E-03	1.33E-03	8.15E-04
75000	3.63E-03	3.63E-03	3.63E-03	4.00E-03	5.77E-03	5.89E-03	5.80E-03	5.84E-03	5.83E-03	5.84E-03	4.07E-03	3.63E-03
60000	2.92E-02	2.92E-02	2.88E-02	2.86E-02	3.26E-02	3.30E-02	3.30E-02	3.29E-02	3.30E-02	3.28E-02	2.88E-02	2.88E-02
50000	9.29E-02	9.30E-02	8.81E-02	8.80E-02	7.82E-02	7.72E-02	7.71E-02	7.74E-02	7.73E-02	7.77E-02	8.82E-02	8.83E-02
September Drawdown												
110000	1.98E-05	1.98E-05	1.98E-05	1.25E-04	3.05E-05	1.59E-04	4.54E-05	1.60E-04	1.83E-04	5.28E-05	9.02E-05	1.98E-05
95000	1.82E-04	1.82E-04	1.82E-04	5.27E-04	2.91E-04	7.11E-04	3.60E-04	7.10E-04	7.62E-04	3.92E-04	4.43E-04	1.82E-04
85000	8.15E-04	8.15E-04	8.15E-04	1.43E-03	1.31E-03	1.99E-03	1.45E-03	1.98E-03	2.04E-03	1.51E-03	1.33E-03	8.15E-04
75000	3.63E-03	3.63E-03	3.63E-03	4.00E-03	5.77E-03	5.89E-03	5.80E-03	5.84E-03	5.83E-03	5.84E-03	4.07E-03	3.63E-03
60000	2.92E-02	2.92E-02	2.88E-02	2.86E-02	3.26E-02	3.30E-02	3.30E-02	3.29E-02	3.30E-02	3.28E-02	2.88E-02	2.88E-02
50000	9.29E-02	9.30E-02	8.81E-02	8.80E-02	7.82E-02	7.72E-02	7.71E-02	7.74E-02	7.73E-02	7.77E-02	8.82E-02	8.83E-02
Phased Drawdown												
110000	1.98E-05	1.98E-05	1.98E-05	1.25E-04	3.05E-05	1.59E-04	4.54E-05	1.60E-04	1.83E-04	5.28E-05	9.02E-05	1.98E-05
95000	1.82E-04	1.82E-04	1.82E-04	5.27E-04	2.91E-04	7.11E-04	3.60E-04	7.10E-04	7.62E-04	3.92E-04	4.43E-04	1.82E-04
85000	8.15E-04	8.15E-04	8.15E-04	1.43E-03	1.31E-03	1.99E-03	1.45E-03	1.98E-03	2.04E-03	1.51E-03	1.33E-03	8.15E-04
75000	3.63E-03	3.63E-03	3.63E-03	4.00E-03	5.77E-03	5.89E-03	5.80E-03	5.84E-03	5.83E-03	5.84E-03	4.07E-03	3.63E-03
60000	2.92E-02	2.92E-02	2.88E-02	2.86E-02	3.26E-02	3.30E-02	3.30E-02	3.29E-02	3.30E-02	3.28E-02	2.88E-02	2.88E-02
50000	9.29E-02	9.30E-02	8.81E-02	8.80E-02	7.82E-02	7.72E-02	7.71E-02	7.74E-02	7.73E-02	7.77E-02	8.82E-02	8.83E-02
November Drawdown												
110000	1.98E-05	1.98E-05	1.98E-05	1.25E-04	3.05E-05	1.59E-04	4.54E-05	1.60E-04	1.83E-04	1.02E-04	3.14E-04	1.98E-05
95000	1.82E-04	1.82E-04	1.82E-04	5.27E-04	2.91E-04	7.11E-04	3.60E-04	7.10E-04	7.62E-04	5.55E-04	9.16E-04	1.82E-04
85000	8.15E-04	8.15E-04	8.15E-04	1.43E-03	1.31E-03	1.99E-03	1.45E-03	1.98E-03	2.04E-03	1.77E-03	1.95E-03	8.15E-04
75000	3.63E-03	3.63E-03	3.63E-03	4.00E-03	5.77E-03	5.89E-03	5.80E-03	5.84E-03	5.83E-03	5.84E-03	4.31E-03	3.63E-03
60000	2.92E-02	2.92E-02	2.88E-02	2.86E-02	3.26E-02	3.30E-02	3.30E-02	3.29E-02	3.30E-02	3.28E-02	2.88E-02	2.88E-02
50000	9.29E-02	9.30E-02	8.81E-02	8.80E-02	7.82E-02	7.72E-02	7.71E-02	7.74E-02	7.73E-02	7.77E-02	8.82E-02	8.83E-02

IV. Results of Combined Regulated Flood Frequency Curve

Using the procedure described in Step 5 and the exceedance probability values previously presented in Table M.06 though Table M.13, for each selected flow values, the combined exceedance probability of the regulated flood flow was determined. Tables M.14 through M.19 show the combined regulated 5-, 2-, 1-, 0.5-, and 0.2-percent flood flows. Tables M.20 and M.21 show the percent change of the alternative operation compared to the Baseline. The results indicate that the September Drawdown operation and the Phased Drawdown operation would have no impact on flood frequency flows at Kingston for the 1961 and 1990 hydrograph shapes and would slightly reduce the flood frequency flows at Kingston for the 1979 hydrograph shape. The September Drawdown operation and the Phased Drawdown operation would have no impact on flood frequency flows at Rome-Coosa for the 1961 hydrograph shape and would slightly reduce the flood frequency flows at Rome-Coosa for the 1979 and 1990 hydrograph shapes. The November Drawdown operation would have no impact on flood frequency flows at Kingston for the 1961 and 1990 hydrograph shapes and would slightly increase the flood frequency flows at Kingston for the 1979 hydrograph shape. The November Drawdown operation would have no impact on flood frequency flows at Rome-Coosa for the 1961 hydrograph shape and would slightly increase the flood frequency flows at Rome-Coosa for the 1979 and 1990 hydrograph shapes.

Table M.14 Combined Regulated Flood Frequency Flows in cfs at Kingston based on 1961 Hydrograph Shapes

Standard FF	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.002	15,874	15,874	15,874	15,874
0.005	14,520	14,520	14,520	14,520
0.01	13,471	13,471	13,471	13,471
0.02	12,412	12,412	12,412	12,412
0.05	10,976	10,976	10,976	10,976

Table M.15 Combined Regulated Flood Frequency Flows in cfs at Kingston based on 1979 Hydrograph Shapes

Standard FF	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.002	38,136	37,895	37,885	38,386
0.005	34,579	34,450	34,445	34,713
0.01	31,896	31,844	31,842	31,949
0.02	29,238	29,238	29,238	29,238
0.05	25,774	25,774	25,774	25,774

Table M.16 Combined Regulated Flood Frequency Flows in cfs at Kingston based on 1990 Hydrograph Shapes

Standard FF	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.002	25,114	25,114	25,114	25,114
0.005	23,124	23,124	23,124	23,124
0.01	21,601	21,601	21,601	21,601
0.02	20,051	20,051	20,051	20,051
0.05	17,526	17,526	17,526	17,526

Table M.17 Combined Regulated Flood Frequency Flows in cfs at Rome-Coosa based on 1961 Hydrograph Shapes

Standard FF	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.002	82,878	82,878	82,878	82,878
0.005	75,812	75,812	75,812	75,812
0.01	70,336	70,336	70,336	70,336
0.02	64,786	64,786	64,786	64,786
0.05	57,256	57,256	57,256	57,256

Table M.18 Combined Regulated Flood Frequency Flows in cfs at Rome-Coosa based on 1979 Hydrograph Shapes.

Standard FF	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.002	79,909	79,583	79,643	80,645
0.005	71,958	71,830	71,846	72,222
0.01	66,660	66,591	66,599	66,801
0.02	61,315	61,302	61,304	61,342
0.05	54,540	54,540	54,540	54,540

Table M.19 Combined Regulated Flood Frequency Flows in cfs at Rome-Coosa based on 1990 Hydrograph Shapes

Standard FF	Baseline	September Drawdown	Phased Drawdown	November Drawdown
0.002	80,362	80,311	80,311	80,514
0.005	73,429	73,429	73,429	73,449
0.01	68,229	68,229	68,229	68,241
0.02	62,968	62,968	62,968	62,972
0.05	55,230	55,230	55,230	55,230

Table M.20 Change in Percent from Baseline at Kingston

Exceedance Probability (%)	1961 Hydrograph Shape			1979 Hydrograph Shape			1990 Hydrograph Shape		
	September	**Phased**	**November**	**September**	**Phased**	**November**	**September**	**Phased**	**November**
0.2	0.000	0.000	0.000	-0.631	-0.656	0.657	0.000	0.000	0.000
0.5	0.000	0.000	0.000	-0.374	-0.389	0.388	0.000	0.000	0.000
1	0.000	0.000	0.000	-0.162	-0.168	0.167	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table M.21 Change in Percent from Baseline at Rome-Coosa

Exceedance Probability (%)	1961 Hydrograph Shape			1979 Hydrograph Shape			1990 Hydrograph Shape		
	September	**Phased**	**November**	**September**	**Phased**	**November**	**September**	**Phased**	**November**
0.2	0.000	0.000	0.000	-0.408	-0.333	0.921	-0.063	-0.063	0.190
0.5	0.000	0.000	0.000	-0.178	-0.156	0.367	0.000	0.000	0.027
1	0.000	0.000	0.000	-0.103	-0.090	0.212	0.000	0.000	0.017
2	0.000	0.000	0.000	-0.021	-0.019	0.044	0.000	0.000	0.007
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Figures M.32 through M.37 show the combined regulated flood frequency curves at Kingston and Rome-Coosa. The figures illustrate that the September Drawdown operation and the Phased Drawdown operation would have no impact on flood frequency flows at Kingston for the 1961 and 1990 hydrograph shapes and would slightly reduce the flood frequency flows at Kingston for the 1979 hydrograph shape. The September Drawdown operation and the Phased Drawdown operation would have no impact on flood frequency flows at Rome-Coosa for the 1961 hydrograph shape and would slightly reduce the flood frequency flows at Rome-Coosa for the 1979 and 1990 hydrograph shapes. The November Drawdown operation would have no impact on flood frequency flows at Kingston for the 1961 and 1990 hydrograph shapes and would slightly increase the flood frequency flows at Kingston for the 1979 hydrograph shape. The November Drawdown operation would have no impact on flood frequency flows at Rome-Coosa for the 1961 hydrograph shape and would slightly increase the flood frequency flows at Rome-Coosa for the 1979 and 1990 hydrograph shapes.

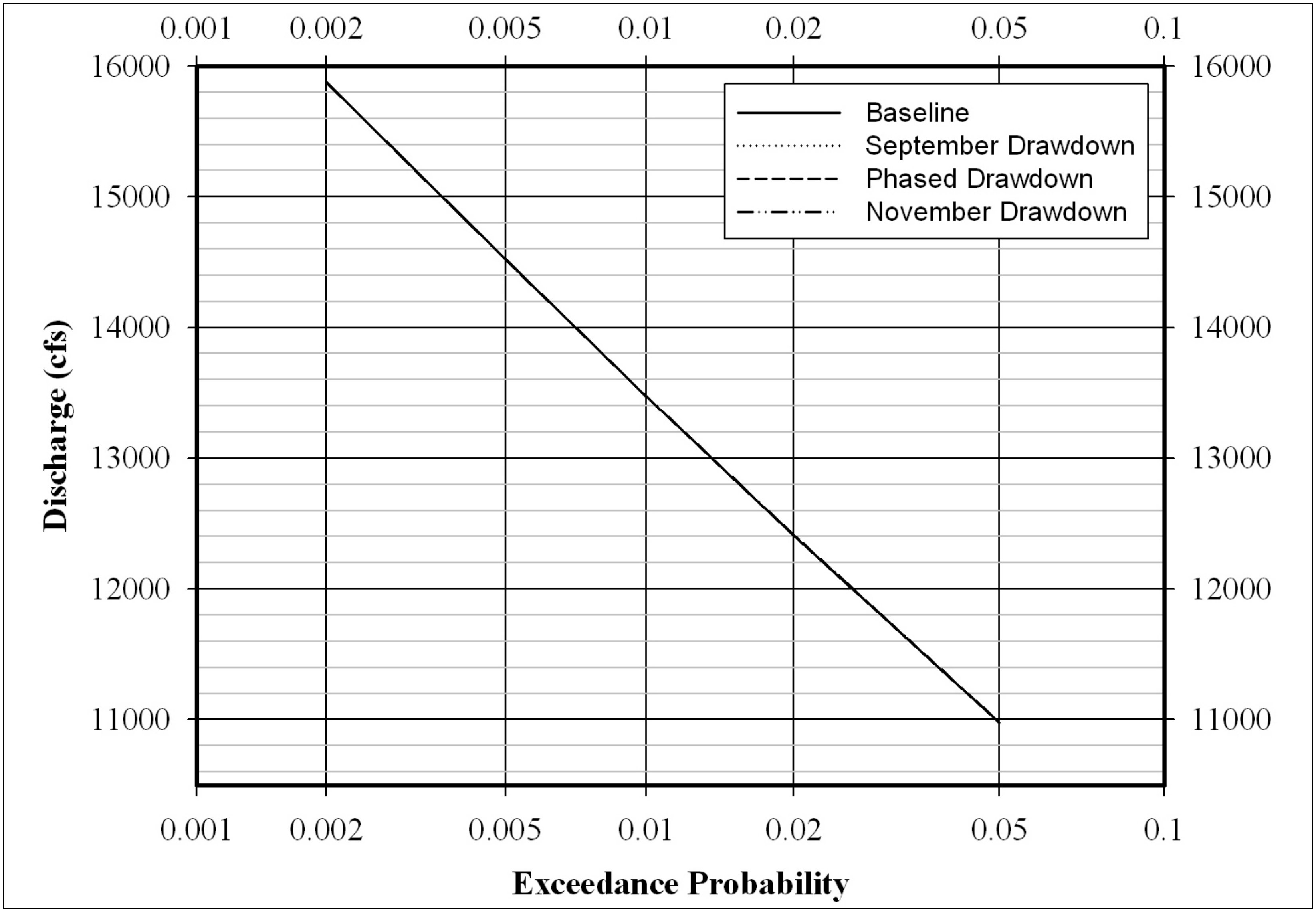


Figure M.32 Combined Flood Frequency Curves at Kingston based on 1961 Hydrograph Shapes

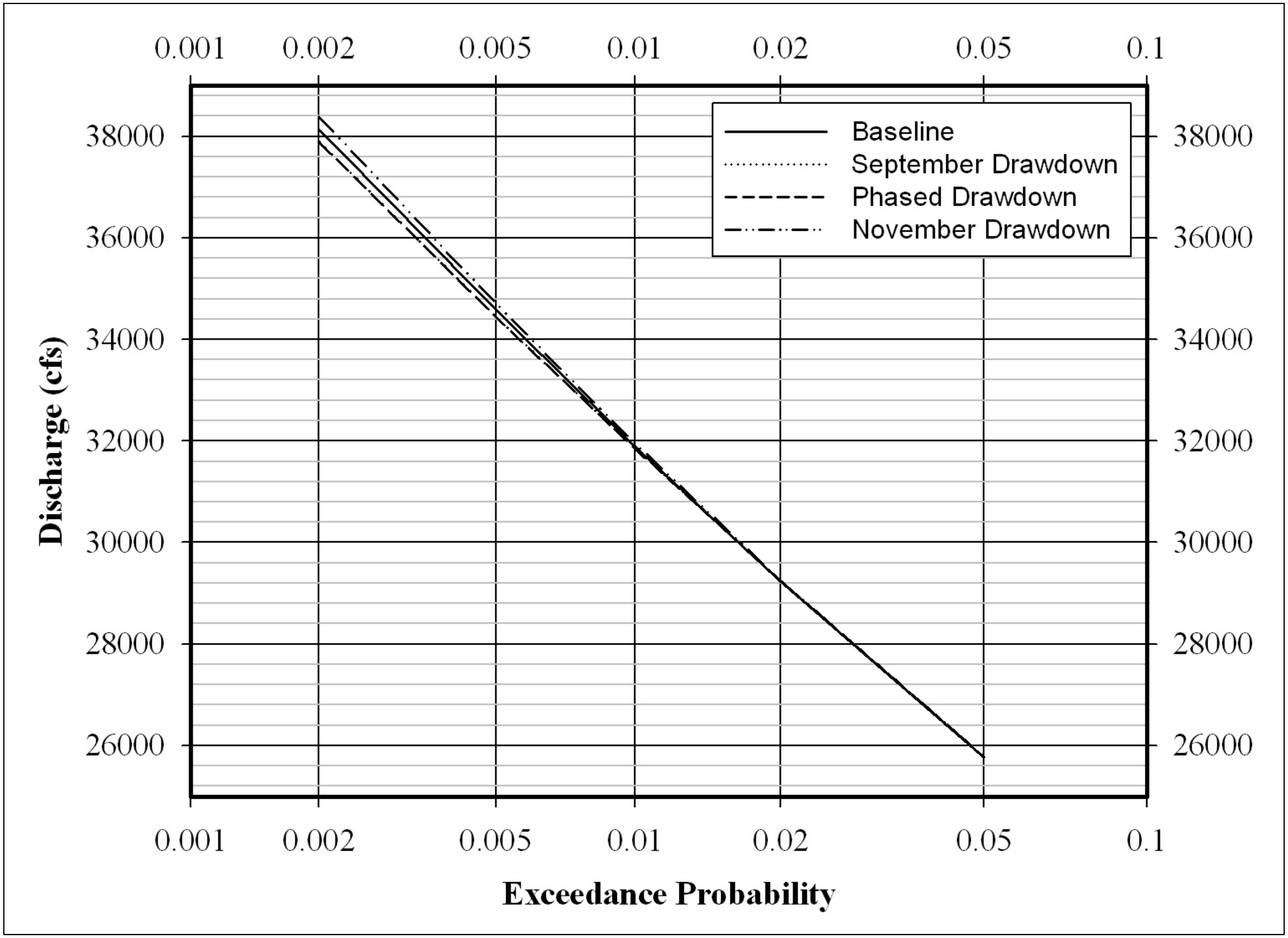


Figure M.33 Combined Flood Frequency Curves at Kingston based on 1979 Hydrograph Shapes

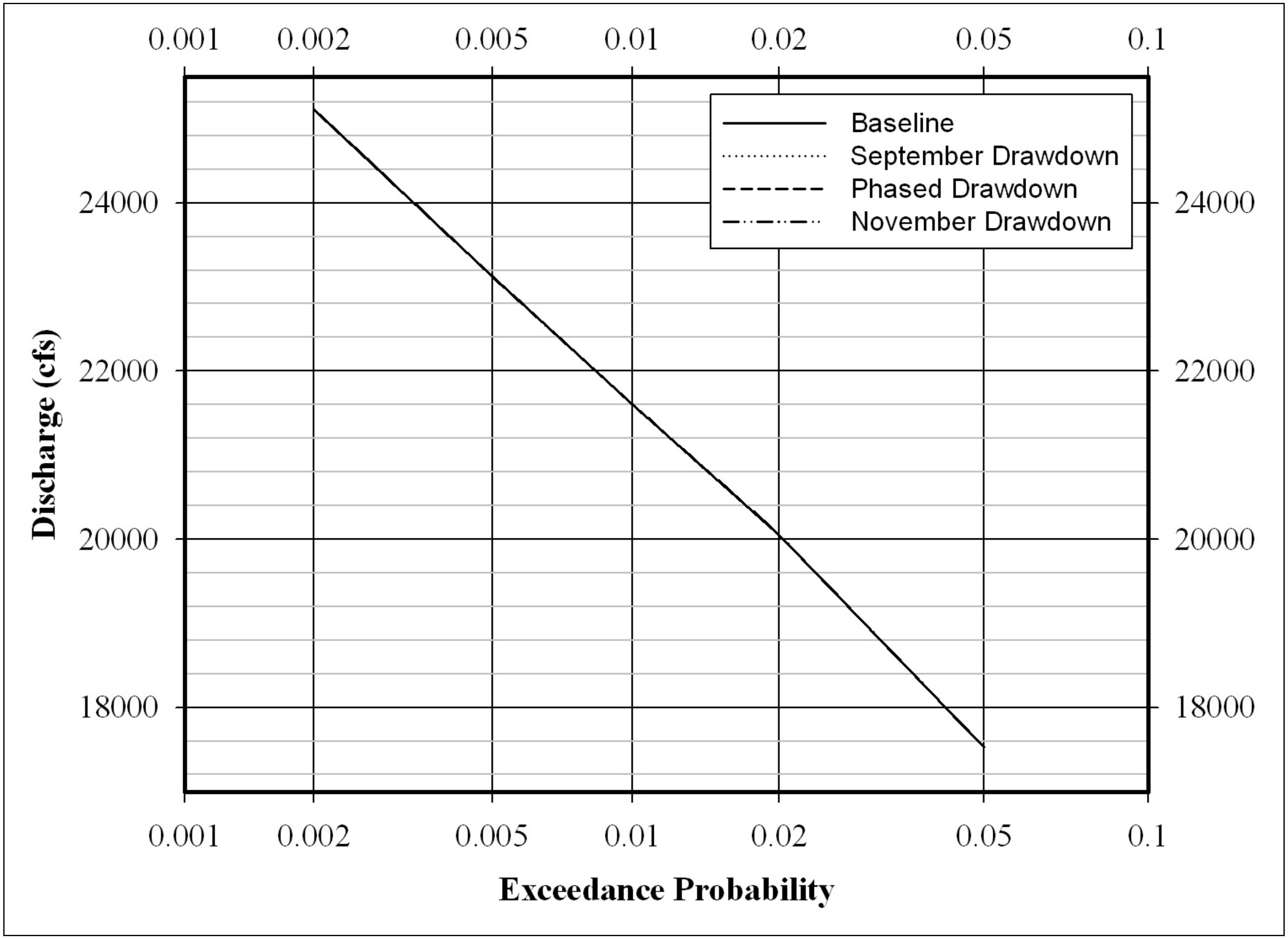


Figure M.34 Combined Flood Frequency Curves at Kingston based on 1990 Hydrograph Shapes

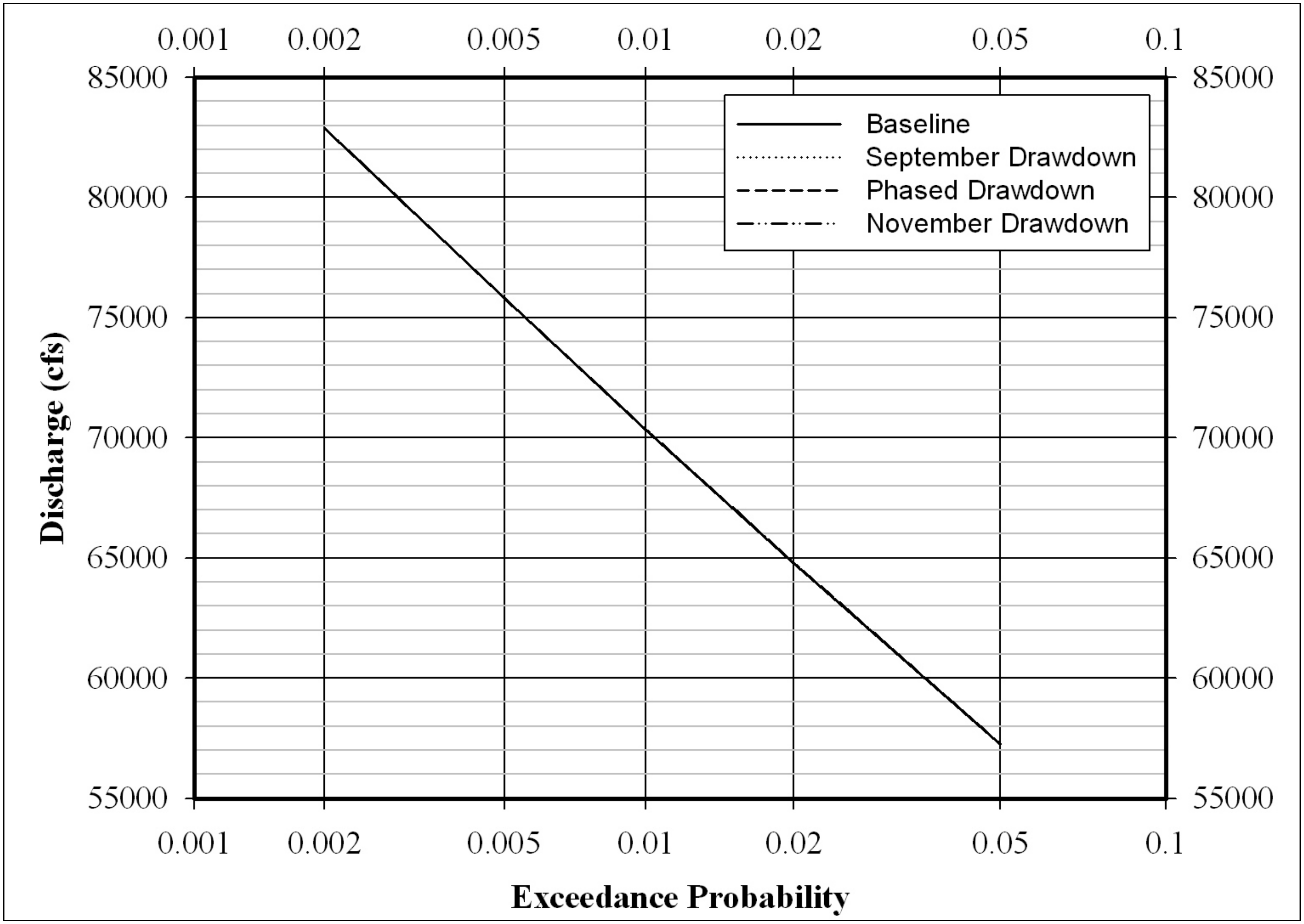


Figure M.35 Combined Flood Frequency Curves at Rome-Coosa based on 1961 Hydrograph Shapes

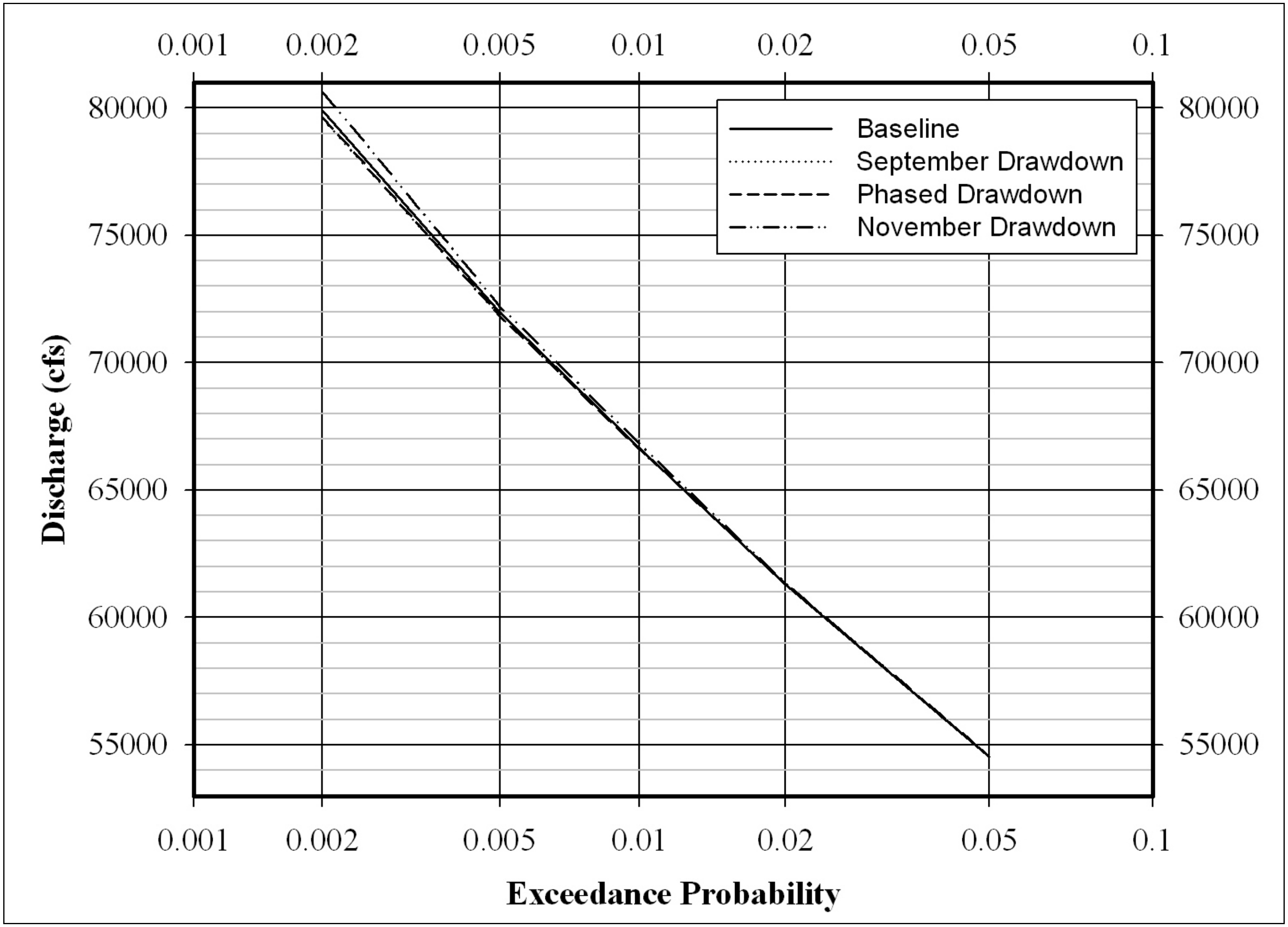


Figure M.36 Combined Flood Frequency Curves at Rome-Coosa based on 1979 Hydrograph Shapes

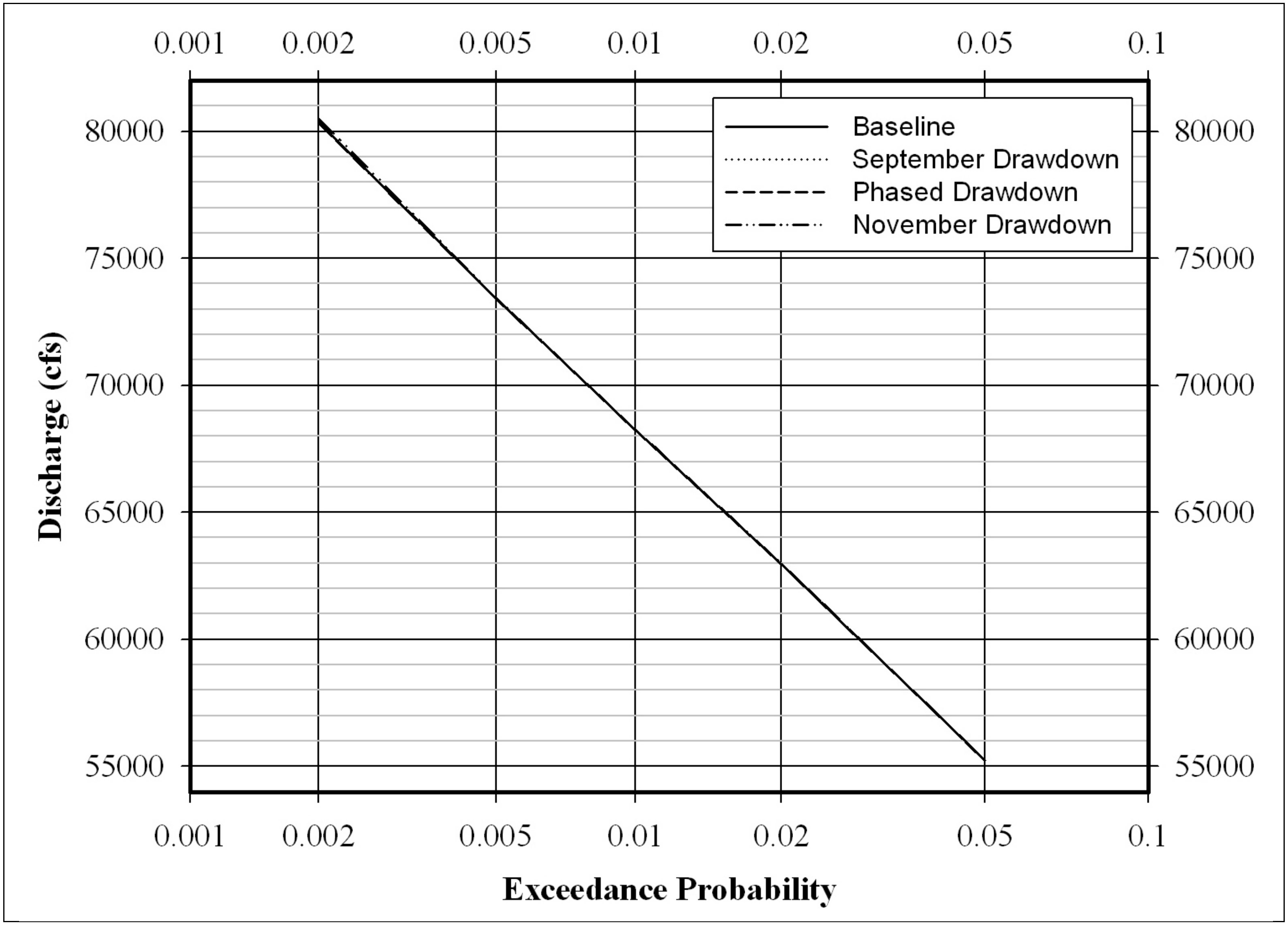


Figure M.37 Combined Flood Frequency Curves at Rome-Coosa based on 1990 Hydrograph Shapes

V. Appendix M - References

U.S. Army Corps of Engineers (1993). Engineering and Design Hydrologic Frequency Analysis, *Engineering Manual No. 1110-2-1415*, March 5, 1993.

U.S. Army Corps of Engineers (2009). *Development of Unimpaired Hourly Hypothetical Storm Hydrographs for the Apalachicola Chattahoochee Flint (ACF) River System from West Point to Columbus*, Mobile District, July 2009.

Alabama-Coosa-Tallapoosa (ACT) Watershed

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

Appendix N – Description of Alternatives

March 2011 (DRAFT)

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

I. Introduction

Based upon many years of operational experience and extensive stakeholder input during scoping, the Corps identified numerous operational measures for possible consideration in the updated ACT Master WCM. These measures included variations for revising reservoir drawdown and refill periods, reshaping action zones, revising hydropower generation, revising drought procedures and environmental flows, and development of navigation-specific operations Various alternative system operations were developed to formulate a recommended plan. This Appendix discusses the implementation of ResSim to represent the alternatives. No physical changes to the projects were considered during the alternative formulation, consequently variations in alternatives limited to operation changes. The following section briefly describes the operation sets of each ACT project used to simulate the alternatives.

The ACT system contains 17 projects. These 17 projects are modeled in the HEC-ResSim model of the system. In addition, a “dummy” project was modeled to account for losses from Jordan Lake. The projects included in the ResSim model are as follows:

1.) Allatoona
2.) Carters
3.) Carters Re-Reg
4.) Claiborne
5.) HN Henry
6.) Harris
7.) Jordan
8.) Jordan Lake Losses
9.) Lay
10.) Logan Martin
11.) Martin
12.) Millers Ferry
13.) Mitchell
14.) RF Henry
15.) Thurlow
16.) Walter Bouldin
17.) Weiss
18.) Yates

Various operation sets were modeled to study the operating alternatives on the ACT system. These operation sets will be described in detail in this document. There are 12 operating alternatives in the model. The alternatives are as follows:

1.) Baseline
2.) DroughtPln
3.) Burkett
4.) DragoA
5.) DragoB
6.) RPlanA
7.) RPlanB
8.) RPlanC
9.) RPlanD
10.) RPlanE
11.) RPlanF
12.) RPlanG

Table N.01 shows the alternative matrix with relevant operation set per Alternative and Reservoir.

Table N.01 Matrix of Alternative Operation Sets (by Reservoir)

Alternative Matrix showing relevant operation set per Alternative and Reservoir

	Baseline	**DroughtPln**	**Burkett**	**DragoA**	**DragoB**	**RPlanA**	**RPlanB**	**RPlanC**	**RPlanD**	**RPlanE**	**RPlanF**	**RPlanG**
Allatoona	Baseline	Baseline	Burkett	DragoA	DragoB	Burkett B	Burkett B	Burkett B	Burkett B	**Burkett C**	**Burkett C**	**Burkett D**
Carters	Baseline	Baseline	Seasonal									
Carters ReReg	Baseline	Baseline	Seasonal									
Claiborne	Flow-Thru											
HN Henry	Baseline	Winter Pool 507										
Harris	Baseline											
Jordan	Baseline	Drought										
JordanLL	Flow-Thru											
Lay	Flow-Thru											
Logan Martin	Baseline	Nav_Drought	Nav_Drought	Nav_Drought	Nav_Drought	Nav_Drought	**Nav_Drought_Snail**	**Nav_Drought-rev**	**Nav_Drought_Snail-rev**	Nav_Drought-rev	**Nav_Drought_Snail-rev**	Nav_Drought_Snail-rev
Martin	Baseline	Nav_Drought	Nav_Drought	Nav_Drought	Nav_Drought	Nav_Drought	Nav_Drought	**Nav_Drought-rev**	Nav_Drought-rev	Nav_Drought-rev	Nav_Drought-rev	Nav_Drought-rev
Millers Ferry	Baseline	Nav_Drought										
Mitchell	Flow-Thru											
RF Henry	Baseline											
Thurlow	Flow-Thru											
W. Bouldin	Baseline											
Weiss	Baseline											
Yates	Flow-Thru											

Table N.02 shows the measures selected for each alternative. The measures included variations for revising reservoir drawdown and refill periods, reshaping action zones, revising hydropower generation, revising drought procedures and environmental flows, and development of navigation-specific operations. See Section III of main report for more detailed information.

Table N.02 Measures Selected for Each Alternative

Measure	Alternative										
	Baseline	DroughtPln	Burkett	Drago A	Drago B	RPlan A	RPlan B	RPlan C	RPlan D	RPlan E	RPlan F	RPlan G
Current Ops	XX	XX										
2006 Water Use	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Navigation Support: APC & COE		XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Drought Plan		XX	XX	XX	XX	XX						
Drought Plan Revised								XX		XX		
Drought Plan, FWS Enhancement							XX					
Drought Plan Revised, FWS Enhancement									XX		XX	XX
Carters Seasonal Release			XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Alltoona, Burkett Scenario			XX									
Alltoona, Drago A Scenario				XX								
Alltoona, Drago B Scenario					XX							
Alltoona, Burkett B Scenario						XX	XX	XX	XX			
Alltoona, Burkett C Scenario										XX	XX	
Alltoona, Burkett D Scenario												XX

Drought Plan, FWS Enhancment	Drought Plan plus Coosa DL2 flow reduction from 3,000 to 2,500 for months Apr-15Jun; Coosa DL3 flow increase from 1,600 to 1,800 for Oct-Nov
Drought Plan Revised -	Alabama River flows chaned from 3900 to 3700, State Line 7Q10 values changed to COE values, corrected ramp in Coosa DL2 flows from Jul to Dec
Drought Plan Revised, FWS Enhancment	months Apr-15Jun; Coosa DL3 flow increase from 1,600 to 1,800 for Oct-Nov; reduce Alabama DL2 flow from 4,200 to 3,700 for May

II. Baseline Alternative

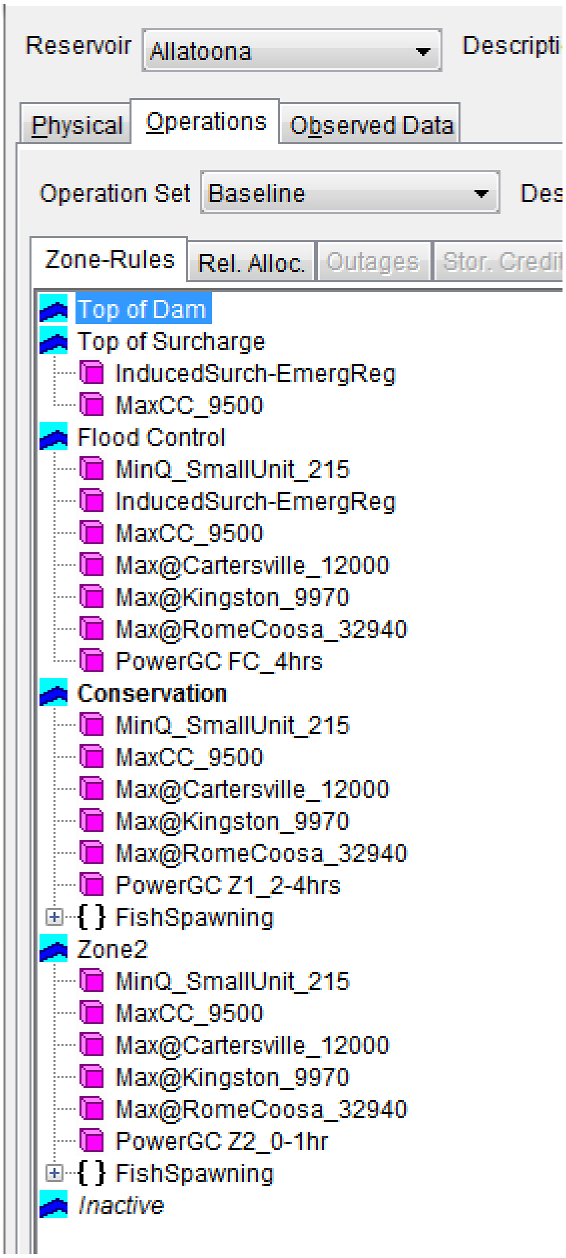
Table N.03 shows the operation sets used in the Baseline alternative.

Table N.03 Operation Sets Used in Baseline Alternative

Project	Operation Set	Described Previously
Allatoona	Baseline	No
Carters	Baseline	No
Carters ReReg	Baseline	No
Claiborne	Flow-thru	No
HN Henry	Baseline	No
Harris	Baseline	No
Jordan	Baseline	No
Jordan Lake Losses	Flow-thru	No
Lay	Flow-thru	No
Logan Martin	Baseline	No
Martin	Baseline	No
Millers Ferry	Baseline	No
Mitchell	Flow-thru	No
RF Henry	Baseline	No
Thurlow	Flow-thru	No
Walter Bouldin	Baseline	No
Weiss	Baseline	No
Yates	Flow-thru	No

A. Allatoona

The Baseline operation set was used in the Baseline alternative at Allatoona. The project contains six zones. The zones include Top of Dam, Top of Surcharge, Flood Control, Conservation, Zone2, and Inactive. The Top of Dam and Inactive zones contain no rules. The rule set for the Baseline operation set for Allatoona is shown in Figure N.01.



Reservoir: Allatoona

Operation Set: Baseline

- Top of Dam
- Top of Surcharge
  - InducedSurch-EmergReg
  - MaxCC_9500
- Flood Control
  - MinQ_SmallUnit_215
  - InducedSurch-EmergReg
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC FC_4hrs
- **Conservation**
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC Z1_2-4hrs
  - { } FishSpawning
- Zone2
  - MinQ_SmallUnit_215
  - MaxCC_9500
  - Max@Cartersville_12000
  - Max@Kingston_9970
  - Max@RomeCoosa_32940
  - PowerGC Z2_0-1hr
  - { } FishSpawning
- *Inactive*

Figure N.01 Rule Set for Allatoona Baseline Operation Set

1. InducedSurch-EmergReg

The induced surcharge function rule was coded into both the Top of Surcharge Zone and the Flood Control Zone. The function is defined by the ESRD curves which specify the minimum required release based on the pool elevation and the inflow into the project. The curves are shown in Figure N.02. The time for pool decrease is set to 24 hours. This is the amount of time that the pool needs to be falling before the operations transition from the surcharge function to the falling pool options. The falling pool option for Allatoona is to maintain the peak gate openings. The falling pool option is in effect until the pool drops down to the falling pool transition elevation of 859.5 ft. The falling pool options are shown in Figure N.03.

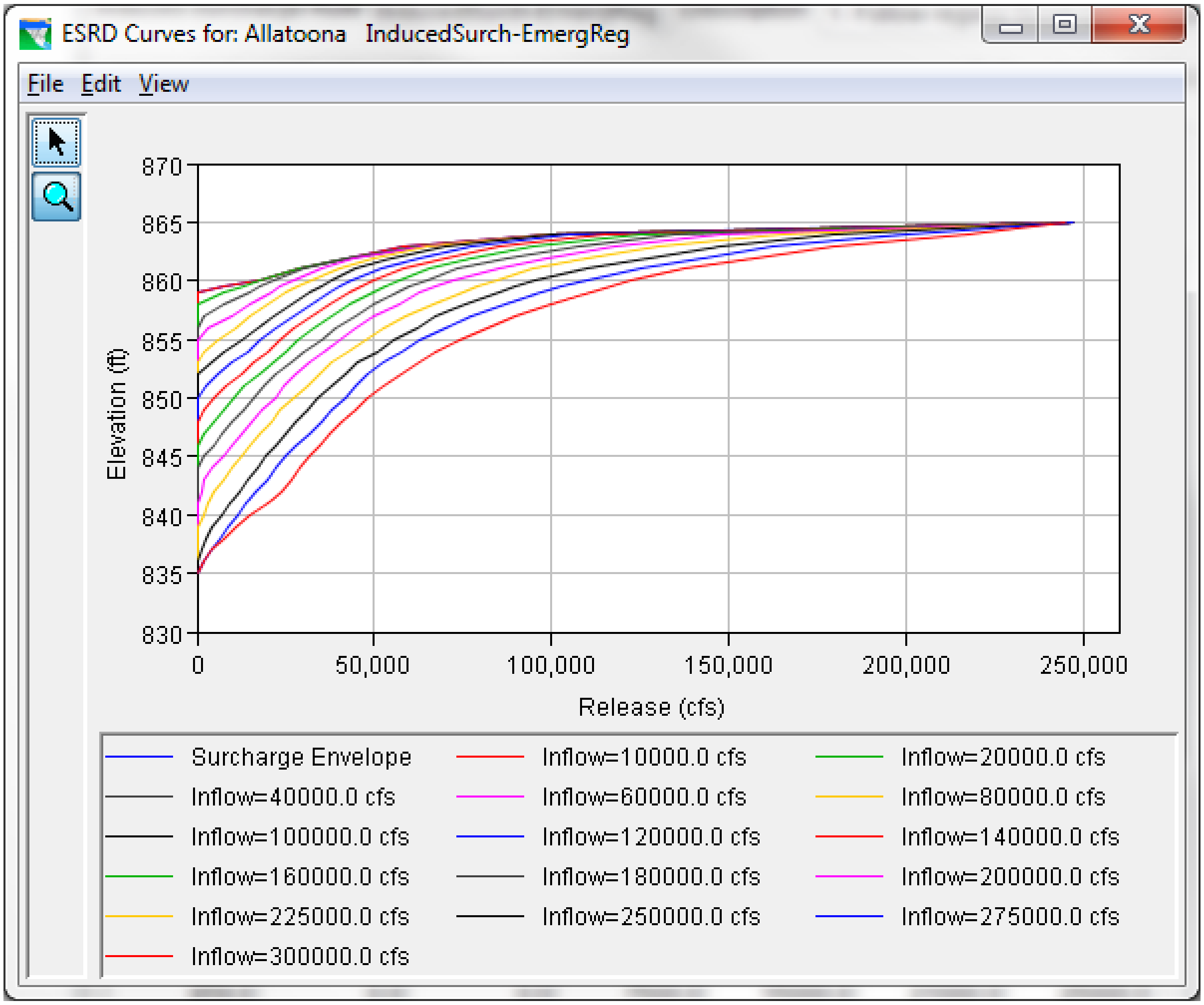
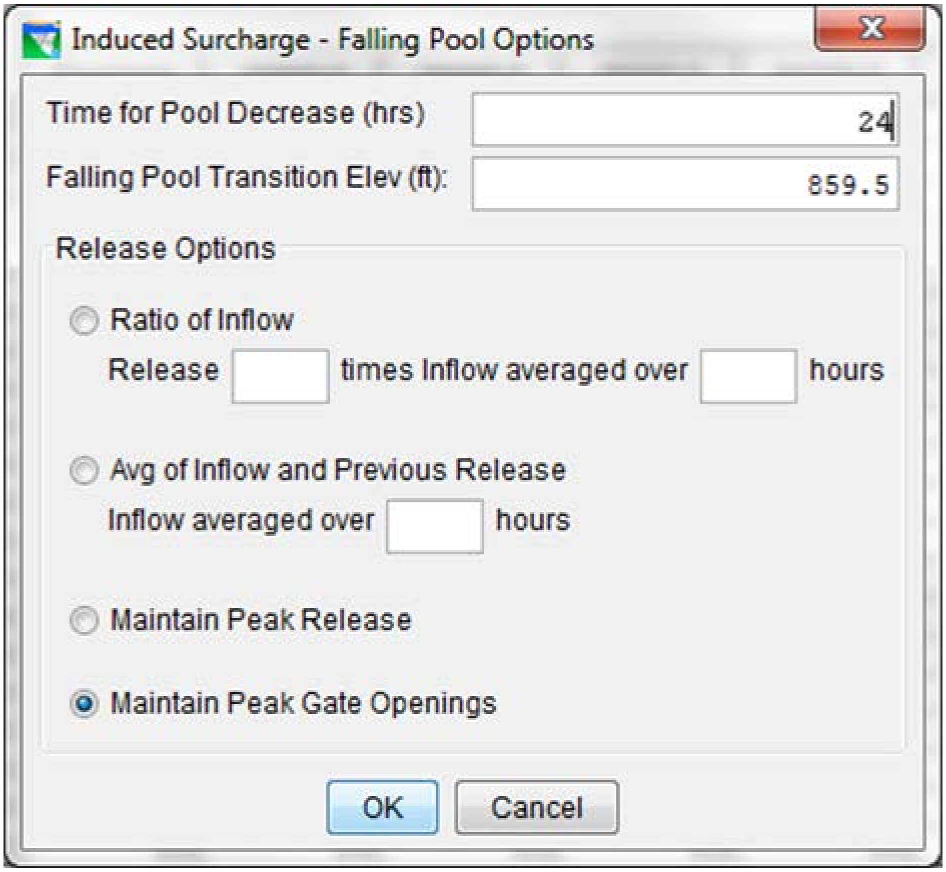


Figure N.02 Induced Surcharge Curves for Allatoona



Induced Surcharge - Falling Pool Options

Time for Pool Decrease (hrs): 24

Falling Pool Transition Elev (ft): 859.5

Release Options

○ Ratio of Inflow

Release ☐ times Inflow averaged over ☐ hours

○ Avg of Inflow and Previous Release

Inflow averaged over ☐ hours

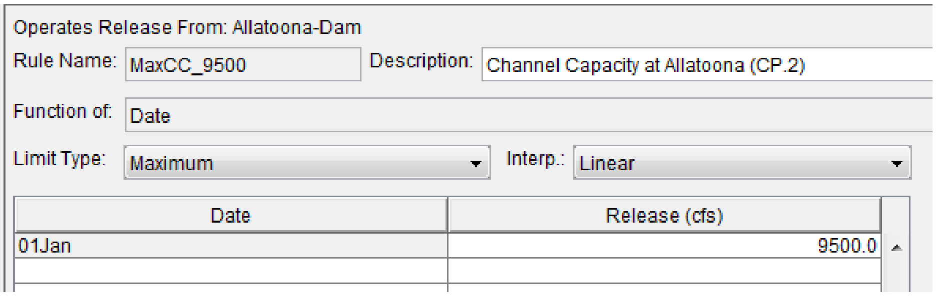
○ Maintain Peak Release

● Maintain Peak Gate Openings

Figure N.03 Induced Surcharge Falling Pool Options for Allatoona

2. MaxCC_9500

This rule is applied in Top of Surcharge, Flood Control, Conservation, and Zone2. It specifies a maximum release of 9,500 cfs from Allatoona throughout the entire year. The rule is shown in Figure N.04.



Operates Release From: Allatoona-Dam

Rule Name: MaxCC_9500

Description: Channel Capacity at Allatoona (CP.2)

Function of: Date

Limit Type: Maximum

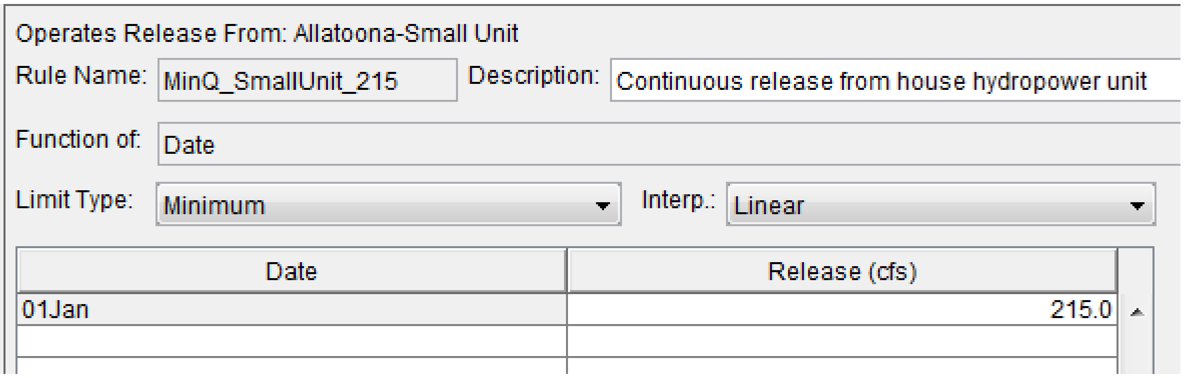
Interp.: Linear

Date	Release (cfs)
01Jan	9500.0

Figure N.04 MaxCC_9500 Rule at Allatoona

3. MinQ_SmallUnit_215

This rule is applied in Flood Control, Conservation, and Zone2. This rule requires a minimum release from the small unit outlet at Allatoona of 215 cfs throughout the entire year. This rule is shown in Figure N.05.



Operates Release From: Allatoona-Small Unit

Rule Name: MinQ_SmallUnit_215

Description: Continuous release from house hydropower unit

Function of: Date

Limit Type: Minimum

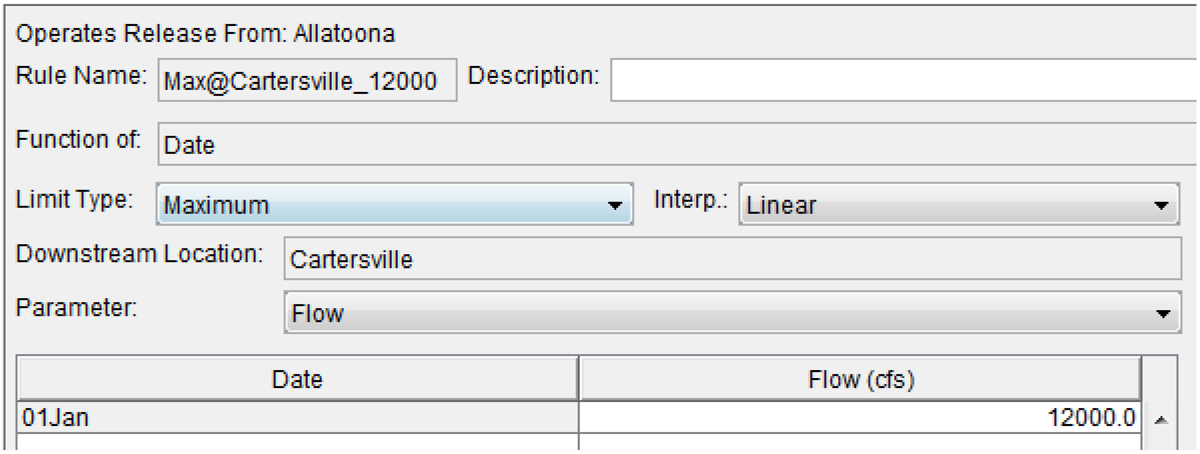
Interp.: Linear

Date	Release (cfs)
01Jan	215.0

Figure N.05 MinQ_SmallUnit_215 Rule at Allatoona

4. Max@Cartersville_12000

This rule is applied in Flood Control, Conservation, and Zone2. This rule sets the maximum flow at the downstream location of Cartersville to 12,000 cfs throughout the entire year. This rule is shown in Figure N.06.



Operates Release From: Allatoona

Rule Name: Max@Cartersville_12000

Description:

Function of: Date

Limit Type: Maximum

Interp.: Linear

Downstream Location: Cartersville

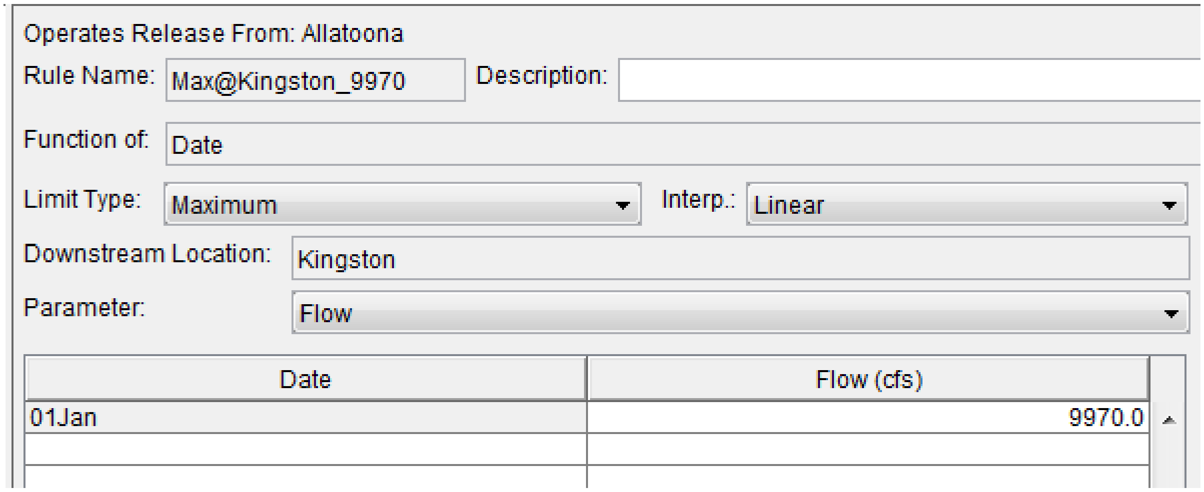
Parameter: Flow

Date	Flow (cfs)
01Jan	12000.0

Figure N.06 Max@Cartersville_12000 Rule at Allatoona

5. Max@Kingston_9970

This rule is applied in Flood Control, Conservation, and Zone2. This rule sets the maximum flow at the downstream location of Kingston to 9,970 cfs throughout the entire year. This rule is shown in Figure N.07.



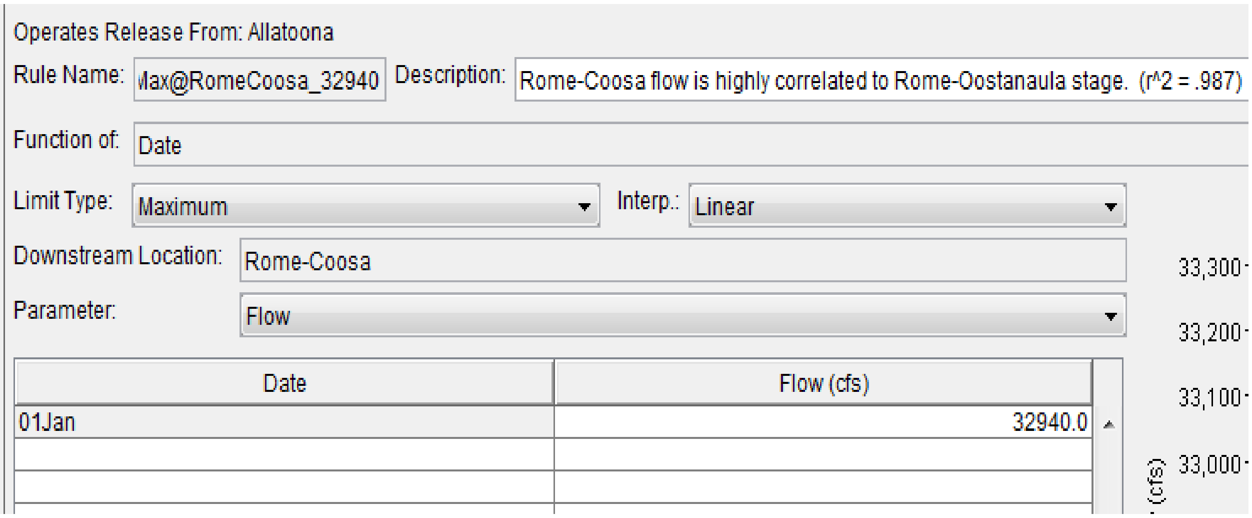
Operates Release From: Allatoona
Rule Name: Max@Kingston_9970
Description:
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: Kingston
Parameter: Flow

Date	Flow (cfs)
01Jan	9970.0

Figure N.07 Max@Kingston_9970 Rule at Allatoona

6. Max@RomeCoosa_32940

This rule is applied in Flood Control, Conservation, and Zone2. This rule sets the maximum flow at the downstream location of RomeCoosa to 32,940 cfs throughout the entire year. This rule is shown in Figure N.08.



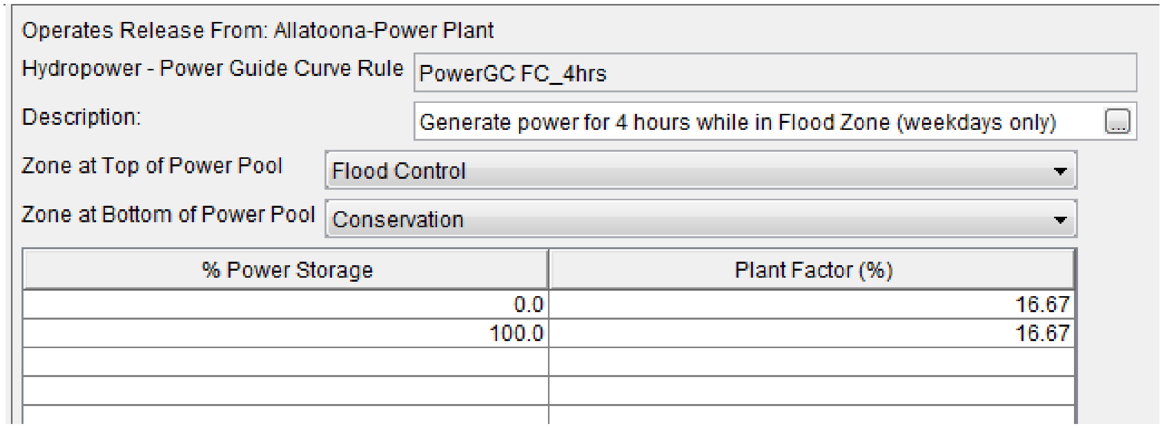
Operates Release From: Allatoona
Rule Name: Max@RomeCoosa_32940
Description: Rome-Coosa flow is highly correlated to Rome-Oostanaula stage. (r^2 = .987)
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: Rome-Coosa
Parameter: Flow

Date	Flow (cfs)
01Jan	32940.0

Figure N.08 Max@RomeCoosa_32940 Rule at Allatoona

7. PowerGC FC_4hrs

This rule is applied in Flood Control. This rule set the plant factor to 16.67% for all values of % Power Storage. The Power Storage in this rule ranges from the top of Flood Control to the top of Conservation. The 16.67% plant factor is equivalent to 4 hrs of generation at full capacity each day. This required generation occurs only on the weekdays. The power generation rule is shown in Figure N.09 and the power generation pattern is shown in Figure N.10.



Operates Release From: Allatoona-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC FC_4hrs

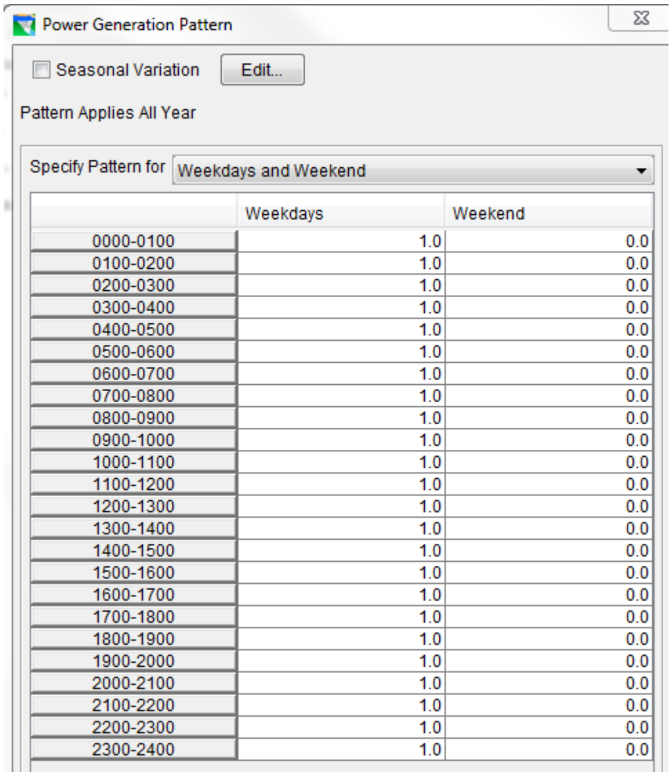
Description: Generate power for 4 hours while in Flood Zone (weekdays only)

Zone at Top of Power Pool: Flood Control

Zone at Bottom of Power Pool: Conservation

% Power Storage	Plant Factor (%)
0.0	16.67
100.0	16.67

Figure N.09 Flood Control Zone Power Generation Rule at Allatoona



☐ Seasonal Variation

Pattern Applies All Year

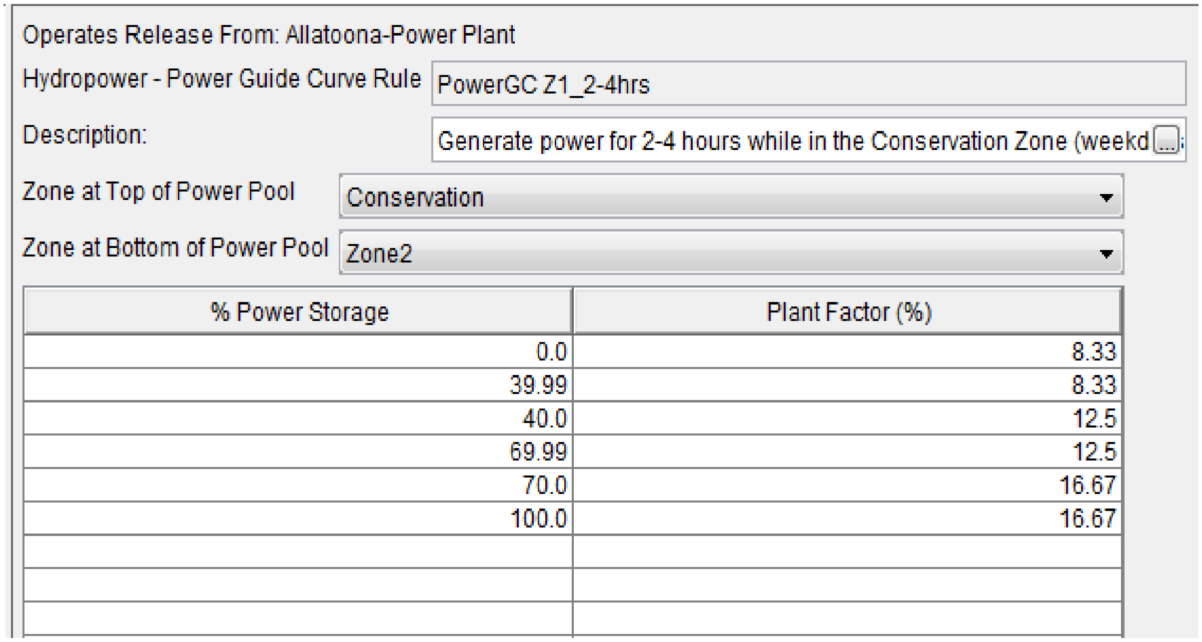
Specify Pattern for: Weekdays and Weekend

	Weekdays	Weekend
0000-0100	1.0	0.0
0100-0200	1.0	0.0
0200-0300	1.0	0.0
0300-0400	1.0	0.0
0400-0500	1.0	0.0
0500-0600	1.0	0.0
0600-0700	1.0	0.0
0700-0800	1.0	0.0
0800-0900	1.0	0.0
0900-1000	1.0	0.0
1000-1100	1.0	0.0
1100-1200	1.0	0.0
1200-1300	1.0	0.0
1300-1400	1.0	0.0
1400-1500	1.0	0.0
1500-1600	1.0	0.0
1600-1700	1.0	0.0
1700-1800	1.0	0.0
1800-1900	1.0	0.0
1900-2000	1.0	0.0
2000-2100	1.0	0.0
2100-2200	1.0	0.0
2200-2300	1.0	0.0
2300-2400	1.0	0.0

Figure N.10 Power Generation Pattern at Allatoona

8. PowerGC Z1_2-4hrs

This rule is applied in Conservation. This rule set the plant factor between 8.33% and 16.67% depending on the % Power Storage in use. The Power Storage in this rule ranges from top of Conservation to top of Zone2. The plant factor is set to 8.33% (equivalent to 2 hours of generation) from 0% to 39.99% Power Storage. It is set to 12.5% (equivalent to 3 hours of generation) from 40% to 69.99% Power Storage. It is set to 16.67% (equivalent to 4 hours of generation) from 70% to 100% Power Storage. This required generation occurs only on the weekdays. These generation amounts are seasonal being reduced by a factor of 0.5 in February, by 0.45 in April and May, and by 0.85 in June. They are increased by a factor of 1.3 in October. The power generation rule is shown in Figure N.11.



Operates Release From: Allatoona-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC Z1_2-4hrs

Description: Generate power for 2-4 hours while in the Conservation Zone (weekd

Zone at Top of Power Pool: Conservation

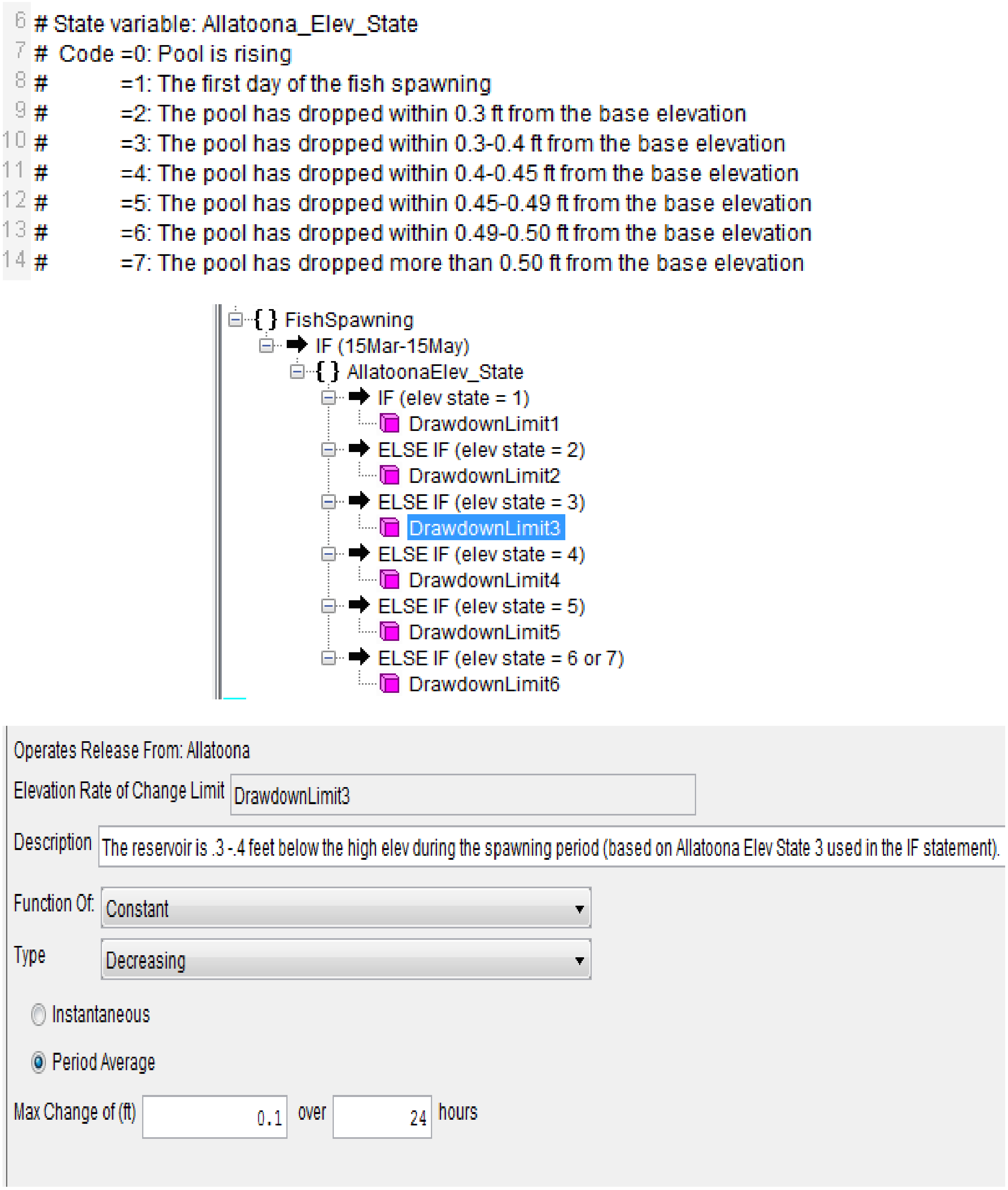
Zone at Bottom of Power Pool: Zone2

% Power Storage	Plant Factor (%)
0.0	8.33
39.99	8.33
40.0	12.5
69.99	12.5
70.0	16.67
100.0	16.67

Figure N.11 Conservation Zone Power Generation Rule at Allatoona

9. FishSpawning

The fish spawning rule is applied to both Conservation and Zone2. It is in effect from 15Mar through 15May. The maximum allowable drawdown during this time period is dependent on the value of the state variable, Allatoona_Elev_State. This state variable is assigned a value from 0 to 7 based on how far the pool has fallen from the base elevation. This state variable is described in more detail in the state variable appendix. A high state variable value indicates a greater amount that the pool has fallen from its base elevation. As the value of the state variable increases, the maximum allowable rate of change decreases. The allowable drawdown amounts at elevation state 6 and 7 is 0.0 ft over 24 hrs. A portion of the state variable code along with the FishSpawning rule is shown in Figure N.12.



```
# 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
```

```
{ } FishSpawning
    IF (15Mar-15May)
        { } AllatoonaElev_State
            IF (elev state = 1)
                DrawdownLimit1
            ELSE IF (elev state = 2)
                DrawdownLimit2
            ELSE IF (elev state = 3)
                DrawdownLimit3
            ELSE IF (elev state = 4)
                DrawdownLimit4
            ELSE IF (elev state = 5)
                DrawdownLimit5
            ELSE IF (elev state = 6 or 7)
                DrawdownLimit6
```

Operates Release From: Allatoona

Elevation Rate of Change Limit: DrawdownLimit3

Description: 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).

Function Of: Constant

Type: Decreasing

○ Instantaneous

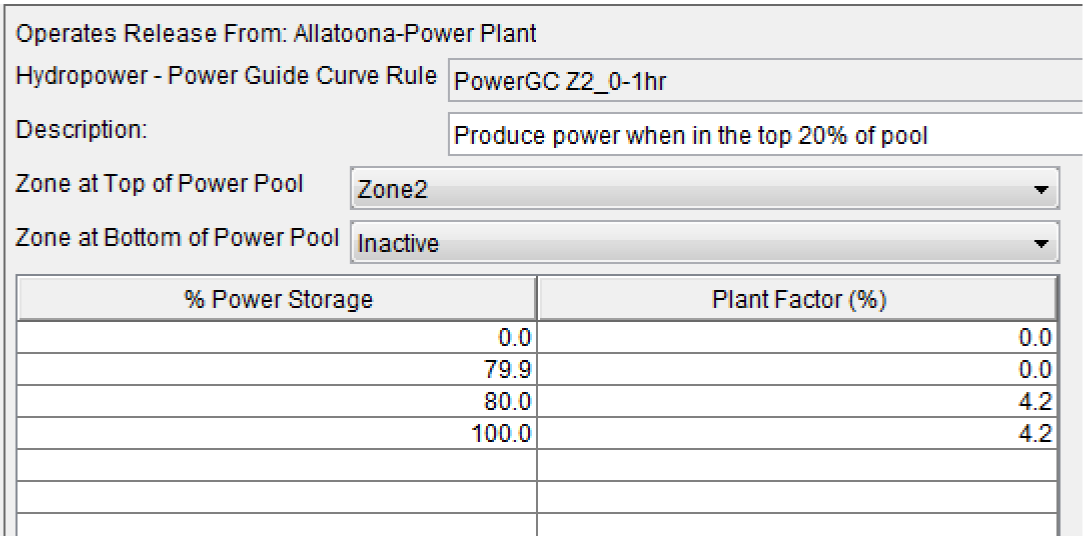
● Period Average

Max Change of (ft) 0.1 over 24 hours

Figure N.12 FishSpawning Rule at Allatoona

10. PowerGC Z2_0-1hrs

This rule is applied in Zone2. This rule set the plant factor between 0.0% and 4.2% depending on the % Power Storage in use. The Power Storage in this rule ranges from top of Zone2 to top of Inactive. The plant factor is set to 0.0% (equivalent to 0 hours of generation) from 0% to 79.9% Power Storage. It is set to 4.2% (equivalent to 1 hour of generation) from 80% to 100% Power Storage. This required generation occurs only on the weekdays. The power generation rule is shown in Figure N.13.



Operates Release From: Allatoona-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC Z2_0-1hr

Description: Produce power when in the top 20% of pool

Zone at Top of Power Pool: Zone2

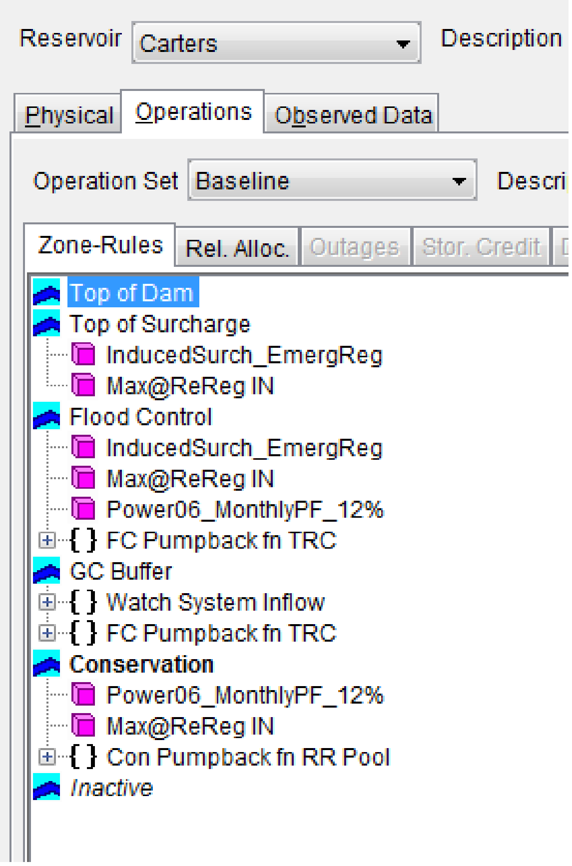
Zone at Bottom of Power Pool: Inactive

% Power Storage	Plant Factor (%)
0.0	0.0
79.9	0.0
80.0	4.2
100.0	4.2

Figure N.13 Zone2 Power Generation Rule at Allatoona

B. Carters

The Baseline operation set was used in the Baseline alternative at Carters. The project contains six zones. The zones include Top of Dam, Top of Surcharge, Flood Control, GC Buffer, Conservation, and Inactive. The Top of Dam and Inactive zones contain no rules. The rule set for the Baseline operation set for Carters is shown in Figure N.14.



Reservoir: Carters

Operation Set: Baseline

- Top of Dam
- Top of Surcharge
  - InducedSurch_EmergReg
  - Max@ReReg IN
- Flood Control
  - InducedSurch_EmergReg
  - Max@ReReg IN
  - Power06_MonthlyPF_12%
  - { } FC Pumpback fn TRC
- GC Buffer
  - { } Watch System Inflow
  - { } FC Pumpback fn TRC
- **Conservation**
  - Power06_MonthlyPF_12%
  - Max@ReReg IN
  - { } Con Pumpback fn RR Pool
- *Inactive*

Figure N.14 Rule Set for Carters Baseline Operation Set

1. InducedSurch_EmergReg

The induced surcharge function rule was coded in both the Top of Surcharge Zone and the Flood Control Zone. The function is defined by the ESRD curves which specify the minimum required release based on the pool elevation and the inflow into the project. The curves are shown in Figure N.15. The time for pool decrease was set to 24 hours. This is the amount of time that the pool needs to be falling before the operations transition from the surcharge function to the falling pool options. The falling pool option for Carters is to maintain the peak release. The falling pool option is in effect until the pool drops down to the falling pool transition elevation of 1099.0 ft. The falling pool options are shown in Figure N.16.

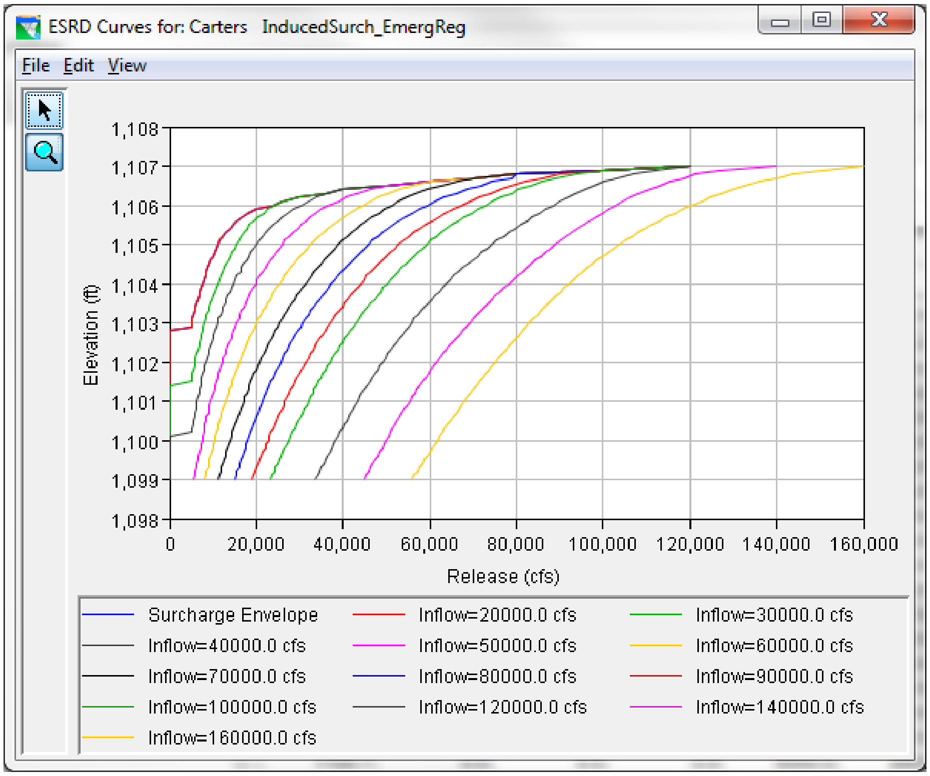
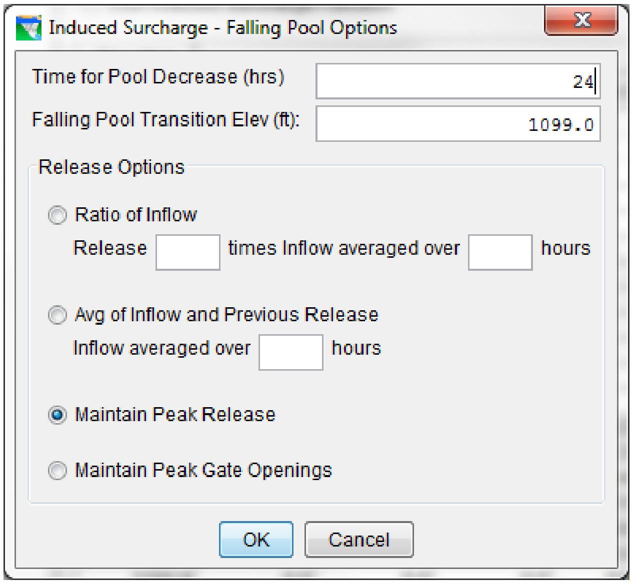


Figure N.15 Induced Surcharge Curves for Carters


Induced Surcharge - Falling Pool Options

Time for Pool Decrease (hrs): 24

Falling Pool Transition Elev (ft): 1099.0

Release Options

○ Ratio of Inflow
Release ☐ times Inflow averaged over ☐ hours

○ Avg of Inflow and Previous Release
Inflow averaged over ☐ hours

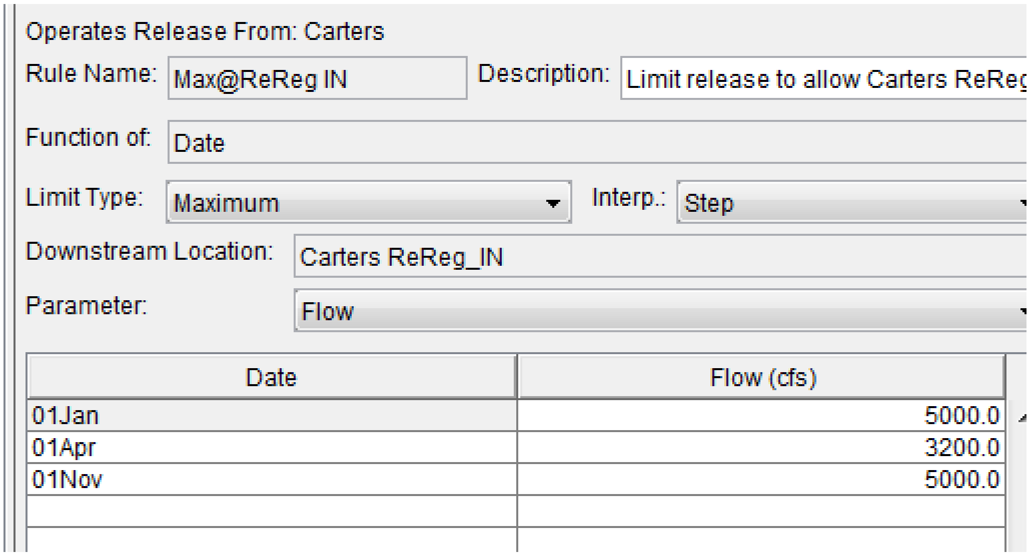
● Maintain Peak Release

○ Maintain Peak Gate Openings

Figure N.16 Induced Surcharge Falling Pool Options for Carters

2. Max@ReReg IN

This rule is applied in Top of Surcharge, Flood Control, and Conservation. This rule sets the maximum inflow into the downstream project of Carters ReReg between 3,200 cfs and 5,000 cfs depending on the time of year. The values are given as a step function beginning with 5,000 cfs on 01Jan, then going to 3,200 cfs on 01Apr, returning to 5,000 cfs on 01Nov. This rule is shown in Figure N.17.



Operates Release From: Carters

Rule Name: Max@ReReg IN

Description: Limit release to allow Carters ReReg

Function of: Date

Limit Type: Maximum

Interp.: Step

Downstream Location: Carters ReReg_IN

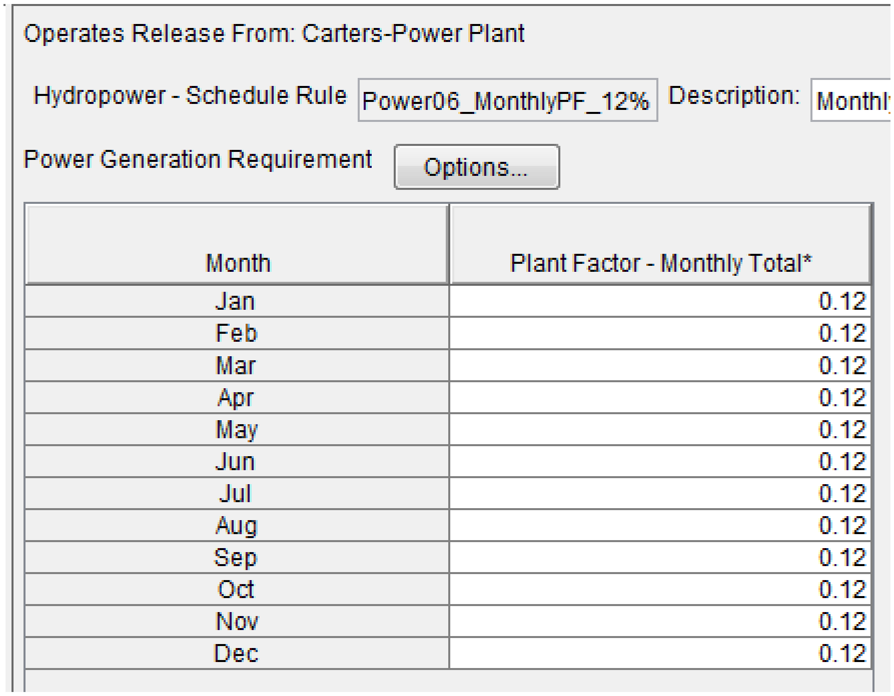
Parameter: Flow

Date	Flow (cfs)
01Jan	5000.0
01Apr	3200.0
01Nov	5000.0

Figure N.17 Max@ReReg IN Rule at Carters

3. Power06_MonthlyPF_12%

This rule is applied in Flood Control and Conservation. This rule 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. This rule is shown in Figure N.18.



Operates Release From: Carters-Power Plant

Hydropower - Schedule Rule: Power06_MonthlyPF_12%

Description: Monthl

Month	Plant Factor - Monthly Total*
Jan	0.12
Feb	0.12
Mar	0.12
Apr	0.12
May	0.12
Jun	0.12
Jul	0.12
Aug	0.12
Sep	0.12
Oct	0.12
Nov	0.12
Dec	0.12

Figure N.18 Power Generation Rule at Carters

4. FC Pumpback fn TRC

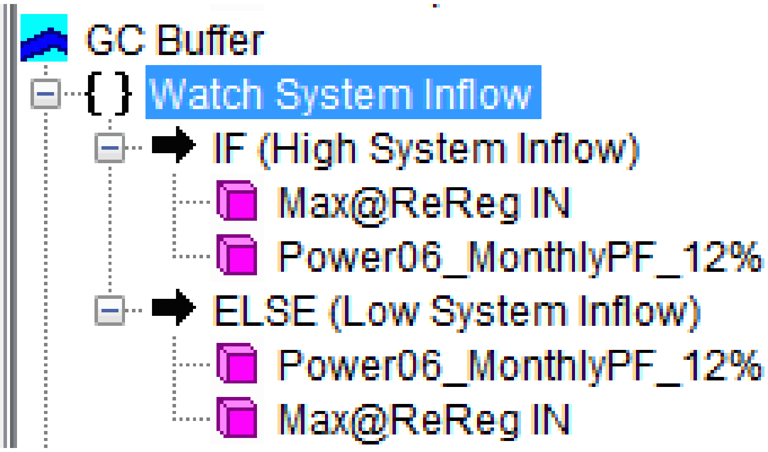
This conditional IF-Block structure allows for specifying a relationship between the flow coming in from Talking Rock Creek and the number of hours to pump back water to Carters. Talking Rock Creek connects just downstream of the outlet at Carters. This pumpback function uses the flow at Talking Rock 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 N.04 summarizes the relationship between Talking Rock Creek flow and Carters pumping operations.

Table N.04 Carters Pumpback Relationship with Talking Rock Creek Flow

Talking Rock Creek Flow	Number of Hours of Pumping
TRC > 3000 cfs	5.0
TRC > 2500 cfs	4.25
TRC > 2000 cfs	3.5
TRC > 1500 cfs	2.75
TRC > 1000 cfs	2.0
TRC >= 500 cfs	1.5

5. Watch System Inflow

Within a lower flood control zone named GC Buffer, this series of if-statements 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 from 2 days into the future. This rule is shown in Figure N.19.



GC Buffer
{ } Watch System Inflow
IF (High System Inflow)
Max@ReReg IN
Power06_MonthlyPF_12%
ELSE (Low System Inflow)
Power06_MonthlyPF_12%
Max@ReReg IN

Figure N.19 Watch System Inflow Rule at Carters

6. Con Pumpback fn RR Pool

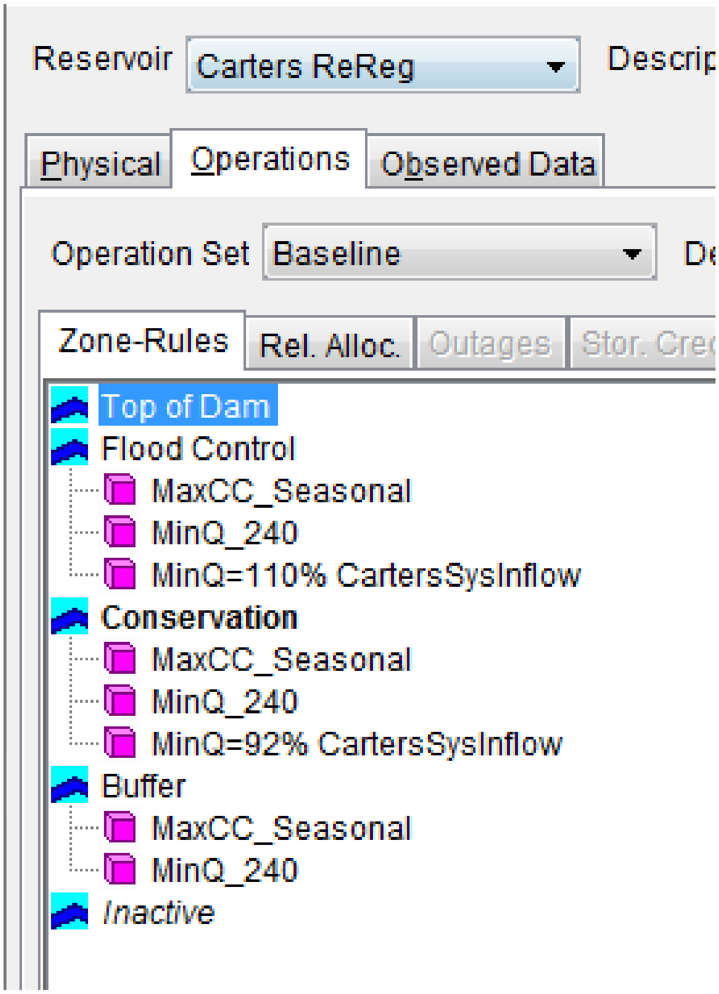
This rule is a function of the pool elevation at Carters ReReg Pool and uses logical statements based on the ReReg’s pool elevation to determine the appropriate pumping values. If the pool elevation is greater than 686 feet then the pump will operate at full capacity for 8.75 hours at night to pump water 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. 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. Table N.05 summarizes the relationship between Carters ReReg Pool Elevation and Carters pumping operations.

Table N.05 Carters Pumpback Relationship with Carters ReReg Pool Elevation

Carters ReReg Pool Elevation	Number of Hours of Pumping
> 686 ft	8.75
> 684 ft	6.5
> 682 ft	4.5
> 680 ft	3.0
<= 680 ft	1.0

C. Carters ReReg

The Baseline operation set was used in the Baseline alternative at Carters ReReg. The project contains five zones. The zones include Top of Dam, Flood Control, Conservation, Buffer, and Inactive. The Top of Dam and Inactive zones contain no rules. The rule set for the Baseline operation set for Carters ReReg is shown in Figure N.20.



Reservoir Carters ReReg

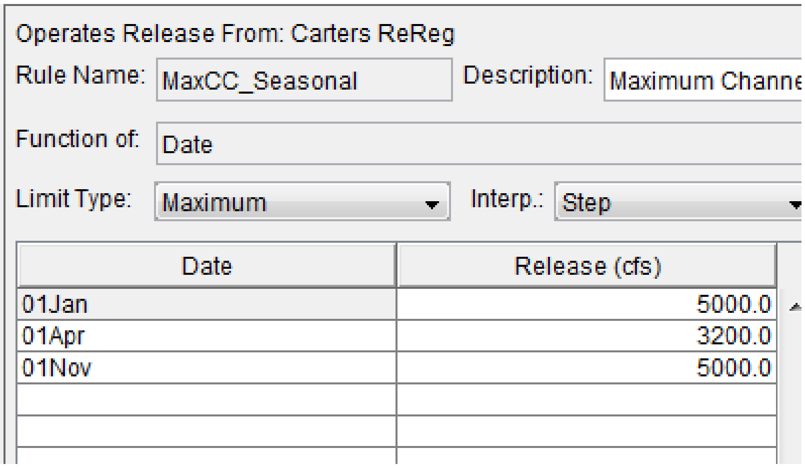
Operation Set Baseline

- Top of Dam
- Flood Control
  - MaxCC_Seasonal
  - MinQ_240
  - MinQ=110% CartersSysInflow
- Conservation
  - MaxCC_Seasonal
  - MinQ_240
  - MinQ=92% CartersSysInflow
- Buffer
  - MaxCC_Seasonal
  - MinQ_240
- *Inactive*

Figure N.20 Rule Set for Carters ReReg Baseline Operation Set

1. MaxCC_Seasonal

This rule is applied in Flood Control, Conservation, and Buffer. It sets the maximum release from Carters ReReg from 3,200 cfs to 5,000 cfs in a step function. Beginning on 01Jan, the maximum release is 5,000 cfs, becoming 3,200 cfs on 01Apr, then back to 5,000 cfs on 01Nov. This rule is shown in Figure N.21.



Operates Release From: Carters ReReg

Rule Name: MaxCC_Seasonal

Description: Maximum Channe

Function of: Date

Limit Type: Maximum

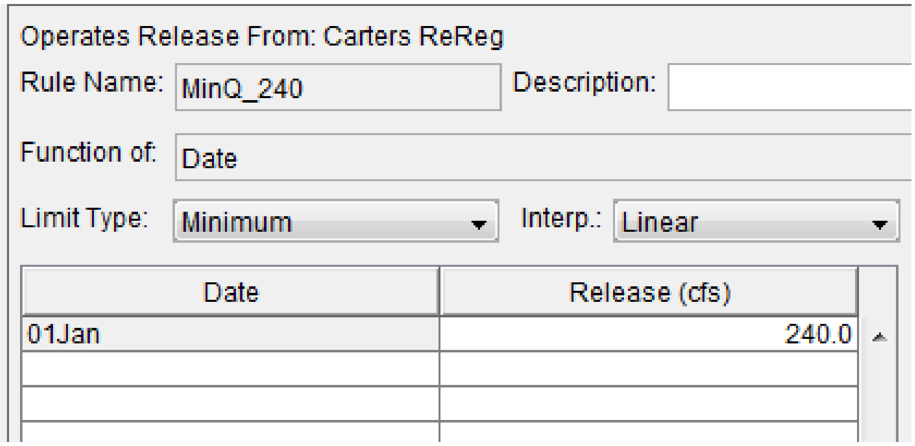
Interp.: Step

Date	Release (cfs)
01Jan	5000.0
01Apr	3200.0
01Nov	5000.0

Figure N.21 MaxCC_Seasonal Rule for Carters ReReg

2. MinQ_240

This rule is applied in Flood Control, Conservation, and Buffer. It sets the minimum release from Carters ReReg to 240 cfs throughout the entire year. This rule is shown in Figure N.22.



Operates Release From: Carters ReReg

Rule Name: MinQ_240

Description:

Function of: Date

Limit Type: Minimum

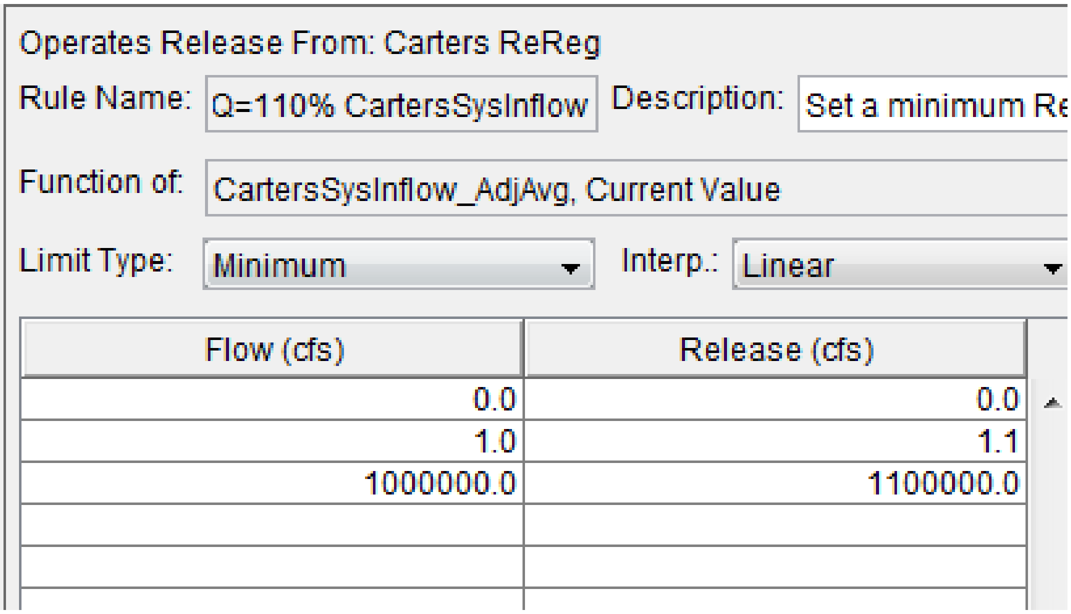
Interp.: Linear

Date	Release (cfs)
01Jan	240.0

Figure N.22 MinQ_240 Rule for Carters ReReg

3. MinQ=110% CartersSysInflow

This rule is placed in the Flood Control zone and sets the 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 Tuesdays but can be adjusted on Sundays if inflow has changed by at least 15%. This rule is shown in Figure N.23.



Operates Release From: Carters ReReg

Rule Name: Q=110% CartersSysInflow

Description: Set a minimum Re

Function of: CartersSysInflow_AdjAvg, Current Value

Limit Type: Minimum

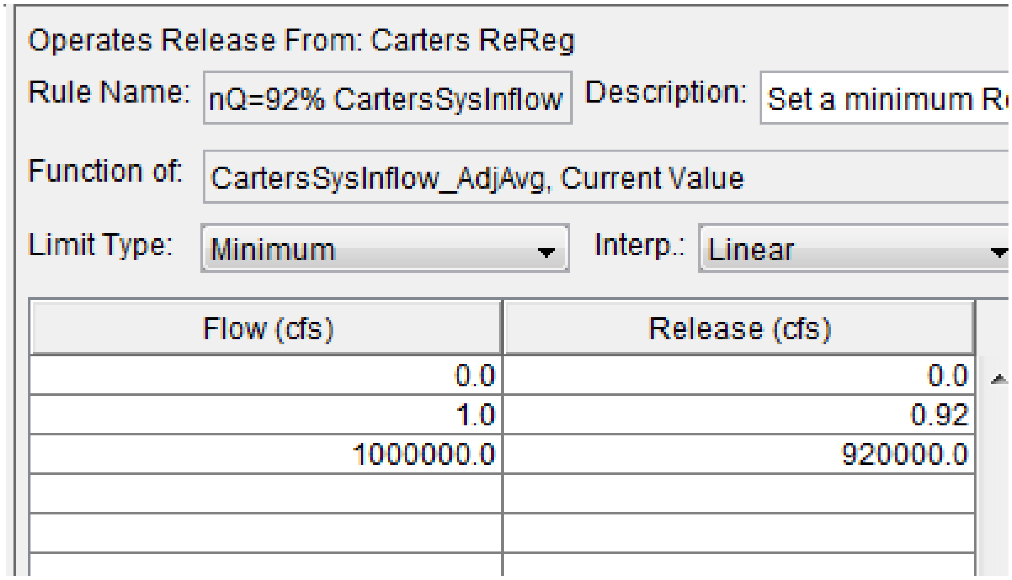
Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	0.0
1.0	1.1
1000000.0	1100000.0

Figure N.23 MinQ=110% CartersSysInflow Rule in Carters ReReg

4. MinQ=92% CartersSysInflow

This rule is placed in the Conservation zone and sets the 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 Tuesdays but can be adjusted on Sundays if inflow has changed by at least 15%. This rule is shown in Figure N.24.



Operates Release From: Carters ReReg

Rule Name: nQ=92% CartersSysInflow

Description: Set a minimum R

Function of: CartersSysInflow_AdjAvg, Current Value

Limit Type: Minimum

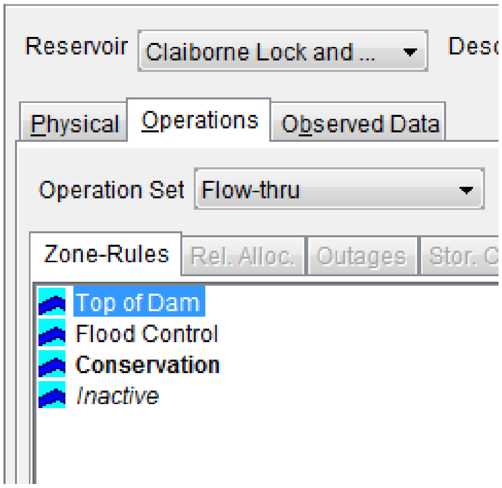
Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	0.0
1.0	0.92
1000000.0	920000.0

Figure N.24 MinQ=92% CartersSysInflow Rule in Carters ReReg

D. Claiborne

The Flow-thru operation set was used in the Baseline alternative at Claiborne. The project contains four zones. The zones include Top of Dam, Flood Control, Conservation, and Inactive. None of the zones contain rules. The rule set for the Flow-thru operation set for Claiborne is shown in Figure N.25.



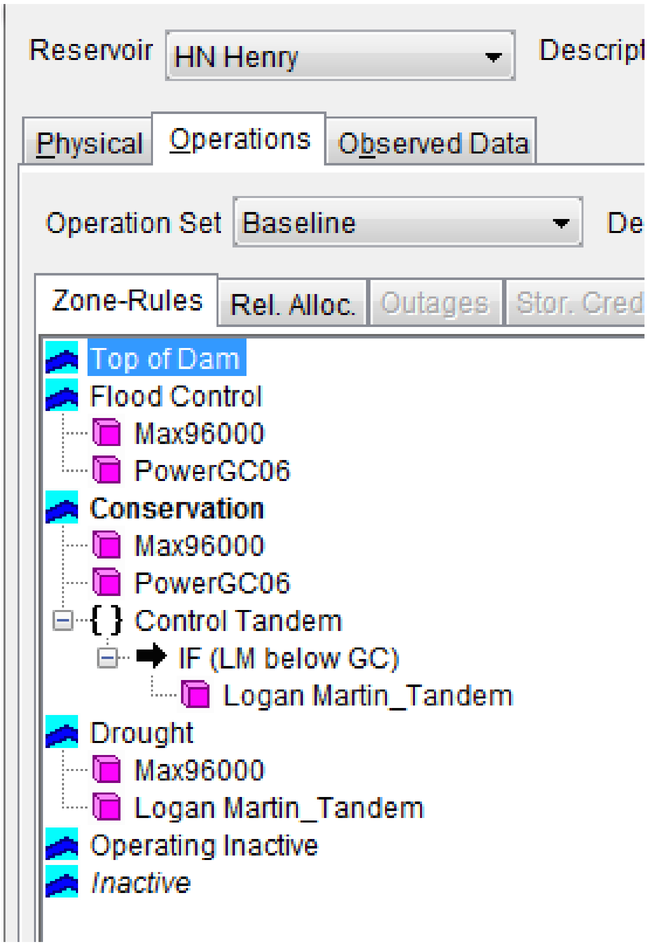
Reservoir: Claiborne Lock and ...

Operation Set: Flow-thru

Figure N.25 Rule Set for Claiborne Flow-thru Operation Set

E. HN Henry

The Baseline operation set was used in the Baseline alternative at HN Henry. The project contains six zones. The zones include Top of Dam, Flood Control, Conservation, Drought, Operating Inactive, and Inactive. The Top of Dam, Operating Inactive, and Inactive zones contain no rules. The rule set for the Baseline operation set for HN Henry is shown in Figure N.26.



Reservoir HN Henry

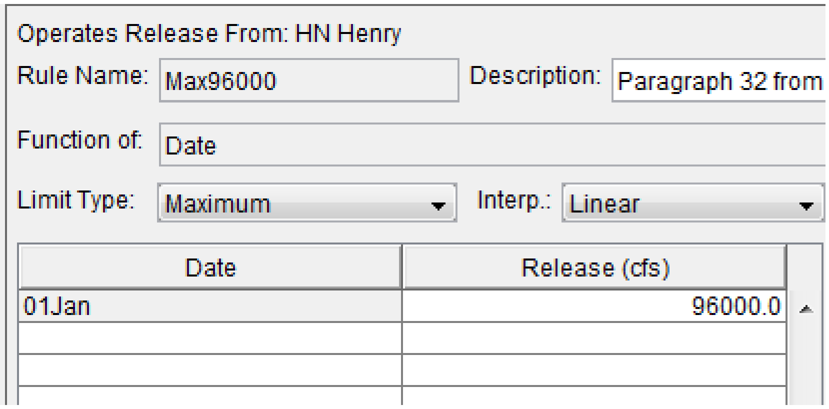
Operation Set Baseline

- Top of Dam
- Flood Control
  - Max96000
  - PowerGC06
- Conservation
  - Max96000
  - PowerGC06
  - { } Control Tandem
    - IF (LM below GC)
      - Logan Martin_Tandem
- Drought
  - Max96000
  - Logan Martin_Tandem
- Operating Inactive
- *Inactive*

Figure N.26 Rule Set for HN Henry Baseline Operation Set

1. Max96000

This rule is applied in Flood Control, Conservation, and Drought. It sets the maximum release from HN Henry to 96,000 cfs. This rule is shown in Figure N.27.



Operates Release From: HN Henry

Rule Name: Max96000

Description: Paragraph 32 from

Function of: Date

Limit Type: Maximum

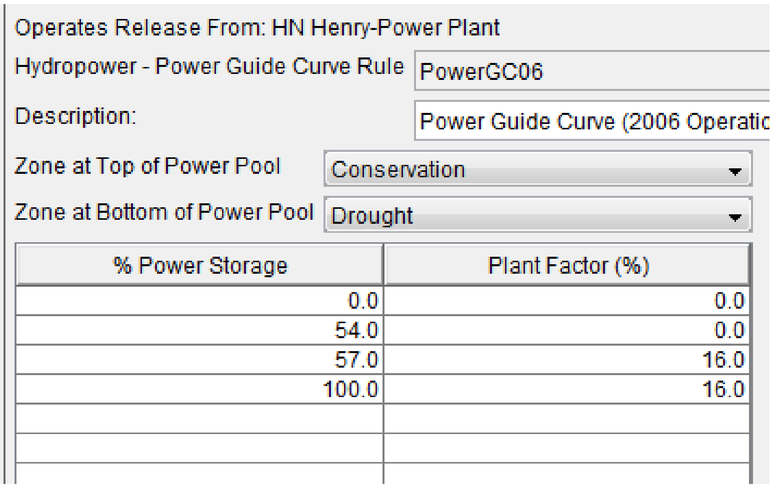
Interp.: Linear

Date	Release (cfs)
01Jan	96000.0

Figure N.27 Max96000 Rule in HN Henry

2. PowerGC06

This rule is applied in Flood Control and Conservation. It sets the plant factor at either 0% or 16% depending on the % Power Storage in use. The power storage is from top of Conservation to top of Drought. From 0% to 54% of power storage in use, the plant factor is 0% (equivalent to 0 hours of generation). From 57% to 100% of power storage in use, the plant factor is 16% (equivalent to 3.84 hours of generation). The plant factor increases linearly from 0% to 16% as the power storage in use transitions from 54% to 57%. This required power generation is for weekdays only. The power generation rule is shown in Figure N.28.



Operates Release From: HN Henry-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC06

Description: Power Guide Curve (2006 Operatic

Zone at Top of Power Pool: Conservation

Zone at Bottom of Power Pool: Drought

% Power Storage	Plant Factor (%)
0.0	0.0
54.0	0.0
57.0	16.0
100.0	16.0

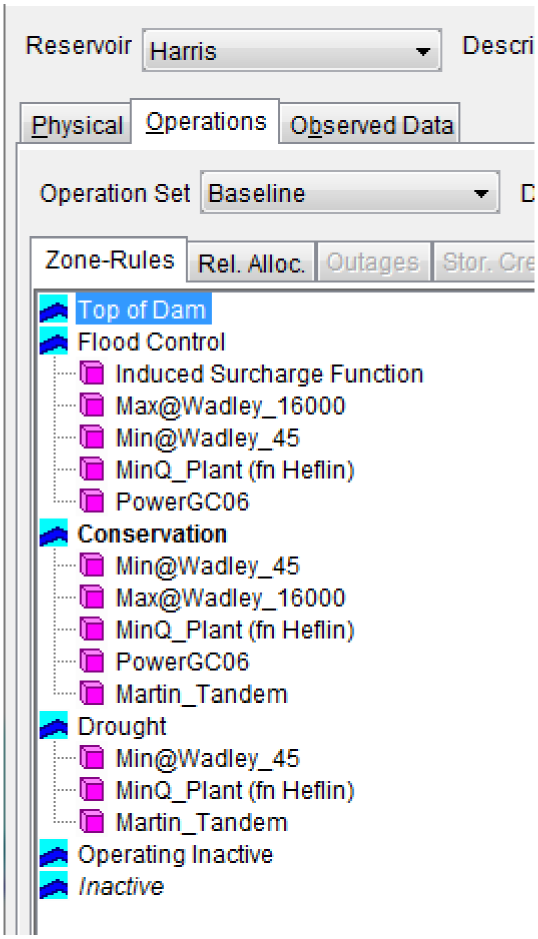
Figure N.28 PowerGC06 Rule at HN Henry

3. Logan Martin Tandem

In both Conservation and Drought, HN Henry is operated in tandem with its downstream project, Logan Martin. In Drought, this is a stand-alone rule. In Conservation, this rule is dependent on how close Logan Martin pool elevation is to the top of Conservation. If the pool is within .025 ft of the top of Conservation, the tandem rule will not be activated. This test is accomplished through the use of the state variable, LoganMartin_GCBuffer.

F. Harris

The Baseline operation set was used in the Baseline alternative at Harris. The project contains six zones. The zones include Top of Dam, Flood Control, Conservation, Drought, Operating Inactive, and Inactive. The Top of Dam, Operating Inactive, and Inactive zones contain no rules. The rule set for the Baseline operation set for Harris is shown in Figure N.29.



Reservoir Harris

Operation Set Baseline

- Top of Dam
- Flood Control
  - Induced Surcharge Function
  - Max@Wadley_16000
  - Min@Wadley_45
  - MinQ_Plant (fn Heflin)
  - PowerGC06
- **Conservation**
  - Min@Wadley_45
  - Max@Wadley_16000
  - MinQ_Plant (fn Heflin)
  - PowerGC06
  - Martin_Tandem
- Drought
  - Min@Wadley_45
  - MinQ_Plant (fn Heflin)
  - Martin_Tandem
- Operating Inactive
- *Inactive*

Figure N.29 Rule Set for Harris Baseline Operation Set

1. Induced Surcharge Function

This rule is applied in Flood Control. It uses the induced surcharge envelope curve which specifies the minimum required release for a given elevation. The time of recession is 48 hrs. The time for pool decrease is 24 hrs, meaning that the pool has to be falling for 24 hrs for the operation to transition from the induced surcharge function to the falling pool option. The falling pool option is to maintain the peak release and is maintained until the falling pool transition elevation of 793.0 ft is reached. The induced surcharge envelope curve is shown in Figure N.30.

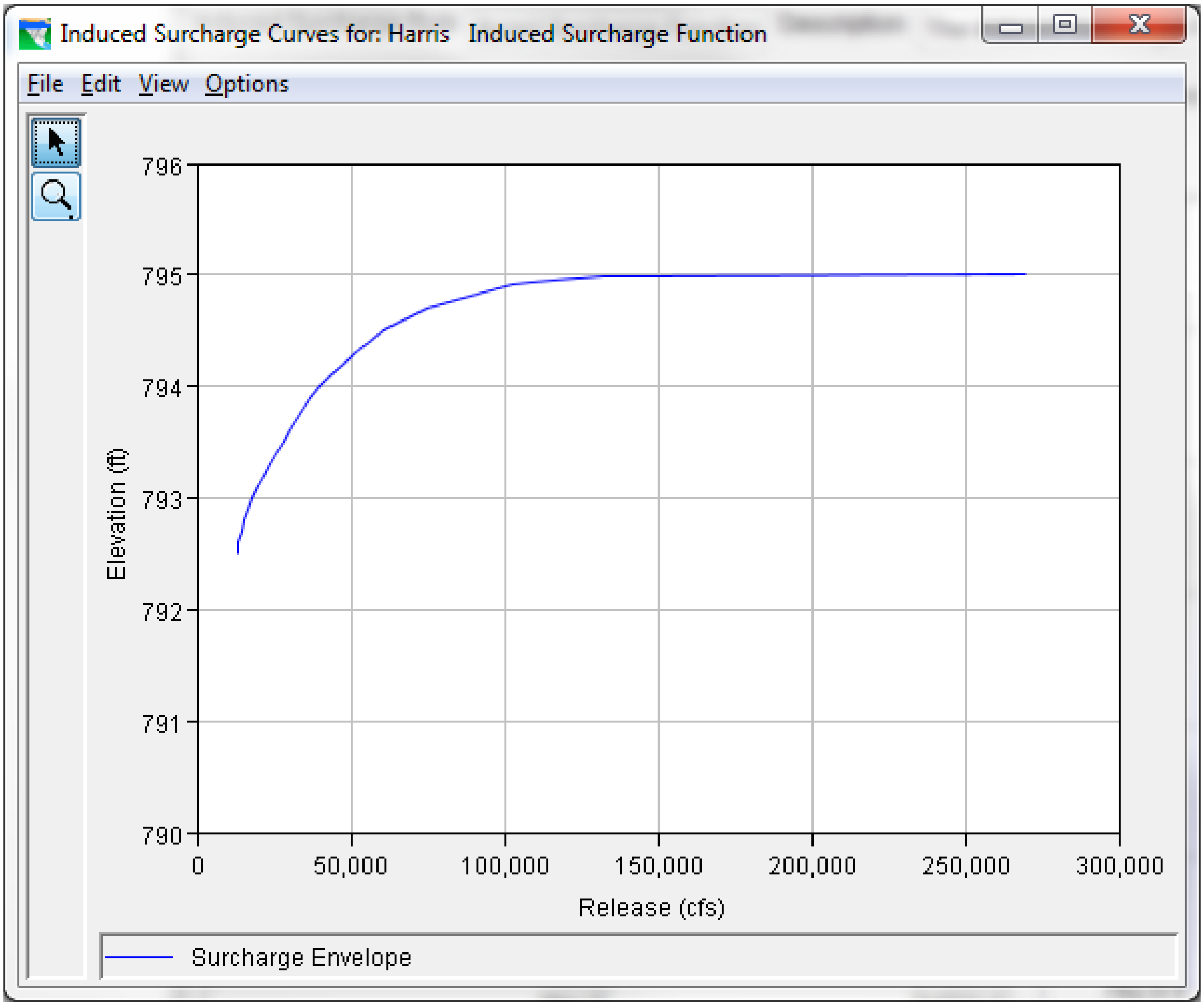
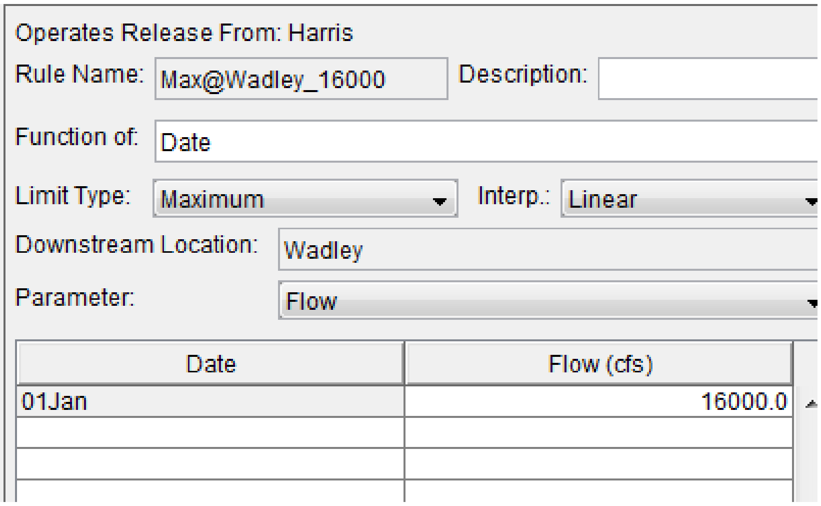


Figure N.30 Induced Surcharge Envelope Curve for Harris

2. Max@Wadley_16000

This rule is applied in Flood Control and Conservation. It sets the maximum flow at the downstream location of Wadley to 16,000 cfs throughout the entire year. The rule is shown in Figure N.31.



Operates Release From: Harris

Rule Name: Max@Wadley_16000

Description:

Function of: Date

Limit Type: Maximum

Interp.: Linear

Downstream Location: Wadley

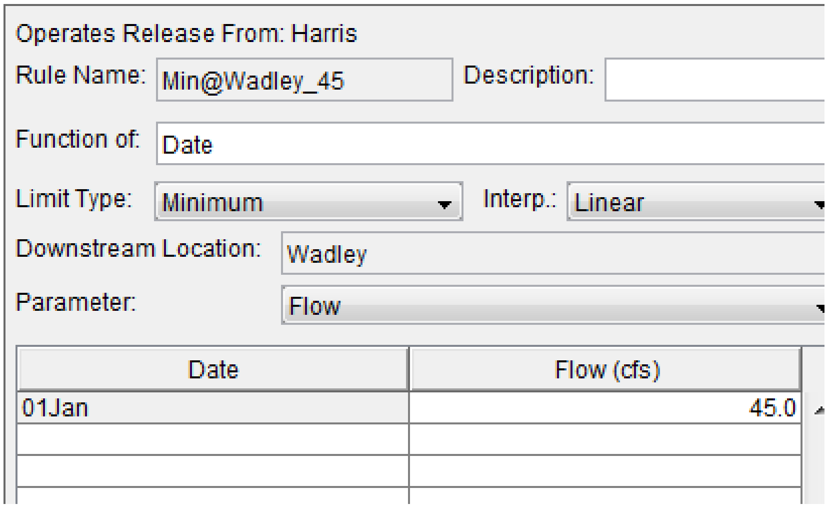
Parameter: Flow

Date	Flow (cfs)
01Jan	16000.0

Figure N.31 Max@Wadley Rule for Harris

3. Min@Wadley_45

This rule is applied in Flood Control, Conservation, and Drought. It sets the minimum flow at the downstream location of Wadley to 45 cfs throughout the entire year. The rule is shown in Figure N.32.



Operates Release From: Harris

Rule Name: Min@Wadley_45

Description:

Function of: Date

Limit Type: Minimum

Interp.: Linear

Downstream Location: Wadley

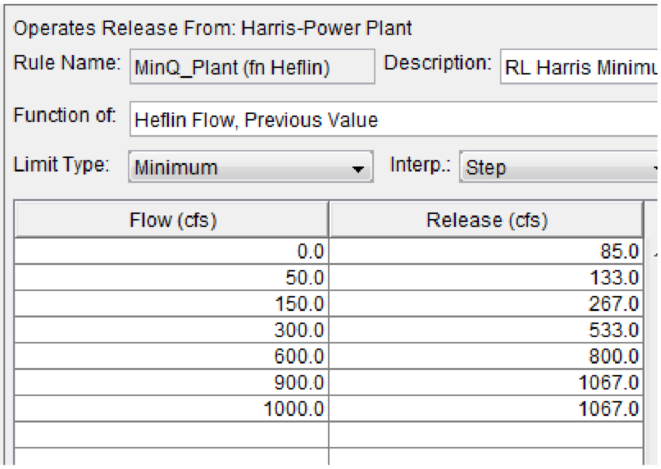
Parameter: Flow

Date	Flow (cfs)
01Jan	45.0

Figure N.32 Min@Wadley Rule for Harris

4. MinQ_Plant (fn Heflin)

This rule is applied in Flood Control, Conservation, and Drought. It sets the minimum release from the power plant at Harris based on the previous flow value at the upstream gage of Heflin. The function is given as a step function. This rule is shown in Figure N.33.



Operates Release From: Harris-Power Plant

Rule Name: MinQ_Plant (fn Heflin)

Description: RL Harris Minimu

Function of: Heflin Flow, Previous Value

Limit Type: Minimum

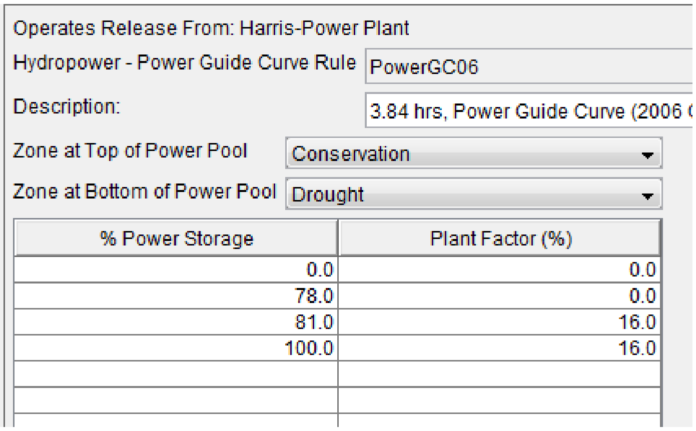
Interp.: Step

Flow (cfs)	Release (cfs)
0.0	85.0
50.0	133.0
150.0	267.0
300.0	533.0
600.0	800.0
900.0	1067.0
1000.0	1067.0

Figure N.33 MinQ_Plant (fn Heflin) Rule for Harris

5. PowerGC06

This rule is applied in Flood Control and Conservation. It sets the plant factor at either 0% or 16% depending on the % Power Storage in use. The power storage is from top of Conservation to top of Drought. From 0% to 78% of power storage in use, the plant factor is 0% (equivalent to 0 hours of generation). From 81% to 100% of power storage in use, the plant factor is 16% (equivalent to 3.84 hours of generation). The plant factor increases linearly from 0% to 16% as the power storage in use transitions from 78% to 81%. This required power generation is for weekdays only. The power generation rule is shown in Figure N.34.



Operates Release From: Harris-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC06

Description: 3.84 hrs, Power Guide Curve (2006

Zone at Top of Power Pool: Conservation

Zone at Bottom of Power Pool: Drought

% Power Storage	Plant Factor (%)
0.0	0.0
78.0	0.0
81.0	16.0
100.0	16.0

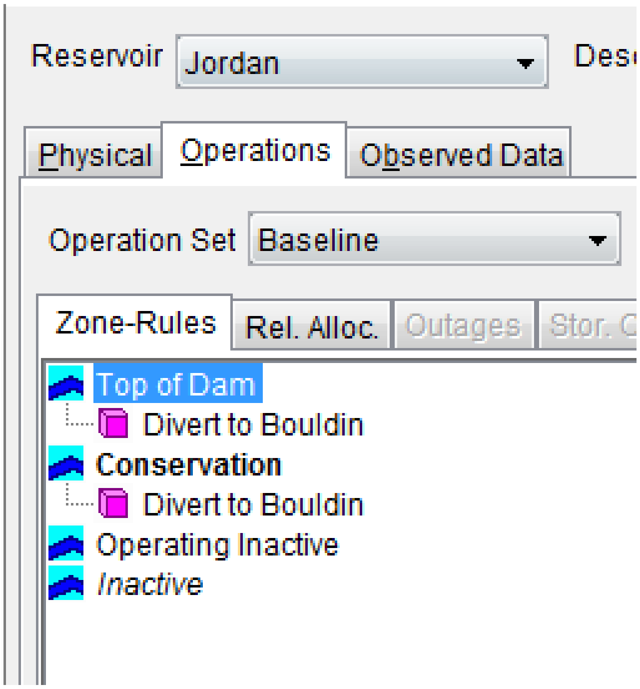
Figure N.34 PowerGC06 Rule at Harris

6. Martin_Tandem

In both Conservation and Drought, Harris is operated in tandem with its downstream project, Martin.

G. Jordan

The Baseline operation set was used in the Baseline alternative at Jordan. The project contains four zones. The zones include Top of Dam, Conservation, Operating Inactive, and Inactive. The Operating Inactive and Inactive zones contain no rules. The rule set for the Baseline operation set for Jordan is shown in Figure N.35.



Reservoir Jordan

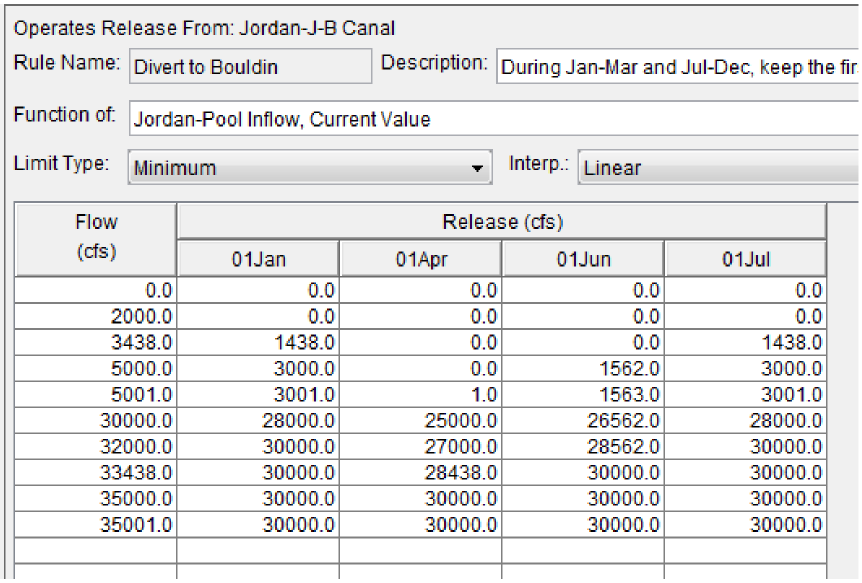
Operation Set Baseline

- Top of Dam
  - Divert to Bouldin
- Conservation
  - Divert to Bouldin
- Operating Inactive
- *Inactive*

Figure N.35 Rule Set for Jordan Baseline Operation Set

1. Divert to Bouldin

This rule is applied in both the Top of Dam and Conservation zones. It sets the minimum amount that will be diverted to Bouldin Reservoir through the Jordan-Bouldin Canal. The diversion amount is dependent on both the inflow into Jordan and the time of year. The inflow is used as a linear relationship with required diversion amounts while the time of year is treated as a step function. This rule is shown in Figure N.36.



Operates Release From: Jordan-J-B Canal

Rule Name: Divert to Bouldin

Description: During Jan-Mar and Jul-Dec, keep the fir

Function of: Jordan-Pool Inflow, Current Value

Limit Type: Minimum

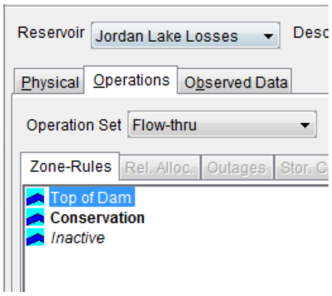
Interp.: Linear

Flow (cfs)	Release (cfs)			
	01Jan	01Apr	01Jun	01Jul
0.0	0.0	0.0	0.0	0.0
2000.0	0.0	0.0	0.0	0.0
3438.0	1438.0	0.0	0.0	1438.0
5000.0	3000.0	0.0	1562.0	3000.0
5001.0	3001.0	1.0	1563.0	3001.0
30000.0	28000.0	25000.0	26562.0	28000.0
32000.0	30000.0	27000.0	28562.0	30000.0
33438.0	30000.0	28438.0	30000.0	30000.0
35000.0	30000.0	30000.0	30000.0	30000.0
35001.0	30000.0	30000.0	30000.0	30000.0

Figure N.36 Divert to Bouldin Rule for Jordan

H. Jordan Lake Losses

The Flow-thru operation set was used in the Baseline alternative at Jordan Lake Losses. The project contains three zones. The zones include Top of Dam, Conservation, and Inactive. None of the zones contain any rules. The rule set for the Flow-thru operation set for Jordan Lake Losses is shown in Figure N.37.



Reservoir Jordan Lake Losses

Operation Set Flow-thru

Figure N.37 Rule Set for Jordan Lake Losses Flow-thru Operation Set

I. Lay Lake

The Flow-thru operation set was used in the Baseline alternative at Lay Lake. The project contains four zones. The zones include Top of Dam, Conservation, Operating Inactive, and Inactive. None of the zones contain any rules. The rule set for the Baseline operation set for Lay Lake is shown in Figure N.38.

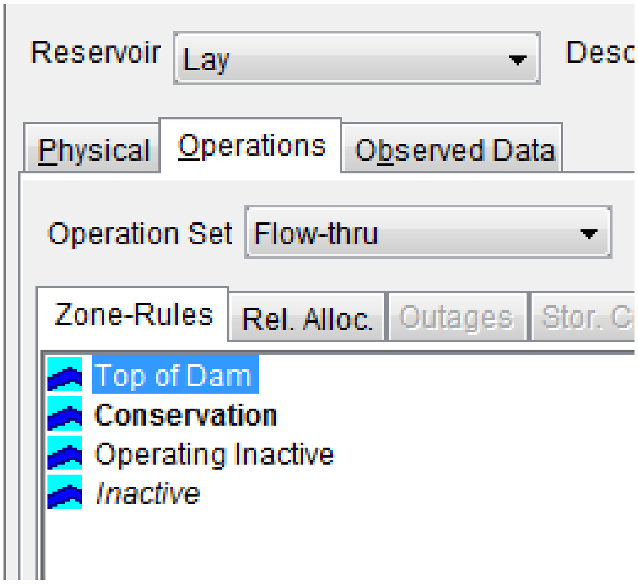
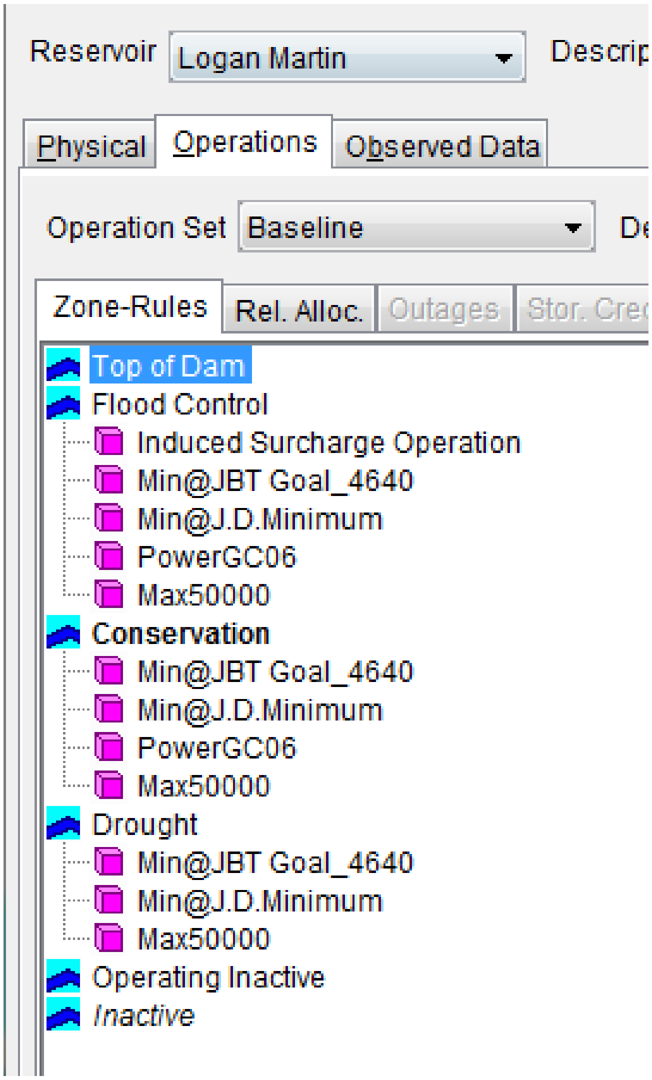


Figure N.38 Rule Set for Lay Lake Flow-thru Operation Set

J. Logan Martin

The Baseline operation set was used in the Baseline alternative at Logan Martin. The project contains six zones. The zones include Top of Dam, Flood Control, Conservation, Drought, Operating Inactive, and Inactive. The Top of Dam, Operating Inactive, and Inactive zones contain no rules. The rule set for the Baseline operation set for Logan Martin is shown in Figure N.39.



Reservoir Logan Martin

Operation Set Baseline

- Top of Dam
- Flood Control
  - Induced Surcharge Operation
  - Min@JBT Goal_4640
  - Min@J.D.Minimum
  - PowerGC06
  - Max50000
- Conservation
  - Min@JBT Goal_4640
  - Min@J.D.Minimum
  - PowerGC06
  - Max50000
- Drought
  - Min@JBT Goal_4640
  - Min@J.D.Minimum
  - Max50000
- Operating Inactive
- *Inactive*

Figure N.39 Rule Set for Logan Martin Baseline Operation Set

1. Induced Surcharge Operation

This rule is applied in Flood Control. It uses the induced surcharge envelope curve which specifies the minimum required release for a given elevation. The time of recession is 120 hrs. The time for pool decrease is 24 hrs meaning that the pool has to be falling for 24 hrs for the operation to transition from the induced surcharge function to the falling pool option. The falling pool option is to maintain the peak gate openings until the falling pool transition elevation of 465.0 ft is reached. The induced surcharge envelope curve is shown in Figure N.40.

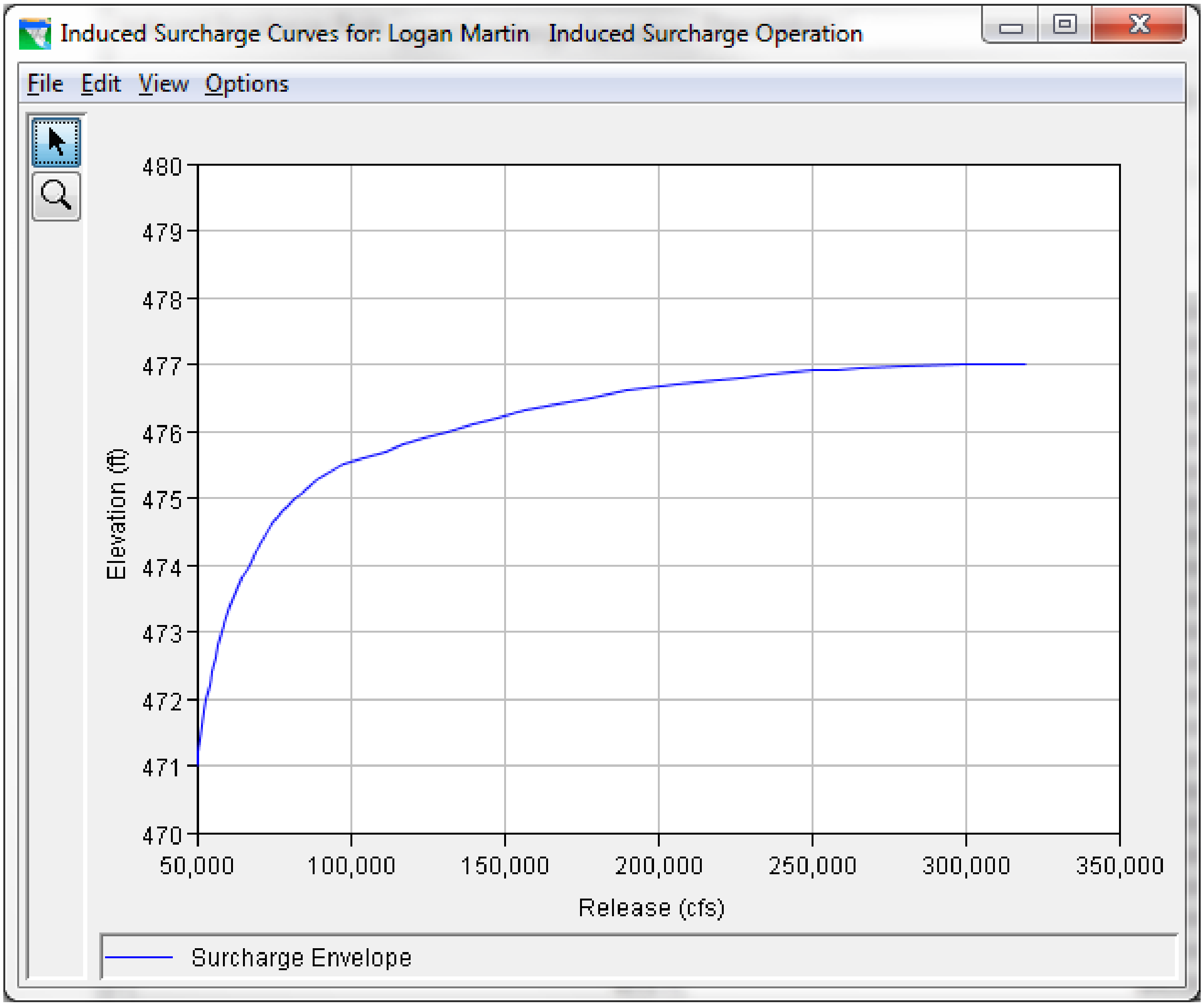
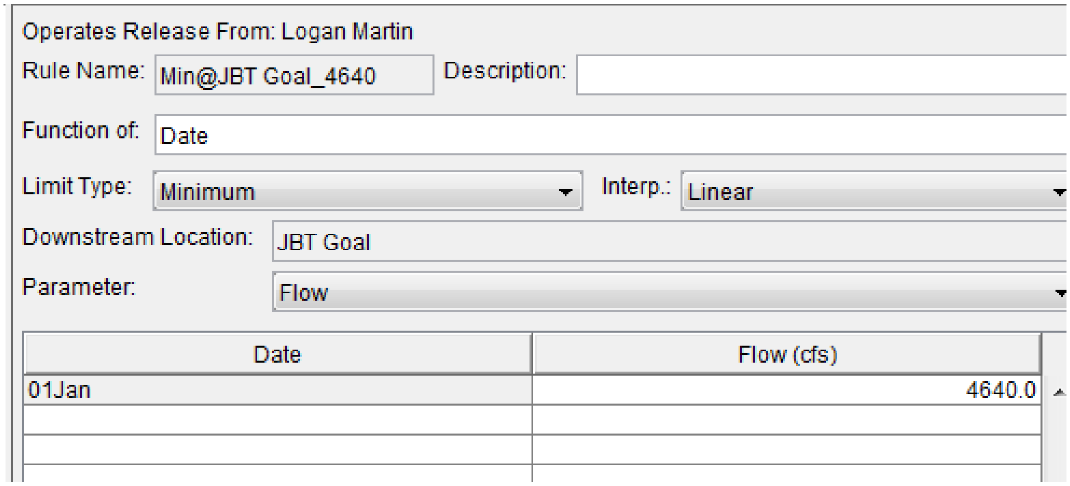


Figure N.40 Induced Surcharge Envelope Curve for Logan Martin

2. Min@JBT Goal_4640

This rule is applied in Flood Control, Conservation, and Drought. It sets the minimum flow at the downstream location of JBT Goal to 4,640 cfs throughout the entire year. This rule is shown in Figure N.41.



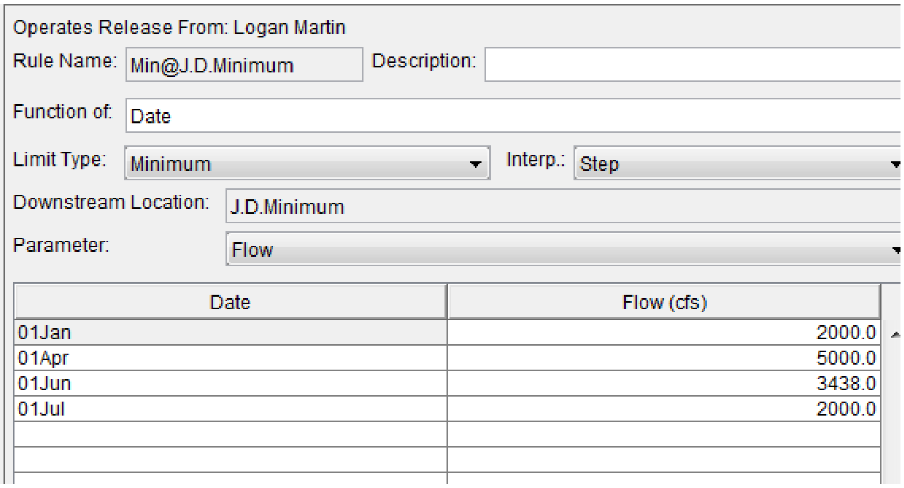
Operates Release From: Logan Martin
Rule Name: Min@JBT Goal_4640
Description:
Function of: Date
Limit Type: Minimum
Interp.: Linear
Downstream Location: JBT Goal
Parameter: Flow

Date	Flow (cfs)
01Jan	4640.0

Figure N.41 Min@JBT Goal_4640 Rule at Logan Martin

3. Min@J.D. Minimum

This rule is applied in Flood Control, Conservation, and Drought. It set the minimum flow at the downstream location of J.D. Minimum between 2,000 cfs and 5,000 cfs depending on the time of year. The relationship between time of year and minimum flow is given as a step function. Beginning on 01Jan the minimum flow is 2,000 cfs; on 01Apr it becomes 5,000 cfs, then drops to 3,438 cfs on 01Jun, and returns to 2,000 cfs on 01Jul. This rule is shown in Figure N.42.



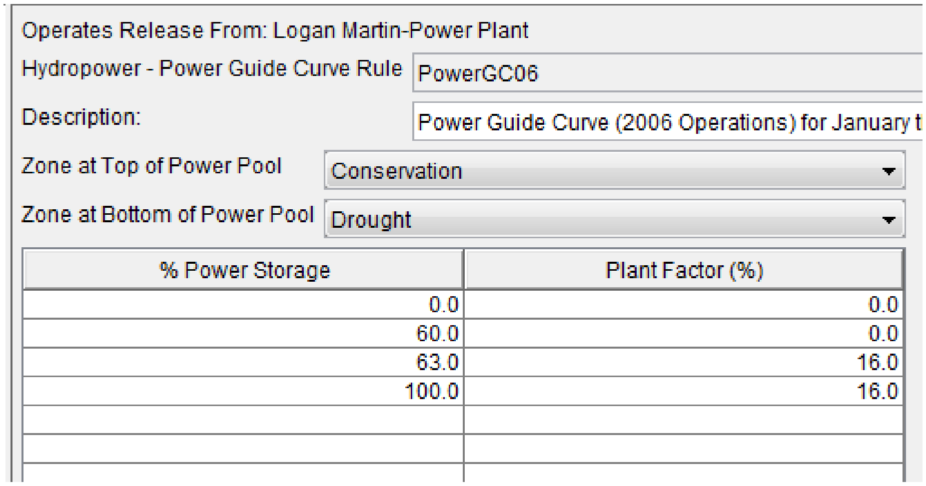
Operates Release From: Logan Martin
Rule Name: Min@J.D.Minimum
Description:
Function of: Date
Limit Type: Minimum
Interp.: Step
Downstream Location: J.D.Minimum
Parameter: Flow

Date	Flow (cfs)
01Jan	2000.0
01Apr	5000.0
01Jun	3438.0
01Jul	2000.0

Figure N.42 Min@J.D. Minimum Rule at Logan Martin

4. PowerGC06

This rule is applied in Flood Control and Conservation. It sets the plant factor at either 0% or 16% depending on the % Power Storage in use. The power storage is from top of Conservation to top of Drought. From 0% to 60% of power storage in use, the plant factor is 0% (equivalent to 0 hours of generation). From 63% to 100% of power storage in use, the plant factor is 16% (equivalent to 3.84 hours of generation). The plant factor increases linearly from 0% to 16% as the power storage in use transitions from 60% to 63%. This required power generation is for weekdays only. The power generation rule is shown in Figure N.43.



Operates Release From: Logan Martin-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC06

Description: Power Guide Curve (2006 Operations) for January t

Zone at Top of Power Pool: Conservation

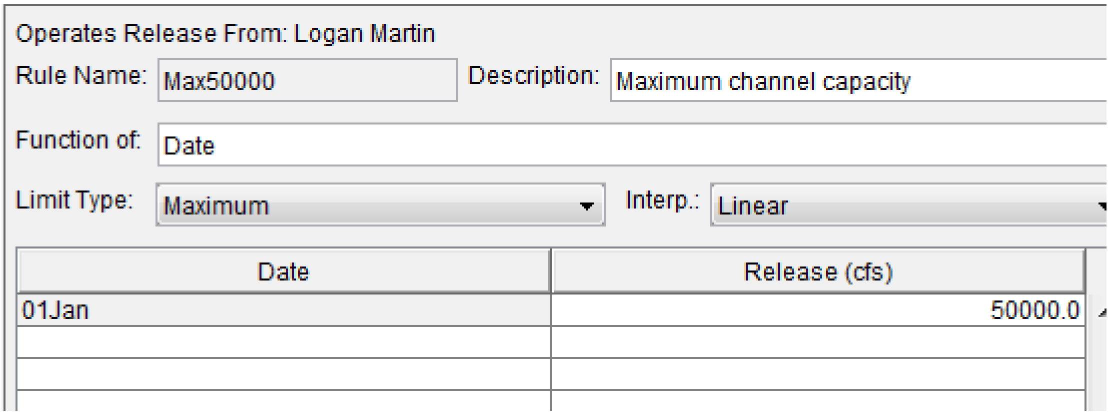
Zone at Bottom of Power Pool: Drought

% Power Storage	Plant Factor (%)
0.0	0.0
60.0	0.0
63.0	16.0
100.0	16.0

Figure N.43 Power Generation Rule at Logan Martin

5. Max50000

This rule is applied in Flood Control, Conservation, and Drought. It sets the maximum release from Logan Martin to 50,000 cfs throughout the entire year. This rule is shown in Figure N.44.



Operates Release From: Logan Martin

Rule Name: Max50000

Description: Maximum channel capacity

Function of: Date

Limit Type: Maximum

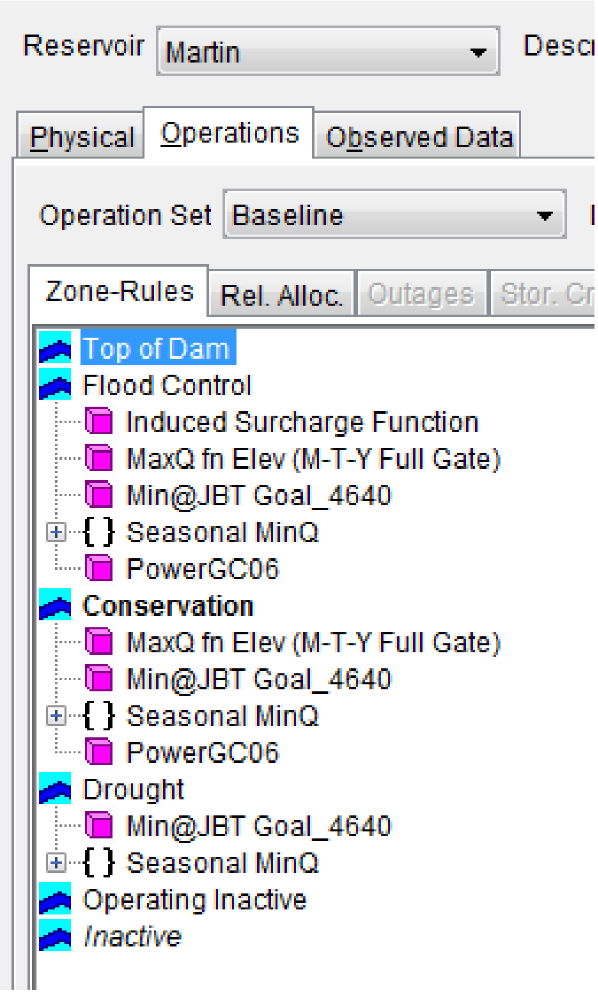
Interp.: Linear

Date	Release (cfs)
01Jan	50000.0

Figure N.44 Max50000 Rule at Logan Martin

K. Martin

The Baseline operation set was used in the Baseline alternative at Martin. The project contains six zones. The zones include Top of Dam, Flood Control, Conservation, Drought, Operating Inactive, and Inactive. The Top of Dam, Operating Inactive, and Inactive zones contain no rules. The rule set for the Baseline operation set for Martin is shown in Figure N.45.



Reservoir: Martin

Operation Set: Baseline

- Top of Dam
- Flood Control
  - Induced Surcharge Function
  - MaxQ fn Elev (M-T-Y Full Gate)
  - Min@JBT Goal_4640
  - { } Seasonal MinQ
  - PowerGC06
- Conservation
  - MaxQ fn Elev (M-T-Y Full Gate)
  - Min@JBT Goal_4640
  - { } Seasonal MinQ
  - PowerGC06
- Drought
  - Min@JBT Goal_4640
  - { } Seasonal MinQ
- Operating Inactive
- *Inactive*

Figure N.45 Rule Set for Martin Baseline Operation Set

1. Induced Surcharge Function

This rule is applied in Flood Control. It uses the induced surcharge envelope curve which specifies the minimum required release for a given elevation. The time of recession is 48 hrs. The time for pool decrease is 24 hrs meaning that the pool has to be falling for 24 hrs for the operation to transition from the induced surcharge function to the falling pool option. The falling pool option is to maintain the peak gate openings until the falling pool transition elevation of 487.5 ft is reached. The induced surcharge envelope curve is shown in Figure N.46.

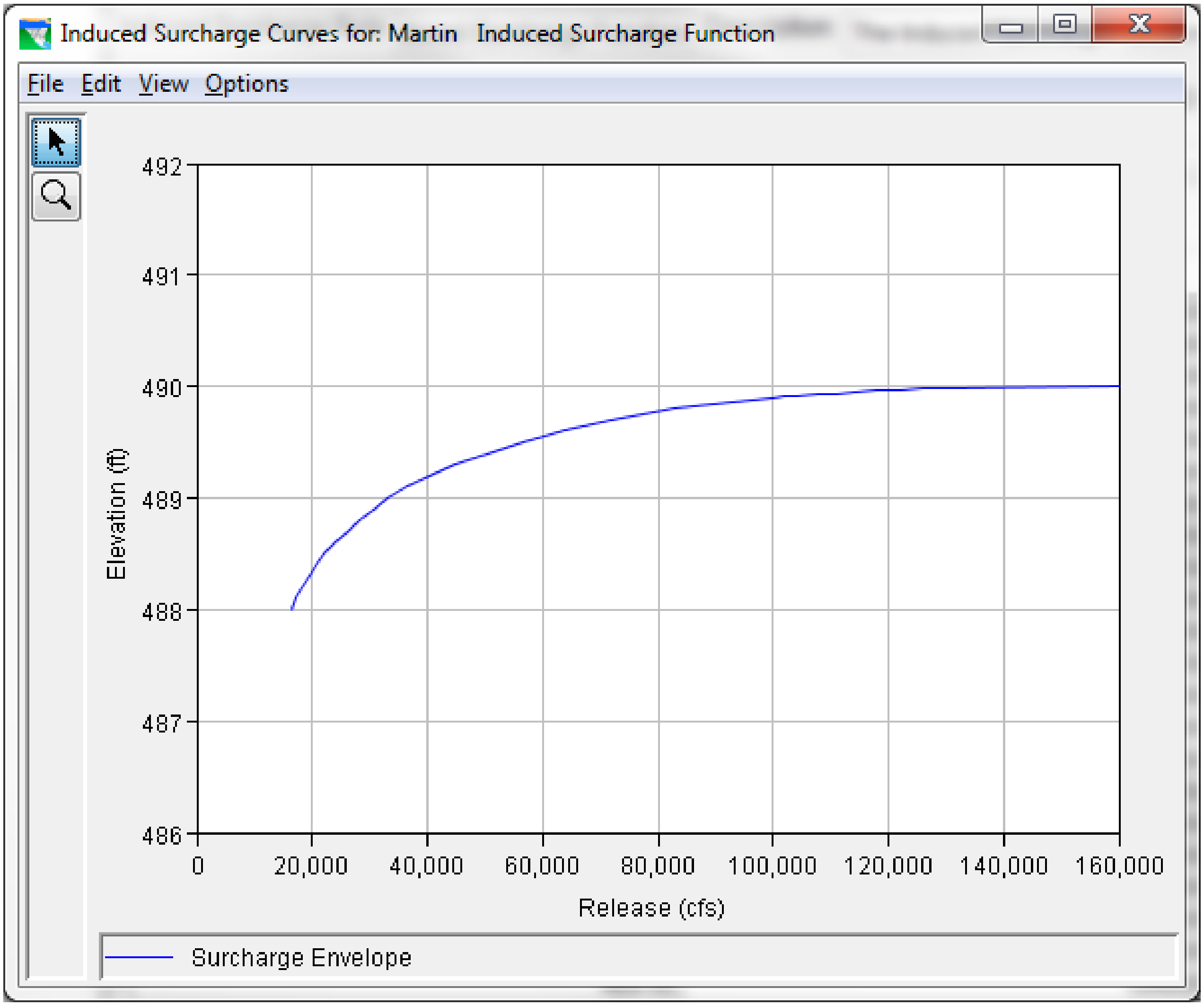
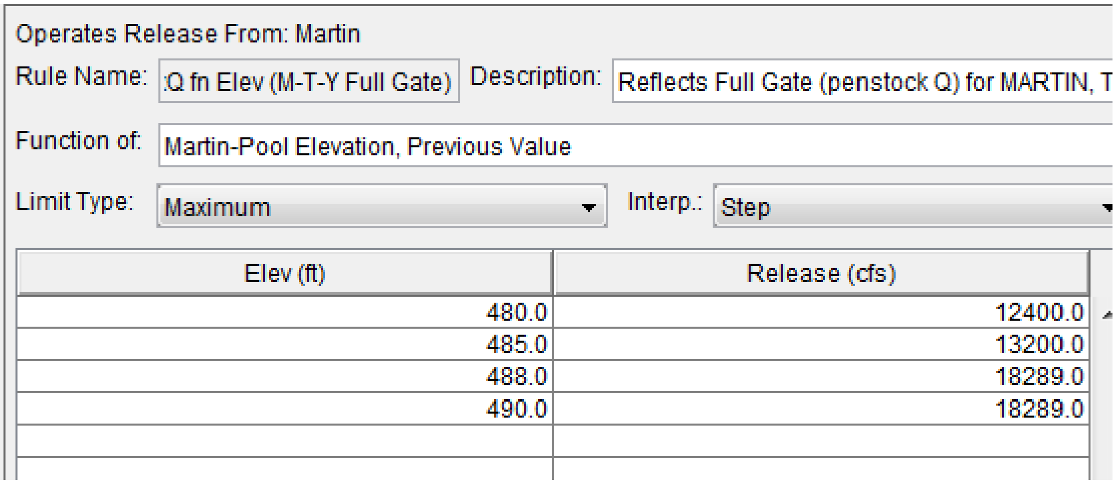


Figure N.46 Induced Surcharge Envelope Curve for Martin

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

This rule is applied in Flood Control and Conservation. It set the maximum release from Martin based on the pool elevation at Martin. The relationship between Martin pool elevation and maximum release is given as a step function. At elevation 480.0 ft, the maximum release is 12,400 cfs, changing to 13,200 cfs at elevation 485.0 ft, then becoming 18,289 cfs at elevation 488.0 ft. This rule is shown in Figure N.47.



Operates Release From: Martin

Rule Name: :Q fn Elev (M-T-Y Full Gate)

Description: Reflects Full Gate (penstock Q) for MARTIN, T

Function of: Martin-Pool Elevation, Previous Value

Limit Type: Maximum

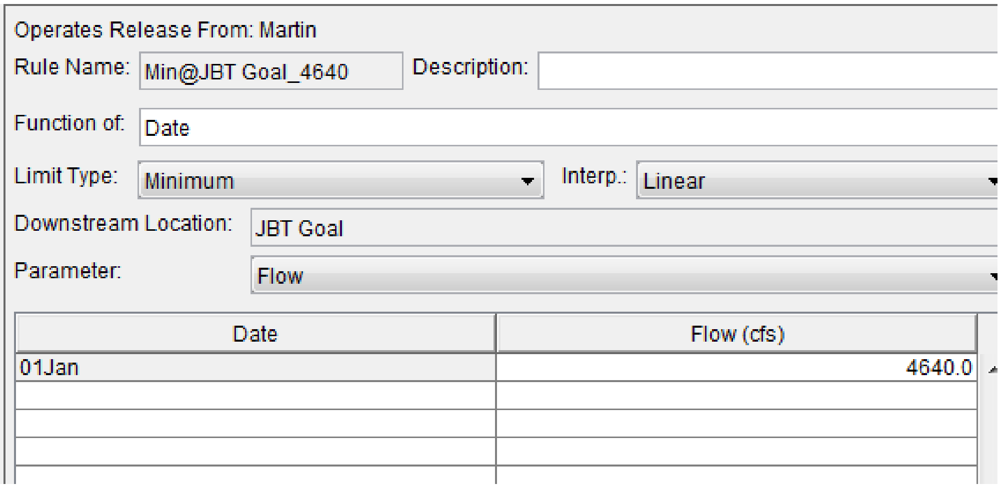
Interp.: Step

Elev (ft)	Release (cfs)
480.0	12400.0
485.0	13200.0
488.0	18289.0
490.0	18289.0

Figure N.47 MaxQ fn Elev (M-T-Y Full Gate) Rule at Martin

3. Min@JBT Goal_4640

This rule is applied in Flood Control, Conservation, and Drought. It sets the minimum flow at the downstream location of JBT Goal to 4,640 cfs throughout the entire year. This rule is shown in Figure N.48.



Operates Release From: Martin

Rule Name: Min@JBT Goal_4640

Description:

Function of: Date

Limit Type: Minimum

Interp.: Linear

Downstream Location: JBT Goal

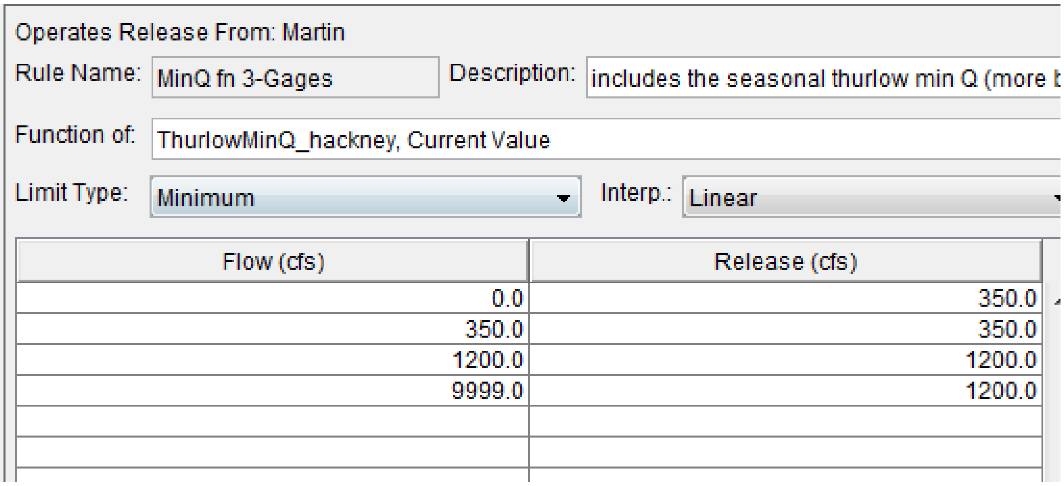
Parameter: Flow

Date	Flow (cfs)
01Jan	4640.0

Figure N.48 Min@JBT Goal_4640 Rule at Martin

4. Seasonal MinQ

This logical statement is applied in Flood Control, Conservation, and Drought. It sets the minimum release from Martin based the time of year. In the months of November through May, the minimum release is dependent on the current value of the state variable, ThurlowMinQ_hackney. This state variable computes a minimum release based on the data at Heflin, Hackneyville, and Martin. The minimum release 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 titled, MinQ fn 3-Gages and is shown in Figure N.49. In the months of June through October, the minimum flow at the downstream location of Tallassee is set to 1,200 cfs throughout the entire year. This rule is titled Min@Tallasse_1200 and is shown in Figure N.50.



Operates Release From: Martin

Rule Name: MinQ fn 3-Gages

Description: includes the seasonal thurlow min Q (more

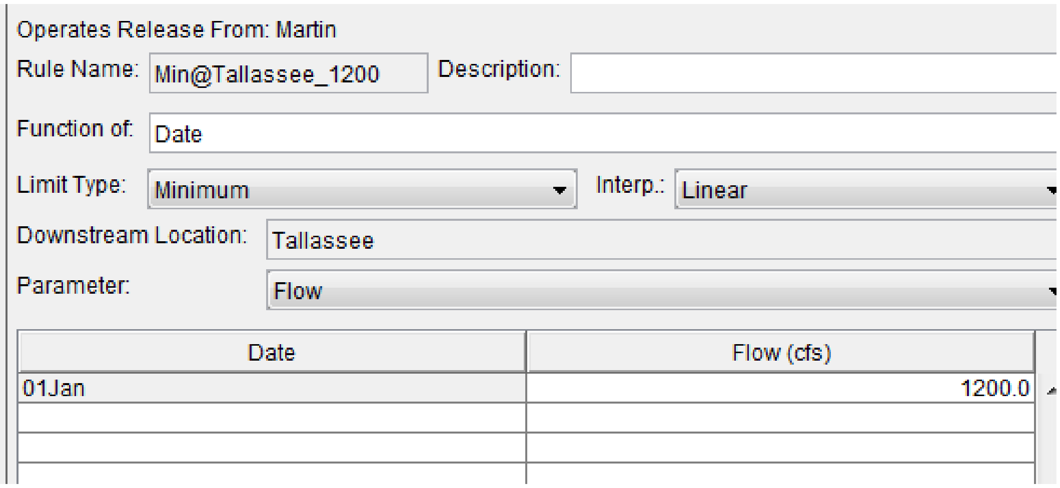
Function of: ThurlowMinQ_hackney, Current Value

Limit Type: Minimum

Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	350.0
350.0	350.0
1200.0	1200.0
9999.0	1200.0

Figure N.49 MinQ fn 3-Gages Rule at Martin



Operates Release From: Martin

Rule Name: Min@Tallassee_1200

Description:

Function of: Date

Limit Type: Minimum

Interp.: Linear

Downstream Location: Tallassee

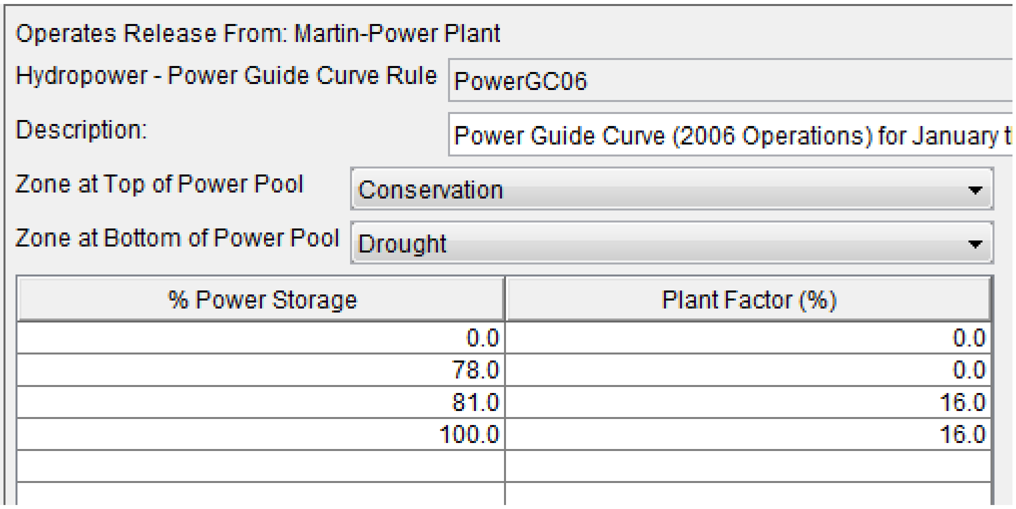
Parameter: Flow

Date	Flow (cfs)
01Jan	1200.0

Figure N.50 Min@Tallassee_1200 Rule at Martin

5. PowerGC06

This rule is applied in Flood Control and Conservation. It sets the plant factor at either 0% or 16% depending on the % Power Storage in use. The power storage is from top of Conservation to top of Drought. From 0% to 78% of power storage in use, the plant factor is 0% (equivalent to 0 hours of generation). From 81% to 100% of power storage in use, the plant factor is 16% (equivalent to 3.84 hours of generation). The plant factor increases linearly from 0% to 16% as the power storage in use transitions from 78% to 81%. This required power generation is for weekdays only. The power generation rule is shown in Figure N.51.



Operates Release From: Martin-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC06

Description: Power Guide Curve (2006 Operations) for January t

Zone at Top of Power Pool: Conservation

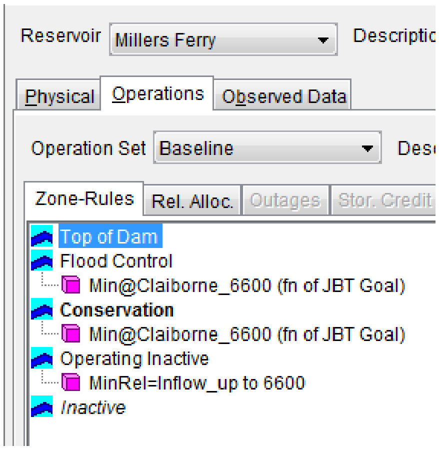
Zone at Bottom of Power Pool: Drought

% Power Storage	Plant Factor (%)
0.0	0.0
78.0	0.0
81.0	16.0
100.0	16.0

Figure N.51 Power Generation Rule at Martin

L. Millers Ferry

The Baseline operation set was used in the Baseline alternative at Millers Ferry. The project contains five zones. The zones include Top of Dam, Flood Control, Conservation, Operating Inactive, and Inactive. The Top of Dam and Inactive zones contain no rules. The rule set for the Baseline operation set for Millers Ferry is shown in Figure N.52.



Reservoir: Millers Ferry

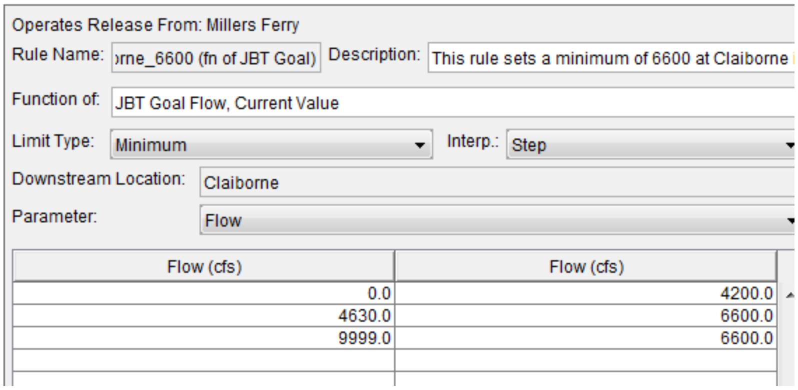
Operation Set: Baseline

- Top of Dam
- Flood Control
  - Min@Claiborne_6600 (fn of JBT Goal)
- **Conservation**
  - Min@Claiborne_6600 (fn of JBT Goal)
- Operating Inactive
  - MinRel=Inflow_up to 6600
- *Inactive*

Figure N.52 Rule Set for Millers Ferry Baseline Operation Set

1. *Min@Claiborne_6600 (fn of JBT Goal)*

This rule is applied in Flood Control and Conservation. It sets the minimum flow at the downstream project Claiborne based on the current flow value at JBT Goal. The relationship between JBT Goal flow and the minimum flow at Claiborne is a step function. For JBT Goal flows from 0 cfs to 4630 cfs, the minimum flow at Claiborne is 4,200 cfs. Above 4,630 cfs flow at JBT Goal, the minimum flow at Claiborne is 6,600 cfs. This rule is shown in Figure N.53.



Operates Release From: Millers Ferry

Rule Name: rne_6600 (fn of JBT Goal)

Description: This rule sets a minimum of 6600 at Claiborne

Function of: JBT Goal Flow, Current Value

Limit Type: Minimum

Interp.: Step

Downstream Location: Claiborne

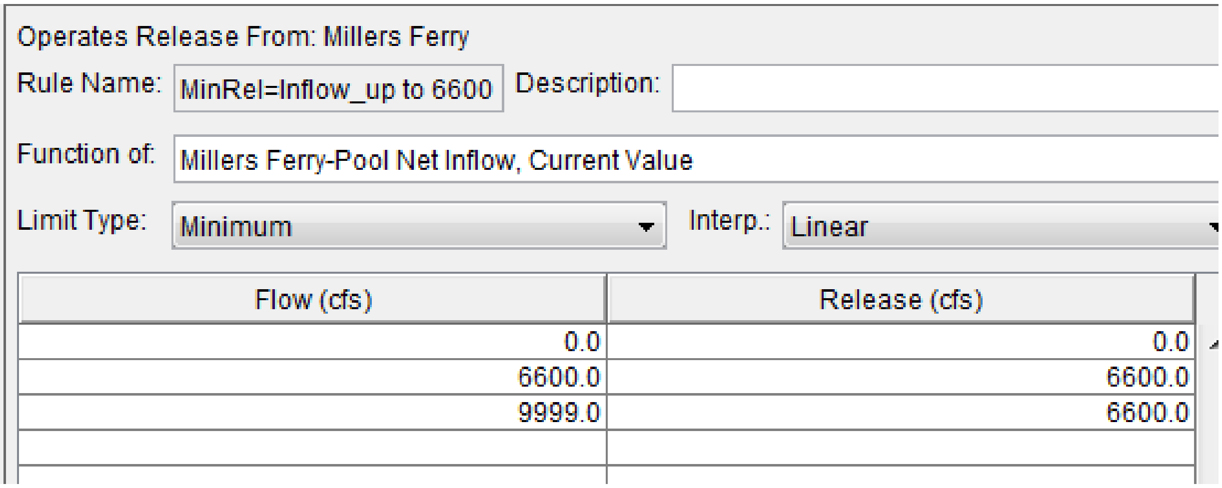
Parameter: Flow

Flow (cfs)	Flow (cfs)
0.0	4200.0
4630.0	6600.0
9999.0	6600.0

Figure N.53 Min@Claiborne_6600 (fn of JBT Goal) Rule at Millers Ferry

2. MinRel=Inflow_up to 6600

This rule is applied in Operating Inactive. It sets the minimum release from Millers Ferry based on the current value of the net inflow into Miller Ferry. For values of net inflow from 0 cfs to 6,600 cfs, the minimum release is set equal to the net inflow. For net inflow values above 6,600 cfs, the minimum release remains constant at 6,600 cfs. This rule is shown in Figure N.54.


Operates Release From: Millers Ferry

Rule Name: MinRel=Inflow_up to 6600

Description:

Function of: Millers Ferry-Pool Net Inflow, Current Value

Limit Type: Minimum

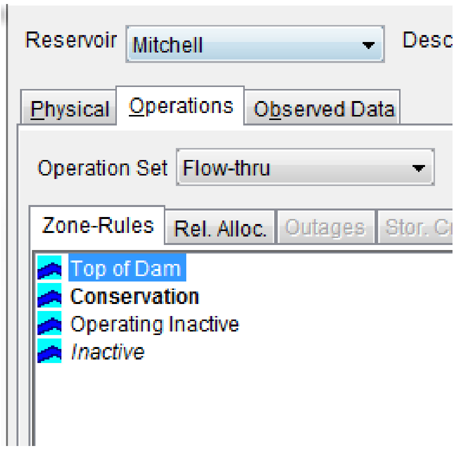
Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	0.0
6600.0	6600.0
9999.0	6600.0

Figure N.54 MinRel=Inflow_up to 6600 Rule at Millers Ferry

M. Mitchell

The Flow-thru operation set was used in the Baseline alternative at Mitchell. The project contains four zones. The zones include Top of Dam, Conservation, Operating Inactive, and Inactive. None of the zones contain any rules. The rule set for the Flow-thru operation set for Mitchell is shown in Figure N.55.

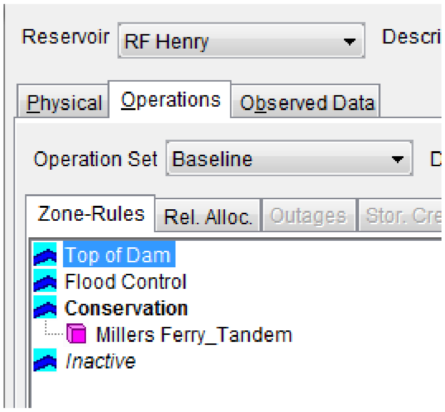

Reservoir: Mitchell

Operation Set: Flow-thru

Figure N.55 Rule Set for Mitchell Flow-thru Operation Set

N. RF Henry

The Baseline operation set was used in the Baseline alternative at RF Henry. The project contains four zones. The zones include Top of Dam, Flood Control, Conservation, and Inactive. The Top of Dam, Flood Control, and Inactive zones contain no rules. The rule set for the Baseline operation set for RF Henry is shown in Figure N.56.



Reservoir RF Henry

Operation Set Baseline

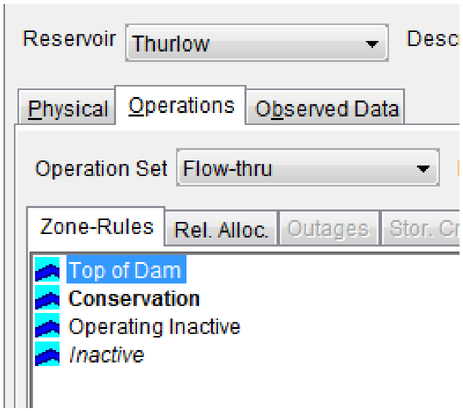
Figure N.56 Rule Set for RF Henry Baseline Operation Set

1. *Millers Ferry_Tandem*

When RF Henry is in Conservation, it operates in tandem with the downstream project, Millers Ferry.

O. Thurlow

The Flow-thru operation set was used in the Baseline alternative at Mitchell. The project contains four zones. The zones include Top of Dam, Conservation, Operating Inactive, and Inactive. None of the zones contain any rules. The rule set for the Flow-thru operation set for Thurlow is shown in Figure N.57.



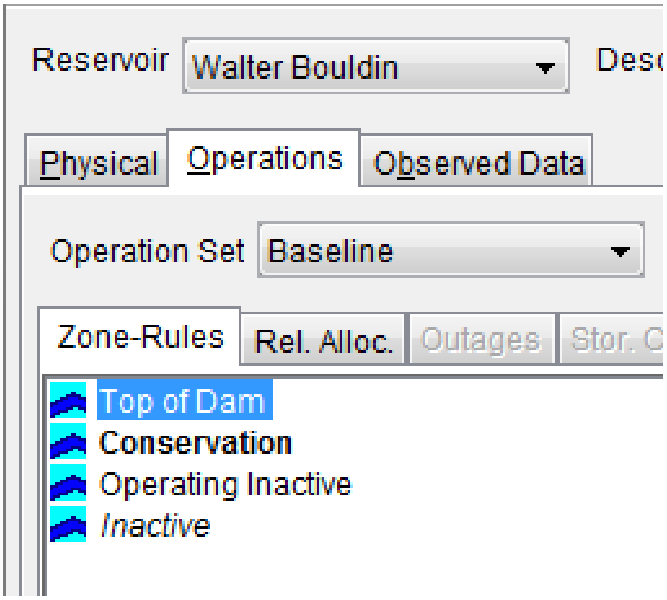
Reservoir Thurlow

Operation Set Flow-thru

Figure N.57 Rule Set for Thurlow Flow-thru Operation Set

P. Walter Bouldin

The Baseline operation set was used in the Baseline alternative at Walter Bouldin. The project contains four zones. The zones include Top of Dam, Conservation, Operating Inactive, and Inactive. None of the zones contain any rules. The rule set for the Baseline operation set for Walter Bouldin is shown in Figure N.58.

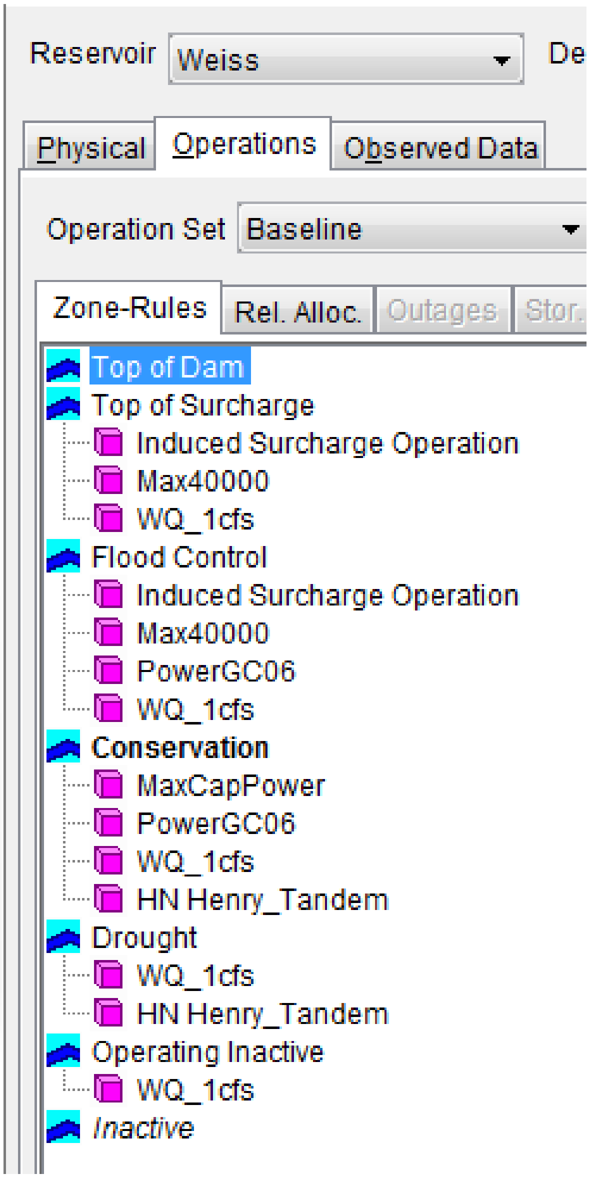

Reservoir Walter Bouldin

Operation Set Baseline

Figure N.58 Rule Set for Walter Bouldin Baseline Operation Set

Q. Weiss

The Baseline operation set was used in the Baseline alternative at Weiss. The project contains seven zones. The zones include Top of Dam, Top of Surcharge, Flood Control, Conservation, Drought, Operating Inactive, and Inactive. The rule set for the Baseline operation set for Weiss is shown in Figure N.59.



Reservoir Weiss

Operation Set Baseline

- Top of Dam
- Top of Surcharge
  - Induced Surcharge Operation
  - Max40000
  - WQ_1cfs
- Flood Control
  - Induced Surcharge Operation
  - Max40000
  - PowerGC06
  - WQ_1cfs
- **Conservation**
  - MaxCapPower
  - PowerGC06
  - WQ_1cfs
  - HN Henry_Tandem
- Drought
  - WQ_1cfs
  - HN Henry_Tandem
- Operating Inactive
  - WQ_1cfs
- *Inactive*

Figure N.59 Rule Set for Weiss Baseline Operation Set

1. Induced Surcharge Operation

This rule is applied in Top of Surcharge and Flood Control. It uses the induced surcharge envelope curve which specifies the minimum required release for a given elevation. The time of recession is 96 hrs. The time for pool decrease is 24 hrs meaning that the pool has to be falling for 24 hrs for the operation to transition from the induced surcharge function to the falling pool option. The falling pool option is to maintain the peak gate openings until the falling pool transition elevation of 564.0 ft is reached. The induced surcharge envelope curve is shown in Figure N.60.

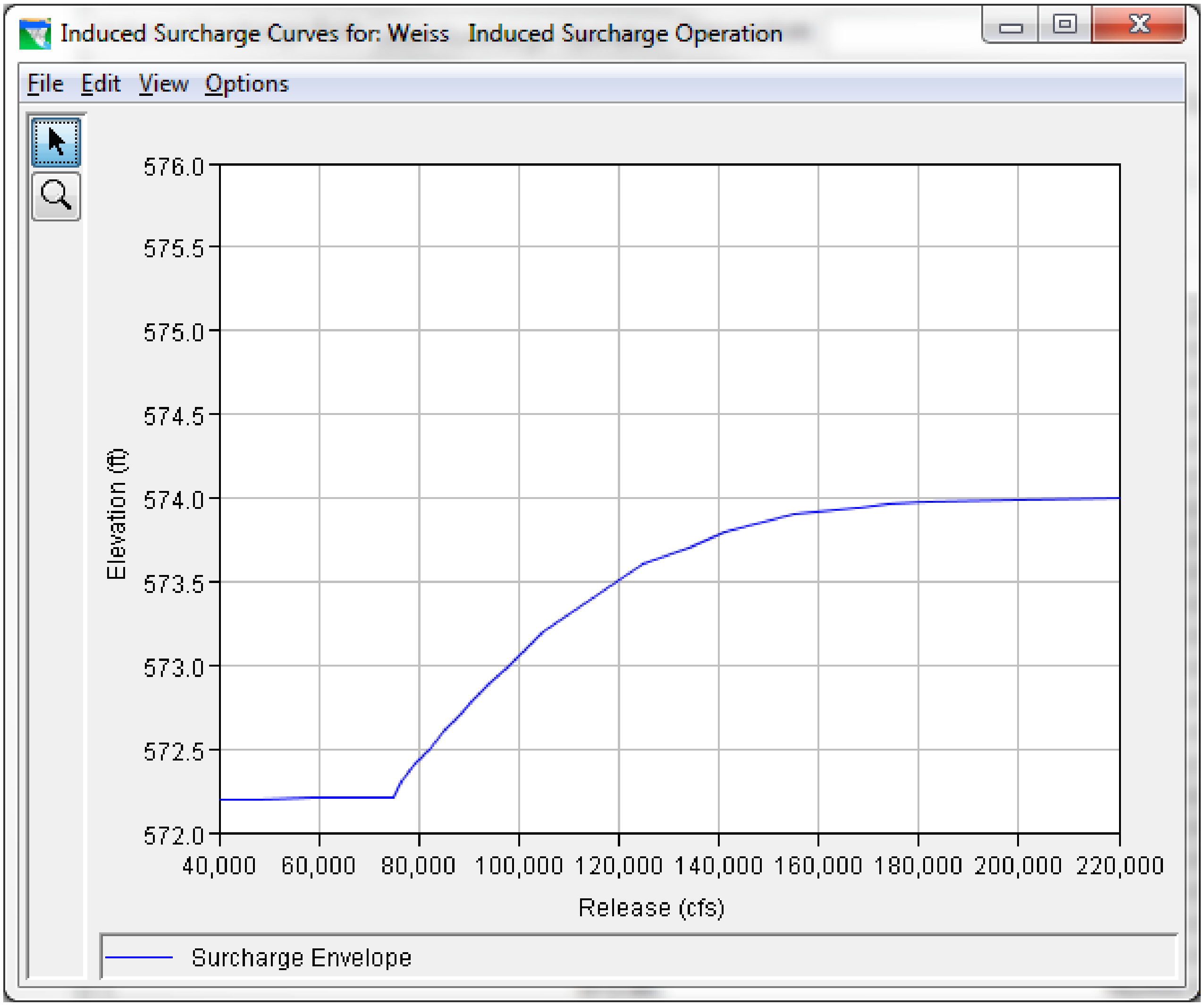
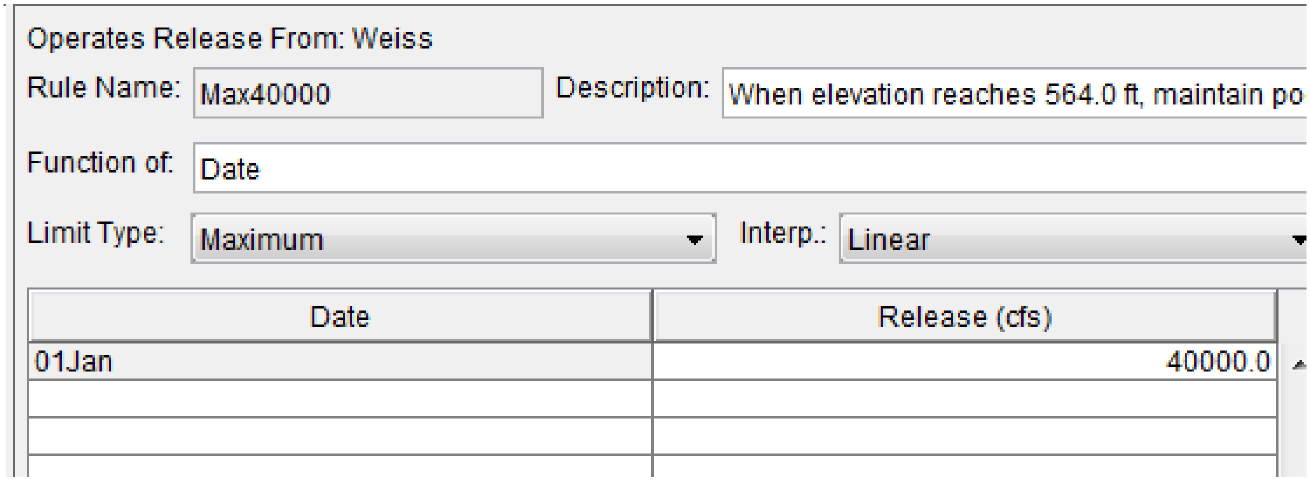


Figure N.60 Induced Surcharge Envelope Curve for Weiss

2. Max40000

This rule is applied in Top of Surcharge and Flood Control. It sets the maximum release from Weiss to 40,000 cfs throughout the entire year. The rule is shown in Figure N.61.



Operates Release From: Weiss

Rule Name: Max40000

Description: When elevation reaches 564.0 ft, maintain po

Function of: Date

Limit Type: Maximum

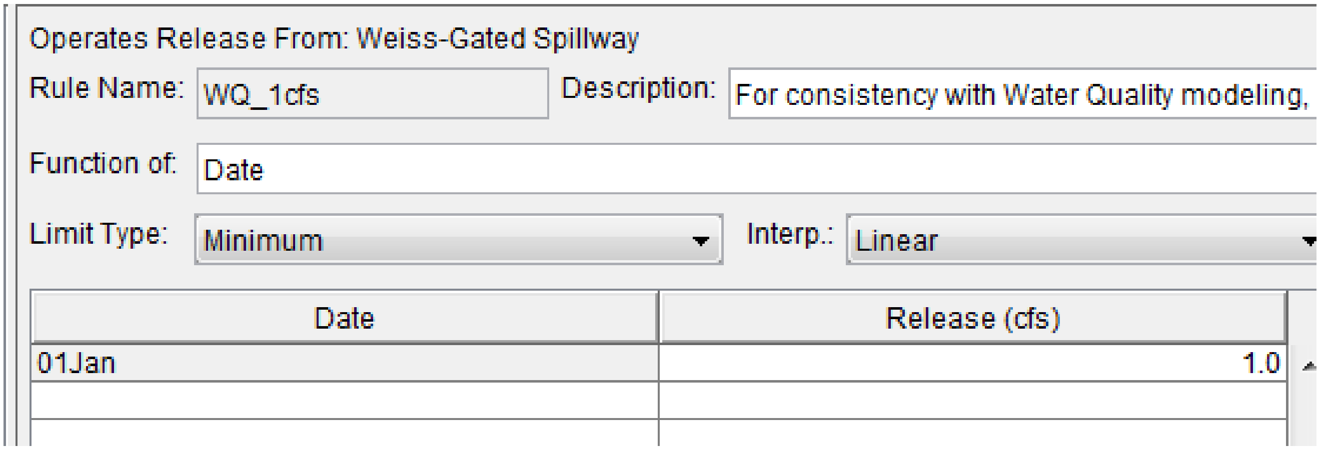
Interp.: Linear

Date	Release (cfs)
01Jan	40000.0

Figure N.61 Max40000 Rule at Weiss

3. WQ_1cfs

This rule is applied in Top of Surcharge, Flood Control, Conservation, Drought, and Operating Inactive. It sets the minimum release from the spillway at Weiss to 1 cfs throughout the entire year. The rule is shown in Figure N.62.



Operates Release From: Weiss-Gated Spillway

Rule Name: WQ_1cfs

Description: For consistency with Water Quality modeling,

Function of: Date

Limit Type: Minimum

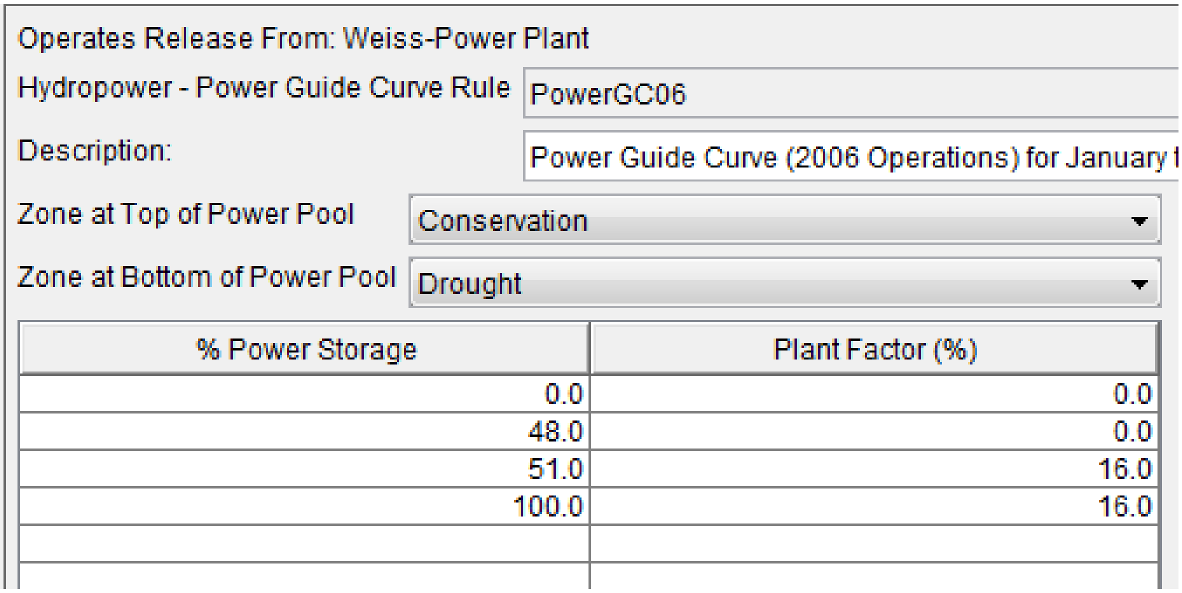
Interp.: Linear

Date	Release (cfs)
01Jan	1.0

Figure N.62 WQ_1cfs Rule at Weiss

4. PowerGC06

This rule is applied in Flood Control and Conservation. It sets the plant factor at either 0% or 16% depending on the % Power Storage in use. The power storage is from top of Conservation to top of Drought. From 0% to 48% of power storage in use, the plant factor is 0% (equivalent to 0 hours of generation). From 51% to 100% of power storage in use, the plant factor is 16% (equivalent to 3.84 hours of generation). The plant factor increases linearly from 0% to 16% as the power storage in use transitions from 48% to 51%. This required power generation is for weekdays only. The power generation rule is shown in Figure N.63.



Operates Release From: Weiss-Power Plant

Hydropower - Power Guide Curve Rule: PowerGC06

Description: Power Guide Curve (2006 Operations) for January t

Zone at Top of Power Pool: Conservation

Zone at Bottom of Power Pool: Drought

% Power Storage	Plant Factor (%)
0.0	0.0
48.0	0.0
51.0	16.0
100.0	16.0

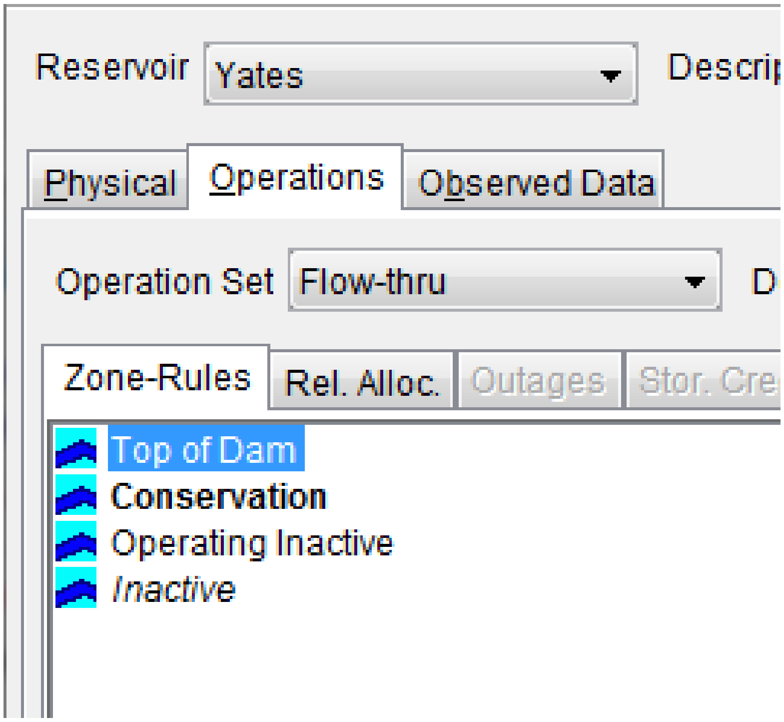
Figure N.63 Power Generation Rule at Weiss

5. HN Henry_Tandem

When Weiss is in Conservation or Drought, it is operated in tandem with the downstream project, HN Henry.

R. Yates

The Flow-thru operation set was used in the Baseline alternative at Yates. The project contains four zones. The zones include Top of Dam, Conservation, Operating Inactive, and Inactive. None of the zones contain rules. The rule set for the Flow-thru operation set for Yates is shown in Figure N.64.



Reservoir Yates

Operation Set Flow-thru

Top of Dam
Conservation
Operating Inactive
Inactive

Figure N.64 Rule Set for Yates Flow-thru Operation Set

III. DroughtPln Alternative

Table N.06 shows the operation sets used in the DroughtPln alternative.

Table N.06 Operation Sets Used in DroughtPln Alternative

Project	Operation Set	Described Previously
Allatoona	Baseline	Yes
Carters	Baseline	Yes
Carters ReReg	Baseline	Yes
Claiborne	Flow-thru	Yes
HN Henry	**Winter Pool 507**	No
Harris	Baseline	Yes
Jordan	**Drought**	No
Jordan Lake Losses	Flow-thru	Yes
Lay	Flow-thru	Yes
Logan Martin	**Nav_Drought**	No
Martin	**Nav_Drought**	No
Millers Ferry	**Nav_Drought**	No
Mitchell	Flow-thru	Yes
RF Henry	Baseline	Yes
Thurlow	Flow-thru	Yes
Walter Bouldin	Baseline	Yes
Weiss	Baseline	Yes
Yates	Flow-thru	Yes

In the **DroughtPln** alternative, *five projects* have an operation set that is *different from the Baseline* alternative. These projects are *HN Henry, Jordan, Logan Martin, Martin,* and *Millers Ferry*. The differences in the operation sets are discussed in the following sections.

A. HN Henry

The Winter Pool 507 operation set is used for the DroughtPln alternative. The rule set is the same as in the Baseline alternative, however, the elevations assigned to the top of Conservation and top of Drought are different. Throughout the entire year, the elevation for top of Conservation and top of Drought are either the same or greater in the Winter Pool 507 operation set. The zone elevation values for Baseline and DroughtPln are shown in Table N.07.

Table N.07 Zone Elevation Values for Top of Conservation and Top of Drought for Baseline and Winter Pool 507 Operation Sets

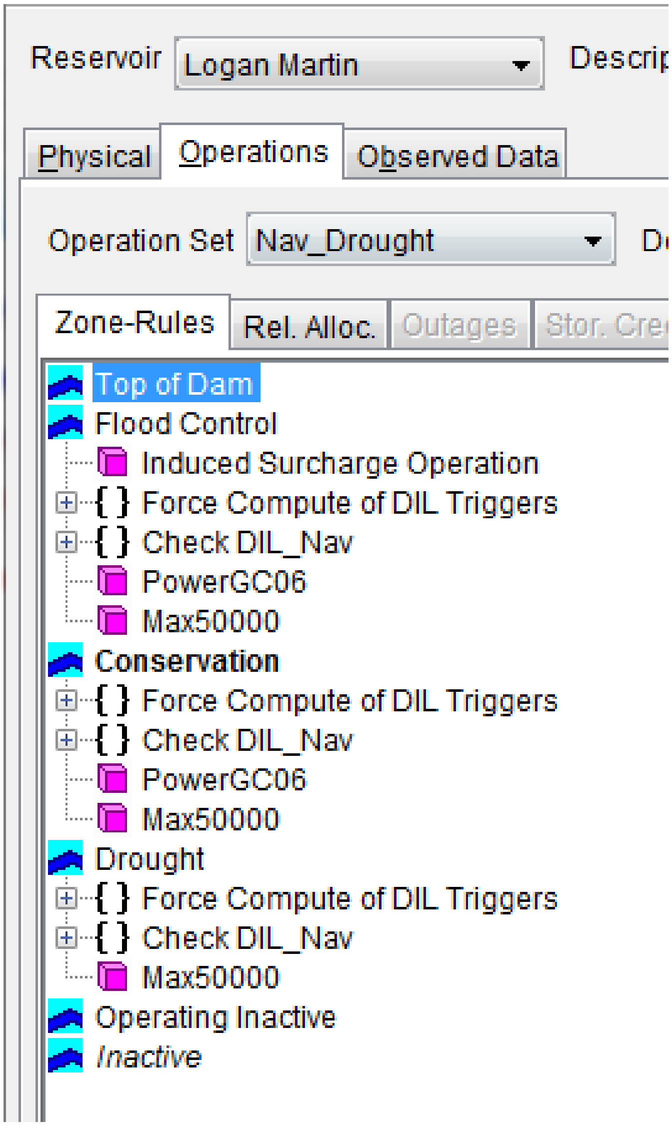
Top of Conservation Elevation (ft)			
Baseline Operation Set		**Winter Pool 507 Operations Set**	
01 Jan	505.0	01 Jan	507.0
01Apr	505.0	01Apr	507.0
01May	508.0	01May	508.0
01Oct	508.0	01Oct	508.0
01Dec	505.0	01Dec	507.0
Top of Drought Elevation (ft)			
Baseline Operation Set		**Winter Pool 507 Operation Set**	
01Jan	504.0	01Jan	505.0
17Apr	504.0	17Apr	505.52
30Apr	505.03	30Apr	505.95
31May	506.96	31May	506.96
30Jun	505.7	30Jun	506.68
31Jul	504.32	31Jul	506.34
07Aug	504.0	07Aug	506.27
31Dec	504.0	31Dec	505.0

B. Jordan

For the DroughtPln alternative, the operation set used at Jordan is the Drought operation set. The only difference between this operation set and the Baseline operation set is that the diversions into Bouldin are made only when the Drought Intensity Level = 0. The Drought Intensity Level is described in greater detail in the Logan Martin section below. The relationship of Jordan inflow and pool elevation with minimum required release into the Jordan-Bouldin canal remains the same.

C. Logan Martin

The DroughtPln alternative uses the same zones as the Baseline alternative. The elevations of these zones are also the same. The Induced Surcharge Operation, PowerGC06, and Max50000 rules remain the same as the Baseline alternative and are applied in the same zones as the Baseline alternative. The difference in this alternative is the application of the minimum flow rules at JBT Goal and at J.D. Minimum. The application of these rules is dependent on the Drought Intensity Level (DIL) and the Basin Inflow State. The rule set for the Nav_Drought operation set for Logan Martin is shown in Figure N.65.



Reservoir: Logan Martin

Operation Set: Nav_Drought

- Top of Dam
- Flood Control
  - Induced Surcharge Operation
  - { } Force Compute of DIL Triggers
  - { } Check DIL_Nav
  - PowerGC06
  - Max50000
- Conservation
  - { } Force Compute of DIL Triggers
  - { } Check DIL_Nav
  - PowerGC06
  - Max50000
- Drought
  - { } Force Compute of DIL Triggers
  - { } Check DIL_Nav
  - Max50000
- Operating Inactive
- *Inactive*

Figure N.65 Rule Set for Logan Martin Nav_Drought Operation Set

1. Force Compute of DIL Triggers

This logical statement is applied in Flood Control, Conservation, and Drought. It is used to determine if the system is operating in drought or normal conditions. The DLR uses multiple drought indicators to describe the onset, magnitude, duration, severity and extent of a drought (also known as the Drought Intensity Level (DIL)). Observations of precipitation and stream flow stations are used to indicate when the ACT is entering into (or recovering from) a “Low State”. Low States are defined as:

Low Basin Inflow- Inflow into the basin is less than the total needed for navigation and to fill APC’s reservoirs

Low State Line Flow- A flow at or below the local 7Q10 observed flows for Coosa River Rome, Georgia as measured near the Alabama/Georgia state line .

Low Composite Storage- Alabama Power Company project composite storage equal to or less than drought contingency elevation/volumes

The “Force Compute of DIL Triggers” rule does not set any releases from Logan Martin. If all of the three state variables associated with the rule are equal to 1, then all of the “low states” have been triggered. Force Compute of DIL Triggers rule has a dummy minimum release of 0 cfs.

2. Check DIL_Nav

This logical statement is used in Flood Control, Conservation, and Drought. If none of the three low states are triggered, then the DIL is set to zero. This is determined by the state variable, “DLR_Drought_Intensity_Level”. If the DIL=0, then the minimum flow at JBT Goal is determined by the value of the state variable, “NAV_CheckBI”. The state variable, “NAV_CheckBI”, computes the basin inflow and assigns a value of 0 if the conditions are considered normal, a value of 1 if the conditions are low, and a value of 2 if the conditions are very low.

The minimum flow amounts at JBT Goal for the three values of “NAV_CheckBI” are given in Table N.08.

Table N.08 Minimum Flow (cfs) at JBT Goal for DIL=0

NAV_CheckBI=0 (normal basin inflow)		NAV_CheckBI=1 (low basin inflow)		NAV_CheckBI=2 (very low basin inflow)	
01Jan	9,280	01Jan	7,960	01Jan	4,640
01May	8,880	01May	7,792	01May	4,640
01Jun	8,480	01Jun	7,624	01Jun	4,640
01Jul	8,080	01Jul	7,456	01Jul	4,640
01Aug	7,680	01Aug	7,288	01Aug	4,640
01Sep	7,280	01Sep	7,120	01Sep	4,640
01Nov	9,280	01Nov	7,960	01Nov	4,640

For values of DIL = 1, 2, and 3, the minimum flow values at JBT and J.D. Minimum are given in Table N.09 and Table N.10.

Table N.09 Minimum Flow (cfs) at JBT Goal for DIL= 1, 2, and 3

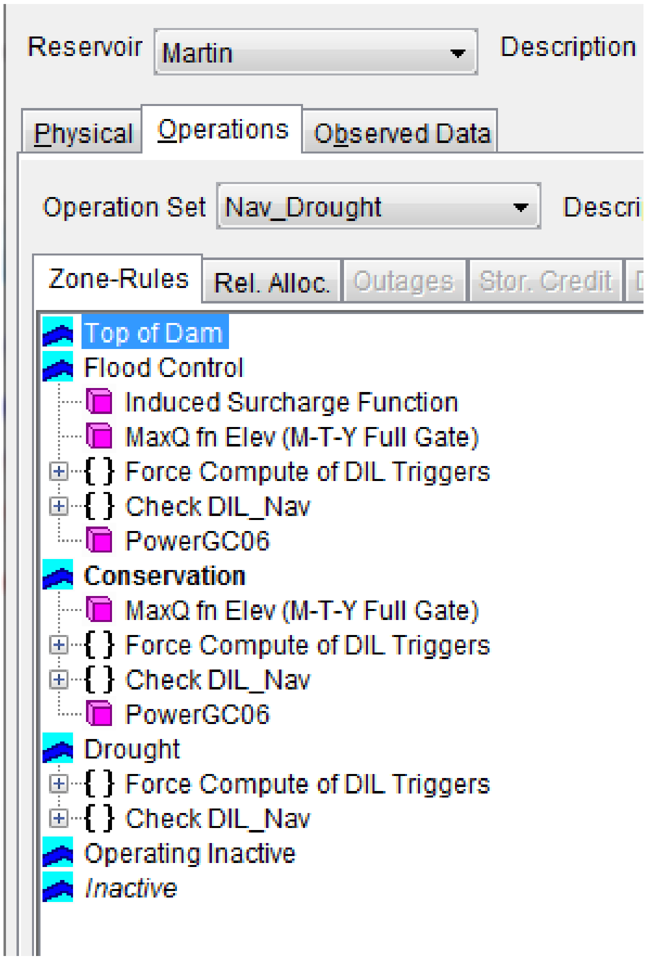
DIL=1 (1 drought level triggered)		DIL=2 (2drought levels triggered)		DIL=3 (3 drought levels triggered)	
01Jan	4,200	01Jan	3,900	01Jan	2,000
30Apr	4,200	30Apr	3,900	30Apr	2,000
01May	4,640	01May	4,200	01May	3,900
30Sep	4,640	30Sep	4,200	30Jun	3,900
07Oct	4,200	07Oct	3,900	01Jul	4,200
				30Sep	4,200
				31Oct	2,000

Table N.10 Minimum Flow (cfs) at J.D. Minimum for DIL = 1, 2, and 3

DIL=1 (1 drought level triggered)		DIL=2 (2drought levels triggered)		DIL=3 (3 drought levels triggered)	
01Jan	2,000	01Jan	1,800	01Jan	1,600
31Mar	2,000	31Mar	1,800	31Mar	1,600
01Apr	4,000	01Apr	3,000	01Apr	1,800
31May	4,000	31May	3,000	30Jun	1,800
15Jun	4,000	15Jun	3,000	01Jul	2,000
01Jul	2,000	01Jul	2,000	30Sep	2,000
31Dec	2,000	30Sep	2,000	01Oct	1,600
		01Oct	1,800	31Dec	1,600
		31Dec	1,800		

D. Martin

The DroughtPln alternative uses the same zones as the Baseline alternative. The elevations of these zones are also the same. The Induced Surcharge Operation, PowerGC06, and MaxQ fn Elev (M-T-Y Full Gate) rules remain the same as the Baseline alternative and are applied in the same zones as the Baseline alternative. The difference in this alternative is that the Min@JBTGoal_4640 and Seasonal Min Q rules are no longer in the rule set, and the Force Compute of DIL Triggers and Check DIL_Nav rules now appear. The rule set for the DroughtPln alternative is shown in Figure N.66.



Reservoir: Martin

Operation Set: Nav_Drought

- Top of Dam
- Flood Control
  - Induced Surcharge Function
  - MaxQ fn Elev (M-T-Y Full Gate)
  - { } Force Compute of DIL Triggers
  - { } Check DIL_Nav
  - PowerGC06
- Conservation
  - MaxQ fn Elev (M-T-Y Full Gate)
  - { } Force Compute of DIL Triggers
  - { } Check DIL_Nav
  - PowerGC06
- Drought
  - { } Force Compute of DIL Triggers
  - { } Check DIL_Nav
- Operating Inactive
- *Inactive*

Figure N.66 Rule Set for Martin Nav_Drought Operation Set

1. *Force Compute of DIL Triggers*

This rule is the same as previously described for Logan Martin. It is applied in Flood Control, Conservation, and Drought.

2. *Check DIL_Nav*

This logical statement is applied in Flood Control, Conservation, and Drought.

For values of DIL = 0, the minimum flows at JBT Goal are the same as the values previously shown in Table N.08.

For value of DIL = 1, 2, or 3, the minimum flows at JBT Goal are the same as the values previously shown in Table N.09.

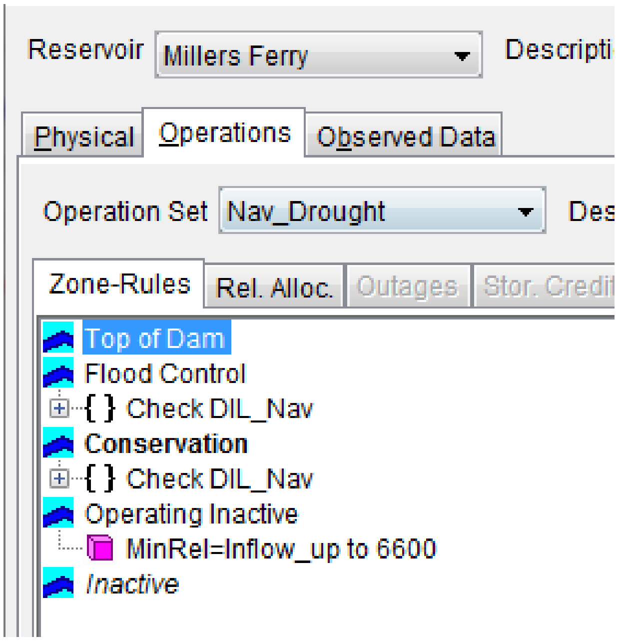
For DIL=1, the minimum flow at Tallassee from January through April is set equal to the current value of the state variable, "DLR_minFlow_fn_Heflin_Yates". This state variable is computed to be the maximum value of either one-half of the inflow in Yates, twice the flow at the Heflin gage, or 350 cfs. The value of the state variable is capped at 1,200 cfs. From May through December, the minimum flow at Tallassee is set equal to the value of the state variable, "DLR_Half_Yates_Inflow". The value of the state variable is computed to be one-half of the Yates inflow limited to the range of 350 cfs to 1200 cfs.

For DIL=2 , the minimum flow at Tallassee from October through April is set to 350 cfs. From May through September, the minimum flow at Tallassee is set equal to the state variable, "DLR_Half_Yates_Inflow".

For DIL=3, the minimum flow at Tallassee is set to 350 cfs throughout the entire year.

E. Millers Ferry

The DroughtPln alternative uses the same zones as the Baseline alternative. The elevations of these zones are also the same. The MinRel-Inflow_up to 6600 rule in the Operating Inactive zone remains the same. The difference in this alternative is that the Min@Claiborne_6600 (fn of JBT Goal) rule has been replaced by the Check DIL_Nav rule in Flood Control and Conservation. The rule set for the DroughtPln alternative is shown in Figure N.67.



Reservoir Millers Ferry

Operation Set Nav_Drought

- Top of Dam
- Flood Control
  - { } Check DIL_Nav
- Conservation
  - { } Check DIL_Nav
- Operating Inactive
  - MinRel=Inflow_up to 6600
- *Inactive*

Figure N.67 Rule Set for Millers Ferry Nav_Drought Operation Set

1. Check DIL_Nav

If the DIL = 0, the minimum flow at Claiborne is determined by the state variable NAV_CheckBI and the flow at JBT Goal. For values of NAV_CheckBI = 0 or 1, the minimum flow at Claiborne is given in Table N.11. When NAV_CheckBI = 2, meaning that the basin inflow is very low, the minimum flow at Claiborne is determined by the flow at JBT Goal. When the flow at JBT Goal is greater than or equal to 4,630 cfs, the minimum flow at Claiborne is 6,600 cfs. When the flow at JBT Goal is less than 4,630 cfs, the minimum flow at Claiborne is equal to the current value of the inflow in Millers Ferry.

Table N.11 Minimum Flow at Claiborne (cfs) when DIL=0

NAV_CheckBI=0 (normal basin inflow)		NAV_CheckBI=1 (low basin inflow)	
01Jan	11,600	01Jan	9,950
01Feb	11,600	01Feb	9,950
01Mar	11,600	01Mar	9,950
01Apr	11,600	01Apr	9,950
01May	11,100	01May	9,740
01Jun	10,600	01Jun	9,530
01Jul	10,100	01Jul	9,320
01Aug	9,600	01Aug	9,110
01Sep	9,100	01Sep	8,900
01Oct	9,100	01Oct	8,900
01Nov	11,600	01Nov	9,950
01Dec	11,600	01Dec	9,950

IV. Burkett Alternative

Table N.12 shows the operation sets used in the Burkett alternative.

Table N.12 Operation Sets Used in Burkett Alternative

Project	**Operation Set**	**Described Previously**
Allatoona	**Burkett**	No
Carters	**Seasonal**	No
Carters ReReg	**Seasonal**	No
Claiborne	Flow-thru	Yes
HN Henry	Winter Pool 507	Yes
Harris	Baseline	Yes
Jordan	Drought	Yes
Jordan Lake Losses	Flow-thru	Yes
Lay	Flow-thru	Yes
Logan Martin	Nav_Drought	Yes
Martin	Nav_Drought	Yes
Millers Ferry	Nav_Drought	Yes
Mitchell	Flow-thru	Yes
RF Henry	Baseline	Yes
Thurlow	Flow-thru	Yes
Walter Bouldin	Baseline	Yes
Weiss	Baseline	Yes
Yates	Flow-thru	Yes

In the **Burkett** alternative, *three projects* have an operation set that is *different from the DroughtPln alternative*. These projects are *Allatoona*, *Carters,* and *Carters ReReg*. The differences in the operation sets are discussed in the following sections.

A. Allatoona

The Burkett operation set includes two additional sub-zones in the conservation pool that were not present in the Baseline operation set. These zones are Zone3 and Zone4. Zone2 is in both operation sets; however, the elevations are different. The comparison of the zones is given in Table N.13.

Table N.13 Allatoona Zone Comparison for Baseline and Burkett Operation Sets

	Baseline – Zone2	Burkett – Zone2	Burkett – Zone3	Burkett – Zone4
01Jan	820.0	822.99999	822.99998	818.0
15Jan	820.0	823.0	823.0	818.0
01Feb	822.57	825.73	825.73	818.0
01Mar	826.79	830.22	830.22	824.0
01May	836.0	840.0	840.0	831.96
01Jun	836.0	840.0	838.49	836.0
30Jun	836.0	840.0	837.07	828.27
01Jul	835.9	840.0	837.02	828.0
01Sep	830.0	835.38	834.0	824.31
16Nov	822.76	829.71	826.11	819.79
15Dec	820.0	823.22	823.10	818.06
16Dec	820.0	823.0	823.0	818.0
31Dec	820.0	823.0	823.0	818.0

1. *PowerGC FC_6hrs*

In the Baseline operation set, the required power generation in Flood Control was set to 4 hours by setting the plant factor to 16.67%. This was changed to 25% in the Burkett operation set to give 6 hours of required generation. All other rules in Flood Control remained the same.

2. *PowerGC Z1_6hrs*

In the Baseline operation set, the required power generation in Conservation was set between 2 and 4 hours by setting the plant factor between 8.33% and 16.67%. This was changed to 25% in the Burkett operation set to give 6 hours of required generation. All other rules in Conservation remained the same.

3. PowerGC Z2_4hrs

In the Baseline operation set, the required power generation in Zone2 was set between 0 and 1 hour by setting the plant factor between 0% and 4.2%. This was changed to 16.67% in the Burkett operation set to give 4 hours of required generation. All other rules in Zone2 remained the same.

4. PowerGC Z3_2hrs

For the Burkett operation set, the rule set for Zone3 is the same as the rule set for Zone2 with the exception of the power generation rule. The required power generation in Zone3 is set to 2 hours by setting the plant factor to 8.33%.

5. Summary of Differences in Baseline and Burkett Operation Sets

In Zone4, there is no required power generation at Allatoona. The difference between the Baseline operation set and the Burkett operations is the additional sub-zones in the conservation pool along with the refinement of the required power generation in the conservation pool.

B. Carters

The Seasonal operation set has an additional sub-zone in the conservation pool that is not in the Baseline operation set. This sub-zone is titled CompositeZone2. All of the other zones are the same with the same elevations assigned to them.

The Top of Surcharge has the same rules applies in both the Baseline and Seasonal operation sets.

1. MinQ_Seas – TRC

Flood Control, GC Buffer, and Conservation have the same rules applied in Baseline and Seasonal operation set except for the addition of one rule in the Seasonal operation set. This rule is titled MinQ_Seas –TRC. This rule sets the minimum release from Carters equal to the current value of the state variable, “Carters_Seasonal_Min”. This state variable computes the minimum release by subtracting the flow from Talking Rock Creek and 240 cfs from the monthly minimum values of flow below Carters given in Table N.14. Negative values from this computation are set to zero.

Table N.14 Monthly Minimum Flow Values below Carters

Month	Minimum Flow Value below Carters (cfs)
January	660
February	790
March	865
April	770
May	620
June	475
July	400
August	325
September	250
October	275
November	350
December	465

2. Check Composite Zone

The rules in CompositeZone2 are the same as the rules in Conservation with one exception. The application of the MinQ_Seas – TRC rule is dependent on the state variable, “CartersReRegCompositeZone”. This state variable computes the total composite storage of Carters and Carters Rereg. The Rereg storage used in this computation is the amount of storage in use above the Buffer zone and below the Top of Conservation. This amount is added to the total storage in use at Carters. This sum is then compared to the total storage at CompositeZone2 at Carters. If the sum is greater than the CompositeZone2 storage at Carters, the state variable is set to 1 and the MinQ_Seas – TRC rule is activated. If it is not greater than the CompositeZone2 storage at Carters, the state variable is set to 2 and the MinQ_Seas – TRC rule is not activated.

C. Carters ReReg

The Baseline and Seasonal operation sets use the same zones with the same elevation values assigned to the zones.

1. CompositeStorageOps

The rules in Flood Control, Conservation, and Buffer are the same in the Baseline and Seasonal operation sets with the exception of the MinQ_240 rule. This rule has been replaced in the Seasonal operation set with the rule, CompositeStorageOps. In this rule, the state variable "CartersReRegCompositeZone" is used. If this state variable is equal to 1, the minimum release from Carters ReReg is given in Table N.15. If the state variable is equal to 2, the minimum release from Carter ReReg is set to 240 cfs.

Table N.15 Minimum Release from Carters ReReg when "CartersReRegCompositeZone" = 1

Date	Minimum Release (cfs)
01Jan	660
01Feb	790
01Mar	865
01Apr	770
01May	620
01Jun	475
01Jul	400
01Aug	325
01Sep	250
01Oct	275
01Nov	350
01Dec	465

V. DragoA Alternative

Table N.16 shows the operation sets used in the DragoA alternative.

Table N.16 Operation Sets Used in the DragoA Alternative

Project	Operation Set	Described Previously
Allatoona	**DragoA**	No
Carters	Seasonal	Yes
Carters ReReg	Seasonal	Yes
Claiborne	Flow-thru	Yes
HN Henry	Winter Pool 507	Yes
Harris	Baseline	Yes
Jordan	Drought	Yes
Jordan Lake Losses	Flow-thru	Yes
Lay	Flow-thru	Yes
Logan Martin	Nav_Drought	Yes
Martin	Nav_Drought	Yes
Millers Ferry	Nav_Drought	Yes
Mitchell	Flow-thru	Yes
RF Henry	Baseline	Yes
Thurlow	Flow-thru	Yes
Walter Bouldin	Baseline	Yes
Weiss	Baseline	Yes
Yates	Flow-thru	Yes

In the **DragoA** alternative, *one project* has an operation set that is *different from the Burkett alternative*. The project is *Allatoona*. The differences in the operation sets are discussed in the following sections.

A. Allatoona

The Top of Dam, Top of Surcharge, Flood Control, Conservation, and Inactive zones have the same elevations in both Burkett and DragoA. Burkett has an additional sub-zone in the conservation pool that is not in the DragoA alternative. The zone elevations for both alternatives are given in Table N.17.

Table N.17 Allatoona Zone Elevations for Burkett and DragoA Alternatives

Date	Burkett Zone2	DragoA Zone2	Burkett Zone3	DragoA Zone3	Burkett Zone4
01Jan	822.99999	820.0	822.99998	818.0	818.0
15Jan	823.0	820.0	823.0	818.0	818.0
01Feb	825.73	822.57	825.73	818.0	818.0
01Mar	830.22	826.79	830.22	824.0	824.0
01May	840.0	836.0	840.0	832.0	831.96
01Jun	840.0	836.0	838.49	829.97	836.0
01Jul	840.0	836.0	837.02	828.0	828.0
01Sep	835.38	830.1	834.0	828.0	824.31
16Nov	829.71	822.86	826.11	820.83	819.79
16Dec	823.0	820.0	823.0	818.0	818.0
31Dec	823.0	820.0	823.0	818.0	818.0

1. *PowerGC Z1_2-4hrs*

In the Burkett operation set, the required power generation in Conservation was set to 6 hours by setting the plant factor to 25%. This was changed to between 8.33% and 16.67% in the DragoA operation set to give between 2 and 4 hours of required generation depending on the % Power Storage. These generation amounts are seasonal being reduced by a factor of 0.5 in February, by 0.45 in April and May, and by 0.85 in June. They are increased by a factor of 1.3 in October. All other rules in Conservation remained the same.

2. *PowerGC Z1_0-2hrs*

In the Burkett operation set, the required power generation in Zone2 was set to 4 hours by setting the plant factor to 16.67%. This was changed to between 0.0% and 8.33% in the DragoA operation set to give between 0 and 2 hours of required generation depending on the % Power Storage. All other rules in Zone2 remained the same.

3. Summary of Differences in Burkett and DragoA Operation Sets

The Burkett operation set contained four sub-zones in the conservation pool while the DragoA operation set contains only three. The differences in the rule sets involve the required power generation rules. The power generation requirements were reduced in the DragoA operation set. The power generation for Conservation and Zone2 was discussed above. For Zone3, there is no power generation requirement in the DragoA operation set. In the Burkett operation set, the power generation requirement was for 2 hours in Zone3. There is no power generation requirement in Zone4 of the Burkett operation set. Zone4 does not exist in the DragoA operation set.

VI. DragoB Alternative

Table N.18 shows the operation sets used in the DragoB alternative.

Table N.18 Operation Sets Used in the DragoB Alternative

Project	Operation Set	Described Previously
Allatoona	**DragoB**	No
Carters	Seasonal	Yes
Carters ReReg	Seasonal	Yes
Claiborne	Flow-thru	Yes
HN Henry	Winter Pool 507	Yes
Harris	Baseline	Yes
Jordan	Drought	Yes
Jordan Lake Losses	Flow-thru	Yes
Lay	Flow-thru	Yes
Logan Martin	Nav_Drought	Yes
Martin	Nav_Drought	Yes
Millers Ferry	Nav_Drought	Yes
Mitchell	Flow-thru	Yes
RF Henry	Baseline	Yes
Thurlow	Flow-thru	Yes
Walter Bouldin	Baseline	Yes
Weiss	Baseline	Yes
Yates	Flow-thru	Yes

In the **DragoB** alternative, *one project* has an operation set that is *different from the DragoA alternative*. The project is *Allatoona*. The differences in the operation sets are discussed in the following sections.

A. Allatoona

The DragoA and DragoB operation sets use the same zones, and the elevations are the same for all of the zones *except for Zone3*. The comparison of elevations for Zone3 are shown in Table N.19.

Table N.19 Comparison of Zone Elevations for DragoA and DragoB Operation Sets

Date	DragoA Zone3 Elevation	DragoB Zone3 Elevation
01Jan	818.0	818.0
01Feb	818.0	818.0
01Mar	*824.0*	*822.4*
01May	832.0	832.0
01Jul	*828.0*	*828.27*
01Sep	*828.0*	*824.48*
16Dec	818.0	818.0

The rule sets are identical for DragoA and DragoB.

VII. RPlanA Alternative

Table N.20 shows the operation sets used in the RPlanA alternative.

Table N.20 Operation Sets Used in the RPlanA Alternative

Project	Operation Set	Described Previously
Allatoona	**Burkett B**	No
Carters	Seasonal	Yes
Carters ReReg	Seasonal	Yes
Claiborne	Flow-thru	Yes
HN Henry	Winter Pool 507	Yes
Harris	Baseline	Yes
Jordan	Drought	Yes
Jordan Lake Losses	Flow-thru	Yes
Lay	Flow-thru	Yes
Logan Martin	Nav_Drought	Yes
Martin	Nav_Drought	Yes
Millers Ferry	Nav_Drought	Yes
Mitchell	Flow-thru	Yes
RF Henry	Baseline	Yes
Thurlow	Flow-thru	Yes
Walter Bouldin	Baseline	Yes
Weiss	Baseline	Yes
Yates	Flow-thru	Yes

In the **RPlanA** alternative, *one project* has an operation set that is *different from the DragoB alternative*. The project is *Allatoona*. The differences in the operation sets are discussed in the following sections.

A. Allatoona

The Burkett B operation set has four sub-zones in the conservation pool while the DragoB operation set has only three sub-zones. The elevations for Conservation match for both operation sets, but differ in Zone2 and Zone3. Burkett B has a Zone4 while DragoB does not.

The zones and elevations for Burkett B operation set matches the zones and elevations for the Burkett operation set previously used in the Burkett alternative. The comparison of Zone2 and Zone3 for Burkett B and DragoB is given in Table N.21.

Table N.21 Comparison on Zones and Elevations for Burkett B and DragoB

Date	Burkett B Zone2	DragoB Zone2	Burkett B Zone3	DragoB Zone3	Burkett B Zone4
01Jan	822.99999	820.0	822.99998	818.0	818.0
15Jan	823.0	820.0	823.0	818.0	818.0
01Feb	825.73	822.57	825.73	818.0	818.0
01Mar	830.22	826.79	830.22	822.4	824.0
01May	840.0	836.0	840.0	832.0	831.96
01Jun	840.0	836.0	838.49	830.10	836.0
01Jul	840.0	836.0	837.02	828.27	828.0
01Sep	835.38	830.10	834.0	824.48	824.31
16Nov	829.71	822.86	826.11	819.83	819.79
16Dec	823.0	820.0	823.0	818.0	818.0

1. *PowerGC FC_4hrs*

In the DragoB operation set, the required power generation in Flood Control was set to 6 hours by setting the plant factor to 25%. This was changed to 16.67% in the Burkett B operation set to give 4 hours of required generation. All other rules in Flood Control remained the same. The Burkett B operation set also differs from the Burkett operation set. The Burkett operation set has a plant factor of 25% in Flood Control. The other rules in Flood Control were the same for Burkett and Burkett B.

2. *PowerGC Z1_4hrs*

In the DragoB operation set, the required power generation in Conservation was set between 2 and 4 hours by setting the plant factor between 8.33% and 16.67%. This was changed to 16.67% in the Burkett B operation set to give 4 hours of required generation. All other rules in Conservation remained the same. The Burkett B operation set also differs from the Burkett operation set. The Burkett operation set has a plant factor of 25% in Conservation. The other rules in Conservation were the same for Burkett and Burkett B.

3. *PowerGC Z2_3hrs*

In the DragoB operation set, the required power generation in Zone2 was set between 0 and 2 hours by setting the plant factor between 0.0% and 8.33%. This was changed to 12.5% in the Burkett B operation set to give 3 hours of required generation. All other rules in Zone2 remained the same. The Burkett B operation set also differs from the Burkett operation set. The Burkett operation set has a plant factor of 16.67% in Zone2. The other rules in Zone2 were the same for Burkett and Burkett B.

4. *PowerGC Z3_0-2hrs*

In the DragoB operation set, there is no required power generation in Zone3. The Burkett B operation set has required power generation between 0 and 2 hours with a plant factor between 0% and 8.33%. All other rules in Zone3 remained the same. The Burkett B operation set also differs from the Burkett operation set. The Burkett operation set has required power generation set to 2 hours with a plant factor of 8.33%. The other rules in Zone3 were the same for Burkett and Burkett B.

5. *Summary of Differences in Burkett B, DragoB, and Burkett Operation Sets*

The Burkett B and Burkett operation sets contained four sub-zones in the conservation pool while the DragoB operation set contained only three. The differences in the rule set involved the required power generation rules. Required generation for the Burkett B, DragoB, and Burkett operation set are summarized in Table N.22.

Table N.22 Summary of Required Power Generation for Burkett B, DragoB, and Burkett Operation Sets

Zones	Burkett B Generation	DragoB Generation	Burkett Generation
Flood Control	4 hours	6 hours	6 hours
Conservation	4 hours	2 to 4 hours	6 hours
Zone2	3 hours	0 to 2 hours	4 hours
Zone3	0 to 2 hours	No req’d generation	2 hours
Zone4	No req’d generation	*No Zone4*	No req’d generation

VIII. RPlanB Alternative

Table N.23 shows the operation sets used in the RPlanB alternative.

Table N.23 Operation Sets Used in the RPlanB Alternative

Project	Operation Set	Described Previously
Allatoona	Burkett B	Yes
Carters	Seasonal	Yes
Carters ReReg	Seasonal	Yes
Claiborne	Flow-thru	Yes
HN Henry	Winter Pool 507	Yes
Harris	Baseline	Yes
Jordan	Drought	Yes
Jordan Lake Losses	Flow-thru	Yes
Lay	Flow-thru	Yes
Logan Martin	**Nav_Drought_Snail**	No
Martin	Nav_Drought	Yes
Millers Ferry	Nav_Drought	Yes
Mitchell	Flow-thru	Yes
RF Henry	Baseline	Yes
Thurlow	Flow-thru	Yes
Walter Bouldin	Baseline	Yes
Weiss	Baseline	Yes
Yates	Flow-thru	Yes

In the **RPlanB** alternative, *one project* has an operation set that is *different from the RPlanA alternative*. The project is *Logan Martin*. The differences in the operation sets are discussed in the following sections.

A. Logan Martin

The zones that are defined in the Nav_Drought_Snail operation set for Logan Martin are the same zones with the same elevations found in the Nav_Drought operation set.

1. Check DIL_Nav (Snail)

This rule is applied in Flood Control, Conservation, and Drought and has a slight variation from the Check DIL_Nav rule applied in the same zones in the Nav_Drought operation set. The variation is in the minimum flow at J.D. Minimum for DIL=2 and DIL=3. The differences are given in Table N.24. The remaining rules are the same between the two operation sets.

Table N.24 Minimum Flow at J.D. Minimum for Nav_Drought and Nav_Drought_Snail Operation Sets

Date	**DIL=2 Nav_Drought Operation Set**	**DIL=2 Nav_Drought_Snail Operation Set**	**DIL=3 Nav_Drought Operation Set**	**DIL=3 Nav_Drought_Snail Operation Set**
01Jan	1800	1800	1600	1600
31Mar	1800	1800	1600	1600
01Apr	3000	2500	1800	1800
31May	3000	2500	1800	1800
15Jun	3000	2500	1800	1800
30Jun	2062.5	2031.25	1800	1800
01Jul	2000	2000	2000	2000
30Sep	2000	2000	2000	2000
01Oct	1800	1800	1600	1800
30Nov	1800	1800	1600	1800
01Dec	1800	1800	1600	1600
31Dec	1800	1800	1600	1600

IX. RPlanC Alternative

Table N.25 shows the operation sets used in the RPlanC alternative.

Table N.25 Operation Sets Used in the RPlanC Alternative

Project	**Operation Set**	**Described Previously**
Allatoona	Burkett B	Yes
Carters	Seasonal	Yes
Carters ReReg	Seasonal	Yes
Claiborne	Flow-thru	Yes
HN Henry	Winter Pool 507	Yes
Harris	Baseline	Yes
Jordan	**Drought-rev**	No
Jordan Lake Losses	Flow-thru	Yes
Lay	Flow-thru	Yes
Logan Martin	**Nav_Drought-rev**	No
Martin	**Nav_Drought-rev**	No
Millers Ferry	**Nav_Drought-rev**	No
Mitchell	Flow-thru	Yes
RF Henry	Baseline	Yes
Thurlow	Flow-thru	Yes
Walter Bouldin	Baseline	Yes
Weiss	Baseline	Yes
Yates	Flow-thru	Yes

In the **RPlanC** alternative, *four projects* have an operation set that is *different from the RPlanB alternative*. The projects that changed are *Jordan, Logan Martin, Martin,* and *Millers Ferry*. The differences in the operation sets are discussed in the following sections.

A. Jordan

The zones used in the Drought and Drought-Rev operation sets are the same and use the same elevations.

1. Check DIL –rev

In the Drought operation set, the diversion to Bouldin occurred when the state variable "DLR_Drought_Intensity_Level" was equal to zero. In the Drought–rev operation set, the same amounts are diverted to Bouldin when a different state variable, "DLR_Drought_Intensity_Level_rev", was equal to zero. The difference in the two state variables is the monthly values used to determine whether or not the Low State Line Q criteria has been triggered. These monthly values are shown in Table N.26.

Table N.26 Flows at Rome_Coosa Used for Determining Low State Line Q Criteria

Month	Low State Line Q for DLR_Drought_Intensity_Level	Low State Line Q for DLR_Drought_Intensity_Level_rev
January	2,356	2,544
February	2,957	2,982
March	3,057	3,258
April	2,779	2,911
May	2,300	2,497
June	2,014	2,153
July	1,607	1,693
August	1,569	1,601
September	1,424	1,406
October	1,286	1,325
November	1,574	1,608
December	2,204	2,043

B. Logan Martin

The zones used in the Nav_Drought, Nav_Drought_Snail, and Nav_Drought-rev operation sets are the same and use the same elevations.

1. Check DIL_Nav –rev

In the Nav_Drought_Snail operation set, the minimum flow at J.D. Minimum for DIL=2 and DIL=3 was changed from the values used in the Nav_Drought operation set. For the Nav_Drought-rev operation set, the minimum values for J.D. Minimum return to the values used in the Nav_Drought operation set. However, the JBT Goal minimum flows for DIL=2 and DIL=3 are different in the Nav_Drought-rev operation set. The values for JBT Goal minimum flows are given in Table N.27. In addition, the new State Line Low Flow criteria previously shown in Table N.26 is used.

Table N.27 Minimum Flows at JBT Goal for Nav_Drought, Nav_Drought_Snail, and Nav_Drought-rev Operation Sets

Date	Min@JBT Goal for DIL=2 in Nav_Drought and Nav_Drought_Snail	Min@JBT Goal for DIL=2 in Nav_Drought-rev	Min@JBT Goal for DIL=3 in Nav_Drought and Nav_Drought_Snail	Min@JBT Goal for DIL=3 in Nav_Drought-rev
01Jan	3,900	3,700	2,000	2,000
30Apr	3,900	3,700	2,000	2,000
01May	4,200	3,700	3,900	3,700
31May	4,200	3,700	3,900	3,700
01Jun	4,200	4,200	3,900	3,700
30Jun	4,200	4,200	3,900	3,700
01Jul	4,200	4,200	4,200	4,200
30Sep	4,200	4,200	4,200	4,200
07Oct	3,900	3,700	3,703	3,703
31Oct	3,900	3,700	2,000	2,000

C. Martin

The zones used in the Nav_Drought and Nav_Drought-rev operation sets are the same and use the same elevations.

1. *Check DIL_Nav-rev*

The rule set for the Nav_Drought and Nav_Drought-rev is the same with the exception of one rule. The rule Check DIL_Nav has been replaced with Check DIL_Nav-rev. The difference between the two is the minimum flow at JBT Goal when DIL=2 and DIL=3. The minimum flow at JBT Goal is given in Table N.28. In addition, the new Low State Line Flow criteria previously shown in Table N.26 is used.

Table N.28 Minimum Flows at JBT Goal for Nav_Drought and Nav_Drought-rev Operation Sets

Date	Min@JBT Goal for DIL=2 in Nav_Drought	Min@JBT Goal for DIL=2 in Nav_Drought-rev	Min@JBT Goal for DIL=3 in Nav_Drought	Min@JBT Goal for DIL=3 in Nav_Drought-rev
01Jan	3,900	3,700	2,000	2,000
30Apr	3,900	3,700	2,000	2,000
01May	4,200	3,700	3,900	3,700
31May	4,200	3,700	3,900	3,700
01Jun	4,200	4,200	3,900	3,700
30Jun	4,200	4,200	3,900	3,700
01Jul	4,200	4,200	4,200	4,200
30Sep	4,200	4,200	4,200	4,200
07Oct	3,900	3,700	3,703	3,703
31Oct	3,900	3,700	2,000	2,000

D. Millers Ferry

The zones used in the Nav_Drought and Nav_Drought-rev operation sets are the same and use the same elevations.

1. *Check DIL_Nav-rev*

The rule set for the Nav_Drought and Nav_Drought-rev is the same with the exception of one rule. The rule Check DIL_Nav has been replaced with Check DIL_Nav-rev. These rules have one difference. The Check DIL_Nav rule uses the state variable “DLR_Drought_Intensity_Level” to determine the DIL. The Check DIL_Nav-rev rule uses the state variable “DLR_Drought_Intensity_Level-rev” to determine the DIL. The difference in these two state variables is the Low State Line Flow criteria and was covered in Table N.26.

X. RPlanD Alternative

Table N.29 shows the operation sets used in the RPlanD alternative.

Table N.29 Operation Sets Used in the RPlanD Alternative

Project	Operation Set	Described Previously
Allatoona	Burkett B	Yes
Carters	Seasonal	Yes
Carters ReReg	Seasonal	Yes
Claiborne	Flow-thru	Yes
HN Henry	Winter Pool 507	Yes
Harris	Baseline	Yes
Jordan	Drought-rev	Yes
Jordan Lake Losses	Flow-thru	Yes
Lay	Flow-thru	Yes
Logan Martin	**Nav_Drought_Snail-rev**	No
Martin	Nav_Drought-rev	Yes
Millers Ferry	Nav_Drought-rev	Yes
Mitchell	Flow-thru	Yes
RF Henry	Baseline	Yes
Thurlow	Flow-thru	Yes
Walter Bouldin	Baseline	Yes
Weiss	Baseline	Yes
Yates	Flow-thru	Yes

In the **RPlanD** alternative, *one project* has an operation set that is *different from the RPlanC alternative*. The project is *Logan Martin*. The differences in the operation sets are discussed in the following sections.

A. Logan Martin

The zones used in the Nav_Drought, Nav_Drought_Snail, Nav_Drought-rev, and Nav_Drought_Snail-rev operation sets are the same and use the same elevations.

1. Check DIL_Nav (Snail) – rev

This rule uses the new Low State Line Flow criteria previously shown in Table N.26. The changes to the operation set is to the minimum flow at JBT Goal and minimum flow at J.D. Minimum for DIL=2 and DIL=3. These results are shown in Table N.30 and Table N.31.

Table N.30 Minimum Flows at JBT Goal for Nav_Drought, Nav_Drought_Snail, Nav_Drought-rev, and Nav_Drought_Snail-rev Operation Sets

Date	Min@JBT Goal for DIL=2 in Nav_Drought and Nav_Drought_ Snail	Min@JBT Goal for DIL=2 in Nav_Drought-rev and Nav_Drought_ Snail-rev	Min@JBT Goal for DIL=3 in Nav_Drought and Nav_Drought_ Snail	Min@JBT Goal for DIL=3 in Nav_Drought-rev and Nav_Drought_ Snail-rev
01Jan	3,900	3,700	2,000	2,000
30Apr	3,900	3,700	2,000	2,000
01May	4,200	3,700	3,900	3,700
31May	4,200	3,700	3,900	3,700
01Jun	4,200	4,200	3,900	3,700
30Jun	4,200	4,200	3,900	3,700
01Jul	4,200	4,200	4,200	4,200
30Sep	4,200	4,200	4,200	4,200
07Oct	3,900	3,700	3,703	3,703
31Oct	3,900	3,700	2,000	2,000

Table N.31 Minimum Flows at J.D. Minimum for Nav_Drought, Nav_Drought_Snail, Nav_Drought-rev, and Nav_Drought_Snail-rev Operation Sets

Date	DIL=2 Nav_Drought and Nav_Drought-rev	DIL=2 Nav_Drought_Snail and Nav_Drought_Snail-rev	DIL=3 Nav_Drought and Nav_Drought-rev	DIL=3 Nav_Drought_Snail and Nav_Drought_Snail-rev
01Jan	1800	1800	1600	1600
31Mar	1800	1800	1600	1600
01Apr	3000	2500	1800	1800
31May	3000	2500	1800	1800
15Jun	3000	2500	1800	1800
30Jun	2062.5	2031.25	1800	1800
01Jul	2000	2000	2000	2000
30Sep	2000	2000	2000	2000
01Oct	1800	1800	1600	1800
30Nov	1800	1800	1600	1800
01Dec	1800	1800	1600	1600
31Dec	1800	1800	1600	1600

XI. RPlanE Alternative

Table N.32 shows the operation sets used in the RPlanE alternative.

Table N.32 Operation Sets Used in the RPlanE Alternative

Project	Operation Set	Described Previously
Allatoona	**Burkett C**	No
Carters	Seasonal	Yes
Carters ReReg	Seasonal	Yes
Claiborne	Flow-thru	Yes
HN Henry	Winter Pool 507	Yes
Harris	Baseline	Yes
Jordan	Drought-rev	Yes
Jordan Lake Losses	Flow-thru	Yes
Lay	Flow-thru	Yes
Logan Martin	Nav_Drought-rev	Yes
Martin	Nav_Drought-rev	Yes
Millers Ferry	Nav_Drought-rev	Yes
Mitchell	Flow-thru	Yes
RF Henry	Baseline	Yes
Thurlow	Flow-thru	Yes
Walter Bouldin	Baseline	Yes
Weiss	Baseline	Yes
Yates	Flow-thru	Yes

In the **RPlanE** alternative, *one project* has an operation set that is *different from the RPlanD alternative*. The project is *Allatoona*. The differences in the operation sets are discussed in the following sections.

A. Allatoona

The Burkett C operation set has the same zones as the Burkett and Burkett B operation sets. The elevations of the zones are the same for all three operation sets with the exception of Conservation. The elevations for Conservation are given in Table N.33.

Table N.33 Conservation Elevations for Burkett, Burkett B, and Burkett C

Date	Burkett and Burkett B Conservation Elevations	Burkett C Conservation Elevations
01Jan	823.0	823.0
15Jan	823.0	823.0
01May	840.0	840.0
05Sep	840.0	840.0
01Oct	840.0	835.0
15Nov	829.93	835.0
16Dec	823.0	826.91
31Dec	823.0	823.0

1. Power Generation Rules

The differences in the rule sets focus on the power generation rules. The required weekday generation in Burkett C is the same as the required weekday generation in Burkett B. Table N.34 gives a comparison of the weekday generation for Burkett, Burkett B, and Burkett C operation sets.

Table N.34 Required Weekday Power Generation for Burkett, Burkett B, and Burkett C

Zone	Required Weekday Generation for Burkett	Required Weekday Generation for Burkett B and Burkett C
Flood Control	6 hrs	4 hrs
Conservation	6 hrs	4 hrs
Zone2	4 hrs	3 hrs
Zone3	2 hrs	0 to 2 hrs
Zone4	No req’d generation	No req’d generation

XII. RPlanF Alternative

Table N.35 shows the operation sets used in the RPlanF alternative.

Table N.35 Operation Sets Used in the RPlanF Alternative

Project	Operation Set	Described Previously
Allatoona	Burkett C	Yes
Carters	Seasonal	Yes
Carters ReReg	Seasonal	Yes
Claiborne	Flow-thru	Yes
HN Henry	Winter Pool 507	Yes
Harris	Baseline	Yes
Jordan	Drought-rev	Yes
Jordan Lake Losses	Flow-thru	Yes
Lay	Flow-thru	Yes
Logan Martin	**Nav_Drought_Snail-rev**	Yes
Martin	Nav_Drought-rev	Yes
Millers Ferry	Nav_Drought-rev	Yes
Mitchell	Flow-thru	Yes
RF Henry	Baseline	Yes
Thurlow	Flow-thru	Yes
Walter Bouldin	Baseline	Yes
Weiss	Baseline	Yes
Yates	Flow-thru	Yes

In the **RPlanF** alternative, *one project* has an operation set that is *different from the RPlanE alternative*. The project is *Logan Martin*. The description of the operation set named "**Nav_Drought_Snail-rev**" was previously presented in the **RPlanD** Alternative section.

Another way to describe **RPlanF** is that it's the same as RPlanD -- *except for Allatoona*. In RPlanD, Allatoona uses operation set Burkett B; whereas, in RPlanF, Allatoona uses operation set Burkett C.

XIII. RPlanG Alternative

Table N.36 shows the operation sets used in the RPlanG alternative.

Table N.36 Operation Sets Used in the RPlanG Alternative

Project	Operation Set	Described Previously
Allatoona	**Burkett D**	No
Carters	Seasonal	Yes
Carters ReReg	Seasonal	Yes
Claiborne	Flow-thru	Yes
HN Henry	Winter Pool 507	Yes
Harris	Baseline	Yes
Jordan	Drought-rev	Yes
Jordan Lake Losses	Flow-thru	Yes
Lay	Flow-thru	Yes
Logan Martin	Nav_Drought_Snail-rev	Yes
Martin	Nav_Drought-rev	Yes
Millers Ferry	Nav_Drought-rev	Yes
Mitchell	Flow-thru	Yes
RF Henry	Baseline	Yes
Thurlow	Flow-thru	Yes
Walter Bouldin	Baseline	Yes
Weiss	Baseline	Yes
Yates	Flow-thru	Yes

In the **RPlanG** alternative, *one project* has an operations set that is different from the RPlanF alternative. The project is *Allatoona*. The differences in the operation sets are discussed in the following sections.

A. Allatoona

The Burkett D operation set has the same zones as the Burkett C operation set and uses the same elevations.

1. Power Generation Rules

The power generation rules in Burkett D are the same as the power generation rules in Burkett C, but a seasonal reduction has been added for Burkett D. The required power generation is reduced by one-half in all of the zones that have a required power generation rule in the months of September, October, and November.

Alabama-Coosa-Tallapoosa (ACT) Watershed

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

Appendix O – Development of Sub-daily Flows for the Upper Coosa

March 2011 (DRAFT)

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Appendix O – Sub-daily Flow Development (DRAFT)

DEVELOPMENT OF HOURLY HYPOTHETICAL STORM HYDROGRAPHS FOR THE ALABAMA-COOSA-TALLAPOOSA RIVER SYSTEM BASIN

ABOVE ROME, GEORGIA

US Army Corps of Engineers
Mobile District

JULY 2009

Appendix O – Sub-daily Flow Development (DRAFT)

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Appendix O

Development of Sub-daily Flows for the Upper Coosa

1. INTRODUCTION

The U.S. Army Corps of Engineers (USACE) Mobile District was tasked to develop hourly hypothetical unimpaired flow storm hydrographs for the 5-, 2-, 1-, 0.5-, and 0.2-percent exceedance events on the Alabama Coosa Tallapoosa (ACT) River system basin above Rome, GA. The data will be used to evaluate the impact of varied operation of the federal projects in the basin, Allatoona Dam and Carters Main Dam and Re-regulation Dam. The 4040 square mile ACT basin above Rome, GA is formed by the Oostanaula River and the Etowah River basins. These rivers join at Rome, GA to form the Coosa River. The Oostanaula and Etowah Rivers have approximately the same drainage area. The Oostanaula River is formed by the Conasauga and Coosawattee Rivers near Resaca, GA. Carters Dam and Carters Reregulation Dam are located on the Coosawattee River approximately 1 mile apart. Allatoona Dam is located on the Etowah River. The area is shown in Figure O.01.

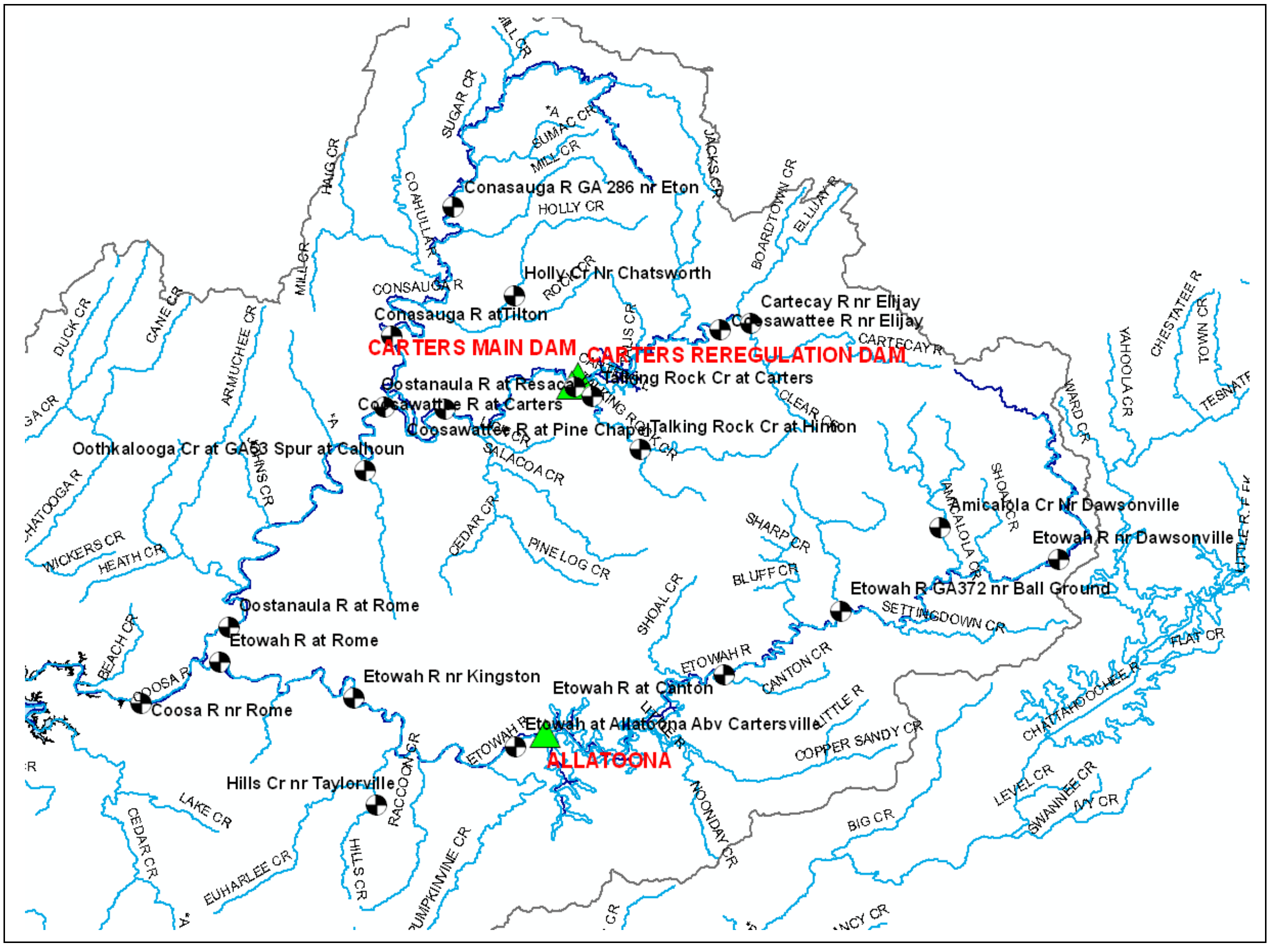

Figure O.01 ACT Basin above Rome, GA

The hourly hypothetical hydrographs developed in this analysis were developed for input to a reservoir system simulation (HEC-ResSim) model of the ACT River system above Rome. The HEC-ResSim model will be used to analyze reservoir operations at Allatoona Dam and at Carters Dam during various hypothetical flood events and determine the downstream impacts at Rome, GA. To develop the hourly hydrographs, a routing model of the basin was constructed using version 3.3 of the Hydrologic Engineering Center's application Hydrologic Modeling System (HEC-HMS). A schematic of the watershed is shown below in Figure O.02.

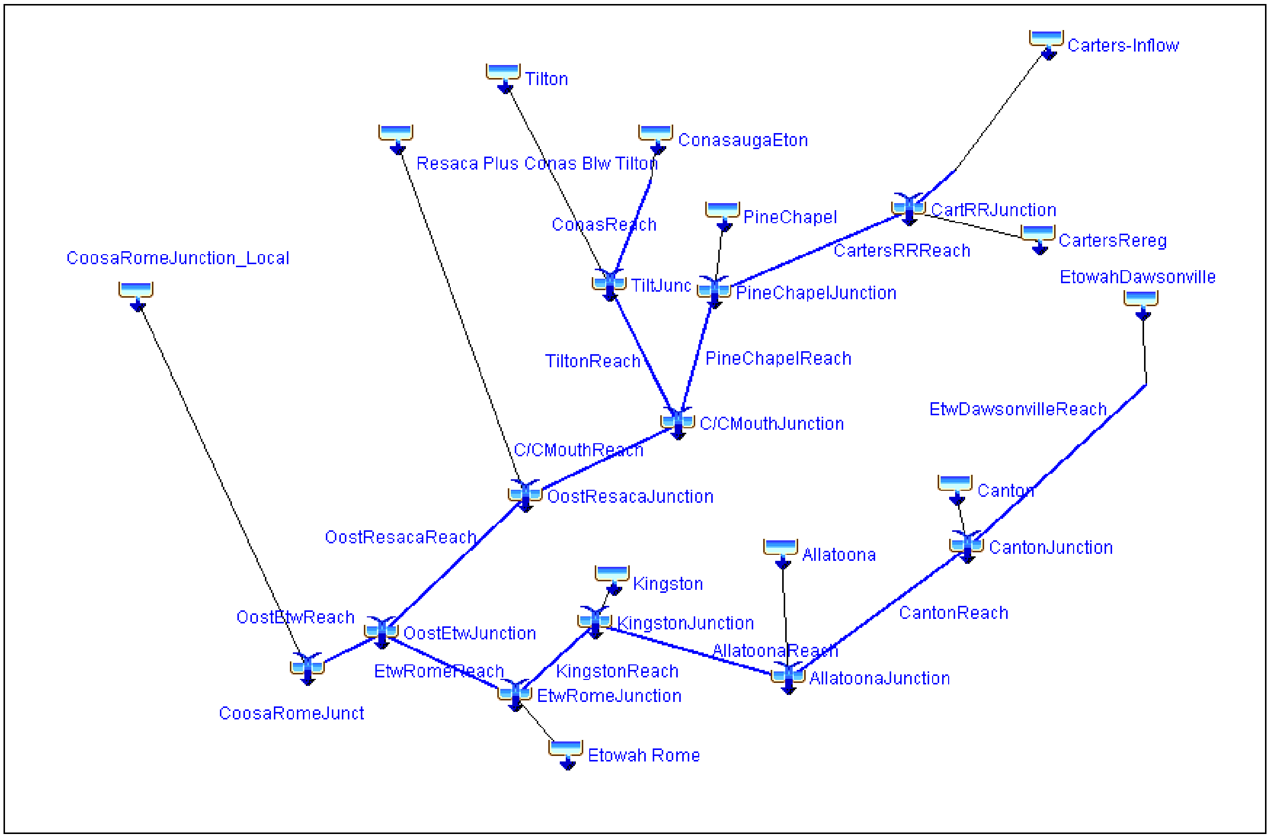

Figure O.02 ACT Above Rome Schematic

In order to determine the hourly hypothetical unimpaired flow storm hydrographs for the 5-, 2-, 1-, 0.5-, and 0.2-percent exceedance events at the inflow locations and points of interest shown in Figure O.02, the USACE Mobile District and the USACE Hydrologic Engineering Center (HEC) developed a 6 step process. This process consisted of (1) generating a daily vs. instantaneous peak flow relationships at various gages throughout the basin, (2) developing instantaneous, 1-, 3-, 5-, and 45-day frequency curves at Rome, (3) identification of three historic storm events, (4) converting the daily unimpaired data to hourly for these three historic storm events, (5) development and calibration of an HEC-HMS model, and (6) scaling the hourly data to produce the 5-, 2-, 1-, 0.5-, and 0.2-percent exceedance events in the HEC-HMS model. Additional details of this process are addressed in the following sections.

2. DEVELOPMENT OF HOURLY HYPOTHETICAL STORM HYDROGRAPHS

2.1 Development Daily vs. Instantaneous Peak Relationship

The first task in the development of the hourly hypothetical storm hydrographs was to generate a daily vs. instantaneous peak relationship at various locations in the basin. This was done by comparing the annual peak flows with the average daily flows on the same day at USGS gages in the basin. Details are provided in Appendix O-A. The daily vs. instantaneous peak relationship at Rome is shown in Figure O.03 below.

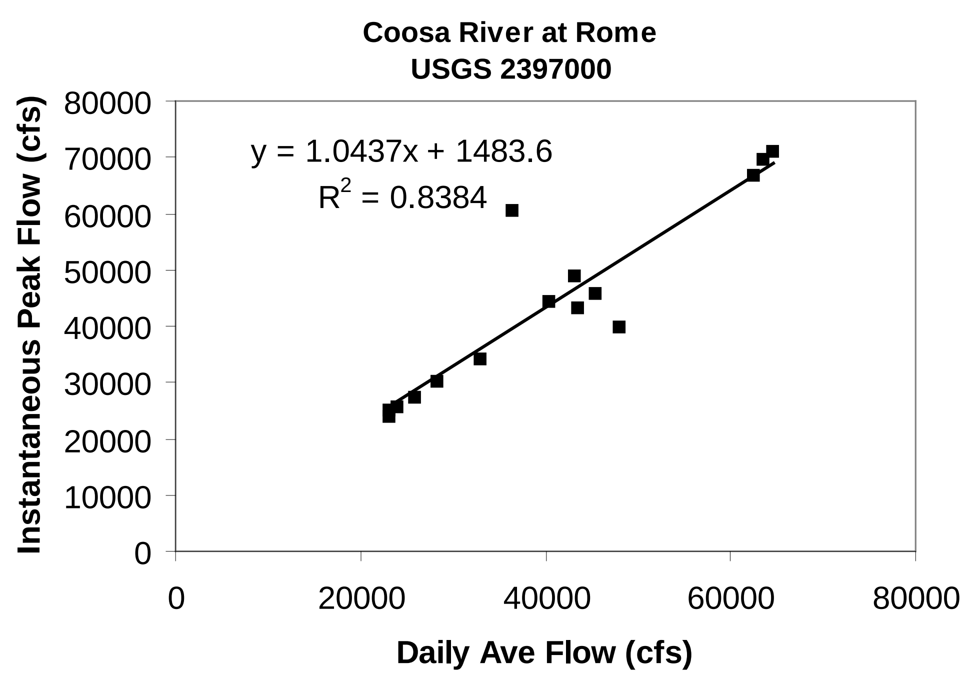

Figure O.03 Instantaneous Peak Flow vs. Daily Average Flow Relationship at Rome

2.2 Development of Unimpaired Flow Frequencies at Rome

The second task in the development of the hourly unimpaired flow hypothetical storm hydrographs was to compute the instantaneous peak, and 1-day, 3-day, 5-day, and 45-day flow frequencies from the USGS gage at Rome. These were computed using the Hydrologic Engineering Center's Statistical Software Package (HEC-SSP) and are shown in Table O.01 below. Details of this analysis are provided in Appendix O-B of this report.

Table O.01 Unimpaired Flow Frequencies at USGS Gage Coosa River at Rome

Percent Exceedance Frequency	Peak	1-Day	3-Day	5-Day	45-Day
99.0	20,767	16,061	14,449	12,171	5,374
95.0	26,871	22,385	20,446	17,676	7,617
90.0	30,723	26,442	24,272	21,217	9,065
80.0	36,022	32,046	29,511	26,082	11,069
50.0	48,377	44,993	41,360	37,062	15,703
20.0	64,183	60,938	55,372	49,877	21,378
10.0	74,047	70,432	63,387	57,075	24,728
5.0	83,123	78,829	70,268	63,159	27,670
2.0	94,425	88,835	78,206	70,053	31,144
1.0	102,645	95,798	83,563	74,624	33,542
0.5	110,674	102,354	88,480	78,756	35,783
0.2	121,086	110,504	94,421	83,661	38,545
0.1	128,856	116,336	98,556	87,015	40,504

2.3 Selection of Storm Events

The third step in development the hourly hypothetical unimpaired flow storm hydrographs for the 5-, 2-, 1-, 0.5-, and 0.2-percent exceedance events was identification of three separate storm events. Three historic storm events were identified from the daily average unimpaired data set for use in this analysis (Nov-Dec 1961, Jan - Mar 1979, and Feb-Apr 1990). These storms were selected from the period of record because of their high 45-day volume, and their high peaks. The daily average unimpaired flow hydrographs for the three events at Rome, GA are shown in Figure O.04, Figure O.05, and Figure O.06.

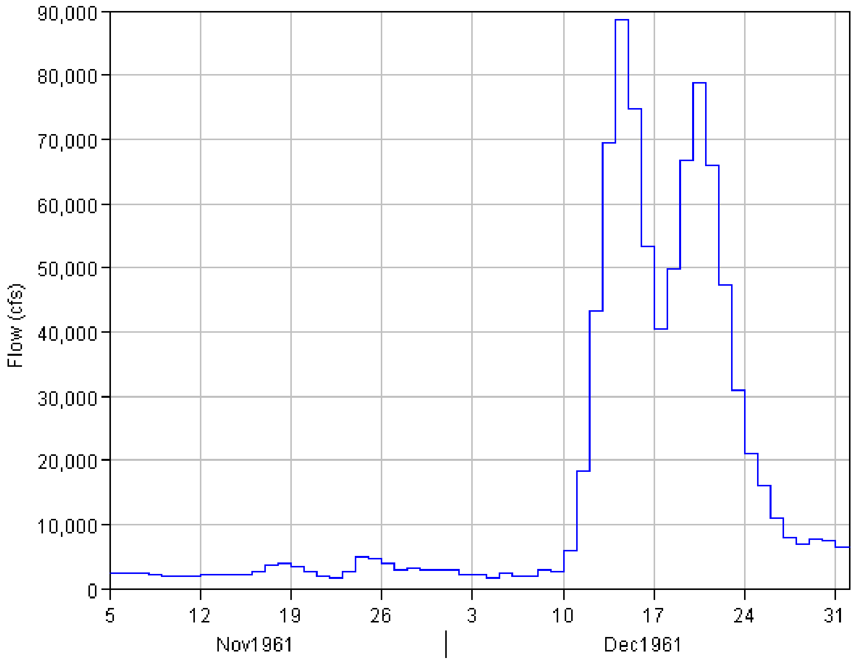

Figure O.04 November – December 1961 Flood Event at Rome, GA

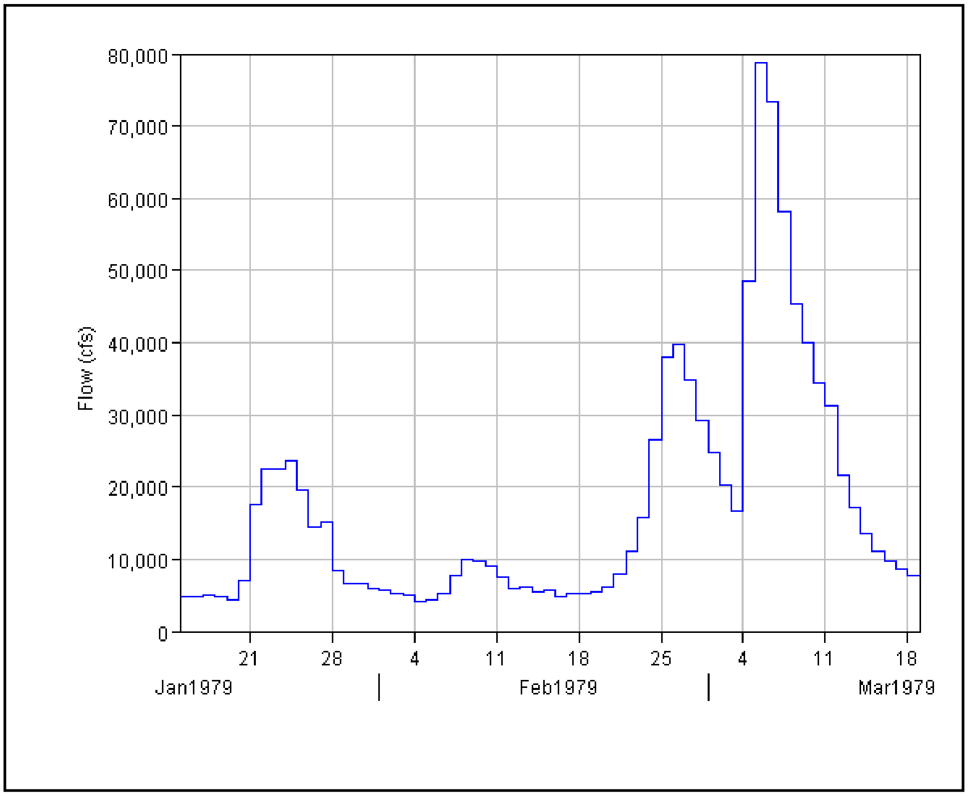

Figure O.05 January - March 1979 Flood Event at Rome, GA

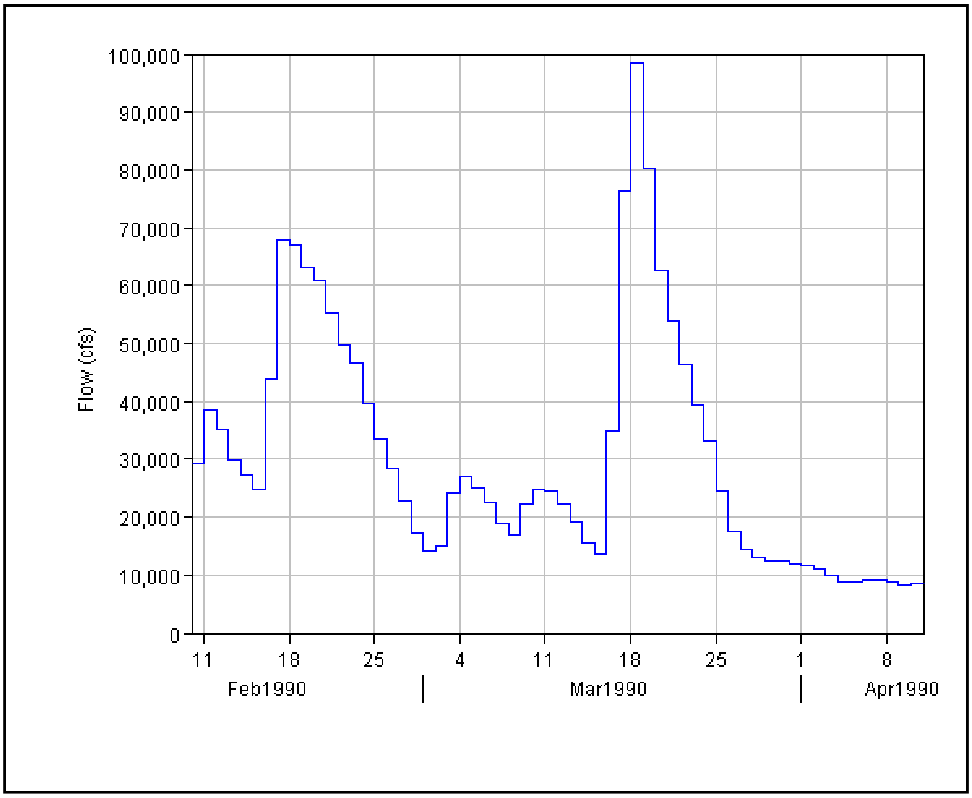

Figure O.06 February – April 1990 Flood Event at Rome, GA

2.4 Conversion of Daily Average Unimpaired Data to Hourly Values

The fourth step in the development the hourly hypothetical unimpaired flow storm hydrographs for the 5-, 2-, 1-, 0.5-, and 0.2-percent exceedance events was to convert the selected flood events from daily average flows to hourly flows at main-stem gages (junctions in the HEC-HMS model), or HEC-ResSim nodes and, for the 1990 flood, the local inflow (between gages) and for the most upstream inflow locations. The hourly hydrographs at these locations were used for calibrating and checking the HMS model. This was done for the 1990 flood because this flood and these local inflows were used to determine routing parameters in the HEC-HMS model. The local inflow for the 1961 and 1979 floods were determined by other means described in Appendix O-C.

To determine the hourly hydrographs, the instantaneous peak flow values derived from methods described in **Section 2.1** were used to shape the hydrograph. For each hydrograph, once the instantaneous peak value was determined, a SCS unit hydrograph was used in Excel spreadsheets to shape the hydrograph around the peak while the rest of the hydrograph was shaped using a combination of power equations, exponential equations, and other methods to shape the hydrograph appropriately. Generally, only the last peak of a multi-peak flood was converted to hourly values using this method, since the timing of this peak would be the most critical. For the prior peaks and other low flow values, the average daily values were used for 24 hours to get the hourly values for that day. However, for the 1961 flood, hourly values for both peaks were developed because the larger peak occurred first at some locations, and because they were relatively close together.

In shaping these hydrographs, the hourly values were adjusted to match not only the peak value, but also to preserve, for each day of the hydrograph, the daily volumes of the existing unimpaired average daily flow hydrograph.

The daily and hourly hydrographs for the three flood events at Rome are shown in Figure O.07, Figure O.08, and Figure O.09.

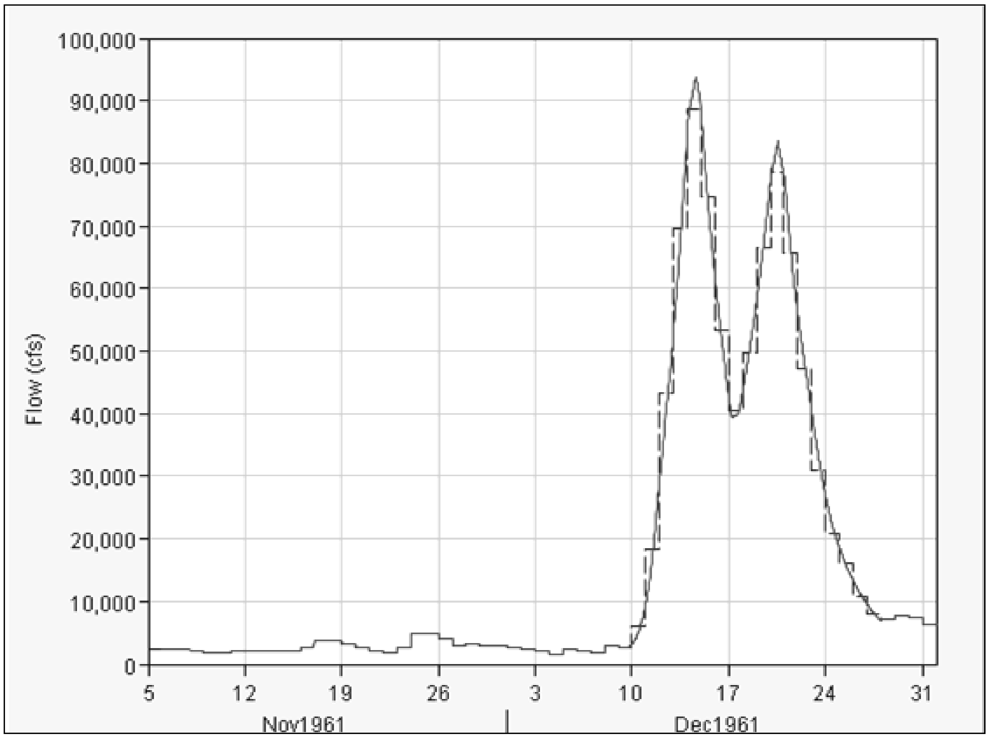

Figure O.07 Daily vs. Hourly Flow Hydrographs for the 5 Nov. – 31 Dec. 1961Storm Event at Rome

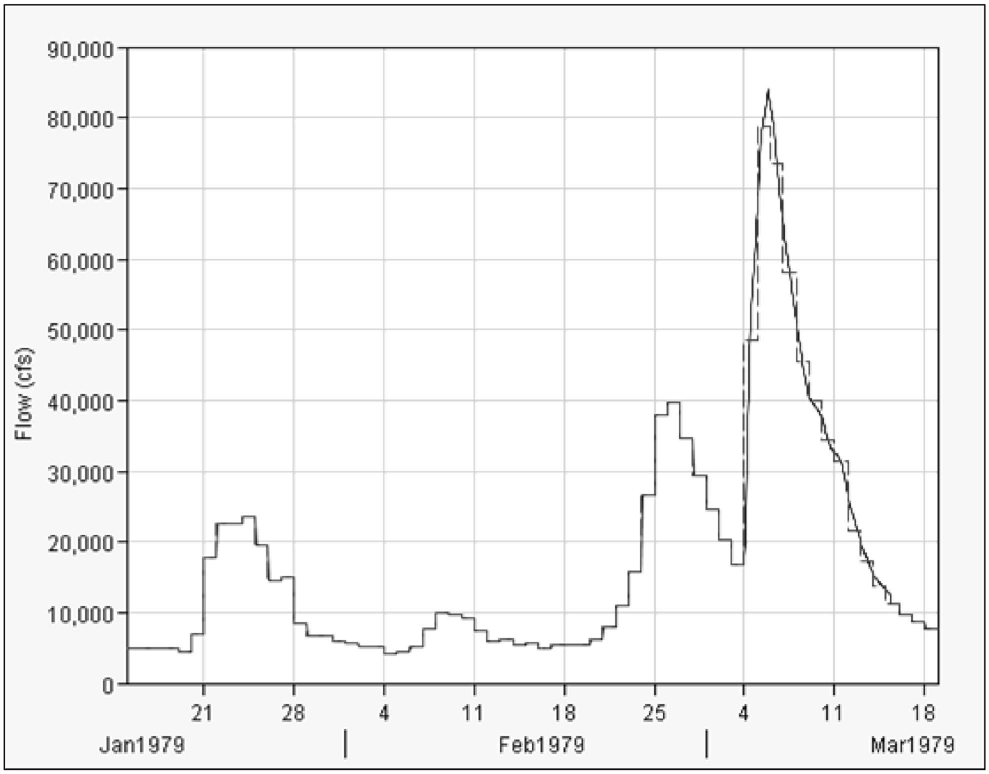

Figure O.08 Daily vs. Hourly Flow Hydrographs for the 15 Jan – 18 Mar 1979 Storm Event at Rome

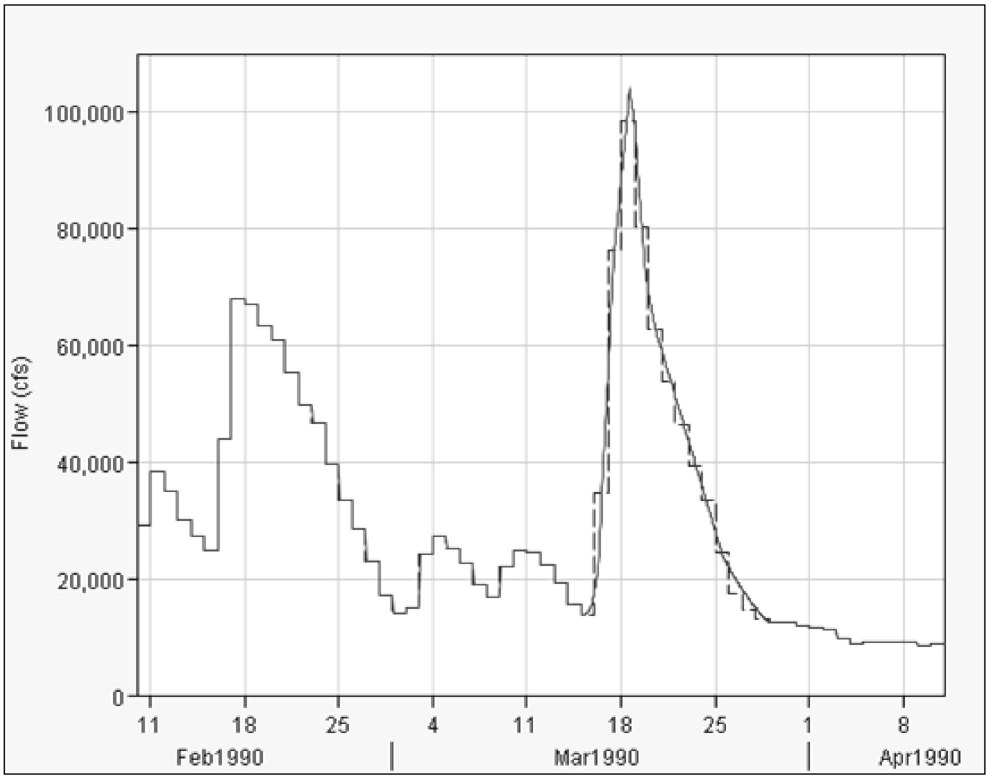

Figure O.09 Daily vs. Hourly Flow Hydrographs for the 10 Feb – 10 Apr 1990 Storm Event at Rome

2.5 Development and Calibration of HEC-HMS Model

The fifth step in the development the hourly hypothetical unimpaired flow storm hydrographs for the 5-, 2-, 1-, 0.5-, and 0.2-percent exceedance events was to develop a calibrated HEC-HMS routing model of the basin above Rome. This was done using Muskingum-Cunge routing method initially, but was later changed to Muskingum because of better matching and ease of calibration. The historic 1990 local inflow (flow between the gages) hydrographs, and cumulative flow at the gages, both of which were converted to hourly values, were used to calibrate the model. The calibration of the HEC-HMS model was done by HEC staff and the details are described Appendix C. The calibrated model was then used for the 1961 and 1979 floods.

2.6 Design Floods.

The sixth step in the development the hourly hypothetical unimpaired flow storm hydrographs for the 5-, 2-, 1-, 0.5-, and 0.2-percent exceedance events at Rome was scaling the hourly data to produce these events in the HEC-HMS model.

Local (incremental) flow hydrographs were developed that would result in the HEC-HMS model in the unregulated instantaneous peak flow of the 5-, 2-, 1-, 0.5-, and 0.2-percent exceedance events at Rome that match the similar data derived from the gage at Rome. The local flows were also adjusted to match the 1-day, 3-day, 5-day, and 45-day unregulated volume-duration frequency curves developed by the Hydrological Engineering Center's Statistical Software Package (HEC-SSP) from the gage data at Rome.

For each of the three storms, these design flow local hydrographs were developed by a two-step process. First, all the historic local hydrographs were multiplied by the same factor. The factor was basically the ratio of the peak from the gage and the peak from the HEC-HMS model at Rome. These were then re-run in the model. The 1-day, 3-day, 5-day, and 45-day unregulated volume-durations were checked in a spreadsheet to assure they matched within 10 percent. For every flood, the 45-day durations did not match those from the HEC-HMS model. Therefore a second adjustment was made to the local hydrograph values preceding or after the 5-day peak up or down and the model re-run. Most of the time, the peaks and the volume durations matched within 10 percent the values from the gage at Rome with the second adjustment. If not a third adjustment was made for the 45-day volumes.

The instantaneous peak frequency data and volume-duration table developed from gage data at Rome for specific design frequencies is shown in Table O.02, Table O.03, and Table O.04, below. The tables also show the frequency table developed for the desired specific design frequencies from the HEC-HMS model at Rome using each of the different flood events as a base. The tables also show the difference between the gage data and the HEC-HMS model data. The difference was kept at 10 percent or lower.

Table O.02. Flow Frequencies from 1961 Flood

Gage and HEC-HMS Flow Frequency and Volume Duration Data at Rome, GA from 1961 Flood															
	From Rome Gage					From HEC-HMS Model using 1961 Flood					Difference (%)				
Percent Chance Exceedance	**Inst Peak Flow**	**1-Day Max Vol-Dur.**	**3-Day Max Vol-Dur.**	**5-Day Max Vol-Dur.**	**45-Day Max Vol-Dur.**	**Inst Peak Flow**	**1-Day Max Vol-Dur.**	**3-Day Max Vol-Dur.**	**5-Day Max Vol-Dur.**	**45-Day Max Vol-Dur.**	**Inst Peak Flow**	**1-Day Max Vol-Dur.**	**3-Day Max Vol-Dur.**	**5-Day Max Vol-Dur.**	**45-Day Max Vol-Dur.**
5	83,123	78,829	70,268	63,159	27,670	83469	80,777	69,330	58,540	26,655	0.42%	2.47%	-1.34%	-7.31%	-3.67%
2	94,425	88,835	78,206	70,053	31,144	94445	91,410	78,426	66,215	29,760	0.02%	2.90%	0.28%	-5.48%	-4.44%
1	102,645	95,798	83,563	74,624	33,542	102,666	99,366	85,253	71,978	32,388	0.02%	3.72%	2.02%	-3.55%	-3.44%
0.5	110,674	102,354	88,480	78,756	35,783	110698	107,140	91,922	77,609	36,432	0.02%	4.68%	3.89%	-1.46%	1.81%
0.2	121,086	110,504	94,421	83,661	38,545	121112	117,219	100,570	84,910	39,860	0.02%	6.08%	6.51%	1.49%	3.41%

All of the design floods were adjusted to match the frequency and volume duration data developed from the gage data within 10 percent.

The 1979 flood calibration table is shown below.

Table O.03. Flow Frequencies from 1979 Flood

Gage and HEC-HMS Flow Frequency and Volume Duration Data at Rome, GA from 1979 Flood															
Percent Chance Exceedance	**From Rome Gage**					**From HEC-HMS Model using 1979 Flood**					**Difference (%)**				
	Inst Peak Flow	**1-Day Max Vol-Dur.**	**3-Day Max Vol-Dur.**	**5-Day Max Vol-Dur.**	**45-Day Max Vol-Dur.**	**Inst Peak Flow**	**1-Day Max Vol-Dur.**	**3-Day Max Vol-Dur.**	**5-Day Max Vol-Dur.**	**45-Day Max Vol-Dur.**	**Inst Peak Flow**	**1-Day Max Vol-Dur.**	**3-Day Max Vol-Dur.**	**5-Day Max Vol-Dur.**	**45-Day Max Vol-Dur.**
5	83,123	78,829	70,268	63,159	27,670	83,123	79,131	68,621	61,956	27,511	0.00%	-0.38%	2.34%	1.90%	0.58%
2	94,425	88,835	78,206	70,053	31,144	94,425	89,890	77,951	70,381	30,645	0.00%	-1.19%	0.33%	-0.47%	1.60%
1	102,645	95,798	83,563	74,624	33,542	102,690	97,755	84,777	76,549	32,816	-0.04%	-2.04%	-1.45%	-2.58%	2.16%
0.5	110,674	102,354	88,480	78,756	35,783	110,674	105,359	91,365	82,491	35,612	0.00%	-2.94%	-3.26%	-4.74%	0.48%
0.2	121,086	110,504	94,421	83,661	38,545	121,086	115,266	99,965	90,265	38,137	0.00%	-4.31%	-5.87%	-7.89%	1.06%

The table shows all values matched within 10 percent.

The 1990 flood calibration table is shown below.

Table O.04. Flow Frequencies from 1990 Flood

Gage and HEC-HMS Flow Frequency and Volume Duration Data at Rome, GA from 1990 Flood															
	From Rome Gage					From HEC-HMS Model using 1990 Flood					Difference (%)				
Percent Chance Exceedance	Inst Peak Flow	1-Day Max Vol-Dur.	3-Day Max Vol-Dur.	5-Day Max Vol-Dur.	45-Day Max Vol-Dur.	Inst Peak Flow	1-Day Max Vol-Dur.	3-Day Max Vol-Dur.	5-Day Max Vol-Dur.	45-Day Max Vol-Dur.	Inst Peak Flow	1-Day Max Vol-Dur.	3-Day Max Vol-Dur.	5-Day Max Vol-Dur.	45-Day Max Vol-Dur.
5	83,123	78,829	70,268	63,159	27,670	82,898	78,727	68,444	60,986	28,306	-0.27%	-0.13%	-2.60%	-3.44%	2.30%
2	94,425	88,835	78,206	70,053	31,144	95,072	90,280	78,480	69,937	31,974	0.69%	1.63%	0.35%	-0.17%	2.67%
1	102,645	95,798	83,563	74,624	33,542	102,232	96,604	83,381	74,745	34,557	-0.40%	0.84%	-0.22%	0.16%	3.03%
0.5	110,674	102,354	88,480	78,756	35,783	109,388	103,367	89,218	79,977	36,976	-1.16%	0.99%	0.83%	1.55%	3.33%
0.2	121,086	110,504	94,421	83,661	38,545	118,563	111,994	96,612	86,645	39,895	-2.08%	1.35%	2.32%	3.57%	3.50%

The table shows all values matched within 10 percent.

Appendix O-A

Instantaneous Peak Flow
vs.
Daily Ave. Flow Relationships

Appendix O-A

Instantaneous Peak Flow
vs.
Daily Average Flow Relationships

This procedure is to develop the instantaneous peak flow vs. daily average flow relationships for various stream gages in the Coosa River basin above Rome, GA. Results from this analysis were used to compute instantaneous peak flow given daily average flow data. This was later used to develop instantaneous unregulated flow frequency curves and 1-hour local runoff hydrographs.

Figure O-A.01shows the Coosa River basin, major reservoir locations and stream gage locations used in this analysis. Table O-A-01 and Table O-A-02 contain a description of USGS stream gages and major reservoirs, respectively.

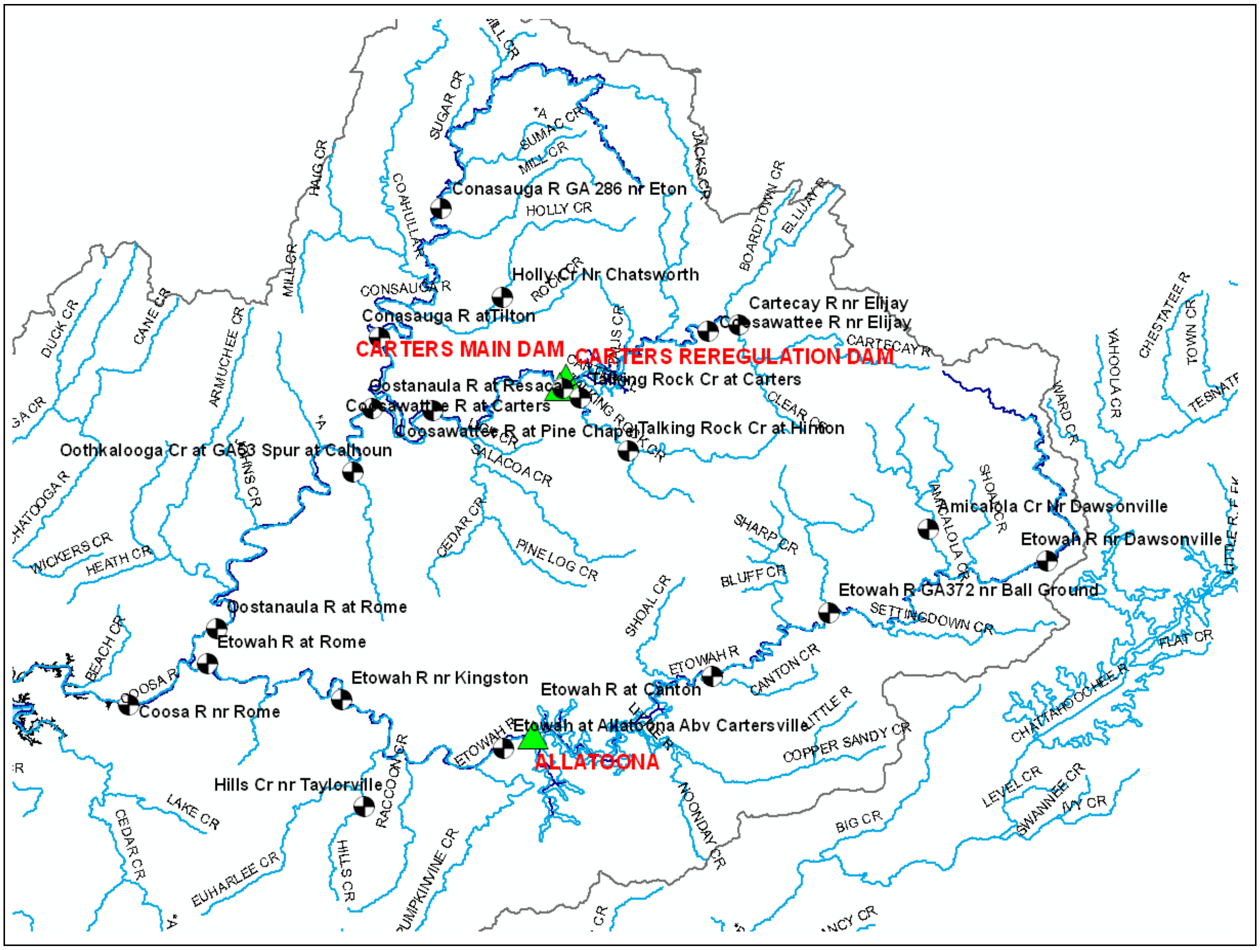

Figure O-A.01 Drainage Basin above Rome, GA.

Table O-A-01. USGS Stream Gages

Gage Name	USGS ID	Latitude	Longitude	Drainage Area (sq miles)
Amicalola Cr Nr Dawsonville	2390000	34.4242	-84.2139	89
Cartecay R Nr Ellijay	2379500	34.6811	-84.4614	134
Conasauga River Ga 286 Near Eton	2384500	34.8278	-84.8492	252
Conasauga River At Tilton	2387000	34.6653	-84.9294	687
Coosa R Nr Rome	2397000	34.2014	-85.2569	4040
Coosawattee River Near Carters	2381500	34.6125	-84.6708	374
Coosawattee River At Carters	2382500	34.6019	-84.6911	521
Coosawattee River Near Ellijay	2380500	34.6733	-84.5008	236
Coosawattee River Nr Pine Chapel	2383500	34.5728	-84.86	831
Etowah R At Allatoon Abv Cartersville	2394000	34.1475	-84.7683	1119
Etowah R At Canton	2392000	34.2386	-84.4953	613
Etowah R Dawsonville (near)	2389000	34.3836	-84.0597	107
Etowah R Ga 1 Loop Nr Rome	2395980	34.2322	-85.1169	1801
Etowah R Ga 372, nr Ball Ground	2391000	34.3183	-84.3442	477
Etowah R Near Kingston	2395000	34.2081	-84.9789	1634
Etowah R Rome (at)	2396000	34.2539	-85.1539	1819
Hills Creek nr Taylorville	2394950	34.0754	-84.9507	25
Holly Creek Near Chatsworth	2385800	34.7164	-84.7697	64
Oostanaula River At Resaca	2387500	34.5764	-84.9389	1602
Oostanaula River Nr Rome	2388500	34.2978	-85.1422	2115
Oothkalooga C At Ga53Spur At Calhoun	2387600	34.4955	-84.9653	63
Talking Rock Cr Nr Carters	2382300	34.5889	-84.6681	142
Talking Rock Cr Nr Hinton,	2382200	34.5228	-84.6053	119

Table O-A-02. Reservoirs

Reservoir Name	Description	Alias	Completion Date	Lat.	Long.	Drainage Area (sq miles)
Allatoona	USACE	Allatoona Lake	1949	34.1633	-84.72833	1117
Carters	USACE	Carters Lake	1977	34.6133	-84.685	373
Carters Reregulation Dam	CE	Carters Reregulation Pool	1977	34.6033	-84.69333	520

An effort was made to remove the influence of reservoirs when developing the instantaneous peak flow vs. daily average flow relationships. Therefore, only stream flow records prior to 1947 (two years prior to the Allatoona Dam completion date) were included in the analysis of the Etowah downstream of Allatoona Dam. On the Coosawattee and Oostanaula, only records prior to 1975 (two years prior to the completion date for Carters Dam) were considered for those gages downstream of Carters Dam. On the Coosa, only records prior to 1947 were used.

These instantaneous peak flow vs. daily average flow relationships were developed by comparing the annual peak discharge and average daily discharge on the day of the peak. The data is available at the gages listed from the USGS.

The relationships were plotted for each of the Oostanaula, Coosawattee, and Etowah basins separately to show the variance with drainage area.

The instantaneous peak flow vs. daily average flow relationship Oostanaula River, shown in Figure O-A.02, shows little difference in the instantaneous peak and corresponding daily average flow from the upper end at Resaca to the lower end at Rome. This is a result of the large drainage area upstream of the Oostanaula at Rome gage, 2115 square miles, and possibly the impact of the backwater from the Etowah River, which meets the Oostanaula at Rome. In addition, the instantaneous peak and corresponding daily average flow at the Coosa at Rome gage is shown for comparison. Figure O-A.03 shows the variance on the Coosawattee River with drainage basin area. This basin has a smaller drainage basin and the variances are greater.

Figure O-A.04 shows the instantaneous peak flow vs. daily average flow relationships for Etowah River gages as well as for the Coosa at Rome gage. The changing slopes of the lines plotted for the Etowah demonstrate the expected variance and trend (toward a 1:1 slope) in the relationships as the basin area increases.

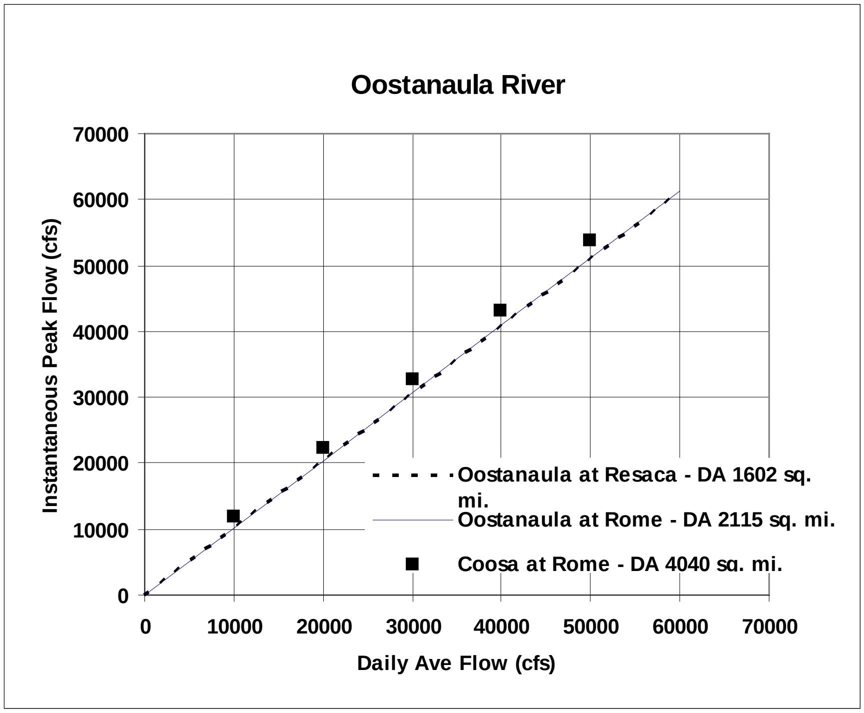

Figure O-A.02 Instantaneous Peak Flow vs. Daily Average Flow Relationship on the Oostanaula River and the Coosa at Rome

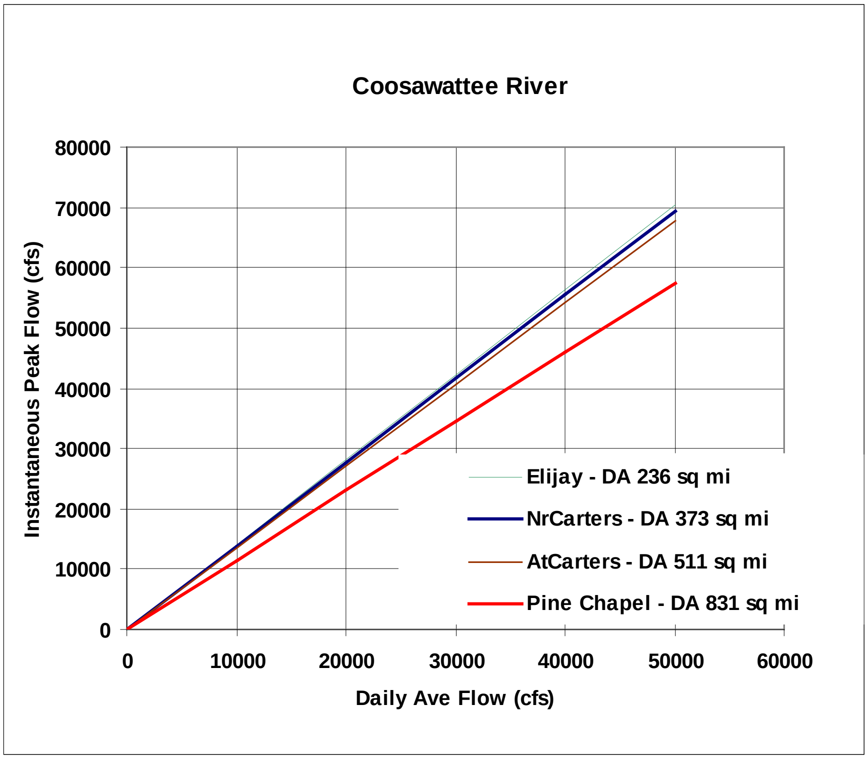

Figure O-A.03 Instantaneous Peak Flow vs. Daily Average Flow Relationship on the Coosawattee River

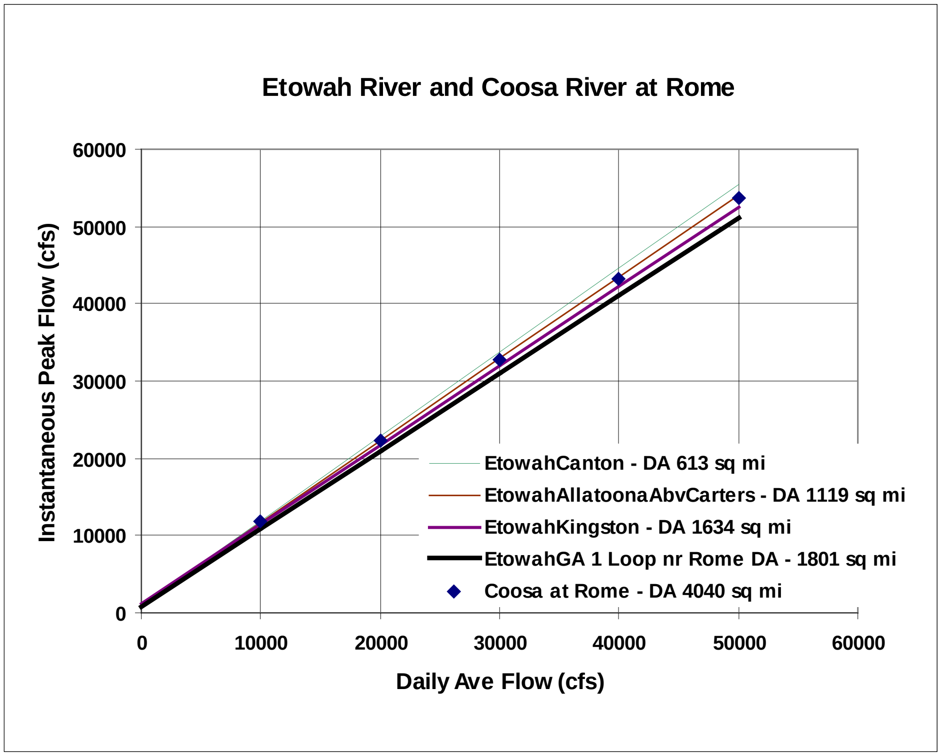

Figure O-A.04 **Instantaneous Peak Flow vs. Daily Average Flow Relationship for Various Stream Gages on the Etowah River and the Coosa River at Rome**

Figures A - 5 through A - 27 show the instantaneous peak vs. daily average flow relationship for each of the USGS gages listed. The data used to develop these figures and relationships is shown in Tables A - 3 through A - 25.

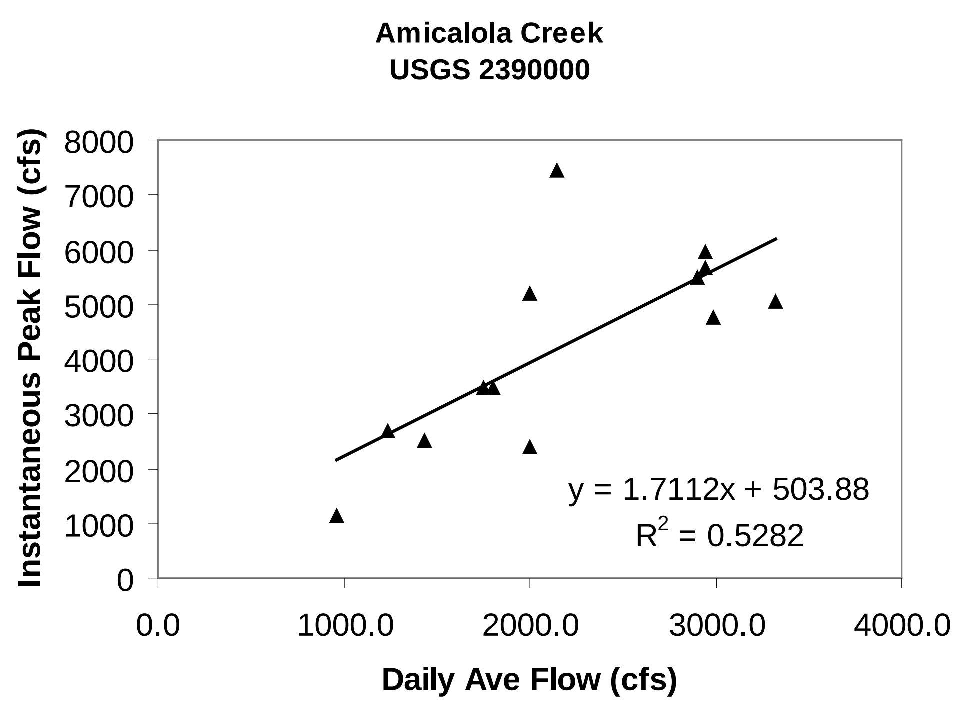

Figure O-A.05 Instantaneous Peak Flow vs. Daily Average Flow Relationship at Amicalola nr Dawsonville

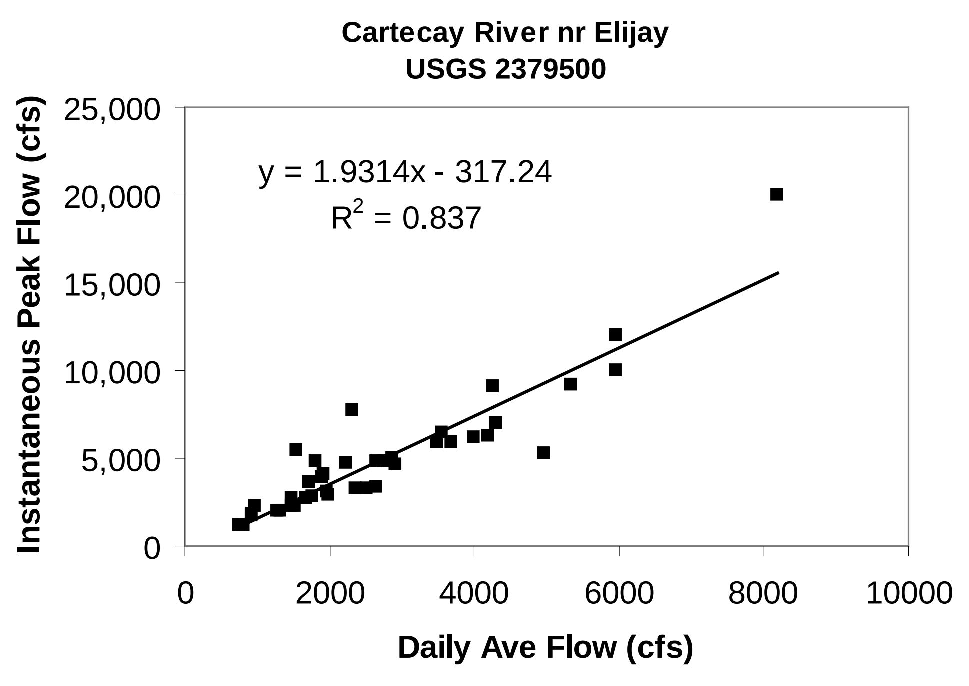

Figure O-A.06 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Cartecay gage nr Elijay

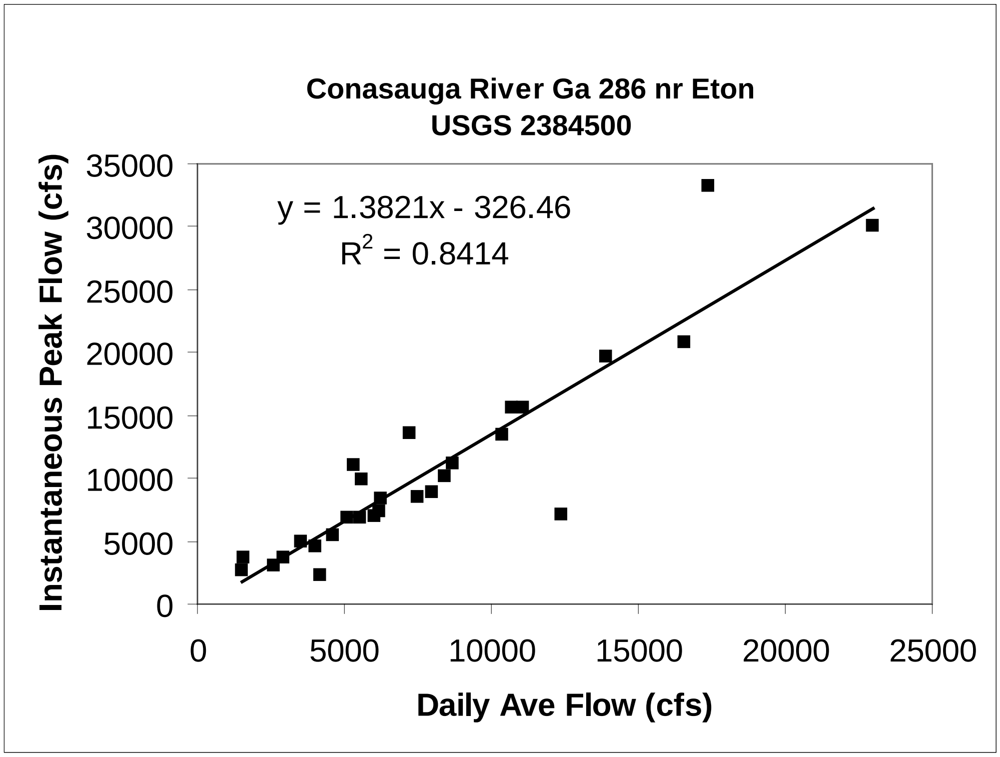

Figure O-A.07 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Conausauga R nr Eton Gage

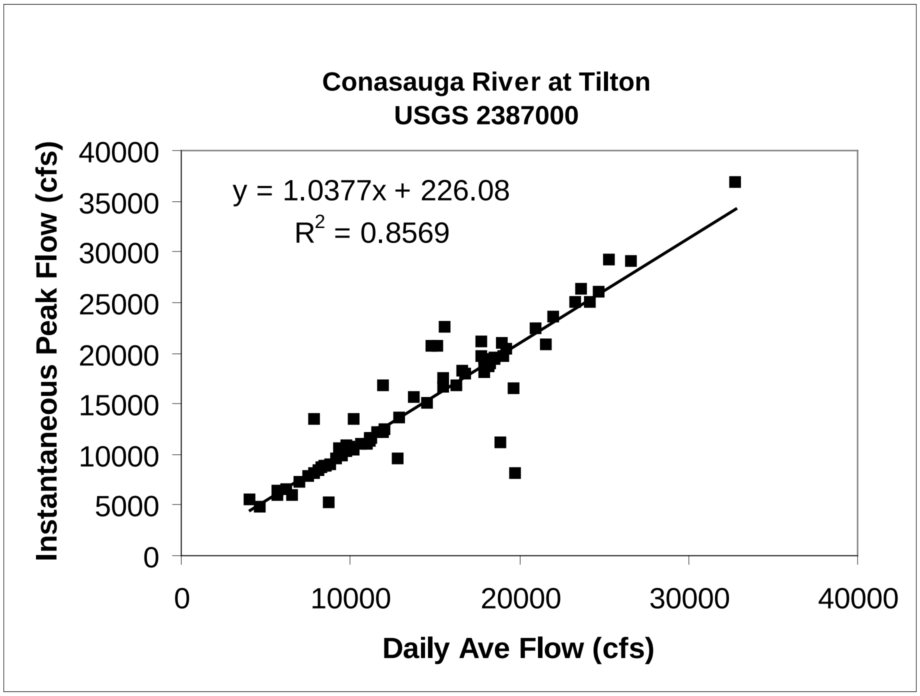

Figure O-A.08 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Canausauga R nr Tilton Gage

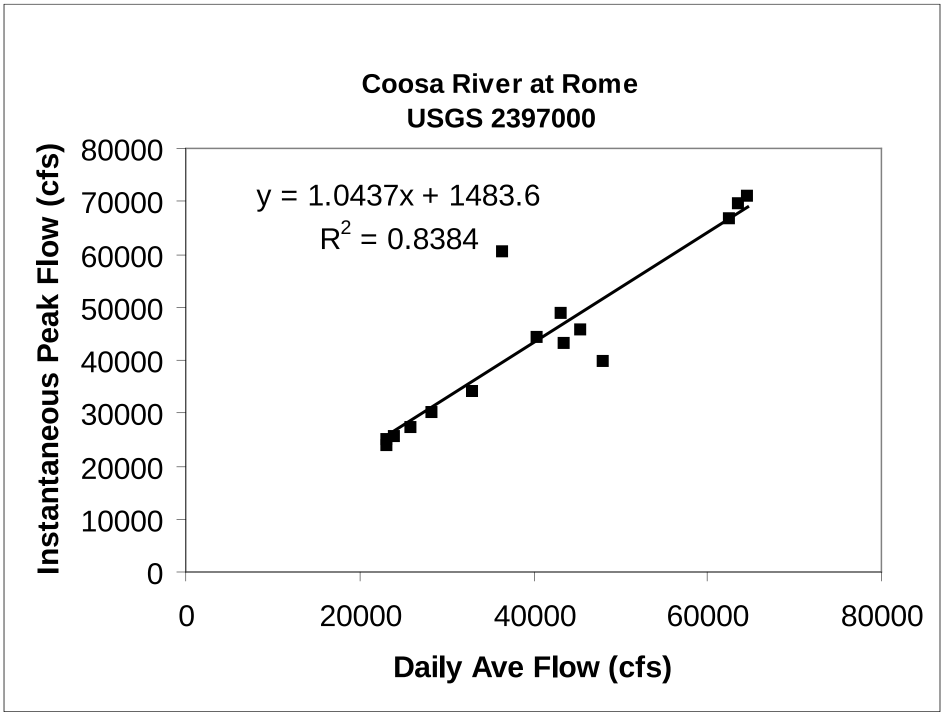

Figure O-A.09 **Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Coosa R nr Rome Gage**

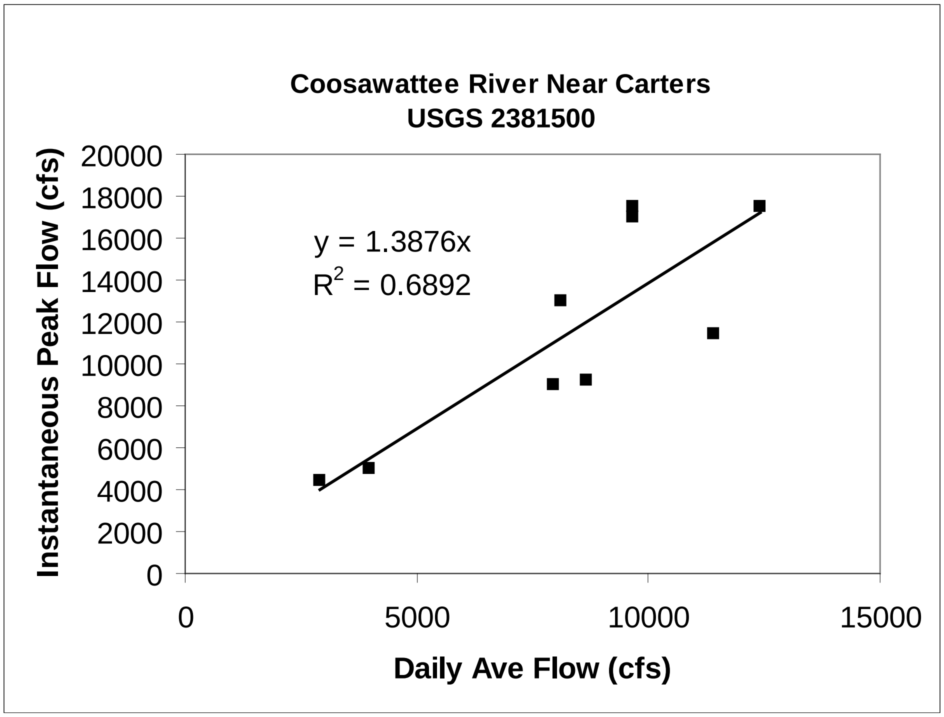

Figure O-A.10 **Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Coosawattee R nr Carters Gage**

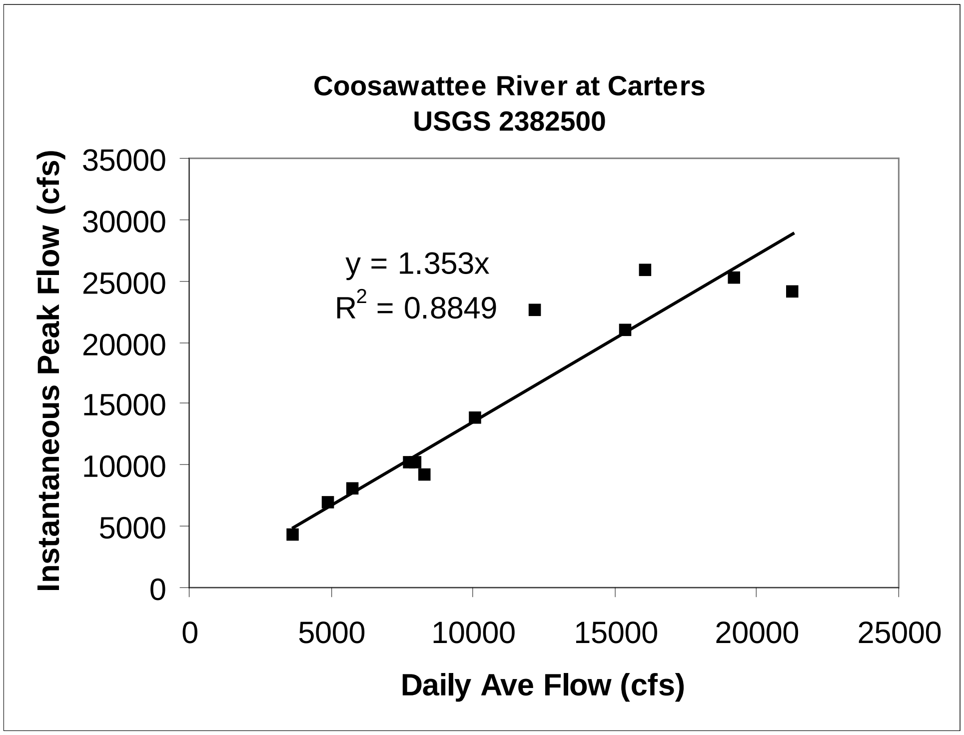

Figure O-A.11 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Coosawattee R at Carters Gage

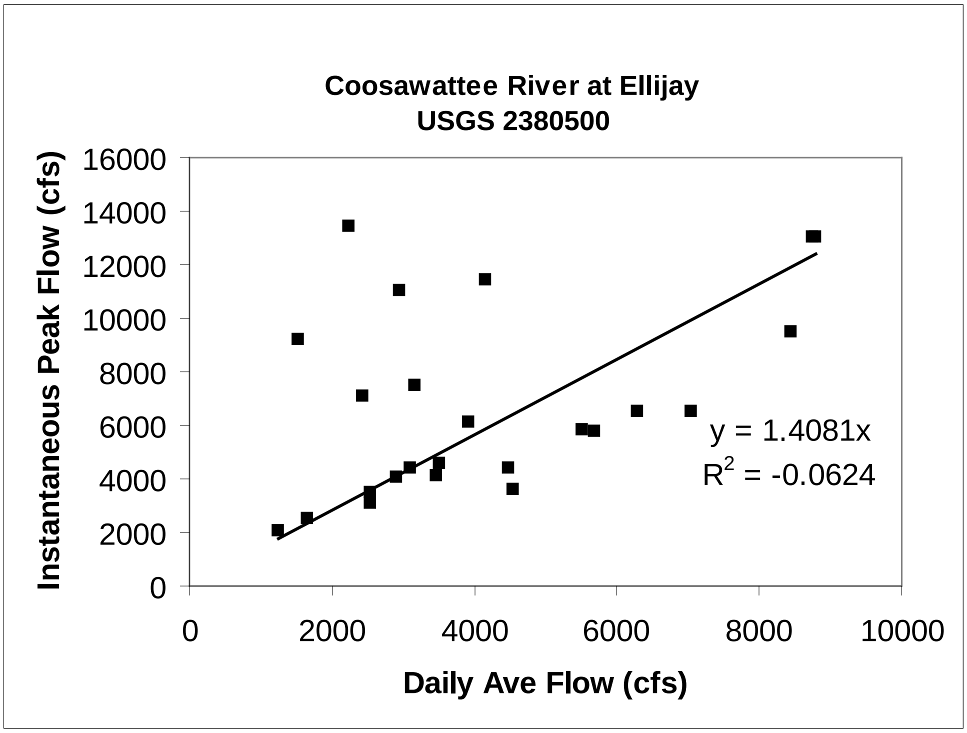

Figure O-A.12 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Coosawattee R at Ellijay Gage

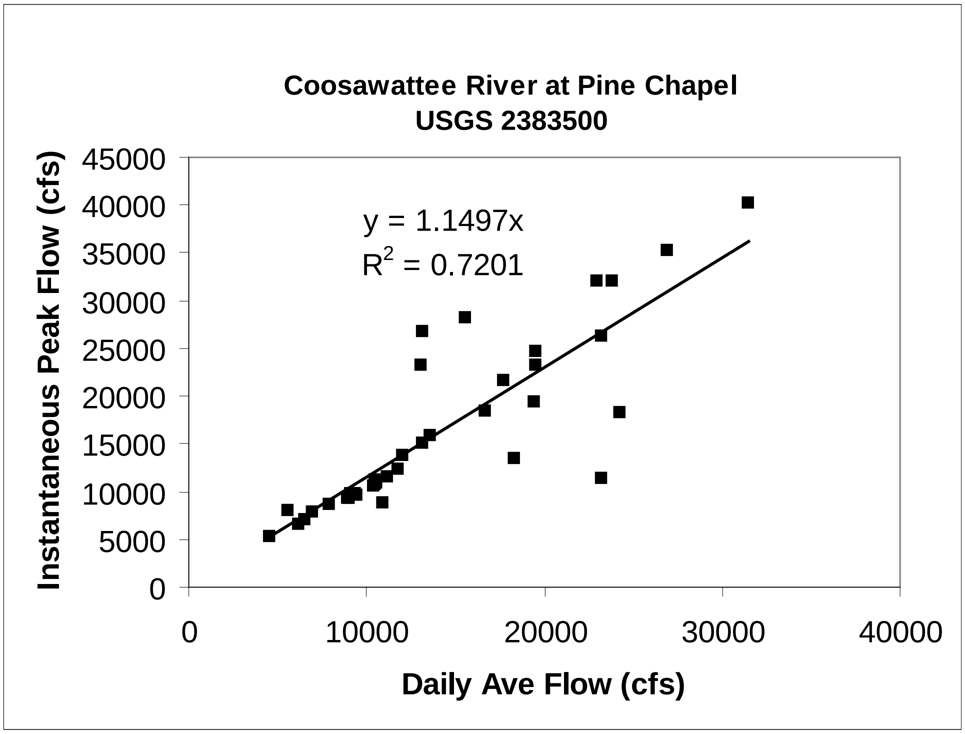

Figure O-A.13 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Coosawattee R nr Pine Chapel Gage

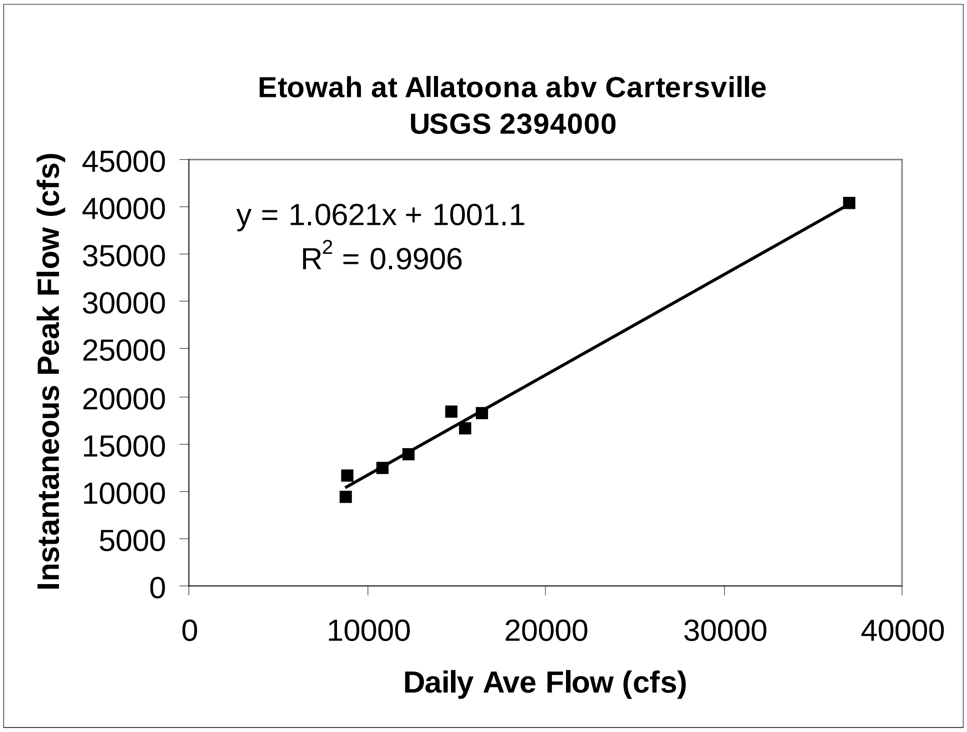

Figure O-A.14 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Etowah at Allatoona above Cartersville Gage

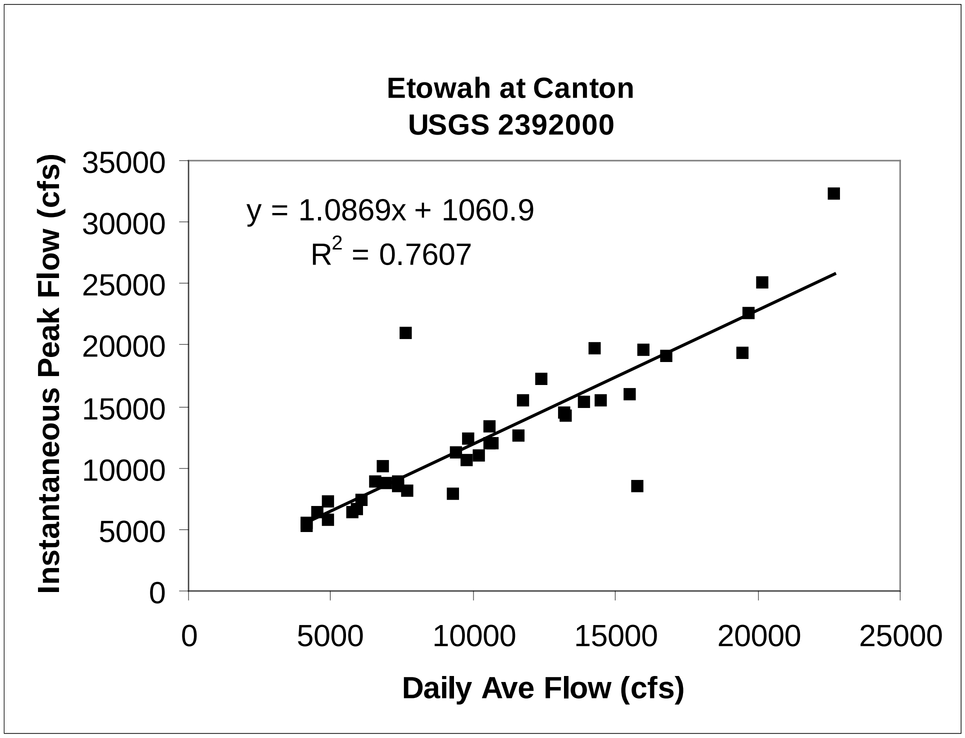

Figure O-A.15 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Etowah R at Canton Gage

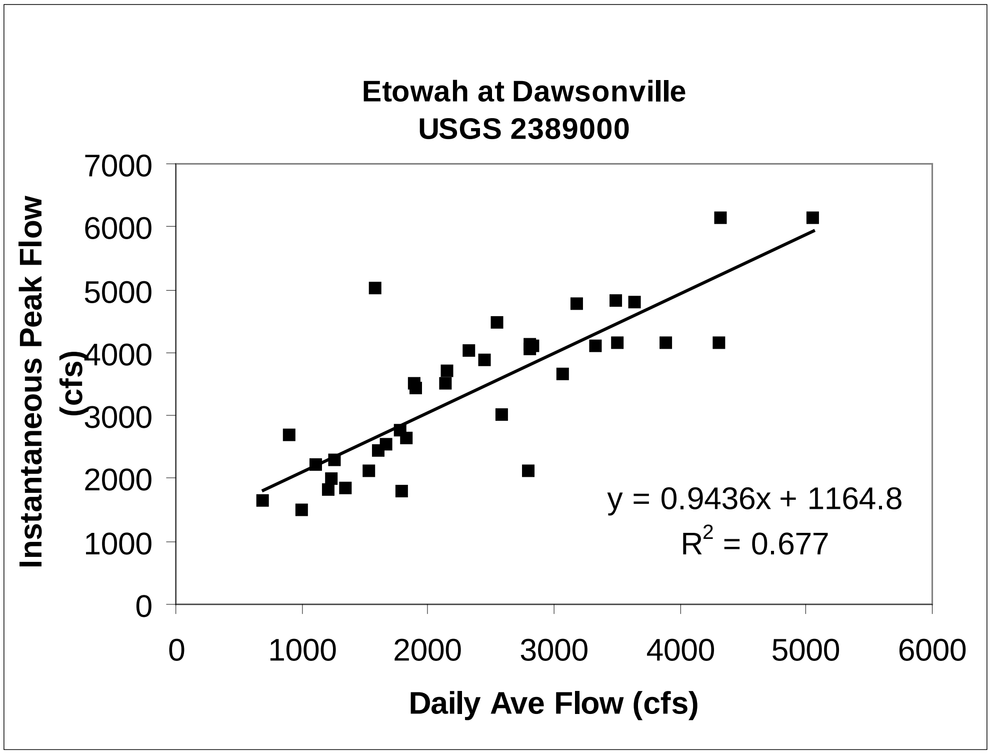

Figure O-A.16 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Etowah R nr Dawsonville Gage

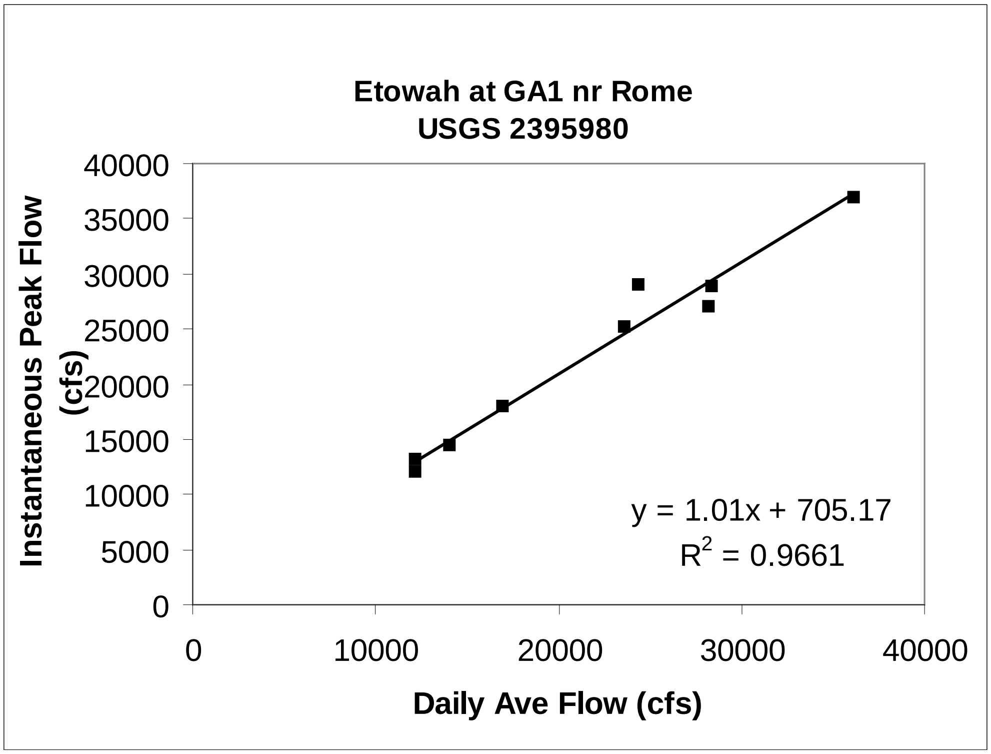

Figure O-A.17 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Etowah R at GA 1 nr Rome Gage

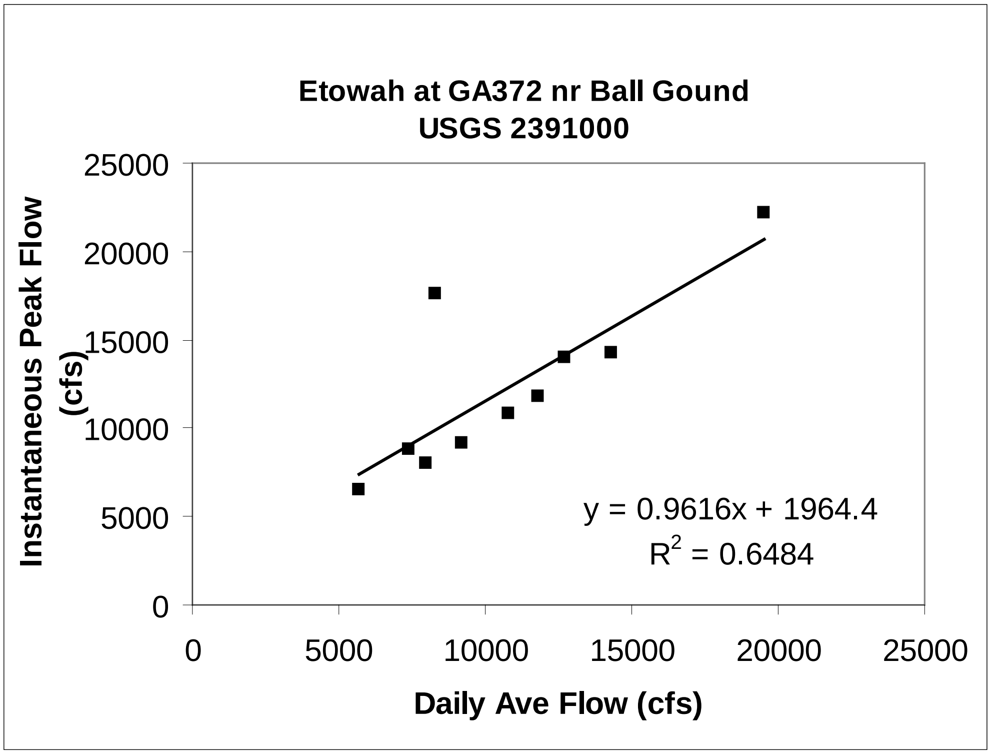

Figure O-A.18 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Etowah R at GA 372 nr Ball Ground

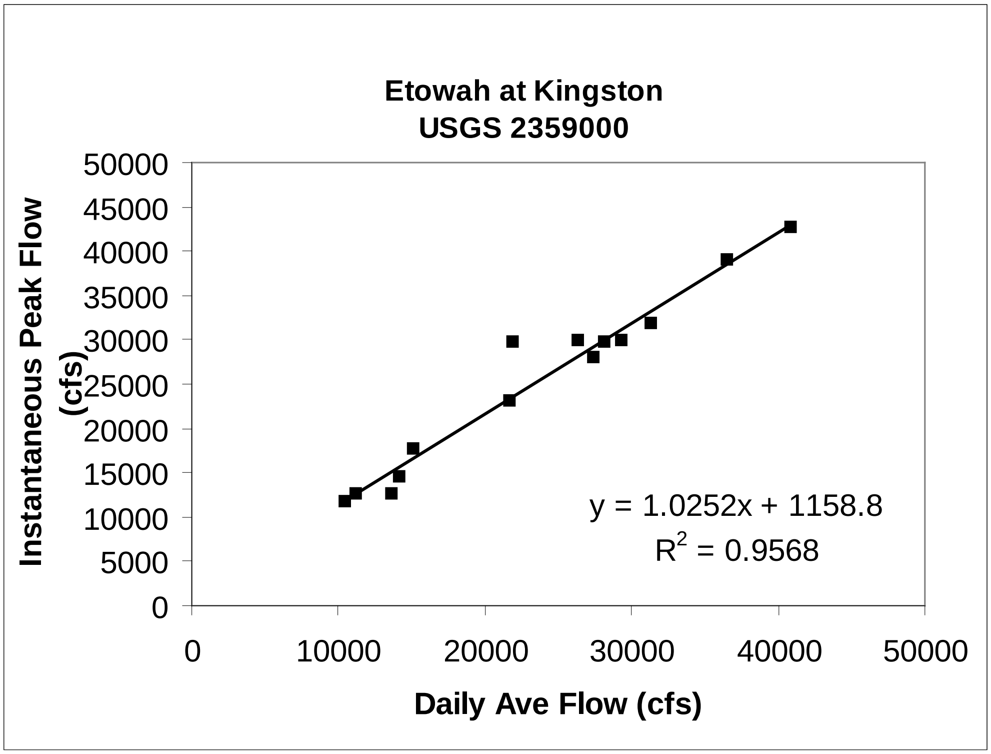

Figure O-A.19 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Etowah R at Kingston gage.

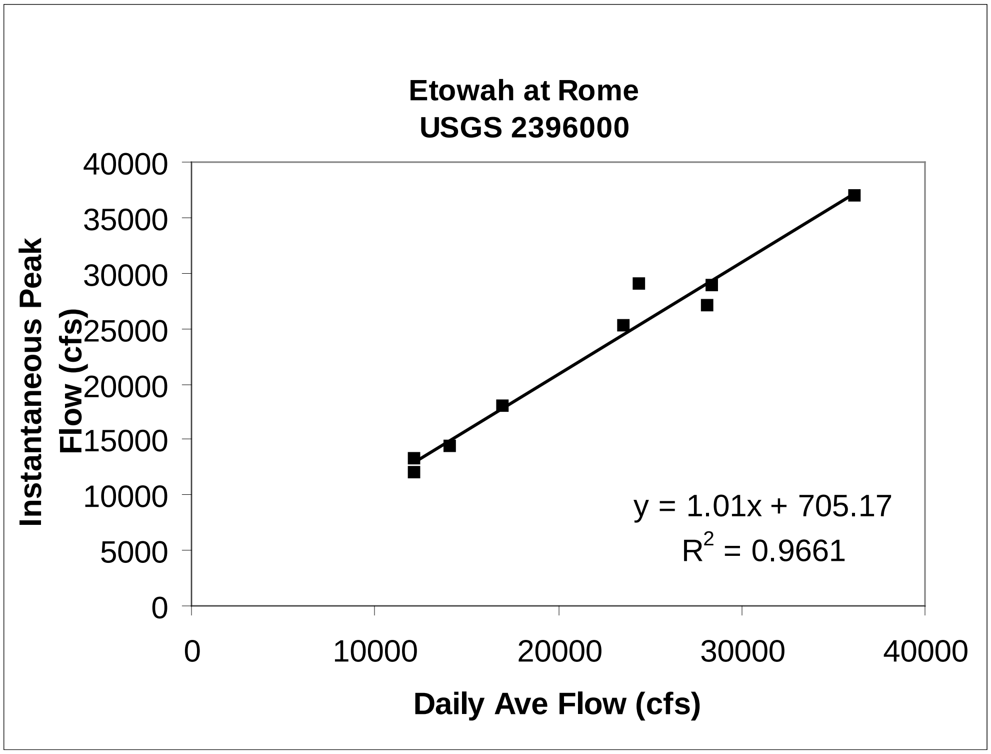

Figure O-A.20 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Etowah R at Rome gage

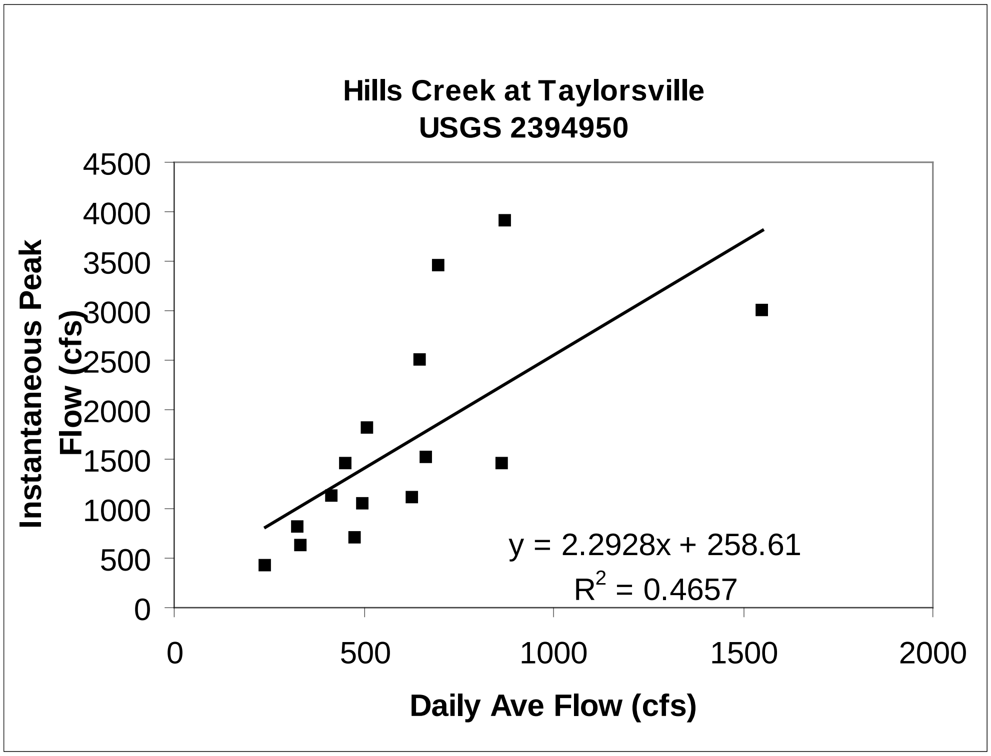

Figure O-A.21 **Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Hills Cr at Taylorsville gage**

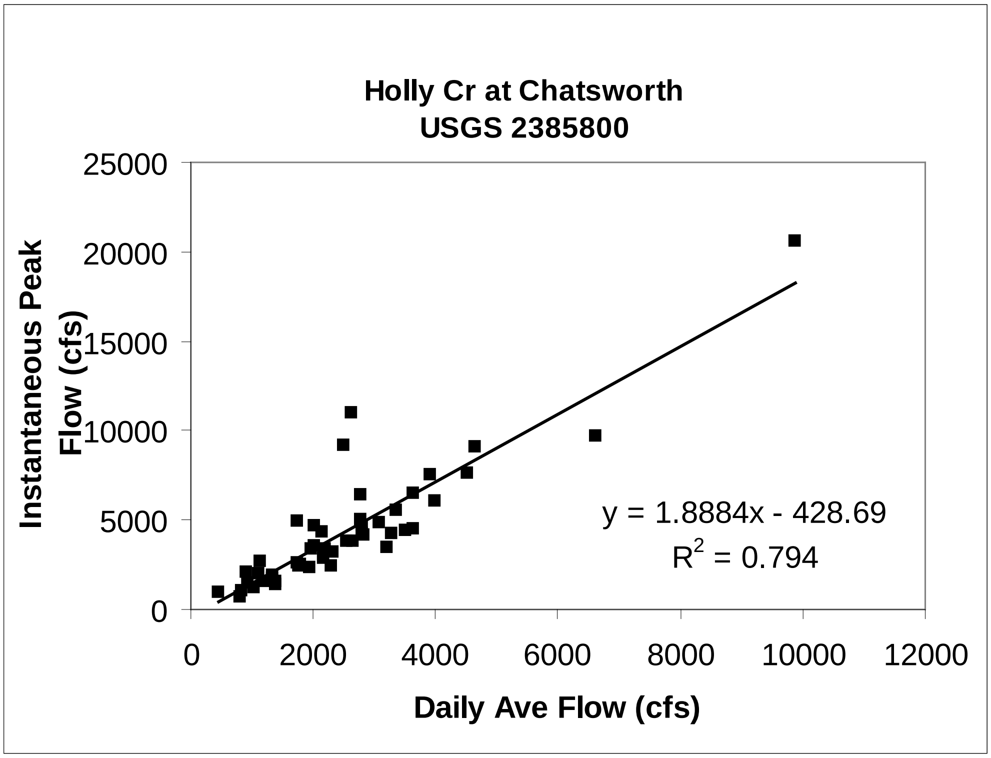

Figure O-A.22 **Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Holly Cr at Chatsworth gage**

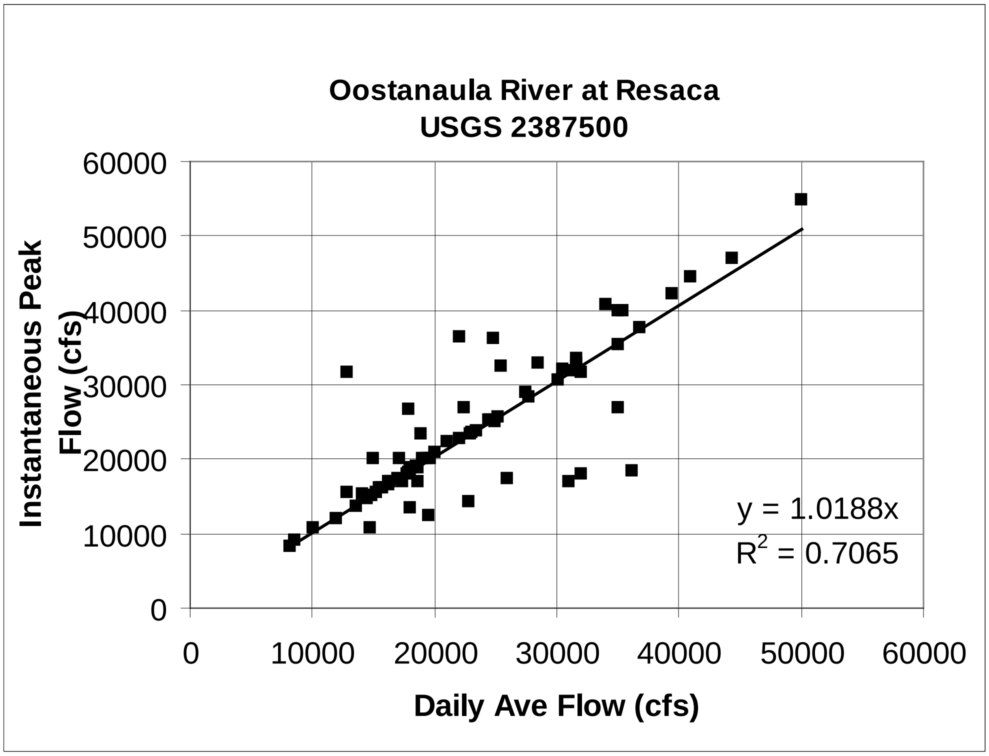

Figure O-A.23 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Oostanaula River at Resaca gage

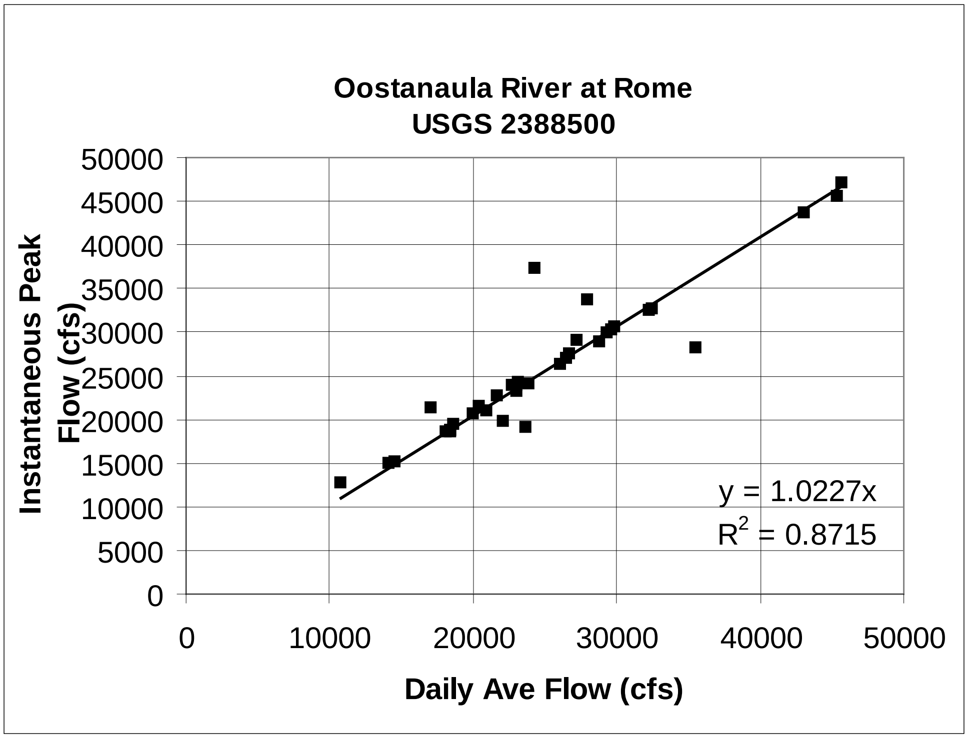

Figure O-A.24 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Oostanaula River nr Rome gage

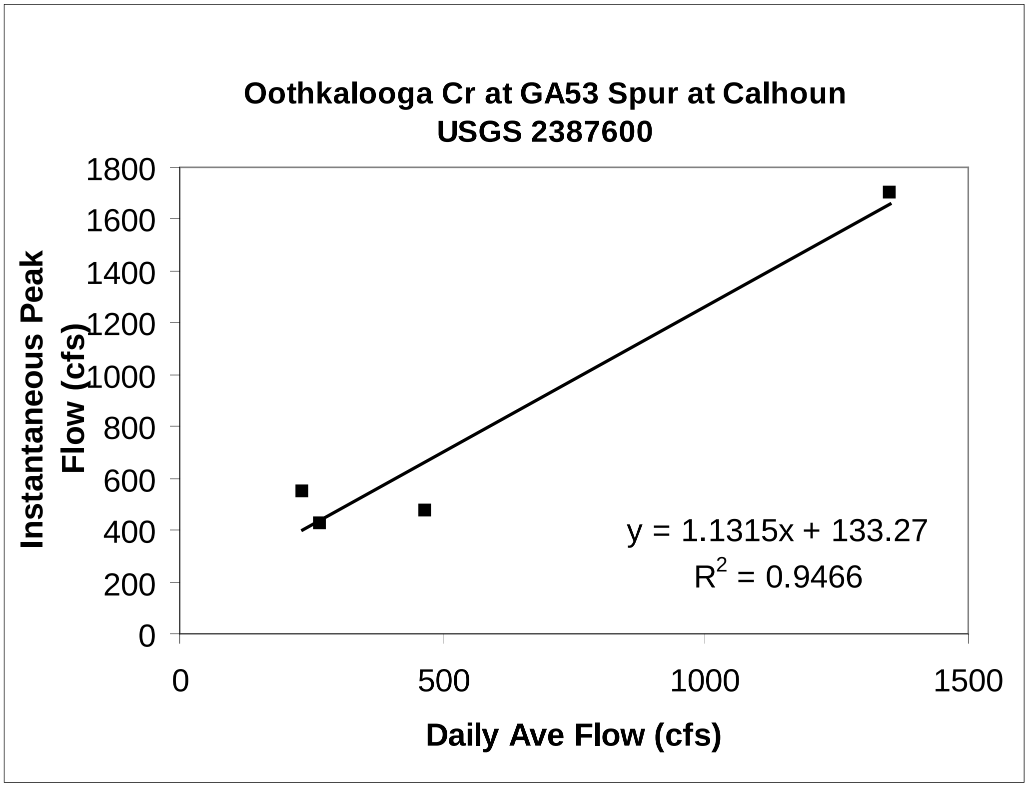

Figure O-A.25 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Oothkalooga Cr at Calhoun gage

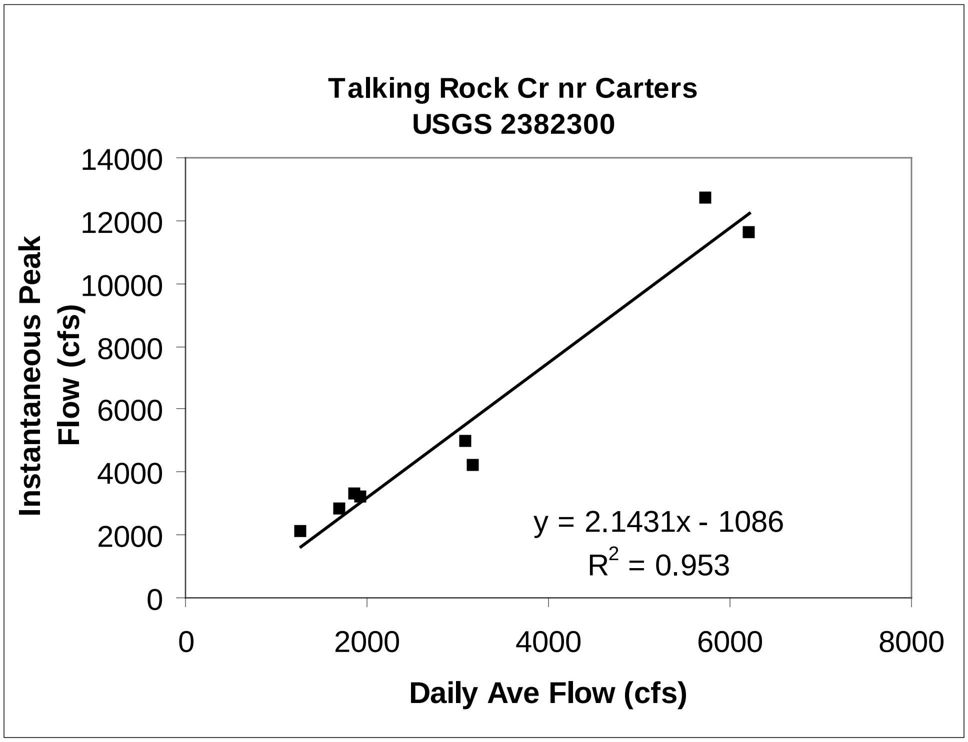

Figure O-A.26 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Talking Rock Cr nr Carters gage

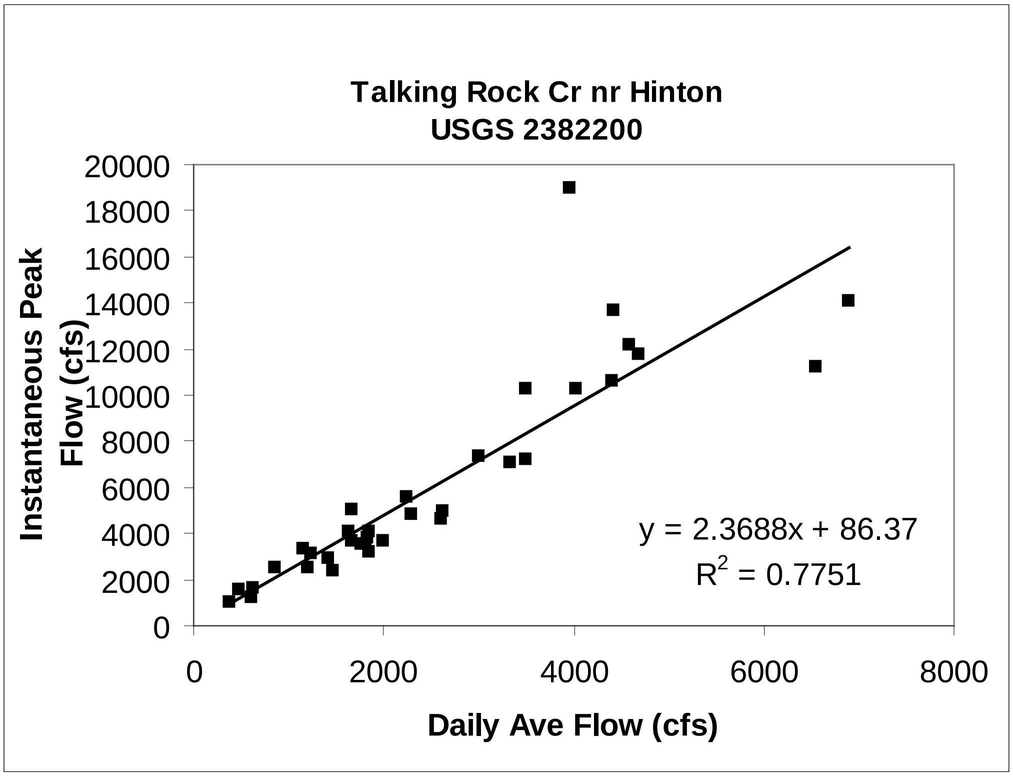

Figure O-A.27 Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Talking Rock Cr nr Hinton gage

Table O-A-03. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Amicalola Gage (2390000)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
14Aug1940 0000	1430	2500
06Jul1941 0000	2000	5200
18Feb1942 0000	2150	7450
30Dec1942 0000	1240	2680
20Mar1944 0000	1750	3460
14Feb1945 0000	965	1130
11Feb1946 0000	3320	5050
21Jan1947 0000	2990	4770
05Aug1948 0000	2940	5650
29Nov1948 0000	2900	5500
14Mar1950 0000	1800	3460
30Mar1951 0000	2000	2380
12Mar1952 0000	2940	5960

Table O-A-04. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Cartecay nr Elijay Gage (2379500)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
08 Apr 38, 24:00	8190	20,000
15 Feb 39, 24:00	1480	2,280
13 Aug 40, 24:00	1290	1,980
05 Jul 41, 24:00	923	1,700
17 Feb 42, 24:00	2660	3,360
29 Dec 42, 24:00	1730	3,620
27 Feb 44, 24:00	1960	3,120
17 Feb 45, 24:00	814	1,150
10 Feb 46, 24:00	4300	6,960
20 Jan 47, 24:00	3680	5,940
12 Feb 48, 24:00	2520	3,240
28 Nov 48, 24:00	1800	4,860
13 Mar 50, 24:00	4200	6,260
29 Mar 51, 24:00	5970	12,000
11 Mar 52, 24:00	2770	4,860
21 Feb 53, 24:00	1990	2,940
16 Jan 54, 24:00	5950	10,000
22 Mar 55, 24:00	2640	4,860
15 Apr 56, 24:00	1900	3,880
04 Apr 57, 24:00	3480	5,940
20 Dec 57, 24:00	964	2,280
21 Jan 59, 24:00	923	1,780
03 Mar 60, 24:00	741	1,140
25 Feb 61, 24:00	4960	5,300
12 Dec 61, 24:00	2310	7,760
30 Apr 63, 24:00	3550	6,440
26 Mar 64, 24:00	4000	6,160
04 Oct 64, 24:00	1540	5,420
04 Mar 66, 24:00	2880	5,010
23 Aug 67, 24:00	1930	4,090
05 Apr 68, 24:00	1530	2,230
02 Feb 69, 24:00	2360	3,240
04 Jun 70, 24:00	1480	2,730
24 Jan 71, 24:00	1320	1,980
10 Jan 72, 24:00	1770	2,790
28 May 73, 24:00	4270	9,100
13 Apr 74, 24:00	2230	4,720
25 Jan 75, 24:00	1670	2,740
15 May 76, 24:00	2910	4,640
30 Mar 77, 24:00	5340	9,190

Table O-A-05. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Conasauga nr Eton Gage 2384500).

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
12Feb1981 0000	1570.0	3680.0
05Jan1982 0000	8720.0	11200.0
03Dec1982 0000	5610.0	9910.0
05May1984 0000	8010.0	8880.0
03Feb1985 0000	7520.0	8510.0
20Feb1986 0000	2590.0	3030.0
21Jan1987 0000	5520.0	6850.0
22Jan1988 0000	3530.0	4940.0
02Mar1989 0000	12400.0	7140.0
17Feb1990 0000	17400.0	33200.0
25Dec1990 0000	7250.0	13600.0
04Dec1991 0000	5130.0	6790.0
25Mar1993 0000	4610.0	5490.0
29Mar1994 0000	23000.0	30000.0
18Feb1995 0000	16600.0	20800.0
28Jan1996 0000	11100.0	15600.0
04May1997 0600	6170.0	7370.0
20Apr1998 0600	10400.0	13400.0
07May1999 0400	6010.0	6990.0
04Apr2000 2030	8440.0	10100.0
21Mar2001 1200	4010.0	4600.0
25Jan2002 2315	6260.0	8370.0
08May2003 0030	13900.0	19700.0
17Sep2004 2245	10700.0	15600.0
25Nov2004 0815	5300.0	11000.0
18Jan2006 2215	2930.0	3730.0
16Nov2006 1815	1500.0	2610.0
07Feb2008 0600	4190.0	2340.0

Table O-A-06. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Conasauga nr Tilton Gage (2387000)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
11Apr1938 0000	19300.0	20300.0
18Feb1939 0000	11200.0	11300.0
17Mar1940 0000	5770.0	5880.0
09Jul1941 0000	4700.0	4700.0
20Feb1942 0000	19800.0	8090.0
01Jan1943 0000	15200.0	20700.0
31Mar1944 0000	16800.0	17900.0
21Feb1945 0000	9950.0	10700.0
13Feb1946 0000	21000.0	22400.0
22Jan1947 0000	24700.0	26000.0
15Feb1948 0000	21600.0	20800.0
01Dec1948 0000	15600.0	22500.0
16Mar1950 0000	18000.0	19300.0
31Mar1951 0000	26600.0	29000.0
14Mar1952 0000	11000.0	11000.0
25Feb1953 0000	9770.0	10800.0
19Jan1954 0000	18000.0	19100.0
10Feb1955 0000	8860.0	8970.0
07Feb1956 0000	11200.0	11600.0
04Feb1957 0000	23300.0	25000.0
21Nov1957 0000	15500.0	17500.0
23Apr1959 0000	9180.0	9530.0
06Mar1960 0000	11600.0	12100.0
26Feb1961 0000	19700.0	16500.0
21Dec1961 0000	14800.0	20700.0
16Mar1963 0000	15500.0	16600.0
18Mar1964 0000	17800.0	21100.0
29Mar1965 0000	18600.0	19500.0
07Mar1966 0000	12000.0	12100.0
11Jul1967 0000	12800.0	9530.0
25Dec1967 0000	7880.0	13400.0
05Feb1969 0000	16700.0	18200.0
05Apr1970 0000	8190.0	8330.0
09Feb1971 0000	8490.0	8820.0
08Jan1972 0000	7910.0	8070.0
19Mar1973 0000	23700.0	26300.0
01Dec1973 0000	9380.0	10500.0
02Apr1975 0000	16300.0	16800.0
08Jul1976 0000	10200.0	10400.0
07Apr1977 0000	17800.0	19700.0
10Nov1977 0000	10000.0	10700.0
07Mar1979 0000	18300.0	18900.0

… Continued …

Table O-A-07. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Conasauga nr Tilton Gage (2387000) - *Continued*

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
	… Continuation …	
24Mar1980 0000	22000.0	23500.0
14Feb1981 0000	5700.0	6300.0
07Jan1982 0000	18200.0	18700.0
05Dec1982 0000	10200.0	13500.0
07May1984 0000	12900.0	13600.0
05Feb1985 0000	9560.0	9870.0
20Feb1986 0000	6600.0	5960.0
03Mar1987 0000	11300.0	11500.0
23Jan1988 0000	7530.0	7820.0
03Mar1989 0000	18900.0	11100.0
18Feb1990 0000	32800.0	36800.0
26Dec1990 0000	13800.0	15600.0
29Feb1992 0000	8580.0	8850.0
27Mar1993 0000	7020.0	7210.0
30Mar1994 0000	25300.0	29100.0
19Feb1995 0000	19000.0	21000.0
30Jan1996 0000	19100.0	19600.0
05May1997 0900	12100.0	12400.0
22Apr1998 0000	18000.0	18000.0
08May1999 2200	9800.0	10200.0
06Apr2000 0900	14600.0	15000.0
22Mar2001 0630	8330.0	8660.0
27Jan2002 0945	10700.0	11000.0
09May2003 1000	24200.0	25000.0
19Sep2004 1745	18600.0	19300.0
26Nov2004 2000	12000.0	16700.0
19Jan2006 1530	6280.0	6480.0
17Nov2006 1000	4040.0	5520.0
08Mar2008 1515	8790.0	5200.0

Table O-A-08. Instantaneous Peak Flow vs. Daily Average Flow Relationship at Coosa nr Rome Gage (2397000)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
18Dec1927 0000	23200.0	23700.0
17Mar1929 0000	43500.0	43000.0
10Mar1930 0000	40500.0	44200.0
18Nov1930 0000	28300.0	30000.0
05Jan1937 0000	36500.0	60500.0
11Apr1938 0000	62600.0	66600.0
02Mar1939 0000	33000.0	34000.0
15Mar1940 0000	24000.0	25500.0
07Jul1941 0000	23200.0	25000.0
23Mar1942 0000	48000.0	39600.0
01Jan1943 0000	43200.0	48800.0
01Apr1944 0000	45400.0	45700.0
15Feb1945 0000	25900.0	27100.0
13Feb1946 0000	63600.0	69500.0
23Jan1947 0000	64600.0	71000.0

Table O-A-09. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Coosawattee nr Carters Gage (2381500)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
19260118	3990	5000
19270410	8670	9200
19280330	7950	9000
19290731	8100	13000
19291115	11400	11400
19310404	2900	4400
19611212	12400	17500
19630306	9680	17500
19640326	9650	17000

Table O-A-10. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Coosawattee at Carters Gage (2382500)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
13Dec1961 0000	19200.0	25200.0
07Mar1963 0000	12200.0	22600.0
27Mar1964 0000	16100.0	25800.0
06Oct1964 0000	21300.0	24100.0
05Mar1966 0000	15400.0	20900.0
25Aug1967 0000	8310.0	9220.0
23Dec1967 0000	7770.0	10100.0
03Feb1969 0000	10100.0	13800.0
06Jun1970 0000	4890.0	6910.0
25Jan1971 0000	5790.0	8030.0
05Jan1972 0000	8000.0	10100.0
26Jan1975 0000	3660.0	4240.0

Table O-A-11. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Coosawattee R at Ellijay Gage (2380500)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
16Feb1939 0000	3520.0	4570.0
14Aug1940 0000	1660.0	2500.0
06Jul1941 0000	1260.0	2040.0
18Feb1942 0000	5690.0	5790.0
30Dec1942 0000	3170.0	7470.0
28Feb1944 0000	3930.0	6090.0
14Feb1945 0000	2550.0	3500.0
11Feb1946 0000	8740.0	13000.0
21Jan1947 0000	8790.0	13000.0
13Feb1948 0000	6300.0	6490.0
29Nov1948 0000	4160.0	11400.0
05Mar1966 0000	1540.0	9210.0
24Aug1967 0000	8440.0	9470.0
23Dec1967 0000	3480.0	4110.0
03Feb1969 0000	5520.0	5810.0
05Jun1970 0000	4550.0	3610.0
25Jan1971 0000	2550.0	3100.0
11Jan1972 0000	4490.0	4410.0
29May1973 0000	2250.0	13400.0
01Jan1974 0000	2440.0	7090.0
26Jan1975 0000	2900.0	4060.0
16May1976 0000	7050.0	6500.0
31Mar1977 0000	2950.0	11000.0
06Nov1977 0000	3100.0	4400.0

Table O-A-12. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Coosawattee R at Pine Chapel Gage (2383500)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
17Feb1939 0000	9480.0	9680.0
14Jul1940 0000	6180.0	6560.0
17Jul1941 0000	4600.0	5290.0
19Feb1942 0000	18300.0	13500.0
31Dec1942 0000	13100.0	23300.0
31Mar1944 0000	13600.0	15900.0
15Feb1945 0000	9400.0	9750.0
12Feb1946 0000	23000.0	32000.0
22Jan1947 0000	19400.0	19400.0
14Feb1948 0000	23200.0	11300.0
30Nov1948 0000	13200.0	26700.0
15Mar1950 0000	23200.0	26200.0
31Mar1951 0000	31500.0	40200.0
13Mar1952 0000	11800.0	12300.0
11Jan1953 0000	9060.0	9310.0
18Jan1954 0000	26900.0	35200.0
09Feb1955 0000	12000.0	13800.0
18Apr1956 0000	10500.0	10800.0
07Apr1957 0000	19500.0	24600.0
20Nov1957 0000	5630.0	7980.0
15Feb1959 0000	6530.0	7100.0
05Mar1960 0000	9160.0	9840.0
27Feb1961 0000	24300.0	18200.0
14Dec1961 0000	15600.0	28200.0
08Mar1963 0000	17700.0	21600.0
27Mar1964 0000	23800.0	32000.0
28Mar1965 0000	10400.0	10600.0
06Mar1966 0000	16700.0	18400.0
26Aug1967 0000	10900.0	8820.0
12Jan1968 0000	11200.0	11500.0
04Feb1969 0000	13200.0	15000.0
22Mar1970 0000	7910.0	8680.0
26Jan1971 0000	8910.0	9360.0
13Jan1972 0000	10600.0	10900.0
30May1973 0000	19500.0	23200.0
02Jan1974 0000	10500.0	11200.0
15Mar1975 0000	6970.0	7910.0

Table O-A-13. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Etowah R at Allatoona abv Cartersville Gage (2394000)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
01Mar1939 0000	8910.0	11600.0
15Aug1940 0000	12400.0	13800.0
07Jul1941 0000	10900.0	12400.0
22Mar1942 0000	16500.0	18200.0
30Dec1942 0000	14800.0	18400.0
30Mar1944 0000	15500.0	16600.0
26Apr1945 0000	8820.0	9300.0
09Jan1946 0000	37100.0	40400.0

Table O-A-14. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Etowah R nr Canton Gage (2392000)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
04Jan1937 0000	13900.0	15300.0
09Apr1938 0000	14300.0	19700.0
01Mar1939 0000	4570.0	6360.0
14Aug1940 0000	7400.0	8900.0
06Jul1941 0000	6580.0	8820.0
18Feb1942 0000	10600.0	13300.0
31Dec1942 0000	6840.0	10100.0
21Mar1944 0000	9790.0	10600.0
26Apr1945 0000	4160.0	5180.0
08Jan1946 0000	22700.0	32300.0
22Jan1947 0000	13200.0	14500.0
06Aug1948 0000	15800.0	8500.0
30Nov1948 0000	12400.0	17200.0
15Mar1950 0000	7370.0	8500.0
31Mar1951 0000	9330.0	7790.0
24Mar1952 0000	16000.0	19500.0
11Jan1953 0000	7720.0	8140.0
18Jan1954 0000	14500.0	15500.0
08Feb1955 0000	11600.0	12600.0
17Apr1956 0000	6090.0	7300.0
06Apr1957 0000	11800.0	15500.0
22Dec1957 0000	4180.0	5440.0
15Feb1959 0000	4940.0	7230.0
05Apr1960 0000	5760.0	6320.0
27Feb1961 0000	19500.0	19300.0
14Dec1961 0000	7650.0	20900.0
01May1963 0000	19700.0	22600.0
27Mar1964 0000	20200.0	25000.0
26Mar1965 0000	6970.0	8740.0
05Mar1966 0000	16800.0	19000.0
26Aug1967 0000	15500.0	15900.0
12Jan1968 0000	10200.0	11000.0
24Aug1969 0000	10600.0	11900.0
21Mar1970 0000	5940.0	6590.0
25Jul1971 0000	4910.0	5790.0
12Jan1972 0000	13300.0	14200.0
17Dec1972 0000	9420.0	11200.0
06Apr1974 0000	9870.0	12300.0
15Mar1975 0000	10700.0	11900.0

Table O-A-15. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Etowah R nr Dawsonville Gage (2389000)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
14Aug1940 0000	1350.0	1840.0
06Jul1941 0000	1110.0	2200.0
18Feb1942 0000	2840.0	4100.0
30Dec1942 0000	1610.0	2430.0
21Mar1944 0000	1840.0	2640.0
17Sep1945 0000	1210.0	1820.0
08Jan1946 0000	3640.0	4780.0
21Jan1947 0000	3070.0	3660.0
05Aug1948 0000	2810.0	4050.0
07Jan1949 0000	2450.0	3870.0
14Mar1950 0000	1790.0	2760.0
30Mar1951 0000	2800.0	2120.0
12Mar1952 0000	3340.0	4100.0
11Jan1953 0000	1540.0	2120.0
17Jan1954 0000	3510.0	4150.0
08Feb1955 0000	2330.0	4010.0
17Apr1956 0000	1670.0	2520.0
06Apr1957 0000	2590.0	3000.0
21Dec1957 0000	692.0	1630.0
23Jan1959 0000	1270.0	2290.0
29Sep1960 0000	1240.0	1980.0
26Feb1961 0000	4320.0	4150.0
13Dec1961 0000	1590.0	5010.0
13Mar1963 0000	3500.0	4810.0
27Mar1964 0000	3890.0	4150.0
06Oct1964 0000	904.0	2670.0
05Mar1966 0000	4330.0	6140.0
25Aug1967 0000	5060.0	6140.0
13Mar1968 0000	2550.0	4470.0
23Aug1969 0000	1900.0	3500.0
01Jan1970 0000	1000.0	1490.0
23Jul1971 0000	1800.0	1790.0
15May1972 0000	2150.0	3500.0
29May1973 0000	3190.0	4770.0
05Apr1974 0000	1910.0	3420.0
15Mar1975 0000	2160.0	3710.0
01Apr1976 0000	2820.0	4130.0

Table O-A-16. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Etowah R at GA1 nr Rome Gage (2396000)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
02Mar1939 0000	17000.0	18000.0
15Aug1940 0000	14100.0	14400.0
08Jul1941 0000	12200.0	13200.0
23Mar1942 0000	28200.0	27000.0
31Dec1942 0000	24400.0	29000.0
31Mar1944 0000	23600.0	25200.0
27Apr1945 0000	12200.0	12000.0
10Jan1946 0000	36200.0	36900.0
22Jan1947 0000	28400.0	28900.0

Table O-A-17. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Etowah R at GA372 nr Ball Ground Gage (2391000)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
25Mar1908 0000	10800.0	10800.0
15Mar1909 0000	12700.0	14000.0
22May1910 0000	5680.0	6500.0
06Apr1911 0000	7980.0	7980.0
16Mar1912 0000	14300.0	14300.0
16Mar1913 0000	9180.0	9180.0
27Dec1914 0000	7390.0	8780.0
23Dec1918 0000	19500.0	22200.0
11Dec1919 0000	8300.0	17600.0
10Feb1921 0000	11800.0	11800.0

Table O-A-18. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Etowah R at the Kingston Gage (2359000)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
03May1929 0000	28200.0	29700.0
08Mar1930 0000	26400.0	29900.0
17Nov1930 0000	13700.0	12600.0
04Jan1937 0000	31400.0	31800.0
10Apr1938 0000	40900.0	42700.0
01Mar1939 0000	15100.0	17600.0
15Aug1940 0000	14200.0	14500.0
08Jul1941 0000	11200.0	12600.0
23Mar1942 0000	27400.0	28000.0
30Dec1942 0000	21900.0	29800.0
31Mar1944 0000	21700.0	23100.0
26Apr1945 0000	10500.0	11700.0
10Jan1946 0000	36500.0	39000.0
22Jan1947 0000	29300.0	29900.0

Table O-A-19. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Etowah R at Rome Gage (2396000)

(this is the same gage as Etowah R at GA1 Loop nr Rome 2395980, above)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
02Mar1939 0000	17000.0	18000.0
15Aug1940 0000	14100.0	14400.0
08Jul1941 0000	12200.0	13200.0
23Mar1942 0000	28200.0	27000.0
31Dec1942 0000	24400.0	29000.0
31Mar1944 0000	23600.0	25200.0
27Apr1945 0000	12200.0	12000.0
10Jan1946 0000	36200.0	36900.0
22Jan1947 0000	28400.0	28900.0

Table O-A-20. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Hills Cr at Taylorsville Gage (2394950)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
01Feb1960 0000	334.0	624.0
22Feb1961 0000	1550.0	3000.0
13Dec1961 0000	648.0	2500.0
13Mar1963 0000	875.0	3900.0
27Mar1964 0000	864.0	1450.0
13Apr1965 0000	327.0	805.0
05Mar1966 0000	629.0	1110.0
27Apr1967 0000	497.0	1050.0
06Apr1968 0000	476.0	697.0
21Jan1969 0000	239.0	423.0
21Mar1970 0000	512.0	1820.0
24Apr1971 0000	418.0	1130.0
05Jan1972 0000	667.0	1510.0
17Mar1973 0000	452.0	1460.0
05Apr1974 0000	697.0	3460.0

Table O-A-21. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Holly Cr at Chatsworth Gage (2385800)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
24Feb1961 0000	3220.0	3480.0
13Dec1961 0000	1750.0	4920.0
13Mar1963 0000	3080.0	4810.0
16Mar1964 0000	3990.0	6040.0
27Mar1965 0000	2800.0	4700.0
14Feb1966 0000	2640.0	3840.0
28Aug1967 0000	1770.0	2430.0
23Dec1967 0000	1130.0	2700.0
03Feb1969 0000	2170.0	2850.0
01Jan1970 0000	1100.0	2030.0
01Aug1971 0000	942.0	1510.0
06Jan1972 0000	1400.0	1410.0
29May1973 0000	2820.0	4170.0
01Jan1974 0000	2010.0	4700.0
31Mar1975 0000	2200.0	3350.0
06Jul1976 0000	1790.0	2520.0
06Apr1977 0000	3370.0	5500.0
10Jan1978 0000	2560.0	3780.0
05Mar1979 0000	4650.0	9110.0
15Apr1980 0000	2800.0	4210.0
12Feb1981 0000	1200.0	1560.0
05Jan1982 0000	3510.0	4430.0
02Dec1982 0000	1980.0	3380.0
29Dec1983 0000	1750.0	2600.0
02Feb1985 0000	1400.0	1560.0
19Feb1986 0000	1040.0	1170.0
20Jan1987 0000	1940.0	2370.0
21Jan1988 0000	1350.0	1910.0
21Jun1989 0000	3290.0	4260.0
17Feb1990 0000	9890.0	20600.0
24Dec1990 0000	2490.0	9150.0
15Jun1992 0000	2030.0	3540.0
18Dec1992 0000	916.0	2040.0
29Mar1994 0000	3630.0	6490.0
17Feb1995 0000	2780.0	6420.0
28Jan1996 0000	4510.0	7630.0
03May1997 1300	3630.0	4520.0
19Apr1998 1900	2780.0	4980.0
15Jan1999 1000	1350.0	1760.0
04Apr2000 1000	2300.0	2440.0
25Jul2001 1830	2140.0	4310.0
04May2002 2200	2330.0	3170.0
22May2003 1730	3920.0	7520.0
17Sep2004 0930	6620.0	9680.0
24Nov2004 1800	2630.0	11000.0
18Jan2006 0615	838.0	1070.0
16Nov2006 0800	443.0	919.0
04Mar2008 2315	808.0	681.0

Table O-A-22. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Oostanaula R at Resaca Gage (2387500)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
15Feb1900 0000	18000.0	18800.0
14Jan1901 0000	22000.0	22700.0
01Jan1902 0000	21000.0	22300.0
03Mar1903 0000	23500.0	23800.0
25Mar1904 0000	8180.0	8340.0
23Feb1905 0000	17000.0	17300.0
17Mar1906 0000	31000.0	16900.0
21Nov1906 0000	12900.0	31700.0
17Feb1908 0000	14900.0	15100.0
15Mar1909 0000	35400.0	39900.0
22May1910 0000	14600.0	15100.0
10Apr1911 0000	16400.0	16900.0
01Apr1912 0000	19400.0	20000.0
17Mar1913 0000	20000.0	20900.0
16Apr1914 0000	14700.0	10800.0
03Feb1915 0000	18700.0	16900.0
13Jul1916 0000	23000.0	23300.0
07Mar1917 0000	31700.0	33500.0
01Feb1918 0000	18000.0	18400.0
25Dec1918 0000	17400.0	16900.0
05Apr1920 0000	35000.0	39900.0
12Feb1921 0000	41000.0	44400.0
23Jan1922 0000	34000.0	40800.0
19Dec1922 0000	12900.0	15500.0
21Apr1924 0000	19000.0	20000.0
21Jan1925 0000	16300.0	16600.0
20Jan1926 0000	19500.0	12400.0
30Dec1926 0000	15000.0	20000.0
01Apr1928 0000	15500.0	16100.0
26Mar1929 0000	26000.0	17300.0
18Nov1929 0000	17900.0	26700.0
06Apr1931 0000	18000.0	13400.0
17Dec1931 0000	36200.0	18400.0
30Dec1932 0000	22000.0	36500.0
07Mar1934 0000	24600.0	25300.0
14Mar1935 0000	14100.0	15300.0
04Apr1936 0000	35000.0	35300.0
06Jan1937 0000	23100.0	23500.0
10Apr1938 0000	36800.0	37700.0
18Feb1939 0000	16200.0	17000.0
15Mar1940 0000	10100.0	10700.0
09Jul1941 0000	8610.0	9150.0

… Continued …

Table O-A-23. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Oostanaula R at Resaca Gage (2387500) - *Continued*

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
	… Continuation …	
20Feb1942 0000	32000.0	18000.0
30Dec1942 0000	28500.0	33000.0
01Apr1944 0000	27700.0	28300.0
16Feb1945 0000	14500.0	14700.0
12Feb1946 0000	39400.0	42200.0
22Jan1947 0000	44400.0	47000.0
16Feb1948 0000	35000.0	26800.0
01Dec1948 0000	24800.0	36300.0
16Mar1950 0000	31300.0	31900.0
01Apr1951 0000	50000.0	54800.0
26Mar1952 0000	19700.0	20100.0
24Feb1953 0000	15300.0	15600.0
19Jan1954 0000	30100.0	30700.0
10Feb1955 0000	18500.0	19100.0
19Apr1956 0000	17900.0	18200.0
05Feb1957 0000	31700.0	32800.0
22Nov1957 0000	17200.0	20000.0
21Apr1959 0000	12000.0	12100.0
06Mar1960 0000	16300.0	17000.0
28Feb1961 0000	32000.0	31700.0
15Dec1961 0000	25400.0	32400.0
03May1963 0000	25200.0	25700.0
18Mar1964 0000	30500.0	32000.0
30Mar1965 0000	25000.0	25000.0
07Mar1966 0000	24500.0	25200.0
27Aug1967 0000	22800.0	14200.0
26Dec1967 0000	18900.0	23300.0
06Feb1969 0000	22400.0	26800.0
23Mar1970 0000	13600.0	13700.0
27Jan1971 0000	15700.0	16100.0
14Jan1972 0000	17800.0	18100.0
20Mar1973 0000	27500.0	29000.0
04Jan1974 0000	18700.0	18900.0
03Apr1975 0000	18200.0	18800.0

Table O-A-24. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Oostanaula R at Rome Gage (2388500)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
16Mar1940 0000	14200.0	15000.0
09Jul1941 0000	10800.0	12800.0
25Mar1942 0000	22100.0	19700.0
03Jan1943 0000	29300.0	29900.0
02Apr1944 0000	27300.0	29100.0
16Feb1945 0000	18700.0	19400.0
14Feb1946 0000	45400.0	45500.0
24Jan1947 0000	45700.0	47000.0
19Feb1948 0000	35500.0	28200.0
03Dec1948 0000	24300.0	37300.0
18Mar1950 0000	29900.0	30500.0
03Apr1951 0000	43100.0	43600.0
13Mar1952 0000	23100.0	23900.0
23Feb1953 0000	18400.0	18800.0
24Jan1954 0000	28800.0	28900.0
08Feb1955 0000	22700.0	23800.0
18Apr1956 0000	20000.0	20600.0
07Feb1957 0000	32300.0	32500.0
21Nov1957 0000	17100.0	21300.0
22Apr1959 0000	14600.0	15100.0
06Mar1960 0000	18400.0	18600.0
25Feb1961 0000	32500.0	32700.0
20Dec1961 0000	28000.0	33700.0
02May1963 0000	26500.0	27000.0
29Mar1964 0000	29700.0	30200.0
01Apr1965 0000	26100.0	26300.0
06Mar1966 0000	26700.0	27500.0
12Jul1967 0000	23700.0	19000.0
24Dec1967 0000	23200.0	24300.0
08Feb1969 0000	23100.0	23200.0
23Mar1970 0000	18100.0	18500.0
27Jan1971 0000	18500.0	18800.0
15Jan1972 0000	21000.0	21000.0
23Mar1973 0000	23900.0	24100.0
07Apr1974 0000	21700.0	22600.0
01Apr1975 0000	20400.0	21400.0

Table O-A-25. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Oothkalooga Cr at GA 53 Spur at Calhoun Gage (2387600)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
28Jun2005 0400	1350.0	1700.0
21Mar2006 0715	468.0	477.0
16Nov2006 0215	234.0	551.0
11May2008 0745	266.0	428.0

Table O-A-26. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Talking Rock Cr at Carters Gage (2382300)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
27Mar1964 0000	6220.0	11600.0
05Oct1964 0000	1870.0	3300.0
05Mar1966 0000	5740.0	12700.0
25Aug1967 0000	1940.0	3200.0
11Jan1968 0000	3170.0	4200.0
03Feb1969 0000	3090.0	4980.0
20Mar1970 0000	1270.0	2080.0
25Jan1971 0000	1700.0	2830.0

Table O-A-27. Instantaneous Peak Flow vs. Daily Average Flow Relationship at the Talking Rock Cr at Hinton Gage (2382300)

Date	Daily Average Flow cfs	Instantaneous Peak Flow cfs
14Apr1974 0000	2290.0	4850.0
03Jul1975 0000	1760.0	3550.0
16May1976 0000	2600.0	4600.0
05Apr1977 0000	4030.0	10300.0
06Nov1977 0000	1630.0	4060.0
05Mar1979 0000	6890.0	14100.0
22Mar1980 0000	3340.0	7090.0
05Jun1981 0000	858.0	2500.0
04Jan1982 0000	4680.0	11800.0
03Feb1983 0000	1840.0	3170.0
21Mar1984 0000	1810.0	3570.0
02Feb1985 0000	1460.0	2370.0
22Aug1986 0000	622.0	1620.0
01Mar1987 0000	1990.0	3680.0
21Jan1988 0000	1210.0	2530.0
01Oct1989 0000	2620.0	4980.0
17Feb1990 0000	6550.0	11200.0
24Dec1990 0000	1850.0	4050.0
03Jul1992 0000	1830.0	3800.0
26Nov1992 0000	1150.0	3330.0
28Mar1994 0000	3000.0	7320.0
17Feb1995 0000	2250.0	5590.0
28Jan1996 0000	4590.0	12200.0
03May1997 0600	3500.0	7240.0
17Apr1998 0430	4420.0	13700.0
07May1999 1930	1230.0	3110.0
03Apr2000 0345	4410.0	10600.0
19Jan2001 1415	1660.0	3640.0
25Jan2002 0100	1420.0	2940.0
17Jul2003 0000	3960.0	19000.0
17Sep2004 0000	3500.0	10300.0
09Dec2004 0930	1670.0	5050.0
18Jan2006 0000	615.0	1240.0
15Nov2006 2115	479.0	1560.0
04Mar2008 1815	372.0	1040.0

Appendix O-B

Development of Unimpaired Flow Frequency Curves at Rome

Appendix O-B

Development of Unimpaired Flow Frequency Curves at Rome

The following procedure developed by HEC staff shows how the peak, 1-day, 3-day, 5-day, and 45-day unimpaired frequency curves were developed for the Coosa River at Rome.

The 1-day, 3-day, 5-day, and 45-day unimpaired volume duration frequency curves at Rome were initially computed using the Hydrologic Engineering Center's Statistical Software Package (HEC-SSP) and the 1939 – 2007 unimpaired flow data set. These curves are shown in Figure O-B.01. One of the outputs from the HEC-SSP analysis is a series of 1-day maximum flows for each year. HEC-DSSVue was used to copy this record and then these annual maximum daily average flows were converted to instantaneous maximums using the instantaneous peak flow vs. daily average flow relationship developed from USGS gage data, as shown in Appendix O-A and in Figure O-B.02 below. Table O-B-01 contains the 1-day annual maximum and the instantaneous peak flows computed using the linear relationship shown in Figure O-B.02.

The computed instantaneous peak flows were then imported into HEC-SSP and a General Frequency Analysis was performed on the instantaneous peak flow data. Currently, there is no option in HEC-SSP to plot results from Volume-Duration and Bulletin 17B analyses in one graph. Therefore, a spreadsheet was developed that takes output from HEC-SSP and plots all the frequency curves in one graph, as shown in Figure O-B.03 and contained in Table O-B-02.

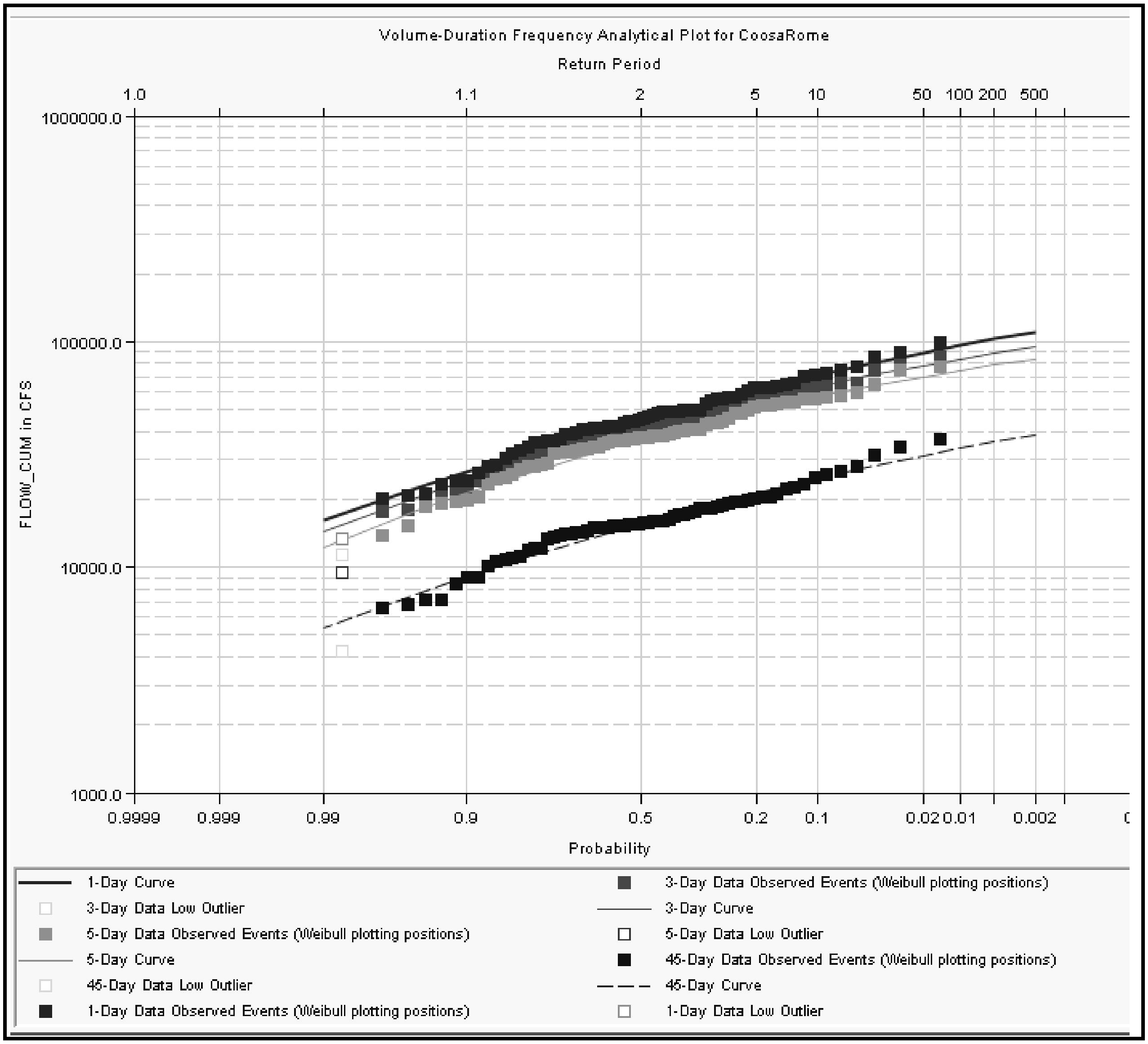

Figure O-B.01 The 1-Day, 3-Day, 5-day and 45-Day Unimpaired Volume Frequency Curves at CoosaRome Gage

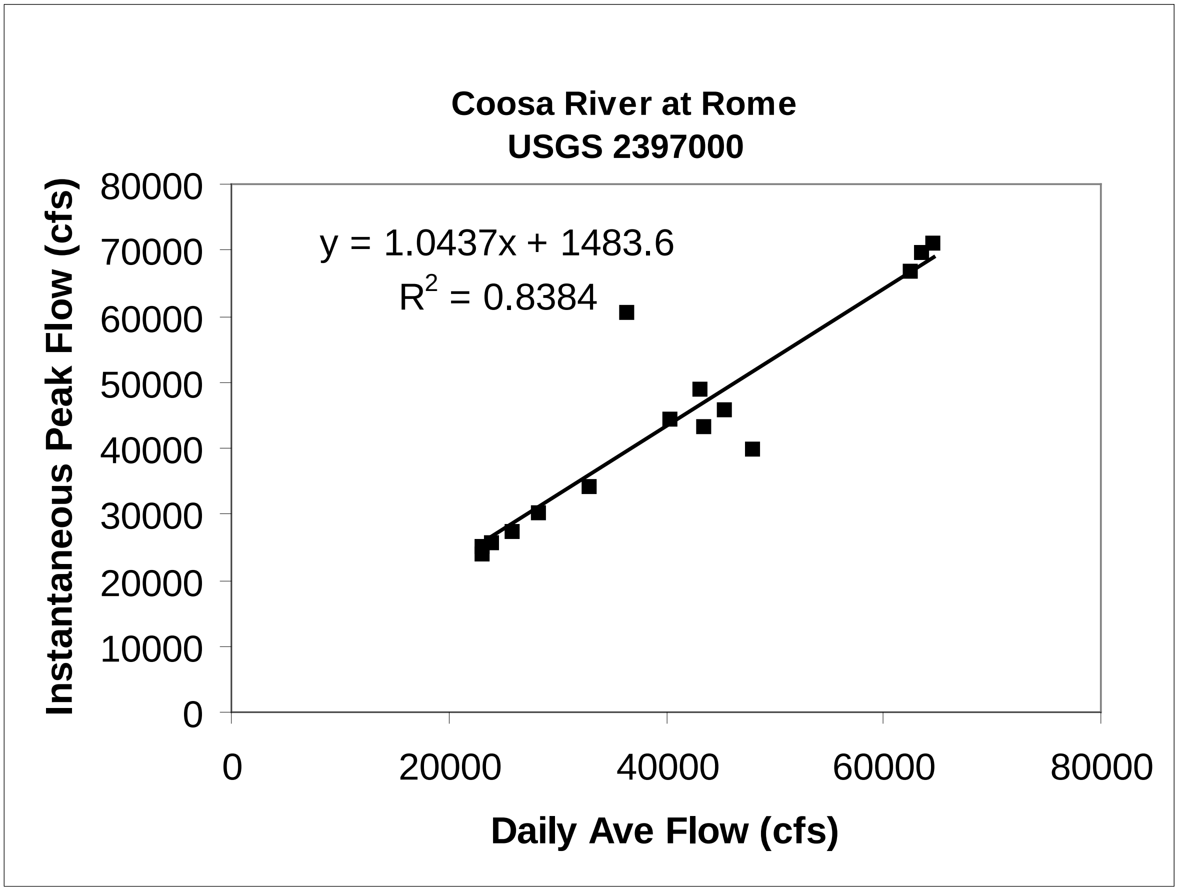

Figure O-B.02 Instantaneous Peak Flow vs. Daily Average Flow Relationship from USGS data at the Coosa Rome Gage

Table O-B-01. 1-Day Max. and Instantaneous Peak Flows at Rome from HEC-SSP

Date	1-Day Annual Maximum CFS	Instantaneous Annual Peak (Compute) CFS
15Mar1940 0000	24027	26560
08Jul1941 0000	23227	25725
01Jan1943 0000	48027	51609
02Jan1943 0000	43227	46599
01Apr1944 0000	45427	48896
16Feb1945 0000	25927	28543
13Feb1946 0000	63627	67891
23Jan1947 0000	64627	68935
02Dec1948 0000	62027	66221
09Jan1949 0000	41327	44616
15Mar1950 0000	41209	44494
31Mar1951 0000	56479	60431
25Mar1952 0000	54809	58688
12Jan1953 0000	33605	36557
18Jan1954 0000	48499	52102
09Feb1955 0000	42033	45353
18Mar1956 0000	31840	34715
07Apr1957 0000	55333	59235
04May1958 0000	21092	23497
21Apr1959 0000	28264	30983
06Mar1960 0000	35329	38357
15Dec1961 0000	88524	93876
15Apr1962 0000	60453	64578
02May1963 0000	57816	61826
28Mar1964 0000	74225	78952
28Mar1965 0000	36412	39487
06Mar1966 0000	54594	58463
27Aug1967 0000	41895	45210
12Jan1968 0000	43990	47396
05Feb1969 0000	35435	38467
23Mar1970 0000	38705	41880
05Mar1971 0000	32570	35477
13Jan1972 0000	48265	51858
19Mar1973 0000	41747	45055
06Apr1974 0000	49157	52789
16Mar1975 0000	46277	49783
02Apr1976 0000	62880	67112
07Apr1977 0000	71602	76214
28Jan1978 0000	44931	48378
15Apr1979 0000	85061	90262
23Mar1980 0000	62257	66462
13Feb1981 0000	27570	30258
05Feb1982 0000	77235	82094
08Dec1983 0000	52623	56406

… Continued …

Table O-B-01. 1-Day Max. and Instantaneous Peak Flows at Rome from HEC-SSP
- Continued

Date	1-Day Annual Maximum CFS	Instantaneous Annual Peak (Compute) CFS
	… Continuation …	
05May1984 0000	40289	43533
04Feb1985 0000	30119	32919
28Nov1986 0000	20023	22382
02Mar1987 0000	48446	52046
22Jan1988 0000	36042	39101
03Oct1989 0000	70862	75442
19Mar1990 0000	98485	104272
22Feb1991 0000	40206	43446
28Feb1992 0000	39087	42278
14Jan1993 0000	48955	52578
30Mar1994 0000	40859	44128
07Oct1995 0000	49350	52990
29Jan1996 0000	68958	73455
03Mar1997 0000	48510	52114
06Feb1998 0000	61633	65810
03Feb1999 0000	23766	26288
06Apr2000 0000	43582	46971
22Mar2001 0000	35970	39025
02Apr2002 0000	38401	41563
09May2003 0000	55910	59837
19Sep2004 0000	47087	50628
13Jul2005 0000	49293	52931
18Nov2006 0000	20513	22893
04Mar2007 0000	13274	15338

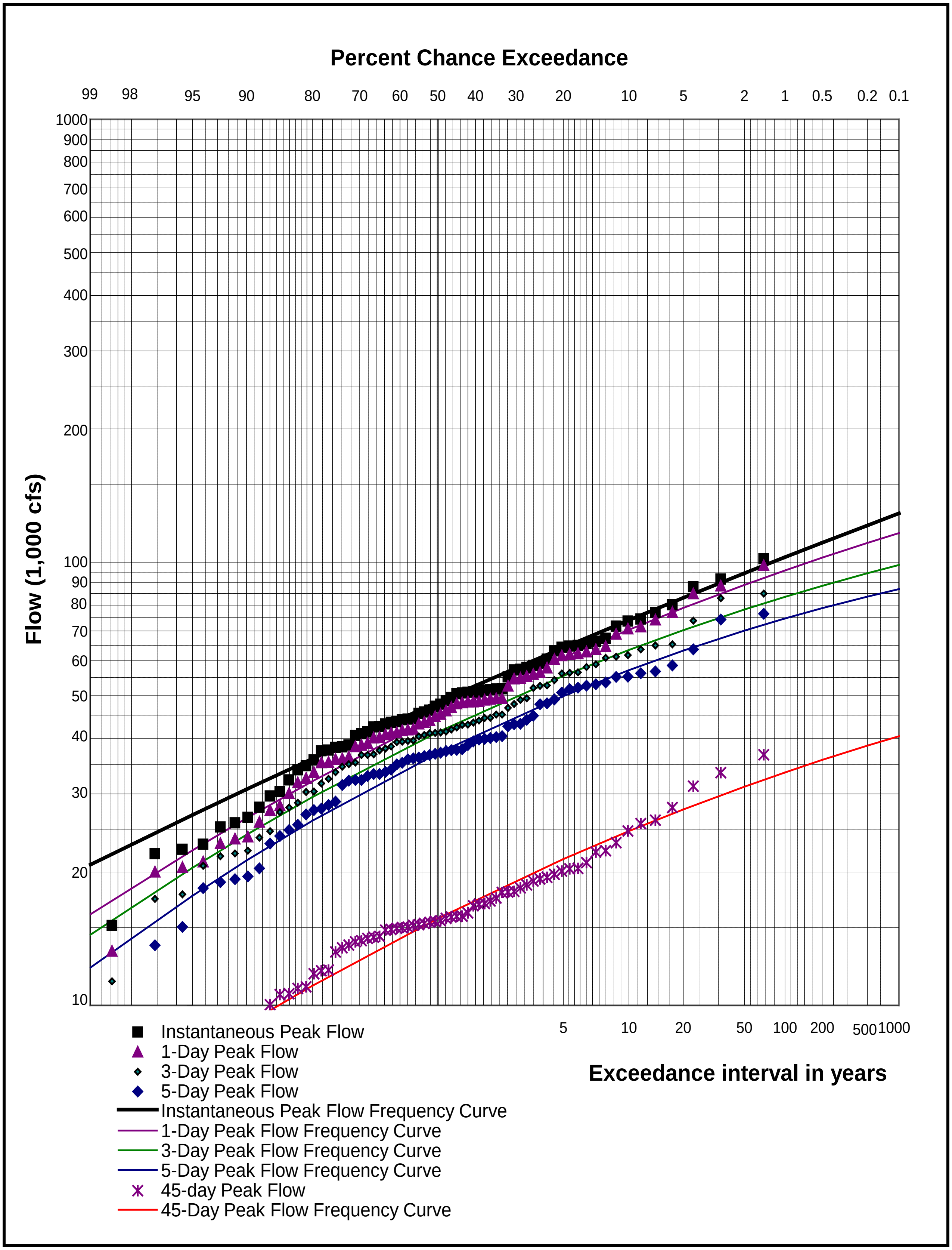

Figure O-B.03 Peak, 1-Day, 3-Day, 5-day and 45-Day Frequency Curves at Rome

Table O-B-02. Peak, 1-Day, 3-Day, 5-day and 45-Day Frequency Curves at Rome.

Frequency	Peak	1-Day	3-Day	5-Day	45-Day
99.0	20,767	16,061	14,449	12,171	5,374
95.0	26,871	22,385	20,446	17,676	7,617
90.0	30,723	26,442	24,272	21,217	9,065
80.0	36,022	32,046	29,511	26,082	11,069
50.0	48,377	44,993	41,360	37,062	15,703
20.0	64,183	60,938	55,372	49,877	21,378
10.0	74,047	70,432	63,387	57,075	24,728
5.0	83,123	78,829	70,268	63,159	27,670
2.0	94,425	88,835	78,206	70,053	31,144
1.0	102,645	95,798	83,563	74,624	33,542
0.5	110,674	102,354	88,480	78,756	35,783
0.2	121,086	110,504	94,421	83,661	38,545
0.1	128,856	116,336	98,556	87,015	40,504

Appendix O-C

Development and Calibration of HEC-HMS Model

Appendix O-C

Development and Calibration of HEC-HMS Model

General

The 4040 square mile ACT basin above Rome, GA is formed by the Oostanaula River and the Etowah River basins. These rivers join at Rome, GA to form the Coosa River. The Oostanaula and Etowah Rivers have approximately the same drainage area. The Oostanaula River is formed by the Conasauga and Coosawattee Rivers near Resaca, GA. Carters Dam and Carters Reregulation Dam are located on the Coosawattee River. Allatoona Dam is located on the Etowah River. The area is shown in Figure O-C.01 below.

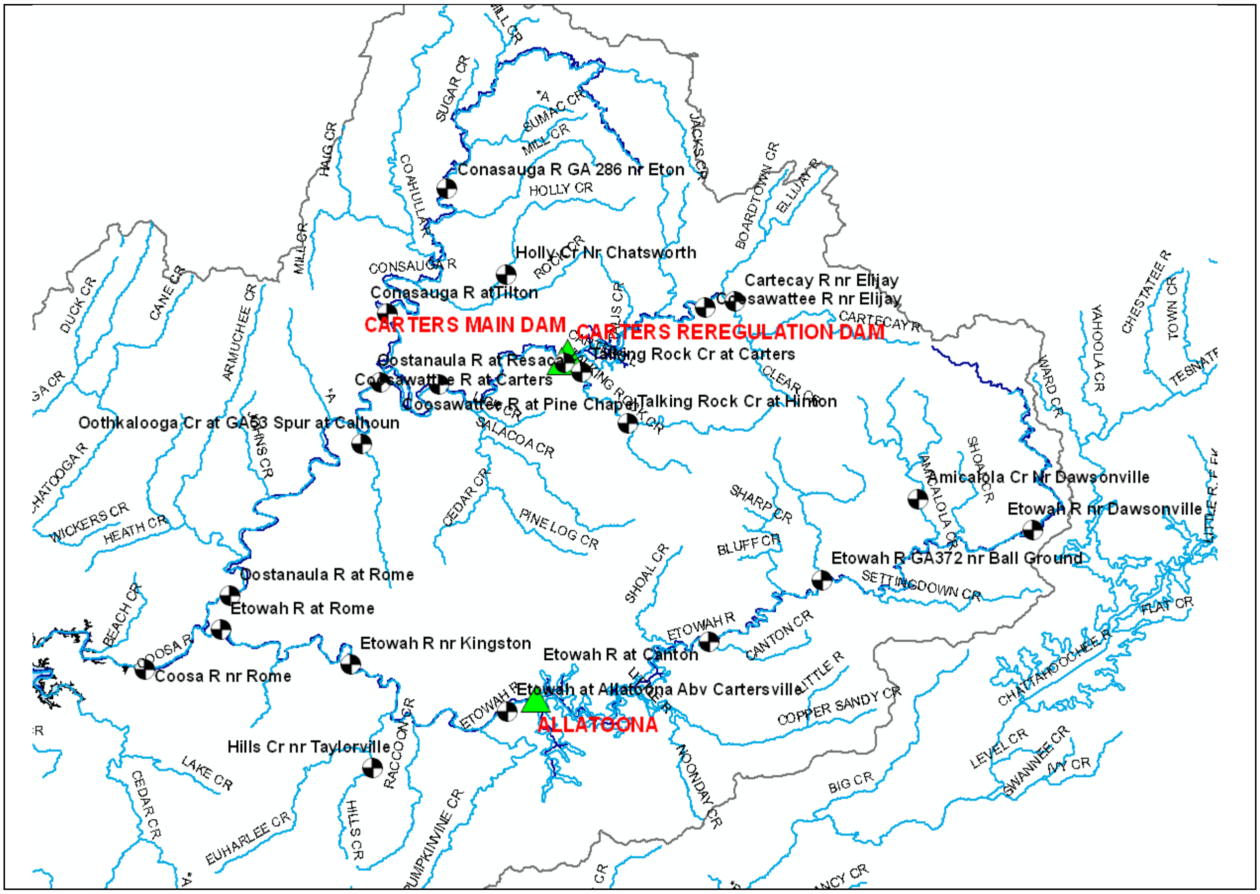

Figure O-C.01 **Drainage Basin above Rome, GA.**

A routing model of the basin was constructed using version 3.3 of the Hydrologic Engineering Center’s application Hydrologic Modeling System (HEC-HMS). The model is similar to the HEC-ResSim model previously developed for the area. A schematic of the watershed is shown in Figure O-C.02. The data developed from the HEC-HMS model will be used in the HEC-ResSim model to route design frequency events to evaluate the impact at Rome of varied operating plans at Carters Dam and Allatoona Dam. The flows for the design frequency events were generated by adjusting three historic storms’ flows up or down to match the target design flow frequency at Rome. The target design flows were the 5-, 2-, 1-, 0.5-, and 0.2-percent exceedance events. This was done for the 1961, 1979, and 1990 storms so that varied storm distributions could be evaluated.

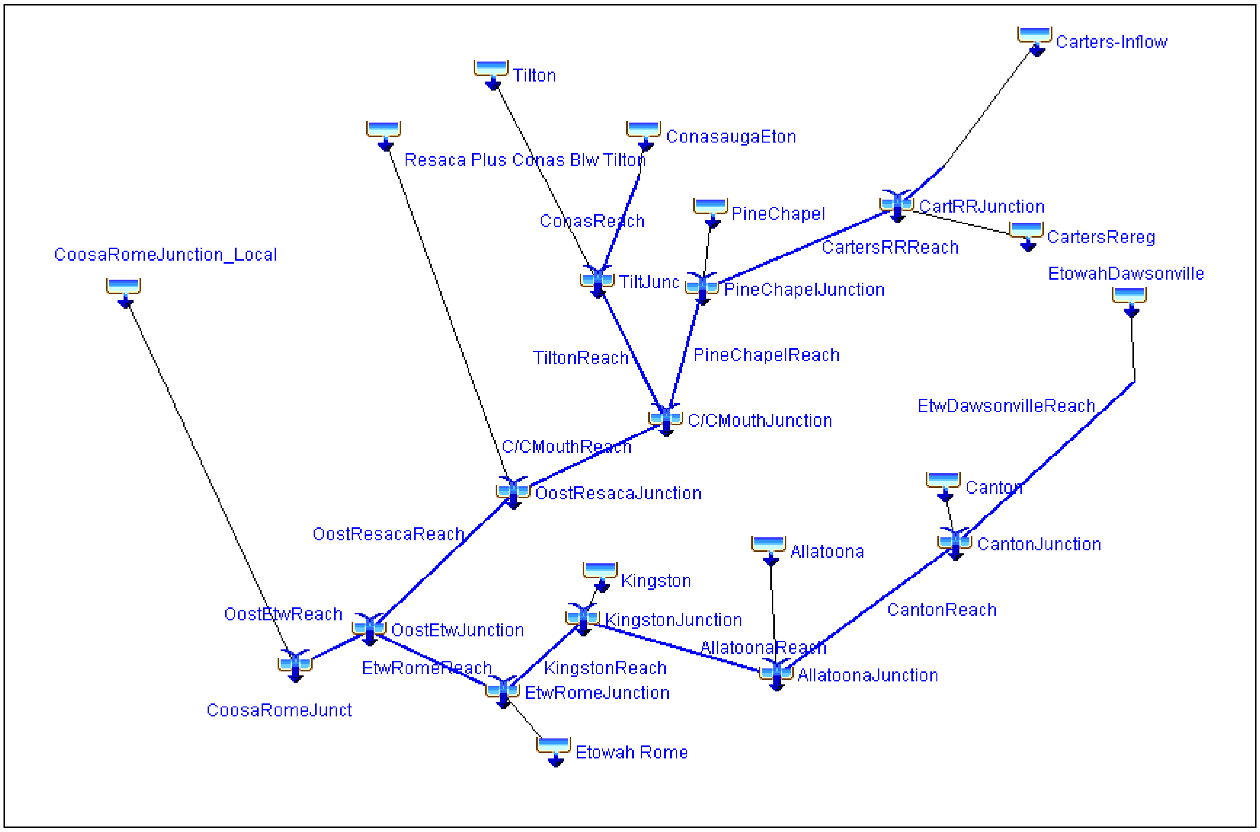

Figure O-C.02 HEC-HMS Schematic

Calibration

The calibration was done using the 1990 flood event existing daily average flow local runoff hydrographs produced in the ACT/ACT Comprehensive Water Resources Study, Surface Water Availability, Volume I, Unimpaired Flow, Corps of Engineers, Mobile District, July 8, 1997. (COE,1997)   These local hydrographs, as well as hydrographs at the upper reach inflow points and at node/gage (junction) locations were converted to hourly hydrographs using the methods described in Section **2.4** of this report. The hourly local inflow and inflow point hydrographs were entered as input to the HMS model. Hourly hydrographs were then computed using HMS at the node/gage locations (junctions). These were checked against the 1990 hourly hydrographs derived at the node/gage locations to adjust the Muskingum parameters.

Development of Local Inflow Hydrographs

As stated above, the local hourly hydrographs for the 1990 flood were determined from the daily values available from the previous (COE, 1997) study.

However, local hydrographs for the 1961 and 1979 events were determined using a different method for reasons explained below. These local hydrographs were determined using only the cumulative hourly flow hydrographs derived at the nodes/gages/junctions as described in **Section 2.4**. Using the calibrated model, these hourly junction hydrographs were routed downstream and subtracted from the next downstream junction hydrograph to compute the local hydrographs between junctions. For the most upstream inflow reaches the hourly hydrographs were developed as described in **Section 2.4** from the average daily values in the COE 1997 study.

This process of determining the local hydrographs by subtracting the junction hydrographs from the routed upstream hydrograph was used for the 1961 and 1979 floods to circumvent the difficulty in calibration of the HEC-HMS model developed for the ACF basin. See the footnote below [1].

The Muskingum parameters developed from the 1990 flood are shown in Table O-C-01, below. The Muskingum K for the C/CMouthReach seemed a bit long. However, it was set by looking at the hydrograph peaks at PineChapelJunction and the OostResacaJunction. Possibly high flows at the confluence of the Conasauga and Coosawattee caused some detention and attenuation.

Table O-C-01. HEC-HMS Routing Parameters

River	Reach Description	HMS Reach Name	Length (mi)	Musk "K"	Musk "X"	Sub-reaches
Coosa	Oostanaula/Etowah confluence to Rome(Coosa) gage (Mayos Bar)	OostEtwReach	7.1	4	0	1
Etowah	Rome(Etowah) gage to Oostanaula/Etowah confluence	EtwRomeReach	2.4	2	0	1
Etowah	Kingston gage to Rome(Etowah) gage	KingstonReach	20	8	0	1
Etowah	Allatoona gage to Kingston gage	AllatoonaReach	26	8	0	1
Etowah	Allatooona gage to Canton Gage	CantonReach	29	3	0	1
Etowah	Dawsonville gage to Canton gage	EtwDawsonvilleReach	51	15	0	1
Oostanaula	Resaca gage to Oostanaula/Etowah confluence	OostResacaReach	45	24	0	1
Oostanaula	Conasauga/Coosawattee confluence to Resaca gage	C/CMouthReach	3.7	14	0	1
Coosawattee	Pine Chapel gage to Conasauga/ Coosawattee confluence	PineChapelReach	6.5	4	0	1
Coosawattee	Carters Rereg gage to Pine Chapel gage	CartersRRReach	18.6	30	0	2
Conasauga	Tilton gage to Conasauga/ Coosawattee confluence	TiltonReach	12.1	8	0	1
Conasauga	Eton gage to Tilton gage	ConasauagEton	31.3	12	0	1

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[1] Basically, several of the ACF routing reaches in that basin were short and the daily time step used in the HEC-HMS model for the COE 1997 study resulted in the use of lag routing in these reaches. This resulted in some negative values in the local inflow hydrographs and accumulated volume errors in the downstream reaches. In an effort to avoid this error in the hourly hydrographs, it was decided to use the hourly gage data to re-compute the local hourly hydrographs where possible. The ACF hydrograph development is documented in the report, Development Of Unimpaired Hourly Hypothetical Storm Hydrographs for the Apalachicola-Chattahoochee-Flint River System from West Point to Columbus, Corps of Engineers, July 2009.

The model calibration results using the 1990 flood are shown in Figure O-C.03 through Figure O-C.11 below.

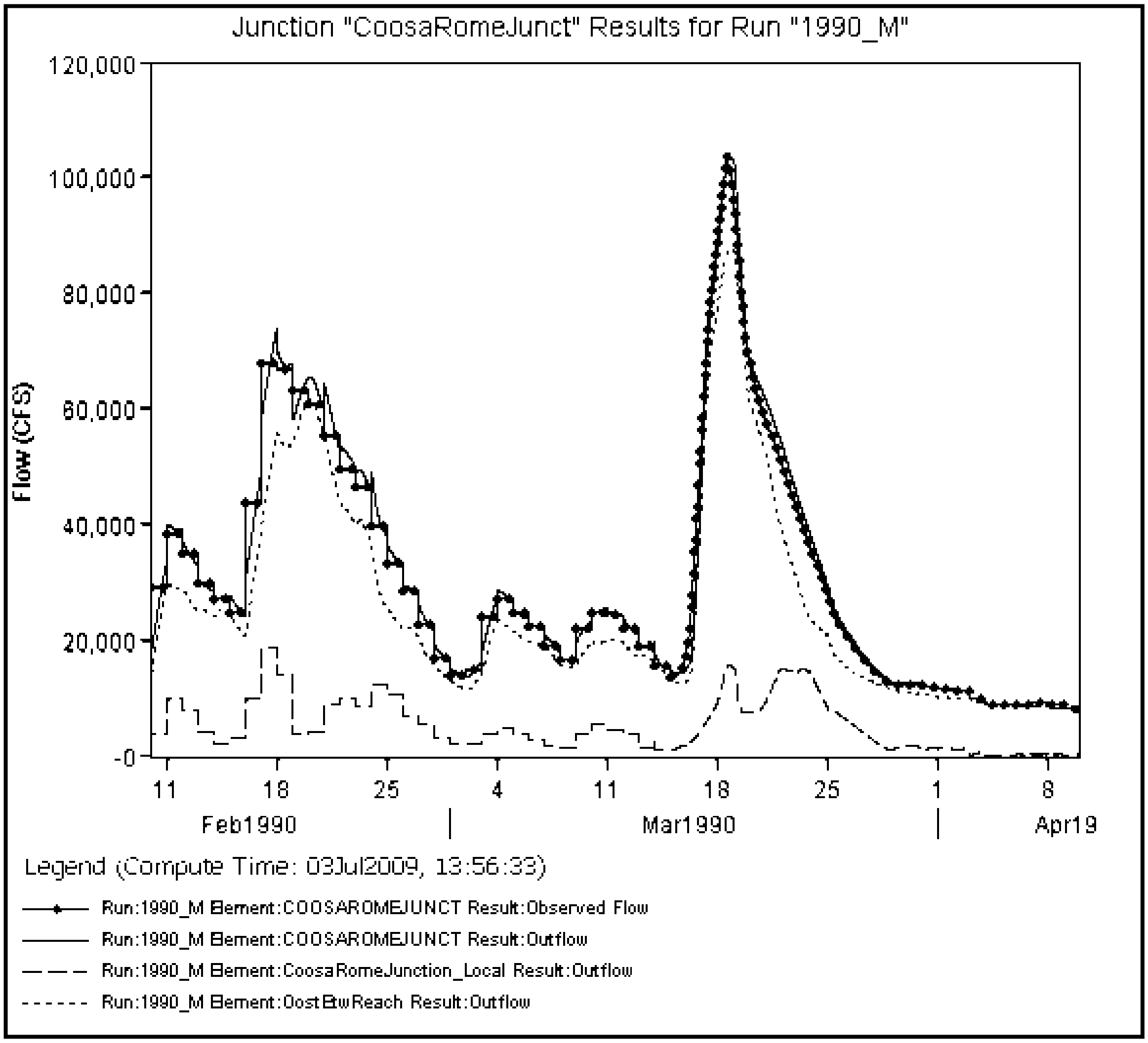

Figure O-C.03 1990 Flood CoosaRome Junction

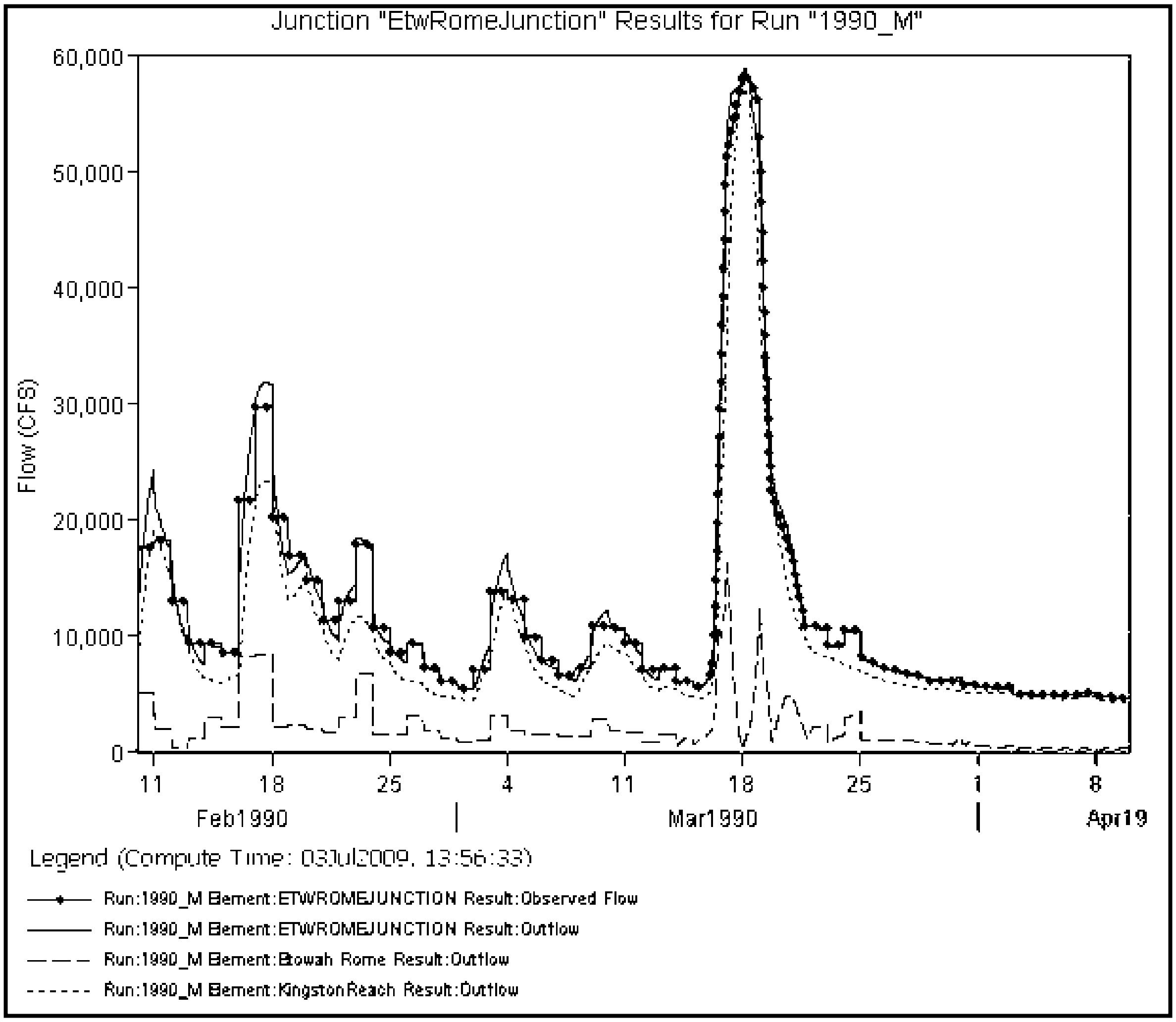

Figure O-C.04 1990 Flood EtowahRome Junction

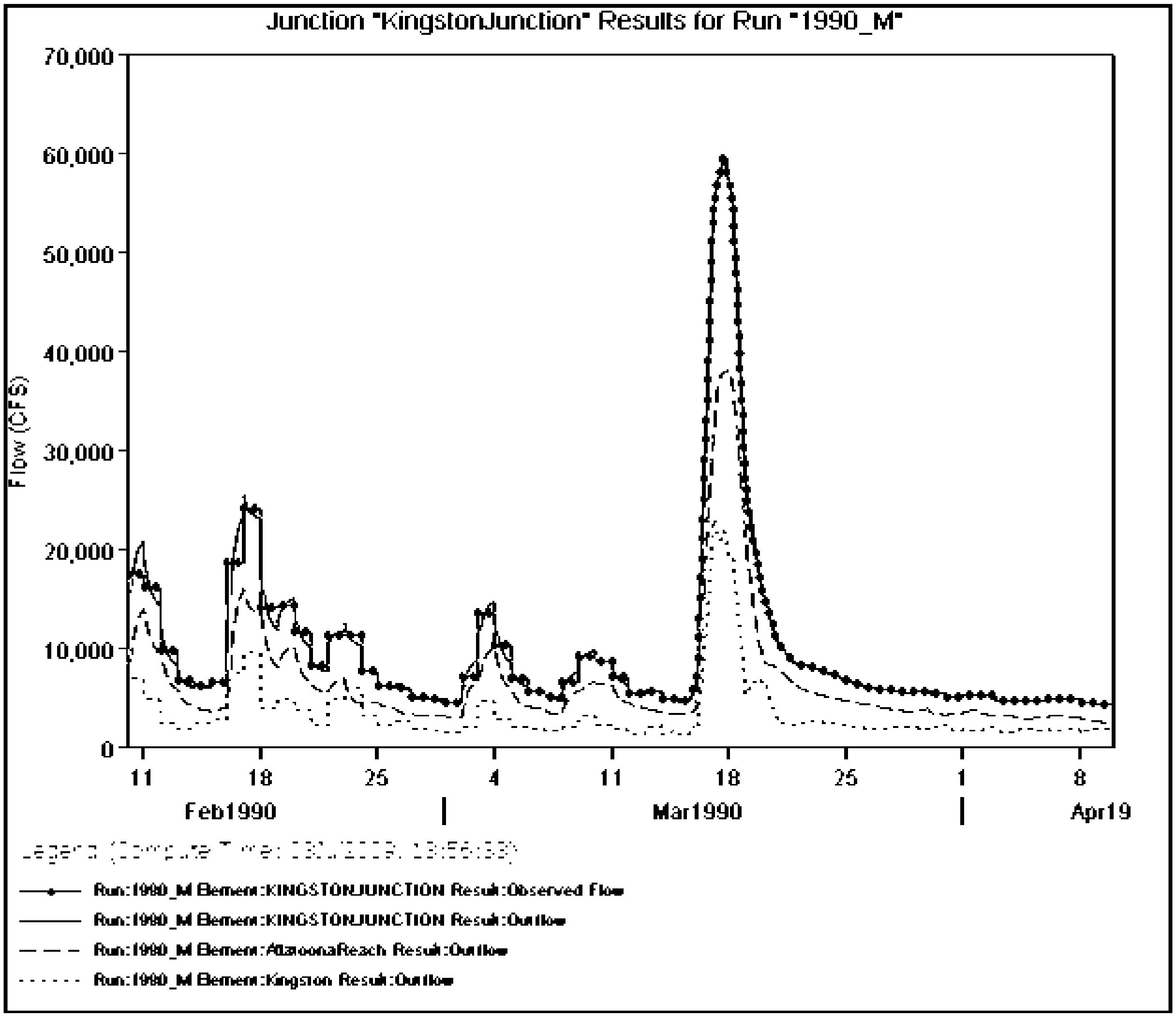

Figure O-C.05 1990 Flood Etowah River Kingston Junction

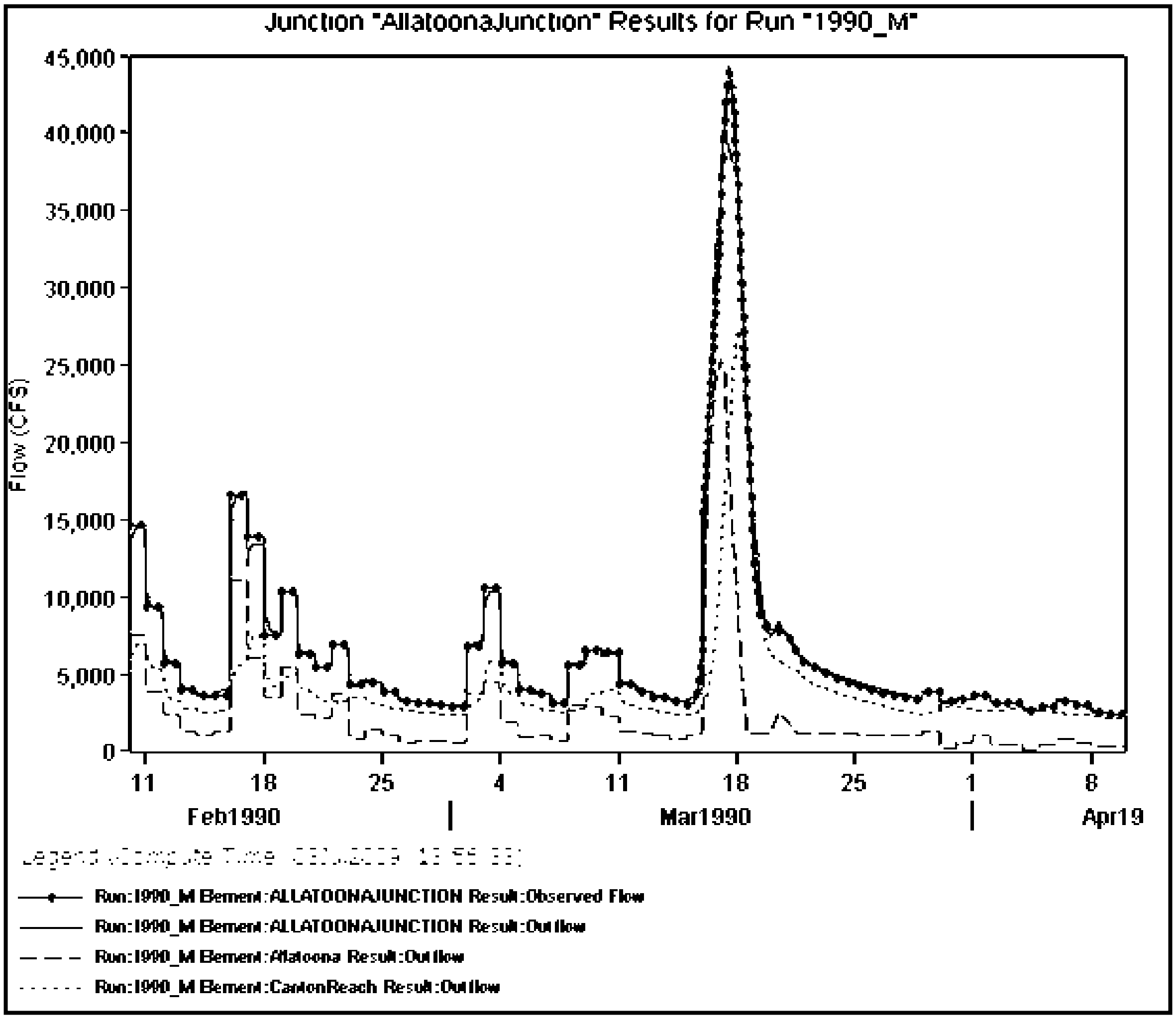

Figure O-C.06 1990 Flood Etowah River Allatoona Junction

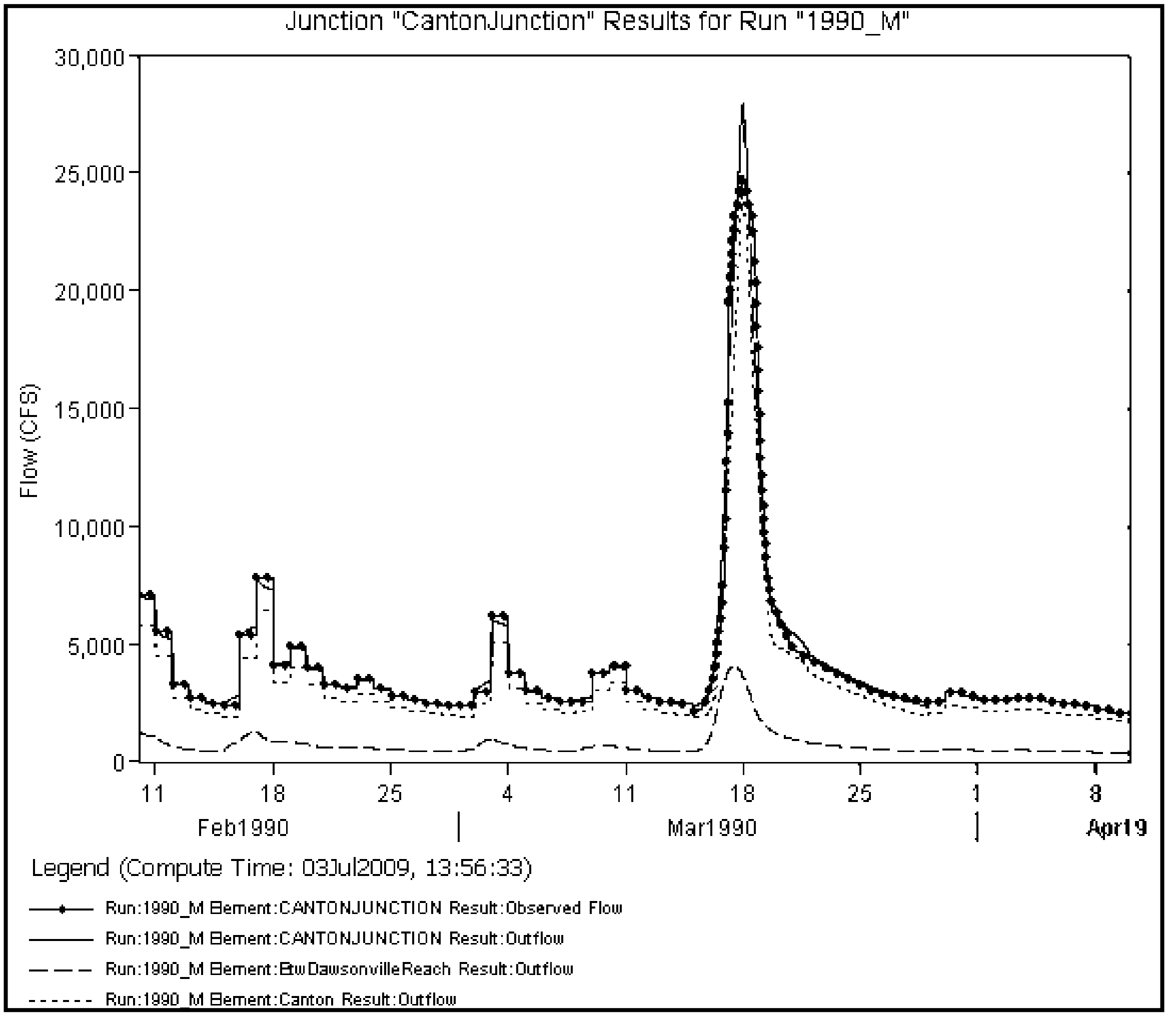

Figure O-C.07 1990 Flood Etowah River Canton Junction

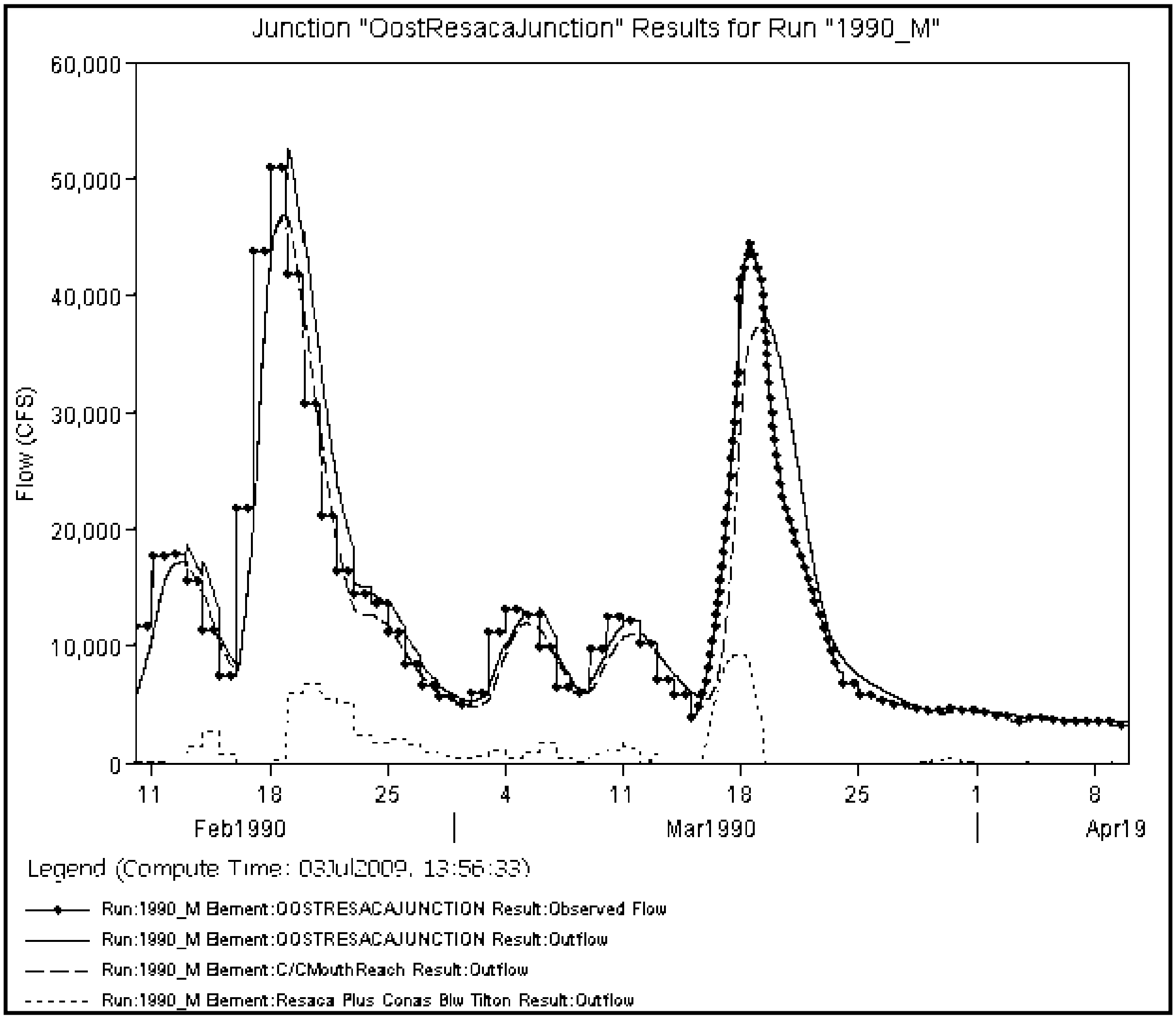

Figure O-C.08 1990 Flood Oostanaula River Resaca Junction

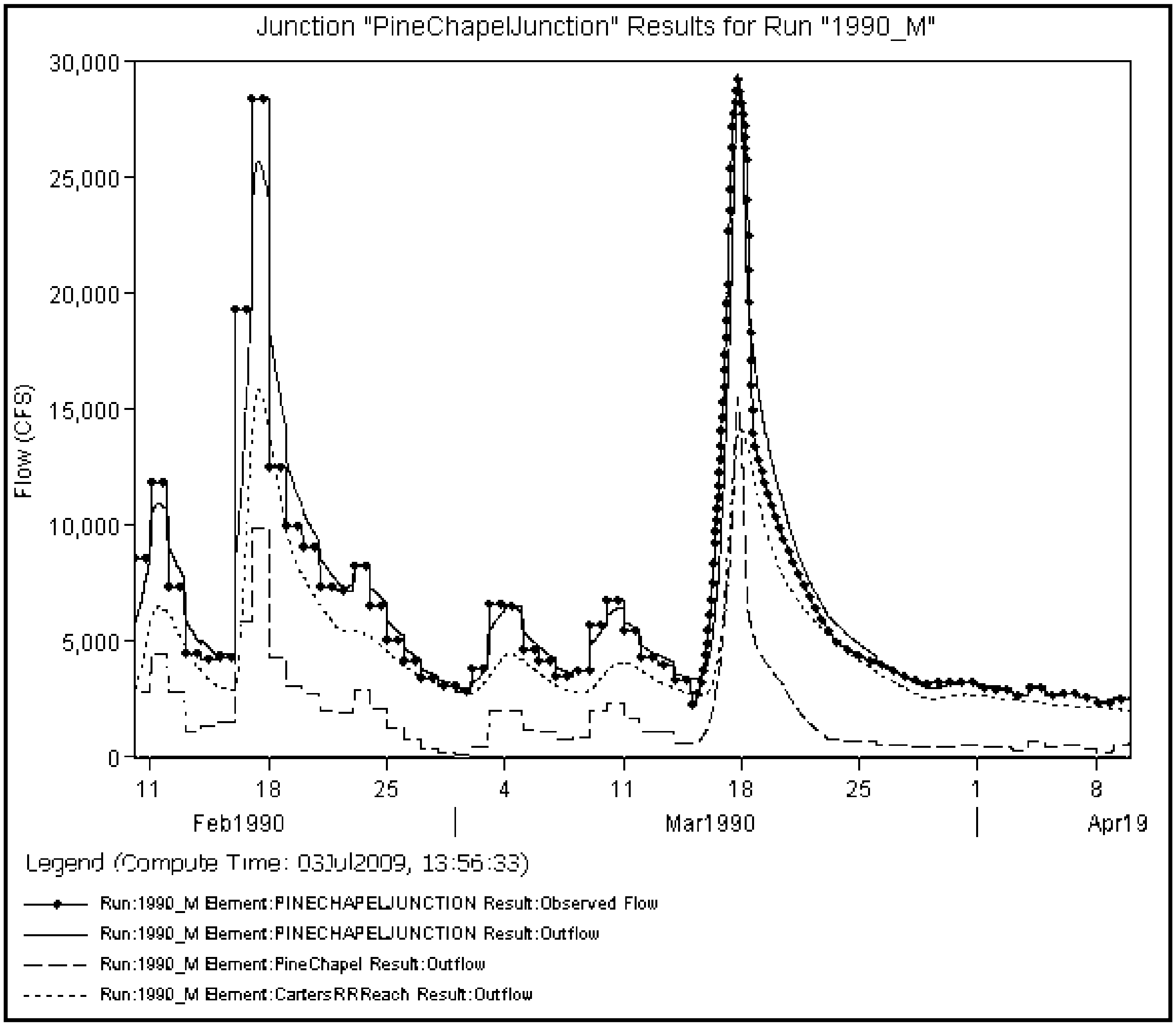

Figure O-C.09 1990 Flood Coosawattee River Pine Chapel Junction

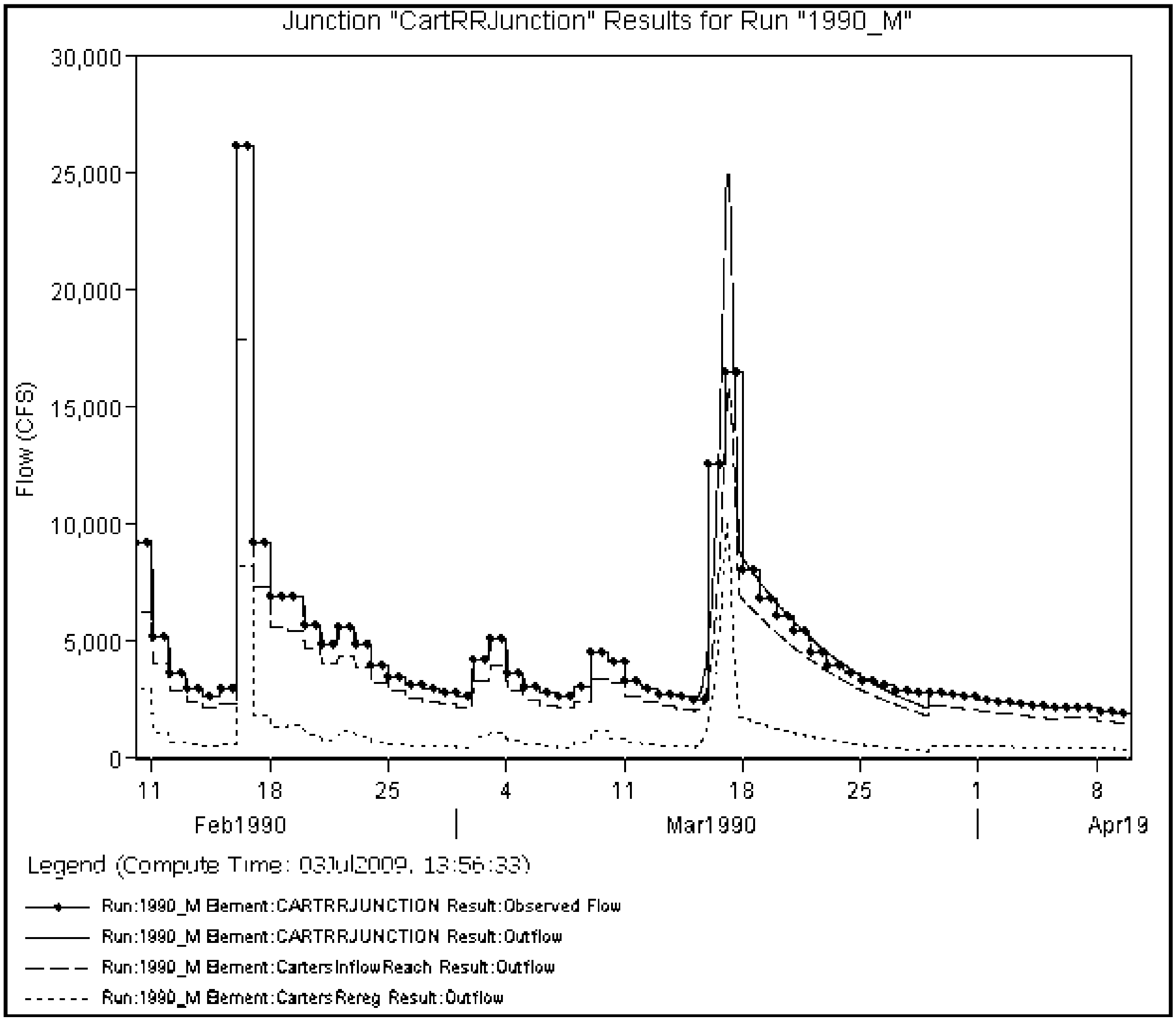

Figure O-C.10 1990 Flood Coosawattee River Carters Rereg Junction

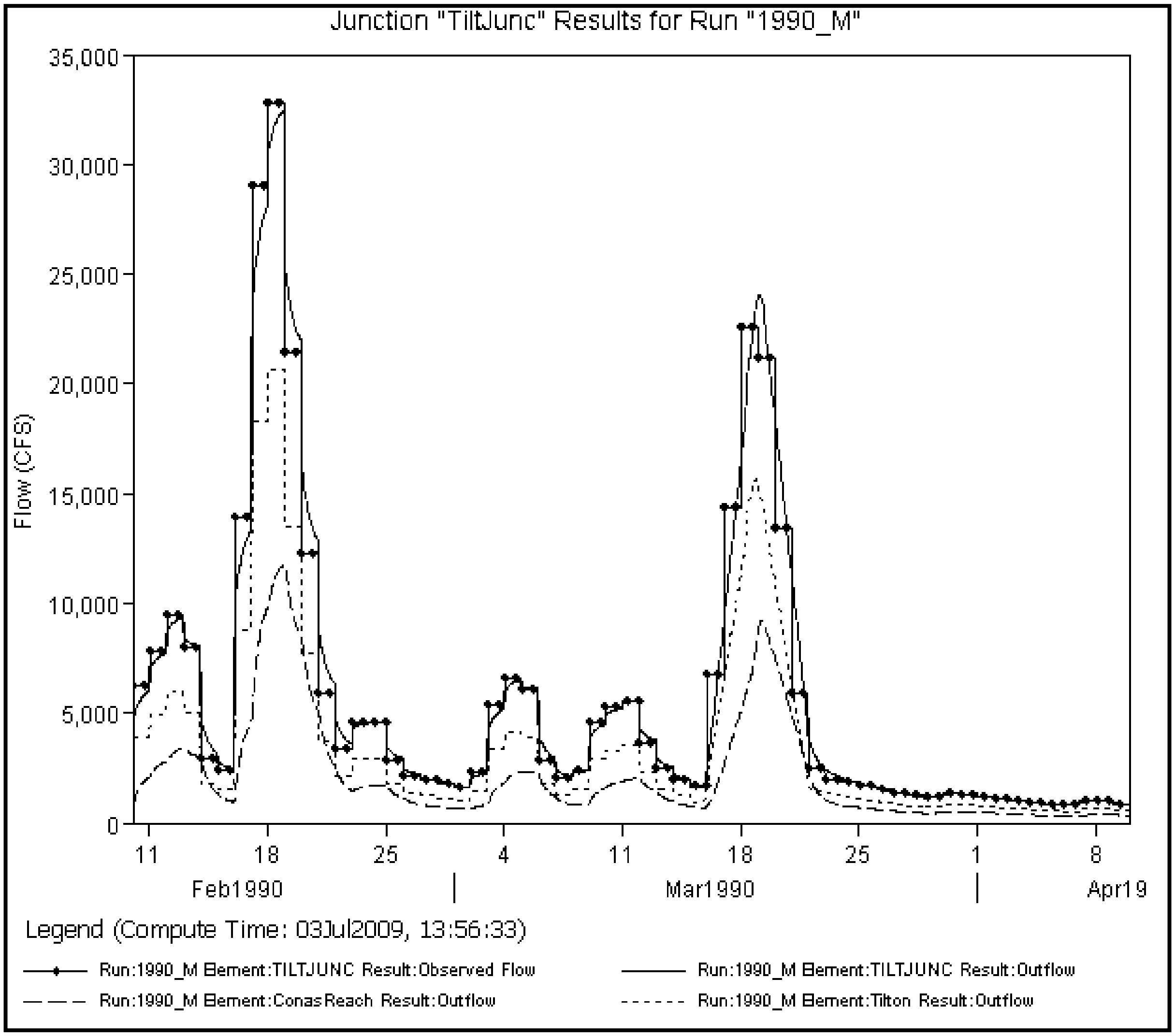

Figure O-C.11 1990 Flood Conasauga River Tilton Junction